

Neonatal Unit Handbook

Christchurch Women's Hospital

With many thanks to past and present consultants, registrars, nurses and allied health teams who have contributed substantially to this handbook and to the care of babies in the NICU.

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Any versions prior to this may not contain accurate information and should be discarded

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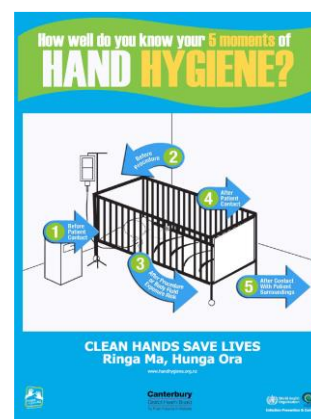
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❖ HAND HYGIENE

- Hand hygiene is the cornerstone of Infection Control programmes and is frequently referred to as the **single most important measure in reducing the transmission of healthcare associated infections**.
- Hand hygiene is a general term that applies to hand washing or use of the alcohol based handrub,
- Hand washing removes blood, body fluids, dirt and transient micro-organisms from the hand using water and either plain or antimicrobial liquid soap (chlorhexidine/green soap).
- Alcohol based hand rubs rapidly destroy micro organisms on the hands and can be used at any time where otherwise hand washing would be carried out but they **must not be used if the hands are visibly soiled or following a procedure where this is likely**.
- The latest approach to hand hygiene is based on the World Health Organisation's '5 moments' approach:
 - Before patient contact
 - Before a procedure
 - After a procedure or body fluid risk exposure
 - After patient contact
 - After contact with a patient's surroundings
- For hand hygiene of any type to be effective, the following must apply:
 - The hands and wrists should be **free of jewellery** (with the exception of wedding bands) eg: rings, bracelets, watches.
 - Nails must be short and clean
 - Any cuts/lesions must be covered



❖ CLINICAL PHOTOS AND CELO

- The accepted and safe way for sharing of clinical photos or imaging is via the secure CELO app.
- See the document below on how to download this app.
- A new feature in 2023 allows the images to be uploaded HCS if appropriate, although it is not a replacement for good quality Medical Illustration photos.



CELO app and
uploading to HCS.p

❖ RESUSCITATION AND ADMISSION GUIDELINES

Labour Ward Attendance

- A member of the paediatric team will attend high risk deliveries or if problems can be anticipated.
- To provide optimal and timely resuscitation which can be predicted from characteristics of the pregnancy, labour, or interventions required to effect delivery.
- The paediatric team members will either be the Paediatric Registrar or NNP on delivery suite duty and contactable on Pager 5019 in the first instance. The Paediatrician on call will be contacted in the event of unavailability due to workload or seriousness of the need.
- The Neonatal Associate Clinical Nurse Manager (ACNM – Pager 5088) is often able to attend deliveries if the RMO / NNP is unavailable. They will also accompany the RMO / NNP if resuscitation is likely (see charts below). They should be contacted preferably prior to delivery, where admission to the neonatal unit is expected.

- It has been estimated that 2-5% of low risk deliveries may require basic resuscitation at birth but only 0.1% require advanced resuscitation skills such as intubation, cardiac massage and medications. This translates into 120–300 babies requiring basic resuscitation and 6 advanced resuscitation at Christchurch Women's Hospital. The deliveries identified as high risk or with anticipated problems may include:
 - premature labour < 35 weeks gestation
 - vaginal breech or other malpresentations
 - instrumental deliveries - forceps, ventouse
 - cord prolapse
 - elective caesareans ie those < 39 weeks, infant of a diabetic, maternal complications
 - fetal distress, IUGR
 - multiple births
 - significant fetal anomaly - check for information in the FAAC folder in Neonatal Reception (especially babies with possible surgical problems)
 - meconium liquor
 - maternal chorioamnionitis (any gestation)
 - maternal illness (diabetes, PET, polyhydramnios, oligohydramnios)
- The Neonatal Consultant should be called before delivery when there is a reasonable chance of the baby needing advanced resuscitation.** For example:
 - For **ALL** category 1 caesarean sections the team to discuss the clinical situation and contact the SMO if needed. This will depend upon the indication for the Cat 1 section and the skills of the team onsite at the time.
 - In other categories of caesarean sections where there are additional factors that increase the chance of advanced resuscitation being required (eg congenital cardiorespiratory anomalies)
 - In vaginal or instrumental deliveries where there is a significant chance of advanced resuscitation being required (eg breech with IUGR)
- Equipment for resuscitation must be checked and ready prior to delivery when anticipated problems exist.
- Other cases which require discussion with the paediatric team prior to delivery:
 - Rhesus iso-immunisation
 - Congenital anomalies
 - Possible intra-uterine infection eg CMV, toxoplasmosis, Syphilis serology positive
 - Gestation 35- 36 weeks – attendance at delivery not required unless additional factor.
 - Suspected IUGR or SGA small for gestational age, where BWT < 2.5kg
- Examine all babies whose deliveries you are requested to attend and are actively involved in and document the findings in the 0-2 hour section of the delivery sheet. If an abnormality is present, show it to and discuss it with the parents. Don't be afraid to tell them frankly if you are not sure of the cause or what to do. If you are uncertain or if a major anomaly is present, consult a senior colleague. Never conceal anomalies from parents.
- Do not do the "24 hour check" at the time of resuscitation as transition will not have occurred and congenital heart conditions will be missed.
- When transporting from the labour ward use the transport incubator. All ventilated infants must be accompanied by medical staff. Tell the parents what you are doing and why. Encourage the partner or (with mother's permission) other support person to accompany you to the unit

Resus in Waipapa ED

- If a birth is imminent in ED at Waipapa it will occur in R3
- Communication flow will be the ED team calls the ACNM who will then contact the SMO and onsite Neonatal team
- Some set-up of equipment will be required and this may be done by the ED nurses, midwifery or neonatal team attending
- Checklists are available with the resuscitaire to help with this process
- There are 2 packs with equipment – airway pack and neonatal pack
- Refer to the video on the Neonatal Intranet – Staff education tab

Set-Up

- Resuscitaire to be plugged in
- Blender will need to be used – remove air and oxygen flow meter from the pendant and screw in the appropriate connections from the blender stand (note the blender is not always set up as Paeds do not require this)
- Temperature probe will be available on the blender stand
- Neopuff to be set up and the green tubing needs to be attached to the blender
- Suction catheter to be attached to the suction equipment at the base of the pendant
- A standalone monitor will be brought in by ED staff for saturation monitoring
- There is no Apgar clock so use the timer in the room if available

Communication for Neonatal Attendance at Deliveries

- The standard communication is for a Midwife or Obstetric Registrar to phone the Neonatal Registrar or NNP with the details of the case and its location. ISBAR should be used to communicate who is calling, what the situation is, the details of the case, location and expectation of timing.
- A '777' call is an emergency call made through the switchboard when neonatal presence is urgently required. This requires the call to be answered and switchboard will pass on the message. The '777' Neonatal team is the RMO / NNP and ACNM.
- If the Neonatal Consultant is required they will have to be phoned directly separately.

Caesarean Section Categorisation

Caesarean sections are categorised according to the Table below. It is no longer acceptable for the phrase 'emergency' or 'crash' to be used. The Categorisation must be stated in communications.

Category 1 – threat to the life of the woman or fetus

Category 2 – maternal or fetal compromise requiring rapid delivery

Category 3 – maternal or fetal clinical situation requiring early delivery

Category 4 – delivery at a time to suit the woman and maternity service

The table below outlines examples of when neonatal attendance is expected at Category 1, 2, 3, 4 sections.

Caesarean Classification	Neonatal NNP/RMO	ACNM	Neonatal Consultant
Any General Anaesthetic	Yes	Yes	Yes
If a credentialled Senior Registrar or NNP is available and the GA is for indications such as inability to site a spinal or maternal anxiety in the setting of no maternal or fetal distress then they are to discuss the case with the SMO who may not need to attend the delivery.			
Category 1	Yes	Yes	Yes - if requested by the onsite team
eg: maternal arrest, cord prolapse, uterine scar dehiscence, fetal bradycardia < 100/min for ≥ 5mins, fetal scalp pH < 7.0 and/or lactate ≥ 5.8, placenta praevia and/or major haemorrhage + maternal/fetal compromise			
Category 2	Yes	Yes	Not routinely but have low threshold for calling
eg: CTG abnormality (ie: late decelerations) +/- with scalp pH 7.01 – 7.20 and/or lactate 4.8-5.7, breech presentation in active labour unsuitable for vaginal delivery, meconium with fetal distress			
Category 3	Yes – see below No – booked for elective section and present in labour with no risk factors	Not routinely	No
eg: Failed induction of labour presuming indication for induction still exists, pre-eclampsia at term unsuitable for vaginal delivery, suspected IUGR unsuitable for vaginal delivery with normal CTG, delay in progress in labour with no evidence of maternal / fetal compromise, abnormal Dopplers or maternal PET necessitating preterm delivery, APH			
Category 4	Yes – see below No – if no risk factors, singleton, ≥39 weeks	Not routinely	No
eg: Congenital abnormality, maternal diabetes, oligohydramnios, polyhydramnios, maternal BMI>30, prolonged rupture of membranes, placenta anterior/accreta/praevia, maternal drug use, breech presentation			

Vaginal Delivery Categorisation

Clinical Scenario		Neonatal NNP / RMO	ACNM	Neonatal Consultant
Preterm Singleton Deliveries	< 28 weeks	Yes	Yes	Yes
	28 – 34 ⁺⁶ weeks	Yes	Yes	Neonatal ACNM/RMO/NNP to consider calling
	35-37 weeks	Yes	No	No
Multiple Births	< 30 weeks	Yes	Yes	Yes
	30-36 weeks	Yes	Yes	Neonatal ACNM/RMO/NNP to consider calling
Antenatal Diagnoses	Fetal abnormality likely to affect cardiorespiratory condition at birth eg: diaphragmatic hernia or neck mass	Yes	Yes	Yes
	Vaginal breech	Yes	Yes	Yes If a credentialed Senior Registrar or NNP is available then they are to discuss the case with the SMO who may not need to attend the delivery
	Fetal growth restriction < 3% with estimated weight < 2.5 kg	Yes	Not routinely unless CTG abnormal	No
Perinatal Complication	Cord Prolapse	Yes	Yes	Yes
	Pathological CTG eg: sinusoidal trace, sustained bradycardia < 100 for ≥ 5 mins	Yes	Yes	Yes
	Fetal Scalp pH < 7.0 and/or lactate ≥ 5.8	Yes	Yes	Neonatal ACNM/RMO/NNP to consider calling
	Meconium liquor	Yes	Not routinely unless CTG abnormal	No
	Maternal Chorioamnionitis	Yes	No	No
Instrumental Delivery	Ventouse / Kiwi Cup	Yes	No	No
	Mid cavity forceps	Yes	No	No
	Lift out forceps	Yes	No	No

Preparation for Resuscitation

Notify the consultant on duty of all Level III admissions, plus any others who are significantly unwell, or about whom you have urgent questions.

Good stabilisation is important in the management of all infants and can make a critical difference to a sick or premature baby's subsequent course. However, comprehensive assessment and management must be undertaken, as far as possible, in a way that minimises stress to the baby and facilitates parent/infant contact.

High Risk Deliveries

- At the beginning of the shift, visit labour ward so that you can anticipate high risk deliveries.
- When attending a high risk delivery, ask the ACNM or another neonatal nurse to accompany you.
- Call the consultant if the baby is < 28 weeks, or if there is any other reason to expect that the baby will need a full resuscitation (eg. severe fetal distress, major congenital malformations, significant hydrops etc.) **or if you have any other concerns.**
- Take surfactant to the delivery of babies < 28 weeks
- Surfactant dosing: 100 mg/kg (1.25 mL/kg) in babies after a complete steroid course (need 3 mL vial if > 1.2kg) and 200 mg/kg (2.5 mL/kg) in babies with incomplete steroid courses (3mL vial needed for most babies).
- Remember to return it to the refrigerator if it is not used as it is expensive.
- Prepare the temperature probe for continuous monitoring of temperature at the birth

High Risk Multiple Births

- Multiple births < 30 weeks require additional experienced nursing and medical attendance.
- During the day the Delivery suite Registrar/NNP will discuss the impending delivery with the neonatal consultant on service and the ACNM.
- Staff to attend will be identified so that each baby will have a Registrar/NNP and a neonatal nurse in addition to the consultant and ACNM.
- The Level 3 staff member will be suggested in the first instance as the second Registrar/NNP
- The ACNM will identify nurses with intensive care experience utilising the clinical support nurse and level 3 allocated nurse who will caring for the baby after admission.
- Multiple births <26 weeks should have 2 Neonatal Consultants present

Preparation

- Maternal history for abnormalities of family history, maternal history, pregnancy, labour and delivery.
- Oxygen supply, Suction
- Neopuff
- Laryngoscope (correct blade, good light, clean).
- ET tubes (correct size, open and insert stylet if strong likelihood of intubation)
- Overhead warmer on, 2 warm towels available to dry the baby.
- Get the temperature probe that is stored with the humidification set-up in the Recovery store room to use at the birth for continuous temperature monitoring for preterm deliveries (definitely <32 weeks) or other high risk situations such as gastroschisis
- UVC's are available in both theatre 26 and 27 resuscitaires and also in the storeroom beside the Delivery Suite handover room for birthing rooms deliveries. UVC's are not stocked in every room due to supply issues, expiry dates and infrequent use.
- Intraosseous is available and is stored in NICU in surgical pod
- Draw up resuscitation drugs (1:10,000 adrenaline, normal saline, see later section) and prepare umbilical catheter **and call for consultant help** if there is a strong likelihood they will be needed (eg. persistent fetal bradycardia before emergency delivery).
- Babies < 30 weeks gestation or estimated to be < 1500gm should be placed in a polyethylene plastic bag at delivery to maintain their temperature. The bag should not be removed for auscultation of the heart or cardiac compressions or for giving im vitamin K.
- **If axilla temp is <36.5** – remain in plastic bag and use incubator in radiant warmer mode. Insert peripheral iv and start 10% dextrose. Once axilla temp is between 36.6-37.2 degrees remove from plastic bag and insert umbilical lines
- **If axilla temp is ≥36.5** – remove from plastic bag, nurse in a closed incubator, insert a peripheral iv and start 10% dextrose if there will be a delay in securing umbilical line access, otherwise proceed straight o using the incubator in radiant warmer mode and insert umbilical lines

Intubation

- Baby less than 28 weeks unless the baby is very active and has minimal or no respiratory distress
- Persistent bradycardia (unresponsive to bag and mask ventilation).
- Inadequate or ineffective respiratory effort after 2 minutes.
- Exposure to thick or particulate meconium, or heavily blood stained amniotic fluid **and** the baby requires immediate ventilation. Oropharyngeal suctioning at the perineum is no longer in our protocol. If the baby is not active suction by direct visualisation of the laryngopharynx and suction
- Respiratory distress in the presence of antenatal or postnatal diagnosis of anomalies (such as congenital diaphragmatic hernia, intestinal atresia, abdominal wall defect) in which bag and mask ventilation is generally contraindicated.

Equipment

- Laerdal bag or Neopuff
- Oxygen, Stethoscope, Pedi-cap
- Appropriate sized face mask
- Suction equipment – size 10 at least
- Cardiac monitor and pulse oximeter for neonatal unit intubations
- Laryngoscope and appropriate blade, with a bright light
- Neofit fixation device
- Introducer or Magill's forceps

Technique

- Prepare and check equipment
- Note markings on ET tube and how far to insert through cords (trachea length is 2.5 – 5.0cm from 600g – 5.0kg)
- Position baby and have head slightly extended
- Ensure adequate preoxygenation, which may be by bag and mask ventilation
- If an elective procedure give premedication with morphine, atropine, suxamethonium as per drug protocols
- Place laryngoscope by holding it in the left hand with thumb and first two fingers
- Stabilise head with right hand
- Open the infant's mouth with right index finger
- Introduce blade from right side of mouth, advance to just beyond base of tongue
- Lift blade and observe the landmarks but avoid tilting the laryngoscope
- The epiglottis and cords should come into view
- Cricoid pressure by an assistant may help
- If the laryngoscope is in the oesophagus, withdraw until epiglottis flips into view
- Insert tube through cords into trachea
- An introducer may be necessary to keep the correct curvature on the tube
- Hold tube in place firmly and ventilate
- Check tube position:
 - Observe chest movement
 - Attach pedi-cap and observe for colour change (purple to yellow if in the airway with cardiac output)
 - ET tube may mist up
 - Auscultate to assess tube position
 - Observe response of heart rate and saturation
 - Note length of ET tube at lips/nares
- Attach Neofit to secure the tube in place
- CXR to check tube position

Complications

- Hypoxaemia. If it takes too long to intubate or incorrect tube placement. Do not persist with intubation attempts. If heart rate or saturation fall, stop and bag/mask the baby until they recover
- Bradycardia. Either a vagal response or related to hypoxaemia.
- Trauma. Related to laryngoscope or tube being advanced. Can perforate the oesophagus or trachea, or damage vocal cords.

ET Tube Size	Indication	Comments
2.0	Cannot insert 2.5 ET tube.	Lumen too small to suction down tube, use as a last resort.
2.5	< 1.5 kg	In general, use a tube that is not a tight fit, to reduce the risk of trauma and later subglottic stenosis, however change to a bigger tube if there is excessive air leak.
3.0	1.5 - 2.5 kg	
3.5	2.5 - 4.0 kg	
4.0	4.0 kg	

Insertion distance: because the trachea is short in babies, there is little leeway between a tube that is too short (increased air leak, risk of accidental extubation) and a tube that is too long (bronchial intubation and/or airway trauma). Therefore, it is important to get used to judging correct insertion distance. It is rare to need to insert a tube more than 1 to 1.5 cm below the vocal cords (the exceptions being such situations as trachea-oesophageal fistula or other subglottic anomaly, and the occasional baby in whom elective ventilation of one lung is indicated). The black segment at the tip of the tube is 1 cm long, so that should just disappear below the cords.

The following is a rough guide to tube insertion distance, but the exact distance will need to be individualised because of variation in jaw size, so always check the breath sounds immediately, and request a radiograph promptly. Weight (over 0.5kg) + 6 in cm is also a good guide.

Gestation Age	Weight (kg)	ET Tip to Lip (cm) (Oral)	ET Tip to Nostril (cm) (Nasal)	ET size (mm)
24-25 weeks	0.75	6.5	7.0	2.5
26-28 weeks	1.0	7.0	8.0	2.5
29-32 weeks	1.5	7.5	8.5	3.0
33-34 weeks	2.0	8.0	9.0	3.0
35-36 weeks	2.5	8.5	9.5	3.0
37-39 weeks	3.0	9.0	10.0	3.5
40-42 weeks	3.5	9.5	11.0	3.5

Confirmation of Tube Position

- Chest movement with assisted breaths
- Breath sounds audible in axilla bilaterally with assisted breaths
- ET tube mists with breaths
- Pedi-cap on the end of the ET tube changes colour from purple to yellow but not if cardiac output is low
- Improvement in heart rate and saturations
- CXR – it is important that a double check of the ET tube placement is undertaken by a Consultant and Registrar or NNP. This should be done individually. If in doubt a radiology registrar is available on site between 1700 and 0800 and a radiologist is at the CWH reporting desk between 0800 and 1700.

Neopuff

The Neopuff resuscitator can be used as a ventilation device or be used to deliver CPAP to a baby once an infant has established respirations. It can allow delivery of CPAP from birth rather than waiting until admission to NICU.

Gas source	- desired flow rate is 8-10 l/min.
Maximum pressure relief	- allows maximum PIP to be preset. To set, occlude the PEEP cap, turn PIP control clockwise.
Inspiratory pressure control	- adjust the maximum pressure control knob to desired pressure eg. 35mmHg.
Gas outlet	- allows you to ventilate at a preset PIP by occluding the PEEP cap for the desired inspiratory time.
T-piece PEEP Cap	- gas exits the neopuff through attached tubing to a T piece that has the PEEP cap. This can connect to a mask or ETT.
To deliver PEEP	- the cap can be turned to deliver the prescribed PEEP.
To ventilate	- place mask over the face with PEEP cap uncovered.
To deliver facial O₂	- attach T-piece PEEP cap to ET or mask. Occlude PEEP cap to deliver PIP at desired rate and inspiratory time.
	- loosely place mask near face so gas escapes around the edges

Meconium Aspiration

- Meconium stained amniotic fluid (MSAF) comes in various consistencies – thin, moderate and thick.
- Thin occurs in 50-60% of MSAF deliveries and carries a 2-3% risk of needing some respiratory assistance, with 1% needing ventilation.
- Thick occurs in 15% and 25-30% require significant resuscitation and 10% on going respiratory support

Risk Factors for Meconium Aspiration Syndrome

- Primiparity
- Pacific Island ethnicity
- Male gender
- Low cord pH
- Abnormal CTG (if severe)
- Thick meconium.

8-12% of deliveries are complicated by meconium stained liquor.

In a study by Wiswell 2000, 7% developed respiratory distress of which 3% had MAS and 4% other disorders.

Management of Meconium Stained in the Liquor

- Babies born through meconium stained fluid do not need the mouth and nose suctioned while the head is on the perineum.
- If the baby is flat then the obstetric/midwifery team should stimulate the baby
- There is no requirement to routinely suction below the vocal cords in an infant with meconium aspiration who is apnoeic and flat. In experienced hands airway suction can be done swiftly without causing prolonged hypoxia but if the resuscitator is not experienced at intubation then they should proceed immediately to bag/mask ventilation and normal resuscitation guidelines (NLS Guidelines 2016)
- If the baby shows signs that the nasal passages or airway are blocked and this is impeding the resuscitation then suction of the nose and mouth and below the cords should be performed at that stage
- If the baby is vigorous then usual cares should be given

Cord Gases and Placental Pathology

- Ask for a cord pH if a baby requires active resuscitation with bag and mask, fetal distress on CTG, meconium stained liquor, APGAR < 6 at 5 minutes.
- A segment of cord can be clamped at each end and the blood for this drawn up to 20 minutes later
- It is the joint responsibility of Obstetrics and Neonates to remember to request a cord gas in emergency situations
- Ask for the placenta to be sent to pathology for
 - all cases of suspected intrauterine infection or chorioamnionitis,
 - prolonged rupture of membranes,
 - placental anomalies,
 - all babies in whom a significant resuscitation occurs,
 - when perinatal death occurs and
 - any baby with significant IUGR.

Asking for some cord blood to be saved in a green top tube for later serology or other studies can also be useful.

Drugs for Resuscitation

- Adrenaline is the first choice drug in a newborn resuscitation after establishing effective ventilation.
 - External cardiac massage (ECM) for 1 minute is required to distribute it to the heart.
 - Repeat doses every 3 minutes.
 - Give by ETT, if intubated, until an umbilical venous line is inserted.
- Sodium bicarbonate 8.4% requires dilution with water in equal parts to give 4.2%.
 - Use in prolonged resuscitation (>15minutes) after effective ventilation/ECM is established.
- Note that naloxone was removed from the resus drug inventory in 2018. However, if considered do not give to the baby if the mother is opioid dependant eg: on methadone or buprenorphine

Neonatal Resuscitation Drug Dosing

Weight	0.5 kg	1 kg	1.5 kg	2 kg	2.5 kg	3 kg	3.5 kg	4 kg	4.5 kg	5 kg
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ETT Adrenaline 1:10,000	1.0 mL/kg	0.5 mL	1 mL	1.5 mL	2 mL	2.5 mL	3 mL	3.5 mL	4 mL	4.5 mL	5 mL
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IV Adrenaline 1:10,000											
Dose 1 via UVC (then dose every 3 mins)	0.1 mL/kg	0.05 mL	0.1 mL	0.15 mL	0.2 mL	0.25 mL	0.3 mL	0.35mL	0.4 mL	0.45 mL	0.5 mL
Further doses via UVC	0.3 mL/kg	0.15 mL	0.3 mL	0.45 mL	0.6 mL	0.75 mL	0.9 mL	1.05mL	1.2 mL	1.35 mL	1.5 mL

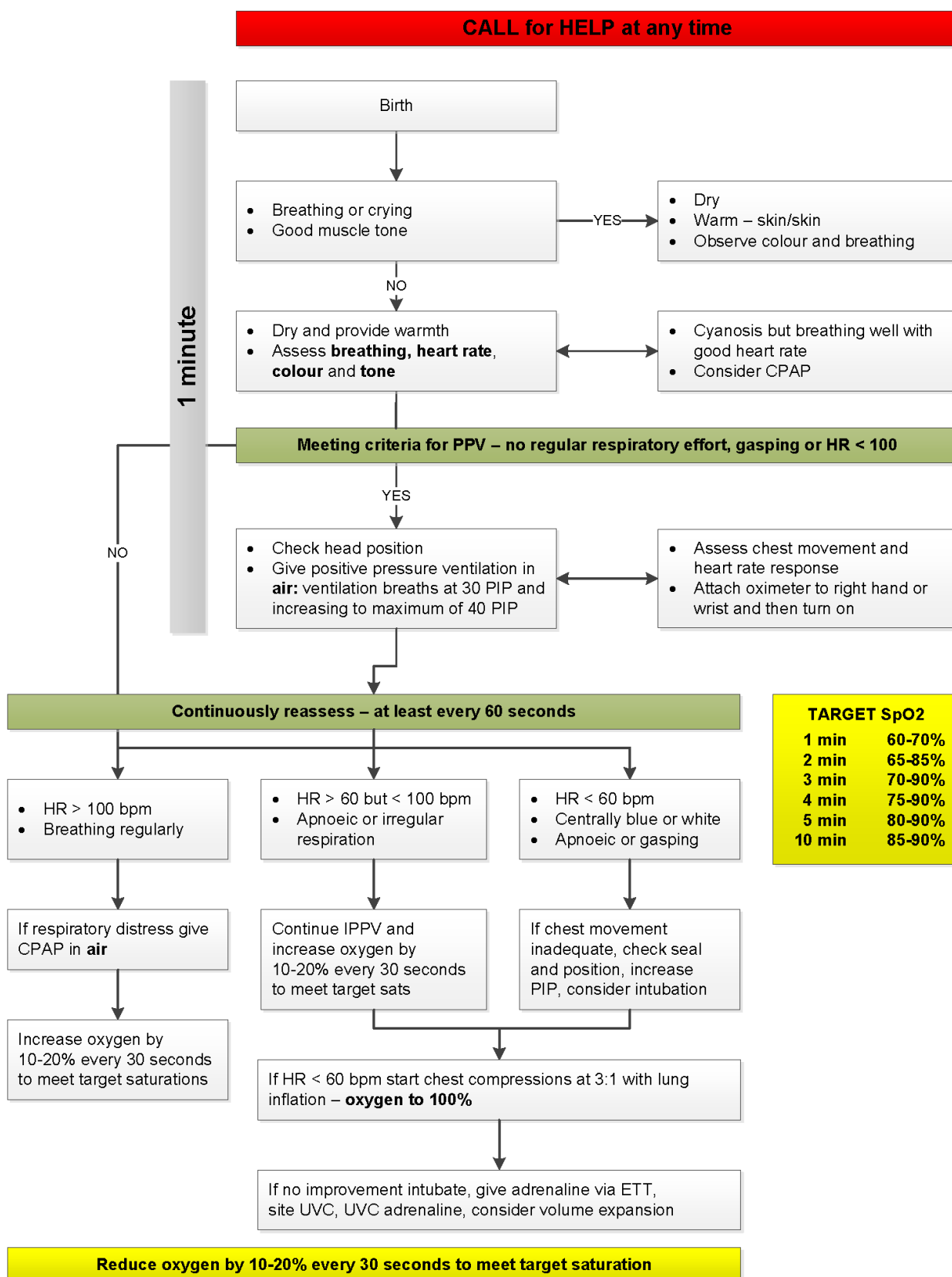
Volume IV over 5-10 min 0.9% saline, whole blood, 4% albumin	10 mL/kg	5 mL	10 mL	15 mL	20 mL	25 mL	30 mL	35 mL	40 mL	45 mL	50 mL
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Glucose 10% iv bolus	2 mL/kg	1 mL	2 mL	3 mL	4 mL	5 mL	6 mL	7 mL	8 mL	9 mL	10 mL
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Sodium Bicarbonate 4.2% slow IV push Dilute 8.4% with equal volume of water If prolonged resus but effective airway and CPR	2 mL/kg	1 mL	2 mL	3 mL	4 mL	5 mL	6 mL	7 mL	8 mL	9 mL	10 mL
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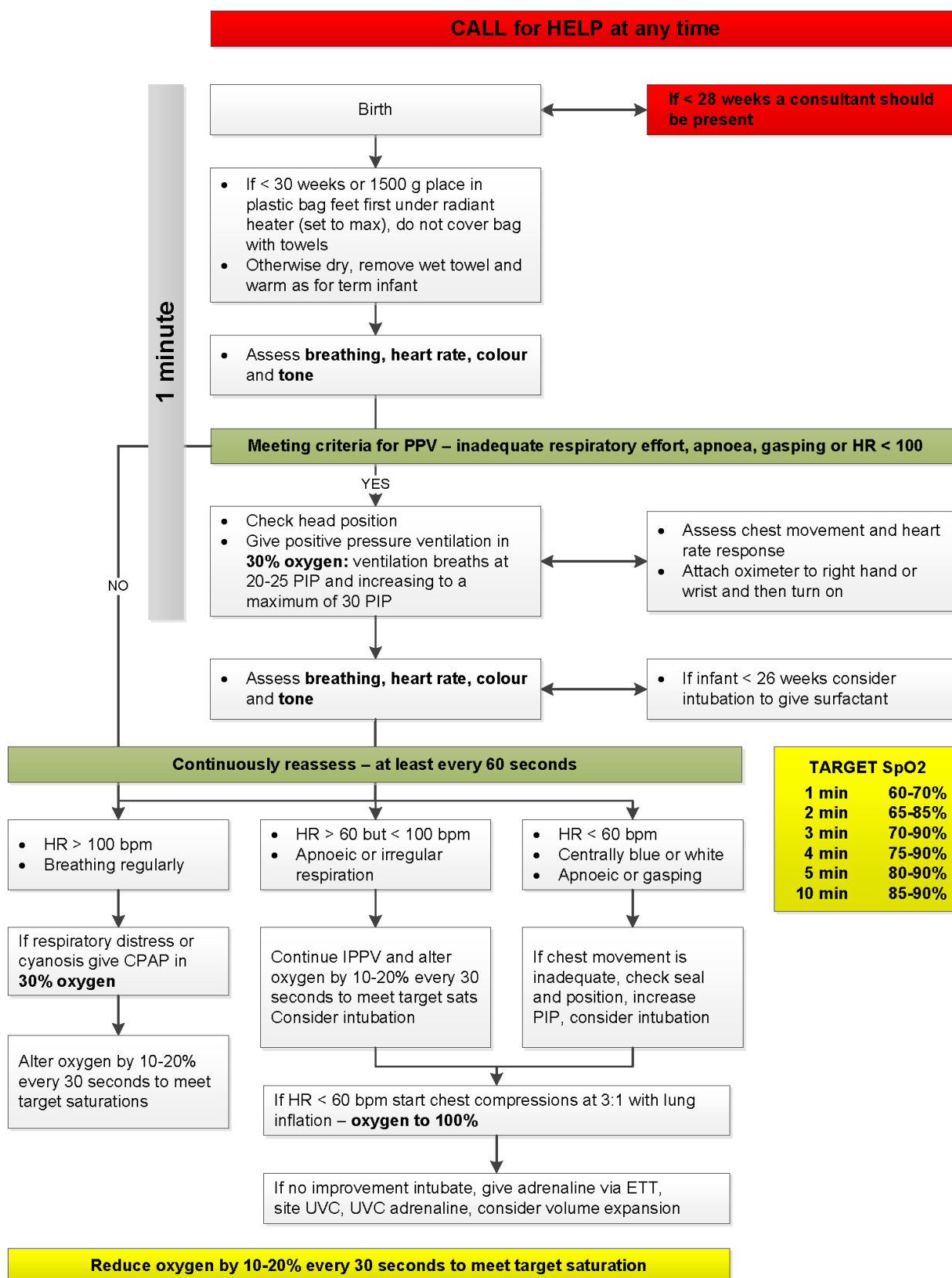
Term (≥ 37 weeks) Newborn Resuscitation Algorithm

(copied from Ref.2404624)



Preterm (< 37 weeks) Newborn Resuscitation Algorithm

(copied from Ref.2404624)



Admission Guidelines

Level 3

- Respiratory support required
- Concern that infant is moderately unwell

Level 2

- Weight < 2.3kg
- No respiratory support required
- For infants needing oxygen, antibiotics, iv fluids, thermoregulation, phototherapy, apnea monitoring, tube feeding
- Infants at risk of neonatal abstinence syndrome
- MIPS mother's stay is usually continuous until discharge unless the baby is preterm or not orally feeding.
- One of the intentions is to maintain mother-infant contact, mothers may be admitted to the parent facility once discharged from postnatal. If beds are short then priority is given to mothers establishing feeding or within 48 hours of discharge.

Admission Routine

- Weight, length and head circumference
- If the baby is in a polyethylene Neohelp bag, **take off 30g** if in a <1000g bag, or, **40g** if in the 1000-2500g bag
- Plot growth parameters on the centile charts
- Physical examination.
- Temperature and blood sugar

Unwell babies may also require:

- Blood Pressure
- Blood Gases
- Blood Cultures
- Full Blood Count with differential
- CRP – at least 6 hours after onset of illness/birth
- Group and Coombs
- Group and hold (on admission for infants < 30 weeks and others likely to need transfusion at any stage)
- Lumbar puncture (this can to be deferred in the presence of severe or unstable respiratory distress or in situations where the risk of sepsis is deemed very low -- if in doubt discuss with consultant)
- Intravenous line and commencement of 10% dextrose with additives (Premix)
- Antibiotic therapy as indicated

Very small and/or seriously ill babies, including those who will need continuous monitoring of blood pressure and frequent sampling for blood gases, biochemistry etc. should also have:

- Umbilical or peripheral arterial line
- Umbilical venous catheter
- Treatment of hypotension (saline, packed red cells, inotropes, second line treatment includes albumin or hydrocortisone)
- CXR/AXR to check position of UAC, UVC and ET tube
- Again remember to explain to the parents what is happening.

Vitamin K

Haemorrhagic disease affects one in 2-400 babies who are not given vitamin K prophylaxis. Recommendations are:

- All infants should have vitamin K prophylaxis (2mg/0.2ml)
- Vitamin K given either as a **single IM injection or as repeated oral** doses is safe and effective in preventing haemorrhagic disease of the newborn in **well** newborns.

- Parents should be free to choose, either an injection or oral doses for their child.
- Oral vitamin K is given as 2mg at birth with the first feed.
- For breastfed infants repeat doses (2mg) should be given at 5 days and at 6 weeks (with the first immunisation).
- IM vitamin K is given as a single injection of 1mg (0.1ml) at birth (< 1500 g 0.5 mg =0.05ml).
- **IM vitamin K is the strongly recommended route for high risk infants** (prematurity, birth asphyxia, traumatic deliveries, known hepatic disease, or any illness that will delay feeding, eg most NICU admissions)
- Maternal phenytoin, primidone or phenobarbitone therapy is an indication for the mother to be given vitamin K (10 mg IM vitamin K) 24 hours before delivery then the baby should have 1 mg IM vitamin K at birth then again 24 hours later.
- Usually maternal warfarin therapy is stopped well before delivery because it crosses the placenta and can cause severe neonatal haemorrhagic disease. Occasionally, it cannot be stopped for maternal reasons. In these circumstances, the baby will need immediate and usually repeated doses of vitamin K, as well as measurement of PT and PTT and fresh frozen plasma on standby.

Admissions to the Neonatal Unit in the first month after birth (or corrected age)

This document is to assist the clinical teams to consider whether an ill infant who presents aged less than one month (corrected age) needs admission to the neonatal unit.

Good communication between GP/Midwife, Paediatric, Paediatric Surgery and Neonatal staff from both the referring and receiving hospitals is essential to ensure the baby is cared for in the appropriate place. **Consultant to consultant discussion facilitates appropriate and timely decisions**

The most common pathway for presentation is via GP/LMC/Ambulance/ED to Paediatrics / CEC. Less frequently, the neonatal team or the paediatric surgeons are contacted directly.

For the specific indications outlined below, neonatal (re)admission can be arranged. Generally, this is for:

- (1) Infants up to one month of age born at term,
 - (2) Infants less than one month corrected age if born preterm,
- AND**
- (3) Infants with “neonatal” conditions as outlined below that require intensive care.

There may be a place for stabilising an infant in NICU prior to retrieval to PICU Starship, or if a short stay is predicted until they are transferred back to PHDU.

Involvement of the ACNM (neonatal co-ordinator pager 5088) is needed early, particularly if the neonatal transport team is required.

Admission to the neonatal unit is dependent on available cot space; sufficient staff and specific requirements (for example, some need isolation).

A neonate who ideally should be admitted to the NICU but is not able to be accommodated there, should be reviewed by the Neonatologist at the time of admission. The neonatologist can provide advice to the admitting paediatrician and surgeon re ongoing management and will review the patient on a daily basis in consultation with the paediatric team (and paediatric surgeons, as required).

Conditions and Severity Which May Need Admission to NICU

Jaundiced babies

- Babies with an SBR >400umol/L or above the exchange transfusion threshold should be discussed with the on-call Neonatologist to review management and to discuss where the baby should receive care.
- Intensive phototherapy can be given in PHDU with bilirubin levels preferably measured on a gas machine for rapid, reliable results less affected by haemolysis to be able to assess response to treatment
- If intensive phototherapy is not sufficient and an exchange transfusion is required the baby should be transferred as NICU has the skills and equipment to perform an exchange transfusion

Surgical babies

- Presentations may include Hirschsprung disease, malrotation with volvulus, bowel obstruction causing ischaemia, and some patients with strangulated inguinal hernias or pyloric stenosis.
- Ex-very preterm infants with major co-morbidity, such as those with chronic lung disease, growth failure < 3rd %.
- The need for post-operative respiratory support.
- The need for TPN post-operatively (or at any time)

Neonates (<1mth corrected) needing surgery must have a **surgeon and a paediatrician or neonatologist** involved in their care.

- The surgeons will inform the neonatal consultant on service as soon as they accept a referral from another DHB who meet the criteria for NICU Admission above or need Neonatal transport
 - to ensure there is a NICU bed available, the appropriate mode of transport and a transport team available.
- The surgeons will inform the Paediatrician of the day as soon as they accept a referral from another DHB for infants not needing NICU.
- Discussion between the teams will decide on the appropriate mode of transfer of the baby (if from another centre) and the most appropriate place for the neonate to be admitted to.
- Where transport is needed the neonatal ACNM pager 5088 should be contacted ASAP.
- Transport of a neonate who may be NBM for >4hrs requires iv access and a neonatal transport team

Respiratory support

- It is more appropriate for neonates with suspected infections and respiratory symptoms such as RSV and pertussis to be admitted to Paediatrics / HDU to prevent the spread of infectious diseases through the neonatal nursery.
- However, if there is a need for escalating respiratory support such as prolonged CPAP or the possibility of short-term ventilation and the isolation room (Room 2) is available then an admission is possible to prevent a transport to Starship
- Neonates with severe seizures due to trauma, meningitis or encephalitis may also require respiratory support in NICU
- **Transfer of neonates from paediatrics to the neonatal unit and vice versa requires consultant to consultant discussion.**

Cardiac

- Neonates with cyanotic congenital heart disease are best cared for in NICU due to the monitoring needed, possible requirement of prostaglandin infusions and the potential need for intubation and transport to Starship
- Diagnosis by echo is required
- A neonatal echo can be discussed by calling the on call NICU SMO. Alternatively the Cardiology technicians will perform the echo.

Transport of babies to weight 5.5kg.

- Neonatal equipment can accommodate infants up to 5.5kg but any infants larger than this need to be transported by the ICU retrieval service
- The neonatal service has an onsite registrar / NNP rostered for neonatal retrievals
- A transport nurse is available from the neonatal unit staff
- Transportation is by **ambulance** for Christchurch units (Rangiora, Oromairaki, Kurawaka) and Ashburton.

- For Timaru transport is either by **ambulance** – low risk, or **helicopter** – high risk, where a shorter time to get to CHCH is important due to clinical condition.
- West Coast – usually fixed wing, occasionally helicopter.
- Weather factors determine the use of fixed wing and at times this requires utilising teams from Dunedin, Wellington
- For medical and surgical transfers > 1 month of age when the baby is under 5.5kg transport is provided by the neonatal service irrespective of where the baby is being admitted.
- If the neonatal team have staffing difficulties there needs to be discussion between the neonatologist and Paediatrician with potential transport options listed below

Retrieval Team Options:

- Team composition will vary depending on workload/acuity/staff availability/equipment availability
 - NICU Transport nurse and NICU Retrieval Reg/NNP
 - NICU Transport nurse and Paed Reg who has NICU experience
 - ICU Retrieval team – not a preferred option as the team have less expertise with small babies and their equipment is often inappropriate
 - Starship retrieval service – this team is not always available and if they are there can be significant delays
 - Nursing discussions to backfill the NICU nurse on transport by a Paediatric nurse if NICU is overfull

❖ Small Baby Protocol – Guidelines for the < 28 Week Neonate

- One of the most challenging aspects of perinatal medicine is the management of the delivery of an extremely premature infant.
- Care of the mother, her fetus and the baby will always need to be individualised.
- The objective of this protocol is to optimise the management of the extremely preterm infant born at < 28 weeks gestation.

Number of babies < 28 weeks admitted to CWH NICU over past 10 years

Time Period	Number Admitted Mean and Range	Survival to Discharge Mean
2006-2015	25 (22-31)	85%
2015-2019	28 (23-34)	85%

Antenatal Care

- Parental hopes and expectations need to be explored with honesty and compassion in a realistic manner, drawing upon available local and national population data.
- Communication and agreed plans must be documented in full and signed legibly.
- These plans may need to be revised frequently based on the best assessment of gestational age, in addition to information regarding the wellbeing of the fetus and parental wishes.

Steroids

- The benefits of antenatal administration of corticosteroids to fetuses at risk of preterm delivery vastly outweigh the potential risks. Benefits include not only a reduction in the risk of RDS but also a substantial reduction in mortality and IVH.
- Treatment consists of two doses of 11.4 mg of betamethasone given intramuscularly 24 hours apart
- No additional benefit has been demonstrated by accelerating the course and giving the second steroid dose at 12 hours instead of at 24 hours
- The effects of steroids last for approximately 7 days after the last dose. Repeated courses are not routinely given. If 10 days have lapsed and a woman remains at risk of giving birth within 48 hours, a single dose of steroids should be considered.
- Steroids should be discussed with the neonatal consultant prior to administration if < 24 weeks gestation.

Antibiotics

- Preterm rupture of membranes and not in labour – oral erythromycin 10 days.
- As premature infants are at risk of E Coli and Group B strep sepsis, antibiotics are given to all women who are in established preterm labour.
- When in labour – IV amoxicillin and gentamicin
- If signs of maternal sepsis – IV amoxicillin, gentamicin and metronidazole

Other

- Magnesium sulphate should be given for neuroprotection in babies <30 weeks as standard management. This is given as a loading dose over 20 minutes and then a maintenance infusion
- Offer enrollment in relevant research trials if appropriate.

Resuscitation Considerations

Preterm labour often progresses rapidly and in these circumstances there may be insufficient time to hold a detailed discussion with the parents before the baby is born. A decision about resuscitation may need to be made based on the most recent management plan, if any, and the available clinical information.

These guidelines apply to singleton pregnancies and have been adapted from the British Association of Perinatal Medicine¹

< 23⁺⁰ weeks

- Babies very rarely survive at this gestation and in favour of the best interests of the baby and standard neonatal practice; it is acceptable for resuscitation not to be commenced

23⁺⁰ to 24⁺⁶ weeks

- At these gestations babies are at the limits of viability.
- Each case needs to be individualised, accounting for parents wishes and the clinical situation
- In 2019 a [New Zealand consensus statement on the care of the mother and baby/ies at perivable gestations](#) which covers antenatal advice and counselling and intrapartum care advice.
- As part of this consensus there is a [Perivability Care plan check list](#) to document multiprofessional discussions and management plans, a [Parent Information and Decision Aid](#) tool to help share decision making and discussions with the family and a [Practice recommendation](#) for a bundle of care for the neonate
- There is also material to help health professionals with counselling. [Perivability information for health professionals](#)
- A decision not to start resuscitation is an appropriate approach if the parents have expressed this wish after discussion with the neonatal team.
- Clinical information to be considered when discussing resuscitation include the gender of the baby, steroid coverage, presence of sepsis and any known congenital abnormalities
- If resuscitation is started with lung inflation, the response of the heart rate will be critical in deciding whether to continue or to stop resuscitation.
- It is usually not appropriate to provide cardiac compressions or give adrenaline at these gestations

≥ 25 weeks

- It is usually considered appropriate to resuscitate babies at this gestation unless there any underlying congenital factors.

Multiple pregnancies

- Fetal maturity is decreased and it may not be appropriate to resuscitate multiple births at < 25 weeks gestation.

Neonatal Resuscitation Preparation

In addition to routine equipment / procedures for the management of the high risk infant, resuscitation and stabilisation of < 28 weeks gestation infant includes:

- Calling the consultant. If possible 2 consultants should be present at births of multiples <26 weeks
- Ask the ACNM or senior nurse to accompany you.
- ACNM to prepare the humidification system for Neopuff or ventilation
- Surfactant –200mg/kg (2.5mL/kg). 3mL vial needed. Return it to the refrigerator if it is not used.
- Size 5F feeding tube for administration of surfactant
- Blade or sterile scissors
- Paper tape measure
- Plastic bag on resuscitaire to pre-warm, pre-cut right hand bottom corner, if Neohelp then no cut is needed
- Transport incubator
- Laryngoscope blade 00 / 0
- 2.5 ET Tube with stylet inserted if required
- Delegate tasks so everyone knows their responsibility at delivery including documentation

Obstetric Resuscitation Preparation

- Place sterile cord clamp on the cord 6cm from base to allow placement of the baby into plastic bag
- Deferred cord clamping for at least 60 seconds if appropriate

Care at Birth

As part of the National consensus of the care of babies at the limits of viability there is a [NZ practice recommendation for the bundle of neonatal care at 23-24-weeks](#) that can also be used as a reference tool.

After delivery

- Infant is transferred to the resuscitaire and place in a Neohelp bag under radiant heater (set to maximum)
- Do not cover bag with towels as it impedes radiant heat
- Only dry face and cover the head with the hood
- Assess breathing, heart rate, colour, tone and perform resuscitation as per neonatal guidelines (see algorithm below)
- Insert pulse oximeter and apply to right hand and then turn it on to obtain pre-ductal saturations and heart rate
- Place temperature probe on the abdomen under a gold heart temperature probe cover
- Do not open the bag to auscultate heart rate

Thermal Management

- Optimal thermal management of preterm infants is a problematic but important aspect of care.
- Low birth weight infants are vulnerable to hypothermia ($\leq 36.4^{\circ}\text{C}$)² since they have impaired ability to prevent heat loss and decreased heat production capability.
- Delivery suites and operating theatres are generally cold environments ($<22^{\circ}\text{C}$) and can cause thermal stress for the newborn which is associated with increased mortality and morbidity³. A warm environment for a neonate would be $24-26^{\circ}\text{C}$.
- Monitor infant's temperature continuously with the temperature probe
 - If skin temperature is ≥ 37.2 decrease radiant warmer by 25%
 - If skin temperature is >37.5 check the axilla temperature and radiant warmer may need to be decreased by 50%
 - Monitor heart rate as hyperthermia leads to tachycardia

Airway

Ventilation

- Aim for a PEEP of around 5cm H₂O
- Use adequate PIP to ensure adequate chest wall movement
- Aim to ventilate at about a rate of 50-60/min
- Use humidified set-up

Intubation

- Consider intubation if the infant is not very active, has not had a complete steroid course and has apnoea, increased work of breathing or oxygen requirement >30%
- Once intubated, most very small infants respond rapidly to IPPV

Gestation	Oral ET Tip to Lip (cm)	Nasal ET Tip to Nostril (cm)
24-25 weeks	6.5	7.0
26-28 weeks	7.0	8.0

Following intubation confirm ETT position:

- Chest movement with assisted breaths
- Breath sounds – audible in axilla bilaterally with assisted breaths
- Change in Pedi-cap colour from purple to yellow except when cardiac output is poor
- Improvement in heart rate and saturations
- Secure ETT prior to giving surfactant with a Neofit (if using a 2.5mm ETT a strip of brown tape around the tube and neofit is required to ensure the tube does not slip)

Oxygen saturations

- Commence IPPV in 30% oxygen
- Reduce/ increase oxygen by 10 – 20 % every 30-60 seconds to meet target saturation
- If CPR required increase oxygen to 100%

Target SpO ₂	
2 min	65-70%
3 min	70- 75%
5 min	80- 85%

Pre-Term (< 37 weeks) Newborn Resuscitation Algorithm

- See algorithm above

Drugs and Administration

Curosurf

- Give in delivery room immediately after delivery via ETT following discussion with consultant
- Dose 1.25– 2.5ml/kg (100 – 200mg/kg). See drug protocol for full details
- Draw up the volume required in a syringe and place on the end of nasogastric tube cut to the length of the ETT (any longer and the surfactant will only go into the right lung)
- During administration check chest movement and be prepared to increase the PIP / oxygen
- Following administration check chest movement and be prepared to reduce the PIP / oxygen

UVC Insertion

- Insert UVC as cleanly as possible (this cannot be a strictly sterile procedure in an emergency situation)
- Insert to 3-5cm and tape to the abdomen

Adrenaline

- Adrenaline is the first choice drug in a newborn resuscitation after establishing effective ventilation
- In order to distribute it to the heart cardiac massage is required for 1 minute.
- ETT Dose: 1:10,000 1ml/kg
- UVC Dose: 1:10,000 0.1ml/kg initially then up to 0.3ml/kg
- Doses can be given every 3 minutes – intravenous is the preferred route

Volume expansion

- Normal saline - readily available
- Whole blood - urgently requested from Blood Bank
- Dose: 10ml/kg - give over 5-10 mins

Sodium Bicarbonate 4.2%

- This is rarely required
- Dilute 8.4% with equal volume of water to make a 4.2% solution
- Dose is 2ml/kg of 4.2% solution given over 2mins
- Administer in prolong resuscitation (> 15minutes) after effective ventilation / cardiac massage

Glucose

- 10% Glucose, dose is 2ml/kg
- Consider if resuscitation has been prolonged and only after documented hypoglycaemia

Vitamin K

- IM, dose for those <1500g is 0.5mg = 0.05ml.
- Give through the plastic of the Neohelp bag

Cord Gases and Placental Pathology

- Request a cord pH and lactate (preferred test if both cannot be done)
- Send the placenta for pathology
- Ask for placental swabs if there is a high index of suspicion for infection

Transfer to NICU when infant is stabilised

- Notify NICU, update parents
- Ensure ETT is secure, leave infant in Neohelp bag and nest in warm towels in incubator
- Check exhaled tidal volumes on the Crossvent ventilator to ensure that the baby is not being over ventilated after receiving surfactant
- Place the name band supplied in delivery suite and when in NICU replace with a posy name band

Care in the Golden Hour

Sick newborns do not tolerate handling or hypothermia. Minimal handling and maintenance of normal temperature are paramount.

The aim should be to undertake all nursing and medical procedures as quickly and with as little disturbance to the infant as possible, usually within 1hr of admission (golden hour) ⁴

Thermoregulation / Humidification

High transepidermal water losses can be reduced by increasing the relative humidity of the infant's environment

- On admission weigh infant in the Neohelp bag and admit into Leo incubator
- If the baby is in a **Neohelp bag** then **take off 30g** for the birthweight if in the <1000g bag or **40g** if in the 1000-2500g bag

The weight of the ETT and Neofit are negligible and can be ignored if ventilated

No need to take off the umbilical cord or clamp weight as it is standard for that to be included

Do not take the baby out of the bag and weigh it to get the birthweight as it will be inaccurate

- Weigh infant on incubator scales and use these scales for subsequent weights
- Humidification settings should commence at 80% if <1000g or <28wks
- It takes 15 minutes from turning on the Leo humidification to achieve 80% and takes 1hour on other incubators so make sure it is turned on so that on admission humidification is underway
- **If axilla temp is <36.5** – remain in plastic bag and use incubator in radiant warmer mode. Insert peripheral iv and start 10% dextrose. Once axilla temp is between 36.6-37.2 degrees remove from plastic bag and insert umbilical lines

- **If axilla temp is ≥ 36.5** – remove from plastic bag, nurse in a closed incubator, insert a peripherally inserted central catheter (PICC) and start 10% dextrose if there will be a delay in securing umbilical line access, otherwise proceed straight to using the incubator in radiant warmer mode and insert umbilical lines
- Place limb band ECG electrodes on infant's ankles or wrists
- Place a skin temperature probe to avoid extremes in temperature
- Once umbilical lines are inserted and secured apply petroleum jelly to torso (above elbows and knees) Avoid application to face or scalp.

Ventilation (See Respiratory section for more details)

Common starting values are:

PTV	Inspiratory time 0.34sec
Tidal volume 4-5ml/kg	
PIP 16-20cm	Rate 50-60 /min
PEEP 6-8 cm	Trigger 0.2

There are no magic set of ventilator settings that will be appropriate for all babies

- When an infant is ventilated it is important to constantly monitor the infant's response including; tidal volumes, chest movement, saturations, blood gases
- Lung compliance can change rapidly following surfactant so need to observe above parameters closely and do a blood gas early to avoid over ventilation
- The second dose of surfactant is determined by CXR and degree of ventilation support required at 12 hours. Consultant's decision.

Acceptable arterial blood gases:

pH	PaCO ₂	PaO ₂
7.25 – 7.35	40 -50 mmHg	50- 70 mmHg

Target Oxygen saturations

Sats Targets on Oxygen	Alarm Limits on Oxygen	Sats Targets in Air	Alarm Limits in Air
90-92%	88- 94%	90-100%	88 -100%

UAC / UVC line insertion (See Procedures for full details)

Babies <26 weeks are not appropriate to have their lines placed by inexperienced staff who need supervision. The central lines should be inserted by the most senior person available ie: SMO/Senior Reg/Fellow/NNP due to the fragility of these extreme preterm infants.

- Ensure a second helper is available
- Wear gown, hat, mask and gloves
- Sterile technique
- Use low strength chlorhexidine (0.1%, blue solution) to prevent burning to the skin
- Ensure skin is allowed to dry before commencing the procedure
- Place cord tie around stump and cut stump below the cord clamp
- Watch for bleeding and tighten cord tie if bleeding occurs
- 3.5g double lumen for UVC and 2.5 or 3.5g single lumen for UAC
- Once lines are inserted suture in and place supporting brown tape flag before x-raying
- Bridging of umbilical lines is not necessary as long as there are well placed flags around the suture material and catheter
- AP and a lateral Xray are required
- Document the type of line that has been placed and how far in
- Document the tip position on Xray and if the line is in a satisfactory position
- Re-Xray if line is manipulated after initial Xray and document tip position
- Use sticker for procedure note

UVC

- Many ways of estimating length – including suggestion below, measure charts, formulas.
- Estimate length by measuring nipple to umbilicus (cm) plus the additional length of the umbilical cord, or see chart below
- Position in the IVC but not in the heart (usually just below the diaphragm is a good guide), any line in the liver should be discussed whether it should be withdrawn to be outside the liver or whether it has passed through the ductus venous and is satisfactory (see procedure section later in the Handbook)

UAC

- Estimate length by measuring shoulder tip to umbilicus or ear to umbilicus (cm) plus the additional length of the umbilical cord, or see chart below
- Position at T6 – T9 or L3 – L4

Birth weight (kg)	UAC length (cm)	UVC length (cm)
0.5	11.0	6.5
1	12.0	7.0
1.5	13.5	8.0

Investigations

(Take bloods off UAC once inserted)

- ABG / BSL
- FBC/differential
- Blood culture, CRP (after at least 6 hours)
- Group and DAT (write on request form extreme preterm infant – so blood bank will prepare quad pack units of blood)
- Consider coagulation screen if severe chorioamnionitis / sepsis
- Gastric aspirate if there is a risk of infection

Record amount of blood withdrawn as accumulative total may be taken into account along with the Hb when deciding on when to transfuse in the first 72 hours.

Fluids (See Neonatal Handbook for full details)

- TPN Starter bag and Lipid 2 g/kg/day
- UAC infusion 0.45% saline plus heparin 1unit/mL
- Record fluid intake and output
- If hypoglycaemic, BSL< 2.0 mmol/L consider 2ml/kg 10% dextrose and repeat BSL in an hour

Drugs

- Amoxicillin and gentamicin/cefotaxime as per neonatal drug protocols
- Take gentamicin levels after the first dose
- Oral nystatin 0.5ml 8 hourly for fungal prophylaxis
- Sedation with morphine should be individualised depending on the babies comfort and likelihood of extubation
- If morphine is required give a loading dose (may not be required if intubation drugs were given recently) of 50 mcg/kg first before starting an infusion of 10 mcg/kg/hr. May need to be increased to 20mcg/kg/hr if infant very unsettled.
- The need for inotropes will be dictated by the blood pressure and cardiac output assessed with an echocardiogram plus urine output, lactate and perfusion.⁵

Blood Pressure and Cardiac Output

- Central measurement of blood pressure via the UAC is the ideal as manual recordings can be inaccurate.
- Manual recordings at admission will not be needed if a UAC is going to be placed
- In reality we should aim for a MAP that provides adequate blood perfusion to all vital organs and cardiac output also needs to be taken into consideration. The consultant will suggest BP limits.
- The chart below has further details of the 3rd% for BP measurements for gestational age in a newborn in the first few days. (Mullaly R et al. *Arch Dis Child Fetal Neonatal Ed* 2023;0:F1-F8)

Gestation	Sys 3 rd	Dias 3 rd	Mean 3 rd
24	32	15	26
25	34	16	26
26	36	17	27
27	38	17	27
28	40	18	28
29	42	19	28
30	43	20	29
31	45	20	30
32	46	21	30
33	47	22	30
34	48	23	31
35	49	24	32
36	50	25	32

- Also monitor and document urine output, perfusion, colour, acidosis, lactate
- All ventilated infants < 28 weeks should have an echo in the first 12 hours (earlier if necessary) to assess cardiac contractility, output and PDA

Care in Week One

Keep the family up to date with any changes in clinical condition and when any important tests have been done i.e. head ultrasound or echo. Document when parents updated by medical team. A meeting with the SMO should be scheduled within the first 10 days.

Ventilation

- Aim to wean ventilation as able.
- All babies <28 weeks should have a test sent for Ureaplasma colonisation on day 1 if intubated
- Babies 28-29⁺⁶ weeks should have a test sent on day 1 if there is PPROM or chorioamnionitis
 - On day 1 send an ETT aspirate if intubated for Ureaplasma, no other swabs will be accepted by the lab as nasopharyngeal swabs are not validated for this test.
- In the days prior to extubation and to sometimes facilitate extubation to CPAP give loading dose of Caffeine Citrate 20mg/kg IV followed by maintenance 10mg/kg/dose once daily.
- Avoid collapse of alveoli by establishing PEEP via nasal mask or prongs before extubating

Bloods

- NEON at 24hrs of age and then 24 hourly for first few days
- Check phosphate / calcium for refeeding syndrome day 3,5,7 and treat if the level is <1.8 mmol/L (see sodium dihydrogen phosphate drug profile)
- Blood gases between formal NEON can provide 12 hourly electrolyte trends and minimises blood sampling
- Discuss frequency of blood tests with Consultant
- Monitor BSL as hyperglycaemia occurs frequently with the potential of causing an osmotic diuresis with associated weight loss and dehydration.
- Sepsis should also be considered if BSL elevated.

Fluids

- Calculate fluid balance 24 hourly
- Weighing is an accurate way to monitor fluid balance and daily weights may be requested
- Preterm infants have limited but some urine on D1 with increasing amounts from D2 ⁷
- High Sodium TPN may be needed from day 5-7 (rapid fall in sodium or levels <135mmol/L)
- In most extreme premature infants after the first few days there is an ongoing loss of sodium due to their inability to reabsorb sodium⁸
- Upon reviewing sodium results need to consider weight and effects of any current medication eg: indomethacin, diuretics.

- If hypernatremic:
 - Change any infusions made with 0.9% saline to 0.45% saline or dextrose.
 - If need to increase mls/kg/day – increase total TPN volume or commence dextrose sideline
- If hyperglycaemic:
 - Review glucose intake using glucose calculator in TPN folder (aim for <10mg/kg/min)
 - Review infusions and change any in dextrose to 0.45% or 0.9% saline if able
 - A 7.5% glucose TPN bag is available if sugar control is problematic despite insulin
- Lipids: Increase lipids as per neonatal handbook guidelines
- If sufficient EBM aim to give trophic feeds 0.5ml - 1ml 4 hourly from D1
- Start probiotics the day after birth (a patient information sheet is available)
- Feeds to increase as per the feeding guideline
- Addition of HMF to feeds needs to be discussed with Consultant and information provided to parents (a parent information sheet is available)
- Start HMF when the baby achieves 80-100ml/kg/day enteral feeds if no contraindications (see feeding guideline). Otherwise consider the addition of essential amino acids instead with folic acid and phosphate

Drugs

- Consider hydrocortisone for prevention of bronchopulmonary dysplasia
 - Babies ≤26 weeks AND incomplete steroids AND Severe RDS
 - Emerging evidence that hydrocortisone reduces BPD, death and disability at 2 years of age.
 - Refer to the drug profile for further information on patient selection and dosing
- If on antibiotics review at 24 hours with the blood culture result and serial CRP and FBC measurements
- Discuss commencing insulin infusion if 2 consecutive BSL>10mmol/ L
- Hyperglycaemia is likely to be related to insulin resistance and poor production but infection should be considered as well ⁹
- Calculate the glucose load in mg/kg/min to ensure it is not >10mg/kg/min using the Glucose calculator
- Use insulin dosing by the insulin computer
- Caffeine maintenance dose to start at 10mg/kg/day
- Start oral Vitamin A, Vitamin D and Micelle E when lipid stops as per drug protocols
- Start Folic acid if < 1500 gm at birth and are to receive unfortified breastmilk long term
- Continue on nystatin until no longer receiving Level 3 care

Imaging

- Further echos will be needed to follow the PDA and assess response to inotropes if required
- Head ultrasound scan – day 3-5 and repeat on Day 7-10

Longline *(See Procedures for full details)*

- Insert longline if full enteral feeds not likely to be achieved by day 7 as UVC will then need to be removed
- Premicath can be used in infants < 1000gm or in those with difficult veins
- The larger size catheter is preferable in bigger infants as it blocks less often and can tolerate more volume
- Double lumen longlines may be necessary for infants with multiple infusions
- Document which catheter is inserted, how far in and if the position is satisfactory on X-Ray
- If line position is altered re-X-Ray prior to use and re-document
- Use sticker for procedure note
- On confirmation of correct placement on X-Ray remove UVC.

Appropriate tip position:

- Upper extremity lines should end in a subclavian vein or SVC (not the heart as risk of myocardial damage)
- Lower extremity lines should preferably end in an iliac vein or IVC
- Lines can migrate inwards so take this into consideration when deciding on whether the line tip will be satisfactory if this occurs

Humidification

- 80% humidification should continue until day 7
- Day 8 onwards reduce by 5% daily until at 50% - when humidification can be discontinued
- Apply petroleum jelly every 12 hours up to a maximum of 14 days when stratum corneum is matured ^{10 11 12}

❖ Neonatal Intubation and Airway Management

Preparation for Intubation

- Intubation at delivery – see Preparation for Resus (above)
- Intubation later on – similar indications as well as respiratory failure evidenced by deteriorating blood gases
- Intubation should be performed with morphine (occasionally fentanyl), atropine and suxamethonium prior (except if at delivery or as an emergency intubation)
- Atropine should not be used in babies prone to supraventricular tachycardia
- Suxamethonium should not be used in babies with major airway anomalies (in case you can't intubate) or a family history of acetyl cholinesterase deficiency or malignant hyperthermia.

Communicate plan to intubate

- All planned intubation should be discussed with the neonatal consultant on.
- The decision to intubate needs to be communicated to the bedside nurse, ACNM and, whenever possible, the parents should also be informed prior to the procedure.

Assemble team and Assign roles

- Team leader (Senior doctor or senior nurse)- maintains overview and situational awareness at all times
- Airway lead (Intubator)- NNP/ Registrar/ SMO
- Airway assistant (nurse or doctor)- provides equipment to intubator as required, can provide cricoid pressure if required, assists with securing tube
- Medication nurse – administers premedications, assists with securing tube after procedure
- Floating nurse (if available)
- Scribe
- If there are limited staff available some team members will need to fulfil two roles.
- Wherever possible the Team leader role should be preserved as an observation/ leadership role.

Prepare equipment

- See Intubation section under “Preparation for Resuscitation” and Pre-Intubation Checklist

Practice points

- **Less experienced intubators** without supervision (ie. in an emergency or unanticipated intubation scenario) should prioritise ventilation and oxygenation (See Plan B and Plan C- Difficult Airway Pathway) *If you can adequately ventilate and oxygenate with the neopuff then this should be Plan A until experienced support arrives.* If intubation is required, there should be no more than two attempts at intubation until more experienced help arrives. An iGel supraglottic airway could be considered in this scenario.
- **Factors associated with success**
 - Experienced operators/ supervision
 - Premedication
 - Video-laryngoscope
 - Preparation, team work, communication and attention to human factors

Pre-Intubation Checklist

- The Pre-Intubation Checklist (see next page) is designed to provide a framework for preparation for intubations in the NICU environment when the clinical indication allows time for appropriate preparation to occur, this includes any intubation in which we elect to use pre-medication. This will be most of the intubations that occur in the unit but excludes truly emergent intubations eg. Infant collapse, CPR in progress etc.
- It may also be useful when preparing for a delivery in which intubation is anticipated but it is not designed specifically for the birthing suite environment.
- The team leader or scribe can take responsibility for reading each box aloud in a stepwise fashion, and awaiting a response after each question/ statement before moving to the next line.

PLAN

- Notify SMO, ACNM and parents of procedure. If after hours, 2nd Reg/NNP to be notified.
- Assemble team and assign roles
- Are there specific difficulties anticipated? Are the right people present?
- IV access available and working?
- Chart intubation medication (Use calculator and then prescribe)

PREPARE

- Intubation medication charted, drawn-up and checked.
- ET tube (+ one size either side)
- Laryngoscope and blade (consider video-laryngoscope)
- Pedicap
- Neofit (cut to size)
- Suction attached and turned on
- Neopuff + appropriate sized mask
- Aspirate stomach
- Ventilator set-up and calibrated
- Stethoscope and monitoring in place

PAUSE

- Who and why are we intubating?
- Any anticipated risks and escalation plan?
- Appropriate team present?
- The Neopuff is set at PIP and PEEP, oxygen
- "If oxygen saturations are below..... or heart rate below..... or any team member has concerns, this should be stated aloud and the attempt should be abandoned unless successful intubation is imminent."

POSITION AND PREMEDICATE

- Position infant for intubation- consider thermoregulation needs.
- Position monitor, equipment and team members
- Give premedication as charted.

PROCEED

- After each attempt, consider what could be optimised
- After 2 failed attempts, the best available intubator should proceed
- After 3 failed attempts, a difficult airway situation must be declared.

POST PROCEDURE

- Confirm tube placement and order xray
- Document procedure in infant notes with intubation sticker
- Inform parents
- Check ventilator settings and blood gas

Difficult Airway Situations

- All airways should be anticipated to potentially become difficult airway situations.
- Risk factors for a difficult airway include but are not limited to:
 - Craniofacial structural abnormalities eg cleft palate, Pierre Robin
 - Structural compromise to airway eg Laryngomalacia, subglottic stenosis
 - External airway compression eg cystic hygroma
 - Neuromuscular abnormalities eg global hypotonia, arthrogryposis
 - Infants who have had multiple previous intubations
- A difficult airway situation should be declared after 2 failed attempts by an experienced operator

Airway lead should clearly state “*This is now a difficult airway situation with failed intubation, we are activating the difficult airway pathway*”

Challenge and Response Paradigm

- The challenge and response paradigm helps to implement a checklist as an intervention rather than a reference tool which are often under utilised in high-stress situations
- One team member reads aloud the checklist in a stepwise fashion with a yes/no response required to each question/ statement before moving to the next line.
- This framework supports the team to move through each step in the pathway in a logical, step-wise fashion.

Speak up for safety

- All team members, regardless of role or experience, have a responsibility to speak up if they are concerned appropriate steps are not being taken during the intubation procedure.

3 Best attempts

- If intubation has failed it is important to assess what could be changed to optimise the next attempt. Can the baby be re-positioned? Does the airway need suctioning? Do we need a change of intubator?
- After 3 best attempts always ask, is intubation really needed immediately? Can we achieve ventilation/ oxygenation with the technique we are using now?

Neonatal Difficult Airway Pathway

- When a difficult airway situation is declared, one team member should pick up the “Neonatal Difficult Airway Pathway’ card (located on the airway trolley and on the lid of the difficult airway box.)
- They should declare the emergency clearly, ensure appropriate support has been called and the difficult airway box retrieved from Pod 1, Room 1.
- Starting with the green box (PLAN A) each suggestion is read aloud in a stepwise fashion (Challenge) and requires a yes/ no (Response) from the airway lead or team leader.
- This is a list of suggestion to consider- they do not all need to be tried but at least one thing should be changed or optimised before each subsequent attempt
- If intubation is still not successful, or the team is awaiting the arrival of an experienced intubator the reader should move to the yellow box (PLAN B) and read the suggestions aloud, in a stepwise fashion, with a yes/no response required before moving to the next line.
- If the infant can be adequately ventilated with neopuff, then the team should maintain this technique until additional support arrives. Always ask, does this infant really need intubation at this time?
- If adequate ventilation is not able to be obtained with the techniques in the yellow box the team should move to the orange box (PLAN C). If Neonatal SMO is present and the intubation has been unsuccessful, consider the need for specialist support (Paediatric Anaesthetist +/- ENT) to be called.
- Paediatric Anaesthetics/ ENT have additional airway adjuncts and expertise to utilise in difficult airway situations including but not limited to glidoscope/ hyperangulated laryngoscope blades and flexible bronchoscope.
- Surgical airways/ front of neck access is not recommended in neonates and should not be performed by neonatal staff. It should only be considered as an absolute rescue technique and by appropriately experienced/ trained staff ie. ENT.

<p>Declare the emergency.</p> <p>“This is a difficult airway situation.”</p> <p>Has someone called for help? Neonatal SMO/ 2nd Neonatal SMO</p> <p>Consider need for Paediatric Anaesthetist/ ENT</p> <p>Has the difficult airway box been retrieved? (located Pod 1, Room1)</p>			
<p>PLAN A</p> <p>OPTIMISE BASICS FOR BEST ATTEMPT</p> <p>Best available intubator</p> <p>Suction secretions</p> <p>Shoulder roll</p> <p>Cricoid pressure</p> <p>Introducer/ stylet</p> <p>Video-laryngoscope</p> <p>Different blade</p> <p>Smaller ETT</p> <p>Consider 2nd dose of suxamethonium (or premedication, if not used)</p>	<p>PLAN B</p> <p>CONSIDER ALTERNATIVE WAYS TO VENTILATE/ DELIVER OXYGEN</p> <p>Optimise position</p> <p>Check mask size</p> <p>2-person mask ventilation</p> <p>Consider higher PIP for chest rise</p> <p>Adequate PEEP</p> <p>FiO2 100%</p> <p>Attach Pedicap to neopuff</p> <p>Aspirate/ deflate stomach</p> <p>Would airway be improved by infant being prone?</p> <p>Is help coming?</p>	<p>PLAN C</p> <p>OPTIMISE OXYGENATION, MINIMISE AIRWAY TRAUMA UNTIL HELP ARRIVES</p> <p>Ensure O2 set at 100%</p> <p>Consider airway adjuncts:</p> <p>Guedel</p> <p>Supraglottic airway/ LMA</p> <p>Nasopharyngeal airway (using ETT)</p> <p>Consider secondary intubation attempt when help arrives (Refer Plan A for 'best attempt')</p> <p>Call for expert help, if needed</p>	<p>PLAN D</p> <p>UTILISE EXPERT HELP TO SECURE THE AIRWAY</p> <p>Paediatric Anaesthetist +/- Paediatric ENT</p>

Videolaryngoscope

- This is kept in the surgical pod of room 1
- The screen has been attached to a tripod so that it can be stood up for use.
- The bracket that holds the screen is a tight fit, so preferably you won't need to remove the screen
- The laryngoscope handles need to be kept in their case for protection.
- For these reasons there is a stand with a basket, for the screen to sit in and the case to hang from - See photo attached.



- The document below has all the instructions on how to use the videolaryngoscope



Video_Laryngoscope_IFU.pdf

Supraglottic Airways in NICU

- Supraglottic airways (SGAs) are a group of airway devices that can be inserted into the pharynx to allow ventilation, oxygenation, and administration of anaesthetic gases, without the need for endotracheal intubation.
- For anaesthesia, these devices are used for primary airway management, for rescue ventilation when facemask ventilation is difficult, and by an anaesthetist as a conduit for endotracheal intubation.
- We anticipate that in our **neonatal setting** they may be used when endotracheal tube insertion has not been possible but an airway is required.



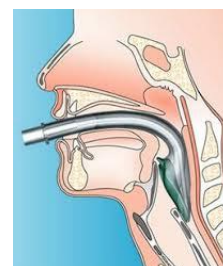
Device	iGel supraglottic airway Size 1, for patients 2-5 kg
Storage location	Stored in Theatre 26 & 27 and in clean store room in labour ward. In NICU – in resus trolleys room 1

Placement

- i-Gel should be lubricated then inserted with supraglottic airway opening facing tongue surface.
- Gently advance to behind the tongue and then check chest wall movement
- If no chest wall movement consider adjusting to optimise ventilation and chest movement (moving up or down)

Protocol

- Resus should follow basic and advanced NLS algorithms
- Airway support is initially by bag/mask ventilation or T-piece (Neopuff)
- If further airways support is needed
 - 2 attempts may be made to intubate
 - If attempts unsuccessful (and baby still needs intubation) move to supraglottic airway
 - If unsuccessful then move back to Neopuff
- Remember that the LMA position may move during use – optimally the mask should cover from the epiglottis to below cords as in the above photo. If chest wall movement is not seen small adjustment of the LMA (in or out) will be required.
- Remember that if further airway support is required to call the neonatal SMO. There is always anaesthetic support available within the hospital if required (in main theatre and in obstetrics).



❖ RESPIRATORY SUPPORT

Antenatal Steroids

(Maternity Guideline: [Antenatal Corticosteroid Therapy \(GLM0065\)](#))

- The benefits of antenatal steroids to fetuses at risk of preterm delivery outweigh any potential risks.
- Antenatal steroids decrease neonatal mortality, respiratory distress syndrome, IVH, NEC, early onset sepsis
- Treatment consists of two doses of 11.4 mg of betamethasone given intramuscularly 24 hours apart.
- Optimal benefit begins 24 hours after completion of the course and lasts 7-10 days.
- Even if delivery seems imminent steroids should still be given as timing of delivery is unpredictable and benefits are still seen after incomplete steroid courses
- No additional benefit has been demonstrated by accelerating the course and giving the second steroid dose at 12 hours so this is not favoured

Indications for Antenatal Steroids

- **22+5 to 23+6 weeks** – to be given if active intervention at birth is the shared decision after joint consultation with the Obstetric team, Neonatal team and parents
- **24+0 to 34+6 weeks** – give steroids if at risk of preterm birth within 7 days

Indications for Repeat Antenatal Steroids

- Give a single repeat dose of betamethasone if:
 - the gestation is <34+ 6 weeks
 - at risk of preterm birth within 7 days
 - it is more than 7-10 days from the completion of the last steroid course
- Up to 3 single repeat doses can be given. If a woman remains at risk of preterm birth after 3 repeat doses a joint discussion should occur between Obstetrics, Neonatal and the parents to weigh up the risk and benefits of further doses.

CPAP

- Flow Driver
 - preferred method for small babies
 - double nasal prongs, wide bore tubing and flow driver
 - adjust flow to achieve target pressure range (5-8cm)
- Bubble CPAP
 - preferred method for babies ≥ 32 weeks
 - bi-nasal with midline prongs and a F&P bubble device.
 - select the oxygen concentration required and set the flow meter at 6-8 L/min
- Single Prong
 - rarely used
 - single nasal prong attached to a ventilator (shortened ETT inserted approximately 2 cm, or about 1/2 the nostril to ear distance).
 - commence with 5 cm water and gas flow of 4-6 L/min
- To assess the adequacy of CPAP, watch for / assess:
 - Bubbly secretions at the mouth.
 - Transmitted hum of gas flow in the chest.
 - Clinical response including improved gas exchange and decrease in respiratory effort.
- If the baby is not responding, consider reasons for failure of CPAP:
 - Inadequate respiratory effort, e.g. secondary to maternal sedation or apnoea of prematurity (consider caffeine)
 - Respiratory failure that is severe or worsening.
 - Inability to achieve an adequate seal (e.g. due to crying or mouth opening).
 - Excessive abdominal distension (this can be because the compliance of the respiratory system has deteriorated so that it is worse than that of the abdomen!).
 - Development of a pneumothorax or other air leak.
 - Unsuitable disease process – e.g. anomaly such as tracheo-oesophageal fistula or diaphragmatic hernia.

Stopping CPAP

- There are many ways to wean CPAP but from May 2014 we have based our [CPAP Weaning Guideline](#) (Ref.2400577) on a multicentre randomised trial published in *Archives of Dis in Childhood Fetal and Neonatal Edition July 2012*
- Babies ≥ 34 weeks gestation usually come off CPAP on the first trial and clinical judgement should be used to decide when they are ready to come off CPAP and the guideline does not need to be used
- The guidelines are to be used for babies <34 weeks gestation
- The guidelines will suit the majority of babies but not all and babies with severe chronic lung disease may have an individualised plan
- Clinical judgement should always be used and CPAP restarted if a baby is clinically unwell but does not fully meet the criteria to restart
- If unable to remain off CPAP after 2 attempts and is ≥ 32 weeks corrected then consider High Flow
- High Flow may also be considered to be a better option in babies born at <28 weeks from 32 weeks corrected if they will need long term respiratory support.
- Consider increasing caffeine prior to weaning if events have been a concern

Stable Criteria

All criteria need to be present for >24 hours to be stable to trial off CPAP:

Corrected GA >28 weeks

PEEP 5-6 cmH₂O

Oxygen ≤ 25%

No significant recession

Tolerating time off with cares (ie: for 15min)

Minimal self correcting events with no clusters (≥ 3 events an hour)

No intercurrent illness being treated, immunisations or eye check due

Sats are <90% less than 10% of the time

Respiratory rate <60/min

Review criteria daily after stopping CPAP to ensure stability and at any time there is a clinical change.

Remain in Level 3 for 48 hours after stopping CPAP (if able) as 80% of babies who become unstable after trialling off CPAP do so within 48 hours (*CWH NICU Audit 2017*)

Unstable Criteria

If ≥ 2 criteria are present then restart CPAP:

1. Increased work of breathing **and** respiratory rate >75/min

Oxygen >25% on nasal prong oxygen (see algorithm below to calculate)

3 or more apnoea/desat/brady in an hour

pH < 7.2

PaCO₂ > 65mmHg or a rise in PaCO₂ >10mmHg

If only 1 criteria present restart CPAP:

Increase work of breathing **and** respiratory rate >90/min

Major apnoea/brady needing IPPV

Once back on CPAP to remain on CPAP for 48 hours before reassessing if they are stable enough to trial off again. If events are the main cause of instability then review the caffeine dose.

Low Flow Oxygen Calculations

Weight (kg)	FiO ₂ = 25% On the following Low Flow Rates	FiO ₂ = 30% On the following Low Flow Rates
1kg	0.02 L/min	0.04 L/min
1.5kg	0.03 L/min	0.06 L/min
2kg	0.04 L/min	0.07 L/min
2.5kg	0.05 L/min	0.08 L/min
3kg	0.06 L/min	0.1 L/min
3.5kg	0.08 L/min	0.12 L/min
4kg	0.1 L/min	0.15 L/min
4.5kg	0.1 L/min	0.18 L/min
5kg	0.1 L/min	0.2 L/min

Adapted from ADHB Guidelines – Oxygen: Low Flow Calculator

<http://www.adhb.govt.nz/newborn/Guidelines/Respiratory/Oxygen/ActualO2.htm>

Heated Humidified High Flow Nasal Cannula Oxygen

HHFNC is defined as oxygen through nasal cannula that is heated and humidified at flows above 1L/minute. It is increasingly being used as another form of respiratory support in addition to CPAP.

Indication

- Infants with corrected gestational age ≥ 32 , after 2 attempts to wean off CPAP, or, as an alternative to CPAP in babies that they are likely to need ongoing respiratory support for weeks (usually <28 wks at birth)
- Directly after extubation if clinically appropriate although CPAP is the preferred post-extubation respiratory support method
- As an alternative to CPAP if still requiring respiratory support and FiO_2 requirement $<40\%$
- It is not for use currently for infants as the initial respiratory support irrespective of gestational age

Potential Benefits

- Provides a warmed and humidified flow of air and/or oxygen mixture (via a blender) to the infant where FiO_2 can be monitored
- There is some degree of end distending pressure, however, debate remains as to how much
- May be better tolerated by some infants becoming unsettled on CPAP
- Reduced gastric distension than on CPAP
- Less pneumothorax
- Less nasal trauma
- Sucking feeds are more easily attempted

Equipment

- Fisher and Paykel Optiflow nasal cannula connected to our humidification circuits
- Size to be determined by nares - aim for most of nare to be filled without pressure
- Nare MUST NOT be tightly filled as the pressure generated will be excessive
- Mouth should be closed for optimal effect but active closure with a chin strap is not required

Management

- Start at 6L/min (maximum rate is 8L/min)
Pressure delivered will increase as flow increases and with decreasing infant weight
High Flow can be stopped from 2-4L/min flow
Flows <1 L/min will have fluid "rainout" so should not be used
- Maximum flow rates vary: **Small prongs – max rate 9L/min**
 Medium prongs – max rate 10L/min
 Large prongs – max rate 23L/min
- Flow must be connected to heated humidification system.
- Infants should be placed back on CPAP if at any stage if:
the FiO_2 increases by more than 10%
there are frequent apnoeas
there is substantial increase in work of breathing

Complications

- Potential for asynchrony in breathing which may result in the infants becoming more tired over long periods; therefore, a good assessment of work of breathing is required
- Potential for nasal erosion remains although less than with nasal CPAP
- There is concern about the unknown distending pressure and varied results gained in research studies, therefore ensure that prongs do not seal the nares and reduce flow as able.
- Potential problems with "rainout" resulting in lavage and apnoea; therefore, nurses need to be aware of clearing "rainout" regularly and ensuring that only heated tubing is used

Weaning Humidified High Flow

- The guideline for [weaning humidified high flow](#) (Ref.2400578) has been based on the CPAP weaning guidelines, however, there are no published data on the best weaning methods
- As for the CPAP weaning guidelines they will fit most babies but not all and babies with severe chronic lung disease may have an individualised plan fine tuned with the information from sleep studies
- Some babies may need higher caffeine doses or treatment for reflux before weaning is successful
- Weaning of flow to commence under direction from Consultant
 - Wean oxygen first then wean flow
 - Generally flow will be reviewed 12-24 hourly and reduced by 1L/min as tolerated until 2-4L/min and then place on low flow oxygen if required

Stable Criteria

All criteria need to be fulfilled for > 24 hours to be stable to wean High Flow by 1 L/min:

1. Oxygen \leq 30%
 No significant recession
 Events are self correcting or are minor and no clusters (\geq 3 events an hour)
 No intercurrent illness being treated, immunisations or eye check due
 Sats are < 90% less than 10% of the time
 Respiratory rate < 80/min

Unstable Criteria

If any criteria are fulfilled then increase the flow rate by 1L/min and consider CPAP if deteriorating:
 Review criteria 12-24 hourly to screen for ongoing instability

1. Increased work of breathing **and** average respiratory rate >90/min
 Rising oxygen requirement \geq 5%
 3 or more events of any type in an hour
 pH < 7.2
 PaCO₂ rise of >10mmHg

SLE 6000 Ventilator

- The SLE ventilator can provide pressure limited / time cycled ventilation, targeted tidal volume ventilation and high frequency ventilation with or without volume guarantee.
- Ventilation has become much more complicated with the development of more versatile ventilators. The basic principles remain the same, **but if in doubt, discuss all issues of ventilator management with a consultant or more senior registrar / NNP** until you have a good grasp of all the ventilator modalities we use.
- There are a series of videos describing the special functions of the SLE6000 at G:\Division\NIC\Common\SLE 6000. There are also videos on Oxygenie, NIPPV and CPAP via the ventilator (dual limb and single limb variable flow).

Modes of Conventional Ventilation

CMV – Continuous Mandatory Ventilation

- All breaths are initiated by the ventilator at the rate that is set
- The ventilator has no capability to synchronise with the baby's breaths therefore it should rarely be used.
- This mode can be used in babies with no respiratory effort ie: heavily sedated or muscle relaxed
- This mode should be changed when the baby starts to have respiratory effort as it is much better for the baby to have synchronised ventilation

SIMV – Synchronised Intermittent Mandatory Ventilation

- The ventilator breaths are synchronised with the baby's breathing efforts
- If the baby does not breathe the ventilator will still produce breaths at the rate that has been pre-set
- The trigger needs to be set (usually at 0.2)
- The trigger senses when there is airflow from the baby. When it reaches the threshold, a breath is triggered
- On SIMV if the baby breathes at a rate above the set rate then these breaths **do not** receive pressure support
- SIMV + Pressure support mode will give pressure to the breaths above the set rate. Pressure support can be set to full PIP or less as a weaning strategy eg: 50% support
- When weaning from this mode drop the PIP first, then wean the rate before extubation

PSV – Pressure Support Ventilation

- In this mode the ventilator breaths are synchronised with the baby's breathing efforts
- In contrast to SIMV, if the baby breaths above the set rate, these breaths **do** always receive pressure support
- If set up as PSV only then the amount of pressure support is 100% for **all** breaths
- When the set % is reached the pressure support will terminate, this is called the termination sensitivity
- It is good to think of the breathing rate as a back-up rate rather than a set rate and it is there in case the baby's breathing efforts are intermittent
- This can be the optimal mode of ventilation in a selected group of infants (e.g. those with musculo-skeletal problems affecting the chest)
- This mode is good to use if the baby needs more ventilatory support than SIMV can provide
- Weaning from this mode is accomplished by decreasing the PIP. Weaning the rate does not decrease the amount of ventilation provided as all breaths are augmented.
- Weaning can also be accomplished by weaning the amount of pressure support which in effect will wean them to SIMV once pressure support is removed

PTV – Patient Triggered Ventilation

- **Our default mode of ventilation**
- This mode is also synchronised
- The trigger is set at 0.2 and the baby triggers ventilation breaths
- The rate that is set is a back up rate only as all breaths are supported
- The difference from PTV and PSV is that the baby's breaths are all supported 100% to the set PIP, whereas in PSV the amount of pressure support can be altered
- Weaning from this mode is achieved by weaning the PIP, weaning the rate will have no effect on the amount of ventilatory support provided

VTV - Volume Targeted Ventilation

- Volume ventilation can be used in conjunction with all of the above methods of ventilation
- This mode can be very useful, especially in babies with rapidly changing pulmonary mechanics as it is continually adjusting for the infants respiratory effort and lung compliance
- It cannot be used if there is a large leak around the ET tube of >30-50%
- It changes from the conventional method of setting pressures to be delivered to setting tidal volumes to be delivered with the PIP and PEEP being set as alarm limits only
- Tidal volumes should range from 4-6ml/kg initially. The ventilator automatically adjusts the PIP to achieve this
- The inspiratory time will change with each breath and consider it as a back up setting only
- The ventilator assesses the expired tidal volume of each breath and adjusts the pressure for the subsequent breath to achieve a pre-determined target tidal volume.
- The ventilator assesses spontaneous breaths and ventilator initiated breaths separately and adjusted pressures correspondingly.
- If the infant takes a large spontaneous breath that exceeds the target volume then the expiratory valve will open and no PIP is given.
- PTV + VTV can be used in any infant with lung disease provided there is an adequate back up rate to provide adequate ventilation if the infant has poor respiratory drive.
- SIMV + VTV can be useful in those infants with little lung disease that require minimal ventilation
- PSV + VTV should be used in infants with good respiratory drive and with little to moderate lung disease that is improving.

Conventional Ventilation Settings

- Generally start with PTV + VTV using volume limited, time cycled, continuous flow mode
- For consistency, the ventilators are usually set up with settings of:

Tidal volume 4-6ml/kg			
Max PIP	20-24 cm	Inspiratory Time	0.34 sec
PEEP	5-8 cm	Oxygen	as required
Gas Flow	8L/min	Trigger	0.2
Rate	50 breaths/min		

There are no magic set of ventilator settings that will be appropriate for all babies, and we are all responsible for carefully assessing each baby to arrive at the best individualised ventilation strategy.

Inspiratory Time

- The T_i is chosen when considering the baby's respiratory time constant which is the product of pulmonary resistance and compliance
- The T_i will be short (0.3 sec) in babies with normal resistance and low compliance (eg: early in RDS)
- The T_i will be longer (0.34-0.4 sec) in babies where the compliance improves (eg: after surfactant)
- The T_i may be much longer (0.5sec) in bigger babies and those with high airways resistance (eg: MAS, BPD)

Tidal volumes

- | | |
|---|-----------|
| • Minimal lung disease or RDS in those >1000g | 4-5ml/kg |
| • Babies <1000g with higher dead space | 4-6ml/kg |
| • Early BPD with homogeneous disease | 5-8ml/kg |
| • Severe BPD with cystic, heterogeneous disease | 8-12ml/kg |

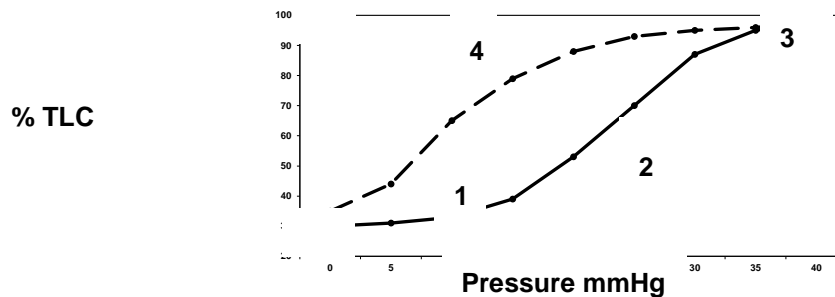
Principles of Ventilation

Lung mechanics are dynamic and change over time so when a baby is ventilated we must constantly monitor the baby's response including - tidal volumes, pressures used, chest movement, saturation, blood gases

Open Lung Volume Concept

- Using an open lung or high volume strategy irrespective of the method of ventilation will be lung protective and better outcomes will be achieved
- Ventilation in this manner improves gas exchange, reduces ventilation induced lung injury, preserves surfactant function and improves lung mechanics
- Open lung volumes can be achieved with recruitment methods in babies with certain respiratory diseases

Lung Hysteresis Curve

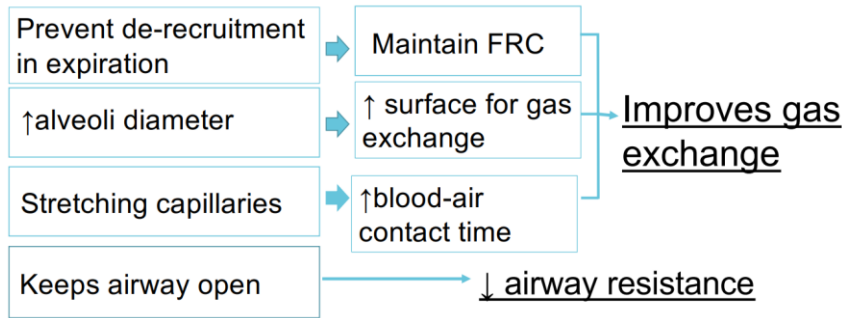


1. **Underinflated**, collapsed lung with low tidal volumes and lung compliance and a high oxygen requirement with poor CO₂ clearance
2. **Improved inflation** and subsequently improved tidal volumes, compliance, oxygenation and ventilation
3. **Overdistended** lungs with deteriorating tidal volumes, lung compliance and a rise in oxygen requirements. Depending on the severity of the overinflation the systemic circulation and blood pressure can be compromised
4. **Optimal inflation** with lungs that have passed through total lung capacity and recruited alveoli which remain open when the MAP is reduced ie: maintaining the same lung volume at a lower pressure. Optimal lung compliance, oxygenation and ventilation are seen at this point in the hysteresis curve

Oxygenation

This is most affected by the mean airway pressure (MAP) and FiO₂

- $MAP = K \left(\frac{PIP - PEEP}{60} \right) \times RR \times Ti + PEEP$
- From the equation you can see that adjusting the PIP, PEEP and Ti can alter the MAP
- Increasing the PIP in steps of 1-2 will improve oxygenation and recruit alveoli but if the PIP is too high this will come with the additional problems of causing volutrauma to the lungs
- As you reach total lung capacity any increase in PIP will not provide an increase in lung volume and so is "unnecessary" pressure that could cause damage
- In some cases a slightly higher FiO₂ may need to be accepted to keep the PIP down
- Increasing the FiO₂ is the easiest way to improve oxygenation but the side effects of oxygen in preterm babies must not be ignored
- Remember that there may be extrapulmonary shunting that is affecting oxygenation eg: PDA, CHD
- The inspiratory time is set at 0.34 sec but may need to be altered depending on the lung condition
- Increasing the PEEP (usually from 5 to 8) can be helpful in a baby who is hard to oxygenate
- Increasing the PEEP increases the MAP more in comparison to PIP changes of the same magnitude
- As the PEEP is increased up to 10 cm H₂O there is a linear increase in alveolar diameter – above this there may just be extra pressure in the alveoli for no increased gain of effect
- A method of lung recruitment on conventional ventilation is stepwise increase of the PEEP to recruit and then lower the PEEP again when the lung has re-opened



Ventilation

- The elimination of CO_2 is proportional to the minute ventilation (200-300ml/kg/min)
- Tidal volume has been reported to be the main determinant of ventilator-induced lung injury rather than inflation pressure.
- Volume ventilation utilises a variable PIP to deliver the dialled targeted tidal volume. This minimises volutrauma.
- Minute ventilation is improved by increasing the targeted tidal volume or increasing the rate
- Increasing the targeted volume or rate up or down to increase the CO_2 is the most often used way to manage the CO_2
- Changes in the rate are usually changed by steps of 5-10 breaths/minute depending on the blood gases
- CO_2 clearance is improved by decreasing dead space, increasing rate, increasing PIP, or adjusting PEEP (PEEP may need to go up or down depending on the effect on alveolar ventilation).
- Increasing the PIP will also help clear CO_2 as it increases the tidal volume.

DCO_2 – Diffusion Coefficient for CO_2

- This parameter is calculated by the ventilator and is a guide for CO_2 clearance
- **$\text{DCO}_2 \text{ (ml}^2\text{/sec) = frequency} \times \text{(tidal volume)}^2$**
- It varies depending on infant weight, disease pathology
- This value is therefore individual to the patient and should be trended rather than trying to achieve a specific number
- In general a higher DCO_2 is associated with improved CO_2 clearance
- May be more stable when using volume ventilation with conventional or HFOV

Weaning

- There is no magic number to reach before extubating a baby and it will depend on their clinical condition
- A rough guide would be to wean a preterm baby to a PIP of around 14-16 and a term baby to around 16-18 and a rate of 30-40/min before extubating
- Infants <30 weeks should be loaded with caffeine before extubation
- In SIMV weaning is achieved by minimising the PIP and then dropping the rate
- In PTV and PSV weaning is achieved by dropping the PIP
- In TTV weaning is achieved by dropping the tidal volume
- See extubation readiness section or the spontaneous breathing test prior to extubation

Blood Gases

Acceptable blood gas ranges for most ventilated babies are:

- pH 7.25-7.35
- PaCO₂ 40-50 mmHg
50-70 mmHg for permissive hypercarbia in babies with severe lung disease as long as the pH is maintained > 7.25
- PaO₂ (arterial) 45-70 mmHg < 1000 grams
50-80 mmHg > 1000 grams
- HC03 20-30 mmol/L levels will rise overtime in babies with chronic lung disease to balance the acidity of higher CO₂ levels. Lower levels may be due to excess loss from premature kidneys or severe acidosis from hypoxia or sepsis, or a metabolic condition
- Lactate < 3 mmol/L persisting higher levels need investigation for the cause such as sepsis, poor cardiac output or perfusion, metabolic conditions

There are many papers in the neonatal literature that suggest that hypocarbia/respiratory alkalosis is associated with worse pulmonary and cerebral outcomes than mild respiratory acidosis, probably due to excessive trauma to the lungs and impairment of cerebral blood flow

High Frequency Ventilation

- This has become a very important method of ventilation for babies with severe respiratory failure
- Ventilation occurs with a high continuous distending pressure, supraphysiologic respiratory rates, small tidal volumes and achieves gas exchange by oscillatory flow
- Discuss with a consultant as it is different from conventional ventilation
- There are a number of different ventilators that can provide HFOV but the ventilators we use at CWH are the SLE or the Sensomedics (only delivers HFOV)
- HFOV tends to be used as a rescue treatment for babies who have failed on conventional ventilation
- However, there is no conclusive evidence that HFOV versus conventional ventilation improves outcomes whether it is used electively or as a rescue method of ventilation
- HFOV can be delivered with and without volume guarantee V/G
- There are no large prospective trials on HFOV V/G vs HFOV alone, however, there are theoretical benefits of using volume guarantee
- HFOV V/G aims to reduce fluctuations in tidal volume and maintain consistent volumes by auto-adjusting amplitude to prevent large fluctuations. This may be particularly useful when the respiratory mechanics change rapidly such as drainage of a pneumothorax, air leak syndromes, or treatment with sedation and muscle relaxation.
- HFOV with V/G is a new mode for our unit and so is currently being used as a second-line HFOV ventilation mode for the most fragile infants over 1kg in weight and under guidance by the SMO
- Some information below will be separated into two sections – HFOV alone and HFOV with volume guarantee as there are different concepts around ventilator set-up, ventilator adjustments and recruitment strategies

Supportive care prior to HFOV

- Correct tube size and well strapped
- Minimal leak around the ET tube
- Sedation ± muscle relaxation
- Transcutaneous monitoring is an important adjunct to avoid large swings in CO₂ when on HFOV
- Correct volume depletion/anaemia if present
- Correct acidosis
- Correct cardiac dysfunction and hypotension
- If PPHN is present – normalise Hb, Ca, Mg levels and manage with NO

Definitions

Mean Airway Pressure (MAP)	cmH₂O	constant distending pressure leading to sustained inflation and maximising lung volume
Amplitude	Δ Delta P	the difference between the maximum and minimum oscillation pressure, or, the wobble around the distended lung volume
Frequency (Rate)	Hz	the speed of the wobbles/breaths
Inspiratory: Expiratory	I:E	ratio of inspiration time and expiration time
Tidal Volume (VT)	mL	calculated or a set value depending on the HFOV mode and will be affected by significant leak and the size and length of the ETT (the smaller and longer the tube the higher the resistance)

High Frequency – Settings

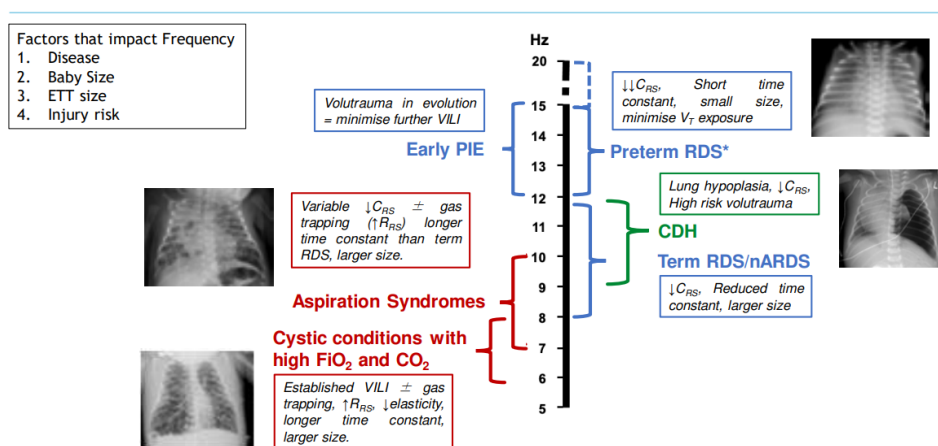
	Initial Setting	Adjustments
MAP	Start with the same MAP or 2-3 cmH ₂ O above the MAP on conventional ventilation	Increase in steps of 1-2 increments to improve oxygenation/lung distension and CO ₂ clearance. Reduce by 1-2 increments when weaning. Aim to wean to 8-12cmH ₂ O before considering a change to conventional ventilation or extubation
Amplitude	Set so the chest is visibly shaking – look and feel the chest and see what tidal volumes are being generated	Increase/decrease in steps of 1-2 units (or more depending on the CO ₂ result) to increase/lower CO ₂ clearance by altering the tidal volume
Frequency	Set as above for the lung pathology. Generally the smaller the baby the higher the frequency.	Aim to set the frequency for the lung pathology and leave it. Manipulations should be d/w SMO and changes made by 1-2Hz steps. Decreasing the frequency will increase tidal volume and increase CO ₂ clearance and vice versa
I:E	Set at 1:2 ratio. Increasing to 1:1 will increase tidal volume but can lead to air trapping	
Tidal Volume	Measured value - aim for 2mL/kg	This value will change by adjusting the MAP, amplitude and frequency but in this mode it is a calculated value

High Frequency Volume Guarantee– Settings

	Initial Setting	Adjustments
MAP	Start with the same MAP or 2-3 cmH ₂ O above the MAP on conventional ventilation	Increase in steps of 1-2 increments to improve oxygenation/lung distension and CO ₂ clearance. Reduce by 1-2 increments when weaning. Aim to wean to 8-12cmH ₂ O before considering a change to conventional ventilation or extubation
Amplitude	Set so the chest is visibly shaking – look and feel the chest.	This will automatically change to achieve the desired tidal volume
Amplitude MAX	Set to 5 above the current amplitude as a limit only	Ensure that with lung dynamic changes that the value remains set at least 5 above the amplitude used to allow for variation
Frequency	Set as above for the lung pathology. Generally the smaller the baby the higher the frequency.	Aim to set the frequency for the lung pathology and leave it. Altering the frequency will have no effect on the tidal volume or CO ₂ clearance as the amplitude will compensate to maintain the set tidal volume
I:E	Set at 1:2 ratio	
Tidal Volume	Start at 2mL/kg (range 1.5-.2.5mL/kg). Note minimum value is 2mL limiting the use of HFOV with V/G to babies 1kg and bigger	This will be automatically generated to the set volume with amplitude variation. If it is not being achieved check that the Amplitude MAX is set high enough, does the baby need suction or is there water in the sensor? Increase the tidal volume by steps of 0.1-0.5mL/kg if the CO ₂ is high and reduce by steps of 0.1-0.5mL/kg if the CO ₂ is low.

Choosing the Frequency

- This will be set for the lung pathology and usually once set is left alone unless the lung state changes, or, the desired result has not been achieved with other manipulations of the ventilator



*Some HFV use 1-2Hz lower

Monitoring on HFOV

- When commencing HFOV a senior doctor should remain by the bedside until the infant is considered stable (often up to an hour after commencing) as rapid changes in pCO₂ can occur.
- SaO₂ monitoring and transcutaneous CO₂ (TcCO₂) are essential as there may be rapid swings in CO₂
- Preferably, the TcCO₂ should be placed prior to switching to HFOV with a blood gas within 15 – 20 minutes to monitor pCO₂ to assess TcCO₂ accuracy if time permits..
- The blood pressure and a chest radiograph must be checked soon after starting HFOV to assess the effect of the MAP on cardiovascular function.
- Check lung volumes (aiming for 9-10 posterior ribs) and cardiac contour (a narrow cardiac contour may imply too high a mean airway pressure or need for blood volume expansion).
- Reduction of the MAP and/or administration of fluid to expand intravascular volume may be necessary.
- Repeat CXR's may be needed to assess lung volume although it is quite an inaccurate method of determining lung volume
- In cases with pulmonary hypoplasia the CXR is an inaccurate method of assessing lung volume
- Check blood gas within one hour (if not done earlier for TcCO₂ monitoring) after commencing this mode to check CO₂ levels and compare with DCO₂.
- When changes are made, especially for ventilation, check resulting DCO₂ or VT values. Changes in DCO₂ will become visible within a minute
- **DCO₂ Decreased** - may indicate decreased compliance due to change in lung pathology, blocked tube, increased secretions. Consider suction, clinical exam, blood gas, CXR, ventilation settings review
- **DCO₂ increased**- may indicate improved compliance and ability to wean ventilation

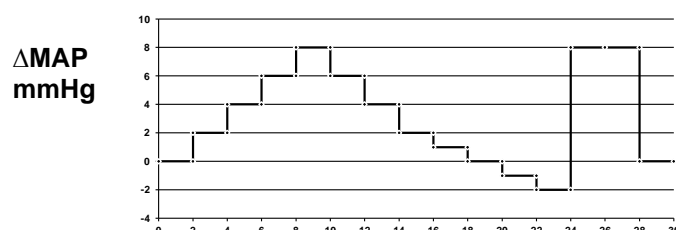
Recruitment Manoeuvres

- The lung volume is increased through total lung capacity (ie: from point 1 to 4 in the lung hysteresis curve graph above)
- Not all disease processes are compatible with recruitment methods and sometimes are contraindicated
- These manoeuvres should only be done by experienced staff who understand the principles behind them
- **Only recruit diseases with atelectasis** – HMD, Pneumonia, PPHN with parenchymal disease, Drained pneumothorax
- **Diseases not to recruit** – PPHN with normal lungs, Pulmonary hypoplasia, Severe PIE, CDH. Await for time dependent recruitment
- If the baby desaturates after suction then increase the MAP by 2 cmH₂O for 2-5 minutes to re-recruit

1. Start at the MAP already in use or start at 8-12cmH₂O
2. Hold O₂ and frequency the same (consider turning Oxygenie off when recruiting)
3. Increase MAP by 2 cmH₂O increments every 2-3min for a preterm baby and 5-10min for a term baby to around 20-25 cmH₂O

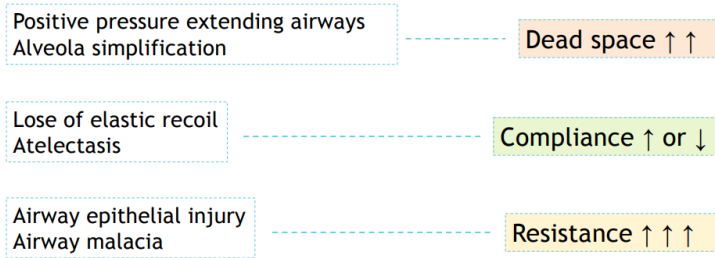
As the lung is recruited: Sats increases, FiO₂ decreases, DC02 increases, TCO2 decreases

4. Stop increasing the MAP when unable to reduce the FiO₂ any further
 5. Note the maximum MAP
 6. Decrease the MAP by increments of 2 cmH₂O until the closing pressure is reached
- As the lung de-recruits: Sats decrease, FiO₂ increases, DC02 decreases, TCO2 increases
7. Re-recruit by increasing the MAP to the maximum pressure for 2-3 minutes
 8. Decrease the MAP to 2 cmH₂O above the closing pressure
 9. The lung will maintain good inflation now but at a lower mean airway pressure



Chronic Lung Disease – Ventilation Strategies

At some stage some babies will have a transition in their lung mechanics from an RDS picture to a chronic lung disease picture – this is not one set timepoint.



- Babies who are not comfortable on their respiratory support will have increased V/Q mismatch, air trapping, air hunger and be distressed and asynchronous with the ventilator.
- Ensure that the baby is able to exhale all their breath before the next inspiration by assessing the ventilator graphics – this may be occurring if the rate is too high

Conventional Ventilation

- Early BPD where the lungs are homogeneous – higher tidal volume 5-8 ml/kg, longer i-time 0.4-0.5 sec and slower rate around 30/min
- Severe, cystic BPD where the lungs are heterogeneous with different areas of injury leading to variable compliance and resistance throughout the lungs – SIMV/PS or PTV - higher tidal volume 8-12 ml/kg, longer i-time 0.5-0.8 sec and a slow rate, PEEP 8 or above

High Frequency

- Low pressure strategy aiming for the lowest MAP possible to maintain oxygenation
- MAP around 10-14cmH₂O and frequency 6Hz
- No recruitment manoeuvres, and accept high FiO₂
- Position best lung up

Nasal Positive Pressure Ventilation (NIPPV)

Overview

- NIPPV superimposes an intermittent peak pressure on CPAP and is delivered to the infant with a ventilator and mask/prongs.
- Synchronised NIPPV works with the baby's spontaneous respiratory effort, whereas non-synchronised delivers PIP irrespective of patient effort. We use synchronised NIPPV.
- NIPPV, in particular when synchronised, improves extubation success in preterm infants, but does not seem to be beneficial for the primary treatment of RDS. NIPPV does not reduce the rate of death or BPD
- NIPPV is **NOT** a replacement for endotracheal ventilation, it should be seen as an alternative to nCPAP. Sepsis and other pathologies should always be considered in infants with increased work of breathing or other respiratory deterioration. Intubation needs to be considered for these infants.

Introduction

- The spontaneously breathing preterm infant is faced with multiple challenges, such as reduced compliance of their lungs, high chest wall mobility, small upper airways, and periodic breathing with apnoeas.
- Intubation and ventilation is an effective way to overcome these challenges, but is associated with side effects especially when prolonged (over 7-14 days), such as chronic lung disease, upper airway damage and infection. The use of NIPPV, in particular if synchronised, reduces the rate of extubation failure when compared to nCPAP.
- While the mode of action is not entirely clear the positive effect of NIPPV may derive from increased mean airway pressure, less alveolar collapse, reduced work of breathing and/or improved gas exchange.

Indications

- NIPPV can be considered for
 - Preterm infants after extubation with low GA/SGA associated with higher prediction of extubation failure
 - Preterm infants with ongoing apnoeas (prior to extubation ensure that the caffeine dose is optimised >12.5-15mg/kg/day)
 - Infants with previous extubation failure(s)

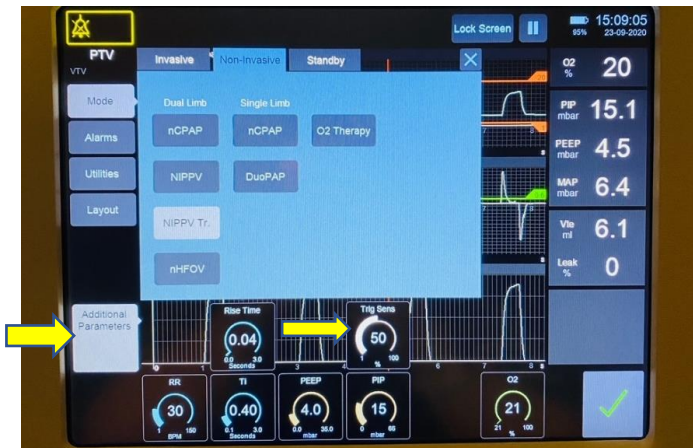
Settings

Ventilator	SLE6000 Ensure all equipment for NIPPV is available prior to commencement (including mask and headgear). Place baby on Neopuff if currently ventilated, switch SLE6000 to non-invasive mode then select NIPPV Tr (synchronised trigger NIPPV)
Peak Inspiratory Pressure (Pinsp)	14 - 20 cm H ₂ O, in discussion with a consultant may be increased to 24 cm H ₂ O.
Positive End Expiratory Pressure (PEEP)	6-8 cm H ₂ O. Aim for the achieved mean airway pressure to be the same as if the baby would be on VF CPAP.
Respiratory Rate (RR)	50 breaths/min, in discussion with a consultant may be increased to 60 breaths/min.
Inspiratory time (Ti)	0.3-0.5s, similar to Ti on the ventilator Inspiratory rise time – starting point approximately 1/3 of inspiratory time
Flow	Auto set by the SLE6000 ventilator. Inspiratory rise time can be set to fine tune.
Flow sensor	Flow sensor at the proximal airway (hotwire) is not utilised in NIPPV and is removed from the circuit. Flow is measured within ventilator.

- Choose mode, change to non-invasive support and NIPPV Tr (baby will be on Neopuff via the ETT for this)



- Set PIP/PEEP, iT, RR, FiO₂.
- Tick to confirm
- Click additional parameters



- Set trigger sensitivity to 100% and only reduce if there is autocycling. Higher numbers are more sensitive (this is the opposite to invasive ventilation).
- Rise time may be altered at this point. Suggest start at 1/3 of iT.
- Once the tick is selected the ventilator is delivering NIPPV Tr
- Mask or prongs should be fitted to the baby and connected to the SLE6000. Once this circuit is connected the baby can be extubated. This prevents alveolar collapse due to loss of volume.

Infant Interface

- Current Infant Interface to use with SLE is the **Fisher & Paykel System**: (as used with Bubble CPAP system)
 - Size Range available to accommodate all gestations of infants:
 - Components: F&P Dual Limb Nasal Tubing/ F&P Bonnet or Headgear/F&P Mask or prongs
 - Default components to initiate therapy: **Bonnet and Mask**.
 - **NOTE:** Pressure Injury Prevention: When providing CPAP cares, mask and bonnet do not need to be alternated with headgear and prongs. But NSRA score must be performed and PIPM care package followed.
- Frequency

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Extubation Readiness

- Up to 40% of ELBW infants are reported to fail extubation^{1,2}, we don't collect data on our own babies, but the goal is to have as low a level as possible
- Failure is associated with: lower GA, SGA, prolonged ventilation (>2 weeks); high FiO₂ requirements in the first 24 hours, extubation from high ventilation settings and severe respiratory failure prior to extubation defined as pH <7.2, pCO₂ >65 mmHg, FiO₂ >50%, MAP > 10^{1,2}
- Extubation failure is associated with adverse outcomes, including cardiovascular collapse, higher rates of death and BPD^{2,3}
- NIPPV is superior to CPAP in preventing extubation failure⁴

Spontaneous breathing tests (SBT)

- Considered to be a strong predictor of extubation success
- Reported sensitivity of 92 – 100% and PPV of 88 – 93%^{5,6}
- An SBT should be done on all ventilated infants with a gestational age <32weeks when extubation is considered

1. If extubating to CPAP:

- Place the infant on ET CPAP at a pressure of 8 for a period of 4 minutes.
- Criteria for failure:
 - Apnoea with desaturation requiring stimulation
 - A 15% increase in FiO₂ requirements from baseline
- Abandon the test if any of these criteria are reached or if there is any concern about the infant's status
- Record test results in the infant's clinical notes

2. If extubating to NIPPV or CPAP Spontaneous Breathing Test not passed

- Local experience has shown that some babies will not pass the initial SBT but if they are given pressure support during the CPAP trial they can be successfully extubated to NIPPV
- Change ventilator mode to PSV with the following settings for the 4 minute trial:
 - PIP 13, PEEP 8, RR 1, iT max 0.5, volume target off (for babies on PEEP 7 pre-trial)
 - PIP 12 PEEP 7, RR 1, iT max 0.5, volume target off (for babies on PEEP 6 pre-trial)
 - PIP 11, PEEP 6, RR 1, iT max 0.5, volume target off (for babies on PEEP 5 pre-trial)
- Criteria for failure:
 - Apnoea with desaturation requiring stimulation
 - A 15% increase in FiO₂ requirements from baseline
- Abandon the test if any of these criteria are reached or if there is any concern about the infant's status
- Record test results in the infant's clinical notes

Reintubation

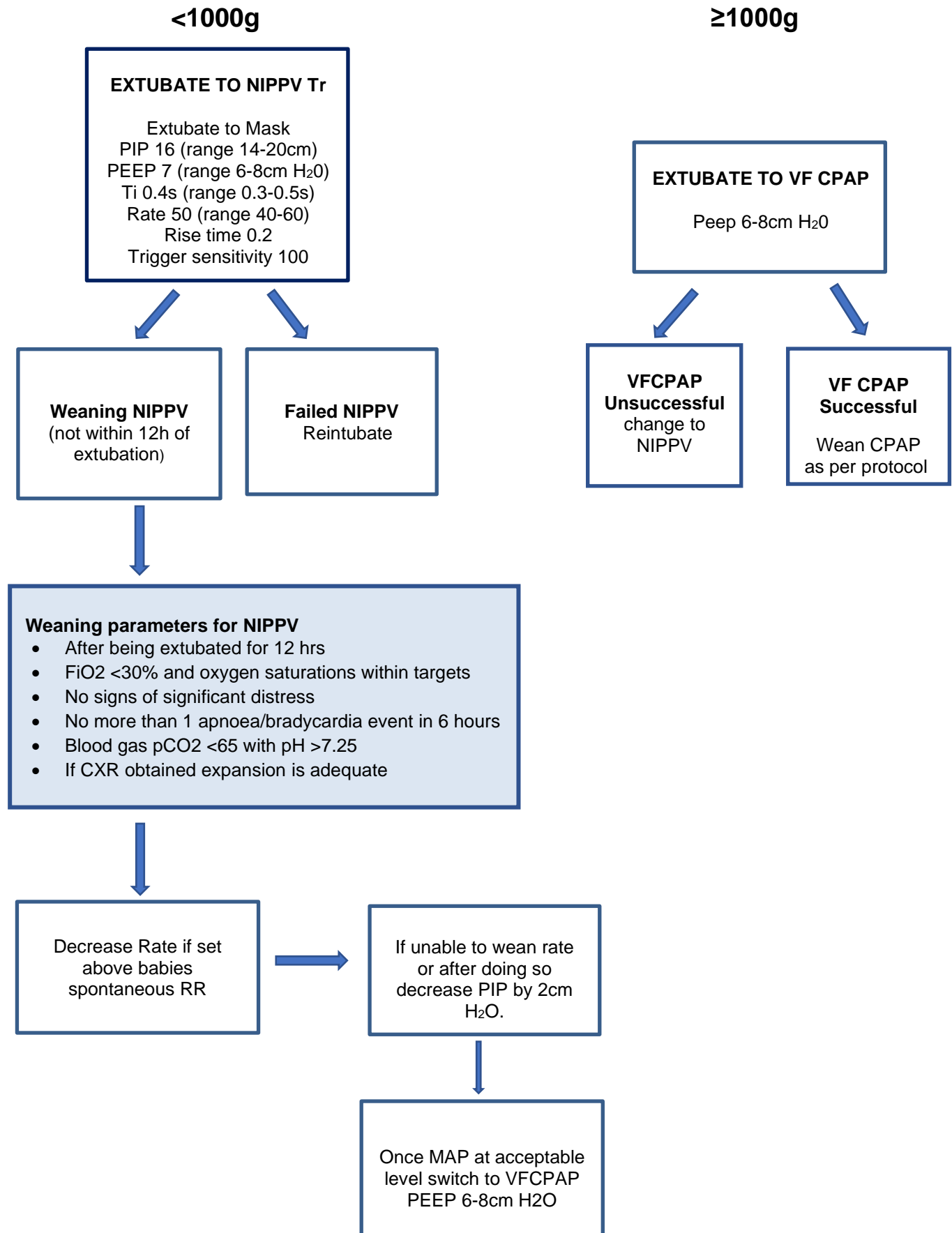
- The decision to reintubate an infant is at the discretion of the responsible SMO
- Always ensure that respiratory stimulant medication and non-invasive ventilation strategies have been optimised
- Consideration should be given to taking that step if the infant has one or more of:
 - more than 4 episodes of apnoea requiring stimulation over a 6-hour period, or
 - more than one significant episode of apnoea requiring bag and mask ventilation, or
 - an increased respiratory rate, chest wall retraction, or work of breathing resulting in tiring and poor handling, or
 - respiratory acidosis (pH <7.25 and pCO₂ >65 mmHg), or
 - FiO₂ >60% to maintain saturations in target range (or increase by >20%)

References (Extubation Readiness and Reintubation)

1. Mhanna MJ, Narayan PI, Mohit J. Respiratory severity score and extubation readiness in very low birth weight infants. *Pediatrics and Neonatology* 2017;58:523-528.
2. Chawla S, Higgins RD. Markers of successful extubation in extremely preterm infants and morbidity after failed extubation. *J Pediatr* 2017;189:113-119.
3. Klugman D, Melton K, Lyren A, et al. Assessment of an unplanned extubation bundle to reduce unplanned extubations in critically ill neonates, infants and children. *JAMA Pediatrics* Published online April 13, 2020; doi:10.1001/jamapediatrics.2020.0268.

4. Lemyre B, Davis PG. Nasal intermittent positive pressure ventilation (NIPPV) versus nasal continuous positive airway pressure (NCPAP) for preterm neonates after extubation. *Cochrane database of systematic reviews* 2017, Issue 2. Art No:CD003212.
5. Chawla S, Gelmini M. Role of spontaneous breathing trial in predicting successful extubation in premature infants. *Pediatr Pulmonol.* 2013;48:443-448.
6. Kamlin COF, Davis PG, Morley CJ. Predicting successful extubation of very low birthweight infants. *Arch Dis Child Fetal Neonatal Ed* 2006;91:F180-F183

Post-Extubation Respiratory Support Guidelines (Infants <32 weeks GA)



Pneumothorax

Clinical Signs

- Respiratory distress
- Increase in oxygen requirement – can be rapid or insidious
- Reduced air entry on one side
- Asymmetric chest movement
- Shocked baby if the pneumothorax is under tension

Causes

- Spontaneous – at delivery
- Iatrogenic – bag/mask resuscitation or artificial ventilation
- Secondary to lung pathology – Respiratory distress syndrome
Meconium aspiration syndrome
Pulmonary hypoplasia

Transillumination

- If a pneumothorax is suspected clinically, use the cold light to transilluminate the chest
- Place the light in the axilla on both sides and below the xiphisternum to rule out pneumopericardium
- If the hemithorax transilluminates unequivocally, then a CXR is not required before definitive management.
False positives occur if there is tissue oedema, lung emphysema or an enlarged stomach
False negatives occur in bigger babies when the light cannot penetrate as well



Management (see procedures section)

- Confirm the presence of a pneumothorax by transillumination or CXR prior to a formal chest drain
- CXR's can be hard to interpret at times as in babies the air leak rises anteriorly under the sternum so a lateral XRay as well as an AP are needed for diagnosis
- Needle aspiration may need to be done urgently without transilluminating or getting a CXR first
- Not every pneumothorax needs to be drained
- Small to moderate pneumothoraces, especially in larger babies who are not on assisted ventilation will often resolve without treatment.
- Even in smaller babies and those on ventilators, one-time needle aspiration will sometimes suffice, especially if the baby can be maintained on relatively low mean airway pressure.
- If there is underlying disease such as meconium aspiration or surfactant deficiency then ventilation, surfactant administration (if indicated) and chest drain insertion is usually needed.
- If the baby needs to be transported the air leak needs to be drained before travelling at altitude as undrained air expands at altitude
- Always re-Xray after aspiration or inserting a chest drain

Sedation for Ventilated Babies

- Many babies who commence mechanical ventilation will not require continuous sedation especially if they look like they will wean quickly and can be managed with CPAP. For those who do (all babies on high frequency and those needing high pressures), we generally begin with 10 mcg/kg/hour morphine. A loading dose of 50 to 100 mcg/kg should be considered (discuss with the consultant) to ensure adequate sedation is achieved in a short time frame, but caution is required if the baby is hypotensive. Infrequently, a baby will need a muscle relaxant (always discuss with consultant).

- Use of sedatives should be kept as low as possible by the optimal use of synchronised modes of ventilation, high frequency ventilation and volume ventilation in appropriate infants. Generally, sedatives should not be used to control the agitation of air hunger and hypercarbia due to less than optimal control of the airway or use of respiratory support.
- Careful positioning of the baby, attention to reduction of noise and light levels, and minimal handling
- However, when gas exchange cannot be improved by other means, or the baby seems uncomfortable or in pain (hypertensive and tachycardic) sedation and analgesia are appropriate to relieve suffering and reduce tissue O_2 demands and CO_2 production to a level that can be matched by cardiorespiratory function.

Artificial Surfactant

- Curosurf is a pig surfactant, administered via ETT
- Surfactant should be drawn up using the needle-less system. Always discuss plans to use surfactant with a consultant. A usual course is two doses 12 hours apart, although the second dose is not always necessary and occasionally a third dose is indicated. If the baby is < 1 kg, the rest of the vial should be labelled with the baby's name, time and date and returned to the refrigerator. It can then be used for the second treatment. Alternatively, twins, or other babies born in rapid succession can be treated from the same vial if their weights are appropriate and careful sterile technique is used. Opened vials older than 24 hours should be discarded.
- We use surfactant in the delivery room for some extremely low birth weight babies (< 1kg, < 28 weeks). For most of these births, there will be a consultant present who can help decide whether to give the surfactant. When given immediately after delivery, the surfactant can usually be given safely and effectively as a single bolus, although most give it in 2 aliquots.
- For most bigger babies, we tend to treat with surfactant in the NICU, as soon as it is obvious that the baby has Respiratory Distress Syndrome. When given after admission to the NICU, it is usual to split the administration into two doses. We do not routinely reposition the baby between fractions of the dose and the aliquots can be given in quick succession (total dose over a minute or two) if the baby is tolerating the process well and saturations have returned to baseline between aliquots.
- Watch for spillage into the ventilator circuit or around the ET tube in the trachea. Examine the chest movement carefully and check tidal volumes and blood gases soon after administration as pulmonary mechanics can improve within a few breaths, necessitating adjustment of ventilator settings.
- On auscultation, the baby's chest may resemble a washing machine for up to hours after the dose. This is not an indication to suction the airway, as you may merely remove the administered surfactant. Occasionally artificial surfactant treatment will mobilise mucous plugs and cause them to block the airway. Suspected airway blockage is a good reason to override the protocol of not suctioning the baby for at least 6 hours after surfactant administration.
- The 2nd dose is determined by the XRay features of HMD and the degree of ventilation support needed. An audit of our use of surfactant from 2002-2004 showed that babies who had received complete antenatal steroids who received their first dose < 90 minutes of age ie: prophylactically in birthing suite were less likely to need a second dose. Many babies are extubated between 6-12 hours of age. If this is the case a second dose of surfactant is not usually required.

Minimally Invasive Surfactant Therapy (MIST)

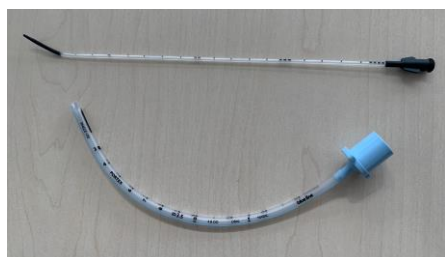
- Infants in the delivery suite who have respiratory distress requiring surfactant should be intubated and have surfactant administered via the endotracheal tube.
- Infants in NICU who fit the following criteria may receive surfactant without sedation whilst spontaneously breathing and then continue on CPAP/NIPPV

Indication for MIST

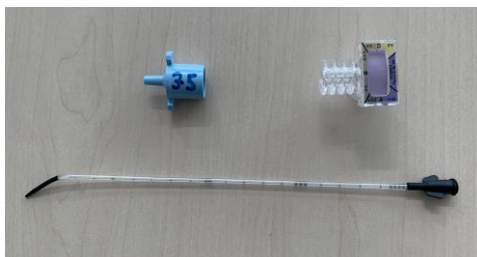
- To be performed in NICU only within first 24 hours of life (preferably <6hrs age)
- ≥ 27 weeks gestation
- History and/or CXR consistent with a diagnosis of Respiratory Distress Syndrome
- Oxygen requirement >30%
- Regular respiratory effort without apnoea
- Surfactant is felt to be needed but not an ongoing period of ventilation

Process

- Refer to video of the procedure – **Neonatal Intranet/Other Guidelines/MISTVideo** (note this was filmed before we had surf catheters so the catheter used will look different)
- Administer sucrose prior to the procedure
- Atropine prior to the procedure may also be considered
- Draw up the surfactant with and extra 0.5mL of air. Attach to an iv connector.
- Baby should remain on CPAP throughout the procedure if at all possible. If the interface on the nose is in the way of the laryngoscope push it out of the way whilst visualising the cords then replace when administering surfactant
- The “Surfcath” is a 6 Fr catheter for MIST and is stored in the **Respiratory Support trolley in Room 1**. It comes with an angled end and markings to aid in how far to insert
- If a less experienced practitioner is inserting the catheter then use the **videolaryngoscope** (when available) and/or attach a Pedi-cap to the blue adaptor from a 3.5 ETT (discard the tube) and when the catheter is placed through the cords attach the ETT adaptor and Pedi-cap to the MIST catheter to detect CO₂. This is to ensure the tube is placed correctly prior to surfactant administration
- Visualise the vocal cords with the laryngoscope and insert the “Surfcath” until the black marking at the end has been inserted (2cm). Magills can be used to help if preferred.
- Remove the laryngoscope and hold the baby’s mouth shut with your hand to secure the “Surfcath” position
- Place Pedi-cap to the catheter as described above to check placement
- Instill the surfactant as a continuous slow bolus over at least 60 seconds
- Remove the “Surfcath” once the surfactant has been given and remain on CPAP
- Be prepared to give positive pressure ventilation if clinically indicated ie: apnoeic, chest not moving, bradycardia
- There may be some refluxing of surfactant into the oropharynx and this is to be expected
- There should be no more than 2 attempts by the Reg/NNP to intubate and 1 attempt by the SMO before the procedure is stopped in favour of premedication and formal intubation



MIST Catheter versus a
3.5 Endotracheal tube



Equipment needed for attaching Pedi-cap to MIST catheter



Oxygen Saturation Targets – NICU Inpatients

Note that the sats targets and limits below are for babies in the NICU. Babies on the postnatal ward should continue to target sats of $\geq 95\%$ in air with neonatal review if sats are $<95\%$.

- Saturation targets should be set for all babies and in particular babies that are ventilated and on oxygen and should be documented in the care plan and updated with any changes.
- These limits were reached by consensus by the Newborn Clinical Network: Practice recommendation for oxygen saturation targets for newborns cared for in neonatal units, NZ (October 2015)
- An individualised approach may be taken for babies if it is deemed more appropriate. For example: a term baby with cyanotic heart disease may have lower saturation targets than in the table below.
- Variation to these targets may be decided by the SMO on service and should be documented and updated with any changes.
- If a decision is made on ward round to keep at set level to keep saturations more stable this needs to be recorded on the multicare pathway
- Oxygen sats will fluctuate but the aim is to keep the sats as stable as possible within the target range.
- There is a trade off between too much oxygen delivery and retinopathy of prematurity and CLD and lower oxygen delivery with less retinopathy but increased disability and mortality.

Corrected Gestation	Saturations Targets on Oxygen	Alarm Limits on Oxygen	Saturation Targets in Air	Alarm Limits in Air
<36 weeks Start oxygen if sats are <90% in room air	90-94%	89-95%	90-100%	89-100%
≥36 weeks Start oxygen if sats are <93% in room air	93-97% ≥95% if PPHN	92-98%	93-100%	92-100%

Caffeine

Starting Caffeine

< 32 wks – start on admission for all babies

≥ 32 wks – start if apnoea/desaturation/bradycardia events occur, usually in the first week, frequent events predominantly occur < 34 weeks corrected gestation but can occur at any gestation.

Initial Maintenance dose: 10mg/kg if <28 weeks
7.5mg/kg if ≥28 weeks

Dose once daily charted for 1000 in the morning

Dose twice daily charted for 1000 and 2200 if the dose is ≥15mg/kg/day and the baby continues to be unstable on once daily dosing

- **Periodic breathing** is a **normal phenomenon** in the preterm infant and can be seen clinically but also inferred if the histogram shows a RR <30/min. However, caffeine does not need to be started for this indication alone, there needs to be clinical events as well that are either significant or frequent.
- It is an appropriate option to simply monitor a baby with infrequent or minor events alone without starting caffeine

Stopping Caffeine

If < 28 weeks at birth – review at 36⁺⁰ weeks

If ≥ 28 weeks at birth – review at 35⁺⁰ weeks

- Longer duration of caffeine is often needed if there were problematic apnoeas and these babies have usually been on ≥ 12.5mg/kg/day caffeine +/- doxapram.
- The respiratory status assessment for when to stop caffeine includes the baby's gestation, current clinical state, Level 2 chart of events and the O₂ saturations and respiratory rate histograms and these should not be looked at in isolation.
- If a baby is becoming ready for discharge but remains on caffeine consider going home on caffeine rather than stopping caffeine in hospital and therefore delaying discharge for a further 5-7 days.

Criteria to Stop

- No apnoeas (1) or no other events (2,3) requiring stimulation (7) for 5 days
- No or infrequent self-correcting desaturation/bradycardia events (2,3,5) for 3 days
maximum of one event in any hour – ie: no suggestion of clustering.
< 3 events per day
observe the respiratory pattern on the monitor looking for periodic breathing
- Saturation histogram —< 5% time with saturations <90% (note: weaning from CPAP or Hiflow criteria <10% time with sats < 90%)
- Respiratory rate histogram - a rate < 30 is suggestive of more frequent short pauses in breathing and a **surrogate measure** for periodic breathing

Assessment after Stopping Caffeine

- A review of the 12 hour saturation histogram is recommended every 2-3 days and on day 7 after stopping caffeine – aiming for <5% time saturations are <90%. If in doubt a sleep study will be needed after 7 days to determine stopping monitoring.
- If desaturations are noted after stopping caffeine then assess the histogram and event record, Caffeine can be restarted without a sleep study.
- Ideally a baby should stay in NICU monitored for 7 days after stopping caffeine but if this is holding up discharge then the baby could go home 5 days after stopping caffeine without a monitor if they have been stable. If there are any clinical concerns at 5 days then the baby needs to stay in hospital on a monitor
- If a baby **restarts caffeine** and is ready for discharge it is recommended they stay **at least 2 days** after restarting caffeine. If they have no events they can go home without monitoring but this should be individualised
- If there are clinical events after **restarting caffeine** the baby should stay at least 5 days and go home with monitoring.

Monitoring in the Unit

- Cardiorespiratory monitoring is required for all babies up to 35 weeks (irrespective of caffeine requirements) and must continue whilst on caffeine and for at least 7 days after stopping. The variation to this is if a baby is ready for discharge, stopped caffeine at least 5 days ago and is stable – they can stop all monitoring and be discharged home
- Refer to OPS Monitoring-of-infants-in-NICU-PPN83 for normal parameters for HR, RR, Temp, BP and further details on monitoring and observations

Considerations for Length of Monitoring in NICU

- Birth gestation
- How difficult was the apnoea of prematurity
 - caffeine needed beyond 38 weeks
 - was doxapram needed
 - was CPAP/High Flow needed beyond 36 weeks
- Chronic lung disease diagnosis – oxygen or respiratory support at 36 weeks. Especially if still needing more than 25% FiO₂ on the shift test.
- Upper airway obstruction abnormalities eg: Pierre-Robin
 - These babies require cardiorespiratory monitoring until review for home.

Home Monitoring

- The decision for monitoring at home will be made by the baby's Consultant and should be discussed during discharge planning. The need for home monitoring would usually be indicated from results of a sleep study.
- Babies born < 32 weeks with a reassuring Level 4 saturation study by 38 weeks with DSI 4s of 10% < 20 do not require monitoring after discharge.
- Bitmos monitors are available for home monitoring and monitor HR and saturations.
- Parents/caregivers will need to be taught CPR and the patient issued with a Direct Access Card if going home on monitoring

Bitmos Monitor

- < 32 weeks at birth, going home on caffeine, will continue caffeine to 44 weeks corrected GA, then if the Level 4 saturation study is normal will stop caffeine and the monitor will stop 1 week later if there have been no alarms. Outreach will review.
- Babies who have restarted caffeine but having self-correcting events are to stay at least 5 days and be discharged with a monitor. Any more serious events such as apnoea or needing stimulation would preclude discharge
- Chronic lung disease (oxygen or respiratory support at 36 weeks GA) babies on home oxygen at discharge. Monitor to continue until off oxygen / clinic review.
- Individual cases in consultation with BD / NA

Home Cardiorespiratory Monitor

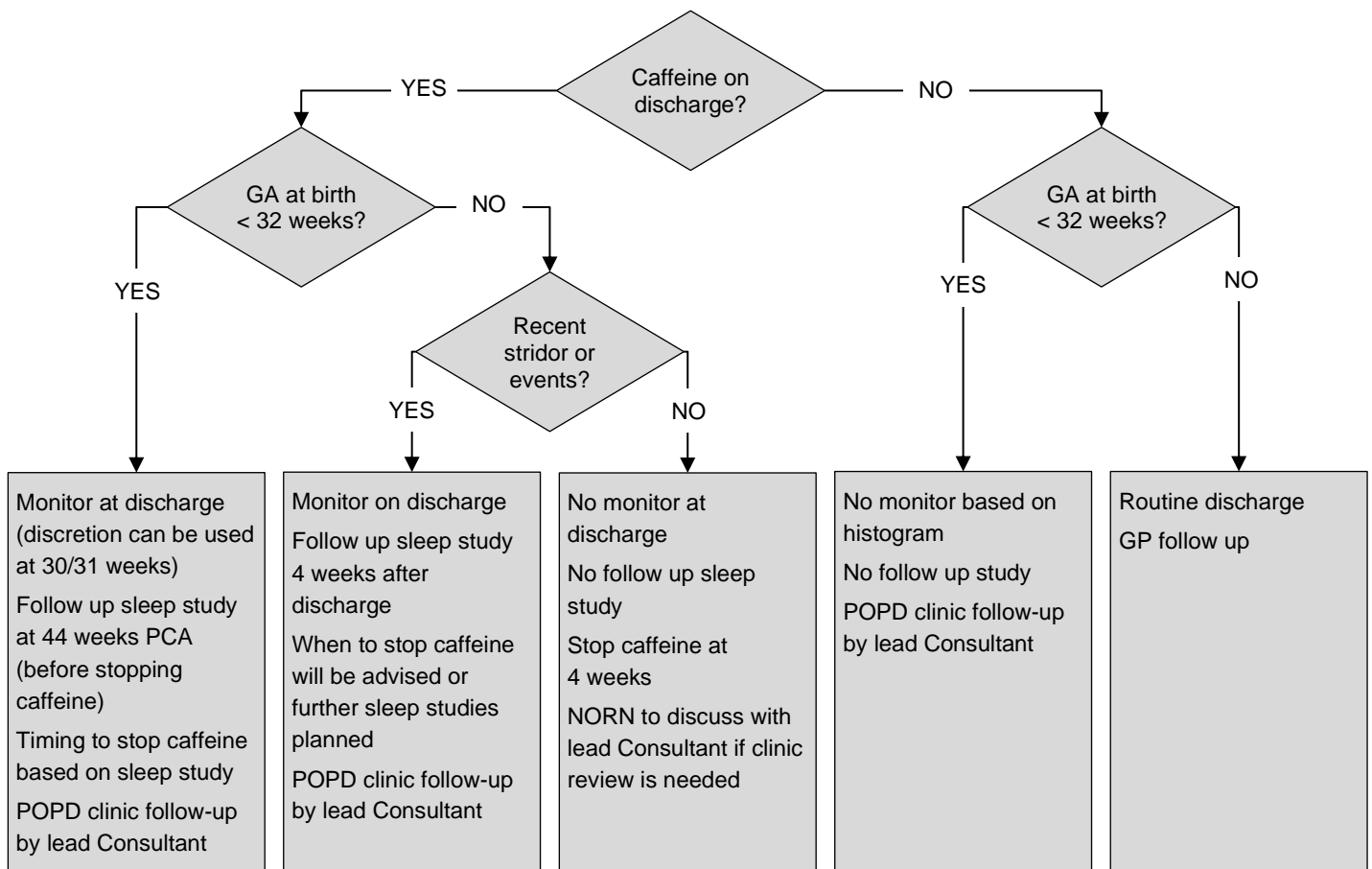
- Obstructive apnoeas eg: Pierre Robin, CHARGE syndrome, airway anomalies
- When the Massimo or polysomnograph indicates obstructive events
- Home oxygen in selected cases

Discharge on Caffeine / Oxygen when a monitor is not required

- Born at term ≥ 37 week infant needing low flow oxygen for meconium aspiration / pneumonia.
 - These babies will need sleep studies to wean from oxygen.
- Born preterm ≥ 32 weeks on caffeine or oxygen for discharge, no stridor, events resolved clinically.
 - They will stop caffeine if there have been no concerns or events 4 weeks after discharge. They will be seen by outreach who can do saturation checks at a visit but do not need further studies. This is based on an audit of cases in 2018. They do not need to be seen in clinic after stopping caffeine unless NORN request.

Follow up summary:

Group	Caffeine at discharge	Monitor at DX	FU sleep study	When to stop caffeine	Clinic FU
< 32 weeks	Yes	Yes Discretion can be used in babies 30-31 wks	Yes Before stopping caffeine	After 44 weeks PCA, and after a home sleep study	Yes Primary consultant POPD
< 32 weeks	No	No Based on histogram	No		Yes Primary consultant POPD
> 32 weeks But stridor / event concerns	Yes	Yes	Yes 4 weeks post discharge prior to stopping caffeine	Decision made after reviewing home sleep study	Yes Primary consultant POPD
> 32 weeks No stridor / events	Yes	No	No	4 weeks after discharge	If requested by NORN



Level 4 Saturation Studies

- Neonatal saturation studies are pulse oximetry studies with a 2 second averaging time that are performed in the neonatal unit
- They are not a full cardiorespiratory sleep study as they only measure heart rate and saturations via a saturation monitor. There may be rare occasions when a full polysomnography study is required (including respiratory monitoring, airflow monitoring). The full sleep studies are usually performed in Christchurch Hospital and so are logistically difficult for a NICU baby. Consider a full study in high risk patients such as with upper airway obstruction or neuromuscular disorders.

Timing

- Studies are usually performed after 36 weeks corrected gestational age
- Studies can be performed earlier when respiratory support and oxygen are ceased in babies < 32 weeks but with the extended use of cardiorespiratory monitoring and histogram checks this should not be necessary as babies < 32 weeks stay monitored until 36 weeks. Many infants will only require a single study and repeat studies should usually be after 2 weeks
- Repeat studies are requested in infants who are having oxygen titrated or where there are clinical concerns.

Indications

- Babies <28 weeks at birth should have a Level 4 saturation study
Day 7-10 after caffeine is stopped
By 38 weeks if still on caffeine / respiratory support /oxygen to assist with timing of weaning
- If desaturations (needing stimulation, or frequent > 1/hour) occur after caffeine is stopped and recommencement of caffeine is being considered and there is time for a study before changing management
- Babies unable to be weaned off oxygen and preparing for discharge
- Babies with upper airway symptoms/congenital malformations/hypotonia – stridor, retrognathia, cleft palate, Pierre Robin, CHARGE, laryngomalacia
- Babies with desaturations during feeding (possible aspiration events or severe GOR) not improving with time and > 39 weeks
- Did not pass a car seat trial

Equipment

- Masimo radical 7 saturation monitor (that has been set up for sleep study software)
- Level 4 saturation study recording sheet

Process

- The Discharge facilitators or ACNM can source the Masimo monitor
- Record for at least 12 hours and preferably 24 hours
- Clear indication of the reason for the study to be on the Observation chart
- Observation chart to be filled in hrly by staff of all handling events/ sleep position to help in data interpretation
- Observations include – sleep position, quiet or active sleep, feeding and by which route, any problems with the trace, reasons for poor pick up
- Once the study is completed the Massimo monitor should be removed and downloaded (on the computer in room 6)

Targets

- Targets will differ depending on the corrected gestational age of infant.
- At times infants will require different saturation targets for specific conditions e.g. may be lower for congenital heart disease or higher for infants who have pulmonary hypertension.

Studies performed between 32-35+6 weeks CGA

- a. The agreed target saturations are Mean saturations > 93%, and 5-10% of the time with saturations < 90% (British Guidelines 2009, Australasian Guidelines).

Studies performed at 36 weeks or greater CGA

- b. The agreed target saturations are Mean saturations > 93%, and < 5% of the time with saturations < 90% (British and Australasian Guidelines 2009, Starship clinical guidelines for domiciliary oxygen accessed 9/8/16).
 - i. The Thoracic Society of Australia and New Zealand position statement on oxygen therapy in infants with chronic neonatal lung disease has been updated in 2018.
 - ii. Prior to discharge on home oxygen (GA < 28 weeks) an echo should be performed to assess for pulmonary hypertension
- Low flow oxygen to be reduced in increments on oxygen regulators - 0.2 / 0.12 / 0.08/ 0.05 / 0.03 / 0.02 L/min
- Babies with chronic lung disease need to be ≤ 0.5 L/min via nasal cannulae to be considered ready for discharge

Reporting

All inpatient Level 4 saturation studies are to be reported by Bronwyn Dixon/Nicola Austin/Elza Cloete

- A copy of the reported study should be put in the notes and imported onto Health Connect South into the clinical investigation section by the NICU secretary/ward clerk

The reporting format should include:

- Quality of recording
- Assessment of mean saturations and time <90% saturations (are targets met)
- Assessment for features such as evidence of reflux or feed incoordination, periodic breathing
- Desaturation index (4%) – located on page 2 of study.
- Any changes in treatment that are required – such as how long caffeine treatment is required for and what monitoring is required and the plan for when study needs to be repeated.

References

<http://www.adhb.govt.nz/newborn/Guidelines/Respiratory/Oxygen/HomeOxygen.htm>

Balfour-Lynn IM. *British Thoracic Society Guidelines for home oxygen in children*, August 1, 2009.

D.A. Fitzgerald, R.J.H. Massie, G. Nixon, A. Jaffe, A. Wilson, L. Landau, J. Twiss, G. Smith, C. Wainwright, M. Harris. *Infants with chronic neonatal lung disease: recommendations for the use of home oxygen therapy. Position statement from the Thoracic Society of Australia and New Zealand*. 2007

Don Hayes, Jr., Kevin C. Wilson, Katelyn Krivchenia, et al on behalf of the American Thoracic Society Assembly on Pediatrics. *Home Oxygen Therapy for Children An Official American Thoracic Society Clinical Practice Guideline*. *Am J Respir Crit Care Med* Vol 199, Iss 3, pp e5–e23, Feb 1, 2019

Oxygen Titration after Discharge

NICU Led

- This is most cases including:
 - a subset of babies on home caffeine
 - chronic lung disease on home oxygen
 - known meconium aspiration on home oxygen
- Sleep studies not more frequently than fortnightly (unless exceptional circumstances)
- NICU Outreach liaising with NICU oximetry reporting team who will recommend when and how to wean
- If NICU consultant has concerns they will refer to the Paediatric Respiratory team as required

Paediatric Respiratory Team Led

- This will be very few cases including:
 - home oxygen in a baby with an unconfirmed diagnosis/cause
 - a term baby with expected long term ongoing oxygen requirement (excluding meconium aspiration)
- Refer to Paediatric Respiratory team whilst an inpatient
- NICU Discharge Facilitator will arrange oxygen for discharge
- Paediatric Respiratory will recommend the home monitoring requirements and oxygen weaning plan
- One outpatient oximetry study arranged by NICU Outreach (the oxygen level to be dictated by the Respiratory team) prior to the Respiratory Outpatient appointment at no later than 6 weeks post discharge
- Handover from NICU Outreach to Children's Outreach will be individualised and discussed at/following the outpatient review

Car Seat Trials

There are no gold standard to refer to regarding assessing the safety of a preterm infant in a car seat, however, in this NICU we will continue to undertake car seat trials prior to discharge as routine practice.

The car seat trial needs to be done in conjunction with family education around safe positioning and use of the car seat.

Criteria

- <37weeks gestation at discharge or < 2500g at discharge
- Other babies if on home oxygen or caffeine, hypotonic, respiratory or airway abnormalities, complex or cyanotic heart disease, abnormal neurology
- Trial to be done at as late a gestation as possible to avoid unsuccessful trials due to immaturity

Process

1. Car seat to be brought in **prior to rooming** in to ensure the car seat trial can be undertaken and the baby deemed safe prior to preparing for rooming in and discharge
2. Attach a Car Seat Trial Massimo monitor on the baby's foot (averaged to 2 seconds)
3. Monitor supine in the cot for 30 minutes and preferably when in a deep sleep. If sats are below 93% commence a sleep study overnight.
4. If the supine cot trace is acceptable then place baby in the car seat and monitor for at least a further 30 min

Car Seat Positioning

- Proper positioning of the infant in the seat is important to minimise the risk of respiratory compromise
- Rear facing car seat – 3 or 5 point harness
- Semi-reclined position – 45 degrees
- Buttocks and back flat against the back of the seat
- Head is upright and airway not compromised – padding can be added for lateral support of the head and neck but any head support should not be pushing the head forward and therefore compromising the airway
- Harness straps at or below the shoulder level – generally at the lowest position
- Secure harness around baby - no more than 1 finger should fit between harness and collarbone
- Harness straps should be snug
- Harness retainer clip at level of armpits or midpoint of chest

Failure Criteria

- Bradycardia <80/min for >20 secs
- Oxygen saturations <90% for >60secs or regular fleeting desats <90%
- Respiratory distress/obstructive episodes

If the baby fails the car seat trial place supine in the cot and commence a sleep study with the Massimo monitor currently on the baby and inform the ACNM, Registrar/NNP and SMO.

Management options

- If the baby stabilises in the cot then a sleep study overnight is all that is required initially
- Oxygen can provide immediate treatment for desaturations but may eradicate periodic breathing and if put on straight away may normalise the trace limiting the information available to assess
- Caffeine may be recommended after review of the sleep study

Car Seat Education

- Staff to show the family how to secure the baby safely in the car seat
- Rear facing and secured on the back seat (tether, strap and bolt if indicated)
- Recommend an adult sit beside the baby in the back seat if possible
- Advise not to leave the baby unsupervised in the car seat at any time
- Baby not to be left to sleep in the car seat – cot or bassinet is the safest place to sleep
- If travelling for > 1hour then stop the journey for at least 10 min every hour and get the baby out of the car seat to stretch and feed if required. This should be continued until the baby has good head control.
- Once you reach your destination take the baby out of the car seat
- Minimise the time the baby is in the car seat
- If the baby is on an apnoea monitor or cardiorespiratory monitor at home this should also be used when in the car seat

❖ FLUIDS

Total Fluids

Day	Normal Birth Weight for Gestation and >1500 g	IUGR or <1500g
1	65 ml/kg/day	65, increase to 90 if recurrent low BSL on 65 ml/kg/day
2-3	90	90 - 120
3-5	120	120 - 150
5-7	150	150 - 180
>7	150 - 180	150 - 180

- Just as with ventilator settings, there is no magic fluid prescription that will work for all babies.
- The baby's weight and serum sodium tend to be the best guides to hydration status in the first few days. A high serum sodium in the first few days is much more likely to be due to dehydration than to an elevated total body sodium (a rise in serum sodium of 10 mmol indicates 10% dehydration), and conversely, hyponatremia is commonly caused by overhydration. Although many babies in intensive care are too sick to weigh often, weight measurements can be very useful. In using weight as a guide, allow for a weight loss of 2-4% per day for the first few days. Measured fluid intake, urine output, blood pressure and clinical appearance are also important cues in estimating fluid requirements. Urinary electrolytes have a role in some babies but are useless in babies who are on diuretics. Measurement of losses via other routes such as ostomies and gastric aspirates can be very useful in selected babies. Two caveats are that overhead warmers and phototherapy lights may increase insensible losses, whereas (due to enhanced diffusion of water vapour) high frequency ventilation can result in net free water uptake.
- We usually base decisions about fluid management on results from samples analysed in the main Canterbury Health Laboratories. The blood gas machine measures electrolytes can provide a useful guide to the electrolytes and to follow trends but the values are not always accurate. Keep in mind that the unit machine measures whole blood electrolytes, so the normal ranges are about 3-5% **lower**, (e.g. about 132 - 142 for Na). Also, suspected erroneous results are usually too low, rather than too high. **Thus, elevated results from the unit machine should be taken seriously.**
- In general, both premature and term babies are born with a reserve of extracellular fluid and sodium equivalent to 5-7% of birth weight (roughly 150-300 ml in a term baby) that they can lose after birth without a rise in aldosterone levels or any other indication of dehydration. Creatinine clearance is low immediately after birth and increases with advancing post-natal age. This is the reason why the prescribed fluid intake is initially low and increases.
- Typical insensible water loss at term is about 20-60 ml/kg/day and can be far greater in very premature babies, who have a much less adequate cutaneous barrier to water loss, and in infants under radiant warmers and/or phototherapy lights. Thus, all these infants need very careful attention to their fluid balance.
- We have a protocol for the use of petrolatum (Vaseline®) on <1000 gram babies to reduce transepidermal water loss. However, an extremely low birth weight baby < 28 weeks should be nursed in a humidified incubators
- Small babies, particularly those with arterial lines in and those on multiple medications can end up receiving a large amount of their projected daily fluid and sodium requirements as flushes. The nurses record these for intensive care babies and the total volume received in the last 24 hours should be noted. If it is significant, it should be recorded in the notes and discussed in the planning of the next day's fluids. The amount that is 'significant' may vary with the size of the baby, the severity of illness and the baby's particular problems, but if the flush volume exceeds 15% of the projected daily fluid intake, it is worth mentioning.

Intravenous Fluids

Dextrose

- Usually 10% dextrose
- May need another dextrose concentration if hyperglycemic (7.5%) or hypoglycaemic (12.5-15%)

Sodium

- Commence sodium on the first or second day unless serum sodium is >145 , discuss with the consultant on the morning or afternoon round.
- Subsequently, aim to keep the serum Na in the normal range (135-145 mmol/L). Remember that the baby may already be receiving a substantial amount of sodium via arterial lines and flushes so this intake may need to be calculated and subtracted from the amount given intravenously. Babies who have been fully orally fed and switch to IV therapy should have some sodium added from the beginning.

Potassium

- Usually, due to low renal potassium excretion, low levels of potassium are needed for the first one to two days. After that, provided the serum potassium is <5.5 mmol/L on an unhaemolysed sample, start K to keep the serum K 3.5-5 mmol/L.

Calcium and Phosphate

- It is very difficult to ensure optimum calcium and phosphate without enteral feeding. Normal ranges for serum Ca are 2.2-2.8mmol/L corrected (accept up to 3.0mmol/L if it is transient) and **ionized calcium** from the blood gas analysis 1.15-1.45. Phosphate aiming for 1.5-3mmol/L but targeting 1.8-3mmol/L in those at risk of refeeding syndrome in the first 2 weeks of life. This includes babies <32 weeks or any baby in NICU $<3^{rd}$ %.
- Referral to Endocrine if the corrected Ca is consistently >3.0 mmol/L
- The reason to use ionized calcium as the guide is that it is the 'functional' calcium and is also the regulator of calcium balance. The ratio of ionized to total calcium is higher in the presence of acidosis and hypoproteinemia, both of which are common in sick and premature babies.
- Aim for 1.5 mmol/kg/day calcium intake. However, because calcium is a potent sclerosing agent, especially in very small veins, and can cause severe tissue necrosis if the IV infiltrates, it is impossible to give this much through a peripheral IV.
- Ca gluconate in a **peripheral** IV line should not exceed **15 ml of 10% solution in 500ml**
- **Ca gluconate in a central** line should not exceed **50 mls of 10% solution in 500 ml** and for ease of charting **30mls in 500ml bag** has been chosen to be the standard amount in babies without specific Ca issues
- In an emergency (e.g. cardiac arrhythmia, decreased cardiac output thought to be secondary to hypocalcemia, during exchange transfusion), a bolus of 2 ml/kg 10% calcium gluconate, diluted 1:5 can be given over 5-10 min via a syringe pump or as a slow push. You can use a good peripheral IV for this if necessary, but the infusion site must be watched closely.
- **Never** infuse calcium-containing solutions into peripheral arterial lines, and only into umbilical arterial lines after specific discussion with a consultant, and weighing up the alternatives.
- Phosphate should be replaced iv or orally if <1 mmol/L. See drug profiles for further information.

Prescribing Additives

Day 1

- If unable to receive enteral feeds and TPN is not required then start Premix fluids 500ml bag -10% dextrose, 15mmol NaCl, 10mmol KCl at 65ml/kg/day
- Use 10% glucose from birth in babies with hypernatraemia, hyperkalaemia or potential for renal impairment and oliguria/anuria. For example – HIE, known renal abnormalities.
- 10% glucose can be used for short-term situations such as when a baby has an iv sited prior to insertion of central lines with the intention of starting TPN when the central lines are in place

Day 2 onwards

- Most babies will require electrolyte additives by 24-48 hours
- Change fluids (if not already on premix) to the 500ml premix fluid bag containing 10% dextrose, 15mmol NaCl, 10mmol KCl
- Fluid rate will usually be 90ml/kg/day on day 2 and volumes graded up as discussed on the ward round

- The more volume the baby gets the more additives they will receive in the same way as TPN is given
- The bag can be hung for 48 hours before being changed unless Ca is added to the bag when it should be changed 24 hourly
- Ca should be replaced in babies that are proven to be hypocalcaemic (ionised Ca <1, formal < 2)
- Usually babies on fluids with additives will be receiving some milk enterally which should prevent hypocalcaemia. If they are not receiving milk over a few days then TPN may be a better fluid option.
- If Ca gluconate is being given peripherally – add 3.3mmol (15mls) per 500ml bag (no need to remove 15ml first)
- If Ca gluconate is being given centrally – add 6.6mmol (30mls) per 500ml bag (no need to remove 30ml first)
- Below are the amounts of electrolytes that will be provided at the fluids rates stated.

Fluids ml/kg/day	Dextrose	Na mmol/kg/day	K mmol/kg/day	Ca mmol/kg/day Peripheral	Ca mmol/kg/day Central
65	10%	2	1.3	0.4	0.8
90	10%	2.7	1.8	0.6	1.2
120	10%	3.6	2.4	0.8	1.6
150	10%	4.5	3	1	2

Individual Fluids with Additives

- If a baby has complex electrolyte requirements and an individual TPN bag is unable to be obtained or is not felt to be required then individual fluids with additives can be prescribed as per the instructions below.
- The Electrolyte Calculator on the G:Drive in the Drugs Folder can be used to calculate doses and volumes as well.
- Standard solutions used for preparation of IV fluids:

	Stock Solution	Typical Dose
NaCl 23%	4mmol/ml	2-6mmol/kg/day
KCl 15%	1mmol/ml	1-2mmol/kg/day
Ca Gluconate 10%	0.22mmol/ml	1-2mmol/kg/day

Start at the lower end and increase if there is a significant deficit

Step	Example for 1.2 kg baby
a) Decide the total fluids for the day.	150 ml/kg = 150 x 1.2 = 180 ml
b) Subtract non-nutritional fluid, such as arterial line and other infusions	UAC at 1 ml/h = 24 ml/day => IV fluid is (180-24) = 156 ml/day = 6.5 ml/hr
c) Decide planned electrolyte intake.	3 mmol/kg Na 2 mmol/kg K 1.5 mmol/kg Ca
d) Multiply by the ratio of 500/IV fluid volume (from step b) because the nurses make up 500 ml bags of fluid.	NaCl: 3mmol x 1.2kg x 500ml bag / 156ml = 11.5 mmol KCl 2mmol x 1.2kg x 500ml bag / 156ml = 7.7 mmol CaGluc 1.5mmol x 1.2 x 500ml bag / 156ml = 5.8 mmol
e) Convert the mmol dose to the volume of stock solution to be added to the 500 ml bag (see above).	NaCl 11.5mmol/4mmol = 2.8 ml KCl 7.7mmol/1mmol = 7.7 ml CaGluc 5.8mmol/0.22mmol = 26.4 ml
f) Check that the calcium concentration is appropriate to the type of line being use	Peripherally max amount = 15 mls in 500ml bag Centrally max amount = 50mls in 500ml bag.
g) Add 0.1 unit heparin per ml if infusing through anything other than a peripheral IV.	0.1 unit/ml of heparin in a 500ml bag

Step	Example for 1.2 kg baby
h)	Check that the total volume of additives doesn't exceed 50 ml. If it does, write the prescription with instructions to remove a volume equivalent to the total volume of additives first (to avoid major dilution errors in the electrolytes).

Thus, the fluid prescription for the baby in the example (if CVL) would be:

10% dextrose 500 ml. Add:
 2.8 ml 23% NaCl (4mmol/ml) (3 mmol/kg/day)
 7.7 ml 15% KCl (1mmol/ml) (2 mmol/kg/day)
 26.4 ml 10% Ca Gluconate (0.22mmol/ml), or (1.5 mmol/kg/day)
 0.1unit/ml heparin (0.05ml of 1000units/ml solution) Run at 6.5 ml/hour

If you write out this detail, your prescription can be readily checked by the nurses.

Calculating Dextrose Concentrations

- **To make 500ml bags of:**
 - 7.5% dextrose** Add 250ml 5% and 250ml 10% dextrose
 - 12.5% dextrose** Add 470ml 10% and 30ml 50% dextrose
 - 15% dextrose** Add 440ml 10% and 60ml 50% dextrose
 - 20% dextrose** Add 380ml 10% and 120ml 50% dextrose
- **To make a 10% premix iv fluid bag up to 12.5% dextrose**
 Remove 30mls from the 500ml premix bag and replace with 30mls of 50% dextrose
 Concentration of additives will now be:

Fluids ml/kg/day	Dextrose	Na mmol/kg/day	K mmol/kg/day
65	12.5%	1.9	1.2
90	12.5%	2.5	1.7
120	12.5%	3.4	2.3
150	12.5%	4.2	2.8

- **To make a 10% premix iv fluid bag up to 15% dextrose**
 Remove 60mls from the 500ml premix bag and replace with 60mls of 50% dextrose
 Concentration of additives will now be:

Fluids ml/kg/day	Dextrose	Na mmol/kg/day	K mmol/kg/day
65	15%	1.8	1.1
90	15%	2.4	1.6
120	15%	3.2	2.1
150	15%	4.0	2.6

Hyponatraemia ($\text{Na}^+ < 135\text{mmol/L}$)

Hyponatraemia can be caused by:

- Increased water retention eg: renal failure, SIADH after an asphyxial insult, early days of RDS
- Increased Na losses eg: leaky preterm kidneys, 3rd spacing after surgery, diuretics

Mild Hyponatraemia ($\text{Na } 130\text{-}135 \text{ mmol/L}$)

- Start or increase the oral supplements if on some enteral feeds
- Increase the amount of Na additives to the 10% dextrose maintenance fluids
- Increase the TPN rate to provide more Na per day
- Change to High Na TPN

If none of the above are appropriate – for example in a baby on Standard Na TPN at 165ml/kg/day who is NBM because of aspirates and can't have oral supplements and a High Na TPN bag is unavailable or inappropriate – a Na sideline needs to be started

Severe Hyponatraemia ($\text{Na} < 130 \text{ mmol/L}$)

- If the Na is below 130mmol/L it is best to firstly correct the deficit with a Na correction and then increase the daily maintenance provided by the methods in “mild hyponatraemia” above or order an individual TPN bag with an increased concentration of Na.
- If the baby is well and is on mainly enteral feeds then the daily sodium supplements could be increased and the sodium corrected over 24 hours. Using this method would depend on how low the sodium is, the rate of fall of the sodium level and how well the baby is.

Sodium Correction

- Calculate the Na deficit using the formula: **(Target Na – Current Na) x 0.6 x weight (kg) = mmol deficit**
- Target Na is usually 135mmol/L
- Add the deficit to a 10% dextrose sideline as per the infusion sheet - [Sodium Chloride Correction Infusion](#)
- Replace the deficit usually over 6-12 hours but the larger the deficit the slower the replacement should be
- Infuse the fluid into the same line as the TPN as this will further dilute the infusion as it enters the vein

Hypokalaemia

($\text{K}^+ < 3.5 \text{ mmol/L}$)

Hypokalaemia can be caused by:

- Insufficient maintenance eg: K^+ additives not introduced into maintenance fluids, on TPN but due to multiple other infusions the amount of K received is minimal
- Increased K losses eg: vomiting, 3rd spacing after surgery, diuretics, renal disorders, CAH
- Other eg: insulin, alkalosis, drugs such as fluconazole, amphotericin,

Mild Hypokalaemia ($\text{K}^+ \geq 2\text{mmol/L}$)

- Start oral supplements at 1-2mmol/kg/day (potassium chloride or potassium dihydrogen phosphate) 6 hourly if on half enteral feeds, or
- Increase the rate of the premix 10% dextrose bag to provide more K, or
- Increase the K additives to an individually prescribed 10% dextrose fluid bag
- Increase the TPN rate to provide more K, or
- Prescribe an individual TPN bag with increased K in it, or

Symptomatic or Severe Hypokalaemia ($K^+ \leq 2.0$ mmol/L)

- Acute treatment is needed to correct the deficit and a potassium correction is needed
- Only use in the most severe of cases as high concentration potassium infusions are not without risk
- Signs of symptomatic hypokalaemia that are seen in neonates are ECG changes (ST segment depression, low-voltage T waves, U wave.). Other signs include neuromuscular weakness, ileus, urinary retention
- Use the [Potassium Chloride Infusion](#) to calculate the potassium infusion (do not use KH_2PO_4)
- The replacement is calculated to replace 0.6mmol/kg over 4 hours using a 40mmol/L solution if via a peripheral line and a 60mmol/L solution if there is a central line and a need to restrict the volume.
- The rate at which the infusion can be infused should not exceed 0.2mmol/kg/hr

Hypernatremia

- Defined as a serum sodium level > 145 mmol/L
- ELBW babies need 6-12 hourly electrolytes on ABG or formal blood tests in the first few days as they are at a high risk of developing hypernatraemia

Risk Factors

- Insensible water loss
- Iatrogenic (Na bicarbonate, Na in fluids or TPN, arterial line infusion, oral supplements)
- Gastrointestinal loss of fluid eg: 3rd space loss in NEC, post surgery, high bile stained NG loss
- Glycosuria causing an osmotic diuresis
- Diabetes insipidus (central or nephrogenic)
- Sample technique (eg. excessive squeezing from a heelprick)

Diagnosis

- High serum Na on a formal lab test or an upward trend on ward gas machine results (these may be very different and if in doubt repeat as a formal lab specimen)
- Weight loss and decreased urine output suggest dehydration.
- Dilute urine with normal or increased urine output suggest glycosuria or diabetes insipidus
- Na in 1st 48 hours almost always reflects free water deficit.
- Increased Na in 1st 48 hours does not equal increased total body Na

Treatment

- In the first few days of life increase total daily fluid (water) intake
- Increase fluids by 30ml/kg/day increments (eg. 90 to 120ml/kg/day) either as an increase in the maintenance fluids or TPN or as an additional sideline of 10% dextrose.
- If the Na rises despite 180 mls/kg/day intravenously, a continuous infusion of water nasogastrically at 40 mls/kg/day can be used. Eg. 0.6kg infant: $0.6 \times 40 = 24$ mls / 24 hrs run at 1 ml / hr NG. Stop when Na falls to 150mmol/L.
- If there is evidence of fluid overload (oedema, weight gain, rising Na) then restrict Na and water intake.
- After the first 48 hours of age, hypernatraemia is still likely to be due to a free water deficit, so increase maintenance volume but be careful with added electrolytes.
- If TPN prescribed with more Na^+ than required reduce volume and add a sideline of dextrose.

Hypernatraemic Dehydration

- Some babies are readmitted to NICU from the community for management of moderate-severe hypernatraemic dehydration. By far the commonest reason is unidentified inadequate intake of milk.
- There may be risk factors able to be identified in the mother and baby:

Mother: eg: primip, prolonged and difficult labour, antepartum or postpartum haemorrhage, maternal illness, delayed onset of lactation

Baby: twin, preterm, IUGR, congenital abnormalities, mouth or jaw structural abnormalities.

Refer to the Clinical Practice Recommendation for management of moderate-severe hypernatraemic dehydration
<https://www.starship.org.nz/guidelines/practice-recommendations-for-weight-loss-dehydration-and-hypernatraemic/>

Hyperkalaemia

- Defined as a serum potassium level $> 6\text{mmol/L}$
- Hyperkalaemia is a life threatening condition and when identified, needs to be managed promptly and aggressively.
- Hyperkalaemia most commonly occurs around 24-48 hours of age in the unwell, preterm infant < 28 weeks, in renal failure or a baby with ischaemic bowel
- Always discuss treatment plan with the consultant before commencing

Risk factors

- Extreme prematurity
- Haemodynamic instability with low systemic blood flow
- Hypoxic ischaemic encephalopathy
- Acute renal failure
- Hypothermia
- Blood transfusion with old blood
- Sepsis
- Metabolic acidosis

Signs of Hyperkalaemia

- ECG changes with peaked T waves
- Widened QRS complexes
- Arrhythmias

Those babies identified as having risk factors for hyperkalaemia should have regular K levels checked in the first 24-48 hours ie: 6-12 hourly, from a free flowing sample to remove the effect of haemolysis on the potassium level.

Mild Hyperkalaemia: 6 - 7mmol/L

- Stop any potassium containing infusions or medications
- Stop any potassium sparing diuretics eg: spironolactone
- Correct any hypocalcaemia with 10% calcium gluconate (aim to keep ionised Ca $> 1.2\text{mmol/L}$)
- Correct any metabolic acidosis with sodium bicarbonate and by treating the underlying cause

Moderate Hyperkalaemia: 7- 8 mmol/L

- As above, and
- Insulin/dextrose infusion (see drug protocol sheets and below)
- Salbutamol iv (see drug protocol sheets and below)

Severe Hyperkalaemia: $> 8\text{ mmol/L}$ or any raised level with arrhythmias

- As above, and
- 10% calcium gluconate infusion immediately to stabilise the myocardium from arrhythmias

Insulin/Dextrose Infusion

- Effective in treating hyperkalaemia.
- Rigorous monitoring of the blood sugars (as well as the K levels) is essential as the complications of the infusion can include hyperglycaemia and hypoglycaemia.
- A central line is required as the dextrose concentration of 25-50% is too high to go peripherally.

Salbutamol IV

- IV salbutamol is also effective in temporarily lowering the potassium (for 1-2 hours) and may be easier to prepare quickly in an emergency situation rather than an insulin/dextrose infusion.
- However, the use of salbutamol for non-oliguric hyperkalaemia in the extreme preterm infant has not been as extensively studied and as such many units would use salbutamol as a second-line treatment for hyperkalaemia not responding to insulin/dextrose infusion.
- Salbutamol does not lower the potassium level in babies with persistent metabolic acidosis
- Side effects of using salbutamol include, tachycardia, tremor, hyperglycaemia.

❖ NEONATAL NUTRITION GUIDELINES

Feeding Guidelines

Babies born < 32 weeks OR Birthweight < 1800g * Refer to dietitian at any time that growth is inadequate*				
	Transition to Oral Feeding	Stable Growing	Preparation for Discharge	At Discharge
Feed	TPN if ≤30 weeks or <1500g (31/32 weekers or 1500-1800g may also need TPN – individualise care) → Breast milk, PDM or standard milk mixture If <32 weeks or <1500g start Infloran probiotic on the day after birth (for prevention of NEC)	Continue HMF additives in EBM/PDM or Preterm milk mixture alone Review and stop other phosphate supplements if on HMF and phosphate level > 1.8mmol/L If not on HMF, folate and phosphate supplements to continue until 37 weeks	Stop HMF additives in EBM/PDM or change from Preterm milk mixture to Standard milk mixture from 2.7kg or 37 weeks Stop probiotics at 36 weeks corrected	Breast milk or Standard milk mixture.
Frequency	Start feeds and grade up as per the chart below Aiming for hrly feeds <1250g and 2hrly feeds 1250-1800g. Include feeds when: <1000g:0.5ml/hr or 1ml 2hrly ≥1000g:1ml/hr	Grade up to 3 Hourly feeds as tolerated	Begin sucking feeds 3 or 4 hourly feeds or on demand	Begin sucking feeds 7- 8 feeds per day or responsive feeding
Feed/Fluid Volume	Day 1 65-90 ml/kg/day Day 2-3 90-120 ml/kg/day Day 3-5 120-150 ml/kg/day Day 5-7 150-165 ml/kg/day Day >7 165 ml/kg /day Increase TPN to 165ml/kg/day when on oral feeds >30ml/kg/day prior to HMF introduction. If not increasing to 165ml/kg/day then consider changing to concentrated TPN	180 ml/kg/day or as tolerated. Increase to 200ml/kg if poor growth	180-200 ml/kg/day as tolerated or on demand	150-165 ml/kg/day as tolerated as responsive feeding
Supplements	Review phosphate levels day 3,5,7 and start 1-2 mmol/kg/day oral phosphate if <1.8mmol/L Start HMF when on about 80ml/kg/day enteral feeds. Or consider essential amino acids if HMF contraindicated Stop lipid when approaching 150ml/kg/day enteral feed (and prior to stopping the TPN bag) and start vitamins: Vitamin D - Two drops/day Vitamin A – Three drops/day if <30 weeks, or Two drops/day if 30-34 ⁺⁶ weeks Micelle E 30IU/day <1250g or<30wks Folic Acid 50µg/day <1500g if unfortified EBM long term	Monitor phosphate levels if on supplements aiming for a level of 1.8-3 mmol/L whilst transitioning to full enteral feeds Consider need for other supplementation if growth is a concern – Na, Zinc, Liquigen Vitamin D level D28 if <28 weeks and repeat 2 weekly if low <50 nmol/L Start Fe at 2-4weeks at 3mg/kg/day if, not on HMF (FM85 fortifier) or Preterm formula, MM Some on Preterm MM might need some Fe supplementation after dietitian review	At 36 weeks, if off respiratory support then stop Vitamin A	Vitamin D one drop/day to 1 year age Iron 3mg/kg/day if breastfed or mixed feeds breastmilk and milk mixture to 1 year age Stop Iron if on exclusive milk mixture Stop Vitamin A if still on it Stop Folic acid Stop Micelle E Stop Zinc

Babies born ≥ 32 weeks OR Birthweight ≥ 1800 g

* Refer to dietitian at any time that growth is inadequate*

	Transition to Oral Feeding	Stable Growing	Preparation for Discharge	At Discharge
Feed	Breast milk, PDM or Standard milk mixture	Breast milk, PDM or Standard milk mixture	Breast milk, PDM or Standard milk mixture	Breast milk or Standard milk mixture
Frequency	3 hourly unless risk of hypoglycaemia or other medical concerns	3 hourly feeds	3 hourly feeds or responsive feeding	7-8 feeds per day or responsive feeding
Feed Volume	Day 1 65ml/kg/day Day 2 90ml/kg/day Day 3-4 120ml/kg/day Day 5-7 150ml/kg/day Day >7 150-165 ml/kg /day Include feeds when 1ml/hr	180ml/kg/day or as tolerated	180 - 200 ml/kg/day as tolerated or on demand	150-165 ml/kg/day as tolerated or responsive feeding
Supplements	Vitamin D <35 weeks 2 drop/day ≥ 35 weeks 1 drop/day Vitamin A two drops/day if <35 weeks Consider HMF if <2000g and not reached birthweight by 2 weeks, or, <3 rd % and poor weight gains	Start Fe at 4weeks at 3mg/kg, not on FM85 fortifier or Preterm formula, MM Some on Preterm MM might need some Fe supplementation after dietician review	At 36 weeks, if off respiratory support then stop Vitamin A	Vitamin D one drop/day to 1 year of age Iron 3mg/kg/day if breastfed or mixed feeds breastmilk and milk mixture to 1year of age Stop Iron if on exclusive milk mixture Stop Vitamin A if still on it

CURRENT WEIGHT	FEED VOLUME AND FREQUENCY Increase 24hrly if tolerated	GRADING FEEDS	INCREASE TPN to 165 mL/kg/day prior to HMF or change to Concentrated TPN	START HMF and reduce TPN to 150mL/kg/day when HMF is tolerated	DAYS TO FULL FEEDS (150 mL/kg/day) and removal of central line
Review serum phosphate levels on day 3, 5, 7, 10 and supplement orally if <1.8mmol/L * Volume to include feeds in the total fluids when tolerated					
< 1000 g	0.5 mL Q4H 1 mL Q4H *1 mL Q2H 1 mL Q1H	Then increase by 0.5 mL 24QH then 0.5 mL 12QH	When on 1mL/hr milk	When on 2.5 mL/hr milk	10-12 days
1000-1249 g	1 mLQ4H 1 mLQ2H *1 mLQ1H	Then increase by 1 mL 24QH then 1 mL 12QH	When on 2mL/hr milk	When on 3mL/hr milk	8-10 days
1250-1799 g	*2 mL Q2H	Then increase by 1 mL Q8H then 1-2 mL Q6H	When on 5mL 2 hrly	When on 8mL 2 hrly	5-8 days
≥ 1800 g	65 mL/kg/day aiming for feeds Q3H	Titrate IV fluids with EBM/PDM	N/A	N/A	3-5 days

Transpyloric Feeds

Transpyloric feeding has several potential advantages over gastric feeding, including improved feeding tolerance and prevention of bronchopulmonary dysplasia, presumably due to reduced risk of aspiration (Wallenstein et al. 2019). However, definitive evidence is lacking (Watson & McGuire 2013), so it should be used with caution.

Indications

- Gastroesophageal reflux causing feeding intolerance or respiratory compromise
- Preterm infants with severe lung disease
- Older infants with severe bronchopulmonary dysplasia
- Note: placement in children post diaphragmatic hernia and other abdominal conditions is more difficult and may need interventional radiology assistance.

Procedure (From Clifford et al. 2017, Starship protocol has an alternative approach)

1. This is a joint nursing and medical effort
2. Ensure baby has not had a feed at least 1-2hrs prior to insertion to prevent vomiting and aid stomach motility.
3. Obtain 5 or 6 French feeding tube. Place in fridge for 20-30 minutes. Enteral polyurethane feeding tube such as a Corflo 6fg/91cm is preferred. Remove the stylet it is not to be used with insertion. Note: If using Standard PVC feeding tube for transpyloric placement it will need to be changed weekly.
4. Flush tube with sterile water.
5. Calculate the gastric distance and the advancement distance by measuring the distance from umbilicus to right iliac crest.
Final length of tube should = standard gastric length + distance from umbilicus to right iliac crest
6. Swaddle baby and give oral sucrose (to provide comfort)
7. Place tube to usual gastric distance per standard protocol
8. Put baby right side down and elevate head of bed to 30-45 degree angle
9. Slowly inject 5-10ml air into the gastric tube as you advance the tube 1-2cm at a time to estimated post-pyloric distance position. Listen for air entry over the pylorus (to right of the midline) with the final ml of air.
10. Secure tube well so dislodgement is minimised.
11. Leave the baby right side down for another hour and then obtain an AP abdominal xray
12. Any duodenal position is acceptable, examples shown below:



Nasoduodenal tube tip in the **first**



second, and



third portion of the duodenum

Feeding

- **Continuous feeds only**
- Convert total daily enteral fluid volume to ml/hr for continuous feeds.

Contraindications

- History of NEC, perforation, or other intestinal pathology. Always discuss with consultant before initiating.
- **DO NOT USE FORMULA** for transpyloric feeds, use expressed breast milk or PDM only. Additives, including HMF and amino acids can be used in discussion with the dietician.
- In rare circumstances specific formulas can be used – this needs dietician and Paediatric Gastroenterologist input.

Medications

Most medications are adequately absorbed in the duodenum and can be given at the same dose.

Please refer to this document [Transpyloric Medications](#) for advice on what medications are safe to be given via the transpyloric tube. Most medications are adequately absorbed in the duodenum and can be given at the same dose.

Check with pharmacy regarding all other medications.

References

1. Wallenstein MB, Brooks C, Kline TA, Beck R, Yang W, Shaw GM, Stevenson DK. Early transpyloric vs gastric feeding in preterm infants: a retrospective study. *J Perinatol* 2019;39:837-41.
2. Watson J, McGuire W. Transpyloric versus gastric tube feeding for preterm infants. *Cochrane Data System Rev* 2013;2:CD003487.
3. Clifford P, Ely E, Heimal L. Bedside placement of the postpyloric tube in infants. *Advances Neonatal Care* 2017;17:19-26.

Dietitian Referral Guidelines

Any **Inpatient** with:

- Poor weight gain
- Fluid restricted enteral feeds
- Intolerance to breast milk fortifier or preterm formula
- Extended TPN use
- Surgical GI resection +/- ostomy formation
- NEC
- Recurrent hypoglycaemia when additives or diazoxide are being considered
- Short Bowel syndrome
- Malabsorption
- Chronic lung disease where growth impairment is likely
- Congenital Heart disease
- Gastrointestinal anomaly
- Metabolic disorder
- Chylothorax
- Renal Failure
- Osteopenia requiring additional calcium and phosphate
- Possible Zinc deficiency

Any **Outpatient** with the following requires a Dietician Referral at discharge

- Nasogastric feeds expected > 6 weeks (excluding short-term DOTS patients)
- Caloric supplements at discharge
- Prescribed specialised formulae or concentrated infant formula
- Nasojejunal, PEG, PEJ feeds at discharge
- Syndromes such as Trisomy 21, Noonans
- On HCS – **Referrals tab / Dietitian / Christchurch Hospital** / fill in clinical details as to why dietitian input is required

Calories

	kcal/ml (unless other units given)	g/100ml (unless other units given)
EBM	0.66	1.27g protein
EBM with HMF (1 sachet/25ml)	0.83	2.9g protein
PDM	0.66	1.1g protein
PDM with HMF (1 sachet/25ml)	0.83	2.7g protein
Milk mixture (S26)	0.67	1.5g protein
Milk mixture (Karicare)	0.67	1.4g protein
Premature milk mixture (PreNAN)	0.80	2.9g protein
Pepti Junior	0.67	Whey hydrolysate
Elecare	0.68	Amino Acid formula
TPN Protein	4 kcal/g	
Protifar	3.8 kcal/g	0.9 g protein/g
Duocal (lipid and carbohydrate)	4.7 kcal/g	Start at 1g/100mls and discuss with dietitian
Liquigen	4.5kcal/ml (9kcal/g)	
Calogen	4.5kcal/ml (9kcal/g)	
Polycal	3.8kcal/g	0.94g CHO/g
Lipid	9 kcal/g	
TPN Protein	4 kcal/g	
Liquigen	4.5kcal/ml (9kcal/g)	
Calogen	4.5kcal/ml (9kcal/g)	
Dextrose	3.4 kcal/g	
5% Dextrose	0.19	
10% Dextrose	0.38	
12.5% Dextrose	0.48	
15 % Dextrose	0.57	

Breast Milk Protein Fortification

- Breast milk does not supply enough calories or nutrients for a growing preterm baby
- Growth is important for longer term developmental outcome and early nutrition is important
- CWH audits have shown that as babies wean off TPN there is a drop in protein supply around days 9-15 as the breast milk volumes increase and TPN volumes decrease. Fortification can reduce or prevent this drop off in protein delivery
- ESPGHAN guidelines recommend a protein intake of 3.5 to 4.0g/kg/day for babies <1.8kg

Indications for Fortification

- <32 weeks gestation
- <1800g at birth
- Poor weight gains in babies outside the above criteria ie: crossing centiles
- On the advice of the dietitian if indicated by abnormal ALP, phosphate or albumin levels
- The primary fortification product is Human Milk Fortifier (HMF) but there will be situations where other products may be used (see below)

1. Human Milk Fortifier (HMF)

- HMF contains extensively hydrolysed cow's milk whey protein (similar to the protein component of Pepti-Junior) and provides calories, protein, calcium, phosphate, vitamins and electrolytes and is a complete supplement
- 1 sachet per 25mL of EBM is a full dose and adds 17.2kcal/100ml and 1.6g of protein /100ml
- Aim to start when on about 80ml/kg/day enteral feeds
- It is ordered on the Nutrition Order form by the medical team or dietitian
- If HMF introduction is delayed, not possible or not tolerated then increasing the daily fluid rate to 165 ml/kg/day will help ameliorate the drop in protein intake enterally from un-fortified feeds
- Parent information sheet to be given to parents prior to starting HMF
- Monitor phosphate levels if on oral phosphate as well as HMF
- There is no clear evidence that HMF alone is causative in the pathophysiology of NEC, however, after recovery from NEC protein fortification will start as essential amino acids and after a period of about 4 weeks there should be consideration of whether HMF can be reintroduced.

Precautions to HMF

- Suspected or proven NEC
- After bowel surgery / bowel perforation / milk curd obstruction
- Significant abdominal distension / feed intolerance / gut dysmotility
- Blood in stool
- Heavily bile-stained aspirates
- Sepsis
- Indometacin course – if stable on HMF do not stop but if not on HMF then withhold until course is completed

2. Essential Amino Acids

- This is a completely hydrolysed supplement to single amino acids, similar to the protein component of Neocate. It provides essential amino acids only without other components available in HMF
- **Indications for use include**
 - At risk for feed intolerance – this will need to be individualised but situation may include babies at 23, 24 weeks gestation or severe growth restriction <3rd%
 - Feed intolerance / gut dysmotility
 - Intolerance to HMF and/or Protifar
 - After NEC
 - After bowel surgery / bowel perforation / milk curd obstruction
 - Transpyloric feeds
- The dietitian and SMO will decide which babies will receive essential amino acids
- Dose starts at 0.5g/100mL and can increase to under dietitian guidance. Will need higher doses of 1-1.5g/100mL if on PDM or after analysis of mothers own milk
- Other supplementation required includes – phosphate, sodium, folic acid, iron and potentially the addition also of liquigen and polycal

3. Protifar

- Protifar is a cow's milk based casein protein concentrate that provides additional protein with low levels of calcium and phosphorus and minimal sodium and potassium.
- **Indications for use include** the additional need for protein over and above that provided by HMF. This may be needed if on PDM
- The dietitian will determine the quantity required – usually start at 0.5g/100mL and increase under dietitian guidance
- 1g/100mL protifar will provide 3.8 kcal/100mL and 0.9 g protein/100mL
- It is ordered on the Nutrition Order form by the medical team or dietitian
- Other supplementation required includes – phosphate, sodium, folic acid, iron and potentially the addition also of liquigen and polycal

Comparison of EBM with and without HMF

	Protein (g/kg/day)		Sodium (mmol/kg/day)		Phosphate (mmol/kg/day)	
	EBM	EBM + HMF	EBM	EBM + HMF	EBM	EBM + HMF
150 mL/kg/d	1.9	4.3	1.0	3.4	0.8	2.9
165 mL/kg/d	2.1	4.8	1.1	3.8	0.85	3.1
180 mL/kg/d	2.3	5.2	1.2	4.1	0.9	3.4

Comparison of Fortification Components

		Protein (grams)	KCal	Fat (grams)	Carbohydrate (grams)
HMF	4g /100mL	1.6	17.2	0.8	0.4
Protifar	1g/100mL	0.9	3.8	-	-
Essential Amino Acids	1g/100mL	0.8	3.2	-	-

When to Stop Fortification

- On dietitian advice
- Gestation, weight, ALP, albumin, calcium and phosphate levels all need to be considered before stopping and will be individualised
- Reduce volume of feeds first and continue fortification if weight gains are large.
- As a general rule most babies can stop fortification at about 37 weeks or 2.7kg
- HMF and essential amino acids are not able to be given after discharge so discuss with the Dietitian regarding alternatives

Food Supplements and Vitamins

Breast feeding is encouraged whenever possible. However, premature babies and growth restricted babies < 1800g or < 32 weeks gestation at birth are likely to need supplements to breast milk, which may include the following:

• Probiotics

Infloran is the product available and contains lactobacillus and bifidobacterium species. It is to be started the day after birth for babies <32 weeks or <1500g as a preventative measure for NEC. Mix one capsule with 1mL of milk or water (if insufficient EBM) and give with a feed if in milk or between feeds if mixed in water. Stop at 36 weeks corrected age. Probiotics to continue past 36 weeks for individual patients and should continue if there is a transition from EBM/PDM to formula feeds.

• Standard formula

This is called milk mixture and provides 67-69kcal /100ml. The NICU rotates 2 brands of ready to feed milk mixture, S26 and Karicare. Formula rotation is required to meet BFHI standards. Parents who are going home formula feeding need to receive advice on formula preparation and the type of formula to purchase depending on the baby's requirements.

• Low birthweight formula

This is called premature milk mixture (PreNan) and provides 80kcal /100ml. There is no preterm formula available on discharge.

• Liquigen

A medium chain triglyceride, liquid emulsion used to provide additional calories. It does not require pancreatic lipase or bile acids for digestion and absorption. Start at 1 g/kg/day and increase stepwise to 3 g/kg/day. Chart in drug chart. The dose is divided 8 hourly. 1g Liquigen provides 9.0kcal/g. Check with dietitian to ensure the calorie to protein ratio is ideal.

- **Calogen**

A lipid emulsion of long chain triglycerides to provide additional calorie (contains no MCT). Start at 1 g/kg/day and increase stepwise to 2 g/kg/day. Chart in drug chart. The dose is divided 8 hourly or more frequently if required. 1g Calogen provides 9.0kcal/g. Check with dietitian to ensure the calorie:protein ratio is ideal

- **Duocal**

A carbohydrate/fat mixture, which is particularly useful in bigger babies who have increased energy requirements for various reasons. Discuss with the Dietitian. Start at 1g/100ml and increase up to 2g/100ml. 1g Duocal provides 4.7kcal/g. Special application is required for infants going home on Duocal which will be prescribed and arranged by the Dietitian.

- **Pepti Junior Gold or Neocate/Elecare are special formulas**

Pepti Junior Gold is a semi elemental protein hydrolysate and Neocate/Elecare are a fully elemental formula. Discuss with the Dietitian regarding best formula to use. Premature infants on special formula may require additional calories, protein, electrolytes and minerals discuss with the Dietitian.

- **Specialised Formula for specific medical conditions:**

These formulas will need to be ordered from Auckland and will generally be an overnight delivery. The Dietitian will arrange if needed.

Monogen formula is used for chylothorax

Kindergen is a specialised renal formula

Other specialised formulas for metabolic conditions are available depending on condition

- **Electrolyte Supplements**

When a change is made from TPN or IV to enteral nutrition and the baby has been needing electrolyte supplements in excess of those supplied in the breast milk or formula, oral electrolyte supplements will need to be prescribed as sodium chloride or potassium chloride. Alternatively if also requiring phosphate supplements can use KH_2PO_4 or NaH_2PO_4 (not more than 2mmol/kg/day of either). More common in babies on diuretics or has some other reason to have unusually high obligate electrolyte losses. Urine sodium level less than 20mmol/L indicates sodium depletion. In general, the IV preparations as described in a previous section can be used orally. Distribute the dose 6-8 hourly. The same principle applies if a baby is on oral electrolyte supplements, these will need to be charted IV if the baby cannot feed

- **Phosphate**

Premature infants are at risk of metabolic bone disease and will require phosphate supplementation. A rising ALP with or without a low phosphate is often an indication for supplementation which should be discussed on the ward round. This is primarily given as HMF but there will be clinical situations where HMF does not provide enough phosphate, HMF is not able to be given or is contraindicated.

High risk clinical situations for refeeding syndrome and hypophosphataemia are babies <28 weeks, severe IUGR <3rd%, or any baby requiring TPN. These babies need their phosphate levels reviewed **day 3, 5, 7, 10** on the NEON and have additional phosphate supplement if the level is <1.8mmol/L

The target phosphate levels will vary depending on the birth gestation, chronological age and clinical situation, however, babies <32 weeks or severely growth restricted babies we should aim for a phosphate level between 1.8-3mmol/L as they transition over to full enteral feeds in the first 2 weeks of life. After this the target can be reduced to between 1.5-3.0 mmol/L when the risk of refeeding syndrome has diminished but this may be individualised depending on the baby.

Phosphate is usually given as NaH_2PO_4 and can be mixed with water and given irrespective of the amount of enteral feeds being tolerated. Alternatively if also requiring potassium supplements or serum chloride level is elevated can use KH_2PO_4 .

If the level is <1.5 mmol/L start 2mmol/kg/day

If the level is 1.5-1.7 start 1mmol/kg/day.

HMF is an alternative source of phosphate but is usually started at a later date when tolerating 80ml/kg/day enteral feeds. Some babies will need ongoing phosphate supplementation even when on HMF but the supplements need to be reviewed if the phosphate level has risen to > 2.5 mmol/L.

- **Vitamin D**

- All babies < 37 weeks or <2500g should be prescribed Vitamin D
 - if <35 weeks two drops daily until discharge then one drop daily
 - if ≥35 weeks one drop daily
- Other babies who may need Vitamin D supplementation include those with fat malabsorption (includes babies with Cystic fibrosis and cholestatic liver disease), renal disease, parathyroid issues and those deemed high risk as per Ministry of Health Guidelines) (see below)
- ≥37 weeks high risk term babies if:
 - Partially or Breastmilk fed
 - Breastmilk or formula fed with:
 - naturally dark skin
 - a mother with vitamin D deficiency
 - a sibling who has had rickets or seizures from low blood calcium levels
- At discharge all babies who have been commenced on Vitamin D in NICU will be discharged on ONE drop per day unless they have confirmed deficiency as they may be on higher doses at discharge. It is recommended to continue supplementation until 12 months of age for most babies.
- Babies born <28wks have routine monitoring of Vitamin D levels for babies at 4 wks of age
 - If deficient repeat levels at 2 week intervals
 - If sufficient repeat level at 34 weeks corrected
 - See drug profile for further details on dose escalation and weaning.

- **Vitamin A**

Retinol (vitamin A) is an important co-factor in many biochemical processes and may be preventative in the development of chronic lung disease.

- Babies born <30 weeks to have 3 drops daily the day after lipid stops
- Babies born 30-34⁺⁶ weeks to have two drops daily
- Stop supplementation at 36 weeks if off respiratory support
- Not to routinely be discharged home on Vitamin A

Levels of Vitamin A are no longer checked at day 21 after sequential audits (2016 and 2018) have shown good levels with the current dosing regimen. However, babies with conjugated hyperbilirubinaemia on supplements will benefit from levels being checked to ensure absorption is occurring.

- **Folic acid**

All babies < 1500g who are not receiving fortified breastmilk long term should receive 50 µg daily. These will be babies who have contraindications to HMF, have failed HMF or parents decline HMF. Folic acid will be started after these criteria have been fulfilled (and not when they are still grading up on feeds in the first week of life) Individual babies may have this continued after discharge but it is usually stopped. It is also given to babies who have haemolytic anaemia due to Rhesus isoimmunisation or required an exchange transfusion.

- **Vitamin E**

All babies <1250g or <30weeks will begin Vitamin E 30IU (0.2ml) when tolerating enteral feeds and off lipid Levels are no longer checked after sequential audits (2016 and 2018) showed no improvement in the levels after increasing the dose to 50IU daily. However, babies with conjugated hyperbilirubinaemia on supplements will benefit from levels being checked to ensure absorption is occurring. It is stopped at discharge for most babies but those with malabsorption conditions may be discharged home on Vitamin E and may need special authority forms to be completed

- **Iron**

Babies <2500g or < 37 weeks gestation should receive iron 3mg/kg/day from 4weeks of age until 12 months age if receiving breastmilk or formula. Exclusions to this are babies on Preterm formula who should get enough iron from the formula but individual cases may need iron supplementation after dietician review.

Babies on FM85 fortifier should not receive iron until this has been discontinued as it has 2mg/kg/day iron in it already. If a baby is not on HMF due to contraindications or intolerance they will need to start Fe when on full feeds between 2-4 weeks of age.

Stop iron at discharge if the baby is going home fully formula fed. We usually adjust the dose for weight while the baby is in the NICU, but if the baby is well and there is no ongoing blood loss, it is appropriate to let the baby gradually outgrow the dose after discharge, so write discharge prescriptions for 3 months supply with a rounded

mL volume for ease of administration. Maximum dose of 2ml as doses above this are not tolerated well. For babies who have not started iron at the time of discharge we have taken a pragmatic approach to prescribe the iron dose for the predicted weight at 4 weeks of age after reviewing the growth chart. If predicted to be <3kg then dose is 1mL daily, 3-4 kg dose is 1.5mL and >4kg dose is 2mL. This provides between 2-3mg/kg/day of elemental iron.

- **Zinc**

Take a zinc level if there are concerns that the baby may have acrodermatitis enteropathica (suspect if there is bad thrush or nappy rash and a negative culture for candida) or peripheral oedema where other causes have been excluded, poor growth, low ALP, long term PDM. Babies on loop diuretics are also at risk. Zinc levels are no longer routinely checked on babies <1000g at birth (audit Jan 2019). Zinc deficient babies (serum zinc <10mmol/l) should have an extra 1-2 mg/kg/day elemental zinc. As Zinc competes with Fe for uptake in the intestine, it can be advisable to stop Fe supplements for a few days while Zinc supplementation begins. Recommence the Fe at a different time of day.

- **Magnesium**

It is rare to need to replace Mg but this should be considered if the level is <0.7mmol/L or if <1mmol/L and at risk of arrhythmia. IV replacement dosing for hypomagnesaemia is 0.2-0.4mmol/kg/dose repeated 12 hourly if required. See drug profile for further details. Oral supplementation is not recommended as the oral solution is difficult to make, there is poor absorption and high rates of diarrhoea. Oral supplementation with Gaviscon is not a management option.

Parenteral Nutrition

- The aim of parenteral nutrition is to provide protein, fat, carbohydrate, electrolytes, trace elements and vitamins to allow nutritional needs to be met and to optimise growth.
- The preferred form of nutrition, however, is enteral with breastmilk, pasteurised donor milk, or lastly milk mixture.
- If enteral feeds will not be possible within 3 days parenteral nutrition may be required.
- Premature babies, tolerate starvation much more poorly than older children, and so parenteral nutrition has a very important role to play in neonatal intensive care but it does increase the risk of nosocomial infection, nutrient imbalances and potential toxicity (aluminium)

Indications for TPN:

- All babies ≤30 weeks or <1500g
- Babies who are unlikely to achieve full enteral feeds by day 5
 - this may include 31/32 weekers or those between 1500-1800g and care should be individualised
 - review risk factors for delayed milk availability or the need to introduce feeds slowly, ie: growth restriction, abnormal antenatal Dopplers, maternal illness, birth condition, multiple birth
- Congenital gastrointestinal anomalies eg: gastroschisis, omphalocele, bowel atresia
- Necrotising enterocolitis (NEC)
- Risk of NEC
 - Infants with absent or reversed umbilical artery Dopplers
 - Perinatal asphyxia

IV Access for TPN

- TPN is preferably administered through a central line – this would be via a UVC or longline
- TPN may be administered through a peripheral iv line if:
 - A central line cannot be placed but TPN is still required
 - The risks of a non-ideally positioned central line outweighs the risks of extravasation via a PIV
 - The baby is likely to establish full feeds within 7 days and does not need long term iv access
 - Only the Starter Bag, Peripheral TPN and Term bags may be given peripherally
- If a baby has not achieved 1ml/hr NG feeds by day 5 then plan to insert a longline
- Longlines can be inserted 7 days a week with weekends not being a barrier to line insertion
- The iv access being used needs to be reviewed daily to ensure it is still appropriate for the clinical situation

TPN Components

Fluid Guideline

Day 1	65ml/kg/day and 2g/kg/day lipid 90ml/kg/day if any extra infusions and 2g/kg/day lipid
Day 2-3	90-120 ml/kg/day and 3g/kg/day lipid If on concentrated TPN due to fluid restrictions then the daily fluid rate will be individualised
Day 3-5	120-150 ml/kg/day and 3g/kg/day lipid
Day 5-7	150ml/kg/day and 3g/kg/day lipid Increase to 165ml/kg/day if enteral feeds are ≥ 30 ml/kg/day to support protein intake prior to fortification of feeds Reduce back to 150ml/kg/day when HMF is tolerated but still receiving TPN as the protein intake will be excessive If there are contraindications to increasing to 165ml/kg/day then consider changing to Concentrated TPN to maintain protein intake

- TPN can hang for up to 96 hours / 4 days (Jan 2025) depending on the volume of TPN needed taking in to account the enteral feeding progression and size of the baby
- Lipid can hang for up to 48 hours
- Remember line changes are every 4 days and factor that in to any TPN or Lipid changes

Protein

- Primene is the protein product that is currently in use
- Hang bag for up to 48 hours
- Targeting at least 2g/kg/day on day 1 and increase to 4g/kg/day in preterms and 3g/kg/day terms
- Intolerance to protein can occur due to extreme prematurity, renal and liver impairment and can be seen with high urea levels, hyperammonemia or hyperaminoacidemia.

Dextrose

- Provided as 10-12.5% . Most infants need a minimum of 4-6 mg/kg/min glucose
- Preterm babies may not tolerate >8 mg/kg/min (10% dextrose at 130ml/kg/day = 9mg/kg/min)
- Term babies may not tolerate >13 mg/kg/min
- Use glucose calculator link to easily calculate these rates
- If the baby is hyperglycaemic review all other infusions
- If hyperglycaemia persists then start an insulin infusion (see hyperglycaemia section)
- Amino acids are more potent stimulators of insulin release in premature infants than glucose, so the glucose tolerance may improve when TPN is started (conversely, lipid can impair glucose tolerance).

Heparin

- Prolongs the life of the catheter, decreases occlusion rates and catheter related sepsis
- 0.5 IU/ml heparin is added to TPN

Electrolytes

- Na, K, Ca, PO_4 , Mg, Cl are provided

Trace Elements

- Zinc, Selenium, Iodine, Copper, Manganese, Chromium are supplied as Baxter Paediatric Multivitamin trace element solution

Acetate

- Acetate is used to increase the HCO_3 lowered in metabolic acidosis and increased renal losses.
- Very preterm babies usually need between 1 - 4 mmol/kg/day of acetate
- Term babies do not require as much acetate and there is less in the Term bag.

Calories

- Aiming for 85 - 110 kcal/kg/day
- Some babies will have higher requirements if they are growth restricted or have co-existing diseases
- The dietitian should be consulted if advice is needed.
- Babies need to be weighed as a minimum every 4 days

TPN Bags

Starter (500mL)

- To be used by all babies receiving TPN on day 1 and safe for peripheral lines
- Targeted to give at least 2g/kg/day protein when receiving 65ml/kg/day fluids or 90ml/kg/day with other infusions
- To be used for 24 hours depending on the electrolyte status of the baby
- **Not to be given at rates >90ml/kg/day on day 1** as the protein content will be too high
- Lower sodium content and no potassium content

Peripheral Preterm (750mL)

- Used for preterm infants from 24 hours of age or earlier if hyponatraemic
- Peripheral line safe, however if infusing peripherally this needs to be reviewed daily to balance the risks of potential peripheral extravasation versus insertion of a central line

Standard Preterm (750mL)

- Most commonly used bag for preterm infants
- Contains higher amounts of Ca and PO₄ compared to the standard peripheral bag and therefore needs a central line

Concentrated Preterm (750mL)

- New bag introduced in 2023
- To be used from 24 hours of age for babies on multiple infusions which are impacting on the volume of TPN available to be infused
- **Maximum TPN volume (ie: note this is not the total daily fluid volume) not to exceed 100ml/kg/day**
- Must be infused through a central line
- If a baby has reached sufficient enteral feeds to allow TPN to increase to 165ml/kg/day, but, there are contraindications to increasing the fluid rate such as hyperglycaemia or fluid overload then changing to concentrated TPN will ensure there is not a drop off in protein

High Sodium (750mL)

- For hyponatraemic babies
- Must be infused through a central line due to the calcium content
- Often needed by day 5-7 in extremely preterm infants

34 Weeks to Term (1200mL)

- Solution for near term/term babies from 24 hours of age
- Less protein and acetate compared to other bags
- Can be infused through a peripheral line although central line is preferred

Low Glucose (750mL)

- This bag is an alternative to use in a baby with hyperglycaemia, however, the standard practice for this unit is to treat hyperglycaemia firstly with insulin and only then reduce the dextrose content

	Starter		Peripheral	Standard	Concentrated	High	34 Wk-Term	Low Glucose
	65ml/kg/day 2g/kg/d lipid	90ml/kg/day 2g/kg/d lipid + 1 infusion	150ml/kg/d 3g/kg/d lipid	150ml/kg/d 3g/kg/d lipid	100ml/kg/day TPN only	150ml/kg/day 3g/kg/d lipid	150ml/kg/day 3g/kg/d lipid	150ml/kg/d 3g/kg/d lipid
	P	P	P	C	C	C	P	C
Glucose	10%	10%	10%	10%	12.5%	10%	10%	7.5%
Protein g/kg/d	2.1	2.6	4.5	4.5	4	4.5	3	4.5
Na mmol/kg/d	1.8	2.2	5	5	5	8	3	5
K	0	0	3	3	3.5	3	2.6	3
Ca	0.5	0.7	1.3	2.6	2.7	2.6	1.2	2.6
PO4	1.0	1.1	1.3	2.6	2.7	2.6	1.2	2.6
Mg	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Acetate	0	0	3.4	2	2.6	3.4	1.1	2

Prescribing TPN

- The protein, lipid and electrolyte requirements are discussed on ward rounds
- In those unstable babies who have additional requirements an individual TPN bag can be requested (this is rare and only a few of times a year – if required consult the dietitian)
- TPN should be started as soon as there is iv access
- The TPN bags can be hung for 96 hours
- If iv access is changed the only time when a new bag is needed for sterility reasons is when access changes from a peripheral to a central site.
- Increase the strength of other infusions to provide more volume per day to be provided as TPN
- Manipulations can be made in the mmol/kg/day of electrolytes provided by altering the volume of TPN given per day and altering infusion solutions.

Prescription Instructions

- Open the template in the TPN folder on the G:drive.
- Save the template into a new folder for the baby
- Enter data into the white boxes only, the yellow boxes values will be calculated for you
- Entering the ml/day of infusions that are in 0.9% saline and 0.45% saline is to calculate the extra Na these infusions will provide. **Do not include insulin** as this is over and above fluid requirements.
- Entering the ml/day of dextrose infusions is to calculate the extra kcal/kg/day that this will provide.
- Enter the enteral feeds if they are being included in the total daily volume
- Chart the fluids on the Level 3 fluid sheet
- Correct charting includes writing the type of TPN bag being prescribed and the rate in ml/hr
- If the baby is on enteral feeds chart TPN (overlapping with feeds) and the total rate in ml/hr of nutrition whether it be TPN or enteral feeds

Charting TPN again on the same patient

- Open up the patients file – G:drive, TPN folder
- Open up the form that was used the day before
- Use the same form for the week, print the summary for the week (Page 1) on a Sunday and file in notes
- When the baby stops TPN - Print page 1 only of the form and file it in the notes
- When the baby needs TPN the next week open up a new template and save with the new date

Individual Bag Prescription Instructions

- The need for an individual TPN bag will be decided by the consultant and dietitian
- They can only be ordered on a week day



Process to Order
Individual TPN.docx

- Complete the Individual TPN prescription excel worksheet.
- It is similar to fill in as the usual bags but has less calculations done for you as you will be deciding the dextrose, electrolytes and protein that you will need.
- Decide on whether the TPN prescription can run for 1 or 2 days and the volume required (eg: 500, 750, 1000, 1200mL)
- Dietitian to complete the Baxter Order Form and email to pharmacysterileunit@cdhb.health.nz by 1030



Baxter Order Form

- Sterile Pharmacy will order the TPN from Baxter
- Any alterations to the request by Baxter will be communicated to the Dietitian who will then amend the TPN excel worksheet and Baxter Prescription Form and resend this form to Sterile Pharmacy so they can check the TPN when it arrives to ensure it matches the prescription
- Sterile Pharmacy will then deliver the TPN bag/s to NICU usually around 5pm that day

Prescribing Lipid

- Standardised Lipid Syringes will be supplied by Baxter with lipid and vitamins
- SMOFlipid contains 30% soya oil, 30% MCT coconut oil, 25% olive oil, 15% fish oil
- All syringes contain the same contents (see below) and are light protected with amber syringes and tubing as peroxidation of fatty acids occurs if exposed to light
- Run through a lipid filter for up to 48 hours if volume allows
- Use the baby's exact weight when calculating rates
- Stable for 7 days after being compounded
- Infuse for 48 hours using the lipid filter
- Start at 2g/kg/day on all babies and increase to 3 g/kg/day after 24 hours for most babies
- Reasons to not increase to 3g/kg/day or to reduce to 2g/kg/day are:
 - Babies <25 weeks increase lipid on alternate days and consider triglyceride levels if concerned (if >2.8mmol/L reduce lipid by 1g/kg/day). Note: this is not routine
 - Significant jaundice - free fatty acids can displace bilirubin from binding sites on albumin
 - Severe thrombocytopenia - hyperlipidemia can impair platelet function
 - Severe sepsis – although limited evidence around this recommendation
- Stop lipid when enteral feeds approaching 150ml/kg/day when there is not enough mL/hr available to run both TPN and Lipid within the total daily fluid rate. Stop the lipid infusion first before the aqueous TPN solution
- Prescribe the lipid on the level 3 chart indicating g/kg/day lipid, rate in ml/hr and guardrail in mg/kg/hr

Total Volume 50ml		
SMOFlipid 20%	45ml	
Baxter Paed Multivitamin	5ml	

Lipid	Volume to be prescribed	
	*values rounded, exact values given in TPN worksheet	Guardrail
1g/kg/day	*0.23 ml/kg/hr	42 mg/kg/hr
2g/kg/day	*0.46 ml/kg/hr	83 mg/kg/hr
3g/kg/day	*0.69 ml/kg/hr	125 mg/kg/hr

TPN for Babies <25 weeks

- Tiny babies <25 weeks have metabolic instability and their parenteral nutrition components need to be carefully considered
- The TPN worksheet should be reviewed daily, preferably on the morning ward round, to balance the nutritional needs such as the protein, glucose, electrolyte and fluid requirements
- These babies often do not tolerate carbohydrate loads leading to hyperglycaemia and may not tolerate protein and lipid at levels that older gestational age babies will tolerate
- Use Starter TPN on Day 1 and then change to 7.5% dextrose TPN to prevent/minimise the need for insulin for hyperglycaemia
- Review the daily glucose load (this is calculated at the bottom of the TPN excel worksheet) aiming for about 4-6mg/kg/min
- If the daily fluid rates are high due to hypernatraemia then manipulations of the amount of TPN vs additional 5% dextrose sidelines will be needed to manage the glucose load as well as the protein intake
- Protein intake aiming for a maximum of around 3 - 3.5g/kg/day as they may not tolerate protein of 4g/kg/day or higher in the first week
- Consider starting Lipid at 1-2g/kg/day and increase more slowly every alternate day up to 3g/kg/day to allow better tolerance
- If hyperglycaemic holding the lipid at 2g/kg/day may improve glycaemic control

Laboratory Monitoring on TPN

Extreme Preterms

- These babies have more electrolyte instability particularly with Na and K.
- Na can rise rapidly from increased insensible losses.
- K can rise and peak around 24 hours because of hypothermia, traumatic delivery, haemodynamic instability and metabolic acidosis.
- Electrolytes should be taken at birth and monitored closely for the first 48 hours or until stability is achieved (with NEON and gas electrolytes)
- Phosphate levels may drop from day 3 and need consideration for oral supplementation if <1.8mmol/L
- The need for High Na TPN is predictable and is needed from day 5 to 7 due to increased renal loss

Refeeding Syndrome

- Neonatal refeeding syndrome is a condition that is characterised by metabolic acidosis, low phosphate/potassium/magnesium and high calcium/glucose/sodium
- It is seen in the setting of preterm babies in the first 1-2 weeks of life due to a combination of the TPN with high amino acid intakes and low electrolyte intakes. Insulin drives phosphate and potassium into the cells. Bones try to correct by releasing phosphate to correct the low levels with the side effect of also rising calcium levels.
- Babies at risk include those <32 weeks / < 1500g and growth restricted babies <3rd%
- The electrolyte disturbances that most commonly need management are the low phosphate and high glucose and sodium and occur by day 5 and can last up to 2 weeks.
- Ensure a NEON is taken around day 3,5,7,10 to review the phosphate and calcium levels.
- Also review the ionised Ca in the gas as if it is rising >1.4 mmol/L this is a sign of ensuing hypercalcaemia
- A low glucose TPN bag is available with maximised phosphate content and lower glucose (7.5%)
- Phosphate should be replaced if it is <1.8mmol/L. Refer to the phosphate information in the Food Supplement and Vitamins section and note that oral replacement is the preferred method.
- Note that haemolysed samples will give a result as a <value. The number reported is the highest the value will be but in reality this will be an overestimation due to the haemolysis
- Also note that the normal ranges from the lab are adult ranges and are different from those that we use for preterm babies and so abnormal results for our population may not be flagged as a "red" result

Stable Babies

- Blood gas and electrolytes once a day while they are being started on TPN.
- When the baby is clinically stable it is appropriate to space out sampling to alternate days or twice weekly.
- All babies on TPN should have liver function tests and a conjugated bilirubin checked if there is jaundice or concern regarding hepatic dysfunction.

Prolonged TPN >1month

- Referral to Prof Andrew Day Gastroenterologist
- Refer to National Intestinal Failure Service if remains on TPN at 31 days if born ≥34 weeks or on TPN at 42 days if <34 weeks at birth (liaise with dietician)

The Milk Bank

The Milk Bank provides pasteurised donated milk (PDM) for the NICU and the Maternity Ward when supplies allow according to the prioritisation tool below. Schol O'Bery is the Milk Bank Managers and they are supported by the executive team.

The main aim of the Milk Bank is to have pasteurised milk available to **NICU** patients to:

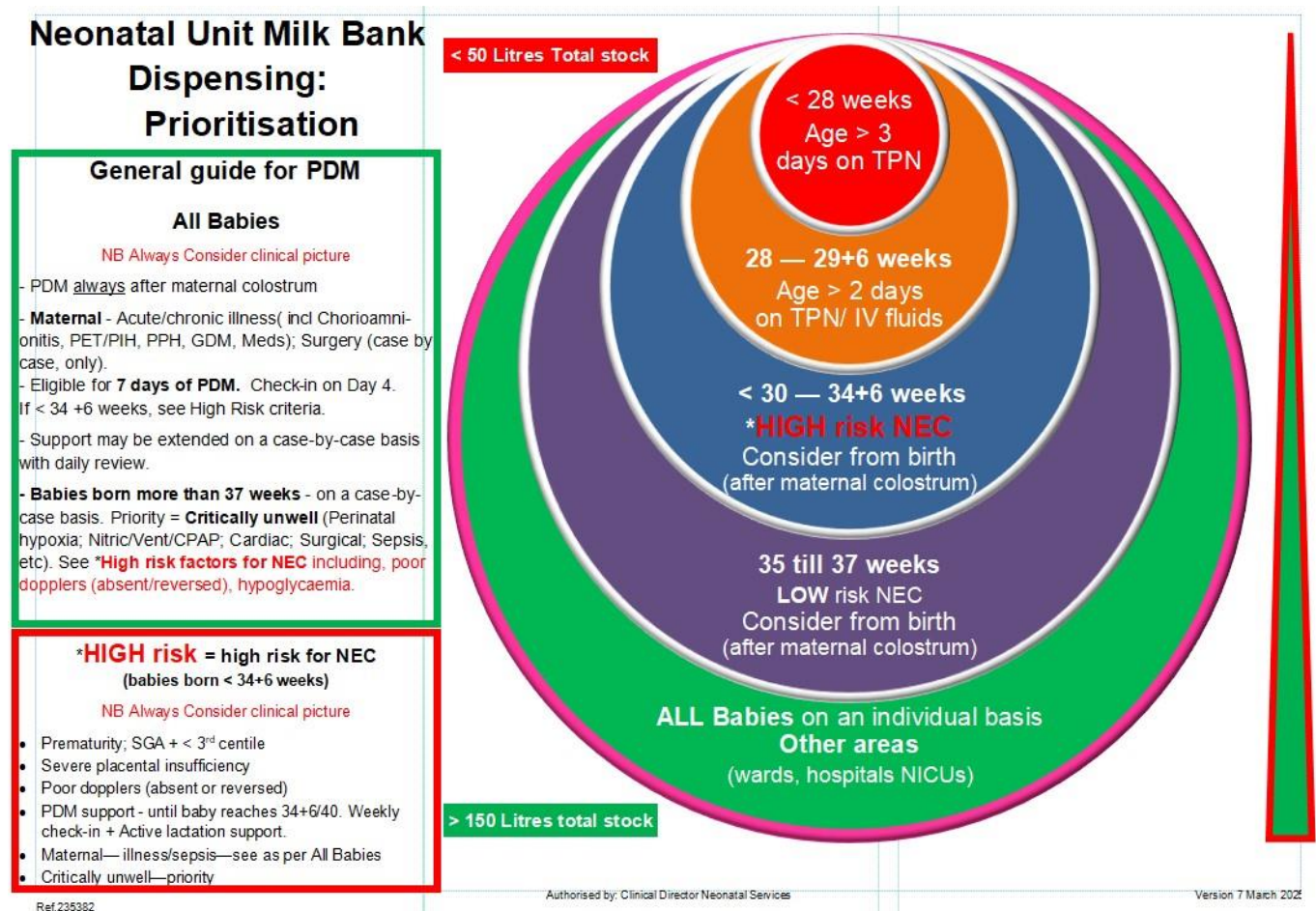
- Support women as they establish their milk supply following the birth of their sick or preterm baby
- Reduce formula exposure in infants at risk of Necrotising Enterocolitis (NEC)

Parent information leaflets and consent forms are held in reception. Information is also available on the INTRANET <http://cdhbintranet/WomensandChildrensHealth/ChildHealthClinicalResources/SitePages/Human%20Milk%20Bank.aspx>

Milk Bank RECIPIENTS

Identifying Who Is Eligible

The diagram below shows the Milk Bank prioritisation system. The aim of this system is to ensure that when PDM is made available to a specific baby, there will be enough supplies for at least 1 week. This eligibility criteria will be updated on a weekly basis depending on PDM stock supplies.



When the prioritisation colour is **GREEN** (indicating ample supply)

- The priority remains with those at risk of NEC and the moderately preterm or late preterm infants where a mother is aiming to breastfeed
- Infants > 34 completed weeks at birth will also be eligible for the first week of life as their mother establishes breast milk supply
- PDM should not be offered routinely to term infants admitted from the postnatal ward who have already had formula unless they demonstrate feeding intolerance.
- PDM can be offered to infants < 34 completed weeks at birth whose mothers intend to formula feed

There are some other important points to consider when a baby has been identified as eligible for PDM:

- ALL babies should receive their mothers colostrum where possible prior to receiving PDM
- The mothers own expressed breast milk remains the first choice which is why the mothers should be encouraged and educated regarding expressions techniques and frequency of expression
- In babies < 30 weeks receiving TPN, the aim should be to delay commencement of PDM for 5 days (7 days for <28 weeks) to positively reinforce the message that the baby's mother's milk is first choice.

Consent for Milk Bank Recipients

- The recipient consent form needs to be signed by one of the parents/caregivers of the baby
- Consent can be obtained by all neonatal staff that have been trained in the consenting process. A short video illustrating the process of consent can be found on the intranet under Human Milk Bank
 - <https://cdhbintranet.cdhb.health.nz/WomensandChildrensHealth/ChildHealthClinicalResources/SitePages/Instructional%20videos.aspx?WikiPageMode=Edit&InitialTabId=Ribbon.EditingTools.CPEditTab&VisibilityContext=WSSWikiPage>
- The commonest question likely to be asked by the parents of a potential recipient is:
- "What is the risk to my baby of receiving pasteurised human milk?"
 - The information leaflet addresses this question
 - The donors are screened and tested and the Milk Bank only accept donors that meet set criteria
 - The milk is tested before and after pasteurisation and discarded if there is evidence of infection

Prescribing for Milk Bank Recipients

- All staff trained to consent Milk Bank recipients, including nurses, are able to prescribe PDM on the nutritional additives sheet (Ref.2400173) once consent has been obtained, and to annotate the review dates.
- Once PDM is commenced it is guaranteed for 7 days only but supply can be extended if stocks allow and circumstances suggest that a few extra days may allow the mother to reach the required supply. eg multiple pregnancy, lactation support strategy in place, mummy time, advice of Infant Feeding Specialist or Lactation Consultant

Administering Donor Milk

The Human Milk Bank Policy has a detailed dispensing procedure which should be followed.

Overlapping to Formula from PDM

For babies birth weight < 1250 g and/or has significant feeding tolerance issues or high risk of NEC:

Overlap over 4 days unless specified otherwise by SMO

- Day 1 start with 25% formula
- Day 2 advance to 50 % formula
- Day 3 advance to 75 % formula
- Day 4 full formula feeds
- Continue Probiotics until transition is completed

For babies with no concerns

- Day 1 If still PDM available alternate feeds with formula/any EDM available
- Day 2 full formula feeds supplemented with any EBM available

Milk Bank DONORS

Recruiting Donors

- Those that donate to the Human Milk Bank are called 'Donors' and are recruited from mothers who have a surplus supply of expressed breast milk for present or future needs. A Donor can be mothers from the NICU or the Community.

Enquiries About Donating

Please direct all internal enquiries to the Milk Bank or to the NICU feeding, dietetic or lactation staff. All external enquiries should be directed to the Human Milk Bank Website (<http://cdhbintranet/WomensandChildrensHealth/ChildHealthClinicalResources/SitePages/Human%20Milk%20Bank.aspx>) or the Milk Bank Manager can be emailed at: MilkBankNICU@cdhb.health.nz

Consenting and screening donors

- All donors must meet the criteria set out on the Milk Bank Health questionnaire and should only be formally consented if this criteria is met.
- Consent of donors will primarily be completed by the Milk Bank Manager, Infant Feeding Specialist or Lactation Consultant.
- Once a mother has consented she needs to have screening bloods taken and staff should be aware that the results may take up to a week.

Community Donated Milk Pick Up Service

- A weekly community service provided by Nurse Maude volunteers picks up donations from registered donors' homes and delivers them to the Milk Bank.

Resources

The following people are on the Milk Bank Executive Committee and should be able to be used as resources:

- Schol O'Bery (Milk Bank Manager), Nicky Clark (Paediatric Dietician), Hazel McGregor (Infant Feeding Specialist), Bronwyn Dixon (Clinical Director), Nicola Austin (Neonatologist).

Discharge on Tube Support (DOTs)

This programme can be offered to an identified group of infants and their families who have feeding skill but lack stamina and would benefit from discharge with short term home tube feeding support. The aim of the DOTs programme is to enable parents to give nasogastric tube feeds at home with support from the DOTs Outreach Nurse. This enhances the approach to neonatal health care by promoting early discharge, facilitating positive patient and family centred outcomes without jeopardising patient care. For more information please speak with the Discharge/Outreach team.

Infant Criteria

1. Well preterm infants having minimum of 3 oral feeds within 24 hours with a feeding score ≥ 5 and reduced top ups (evidence of basic feeding skill but lacking stamina)
2. Infants ≥ 35 weeks corrected gestation or ≥ 38 weeks for non-complex preterm infants born ≥ 26 weeks. Decision to enter the program made by the named Consultant if birth gestation < 32 weeks and Consultant of the week if birth gestation ≥ 32 weeks
3. Infant is able to maintain axilla temperature $>36.5^{\circ}\text{C}$ in a cot
4. Blood sugar level- stable and within normal range
5. Infant must have finished all monitoring for at least 48 hours or for planned bitmos monitoring at home
6. Infant is medically fit for discharge
7. Weight gain along percentile
8. Parent/carers must have completed the NGT feeding teaching package; and be confident in all aspects of care
9. Risk assessment, no social work concerns
10. The neonatal outreach team is able to provide a safe service with appropriate staffing levels and equipment

❖ NEONATAL SEPSIS AND CONGENITAL INFECTIONS

Thorough handwashing, before and after every contact with every baby is by far the most important method of preventing nosocomial infections.

EARLY ONSET SEPSIS (EOS)

- This is most often perinatally acquired, but nosocomial possible.
- ANZNN definition is the first 48 hours
- *Group B streptococcus (GBS)*, *E coli*, *Streptococci* and *Gram negative* organisms are common causes
- *Listeria monocytogenes* can also occur in a sporadic or epidemic pattern.
- The EOS rate in VLBW infants in a study by Ting et al. 2019, was 1 in 56 with risk factors, whereas when no risk factors are present was 1 in 204.

Maternal Antibiotic Prophylaxis

- CWH adopts a risk based approach to GBS (as opposed to universal antenatal screening).
- Risk factors need to be identified in pregnancy/labour to dictate the course of management.
- 20-30% of women are colonised with GBS.
- Prevalence of *E coli* has been increasing and Gentamicin should be given for all preterm labour < 32 weeks and any with chorioamnionitis.
- GBS neonatal infection occurs early in 80% (<7 days age) and can be a devastating infection if untreated.
- If GBS is present and treated in the pregnancy do not consider that the GBS has been eradicated.
 - ≥ 4 hours of intravenous antepartum antibiotics are required to provide cover to the baby.

[Group B Streptococcus - Management and Prophylactic Antibiotics in Labour](#)

Risk Factors for GBS

- Previous baby with GBS (including late onset)
- GBS in the maternal urine in the current pregnancy
- GBS colonisation on vaginal swabs in the current pregnancy (with the exception of a negative swab at ≥37wk using the selective broth process)
- Prolonged ROM ≥ 24 hrs (increasing risk after 18 hours)
- Preterm labour <37 weeks (with or without ruptured membranes)

Risk factors for Early Onset Neonatal Sepsis

- prolonged rupture of membranes ≥24hrs (increasing risk after 18 hours)
- maternal illness, pyrexia >38.0 C (but any elevation >37.5 C increases risk), WBC > 15, raised CRP >10, suspected chorioamnionitis
- pathogens (e.g. GBS, *E. coli*) present in maternal urine or high vaginal swab
- previous baby with GBS sepsis
- preterm labour < 37 weeks
- fetal distress, tachycardia > 160 bpm or need for resuscitation
- twin gestation
- meconium

Although none of these risk factors alone has particularly good positive predictive value for sepsis, the more that are present, the lower the threshold should be to investigate and treat the baby for even minor clinical signs. In all sepsis, early diagnosis is vital.

Commencing antibiotics based on good clinical judgement will always be supported.

Risk factors may be an indication for investigation but are not in themselves an indication for antibiotics if the baby is born at term and is clinically well.

The decision process needs to balance the potential for unnecessary treatment of uninfected babies with delaying antibiotic treatment in infected babies.

Initial therapy is often commenced on the basis of clinical suspicion, since life-threatening infection can become established extremely quickly.

Signs and Symptoms of Early Onset Sepsis

- All newborn infants with early respiratory distress (tachypnoea, grunting, increased work of breathing, nasal flare) should be assessed for risk of EOS (GBS, E. Coli, other).
- Where grunting is intermittent / and maybe described as “singing” they are not for transfer out from CWH OR if in primary maternity unit may need transfer into CWH.
- Temperature instability – hypothermia and hyperthermia are often due to issues with environmental temperature, but a body temp. of $< 36^{\circ}\text{C}$ or $> 37.5^{\circ}\text{C}$ for greater than 1 hour (if appropriate manoeuvres have been undertaken to correct environmental temperature) is **possible sepsis and warrants clinical review and investigations**
- Previously healthy baby who becomes too sleepy/lethargic to feed
- Listlessness, floppy, lethargy, pallor, mottling and irritability
- New or increased respiratory distress – tachypnoea, increased WOB, grunting, increase in oxygen requirement, need for ventilation
- Jaundice if it develops unusually rapidly in the first 24 hrs
- Abdominal distension or bilious vomiting or nasogastric aspirate suggesting ileus
- Apnoea, especially new onset or increased frequency or severity
- Hypotension
- Seizures
- Persistently high lactate
- Persistent tachycardia
- Hyperglycaemia (also hypoglycaemia but note this is common and due to many other causes)

The antenatal history should be reviewed for risk factors and the baby observed and investigations and management as per the following flowcharts

Management of Babies at Risk of Early Onset Sepsis

- We continue to try to balance the use of antibiotics in well appearing babies versus missing / delaying antibiotics when there are risk factors
- If antibiotics are not started from birth this means that ongoing observation is required and if the clinical picture changes then there is always the opportunity to start antibiotics then.
- No antibiotics does not equate to no care.
- We also have a focus on stopping an antibiotic course as soon as possible and this requires the whole team (medical, nursing, pharmacy) to trigger the first review of antibiotics before the 3rd amoxycillin dose at 24 hrs
- Determining the risk of infection includes stratification of the antenatal sepsis risk, taking into account the clinical picture, repeat clinical reviews and using investigations to help guide the timing and need for antibiotics
- It is usually obvious what to do for a well or clearly sick baby but there are situations when a baby may have some mild symptoms without strong risk factors and these babies could have a period of observation to see if they improve before inserting iv lines, taking bloods and starting antibiotics ie: elective section for IUGR/PET/abnormal Dopplers or maternal reasons and on CPAP in air
- This becomes easier with experience and so if in doubt talk to a senior colleague (NNP or Reg) or SMO
- The flowcharts have been created to help guide you what to do for babies who are well, sick or equivocal with and without antenatal sepsis risk factors

Sepsis Calculator

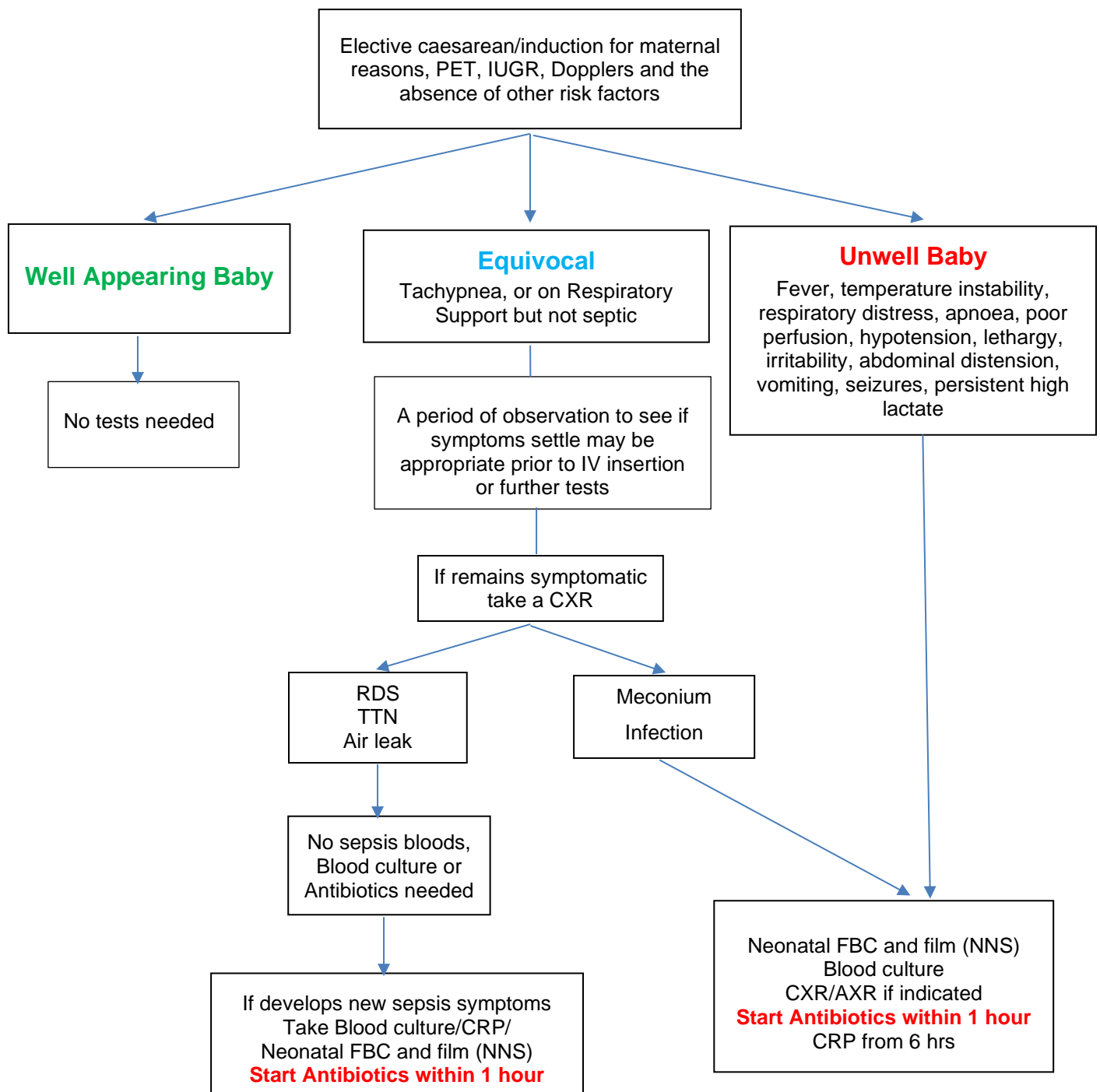
- It is recommended to also use the Sepsis Calculator in babies with sepsis risk factors from 34 weeks.
- Document the calculator findings and recommendations in the clinical notes
- <https://neonatalesepsiscalculator.kaiserpermanente.org/> (validated for babies ≥ 34 wks in the first 12-24hrs of life).
- An app is available – EOS Calculator
- There are 3 Clinical Categories for risk stratification – clinical illness, equivocal presentation and well appearing
- Divided into 3 pathways – treat empirically, observe and evaluate, and continue observation.
- Use 0.4/1000 for the incidence of EOS
- You need to know the highest maternal temp in labour (use 37.0 if unknown) GBS status and duration of antenatal antibiotics

Variances

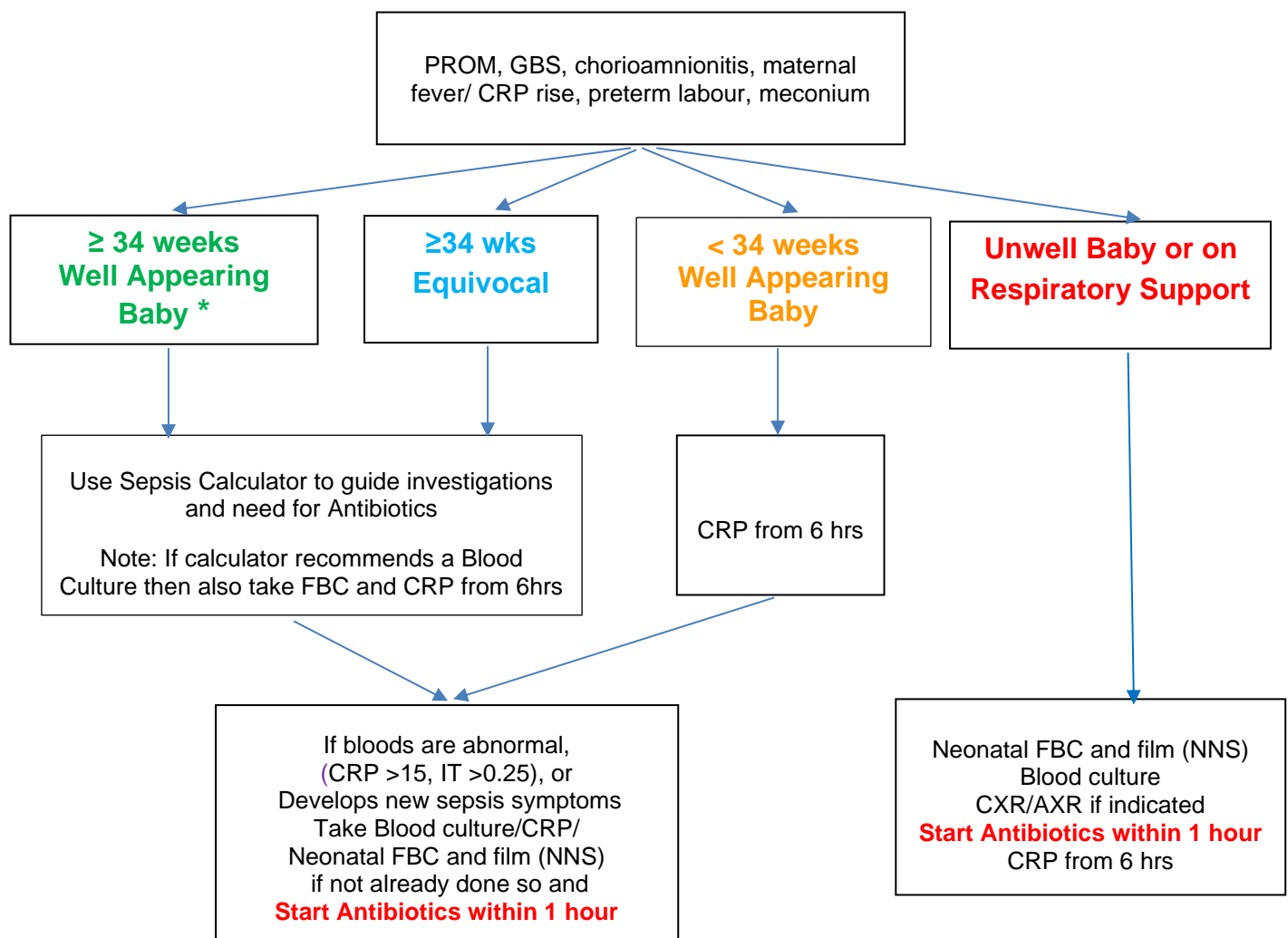
- The Sepsis calculator will recommend or strongly advise antibiotics in any baby from 34 weeks if they are on CPAP. As some of these babies will have no sepsis risk factors ie: elective section at 37 weeks and they have TTN or RDS on their CXR we have decided to only use the calculator for babies with sepsis risk factors to avoid overtreating some babies with antibiotics.
- The calculator may advise to take a blood culture and not other blood tests but we recommend also taking a FBC and a CRP from 6hrs after birth if the recommendation is for a culture \pm antibiotics

Decision Making For Early Onset Sepsis

AT BIRTH – No Sepsis Risk Factors



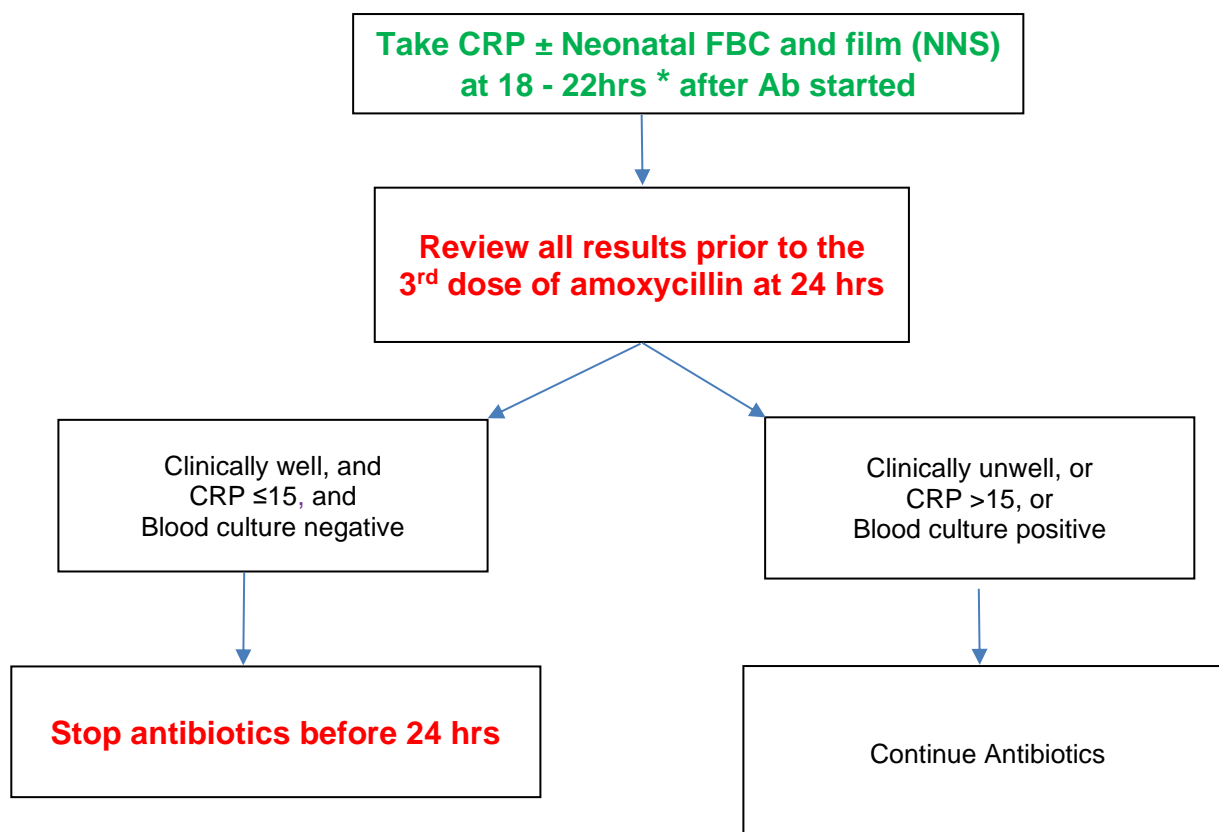
AT BIRTH - Risk Factors for Sepsis:



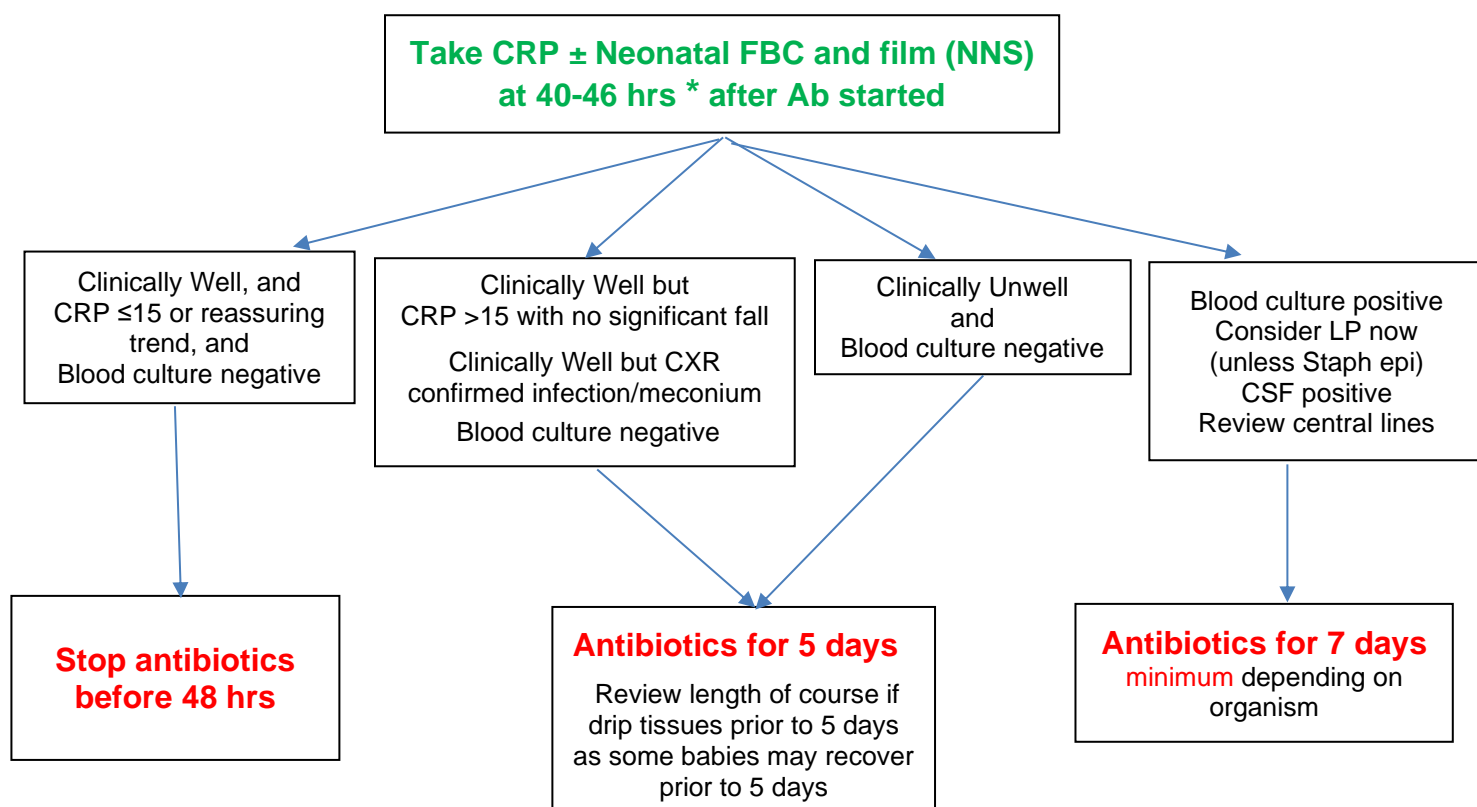
*If on Maternity, Well Baby, no Sepsis Calculator recommendation for antibiotics:

- Sepsis Risk Observations at 1hr, 4hrs and 4hrly for 24 hrs
- <37 weeks
 - daily neonatal review and admission may be up to 4 days due to prematurity
- ≥ 37 weeks
 - Clinical Chorioamnionitis – not to transfer or discharge until after 24hrs
 - Sepsis Risks and Intrapartum Ab <4hrs – may transfer to birthing unit after 6 hrs or discharge after 24hrs
 - Sepsis Risks and Intrapartum Ab ≥4hrs – may transfer to birthing unit or discharge anytime after birth
 - Midwifery review prior to transfer and NEWS score = 0

REVIEW AT 24 HOURS



REVIEW AT 48 HOURS



*If the CRP is taken earlier than the timeframes stated due to aligning with the baby's cares or blood gases then as long as there has been a time interval of at least 12 hours then they are still useful

Investigations for Early Onset Sepsis

There is no test with perfect sensitivity or specificity so the clinical scenario needs to be taken into account along with the blood test findings to decide if sepsis is present

Usual first line investigations are

- FBC – tick Neonatal CBC + FILM (NNS) for a full blood count, differential, retics, IT ratio and blood film
- Blood Culture
- CXR
- CRP from 6hrs of illness onset

FBC

- Total WBC < 5 and neutropenia < 1
- Immature/Total neutrophil ratio* >0.25 on day 1, >0.20 from day 5
*This is immature neutrophils, (ie. bands + myelocytes + metamyelocytes) divided by the total of immature neutrophils plus the mature neutrophils.
- Toxic granulation, vacuolisation or Dohle bodies present on the film.
- Thrombocytopenia < 100 – think about Candida or NEC
- Note that a Neonatal Screen (NNS) should only be asked for in the setting of concern around sepsis
- Neonatal CBC (HBN) should be requested at other times such as checking an Hb or platelet count
- Reticulocytes box needs to be ticked separately but can also be requested later on if required but may not be possible if there is not sufficient blood remaining.

CRP

- An acute phase reactant synthesised within 6-8 hours in response to tissue injury. Levels peak at 24-48 hrs
- Non-infectious processes can also elevate the CRP ie: PROM, perinatal asphyxia, IVH, pneumothoraces, meconium, infarction, trauma, immunisation
- A normal CRP at the start of an illness or at birth lacks the sensitivity to rule out sepsis but if taken at >6hrs the sensitivity improves to >90%, this continues to improve with serial normal CRP levels.
- A level of ≤ 15 mg/L has a high sensitivity for excluding sepsis
- Our guideline is to start with an initial CRP and a second one after a time gap to have two to review prior to the 3rd amoxycillin dose at 24 hrs of the antibiotic course, or a third at 48hrs of the antibiotic course to review prior to the 5th dose of amoxycillin.
- The flowchart states a CRP at 18-22hrs or 40-46 hrs and these times refer to the time antibiotics were started and not birth or illness onset. However, these times are just guides to ensure that CRPs are taken at an interval and prior to an antibiotic dose being given to allow time to review the clinical picture, blood results and make a decision if antibiotics can be stopped in a timely manner. If they are taken earlier to align with the babies cares/blood gases and occur earlier than the timeframes stated they are still useful

Blood Culture

- 1ml of blood is required for an adequate blood culture - smaller volumes may miss bacteraemia
- A negative blood culture result can be due to lack of infection, inadequate sample size or intrapartum antibiotics

CXR

- AP & Lateral views for first X-ray.
- If concern re pneumothorax a AP shoot through will verify an anterior pneumothorax

Urine

- Urine for Group B Strep antigen is no longer available (Dec 2023)
- Microscopy and culture is not required for the evaluation of early-onset sepsis as the likelihood of a UTI is extremely low

Gastric Aspirate and Surface Swabs

- These have limited value and are not required routinely as the result only indicates colonisation
- Gastric aspirates should be done for admissions of extremely preterm infants (<28wks) with a high index of suspicion of infection (eg chorioamnionitis).

Ureaplasma

- There is a significant association between Ureaplasma respiratory tract colonisation and developing bronchopulmonary dysplasia .
- It is unknown whether treatment after birth can prevent infection-mediated lung injury
- Colonisation rates vary from 20-45% in infants <28 weeks
- Rates of colonisation are higher the lower the gestation and with increasing length of preterm prolonged rupture of membranes and preterm labour. However, colonisation is also seen after delivery for maternal indications or for fetal factors without PPROM or labour.
- It is most likely that an inflammatory response to the colonisation starts in-utero but swabs for Ureaplasma are not a routine antenatal investigation
- All babies <28 weeks should have a test sent for Ureaplasma colonisation on day 1
- Babies 28-29⁶ weeks should have a test sent on day 1 if there is PPROM or chorioamnionitis
- Send an ETT aspirate for Ureaplasma – no other swab sites will be cultured by the lab as nasopharyngeal swabs are not validated for this test
- Treatment is a 3 day course of oral azithromycin. This has been shown to eradicate colonisation whereas erythromycin is not as successful and thus we have changed to azithromycin (June 2020)
- Consider empiric treatment whilst awaiting the swab result if there is definite chorioamnionitis or PPROM with a high neutrophil count

Lumbar Puncture

- This should be considered in a baby with a positive blood culture and in those babies with a negative blood culture but have significant blood changes or if there is a strong clinical suspicion for meningitis, or they are not responding as expected to the antibiotic course
- Should be discussed with the Consultant
- This is never an urgent investigation (generally done in daytime hours) and can be delayed if the baby would not tolerate the procedure ie: unstable, ventilated, coagulopathy
- Meningitis antibiotic doses are indicated until LP undertaken
- Consider Acyclovir if delay in LP and history of herpes simplex exposure

LATE ONSET SEPSIS (LOS)

- Usually nosocomial
- ANZNN define as from 48 hours of age
- VLBW infants with indwelling catheters, central lines, chest drains, etc are at higher risk
- In premature infants is predominantly caused by *Coagulase negative staphylococci* although since introducing the line bundle of care our rate is now very low.
- Other causative organisms include Gram negative organisms (e.g. *E coli*, *Klebsiella* sp. which can also be extended spectrum beta-lactamase producers – ESBL) late onset GBS, fungal sepsis (usually *Candida parapsilosis* or *Candida albicans*) and *Staph. aureus*,
- Multiresistant organisms are on the rise and key to management of this is meticulous standard hygiene measures (hand washing particularly and aseptic technique)
- Antimicrobial stewardship is also part of our obligation.
- With local sensitivities and pathogens identified this informs our choice of antibiotics.

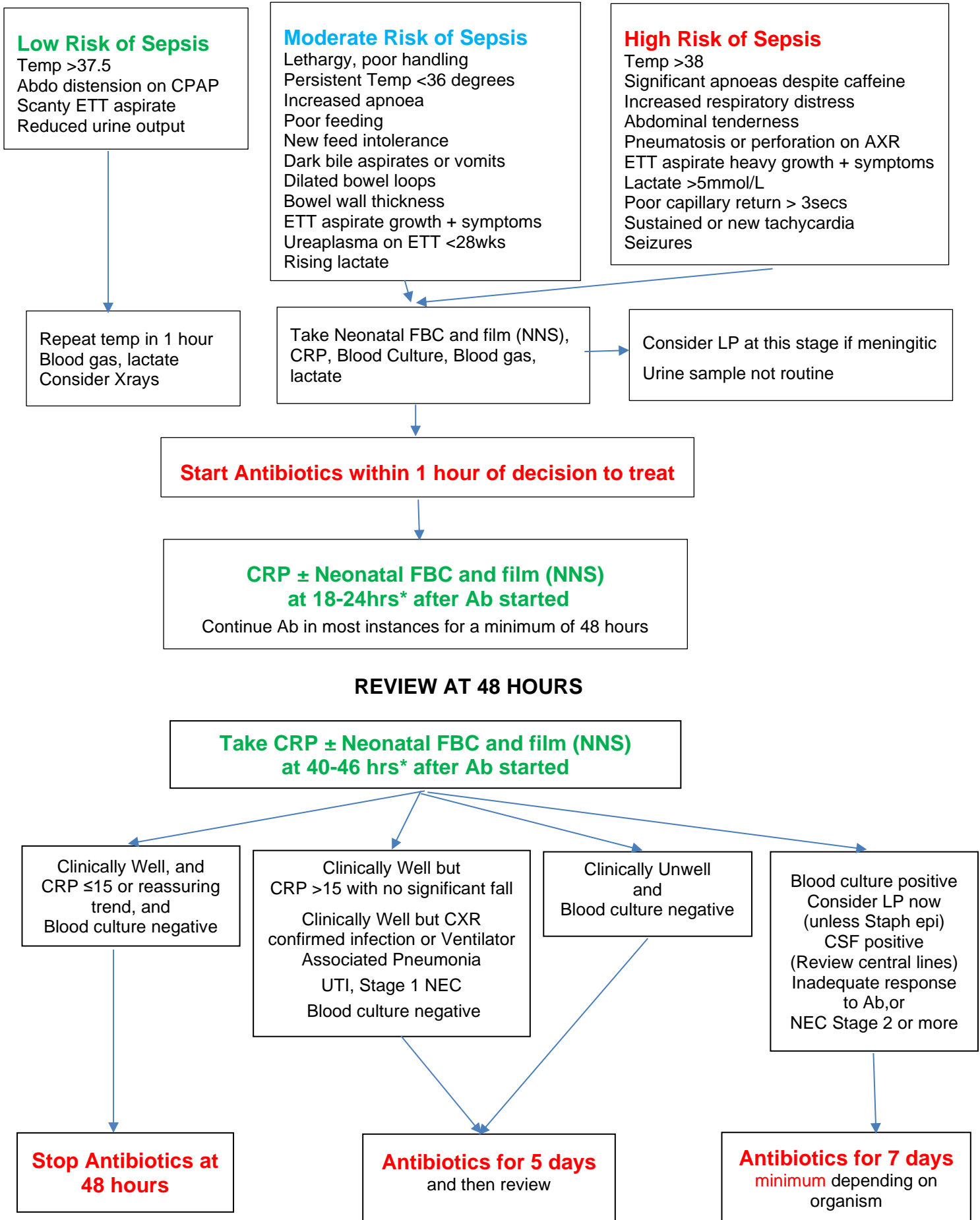
Prevention

The following are important in preventing late onset sepsis

- Hand hygiene
- Limiting central line days
- CLABSI bundle and recognition of success
- Oral colostrum for cares
- Probiotics starting day after birth in those <32 weeks
- EBM or PDM with minimal MM early on in preterms
- Scrub the hub 30sec chlorhex and alcohol

Decision Making For Late Onset Sepsis

- Signs and symptoms include those seen in Early Onset Sepsis but can be subtle and the list table is not inclusive. Nursing assessment of poor handling, and “not being right” are important concerns to include in the assessment



*If the CRP is taken earlier than the timeframes stated due to aligning with the baby's cares or blood gases then as long as there has been a time interval of at least 12 hours then they are still useful

Investigations for Late Onset Sepsis

- Refer to the information under Early-Onset Sepsis
- Differences would be that gastric aspirates and surface swabs are not required
- Ureaplasma is usually looked for in the first 1-2 days in a ventilated <28 weeker so less relevant in the setting of late onset sepsis
- Urine samples are not routine but a BPU or catheter urine should be taken if a UTI is on the differential, especially in those with antenatal renal abnormalities or family history of renal abnormalities

Neonatal Antibiotics

Considerations

- Antibiotics for infants with sepsis can be lifesaving
- Overuse of empirical antibiotics can facilitate antibiotic resistance and prolonged use is associated with adverse outcomes.
- Prolonged antibiotic courses without a positive microbiology should be exception rather than the rule
- Culture media with antimicrobial neutralization properties enhance the reliability of blood cultures when the mother has received intrapartum antibiotics
- Antibiotic use has been linked to disruptions in the microbiome and is postulated to have a critical role in development of significant neonatal morbidities eg CLD, NEC, ROP & PVL, along with asthma, inflammatory bowel disease and childhood obesity
- A baby on IV antibiotics must be **reviewed daily**. If results are normal, stopping antibiotics at 24-36 hours is good clinical practice.
- If antibiotic duration required has been determined to be > 48 hours, but the baby is now well, CRP has normalised ≤ 15 or the drip tissues, an SMO review may help to reduce the length of the antibiotic course

Antibiotics for Early Onset Sepsis

- The first choice antibiotics for suspected or proven sepsis presenting within 48 hours and **admitted to NICU**:
Amoxycillin - 50mg/kg/dose, Q12H, 100mg/kg/dose if suspected meningitis or severe sepsis
Gentamicin (IV infusion based on locally devised extended interval dosing) or **Cefotaxime** if <750g
- The first choice antibiotics for suspected or proven sepsis presenting within 48 hours and remaining on the **postnatal ward** with no requirement for NICU admission are:
Amoxycillin - 50 mg/kg/dose, Q12H
Cefotaxime - 50mg/kg/dose Q12H
 (Gentamicin is currently not given on the postnatal ward as it is an infusion with levels required. However, discuss each case at an appropriate time with the SMO as there may occasionally be clinical factors that dictate gentamicin to be more appropriate)
- For babies who start their antibiotic course in NICU and are transferred to the ward:
 Amoxycillin
 Change Gentamicin to Cefotaxime only if a 5 day course is required - this needs to be charted to start at the time that the next gentamicin dose was due (60 hours)
 These babies are reviewed daily on ward. Discuss with SMO covering room 5/6/7.
- The preference is for babies on the postnatal ward to have their IV line sited on the postnatal ward.
 Consider using the Maternity Midwife/ACNM or Clinical Support Nurse (NICU) when available to help hold and tape.
 If it is necessary to bring the baby down to NICU for an IV line then call the NICU ACNM to coordinate where this is best to be done given NICU workloads. The intention then would be for the IV line to be placed and the baby returned to the postnatal ward for antibiotic administration
- For **suspected meningitis** the preference is to start with **Amoxycillin and Gentamicin** and alter antibiotic choice with the LP results rather than adding in cefotaxime immediately. Meningitis rates are low and we are trying to limit the use of cephalosporins.
 - Group B streptococcus, consider changing the antibiotic treatment to: benzylpenicillin 50 mg/kg every 12 hours for at least 14 days and gentamicin, treatment lasting for 5 days.
 - Listeria (blood culture or cerebrospinal fluid culture is positive), continue with amoxicillin and gentamicin.
 - Gram-positive bacterium other than group B streptococcus or listeria, seek expert microbiological advice on management

Antibiotics for Late Onset Sepsis

- Antibiotic choice will change in June 2025 due to a changing picture of the bacteria in the unit and the emergence of multi-resistant strains that are less responsive to gentamicin. Please continue to use vancomycin and cefotaxime until notified that this change is happening.
- For **presumed late onset sepsis** the initial antibiotics are **Flucloxacillin and Amikacin**
- If a baby has a central line in-situ and *Coagulase Negative Staphylococcus* is considered as the potential organism. Start with **Flucloxacillin and Amikacin**. Waiting for a positive blood culture is acceptable and then rationalising antibiotics with sensitivities. Note that most *Coagulase Negative Staphylococcus* remain susceptible to Amikacin
- For **proven or suspected NEC** (Necrotising Enterocolitis) – **Amoxycillin, Amikacin and Metronidazole** are the preferred antibiotic choices. If a baby has an undifferentiated illness and has started on Flucloxacillin and Amikacin but evolves into a NEC picture then change to Amoxycillin, Amikacin and Metronidazole
- For **suspected meningitis** the preference is to start with **Flucloxacillin and Amikacin** and alter antibiotic choice with the LP results rather than adding in cefotaxime immediately. Meningitis rates are low and we are trying to limit the use of cephalosporins.
- Note that for potential late Group B Streptococcus infections that Amoxycillin will be needed for specific cover
- For Staphylococcal skin sepsis or pneumonia treat with flucloxacillin IV or oral depending on the situation and if severe use in conjunction with gentamicin
- Babies with proven or suspected UTI or renal tract anomalies should receive oral trimethoprim
- PHARMAC have stated that some antibiotics require Infectious Diseases approval. These are - imipenem, meropenem, ciprofloxacin, piperacillin, amphotericin and vancomycin
- This information is noted on the drug profiles.
- The antibiotic course can be started without delay but then individual patients will need to be discussed (or email) with Tony Walls (or if unavailable Adult Infectious Diseases) during usual work hours to get approval to continue the course of antibiotics or to discuss other options.

Gentamicin Levels

- Gentamicin is the first-line Gram negative cover for babies $\geq 750\text{g}$ in NICU
- Babies $< 750\text{g}$ do not clear gentamicin well and so cefotaxime is preferred in most situations
- Our NICU has researched gentamicin dosing in neonates for many years and now uses extended dosing interval treatment with gentamicin given 60 hourly (see drug profile)
- Gentamicin monitoring is important to ensure that babies receive adequate doses for bacterial kill as well as adequate clearance of the drug to minimise the risks of toxicity
- A pragmatic approach to this has been taken as most babies are receiving short courses of empirical antibiotics and we are trying to avoid unnecessary gentamicin levels/blood tests being taken
- 75% of babies receiving gentamicin at this NICU have a single dose only and so gentamicin levels are **usually** not required (**see below****)
- Babies receiving gentamicin courses ≥ 5 days in length or those in certain clinical situations (**see below****) require drug monitoring

Standard process for empirical gentamicin given soon after birth

- Baby is admitted to NICU after birth and gentamicin is given
- At this stage we will not know the length of the antibiotic course
- The blood taken for the **CRP (0.6mL, needs a full tube)** at around 6 hrs of age can be used to retrospectively run a gentamicin level when a decision is made to continue for 5 or more days and will act as the first level (this decision is usually made around 24 hrs of age)
- Call the Biochem lab on 80376 and inform them on which blood test to analyse the gentamicin level on (if not specified they default to the most recent blood received in the lab)
- Also inform the lab of the gentamicin dose, time of administration and dose interval so that can be added to the lab report

- If there has been no blood sample taken after administration of gentamicin when the decision is made for 5 or more days of antibiotics then take a blood sample for a first gentamicin level immediately
- A second level will also need to be taken at 24-36 hours (d/w Pharmacist if unsure when to take it)
- Pharmacist will use the two levels to advise on the dose and timing of the next gentamicin dose and if further gentamicin levels are required

**** Exceptional situations where gentamicin levels are required on the First Dose**

The process above works for the majority of babies but there are exceptions where close gentamicin monitoring is needed at the initiation of gentamicin:

- At birth a decision is made for at least 5 days of antibiotics prior to the Ab course starting
- Gentamicin given after 1 week of life – clearance is much higher so the dose may need to be bigger and more frequent. In this instance we are usually treating a true sepsis situation rather than empirical antibiotics after birth
- Renal impairment (congenital renal anomaly, HIE, oliguria) – at risk of poor clearance
- Hydrops, severe oedema – true body weight and volume of distribution will be affected
- Concomitant use of other nephrotoxic drugs – indomethacin, frusemide, vancomycin
- Suspected or confirmed Gram negative sepsis – need to optimise gentamicin dosing to treat infection
- Concern about clinical response to antibiotics

Intramuscular Antibiotics

- Ideally antibiotics are given iv however there will be situations when an iv line cannot be sited and the clinical situation will need to be discussed with the consultant
- The usual antibiotics that can be given im are amoxicillin and cefotaxime and these can be drawn up with 1% lignocaine to help with the pain after injection
- Due to the potential four-fold error in drawing up the more concentrated gentamicin (80mg/2ml) for im injection versus our usual 10mg/ml concentration a decision has been made not to give gentamicin im

First Dose of Antibiotic

- Baby with **signs of sepsis** and unable to site a peripheral iv line
Insert a UVC
- Baby with **risk factors** for sepsis but is **well** and unable to site a peripheral line
D/W SMO to see if a UVC is felt to be necessary to give antibiotics , or
D/W SMO to see if antibiotics are required or if taking FBC, CRP, blood culture and observation are appropriate, or,
Give IM cefotaxime 250mg/ml made up with 1% lignocaine as the sole antibiotic with Gram negative and GBS cover (do not give amoxicillin as well to avoid the baby receiving 2 im injections) and review the route of administration prior to the next dose

Subsequent Dose of Antibiotic

- Baby with **signs of sepsis**, peripheral iv has tissueed after receiving at least 1dose of amoxicillin and gentamicin
Insert a UVC, or,
Give IM amoxicillin 250mg/ml made up with 1% lignocaine as the sole antibiotic, as initial gentamicin dose will be providing coverage for 60 hours and review the amoxicillin route of administration prior to the next dose
- Baby with **risk factors** for sepsis but is **well** and peripheral iv has tissueed after receiving at least 1 dose of amoxicillin and gentamicin
D/W SMO to see if antibiotics are still required or if taking FBC, CRP, blood culture and observation are appropriate, or,
Give IM amoxicillin 250mg/ml made up with 1% lignocaine as the sole antibiotic, as initial gentamicin dose will be providing coverage for 60 hours and review the amoxicillin route of administration prior to the next dose

Culture of Lines and Tips

- There is usually a low yield for sending tips to microbiology for culture and it does not often change our management of the patient
- In certain circumstances the clinical care may be helped by knowing what the baby is colonised with. For example: sending a longline tip would be appropriate if there were concerns for a central line infection
- A consensus decision has been made that:
UAC, UVC, LL and ETT tips – not to be sent for culture routinely but may be requested on an individual basis by the SMO

Sticky Eyes

- The commonest cause of a sticky eye is a blocked tear duct
- If the eyes are sticky and the conjunctiva are red and swollen, send an urgent gram stain and appropriate swab for culture to exclude gonococcal ophthalmitis (call microbiology).
- A chlamydia swab should also be taken and sent for immunofluorescence
- Chlamydia swabs (special pink swabs) are kept in the fridge in Level 3, or may need to be requested from the laboratory. A vigorous scraping of the conjunctiva should be undertaken, prior to the baby being commenced on treatment. If the immunofluorescence is positive, commence systemic erythromycin.
- A routine bacterial culture should also be sent. Routine treatment for purulent eye discharge is chloramphenicol eye drops, one drop each eye four times a day for one week. Fusidic acid is an alternative

Staphylococcal Infections

Staphylococcus aureus skin colonization

- Some babies may be colonized by *Staph. aureus* in the first 24 hours, but, only 30% of infants in one study were found to be colonized by bacteria at 6 days of age.
- Staph. colonization does not always correlate directly with incidence of infection presumably because of variable virulence of the organisms and host resistance.
- Male infants appear to have higher infection rates of bacterial infection compared to females.
- The sites most commonly colonised by *Staph. aureus* are the umbilicus, skin flexures and the nares.

Staphylococcus aureus superficial infections

- **Omphalitis** - erythema and/or induration with purulent discharge from the umbilical stump, due to gram+ve / gram-ve/ anaerobic organisms.
- **Paronychia** - inflammation of the nail bed
- **Pustulosis** - localised collections of vesicopustules on an erythematous base in an otherwise asymptomatic baby. Gram stain will show Gram-positive cocci and abundant neutrophils, and culture will confirm *Staph. aureus*.

Treatment for *Staphylococcus. aureus* skin infections

- Any systemic sign of infection take blood cultures and give systemic iv antibiotics
- Any Staphylococcal infection in a preterm infant < 35 weeks
blood cultures and systemic iv antibiotics: iv for minimum 24-48 hours, after which oral antibiotics to complete a 5 day course if the baby remains well
- Isolated Staphylococcal skin pustules in a well baby > 35/40
consider chlorhexidine body wash and repeat at 24 hours if improved
start oral flucloxacillin if not improved within 24 hours and treat for 5 days
- Isolated Staphylococcal superficial omphalitis
oral flucloxacillin for 5 days
consider adding topical treatment with alcohol wipes as well
- Open, purulent sites may need contact precautions (gloves and aprons) in addition to universal precautions.

Chlorhexidine wash protocol

- Wet the baby's body, face, eyes and ears with warm water.
- Ensure the obstetric cream is charted as pharmacy need to collect patient data
- Spread 1% chlorhexidine white obstetric cream over the whole body **except the eyes**. All creases, the perianal area, periumbilical area, axillae and the neck folds should be treated.
- Massage the chlorhexidine cream gently into the scalp.
- Leave the cream in contact with the skin for 60 seconds or more.
- Wash all of the cream off gently or sponge off with warm water.
- If chlorhexidine cream accidentally gets into the eyes, gently rinse with a liberal amount of warm water only.
- An in vitro study showed that an increasing duration of exposure of *Staphylococcus aureus* to chlorhexidine 0.5% solution from 15 to 30 and 60 seconds reduced the colony count by 37%, 77% and 93% respectively.

Staphylococcal Scalded Skin Syndrome

This condition is characterised by red blistering skin which is caused by the release of two exotoxins (epidermic toxins A and B) from toxigenic strains of *Staphylococcus aureus*. Neonates are particularly at risk due to the lack of specific immunity to the toxins and an immature renal clearance system. Outbreaks in Neonatal units may be due to a staphylococcal carrier in the staff. When a baby is thought to have staphylococcal scalded skin syndrome the management will include:

- Specimen (skin swab) to be sent to the Institute of Environmental Science and Research (ESR) along with a detailed history to determine whether the *Staphylococcus aureus* is a toxigenic strain.
- Place the infant into contact isolation until the results are available (1-2 weeks)
- When the infant is being bathed they should be washed with 1% chlorhexidine obstetric cream (as above) until discharge. This is aimed at suppressing the organism on the affected infant and reduces the likelihood of transmission to other infants in the unit.
- Consider contact tracing of staff
- Strict hand hygiene is the key to prevention and further transmission.

MRSA

- MRSA stands for Methicillin Resistant *Staphylococcus aureus*
- The term is used to describe a number of strains of the bacterium *Staphylococcus aureus* which have developed resistance to antibiotics commonly used to treat staphylococcal infections therefore limiting treatment options.
- MRSA is an opportunistic bacterium which may colonise and grow readily on the skin and mucous membranes of a person, without harm to that person.
- It is commonly isolated from warm, moist body sites such as the nose, groin and perineum.
- MRSA colonisation can lead to infection such as infected skin lesions.
- The main focus of this guideline is to prevent MRSA infection in our patients and to limit spread between vulnerable patients in NICU.
- If MRSA is isolated inform the SMO on service, the Clinical Nurse Specialist Infection Prevention & Control (CNS-IPC) and Dr Tony Walls , Paediatric Infectious Diseases
- Parent information sheets are available to be given to the family and are on the Neonatal Intranet site
- The discharge letter must document if the baby tested positive for MRSA

MRSA – Screening Swabs on Baby

General MRSA screen as per the MRSA screening guidelines: [Multi Drug Resistant \(MDRO\) Flowchart](#)

- A blue bacterial swab is used to sample the following sites:
 - Nasal Swab (one swab for both nostrils)
 - Groin Swab (one swab for both sides)
 - Perineum Swab (natal cleft)
 - Additional sites- urine if catheterised, wound sites or device insertion sites i.e. IV lines, drains

MRSA – Positive Swab on Baby

This can be either due to **colonisation** being detected incidentally with a positive swab for MRSA in a well baby, or, **infection** detected with a positive swab for MRSA from a wound/infected site

- No further swabs are required
- Isolate the baby in Contact Precautions for the remainder of the admission
 - All staff to wear gown/apron and gloves when tending to the baby
 - Practice 5 Moments for Hand Hygiene
 - Relatives do not need to wear gowns or gloves
- Decolonise the baby (see below) to suppress the MRSA to reduce the risk of cross infection in the NICU
- IV antibiotics (vancomycin) as well if MRSA is thought to be the causative organism for an active infection
- Repeat swabs after the decolonisation regime are not required
- The most likely source of the MRSA is the family and there is no need to screen the family to see if they are colonised with MRSA as the management of the baby will not change
- A risk assessment should be done, however, by asking the family members if any of them have wounds or skin infections that may need treatment by their GP or Obstetrics if still an inpatient

MRSA – Positive Swab on Mother

This can be either due to **colonisation** in the mother (within the past 2 years) or from a swab from an active **infection** site such as a wound

- No further swab are required on the mother
- The baby does not need any screening swabs to be taken
- Isolate the baby in Contact Precautions for the remainder of the admission
 - All staff to wear gown/apron and gloves when tending to the baby
 - Practice 5 Moments for Hand Hygiene
 - Relatives do not need to wear gowns or gloves

Decolonisation/Suppression Treatment:

- Mupirocin 2% nasal ointment (Bactroban) – applied to the skin covered area of the anterior nares just inside each nostril using a clean cotton bud for each application **three times a day for 7 days**
- Chlorhexidine 1% cream applied to all skin areas, including the head and then washed off with a bath or warm flannels, **once a day for 7 days**
- If the MRSA strain demonstrates resistance to Mupirocin 2% (Bactroban) alternative treatment options are available e.g. Bacitracin.

MRSA Breakout

- If there are multiple cases testing positive for MRSA, Tony Walls and the CNS-IPC would be consulted and give advice on contact tracing and screening

Congenital Infections

The presentation of these diseases is rarely specific and maternal infections antenatally are often asymptomatic or only mildly symptomatic. Therefore consider congenital infections in infants who have:

- IUGR, Purpura, jaundice, chronic rash, anaemia, seizures, cerebral calcification, hepatosplenomegaly, chorioretinitis, microphthalmia, pneumonitis, cataract

The investigation and treatment of these diseases is complicated and should be done in consultation with the **Neonatal consultant and the Paediatric infectious disease consultant Tony Walls**. At discharge discuss the follow up needs of infants with congenital infection with the consultant. Most will need developmental follow up and many will need hearing and ophthalmological assessments.

HERPES SIMPLEX (updated from 2013 National Guidelines) (CDHB Labs no longer processes surface swab cultures and only uses PCR)	
Symptoms and Risk	<ul style="list-style-type: none"> • Only 30% of mothers of infected infants have a history of symptomatic genital herpes so need to have an index of suspicion • 85% of disease is contracted during labour with only 10% being contracted postpartum • The risk of HSV infection in an infant born vaginally to a mother with a first episode of primary genital infection is 57% and so caesarean section is indicated • The risk from recurrent genital HSV i is 3% as there is some protection from maternal Ab's • There are no absolute guidelines on how to deliver a mother with an active recurrent lesion, however, caesarean section should be offered but will not eradicate the risk of HSV transmission and is not an absolute indication (see flow charts). • Scalp electrodes and instrumentation must be avoided if there is suspicion of active HSV There may be a history of contact with herpes simplex but most symptoms are non-specific, vesicular lesions (in 40% only), pustules, fever, seizures, encephalopathy, may present with liver disease • Intrauterine disease – IUGR, chorioretinitis, skin scarring, hydranencephaly • Skin/Eye/Mouth – in 45%, good prognosis but readily disseminates if not treated • Disseminated disease – in 25%, with mortality of 30% even if treated • CNS disease – in 30%, presents with encephalitis from day 5-21
Investigation for Mother	<ul style="list-style-type: none"> • Type specific serology testing but not often at the time as results are not immediate • Vesicle fluid sent for HSV/VZV PCR • Acyclovir from 36 weeks may decrease the risk of recurrent lesions at term (if prior outbreak earlier in pregnancy) and decrease the need for a LSCS if there are no lesions present at the time of birth. Aciclovir in this setting does not eliminate viral shedding though
Investigation for Infant if: Suspected or Confirmed Primary HSV Infection at birth or within 6 wks of birth	<ul style="list-style-type: none"> • Delivered by LSCS and membranes ruptured for less than 4 hours <ul style="list-style-type: none"> - Surface swabs of oropharynx, conjunctiva, rectum for PCR 24-48hrs after birth - If swabs are negative – no further treatment required - If baby becomes symptomatic with CNS signs, disseminated disease or skin lesions at any time whilst the initial surface swab results are awaited the admit and investigate as below • <u>Symptomatic or positive surface swabs:</u> <ul style="list-style-type: none"> - Take Blood (PCR and culture), CSF (PCR and culture) prior to starting iv aciclovir - If there are any skins lesion scrape the base of the lesion and send for PCR - Treat for a minimum of 5 days with aciclovir until Blood and CSF (PCR and culture) results remain negative - Treat CNS/ disseminated disease for 21 days , treat for 14 days if skin/eye/mouth disease • Delivered Vaginally or LSCS but membranes ruptured for more than 4 hours <ul style="list-style-type: none"> - Surface swabs of oropharynx, conjunctiva, rectum for PCR immediately after birth - If there are any skins lesion scrape the base of the lesion and send for PCR - Take Blood (PCR and Culture), CSF (PCR and Culture) prior to starting iv aciclovir - Treat for a minimum of 5 days with aciclovir until Blood and CSF (PCR and Culture) results remain negative - Treat CNS / disseminated disease for 21 days, treat for 14 days if skin/eye/mouth disease

HERPES SIMPLEX (updated from 2013 National Guidelines) (CDHB Labs no longer processes surface swab cultures and only uses PCR)	
Investigation for Infant if : Recurrent HSV Infection	<ul style="list-style-type: none"> Vaginal delivery is appropriate even in the presence of recurrent lesions. Often a LSCS is offered, but, it does not eradicate the low risk of transmitting HSV Avoid scalp electrodes and instrumentation even if no lesions are present If there are lesions present at delivery or a history of recurrent lesions in this pregnancy then take surface swabs of oropharynx, conjunctiva, rectum for PCR 48hrs after birth and not before 24 hours As the risk of transmission is very low the baby can be discharged from CWH and the LMC can take the swabs and follow-up the PCR results <p><u>Asymptomatic but positive surface swabs:</u></p> <ul style="list-style-type: none"> If any of the PCR surface swabs taken after 48 hrs age come back positive, in a well baby, there are no current recommendations of what to do in this low risk population. The clinical history and risk factors need to be reviewed and the baby needs a clinical examination and repeat surface swabs taken. This is often best done with a referral to CAA if they are at home. <p><u>Symptomatic:</u></p> <ul style="list-style-type: none"> If baby becomes symptomatic with CNS signs, disseminated disease or skin lesions at any time whilst the initial surface swab results are awaited then admit and investigate with Blood (PCR and culture), CSF (PCR and culture), if there are any skin lesion scrape the base of the lesion and send for PCR. Start on iv aciclovir and treat for a minimum of 5 days with aciclovir until Blood and CSF (PCR and Culture) results remain negative If the baby has confirmed infection then treat CNS / disseminated disease for 21 days and 14 days if skin/eye/mouth disease
Isolation	<ul style="list-style-type: none"> Contact isolation required, especially if skin lesions present. Advise mother about the importance of handwashing if she has active lesions

CONGENITAL CYTOMEGALOVIRUS (C-CMV)	
<p>A child is considered to have congenital CMV infection (cCMV) if they test positive for CMV (usually done with a PCR test) in the first 3 weeks of life</p> <p>Algorithms for antenatal and neonatal diagnosis and management are available in the 2022 ASID Guideline for Management of Perinatal Infections.</p> <p>The link is provided here: Management of Perinatal Infections (ASID)</p>	
Symptoms	<p>Maternal symptoms: asymptomatic and/or viral illness with atypical lymphocytes.</p> <p>Fetal/Neonatal signs: intracerebral calcifications, microcephaly, hydrocephaly, thrombocytopenia, haemolytic anaemia, ascites, hydrops and IUGR .</p> <ul style="list-style-type: none"> Common. 15% of those born after primary infection of their mother will have sequelae. Sensorineural hearing loss is the most common sequelae Infection and disability can occur regardless of timing in pregnancy but most severe will be primary infection in the first trimester. Early trimester infection is more frequently associated with neurological sequelae, IUFD and early neonatal death. Late trimester infection is more often associated with visceral disease including hepatitis, purpura, thrombocytopenia and pneumonia. 90% infants are asymptomatic at birth but are at risk of hearing impairment and learning disability
Investigation for Mother	<ul style="list-style-type: none"> Serology CMV IgG and IgM (if these are positive in the first 20 weeks gestation, the lab will do avidity testing - low avidity means infection < 3 months ago, high avidity means infection > 3 months ago) Repeat serology required in 2 weeks time from first testing, if booking bloods are unavailable. Consider PCR on amniotic fluid in antenatal period (won't confirm that the fetus is infected though). Sensitivity is much higher after 21 weeks gestation Obstetric specialist input required.

CONGENITAL CYTOMEGALOVIRUS (C-CMV)	
Investigation for Infant	<ul style="list-style-type: none"> All infants need <u>one</u> urine sample for PCR taken after birth. Best transported fresh and chilled. The virus can be shed for up to 3 weeks so if diagnosis is delayed urine can still be collected up to 3 weeks of age. A negative CMV PCR on urine makes c-CMV extremely unlikely FBC, LFT Head ultrasound and ophthalmology review if c-CMV positive MRI head could be considered Universal hearing screening with aABR and review at 9 months and annually until 6 years if proven c-CMV positive If the hearing screen team take a buccal swab which is positive for CMV then a urine needs to be taken for CMV PCR to confirm the positive result
Management	<ul style="list-style-type: none"> Treatment of c-CMV positive babies is intensive (6 weeks of iv ganciclovir) or 6 months of oral valganciclovir. These drug are classified as a cytotoxic medications and should be handled with appropriate precautions. Valganciclovir is the preferred option if the infant can tolerate enteral/ oral medication. Precautions need to continue until 72 hours after the last dose. CBC, NEON and LFTs required at baseline and regular monitoring (initially weekly) should be arranged. Robust evidence to support treatment is still emerging and ASID guidelines suggest considering treatment only in cases of moderately to severely symptomatic c-CMV. (Refer to 2022 ASID Guidelines, Algorithm 4). Treatment needs to be initiated prior to 1 month of age and should always be discussed with Paeds ID. Isolation not required but strict handwashing is important On discharge, in addition to audiology infants with confirmed c-CMV infection should have yearly ophthalmology to age 6 and developmental surveillance follow-up with a paediatrician until at least 12 months of age

POSTNATALLY ACQUIRED CYTOMEGALOVIRUS (P-CMV)	
<p>If a baby has a negative CMV PCR test in the first 3 weeks of life and then later tests positive it is classified as post-natally acquired CMV (p-CMV).</p> <p>Postnatally acquired CMV is common in the first few months of life and is usually asymptomatic, but severe disease can occur. It is usually acquired from breastmilk.</p> <p>p-CMV in immunocompetent children, including term infants, is generally a self-limiting infection with few complications. For most infants treatment is not required.</p> <p>Very preterm and VLBW infants are at risk of a more severe, sepsis-like illness during acute infection with p-CMV and some studies have suggested an increased risk of BPD and neurodevelopmental impairment in this group of infants.</p>	
Symptoms	<p>Symptomatic disease in vulnerable infants typically presents in the second and third months of life. It can mimic other forms of infection (bacterial/ viral/ fungal) and symptoms include increased events of prematurity, jaundice and hepatitis including cholestasis, myelosuppression, enteritis and pneumonitis.</p>
Investigation for Infant	<ul style="list-style-type: none"> CMV PCR : send a urine sample. Minimum 0.5ml sample. Differentiating p-CMV from c-CMV can be challenging if CMV is first tested after 21 days of life. Retrospective CMV PCR testing on Newborn Metabolic Screen card could be considered to help determine if the child has c-CMV infection. A positive test on the newborn screen card confirms c-CMV infection, however this test has low sensitivity meaning a negative test does not exclude c-CMV (Email NMSP@adhb.govt.nz, parental consent is required.) FBC, liver function, conjugated bilirubin and NEON should be performed at baseline if they have not been performed recently. Assessment for features of congenital CMV could be considered including audiology review, ophthalmology and head ultrasound

POSTNATALLY ACQUIRED CYTOMEGALOVIRUS (P-CMV)

Management	<ul style="list-style-type: none"> • Treatment is generally recommended for extreme preterm infants with severe p-CMV disease but there is limited evidence base to guide management. (Discuss with Paeds ID but do not delay treatment over a weekend if infant is clinically deteriorating) • The aim of treatment in p-CMV is to suppress viraemia and prevent end-organ damage in the acutely unwell infant. • Treatment with ganciclovir (IV, central line preferred) or valganciclovir (oral) is typically given for 2 weeks with an assessment of response, and can be extended to 3 weeks if appropriate. (Discuss with Paeds ID) • Contact NICU pharmacist. Oral valganciclovir may take 5-10 days to arrive once ordered. IV ganciclovir can be ordered urgently within 24 hours. • Monitoring with at least weekly FBC, LFTs, conjugated bilirubin and NEON is required while on treatment. • CMV viral load testing is generally not clinically helpful in the NICU setting but could be considered (after discussion with Paeds ID) in infants who have not responded as expected to treatment.
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TOXOPLASMOSIS

Symptoms	<p>Maternal Symptoms: sore throat, malaise, fever and lymphadenopathy</p> <p>Fetal/Neonatal signs: hydrocephalus, microcephaly, intracerebral calcifications, hepatosplenomegaly, lymphadenopathy, maculopapular rash, jaundice, thrombocytopenia, seizures, chorioretinitis. 85% of infected infants will appear normal at birth.</p>
Investigation for Mother	<ul style="list-style-type: none"> • Infection in first trimester is less likely to infect fetus (10%) but more likely to cause harm. • Infection in second/third trimester more likely to infect fetus (30-50%) but with milder effects • Toxoplasma IgG and IgM serology and lab will do IgG avidity testing if IgM serology is positive in the first 20 weeks gestation. • High IgG avidity indicates infection >3mths ago, low IgG avidity indicates infection <3mth ago • IgM can be detected 2 weeks after infection, peaks at 1 month and declines by 6 months • IgG peaks 1-2 months after infection and remains lifelong • PCR on amniotic fluid in antenatal period can confirm fetal infection • Placental tissue sample sent for toxoplasma PCR (although most positive placenta samples are also detected by other tests) • If toxoplasma infection is considered then treatment of the mother with pyrimethamine, sulphonamide and folinic acid may decrease the severity of the disease in the fetus. • Serial ultrasounds are needed to monitor the pregnancy
Investigation for Infant	<ul style="list-style-type: none"> • Serology toxoplasma IgM and a baseline IgG (only 75% of congenitally infected infants will produce detectable IgM) • PCR on blood, urine, CSF • Head ultrasound, ophthalmology review, universal hearing screening with aABR
Management	<ul style="list-style-type: none"> • Isolation is not needed • Confirmed congenital infection • Treat with pyrimethamine, sulfamethoxazole, folinic acid for 1 year • IgG will still be present after 1 year and titres will rise • Not confirmed congenital infection (likely maternal infection and no transfer) • IgM should be negative • IgG titres will fall over time (as they are the maternal antibodies) • Transplacental IgG from mother's infection should disappear by 6-12 months

PARVOVIRUS	
Symptoms	<p>Maternal Symptoms: Illness with rash, fever, myalgia, arthritis, +/- anaemia.</p> <p>Fetal/Neonatal Signs: Anaemic or hydropic infant noted on ultrasound scan or known maternal seroconversion in antenatal period particularly between 10 – 20 weeks gestation. Risk of fetal demise is 2-6%.</p>
Investigation for Mother	<ul style="list-style-type: none"> • Serology for Parvovirus IgG, IgM (positive IgM indicates infection within past 2-4mths) • Obstetric specialist input required. • Consider USS, MCA Doppler velocity monitoring and fetal blood sampling if anaemia is suspected • Tissue sample from placenta sent in sterile pottle with no saline.
Investigation for Infant	<ul style="list-style-type: none"> • If hydropic infant or stillborn, send tissue sample from placenta as above, and this will be tested for Parvovirus PCR
Management	<ul style="list-style-type: none"> • No specific treatment available • Contact isolation

RUBELLA	
Symptoms	<p>Maternal Symptoms: Routine antenatal screen at booking. Testing done after contact with rubella or symptoms of fever, erythema, lymphadenopathy or arthralgia.</p> <p>Fetal/Neonatal Signs: Retinal pigmentation, cataracts, glaucoma, microcephaly, sensorineural deafness, pneumonitis, hepatosplenomegaly, thrombocytopenia, blueberry muffin lesions</p>
Investigation for Mother	<ul style="list-style-type: none"> • Rubella IgM and IgG if there is a rubella contact and/or symptoms of rubella • 85% chance of transmission to fetus if contract rubella in first 12 weeks of pregnancy • Obstetric specialist input required
Investigation for Infant	<ul style="list-style-type: none"> • Serology rubella IgM (note there can be false positives and negatives) • Consider sending EDTA tube from cord or infant blood for rubella PCR • Consider urine/CSF for rubella PCR • Head ultrasound and ophthalmology review • Universal hearing screening with aABR
Management	<ul style="list-style-type: none"> • No specific treatment • Can be infectious for the first year of life after congenital rubella • Contact isolation

VARICELLA ZOSTER	
Symptoms	<p>Maternal Symptoms: chicken pox vesicles, pneumonia. Contact with chicken pox later in pregnancy carries a risk for the infant – living with a person in the same household or face to face contact for >5 minutes are considered risk factors.</p> <p>Fetal/Neonatal Signs: infection in the first trimester can cause congenital varicella syndrome in 1-2% - limb hypoplasia, skin scarring, eye and CNS anomalies</p>
Investigation and management for Mother	<ul style="list-style-type: none"> • If vesicles evident, swab the base of the vesicle and send for VZV/HSV PCR • If previous history of Chicken pox is unknown – request urgent VZV IgG serology (IgM is unreliable) <p>Treatment for exposure in seronegative women:</p> <ul style="list-style-type: none"> • If mother is seronegative and she presents within 4 days from chicken pox contact, mother should get ZIG to attempt to prevent infection developing. • If consultation is greater than 4 days from chicken pox contact, no ZIG is required. • Oral aciclovir is given in the 2nd half of pregnancy, in the immuno-compromised, in a smoker or a woman with underlying lung disease.

VARICELLA ZOSTER	
	Treatment of women with active chicken pox <ul style="list-style-type: none"> • If seen within 24 hrs, mother to get oral aciclovir. • If seen after 24 hrs, no aciclovir. • If seen after 24hrs and considered high risk/ at risk of complications, mother to get IV aciclovir. • If mother develops chicken pox 5 days prior to 2 days after birth, infant should receive ZIG.
Management of Infant	<ul style="list-style-type: none"> • If maternal chickenpox onset is 5 days prior to delivery or develops within 2 days of birth, infant to have ZIG • If maternal chickenpox onset is greater than 7 days prior to delivery, no ZIG necessary • Healthy term infants exposed to chicken pox outside these timeframes in a mother who has not had chicken pox do not need ZIG but should seek medical review if any lesions occur as there is a risk of severe disease that may need treatment. Treatment for Infant: <ul style="list-style-type: none"> • In an infant who develops chickenpox and is very preterm, has respiratory disease and or severe chicken pox disease, this infant to have IV aciclovir administered. • ZIG to be given if the neonate is preterm and there is no maternal history of chicken pox • ZIG to be given if <28wks or <1000gm regardless of maternal chicken pox status • Isolate (contact and airborne precautions) if the baby has active lesions until they crust over • Infants with embryopathy at birth do not need isolation

ENTEROVIRUS	
Symptoms	Maternal symptoms: Fever, encephalitis, myositis, Hand Foot and Mouth disease. Fetal/Neonatal Signs: Nonspecific but can include apnea, sepsis, meningitis, hepatitis
Investigations for Infant	<ul style="list-style-type: none"> • Call Microbiologist to discuss appropriate testing required. • Samples can be sent for PCR or culture • Nasopharynx/throat/rectal swabs may be done after discussion with microbiology • If doing an LP send the CSF for PCR
Management	No specific treatment

SYPHILIS

There has been a rapid rise in syphilis cases among women in recent years with a corresponding increase in cases of congenital syphilis. Incorrect or delayed management or inadequate follow up can result in increased morbidity

There should be information in the antenatal folder regarding women that are known to have syphilis

Definitions

Acquired syphilis can be divided into **primary** (ulcer or chancre stage), **secondary** (systemic dissemination), **early latent** (within 2 years of acquisition with no symptoms), **late latent** (> 2 years since acquisition with no symptoms) and **tertiary** syphilis (symptomatic late syphilis e.g. gummas, cardiovascular and neurological involvement).

The risk of congenital syphilis is very high during the first 4 years after acquisition of syphilis and is negligible after 8 years of infection.

Maternal and Antenatal Risk factors

The risk of congenital infection for untreated pregnant women is 100% for primary syphilis and secondary syphilis, 80% for early latent and 10% for late latent syphilis [8](#).

The risk of congenital syphilis in women treated during pregnancy is between 1-2% [9](#)

Antenatal Scans

Ultrasound signs of congenital syphilis in the fetus include hepatomegaly, placentomegaly, polyhydramnios, ascites and elevated middle cerebral artery peak systolic velocity [12,13](#). Less frequent findings include bowel dilatation and long bone abnormalities [13](#). Abnormal ultrasound finding prior to treatment is associated with treatment failure and delivery of a neonate with congenital syphilis [12](#).

Understanding Investigations

EIA	TPPA	RPR	Interpretation
Reactive	Reactive	Reactive	Confirmed syphilis infection
Reactive	Reactive	Non-reactive	Evidence of past treated syphilis or latent infection OR very early infection,
Reactive	Non-reactive	Reactive	Biological false positive OR very early infection Repeat in 2 weeks
Reactive	Non-reactive	Non-reactive	Possible early primary, latent or false-positive, retest in one month
Non-reactive	Not tested	Not tested	No evidence of syphilis, or too early, retest in one month if strong suspicion based on clinical evidence.

A decrease of RPR titres after treatment from 1:16 to 1:4 is indicative of adequate treatment. Conversely for example, a rise in RPR titres after treatment from 1:2 to 1:8 is indicative of re-infection or treatment failure.

Symptoms

Babies born to all women treated for syphilis in current pregnancy require evaluation at birth.

The newborn infant should be examined for the following clinical features:

- IUGR / Unexplained enlarged placenta.
- Hepatomegaly/splenomegaly
- Necrotising funisitis – inflammation of the umbilical cord
- Fever / Jaundice.
- Non immune hydrops fetalis (NB: check for parvovirus).
- Generalised lymphadenopathy.
- Snuffles, haemorrhagic rhinitis.
- Bullous lesions, palmar/plantar rash, mucous patches.
- Condylomata lata.

SYPHILIS	
	<p>Investigations that may suggest diagnosis</p> <ul style="list-style-type: none"> • Osteochondritis/periostitis. • CNS signs, elevated cell count or protein in CSF and no other cause found • Haemolytic anaemia, DIC, thrombocytopenia. • Pneumonitis, Nephrotic syndrome.
Investigation for infant	<p>The interpretation of syphilis serology in neonates requires specialist input as no single test can be used to diagnose congenital syphilis. Passive transfer of maternal antibodies makes interpretation of neonate serology more complex</p> <ul style="list-style-type: none"> • Paired venous blood samples: RPR serology paired with mother <ul style="list-style-type: none"> ○ Send a neonatal venous blood sample for syphilis serology: request serum treponemal EIA, RPR, treponemal IgM (available through select laboratories in NZ). Take blood from the neonate, not the umbilical cord. <p>Send a maternal venous blood sample for serum RPR at the time of delivery if no result available within the past 4 weeks from the same lab</p> <ul style="list-style-type: none"> • Send further tests as clinically indicated below
Management	See in chart on the next page

Category	Findings	Evaluation	Treatment	Follow Up
Proven, or highly probable congenital syphilis	<p>Abnormal physical examination consistent with congenital syphilis</p> <p>OR</p> <p>A serum RPR titre fourfold high than the mother's titre on 2 occasions (e.g. mother's RPR 1:4, infants 1:16) or infant IgM positive</p> <p>OR</p> <p>T. pallidum PCR assay of lesions or body fluids reactive</p>	<ul style="list-style-type: none"> CSF analysis (VDRL, cell count, protein) FBC, EUC, LFT Long-bone X-Rays Other tests if needed: <ul style="list-style-type: none"> Chest X Ray Neuroimaging Ophthalmologic examination Formal audiologic Examination Placental histology and syphilis PCR 	<p>Benzylpenicillin 50,000U (30mg)/kg/dose IV every 12 hours during the first 7 days of life</p> <p>AND</p> <p>every 8 hours thereafter for a total of 10 days *</p>	<ol style="list-style-type: none"> Paediatric review at 6wks, 3mths, 5-6 mths and 12-18 mths of life. RPR expected to be negative at 6 months If congenital neurosyphilis diagnosed at birth- repeat CSF analysis every 6 months until normal parameters If infant RPR increasing or not decreasing may need repeat LP / retreatment
Asymptomatic possible congenital syphilis	<p>Normal clinical examination</p> <p>AND</p> <p>serum RPR equal to or less than fourfold the maternal titre</p> <p>AND ONE OF THE FOLLOWING</p> <p>Mother not treated, inadequately treated or no documentation of treatment</p> <p>OR</p> <p>Mother treated with a non-penicillin regimen</p> <p>OR</p> <p>Mother received recommended treatment <4 weeks before delivery</p>	<ul style="list-style-type: none"> CSF analysis (VDRL, cell count, protein) FBC, EUC, LFT Long-bone X-Rays Placental histology and syphilis PCR 	<p>Benzylpenicillin 50,000U (30mg)/kg/dose IV every 12 hours during the first 7 days of life</p> <p>AND</p> <p>every 8 hours thereafter for a total of 10 days*</p> <p>Note: For some infants where CSF examination and other investigations normal and where follow up can be assured, then benzathine benzylpenicillin tetrahydrate 50,000U/kg IM as a single dose may be used after discussion with Paediatric ID specialist #</p>	<ol style="list-style-type: none"> Paediatric review at 6wks, 3mths, 5-6 and 12-18 mths of life with repeat RPR RPR expected to be negative at 6 months If congenital neurosyphilis diagnosed at birth- repeat CSF analysis every 6months until normal

Category	Findings	Evaluation	Treatment	Follow Up
Congenital syphilis less likely	<p>Normal infant examination</p> <p>AND</p> <p>Serum RPR titre equal to or less than fourfold the maternal titre</p> <p>AND</p> <p>Mother treated appropriately during pregnancy for stage of infection and treatment was administered > 4 weeks before delivery</p> <p>AND</p> <p>Mother has no evidence of reinfection or relapse</p>	None needed	<p>Repeat serology at 3 months</p> <p>OR</p> <p>If any concern regarding follow up or lack of required maternal testing then GIVE benzathine benzylpenicillin tetrahydrate 50,000U/kg IM as a single dose #</p>	<ol style="list-style-type: none"> 1) Repeat syphilis serology at 3 months – if all negative – discharge 2) If syphilis serology reactive then repeat at 3 monthly intervals until negative 3) RPR is expected to be non-reactive at 6 months - any passive cross over of treponemal antibodies will be negative by 15 months of life.

Reference: National Antenatal and Congenital Syphilis Guideline 2020

Notification and Surveillance

- All cases of infectious syphilis and congenital syphilis (confirmed and probable cases as per ESR case definition) are required to be notified under the Health Act 1956 (Section C).
- The neonatal team should notify congenital cases. And fill in the NZ Paediatric Surveillance Unit (NZPSU) forms – available at <https://www.otago.ac.nz/nzpsu/currentstudies/index.html>.
- Midwives who receive positive syphilis screening results refer to specialists who will be responsible for notification.
- The forms can be accessed on the ESR STI surveillance page: https://surv.esr.cri.nz/public_health_surveillance/sti_surveillance.php.
- Case definitions for infectious syphilis and congenital syphilis for ESR are available on: <https://www.health.govt.nz/our-work/diseases-and-conditions/communicable-diseasecontrol-manual/syphilis-case-definition-only>.

[Antenatal and Congenital Syphilis Management Guidelines \(rocketspark.co.nz\)](https://rocketspark.co.nz)

[ASID Management of Perinatal Infections \(ranzcog.edu.au\)](https://www.ranzcog.edu.au)

Candidal Infections

- The rate of invasive candidiasis for ELBW infants is about 2%
- Our incidence of systemic fungal infections (candidaemia, candiduria, candida meningitis) is low
- Invasive infection usually occurs after the first week ie: is a late infection
- Untreated the mortality is >80% and treated mortality is still up to 60%
- Infants who have had systemic candida have a higher morbidity for outcomes such as ROP, CLD and developmental delay
- Candida may be the cause of chorioamnionitis which would require the use of early systemic antifungal agents

Risk Factors

- VLBW
- Prolonged intubation
- Antibiotic use (especially 3rd generation cephalosporins)
- Parenteral nutrition
- Indwelling catheters
- H₂ receptor antagonists
- Vaginal delivery
- Postnatal steroids

Colonisation

- Superficial infections (particularly in napkin area) increase the longer an infant is in the unit and are common
- Transmission may be vertical ie: acquired from the vagina during birth, or nosocomial.
- Colonisation at birth is particularly troublesome for extremely preterm infants (< 28 weeks) so review of maternal swabs in the days before birth and of the initial swabs and gastric aspirate may identify a baby at particular risk.

Clinical Features

- Nonspecific
- Lethargy, respiratory distress, hyperglycaemia, abdominal distension, blood in stools
- Thrombocytopenia is common but not diagnostic

Treatment

- Cutaneous candida should be treated with topical cream as well as oral suspension
- Systemic candida should be treated with intravenous antifungals eg: fluconazole or amphotericin

Prophylaxis

- Systemic candida infection is associated with extreme prematurity, BW < 1000g, prolonged antibiotic treatment, prolonged TPN use and systemic steroids.
- All infants <30 weeks gestation should receive prophylactic oral nystatin until discharge from level 3.
- Infants 30 – 32 weeks should receive nystatin prophylaxis if they are colonised with candida.
- All infants should receive nystatin prophylaxis if they are on a prolonged antibiotic course for > 7days, on postnatal steroids or have long-term central access and TPN use or on H₂ receptor antagonists (ranitidine)

Management of Babies born to Hepatitis B, C and HIV Positive Mothers

- Wear gloves when handling the baby until they have been bathed
- Bath the baby in warm water only to remove any maternal secretions
- Clean the skin with an aqueous chlorhexidine (alcohol-free) swab prior to giving im Vitamin K
- Hep B positive mothers – baby to receive Hep B immunoglobulin and vaccination as soon as possible (see immunisation section)

HIV Positive Mothers

- Pregnant women are routinely offered antenatal HIV screening with the first trimester bloods. Late presenters with high risk factors should be screened after this time.
- The probability of an HIV positive woman transmitting the virus to her baby during pregnancy, labour, delivery or breastfeeding ranges from 15-25% in an industrialised country with no intervention. (Msellati et al 1995, Kreiss 1997).
- It is now well established that combining elective caesarean section and antiretroviral drug therapy and not breastfeeding reduces the risk of vertical transmission to < 1%. (Connor et al 1994, European Collaborative Study 1999, BHIVA 2014).
- In pregnancies where mothers are treated with anti-retrovirals transmission occurred in 0.8% delivered by elective caesarean at 37 weeks. (Mandelbrot et al 1999). More recently where there is undetected viral load before delivery vaginal delivery is deemed acceptable (BHIVA 2014).
- The British HIV association guideline 2014 is a good resource. Recent cohort and RCT data from Africa show maternal ART treated women with suppressed viral load who breast feed have reduced but not abolished transmission. Avoidance of breast feeding remains our recommendation.
- Management of HIV infected women during pregnancy and child birth, is a document found on the CDHB Intranet under Maternity guidelines

Neonatal Management

- The mother will receive antiretroviral therapy starting between 14-34 weeks and will also receive intrapartum antiretroviral therapy as determined by the ID. An ID nurse specialist follows the women closely.
- Written notification of the case antenatally by obstetric staff to Dr Nicola Austin who is responsible for the follow up of these infants
- Notification to Dr Austin and the Infectious Disease specialist involved should occur at birth and especially if delivery is earlier than planned/expected
- An elective caesarean section or vaginal delivery if undetected viral load is offered at 37-38 weeks.
- The baby should be bathed ASAP after birth in warm water to remove any secretions and blood
- The baby will be seen and examined by the neonatal team after birth and should be handled with gloves until washed.
- Vitamin K is recommended for all babies. If formula fed then a single oral dose (2mg) is sufficient. If the IM route is chosen it should be done after the baby has been bathed and the skin must be cleaned with an aqueous chlorhexidine (alcohol-free) swab prior to any injection

Drug Dosing (also refer to Neonatal Drug Profiles)

- With the parents permission the baby should receive the first dose of oral antiretroviral syrup within 4-6 hours of birth. Aim for dosing at 0800 and 2000 if possible and from then on dosing should be given strictly to time
- Zidovudine (AZT) is the usual drug given:

≥ 35 weeks	4mg/kg/dose orally 12 hourly, or 1.5mg/kg/dose IV 6 hourly
< 35 weeks	2mg/kg/dose orally 12 hourly for 2 wks then 3mg/kg/dose orally 12 hourly for 2 wks, or 1.5mg/kg/dose IV 12 hourly
- Treatment should continue for 4 weeks total
- Liaison with pharmacy should have occurred prior to delivery of the infant to ensure this is available. A supply is kept on Birthing Suite when cases are known.
- Cotrimoxazole prophylaxis against *Pneumocystis carinii* may commence at 4-6 weeks of age if there is a recent history in the parents or the HIV PCR is positive after birth. The dose is 120mg (0.5mL of 240mg/5mL syrup) once a day three days a week eg. Mon, Weds, Fri

Blood Monitoring

- Day 2 – FBC and differential baseline and HIV Viral load RNA - 2 but preferably 3 EDTA tubes are needed
- 2 weeks - FBC and differential (AZT can cause anaemia and neutropenia) liver function, renal function
- 6 weeks – FBC and differential and HIV Viral load RNA (tubes as above)
- 4 months – FBC and differential and HIV Viral load RNA (tubes as above)
- If HIV Proviral DNA tests are required (will be determined by Infectious Diseases/ Dr Austin)
 - Blood sample to be taken on a Mon-Wed prior to 1200
 - Fill 2 EDTA tubes
 - Place in a separate bag with a separate request form as these are analysed in Auckland

Feeding

- Recommend formula feeding as a further means of reducing risk of vertical transmission
- The ID specialist obtains funding for formula where appropriate. See MOH, Breastfeeding by women with HIV 2016.

Follow-Up

- Dr Austin will follow up these infants at 2 weeks, 6 weeks of age and 4 months on the neonatal unit in the assessment room.
- BCG or live vaccines should not be given until after the 4month HIV PCR test result is known. The exception is Rotavirus which can be given if the first HIV PCR is negative and the lymphocytes are adequate at 2 weeks.

❖ HAEMATOLOGICAL DISORDERS AND JAUNDICE

Screening for Hyperbilirubinemia

- The goal is to promote early identification and treatment to avoid severe or critical hyperbilirubinemia and kernicterus, while preventing overtreatment of newborns who have physiologic jaundice that will not require treatment
- Due to the high risk nature of infants admitted to the NICU, a **serum bilirubin level should be done and reviewed with the 24-48 hour Guthrie test** or at any time a blood gas is being done

Red Flags for Jaundice Requiring Assessment

The following situations where babies need bilirubin levels

- Known maternal blood group sensitisation with antibodies detected**
eg: Rhesus isoimmunisation (anti-D), ABO incompatibility, other antibodies- Significant haemolysis may increase risk for bilirubin neurotoxicity
- Family history of significant jaundice
eg: due to blood group incompatibilities, hereditary spherocytosis, G6PD deficiency in males
- Preterm infants (less than 37 week's gestation); also higher risk for kernicterus
- Any baby with visible jaundice in the first 24 hours
- Birth trauma or polycythaemia
- eg: significant bruising, cephalohaematoma, polycythaemia due to deferred cord clamping
- Twin-to-twin-transfusion syndrome recipient twin
- Other: macrosomic infant of diabetic mother, IUGR, maternal PET
- Poor feeding and dehydration (weight loss >10% from birth weight)
- Multifactorial pathogenesis (2 or more risk factors) are associated with majority of severe hyperbilirubinaemia cases
- Sepsis†
- HIE or other causes of acidosis*
- Low albumin levels*
- Dark pigmented skin (loss of visual cues)
- Ethnicity
eg: increased risk in Asians, Mediterranean, African, Middle Eastern due to skin colour + risk of G6PD**

*Neurotoxicity risk factors associated with increased risk for kernicterus

†Conditions that may cause both unconjugated and conjugated hyperbilirubinemia

Causes of Jaundice

Isoimmune Haemolytic Disease of the Fetus and Newborn (HDFN)

- **Anti-D:**
 - Most frequent cause of HDFN
 - Women with multiple red blood cell antibodies are more likely to develop significant haemolytic disease[†] of the fetus and newborn than those with a single antibody especially in the presence of anti-(Rh)D.
 - Note that if the mother has received Anti-D in the current pregnancy they may have a false positive DAT result due to lingering Anti-D.
- **ABO incompatibility:**
 - High titres of anti-A or anti-B antibodies can sometimes be found in blood group O women even before their first pregnancy
 - Higher risk of HDFN in infants of African descent
 - ABO blood group incompatibility with a positive DAT may not require phototherapy and **negative DAT** may sometimes cause early and rapidly progressing jaundice because ABO antigens are not fully developed until after the first year of life
 - Significant haemolysis is rare but when present infants are at risk of developing severe, late anaemia by 3-6 weeks of life
- **Non-anti-D erythrocyte alloimmunization** (Anti-C,c,E,e,Kell,Duffy,Diego,Kidd, P, MNSs antigen systems)
 - Most severe haemolytic picture is caused by Anti-c antibodies
 - Most common haemolytic disease of the newborn caused by Kell, Kidd, then Duffy
 - The combination of anti-e and anti-C antibodies is very rare because of severe fetal hydrops

Non-immune Haemolytic Disease

- **Haemoglobinopathies**
 - Alpha-thalassemia (most common and severe)
 - Gamma-thalassemia
- **Red cell enzyme/membrane defect haemolytic disease**
 - Glucose-6-phosphate dehydrogenase (G6PD) deficiency^{*†}
 Infants greater than one week of age with acute rise in SBR $>3.5 \mu\text{mol/L/hour}$ often have G6PD deficiency or other intrinsic haemolytic diseases causing haemolysis and require close follow up (X-linked recessive pattern inheritance (males are deficient or normal but females may have intermediate activity)
 More common in those with African, Mediterranean, Middle Eastern or Asian ancestry
 - Pyruvate kinase deficiency
 - Hereditary spherocytosis, elliptocytosis, ovalocytosis, stomatocytosis, pyknocytosis

Acquired conditions

- Sepsis: bacterial
- Congenital infections with TORCH, Parvovirus B19, or Coxsackie virus
- Ileus; intestinal obstruction due meconium plugging, cystic fibrosis

Decreased conjugation/clearance

- Ethnicity
 - Neonates of East Asian ancestry^{*}
 - Mediterranean, Sephardic Jews, Middle Eastern, Southeast Asian and Sub-Saharan African due to combination with Glucose-6-phosphate dehydrogenase (**G6PD**) deficiency[†]
- Maternal Diabetes
- Congenital hypothyroidism, congenital hypopituitarism[†]
- Polymorphic uridine diphosphate glucuronosyltransferase (UGT1A1) gene variants
- Gilbert Syndrome (usually mild; may contribute to prolonged breast milk jaundice)
- Crigler-Najjar Syndrome I (AR or AD)
 - Consider with persistence of unconjugated hyperbilirubinemia of more than $340 \mu\text{mol/L}$ beyond the first week of life or
 - Repeated need for phototherapy in the absence of an obvious cause of haemolysis

Other Causes

- **Medication use.** Use the following medications with caution in a baby with jaundice as they may displace bilirubin from albumin binding sites
 - Diuretics (frusemide and hydrochlorothiazide)
 - Digoxin

- Sulfamethoxazole such as in trimethoprim/sulfamethoxazole or other sulphur medications is **contraindicated** in a jaundiced or at risk of jaundice baby. Potentially interfere with several steps of bilirubin metabolism and can markedly increase the risk of bilirubin encephalopathy
- **TORCH or Parvovirus B19** infection may be the cause of jaundice in the setting of infants with IUGR, microcephaly, intracranial calcifications, conjunctivitis, rash, hepatosplenomegaly and thrombocytopenia
- Infants with hepatosplenomegaly should have a SBR and conjugated bilirubin done
- **Endocrine/metabolic disorders:** if acute elevated bilirubin levels with suspected metabolic disorder eg: Galactosemia, hypothyroidism, abnormalities of urine organic acids or serum amino acids
 - Urgent testing through Christchurch labs should be considered
 - Call lab to explain urgency and reason for testing
 - Urine samples for reducing substances alone are not reliable or specific for Galactosemia

Investigation of Unconjugated Jaundice

Benign Unconjugated Hyperbilirubinaemia

Physiologic jaundice

- “Physiologic” or non-pathogenic jaundice in term infants is mild and transient and does not usually need phototherapy, but frequent feeds (preferably breast feeds) should be encouraged
- Peaks later in preterm and Asian infants and resolves in 2 weeks
- No set up for haemolysis or neurotoxicity risk factors
- Normal Guthrie test
- Not visible in first 24 hours of life and rate of rise 8 $\mu\text{mol}/\text{hour}$ or less
- Peak at 300 $\mu\text{mol}/\text{L}$ or less

Breastfeeding (lactation insufficiency) jaundice

- Impacts breastfeeding infants in first week of life
- Breastfeeding increases enterohepatic circulation of bilirubin in some infants who have decreased milk intake and who also have suboptimal fluid or low caloric intake
- Resolves with establishment of maternal supply and adequate feeding routine

Breast milk jaundice

- Different from breastfeeding jaundice; the persistence of hyperbilirubinaemia beyond first two weeks of age in term infants and beyond three weeks of age in preterm infants
- May not resolve until over 12 weeks of life
- Levels can be up to 300 $\mu\text{mol}/\text{L}$
- Thought to be caused by an increased concentration of beta-glucuronidase in breast milk → increase in the deconjugation and reabsorption of bilirubin
- Treatment with phototherapy is not necessary for breast milk jaundice unless the total serum bilirubin level of the infant is greater than 340 $\mu\text{mol}/\text{L}$

Pathologic Unconjugated Hyperbilirubinaemia

- **All pathologic causes of hyperbilirubinaemia require a serum bilirubin (SBR) with a capillary gas or formal lab test**
- SBR is the gold standard for unconjugated bilirubin measurement and it measures the albumin-bound unconjugated bilirubin fraction

Jaundice in the first 24 hours of life

- If mother Rh negative and antibody positive
 - Cord blood must be analysed for **blood group, Coomb's, bilirubin, full blood count and reticulocyte count**
- ABO blood group, Rh status and Coombs test
- Full blood count (neutrophils and platelet count may be affected by HDN) reticulocytes and film
- Sepsis evaluation if clinically indicated - CRP, Blood culture
- If haemolytic anaemia is present the most common cause is rhesus or ABO isoimmunisation

Jaundice approaching exchange levels

- **Requires discussion with SMO**
- See section below on Exchange Transfusion
- ABO blood group, Rh status, Coombs test and cross match
- Full blood count (neutrophils and platelet count may be affected by HDN) reticulocytes and film
- Conjugated bilirubin and LFTs

- Sepsis evaluation if clinically indicated - CRP, Blood culture
- Ensure a Guthrie card is taken off before an exchange is started
- Concerning bilirubin levels include the failure of bilirubin to decrease by 20-30 μ mol/L after 4 to 6 hours with phototherapy, or, SBR rising by > 100 μ mol/L/day
- Consider iv immunoglobulin (see section below) and/or requesting blood for exchange transfusion (2 x 85mL/kg)

Jaundice requiring phototherapy on day 2 to 5 in a term infant

- ABO blood group, Rh status and Coombs
- Full blood count if risk factors for Haemolytic Disease of the Newborn
- Make sure Guthrie card has been sent; check results with National Testing Centre
- Consider G6PD deficiency screen (consider ethnicity, determine family history; bite or blister cells on film)
- Review current weight versus birthweight and feeding history (review Na on a gas)

Jaundice in a sick neonate or jaundice that improves and then recurs

- ABO blood group, Rh status and Coombs
- FBC, film, reticulocyte count
- Blood cultures, urine cultures, CSF examination, CRP if concern for sepsis
- TORCH screening if in-utero infection suspected
- Conjugated bilirubin and liver function tests
- NEON
- Make sure Guthrie card has been sent and check results
- Consider G6PD if risk factors

Prolonged Jaundice

- Evaluation should be done for EITHER visible jaundice or SBR of >150 μ mol/L
 - Preterm infant at >21 days
 - Term infant at > 14 days
- Majority associated with breastmilk jaundice or prolonged TPN
- Evaluate for pale chalky stool and/or dark urine
- Obtain SBR and conjugated bilirubin
- Thyroid function tests
- Further evaluation as below for conjugated bilirubin if the result is \geq 25 μ mol/L

Investigation of Conjugated Hyperbilirubinaemia

Conjugated hyperbilirubinemia >20 μ mol/L (cholestasis) needs investigating

Causes

- Most common cause in preterm infants is prolonged TPN use
- Neonates who received in utero blood transfusions
- Consider in infants with hypoxia, shock, severe metabolic acidosis
- Ill appearing infants
 - Infants with hepatomegaly, petechiae, thrombocytopenia, pale stools and dark urine, or other findings suggestive of hepatobiliary disease, metabolic disorder or congenital infection
 - Infectious causes: adenovirus, CMV, enterovirus, HSV, HIV, parvo B19, rubella, UTI, sepsis
- Extrahepatic causes include biliary atresia, choledochal cyst, biliary sludge
- Metabolic/genetic causes: Galactosemia[†], hypothyroidism[†], tyrosinemia[†], cystic fibrosis[†], α_1 -antitrypsin deficiency, Alagille syndrome, Dubin-Johnson and Rotor syndromes

Evaluation should be step wise with Step one before referral to Paediatric Gastroenterology and further evaluation based on Paediatric Gastroenterology input

Step One Evaluation

- Obtain ABO blood group, Rh status and Coombs (if not already done)
- Repeat SBR and **conjugated bilirubin**
- FBC and film
- Free T4 and TSH (use Endocrine Lab form)
- NEON
- LFTS including AST/ALT/GGT/ALP (GGT/ALT ratio of > 1 is strongly suggestive of biliary obstruction)
- Coagulation profile including PT, INR, aPTT
- Check Guthrie results for CF
- Ultrasound of liver
- Consider TORCH titres based on history including urine CMV

Process to organise the liver US

The scan needs to be in a “fasted state” to allow accurate imaging of the gallbladder and therefore the scan requires coordination between NICU, nursing staff and sonographers

- If on 1 hourly feeds an iv needs to be inserted with fluids running for a scan after 3 hours
- If on 2 hourly feeds check a BSL at 2 hours and if appropriate (>3.5 mmol/L) continue to fast for the scan to be completed by 3 hrs and then restart feeds. If the BSL is low then an iv will need to be inserted to allow the scan to occur around 3 hours after the last feed
- If on 3 hourly feeds the scan can be done prior to the next feed

Request form needs to state:

- US is to exclude biliary atresia in the setting of conjugated hyperbilirubinaemia
- Bedside nurses phone extension for sonographers to liaise with the nurse regarding the timing of the scan around feed times and need for iv access

Potential further investigations (based on Paediatric Gastroenterology recommendations)

- Alpha-1 antitrypsin phenotype
- Cholesterol
- Triglycerides
- Ferritin
- Cortisol level
- Cystic fibrosis screen by PCR
- Urine for culture
- Viral hepatitis titres

Management

- Management is guided by the Paediatric Gastroenterologist
- Fat soluble vitamins (A, E, D, K) for conjugated bilirubin $> 50\mu\text{mol/L}$
 - Vitamin A – 0.3mL daily
 - Vitamin E – 0.5mL daily
 - Vitamin D – 0.5mL colecalciferol daily
 - Vitamin K – 2mg daily if INR abnormal (dose may need to increase)
 - Vitamin levels should be checked 2 weekly if cholestasis is ongoing
- Ursodeoxycholic acid (10mg/kg/dose twice daily)
- Lipid cycling over 12 to 20 hours (use specific TPN templates)
- Vitamin A and E are section 29 medications (unregistered in NZ) and are only funded for use in the community under special authority for liver disease. See the link below for further details
- <https://pharmac.govt.nz/assets/form-alphatocopherylacetate-VitaminE-and-Retinol-vitaminA.pdf>

Bilirubin Assessment – SBR

Criteria for SBR Testing

- Jaundice < 24 hours age
- Jaundice > 14 days of age
- Preterm infants < 32 weeks
- Prior to initiating phototherapy
- During or after phototherapy (off > 24 hours)⁸
- TcB is within $50\mu\text{mol/L}$ of phototherapy level or above the grey or purple lines on the phototherapy charts depending on GA
- For TcB values above $250\mu\text{mol/L}$
- When TcB rate of rise is $\geq 8\mu\text{mol/L/hour}$
- A TcB value of $430\mu\text{mol/L}$ or higher is considered a medical emergency and should be treated while awaiting SBR
- TcB measurement is inconsistent with baby's clinical context or anticipated result.
- TcB measurement blinks '340 $\mu\text{mol/L}$ ' (indicates reading is too high to be measured, an SBR is urgently required).
- All babies at 48 hours in NICU will have an SBR checked at the time of the Guthrie test

There will be differences in the bilirubin levels when measured in the lab and on our gas machine in those babies who have received intrauterine blood transfusions or exchange transfusions. This is because their circulating blood will have components of adult Hb.

The more accurate bilirubin measurement after a baby has received adult blood (intrauterine or exchange transfusions) is a formal lab measurement

Bilirubin Assessment - Transcutaneous (TcB)

- Refer to Transcutaneous Bilirubin Measurement document (PPN118)
- TcB meter (Drager JM-105 NICU)
- Noninvasive TcB devices provide a valid estimate of SBR levels in most infants with levels $<250 \mu\text{mol/L}$
- Predictive in identifying babies that need or will need phototherapy
 - Multiple studies demonstrate strong correlation between TcB and SBR measurements
 - Reliable screening tool for evaluating for severe neonatal hyperbilirubinemia with potential caveats
 - Significant correlation with SBR in high skin pigmentation but often $\text{TcB} > \text{SBR}$
 - Less accurate at high levels ($>250 \mu\text{mol/L}$)
 - Potentially less accurate with decreasing gestational age
- Rapid and non-invasive (decreased need for invasive tests)
- Accuracy is dependent on correct usage of the device, therefore all staff are required to have completed Point of Care (POC) training if using the Drager JM-105® bilirubinometer
- Use according to manufacturer's recommendations, including confirming correlation with SBR
- Neonates with high suspicion for pathologic hyperbilirubinemia should be screened immediately using TcB **in addition to SBR** (in order to minimize treatment delay)

Measurement of TcB in NICU

- Obtain TcB for infants ≥ 32 week's gestation daily from 24 hours of life on (see exclusions in section above)
- If bloods are being taken which will include an SBR at 24 hours then a TcB is not required
- Value should be plotted on the appropriate gestational age graph noting "TcB" beside the value
- Subsequent TcB measurements should also be plotted on the graph to allow detection of an unusual trend such as a rapidly rising TcB
- If under threshold for SBR, and any risk factors for hyperbilirubinemia or 'Red Flags' continue to perform TcB daily to detect if bilirubin continues to rise and SBR now required.
- If infant becomes visually jaundice prior to this time, perform TcB immediately.
- If the TcB level is on or above the grey haemolysis or purple TcB trigger line a SBR should be done
- If jaundice peaks then starts to fall and remains below the phototherapy line, TcB monitoring can then be discontinued.
- TcB to be used up to 14 days if age and after that SBR levels are required

How to Use Phototherapy Charts

- These are to be used as a guide for identifying risk level, starting phototherapy or considering an exchange transfusion
- Ensure you have the correct chart using the **birth gestation until 2 weeks of age then use corrected GA and the treatment light level will be higher**
- Treatment levels vary according to the infant's gestation and risk factors
- There are up to 2-3 lines per chart
 - **Red line: Level for considering an exchange transfusion**
 - **Black line: Standard phototherapy level**
 - **Grey line:** Phototherapy levels for babies ≥ 35 weeks with haemolytic disease (there is no evidence to create a similar line for lower gestations). If a TcB measurement is above this grey line then obtain an SBR.
 - **Purple line: TcB trigger line in 32-34⁺⁶ weekers** - if the TcB is above this line then an SBR is required
- Complete all parts of the chart
- Fill in the top box with date and time of birth, maternal blood group, evidence of antibodies or haemolysis
- **Take an infant blood type and Coombs**
 - If mother Rh negative
 - If maternal blood type O and infant clinically jaundiced or at risk of needing therapy (at or above blue line on chart)
 - If maternal minor blood group incompatibility
- Determine whether red flags are present (see above) and indicate if these are present yes or no in the top box. **List all red flags**
- Careful thought about the aetiology of the jaundice and appropriate investigation is at least as important as phototherapy in identification of appropriate treatment
- In the right hand column ensure the date, time and TcB or SBR reading are recorded and plot on the graph (each square is 2 hours). Indicate where a value is an SBR or TcB so trends can be followed.
- Record number and type of treatment devices and light intensity. This is important to help assess the response to treatment

Canterbury

District Health Board
Te Pōari Hauora o Waitaha
CHRISTCHURCH WOMEN'S HOSPITAL
NEONATAL SERVICES

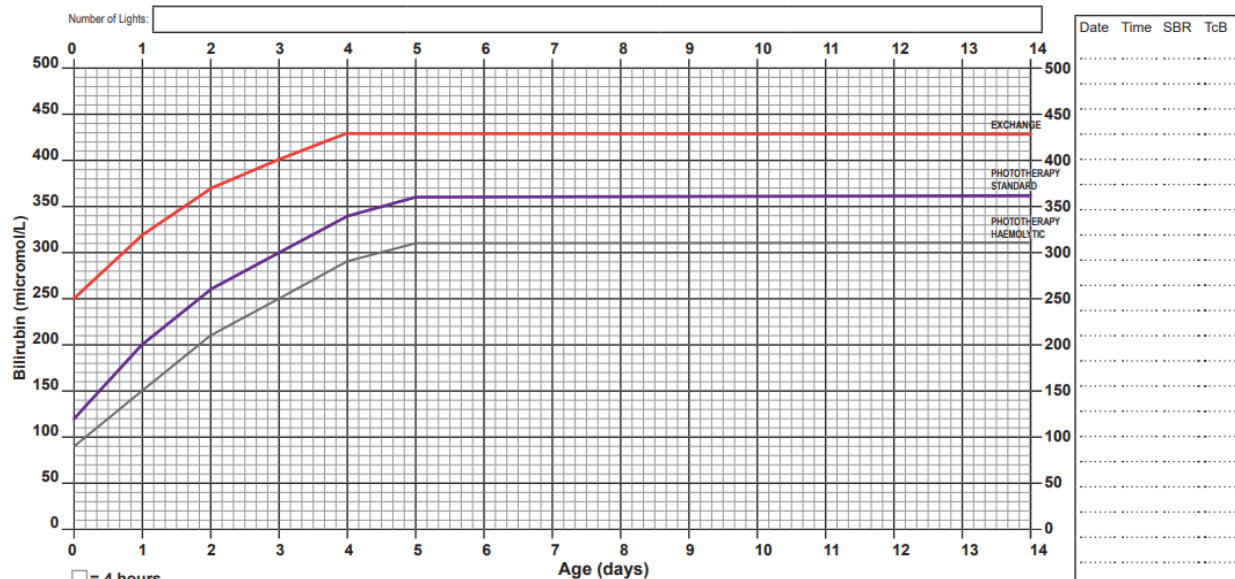
Phototherapy Chart**INFANTS 38 OR MORE WEEKS GESTATION**

Birth gestation: /40

SURNAME: NHI:
FIRST NAME: DOB:
ADDRESS: POST CODE:
(or affix patient label)

Date of birth: Maternal blood group: Red cell antibodies: Red Flag for needing Phototherapy: ☐ Yes ☐ No
(see page 2)
Time of birth: Infant blood group: Infant Coombs test: List:

- Indicate on the chart when phototherapy is started and stopped, and call the **Neonatal Team** for phototherapy management.
- If rate of rise > 10mmol/L/hr call **Neonatal Team** (refer to the neonatal handbook)



INFANTS 38 OR MORE WEEKS

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NEONATAL SERVICES

Information and Investigation Guide

STAFF INFORMATION

Haemolytic Cause for Jaundice - use the grey "phototherapy haemolytic" line on the chart

Rhesus (AntiD), ABO incompatibility, other antibodies, G6PD, pyruvate kinase deficiency, other haemolytic causes.

Red Flags for Jaundice Requiring Phototherapy

Birth trauma (Bruising, cephalhaematoma)	Preterm	Dark skin (loss of visual cues)
Birth Asphyxia/ HIE	Poor Feeding	Family history severe jaundice
Polycythaemia	Dehydration	Ethnicity – Asian, African, Middle Eastern, Mediterranean
	Sepsis	

Testing:**1. Known antenatal haemolytic disease – cord blood sample**

FBC, Bilirubin, Group and Coombs

2. Early jaundice < 24 hours

Bilirubin
Group and Coombs
FBC
CRP, Blood culture, if unwell

3. Jaundice > 24 hours and above phototherapy level

Bilirubin
Group and Coombs
FBC
Guthrie card sent

4. Jaundice approaching exchange level

Bilirubin and conjugated bilirubin
Group and Coombs, cross match
FBC
Liver function tests CRP, NEON
Blood culture
Guthrie card sent

5. Prolonged jaundice – Visible jaundice or unconjugated bilirubin >150 umol/L at 2 weeks (term) or 3 weeks (preterm) OR dark urine/pale stools at any time

Conjugated and unconjugated bilirubin
T4 and TSH
Guthrie card result from National Testing Centre

6. Conjugated Jaundice – conjugated bilirubin >20umol/L

Requires further tests. Discuss with SMO and refer to Neonatal Handbook for investigations

Starting Phototherapy

- Phototherapy should be initiated based on gestational age appropriate nomograms and risk factors
- Level three babies receiving inpatient phototherapy in the NICU should receive “intensive” phototherapy
 - There is no “saturation” limit for irradiance. Higher irradiance correlates with more rapid drop in unconjugated bilirubin
 - **Bililux** is a 5 lamp system (5 lamps is the equivalent of double phototherapy and 3 lamps correlates with single phototherapy)
 - It is recommended that all infants initiating phototherapy in the NICU commence on at least 3 lamps of irradiance
 - 5 lamp irradiance plus a biliblanket is recommended when bilirubin concentrations are approaching the exchange threshold (SBR within 50 $\mu\text{mol/L}$) or are rising rapidly (by more than 8 $\mu\text{mol/litre/hour}$). Interrupting treatment for breast feeding is not recommended at this stage.
- Irradiance levels should be measured regularly (by technicians)
- For neonates with **severe** hyperbilirubinemia, IV fluid administration may be useful
- For most neonates, routine **IV supplementation** is **not** warranted and there is no evidence that IV fluid supplementation effected major clinical outcomes
- Intravenous fluid supplementation may reduce serum bilirubin at certain time points but it is unclear whether this translates into important clinical benefits (Cochrane 2017)
- Maximize surface area exposed to phototherapy by removing unnecessary clothing (minimal/no nappy)

Phototherapy for prolonged jaundice

- After two weeks of life, use the corrected age to determine the phototherapy level and draw this onto a continuation chart
- TcB is only to be used in babies in the first 14 days and so when a continuation chart is used then only SBR levels should be taken
eg: born at 34⁺³ weeks and now 2 weeks old. Use the 35-37 week chart and not the 32-34⁺⁶ week one

Monitoring during phototherapy

- **ALL** bilirubin monitoring during phototherapy should be done via SBR levels; TcB is not accurate
- Infant at risk of requiring exchange transfusion
 - Repeat SBR in 2-4 hours
 - When stable or decreasing repeat SBR q 6 hours
 - When level falling repeat SBR q 12-24 hours
- Infants with
 - Red Flags or with SBR or rate or rise of 8 $\mu\text{mol/L/hour}$ or more
 - Evidence or suspicion of haemolytic disease
 - Neurotoxicity factors including prematurity, sepsis, acidosis
 - Repeat SBR q 6 hours after starting phototherapy
 - When decreasing repeat SBR q 12 hours
- Infant requiring phototherapy with no significant risk factors or rapid rate or rise
 - Repeat SBR about q12 to 24 hours
- Typically a drop of about 30 to 40% in SBR can be expected in the first 24 hours of phototherapy treatment
- Most significant decrease occurs in the first 4 to 6 hours under phototherapy (usually about 9 $\mu\text{mol/L/hour}$)

Stopping Phototherapy

- Decision is made taking into account the risk factors for jaundice, the rate of rise or fall of the SBR, duration of phototherapy and mean SBR/level below treatment line at time of phototherapy cessation
- Risk factors for recurring hyperbilirubinaemia
 - Gestational age < 38 weeks
 - Asian infants
 - Birth weight < 2.5kg
 - Haemolysis present
 - Bruising and polycythaemia
 - Exclusively breastfed infants
 - Younger age at initiation of phototherapy (increased risk if required prior to 60 hours of life)
 - Slow rate of SBR decrease while under phototherapy
- In general it is best to have the bilirubin significantly under the treatment line before stopping lights to minimize rebound risk. Usually phototherapy can be discontinued at 50 $\mu\text{mol/L}$ below the phototherapy initiation threshold

Follow-up After Stopping Phototherapy

- Rebound hyperbilirubinaemia can be predicted well from the infant's gestational age, age at initiation of phototherapy, and relative SBR at phototherapy termination
- Follow up SBR within 24 hours recommended for infants with
 - Haemolytic jaundice
 - Early onset jaundice and discharge before 3-4 days of age
 - Prematurity (<38 week's gestation)
- TcB may be used after phototherapy has been stopped for 24 hours or more

Exchange Transfusion Procedure

Indications

- Serum bilirubin (unconjugated) in exchange transfusion range (this is usually 50 –100 μmol above the phototherapy level depending on gestational and chronological age).
- Check conjugated bilirubin and subtract from total bilirubin, important if baby had in-utero transfusions. Lower exchange levels may be set for sick or extreme preterms, or if there is hypoalbuminaemia (albumin < 25g/L discuss with consultant)
- Rhesus disease - consider if cord Hb <100, cord bilirubin > 80 $\mu\text{mol/L}$, or bilirubin rising >340 $\mu\text{mol/L}$
- Bilirubin increasing despite maximal phototherapy and fluid rehydration
- Drug / toxin / metabolite / immune factor removal

Timing of Exchange Transfusion

- Decided on the basis of the cord haemoglobin results, the rate of fall of the Hb and the rate of rise of the bilirubin:
 - Hb < 100 g/L Immediate exchange likely to be necessary
 - Hb 100-120 g/L Exchange likely to be required in the first day
 - Hb > 120 g/L Wait. Treat with phototherapy

Aims

- Reduce the risk of brain damage and prevent kernicterus (by decreasing unconjugated bilirubin level)
- Prevent further haemolysis by exchanging sensitised red blood cells and removing maternal RBC Ab's
- To control blood volume and relieve heart failure
- To improve anaemia and increase the oxygen carrying capacity

Potential complications

- Infection (bacterial or blood-borne)
- Embolism (air / clot)
- Electrolyte disturbances (including low calcium and magnesium)
- Haemodynamic (overload, shock, anaemia, polycythaemia)
- Clotting abnormality (EDTA in stored blood binds calcium)
- NEC (especially in "single-operator" method)
- Blood reaction
- Rebound hypoglycaemia
- Temperature instability
- Death (mortality 0.5%)

Methods

- A consultant must be present for an exchange transfusion and preferably 2 Reg or NNP

Two catheters / Two operators plus nurse

- Simultaneous withdrawal and delivery using 10 or 20ml aliquots depending on size of infant.
- Each operator drawing in (designated "in") and pushing out (designated "out") blood by using three-way tap attached to their syringe

Venous catheter / Single operator plus nurse

- Only use this method if there is only venous access
- 5ml (<1kg); 10ml (<2kg) or 15-20ml (>2kg) aliquots
- Start with “out” and replace.

Vascular Access

- One artery and one vein (for “two-operator” exchange)
- UAC or peripheral artery (“out” volumes)
- UVC or large vein (eg. cubital fossa) (“in” volumes)
- Umbilical vessels may be used up to 10 days after birth
- Single umbilical vein (for “single-operator” exchange)
- UAC/UVC position checked with X-ray
- UVC preferably in IVC (not in hepatic branch) –use a 5 Fr single lumen catheter

Blood

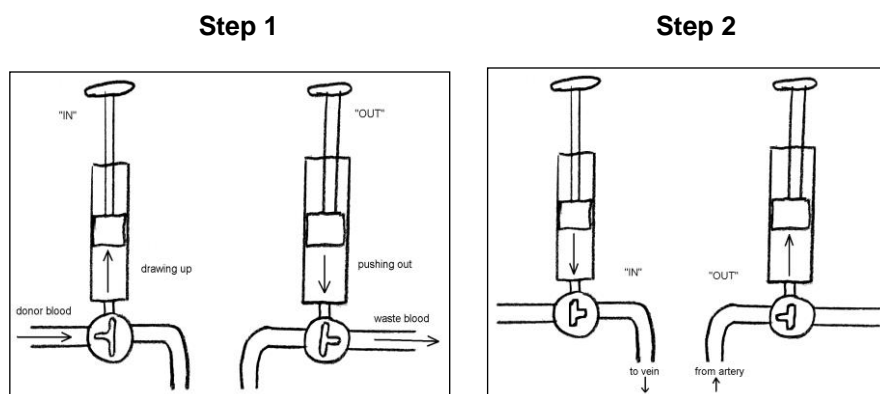
- Volume = 2 x 85ml x Weight (kg) (twice infants blood volume)
- Removes about 85% of baby's red blood cells.
- In most exchanges for rhesus disease the blood is cross-matched against mother's blood and available before delivery.
- Check with blood bank that they are aware of the mother being in labour (we receive a monthly summary of expected deliveries).
- If it is an exchange for a non-rhesus cause occurring after delivery, the blood needs to be cross-matched against the baby
- A baby <1500g or any baby who received intrauterine transfusions must have irradiated, CMV negative, leucocyte depleted blood. This is a preference for all other babies as well but not a necessity in cases where blood is needed urgently.
- In an emergency when urgent O Rh negative blood is used the appropriate leucodepletion filter will need to be used if the blood leaves blood bank before being leucocyte depleted
- Best to use fresh blood <5 days old
- Stored blood has high K⁺ (up to 15mmol/L; ideally < 10mmol/L)
- Irradiated blood must be used within 24 hrs as the potassium level increases post irradiation
- Best to use blood with a haematocrit 0.55 (compared to the usual haematocrit of 0.7 as used for top-ups)
- Anticoagulant is used - citrate phosphate dextrose (binds Ca²⁺ and high dextrose)

Equipment and setup

- See nursing OPS N 292 and 112. WHD 9743
- If not ventilated, nasal O₂ if sats fall (this is usually needed during procedure as stored blood is poorly saturated)
- Monitoring - cardiorespiratory, saturations, blood pressure, temperature (every 15 mins throughout procedure)
- Strict timing of “in” and “out” volumes
- Strict recording of volumes and drugs
- Fresh blood reservoir above level of patient (for easier drawing up)
- Waste blood reservoir below level of patient (to prevent flowing back)
- Donor blood warmed to 37°C and shaken every at every 100ml stage during procedure (as red cells settle in the bag).
- Prophylactic antibiotics not indicated unless specific concerns about sterility.
- Full sterile procedure throughout – sterile gloves and gowns to be worn
- Glasses for all staff involved.
- Temperature, BSL, saturations and blood pH need to be optimal prior to commencement.
- Consent (written informed consent) from parent/guardian.
- Check infant ID and blood pack/s.
- Prepare all tubes and equipment before scrubbing up.
- Gastric contents must be evacuated - 8FG catheter on free drainage
- Baby may need to be pacified during procedure.

- Suction and resus trolley need to be available in case of emergency.
- Lines need to be sited prior to procedure with X-ray position checked

Two Operator Procedure



- Two doctors or CNS (ANP) and nurse recorder with consultant present
- Staff who begin the procedure must remain until procedure completed
- Blood tests from the first "out" specimen:
 - electrolytes, calcium, magnesium, LFT's, SBR, conjugated bilirubin
 - blood culture
 - FBC, diff, film
 - ABG, BSL
 - Blood group and Coomb's (if not already done)
 - Guthrie card
 - Saved specimens: clotted (plain) as well as EDTA samples
- Aim for a rate of 100ml per 15mins (or slower)
- Draw up calcium gluconate in a separate sterile syringe before commencing.
- Check ionised calcium on an ABG halfway through
- 1ml of 10% Calcium gluconate may be added to infused blood exchanged or injected slowly, watching pulse rate and rhythm.
- "In" operator will need to disconnect syringe to draw up calcium (directly from separate syringe and diluted with blood prior to injecting)
- ABG, BSL, calcium, K^+ half-way through exchange (or more frequently in case of concerns eg. ECG changes)
- Blood tests from the last "out" specimen:
 - electrolytes, calcium, magnesium, SBR, conjugated bilirubin
 - blood culture
 - FBC (this is unreliable for a few hours after exchange)
 - ABG, BSL

Subsequent monitoring and management

- Blood sugar - this may drop (rebound result due to high glucose content of the anticoagulant)
 - check hourly for 2 hours post exchange, then 3 hourly for 24 hours
 - must have a continuous infusion of 10% dextrose post exchange
 - infants usually NBM
- SBR
 - post-transfusion expected to be around 50% of pre-transfusion level
 - by 4 hours post-transfusion: \uparrow to 75% of pre-transfusion level
 - may continue increasing, check at 6-hourly intervals.
 - continue intensive phototherapy
- Na - banked blood has high Na content
- FBC
 - major abnormalities with incorrect "out" & "in" balance
 - anaemia may be due to not shaking donor blood bag (ie. concentrated blood exchanged earlier, and thus removed, and dilute blood subsequently)
 - haematocrit more reliable after 4-8hrs post exchange (fluid shifts)

- Other
 - Hourly nursing obs for 6 hours (longer if abnormal)
 - Feeds - careful as ↑ risk of NEC (give breast milk feeds)
 - Inform parents as to outcome of exchange.

IV Immunoglobulin

- IVIG reduces haemolysis and is safe in term neonates with alloimmune HDN (DAT positive Rh or ABO isoimmunization)
- Consider for these infants when the bilirubin level is within 50 $\mu\text{mol/L}$ of the exchange transfusion level or if not responding to phototherapy. Discuss with SMO
- Dose is 1g/kg over 2 to 4 hours IV
- May be repeated after 12 hours if continued high risk for exchange transfusion
- Although data are limited, some concerns for significant side effects in preterm neonate
- See under “Other Blood Products” regarding the process to order IVIG

Follow up for Late Anaemia

- Risk factors for ongoing haemolysis
 - Associated with positive direct Coombs test, retic count above 10%, and G6PD deficiency)
 - Increased incidence with infection (eg: Group B Streptococcus)
 - Associated with need for phototherapy at less than 48 hours of life as well as failure to respond to phototherapy
- Infants who are susceptible should have Hb checked periodically in the first 3 months of life.
- Top up transfusions should be considered if the haemoglobin is $< 70 \text{ g/l}$, especially if the reticulocyte count is low.
- Erythropoietin to prevent the need for transfusions for late anaemia has been used on individual babies. The main indication currently is where parents have objections to transfusion eg. Jehovah's Witness.
- If erythropoietin is started too soon in haemolytic disease to prevent late anaemia, it could increase jaundice to dangerous levels, so this is probably not a useful therapy in babies whose bilirubin levels are still more than about half the exchange level
- Folate deficiency is common and all infants with Rh HDN or any other significant haemolytic anaemia should have supplementary folate (50 mcg daily for 3-4 months)

Follow-up of Bilirubin Induced Neurotoxicity Dysfunction and Kernicterus

- Acute and chronic bilirubin encephalopathy
- **Early phase:** stupor, lethargy, hypotonia and poor suck
- **Later Signs**
 - Hypertonia, fever and high pitched cry
 - Adverse impact on neural respiratory drive (recurrent symptomatic central, mixed, and obstructive apnoea events)
 - Dystonia/choreoathetosis
 - Hearing loss
 - Paresis of upward gaze
 - Dental dysplasia
- Specific unconjugated bilirubin levels have not been found to correlate with signs but other factors like infection, G6PD deficiency are associated

- MRI imaging
 - Hallmark findings include abnormal bilateral, symmetric, initially hypertintense T1 weighted images and later increased T2 signals in the globus pallidus and subthalamic nuclei and on occasion the internal capsule and thalamus
- Auditory Neuropathy Spectrum Disorder (ANSD)
 - Abnormal ABRs may or may not improve over time in infancy
 - Mild ANSD may coexist with normal or mildly abnormal “hearing” and audiogram but with auditory dyssynchrony, difficulty distinguishing sound from background noise, and difficulty in sound localization. Severe ANSD may manifest as absent ABR with profound deafness
- Serial neurologic exams during the first few months of life can be helpful in determining if brain injury has occurred. Early identification and treatment with physical therapy, occupational therapy, and speech therapy can be helpful.
- Some children with classic kernicterus have failure to thrive because of swallowing difficulties, gastroesophageal reflux, and excessive metabolic demands from their movement disorders. Consider SLT evaluation and referral if needed to Enteral Feeding Clinic

Blood Bank Samples and Labelling

- Babies may have a diagnostic sample (pink EDTA tube) for an Antigen Group and Direct Antiglobulin Test (DAT - formerly known as Coombes test) for example in the setting of jaundice
 - Diagnostic samples can use a small patient pre-printed label as blood will not be issued for transfusion based on diagnostic test results
- Babies admitted to the NICU, mainly extreme preterms or surgical babies who may need blood transfusions, should have a pink EDTA specimen sent to Blood Bank for an Antigen Group, Antibody Screen and DAT.
 - Blood Bank microtainer blood samples are to be labelled using the blank stickers available at the central label stations, located in rooms 1,2,4 and 6
 - Blood samples should be labelled at the cotside if possible. If no space is available, forms should be completed at the desk and taken to the cotside to confirm with the patient identification label.. Refer to [Blood Policy – Pre Transfusion](#) for Blood Sample labelling acceptance criteria.
 - All samples must be hand labelled with the baby’s surname and given name(s), NHI and DOB, and signed by the sample collector.
 - A large patient pre-printed label can be used on the Blood Bank Request form. Ensure the sample collector completes the mandatory declaration.
- When requesting blood, please write on the Blood Issue and Administration form if the baby is less than 1000 grams or may require multiple transfusions. Blood Bank will then attempt to reserve all split units from the same donor to minimise exposure to multiple donors should repeated transfusions be required.
- Neonatal results from a pre-transfusion blood sample (not cord blood) taken during this hospital admission are valid until the baby is four months old. After 4 months of age the baby will need a repeat pre-transfusion blood sample sent to Blood Bank within 48 hours of any and all subsequent transfusions.
- Transfer between hospitals and release of a patient home on leave does not interrupt a defined admission

Change of Name:

- A new sample labelled with the new patient identification details is required to be tested to issue blood components or product to the patient using the new details.
- On receipt of information that the baby’s identification and wristband has been changed, any previous tests results will be changed to “Sample no longer valid”. A new blood sample will be required with the updated patient identifiers.
- If a baby changes their name after the blood has been sent for testing then the Blood Issue and Administration form needs to use the label with the original name on it (they need to match). The two common examples are: where the surname changes from mother’s to father’s after the mother is discharged from Maternity or “baby of X Y” now has their own given name.

Emergency Blood Transfusion

- This scenario is usually in delivery suite after the birth of a baby with fetomaternal haemorrhage but may also occur in NICU
- Units issued by Blood Bank will be Whole Blood Plasma Reduced (WBPR)
 - ABO Group O
 - Kell negative
 - Haemolysis negative if the baby is not ABO Group O
 - Compatible with mothers clinically significant antibodies
 - RhD compatible
 - Freshest available usually <14 days old
 - Blood allocated to the mother cannot be used for the baby.

Emergency Blood Transfusion Process

- If the ACMM (if in delivery suite) / ACNM (if in NICU) is not present press emergency bell
- Complete the Blood Issue and Administration form (ref. 2407367)
 - No NHI Allocated** - usual situation
 - Leave this blank - write DOB, surname and first name as Baby of
 - Do not write maternal details
 - Blood Bank will send a unit with the Blood Issue and Administration form plus a Notification of Transfusion of Emergency Blood form. This notification form must be completed as soon as practical by adhering the lower third of the swing label (retain the upper two thirds for adherence to the Blood Issue and Administration form) and a full patient label, and returning the form to Blood Bank for traceability.
 - NHI Allocated**
 - Place a full pre-printed patient label on the form
- Request one critical O negative unit and indicate the urgency by writing URGENT on the top of the form.
- ACMM/ACNM will send a "runner" to run to Blood Bank Parkside West, first floor, ChCh Hospital
- ACMM / ACNM will call Blood Bank to inform them that urgent blood is needed, and a runner is on their way
- Anticipate this process should not take more than 10 minutes

Top-Up Blood Transfusion

- Anaemia of prematurity occurs in most premature babies. It is hypoerythroblastopenic anaemia associated with low erythropoietin levels and it lasts longer and results in a lower nadir Hb levels than the "physiologic" anaemia of infancy.
- It is hard to maintain iron sufficiency via parenteral/enteral nutrition in the first weeks in very premature infants.
- Sick babies are also at risk of anaemia of chronic illness.
- Vitamin E deficiency places some babies at risk of chronic haemolysis
- The greatest reason by far to transfuse babies is the "**anaemia of chronic investigation**". Therefore, keep blood tests to a minimum, and never draw more blood than is needed.

Transfusion Thresholds

A guideline is given below, however, the clinical scenario, birth gestation, postnatal age, Hb level and reticulocyte response all need to be taken into consideration when deciding whether a transfusion is required

120g/L	Term baby with acute blood loss in Week 1, eg: fetomaternal transfusion, Rhesus isoimmunisation Ventilated NIPPV in oxygen
100g/L	NIPPV in air, CPAP, Humidified high flow oxygen, Nasal cannula oxygen Clinical deterioration due to anaemia ie: lethargy, poor feeding, apnoea
80g/L	Well baby over a week of age on no respiratory support Includes babies up to one month corrected age

Reticulocyte Count

- The reticulocyte count should be checked - a good response is 4% or an absolute count of >100 and indicates bone marrow response around 4-6 weeks of age
- If the reticulocyte count is adequate/ improving from previous levels it may be appropriate to not transfuse a well baby who is > 4 weeks old and just monitor the Hb weekly or earlier if there are clinical concerns.

Transfusion Volume

- Transfusion amount is usually 15mls/kg over 3 hours unless the baby requires acute volume expansion.
- In severe anaemia where transfusion volume is 20mls/kg or greater, blood < 5 days old is advised to avoid the effects of hyperkalaemia
- Frusemide (1 mg/kg) may be given if the blood is not being transfused to expand blood volume, although avoid it in the first week in ELBW babies because of literature suggesting that it may increase the risk of symptomatic patent ductus arteriosus. Always check with the consultant.
- Units issued by Blood Bank will be Red Cells Resuspended Neonatal (RCRNeo)
 - ABO Group O,
 - haemolysin negative
 - compatible with mothers clinically significant antibodies
 - usually RhD negative
 - K negative if female
 - up to 35 days old
 - CMV negative
 - If RCRNeo units are not available, standard leucodepleted red cell components may be issued.
 - It is not necessary to irradiate blood for routine top-up transfusions unless there has been a previous intra-uterine transfusion

Top-Up Blood Transfusion Process

- Before transfusing a baby >4 month of age check that Blood Bank still have a valid Pre-Transfusion Test sample and the parental consent form is up to date.
- Send Blood Issue and Administration forms via the Lamson tube system to Blood Bank.
- A light will go on above the Lamson when something has arrived, and it should be retrieved promptly, and light cancelled.
- Transfusion checks should begin immediately upon receipt of a blood unit

Exchange Blood Transfusion

Units issued by Blood Bank will be Whole Blood Plasma Reduced (WBPR)

- ABO Group O
- Kell negative if female
- usually RhD negative
- haemolysin negative
- compatible with mothers clinically significant antibodies
- DAT negative
- up to five days old
- CMV negative
- The unit should be irradiated if baby had an intrauterine transfusion

Irradiation of Blood

- Irradiation is recommended to prevent the risk of transfusion associated graft versus host disease which is a serious and usually a fatal complication of transfusion. Neonates are at increased risk. The majority of TA-GVHD cases reported in neonates have been in apparently immune-competent infants who have had intrauterine transfusion followed by exchange transfusion.
- All units issued to a baby who has received an intrauterine transfusion must be irradiated.
- Irradiation for other reasons such as exchange transfusion is recommended unless the delay would be clinically unacceptable.
- Irradiation is required for infants with suspected T cell immunodeficiency

- Irradiated Red Cells Resuspended Neonatal blood may be routinely requested for premature babies, babies under 1500g or on clinical grounds. Some Red Cells Resuspended Neonatal stock may be irradiated for logistical reasons by NZBS.
- Whole Blood Plasma Reduced is irradiated on request.

Other Blood Products – Platelets, FFP, Immunoglobulin, RhD Ig

Platelet Transfusions

- Irradiation must be performed on platelets transfused in-utero to treat alloimmune thrombocytopenia
- Irradiation must be performed on platelets transfused after birth to infants who have received either red cells or platelets in utero
- Most platelets available in Blood Bank have already been irradiated.

Granulocyte Transfusions

- These are used rarely but in all circumstances the granulocytes must be irradiated and transfused as soon as possible after irradiation.
- Please refer to [Blood Protocol - Components](#) as Granulocyte transfusion has specific requirements for administration

Suspected Congenital Immunodeficiency

- Irradiation of cellular blood products is recommended for all infants with suspected T cell immunodeficiency
- There is no indication for irradiation of cellular blood products in children who are HIV antibody positive or who have AIDS.

Fresh Frozen Plasma

- When requested, FFP will be thawed by Blood Bank. This may take up to 20 minutes
- If the transfusion cannot occur within 30 mins of receiving the product then return it to Blood Bank.
- Once FFP has been thawed, transfusion must be completed within 4 hours.

RhD Immunoglobulin

- This is rarely needed in NICU but in some situations may be recommended by the Transfusion Medicine team if a Rhesus negative baby has been transfused Rhesus positive blood components eg. time critical need for platelets and only rhesus positive platelets are available.
- Suggested dosing could be 125 units = 0.5 mL subcutaneously or intramuscularly - discuss dose and route with the NZBS Transfusion Medicine Registrar or Specialist

IV Immunoglobulin

- Blood Bank have three IV immunoglobulin products – Privigen NZ® (10%), Privigen® (10%), Gamunex (10%).
- Privigen NZ® and Privigen® are not interchangeable and registered as different medication by Medsafe.
- Privigen® and Gamunex® are commercial products while PrivigenNZ® is manufactured from NZ donors. Gamunex is available for patients who do not tolerate Privigen products.
- Privigen NZ® is supplied by volunteer NZ donors and will usually be dispensed by Blood Bank for patients needing long term immunoglobulin (ie 3 months or more)
- Privigen® is supplied by paid USA donors and the preference from Blood Bank is to use this product for patients receiving short-term immunoglobulin infusions. So NICU patients will usually be dispensed this product.

Requesting Immunoglobulin Approval for Use

- There is a national process to request immunoglobulin to ensure appropriate clinical use based on indication using national guidelines
- Approval for Use is required via the **IgO (Immunoglobulin Online) app** (igo.nzblood.co.nz). Prescribers who have not registered previously will need to complete registration prior to completing the request for approval.
- Note that you cannot leave any details blank - if a detail is not available/relevant, you can just put “xxx” to allow the form to go through
- Tick yourself as the responsible clinician and not the SMO the baby is under or they may be contacted after hours when they are not on call

- IgO requests are usually reviewed promptly by the Transfusion Medicine Registrar or Specialist upon receiving a notification from the app on their phones.
- Once approved you will receive a text and email. The approval will identify the product and dose approved as a one off or maintenance dose. This then needs to be prescribed before staff request the blood product from Blood Bank.
- After hours the TMS will need to be called to expedite the process. **It is not automatically approved once the application is submitted.**
- "IVIg" is not a legitimate prescription.
- An Administration Guide is available from NZBS website ([I-Hub](#)) [Toolkit-Administration-Guide.pdf](#)

Blood Donation by Parents of Babies

- The NZ Blood service policy statement does not support the practice of directed donation on the basis that there is no evidence that such components lead to improved patient care nor that they reduce the risk of acquiring transfusion associated infections.
- Because of the possibility of shared HLA haplotypes within families, donations from family members poses particular risk of transfusion associated GVHD **especially** when the recipient is a **neonate**.
- This blood is never available in an emergency situation

Thrombocytopenia

Reference: British Journal of Haematology 2011: 156; 155-162

- Commonly seen in neonates admitted to NICU and most are mild and self-limiting
- In the neonate usually defined as $<150 \times 10^9/L$, severe thrombocytopenia is $<50 \times 10^9/L$
- No exact level where the risk of haemorrhage can be predicted as the clinical scenario is also important
- Higher risk of bleeding if $<50 \times 10^9/L$ with the commonest site being intracranial then gastrointestinal or pulmonary haemorrhage
- Falsely low platelet counts can be seen from cord blood or heel prick samples so a venous sample should be taken to confirm thrombocytopenia

Aetiology

- | | |
|-----------------------|--|
| • Artefact | Clot in specimen. |
| • Dilutional | After exchange transfusion or cumulative top-ups with platelet poor adult blood |
| • Hypoxia | Placental insufficiency, PET, HELLP, IUGR, HIE |
| • Immune disorders | Neonatal Alloimmune Thrombocytopenia (NAIT)
Autoimmune Thrombocytopenia (maternal ITP, SLE) |
| • Consumption | DIC, IVH, Kasabach-Meritt (giant haemangioma), hypersplenism. |
| • Infection | NEC, Bacterial (GBS), viral (CMV, Toxo, Rubella, Coxsackie), fungal, |
| • Congenital | Thrombocytopenia Absent Radius, Fanconi, Trisomy |
| • Metabolic disorders | |
| • Leukaemia | |

Investigation

- Look for a possible cause listed above according to the clinical situation.
- Maternal platelet count
- Coagulation profile
- If NAIT is suspected see below for investigations

Placental Insufficiency – Common

- Platelet count falls to a nadir of $>50 \times 10^9/L$ by day 4-7 and spontaneously recovers in 2 weeks
- Associated transient neutropenia, increased nucleated red blood cells, polycythaemia
- As this is usually self-limiting do not need to investigate further unless the count remains >50 at 2 weeks

Neonatal Alloimmune Thrombocytopenia (NAIT) – Uncommon but severe consequences

- Most important cause of thrombocytopenia to rule out in term babies
- 10-20% will have an intracranial bleed
- Severe thrombocytopenia with no clear aetiology (see list above)
- Due to transplacental passage of maternal antibodies to fetal platelets with paternal HPA antigens that the mother does not have
- Usually resolves in 1-2 weeks but some cases are prolonged
- Screening head ultrasound is required
- Treatment is usually required immediately and before a diagnosis is confirmed
- **Investigations** (D/W Haematologist or NZBS Transfusion Registrar/Specialist)
 - identify maternal anti-HPA antibodies
 - genotype both parents blood for the common HPA antigens (1a,2,3,5b,15) anti-1a and anti-5b are the cause in 95% Caucasians
 - despite doing these tests only about 20% of cases are confirmed in the lab as maternal antibodies can be hard to detect or the HPA antigen may not be one of the common ones that is tested

Management

- Platelet transfusion – see below
- Immunoglobulin – 1g/kg/day iv for 2 days – see IV immunoglobulin section above for products available and how to order

Platelet Count	Clinical Indication
<20x10 ⁹ /L	All Neonates
<30x10 ⁹ /L	<1kg First week life Clinically unstable Minor bleeding – ooze puncture site, petechiae, blood stained secretions Abnormal coag profile Surgery Exchange Transfusion
<50x10 ⁹ /L	Major haemorrhage

Platelet Transfusion

- Adult size packs suitable for neonatal use will be available from Blood Bank for urgent transfusions
- Split packs will be provided for neonates only after a specific request for this. It will take between 1-2 hours for this process to occur and so this can be requested for a non-urgent transfusion and/or for when a baby is identified with ongoing need for platelet transfusions.
- The split pack will on average be 45mL (range 30-60mL) and if larger volumes are needed this needs to be clearly requested on the Blood Issue and Administration form and a call to Blood Bank.
- Platelets only need to be irradiated if there have been any intrauterine platelet transfusions.
- Use a transfusion administration set with a 170-200 micron filter (to remove cellular debris)
- Platelets are CMV negative
- Give 10 mL/kg over 1 hour – infusion needs to be completed within 1 hour
- Platelets have the highest risk of transfusion transmitted infection due to being stored at room temperature for their entire shelf life of 7 days. NZ **Blood Service** Processing cultures every bag of platelets manufactured and observed for 5 days. Any hint of a positive culture is reported to the service caring for that patient and recommendation for commencing broad spectrum antibiotics can be discussed. Most positive cultures reported are false positive.
- Neonatal platelets are suspended in platelet additive solution rather than plasma
- If NAIT suspected the preference is to have HPA-1a, HPA-5b negative platelets but there should not be any delays in transfusing the baby so use neonatal platelets first. For subsequent transfusions discuss with the Transfusion Medicine Specialist about the possibility of NAIT and the availability of appropriate antigen-negative platelets

- If NAIT is suspected then after the first transfusion check the platelet count 1 hour later, then 12 hours later to document the peak and decay of the platelets. This does not need to be repeated after every transfusion
- If concentrated neonatal platelets (10-20mL) are required due to volume overload request these through Blood Bank who will discuss with the Transfusion Medicine Specialist. It takes up to 4 hours to prepare these units and they expire within 4-5 hours of arrival at NICU. The volume for transfusion will be decided on by the Transfusion Medicine Specialist.

Neutropenia

- Defined as an absolute neutrophil count of $< 1 \times 10^6/L$.
- Venous counts are 80% of capillary counts.
- Common causes related to infection e.g. bacterial, viral (especially CMV, HSV, parvovirus, enterovirus, or other viral and non-viral congenital infections in the neonatal period. Later hepatitis A and B, RSV, influenza A and B, measles, rubella, varicella become more prominent). Maternal toxemia is also a possible cause.
- Treatment usually directed at the cause.
- G-CSF (granulocyte colony stimulating factor) can be considered if neutropenia accompanies significant systemic infection (dose of 5 micrograms/kg).
- Occasionally very healthy term babies will have extremely low neutrophil counts due to maternal anti-neutrophil antibodies. These babies may require only careful follow-up.

Polycythaemia

Risk factors

- delayed cord clamping
- cord stripping
- holding baby below mother at delivery
- twin to twin transfusion (typically polycythemic larger and anaemic smaller twin)
- fetal hypoxia due to maternal toxemia, smoking, cyanotic heart disease, severe lung disease.
- infants of diabetic mothers with poor glycemic control.
- infants with syndromes including Down syndrome, Beckwith Weideman syndrome, trisomy 13, trisomy 18
- infants with certain endocrine/metabolic disorders - congenital adrenal hyperplasia, neonatal thyrotoxicosis.

Diagnosis

- Definition usually taken to be Hb > 220 g/l or PCV > 0.65 .
- However, viscosity is not linearly related to PCV
- Capillary samples tend to give PCV results that are 5-20% higher than central venous samples.
- Warming the heel before obtaining the specimen will give a better correlation.
- If the capillary PCV is above 0.65, a fast flowing venous PCV should always be done.

Consequences

- Poor feeding, lethargy and hypotonia, jitteriness, respiratory distress, cardiac failure, cyanosis, jaundice, hypoglycaemia, hypocalcaemia, convulsions, venous thrombosis, thrombocytopenia.

Treatment

- Partial exchange transfusion with saline, using from 20 ml/kg up to 30 ml/kg, with the intention to reduce PCV to about 0.55. Formula for calculating exchange transfusion is as follows:

$$\text{Volume to exchange} = \frac{(\text{actual PCV} - \text{desired PCV})}{\text{actual PCV}} \times 80 \times \text{wt (kg)} = \text{mls}$$

- In infants with high PCVs who are managed without reverse exchange, careful attention to fluid balance (avoidance of dehydration) is essential.

Haemophilia

Mothers who are known to be carriers should have received antenatal counselling with the support of a haematologist and obstetrician. Some of these parents may have opted for antenatal gene testing. A clear management plan for labour and delivery should be in place. Management of the newborn with known haemophilia is outlined below as per the [NZ National Guidelines for the Management of Haemophilia 2022](#). Close liaison should be maintained with the haematology team who will guide management.

Potential New Case of Haemophilia in a Newborn Male

Protocol

- take blood from the umbilical cord (or peripheral vein if cord blood specimen unobtainable/unsatisfactory) for **urgent** (result <3 hours) factor VIII/IX level. Note: these will not be routinely run after hours and so if required this would need discussion with the on-call Haematology team.
- if urgent factor VIII/IX assay unavailable, do coagulation screen (APTT will be elevated)
- avoid heel pricks for coagulation studies or factor assays.
- suggest factor VIII/IX level is done on females born to carrier mothers to detect the occasional carrier female with low levels at risk of symptomatic bleeding.
- oral Vitamin K prophylaxis is effective in preventing classical haemorrhagic disease of the newborn, but ineffective in preventing late HDN. Increasing the dose or giving it weekly for a longer period increases the efficacy of the oral prophylaxis
- alternatively, IM Vitamin K can be given, especially after factor replacement administered, providing pressure is maintained for a minimum of 5-10 minutes.
- Factor IX concentration may be unreliable in the newborn (until approximately 6 months of age). A low level does not confirm haemophilia and a repeat may be necessary

If factor assay indicates severe (<1%) or moderate (1 - 4%) factor VIII/IX deficiency

- sensitive communication of result to parents by experienced staff
- confirm diagnosis with a further factor VIII/IX level
- consider immediate replacement with a single vial of recombinant factor VIII or factor IX without waiting for second result (caution if family history of inhibitors). Doses should be guided by advice of haematologist.
- follow newborn closely for a minimum of 7 days after birth through daily phone contact from Haemophilia Centre or GP and frequent midwife visits.
- educate parents regarding symptoms of intracranial haemorrhage - poor feeding, irritability, listlessness, full fontanelle, convulsions, pallor.
- US head if clinical suspicion of intracranial haemorrhage or at day 3-4 after a NVD or assisted/traumatic delivery of preterm infant.
- if confirmed intracranial haemorrhage - treat according to National Guidelines for Factor Replacement in Haemophilia

In newborns without a family history of haemophilia but coagulopathy suspected

- Investigate for a coagulopathy in any infant with significant or unusual haemorrhage that occurs "spontaneously" eg: intracranial haemorrhage, subgaleal haemorrhage, easy bruising (including significant cephalohaematomas) or prolonged oozing from venepuncture sites, petechiae (especially if more generalised than simply over face which can be induced during a normal delivery) or a family history of a coagulopathy.
- Do not be dissuaded from considering haemophilia if haemorrhage is a presenting feature of a newborn's illness, even if:
 - coagulation screen suggests DIC
 - thrombocytopenia coexists with prolonged APTT
- Initial coagulopathy screen should include:
 - CBC
 - Group and hold
 - Coagulation screen (if APTT is prolonged go on to request Factor VIII/IX levels).

Potential Carrier of Haemophilia in a Newborn Female

- In females born to families with severe haemophilia cord blood factor VIII/IX level should be measured detect the occasional carrier female with low levels at risk of symptomatic bleeding.

Thalassemia

- Thalassemias are generally inherited in an autosomal recessive fashion and are more common in communities from the Mediterranean, Middle East, South East Asia and the Pacific.
- Hopefully mothers with thalassemia will have received antenatal genetic counselling and the results of the infant's father's Hb electrophoresis will be known
- At birth the predominant circulating haemoglobin is Hb F ($\alpha_2\gamma_2$).
- Adult haemoglobin, Hb A ($\alpha_2\beta_2$), becomes the predominant haemoglobin after birth.
- Therefore, infants with α -chain abnormalities tend to be symptomatic at birth (or before)
- Those with β chain problems develop symptoms usually after 4-6 months.
- The cord blood red cells from infants with either α -thalassemia trait or HbH Disease are microcytic, and the level of Hb Bart's (an abnormal haemoglobin composed of only γ -chains) in the cord blood is raised

Investigations

- Cord blood for haemoglobin electrophoresis, particularly Hb Bart's quantitation if α -thalassaemia is suspected
- Venous blood for haemoglobinopathy study.
- If β -globin defect is suspected the specimen should usually be taken at 3 months at the earliest.
- FBC (may be normal in thalassaemia traits)

Beta Thalassemia Minor (trait)

- Mild reduction in beta chain synthesis leading to a reduction in HbA and mild microcytic anaemia
- If both parents have beta thal trait they have a 25% risk of having a child with beta thalassemia major
- If only one parent is affected there is no risk of having a child with beta thal major
- Diagnosis is confirmed by having elevated HbA2 on Hb electrophoresis

Beta Thalassemia Major

- Marked decrease in beta chain synthesis with accumulation and precipitation of alpha chains
- Fetus is unaffected in utero and newborn is haematologically normal
- Symptoms develop in the first 6-12 mths with severe microcytic, hypochromic anaemia, failure to thrive, hepatosplenomegaly and jaundice
- Electrophoresis shows a predominance of HbF with absence or only small amounts of HbA

Alpha Thalassemia – Silent carrier (one alpha gene deleted)

- Clinically and haematologically silent – of no clinical significance to offspring unless partner also affected

Alpha Thalassemia Trait (two alpha genes deleted)

- Causes mild microcytic anaemia
- 5-8% Hb Barts seen on Hb electrophoresis for first 3-6 months but then normal

Hb H Disease (three alpha genes deleted)

- Excess beta chains accumulate and precipitate in red blood cells causing a chronic moderately severe microcytic haemolytic anaemia

Hydrops Fetalis (no alpha chains)

- Causes still birth or immediate post natal death.

❖ NATIONAL TESTING CENTRE (0800-522-7587)

The testing programme aims to detect the below diseases for which effective treatment is available. Four dried blood spots are collected on filter paper and analysed for evidence of these diseases. In each case, early detection, before the child has developed symptoms, has the potential to reduce mortality and/or long term morbidity. Since there are about 60,000 births per year in NZ, there are about 30-35 true positive tests. Many babies with these disorders will be symptomatic before the test results become available, therefore, clinical suspicion and appropriate laboratory testing is still essential. The fax and telephone numbers for the National Testing Centre are in the rolodex at the NICU ward clerk's desk.

If you need results urgently:

- Arrange for the card to be sent urgently to the NTC.
- Call NTC and explain the urgency.
- If the card has already gone and you need results urgently, call and ask for them, rather than waiting for them to appear.

About 1 in 100 tests needs to be repeated. The most common reasons are due to timing of the first sample, or incorrectly filled blood spots. Most babies with an abnormal test should be evaluated by a doctor, even while awaiting the results of a repeat test. The action needed may involve repeating the test and/or urgent treatment

Parent/whānau/consumer information: [Heel prick test - newborn metabolic screening](#)

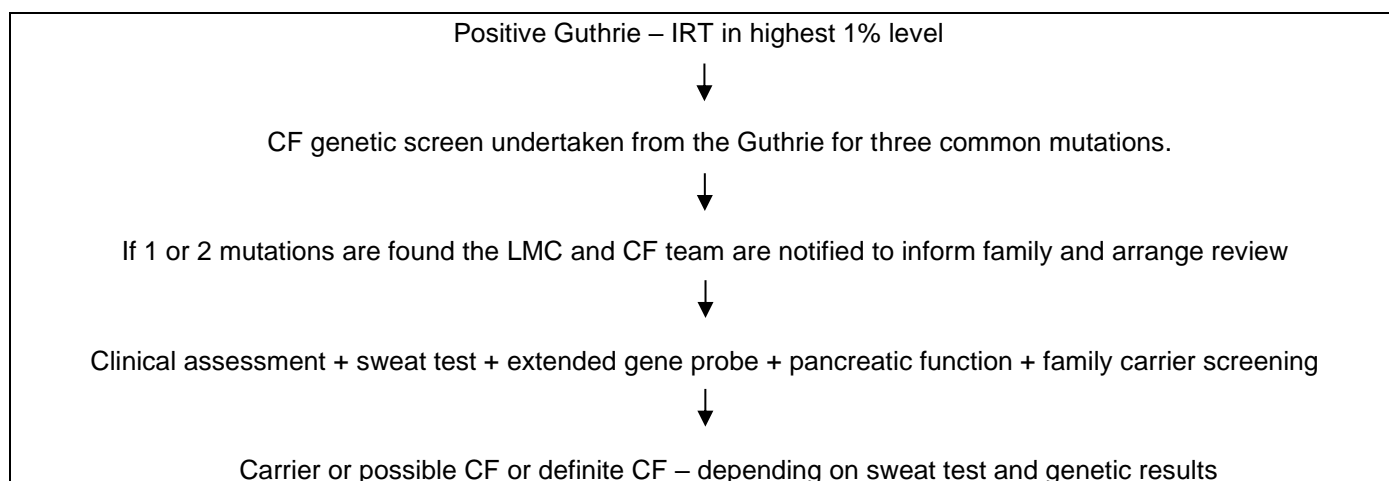
Health professional/clinical/sector information: [Newborn Metabolic Screening Programme](#)

Disorder	Incidence	Test Measures	Why Detect It?	Other Comments
Cystic Fibrosis (autosomal recessive mutation of the CFTR gene)	1 in 3000	Immunoreactive trypsin then PCR for CFTR mutations by PCR	CF causes malabsorption, chest infections, early death. Early detection allows genetic counselling and early treatment (antibiotics, enzyme supplements) delays symptoms, prolongs life.	High false positive rate for IRT. False negatives can occur in babies with minimal or very advanced pancreatic disease at birth.
Hypothyroidism (mixture of genetic and non-genetic causes)	1 in 4500	TSH	Before screening hypothyroidism in infancy was the leading cause of severe but preventable mental retardation. If treatment is begun soon after birth, later intelligence is normal.	Clinical signs and symptoms are difficult to detect until irreversible brain damage has occurred. NB: Test will miss hypothalamic hypopituitarism and primary hypopituitarism.
PKU Phenylketonuria - autosomal recessive disorders of amino acid metabolism	1 in 15,000	Phenylalanine	PKU causes autism, mental retardation and seizures, due to build-up of the amino acid phenylalanine. Consequences can largely be prevented by a special (low phenylalanine) diet throughout childhood.	Test should be done after minimum of 2 days of protein feeding. Highest incidence among Irish and Polish (1 in 6000).
Congenital Adrenal Hyperplasia (autosomal recessive disorders of steroid synthesis)	1 in 20,000	17 OH progesterone	Life-threatening abnormalities of fluid and salt balance, high blood pressure and abnormal sex hormones occur in different variants of CAH. Steroid medications effective.	Premature babies commonly have elevated levels of 17 OH progesterone. They need a repeat test.

Disorder	Incidence	Test Measures	Why Detect It?	Other Comments
Biotinidase Deficiency (autosomal recessive disorder of biotin synthesis)	1 in 50,000	Biotinidase activity	Biotin is essential for many metabolic pathways in the body. Deficiency causes vomiting, lethargy, coma and often death.	Treatment with biotin results in a good prognosis.
Galactosemia (autosomal recessive disorders of breakdown of galactose)	1 in 120000	Galactose and gal-1-PO4	Babies with the condition cannot break down galactose (one of the two types of sugar molecules in mammalian milk). Build up of galactose causes mental retardation, seizures, liver failure, serious infections, cataracts and death if untreated.	Testing should be done after 2 days of milk feedings. Treatment is a milk free diet (e.g. soy formula in infancy).
Maple Syrup Urine Disease (MSUD - autosomal recessive disorder of metabolism of branched chain AA's)	1 in 250,000	Branched chain amino acids.	Build up of branched chain amino acids leads to coma, seizures and death, or mental retardation in survivors.	Treatment is with a special diet low in branched chain amino acids.
Fatty acid oxidation and mitochondrial disorders		Multiple	Associated with SUDI's	Referral / discussion with metabolic consultant Starship
SCID (Severe Combined Immune Deficiency)	1 in 50,000	Levels of TREC (T-cell receptor excision circles)	Rare disorder caused by a deficiency or absence of T cells. Risk of recurrent life threatening infections and death in the first year if untreated.	Can be managed with early antibiotics and isolation and consideration of stem cell transplant if the condition is diagnosed. This improves survival and health outcomes
Spinal Muscular Atrophy (SMA) Introduced 2025	1 in 10,000	SMN1 gene	Rare inherited neurogenetic condition which affects the motor nerves in the spinal cord (motor neurons), causing muscle weakness. Babies may look healthy at birth, but as motor nerves are lost, the muscles become weak, causing difficulties with motor development, breathing and swallowing.	Gene replacement therapy is now available and so early detection and treatment where appropriate is possible

Investigation of Suspected Cystic Fibrosis

- Immunoreactive trypsin levels are checked as part of the Guthrie screen.
- The IRT level is high at birth in carriers and most patients with CF but declines after the newborn period.
- The current process following a positive IRT result is as follows.



- 3 mutation screen – at least 1 present in 98% of NZ CF patients therefore 2% missed
- Screening - 8% false negative rate (a low IRT in those with minimal pancreatic insufficiency and no CFTR genetic mutations detected)
- Screening - 92% false positive rate from high IRT result (75% of those with a high IRT will be carriers only)
- Infants with meconium ileus should have CF genetic mutation analysis and a sweat test organised regardless of the newborn screen result as they often can have a low IRT and be missed on the newborn screen.
- Most useful screen for pancreatic insufficiency (PI) is faecal elastase. >200 is normal, 100-200 is moderate PI and <100 is severe PI.
- In cases where pancreatic insufficiency is suspected infants require supplementation with pancreatic enzymes.

Investigation of Neonates with a Family History of Metabolic Conditions

In these situations it may be necessary to investigate the baby earlier on rather than waiting for a Guthrie result to be available. If there are any concerns talk to the Neonatal Consultant who may need to discuss testing with the Metabolic Specialists or other Specialists at Starship.

- Cystic Fibrosis – take cord blood for CF gene panel and faecal elastase as soon as able after birth
- Hypothyroidism – take Guthrie test as usual at 48 hours and only do further TFT's if Guthrie is abnormal
- Phenylketonuria – take blood for amino acids on day 1
- Congenital Adrenal Hyperplasia – take blood for 17-hydroxyprogesterone on day 1
- Galactosaemia – take Guthrie at 48 hours of age but comment on the card that a sibling has galactosaemia to ensure an enzyme assay is also done
- Biotinidase deficiency – take Guthrie at 48 hours, no other specific tests required
- Maple Syrup Urine Disease – take Guthrie at 48 hours of age, need to wait until then for baby to become catabolic
- Other metabolic conditions need to be individually discussed with the Metabolic Team to decide on the most appropriate timing of tests. Often if there is a family history a plan will have been made prior to birth. An example is MCAD and Auckland have an extensive guideline on this.

❖ GENETICS

Ordering the most appropriate investigation to diagnose a potential genetic abnormality is a rapidly changing field. If in doubt ask.

Referrals to the genetic service in Christchurch is by email to genetic.servicenz@cdhb.health.nz to arrange inpatient review or outpatient clinic appointments

Antenatal

In pregnancies where there have been concerns about possible genetic diagnoses there should be letters under the mothers NHI. If they have seen a neonatal paediatrician there will be a letter or notes on health connect as well as in the fetal anomaly folder in reception.

The radiology investigations should be reviewed and these include the screening ultrasound scans as well as specific investigations such as MRI

The two approaches to genetic investigations are classified as:

- Non Invasive Prenatal (genetic) Screening Testing or NIPS
 - This is a screening test and possible diagnoses should be confirmed with a karyotype or microarray after birth
- Invasive (amniocentesis or chorionic villous sampling)
 - This is a diagnostic test and does not require repeating after birth
 - Amniocentesis results can be filed under laboratory or letters if done outside Christchurch.

Postnatal Tests

If there have been antenatal genetic tests taken and we are arranging follow-up postnatal genetics tests - please add the maternal NHI to the blood request form to assist the lab to link the results together in their assessment

Fluorescent In Situ Hybridisation (FISH) (1 ml Green top)

This is a preliminary test that is able to look for extra genetic material (such as when there is an extra chromosome in Trisomy 21 / 18 or 13), or absent material (eg 22q deletion). Definitive tests are always needed to confirm the results.

Please discuss with the SMO before giving parents any potential results, including provisional results

These results must be confirmed using a karyotype or microarray

Karyotype (1 ml green tube)

This refers to microscopic examination of the numbers of chromosomes and their appearance. It picks up aneuploidy (abnormal numbers of chromosomes (eg Trisomy or Monosomy) as well as observable deletions / translocations and duplications. The report includes % cells affected and whether likely mosaic.

It is recommended that we wait until the report is signed off in the lab before giving parents the results.

Microarray (2 full EDTA + Green) and also send the consent form to the lab

This refers to a more detailed examination of chromosomes where the chromosomes are examined as small sections of DNA material rather than as whole chromosomes. This is now the usual first line test where a range of indeterminable dysmorphic features are present. Decision is by the lead or ward round SMO. Consent from the parents is required. There is a patient information sheet available – [Consent and information for parents about microarray analysis](#).

The result takes 5-10 working days. Don't over promise the timing of a result.

If a microarray was taken antenatally, a repeat postnatal is not required.

Always discuss the finding with the lead SMO. If unavailable contact the consultant of the week.

A referral to the geneticist is usually made and they will visit once the result is through. If the baby's condition is critical inform them so that they can advise on additional tests.

Specific Genetic Studies

If a baby has been reviewed by a Geneticist they may request specific studies looking for a known genetic mutation

Whole Blood Exome testing

Whole blood genome testing is arranged by genetics in consultation with the lead SMO, and occasionally needs additional approval for high cost tests from the CD. The specific consent form is below.



CHL Genetic testing consent form v1.1 Ja

Sample for stored DNA, for later use

(Pink/EDTA)

Suggest this is taken ASAP if a metabolic or genetic condition is suspected and survival not expected.
Often requested by the geneticist (when they are unable to determine a condition clinically)

GENETIC TESTING REQUEST FORM				Extra copy to	Sample Collect DATE DD-MM-YY	Clinicians File #
Surname		Given Names		Charge to (HIC Code)	TIME: HH-MM	Requested by
DOB	Sex	Patient no. (NHI)	TAKEN BY		Beep no.	
Ward		Consultant			MCRN	
<p>Canterbury Health Laboratories will rely on the requestor to obtain informed consent for the requested tests, and any additional related tests, to be performed by the laboratory.</p>						
Test(s) requested: Two independent samples required (predictive testing)? Sample 1 <input type="checkbox"/> Sample 2 <input type="checkbox"/>				<input type="checkbox"/> Test at CHL <input type="checkbox"/> Test at external laboratory Please state which laboratory <input type="checkbox"/> Test on hold pending Sendaway Instruction Form <input type="checkbox"/> Urgent Reason for urgency		
Clinical details: <input type="checkbox"/> I acknowledge that informed consent is the responsibility of the ordering clinician. <input type="checkbox"/> Discussed with GNSNZ (where applicable). Details:						
Proband information: (Or other relevant family information)						
Collect these samples for: <div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> Karyotype or FISH Uth heq (green top) tube Adult: 4mL Child: 2-3mL </div> <div> <input type="checkbox"/> All other Molecular Tests EDTA (beewider top) tube Adult: 8mL Child: 2-5mL </div> <div> <input type="checkbox"/> Other (urine, buccal rinse, saliva, skin biopsy) Please discuss prior to collection. (03) 364 0548 or genlab.test@chlb.health.nz </div> </div>						

Trisomy 21

Diagnosis

The diagnosis of Trisomy 21 or Down Syndrome may have been confirmed on amniocentesis or raised as a significant possibility (high risk screening investigations) in pregnancy. In other cases (22% on a local 10 year audit 2023) it is considered for the first time after birth which can understandably be a shock for the family.

- Screening in pregnancy includes the maternal serum screening MSS1 (nuchal translucency measurement along with blood tests in the first trimester) or MSS2 to quantify the risk for aneuploidy such as trisomy 21
- Non-invasive prenatal screening (NIPS) from maternal blood can also screen for trisomy 21

Discussions with Family

It is important to minimise delay In discussing a possible new diagnosis of Trisomy 21 and ideally both parents should be present. Other considerations are below;

- Call the baby by their name
- Be honest and phrase positively with hope
- Not saying you are sorry that they might have Down syndrome
- Share the main neonatal challenges such as feeding, breathing support, but do not at this stage list all the organ systems that can be involved
- Rapid confirmation with FISH/ Karyotype
- Arrange follow-up discussions with the lead SMO within 1-2 days

Neonatal Findings

All babies are unique and this includes those with trisomy 21. Hypotonia is common and can impact particularly on feeding in the early neonatal period. They also have an increased risk of some neonatal complications that are listed below:

Respiratory

- Obstructive breathing pattern
- Pulmonary vascular development is different and pulmonary hypertension can occur

Cardiovascular

- Congenital heart disease in about 40% of cases (e.g VSD / PDA / ASD / AVSD)

Gastrointestinal

- Duodenal stenosis
- Hirschsprungs

Haematology

- Polycythaemia in the majority
- Transient Myelodysplasia (increased risk of Leukaemia)

Others

- Cataracts
- Thyroid dysfunction

Multidisciplinary Team/Referrals

- Involve the social worker, LC/SLT, developmental physio for all babies
- Social workers have information packs on Down syndrome for families
- Genetics referral at the time of diagnosis if there is an unbalanced Robertsonian translocation as extra tests and counselling would be required for recurrence risk
- Primary Paediatrician can refer to Genetics in outpatients if the parents have ongoing genetic questions
- Referrals to other specialties will depend on the organ systems involved

Investigations

- FISH is a rapid test to confirm trisomy 21 and results are available within 48hrs.
- Karyotype is required to confirm the type of Down syndrome – 95% are standard trisomy 21 but some are mosaic and some are due to a translocation and this has implications for further pregnancies
- Guthrie test is sufficient for screening for hypothyroidism and but formal TFT can be taken at a week of age
- CXR and ECG as baseline
- Pre and post ductal saturations if develops an oxygen requirement
- A POCUS heart should be done prior to discharge in all babies
- FBC to exclude leukaemia

Discharge Planning

- Lead SMO will change to H Bray or E Cloete for discharge planning and outpatient review if from Chch
- Audiology follow-up
- Child Disability Allowance
- Early Intervention
- Neonatal Outreach team
- Blue card if relevant
- Cardiology ECHO should be booked for 4-6 weeks if not able to be completed as an inpatient which is the primary goal

10 year Audit of babies with Trisomy 21 admitted to NICU

- 22% were diagnosed postnatally
- 90% required respiratory support
- Average length of stay was 6 weeks
- 70% discharged home with an NG and 15% on oxygen

Resources

- Ministry of Health - Recommended Clinical Practice Guideline for the Clinical Assessment and Management of Children with Down Syndrome
- NZ Down Syndrome Association
- <https://nzdsa.org.nz/>
- Down Syndrome Australia
- <https://www.downsyndrome.org.au/>

❖ NEUROLOGY

Hypoxic Ischaemic Encephalopathy

Definition

- Hypoxic ischaemic encephalopathy (HIE) is a type of neonatal encephalopathy caused by systemic hypoxia and/or reduced cerebral blood flow resulting from an acute peripartum event. It can be the consequence of perinatal, birth and/or neonatal asphyxia. HIE is classified as mild, moderate, or severe based on the modified Sarnat criteria for encephalopathy.
- Intrapartum hypoxia affects 3 - 5 per 1,000 live births with subsequent moderate or severe HIE in 0.5 -1 per 1,000 live births. Of these, between 10-60% die and at least 25% of the survivors have neurodevelopment sequelae.

Pathophysiology

This is complex and a process over time. The key processes are ischemia-reperfusion phases and primary and secondary energy failure.

- The **primary energy failure** occurs during the ischemic phase which involves ATP pump failure and entrapment of ions inside cells followed by water diffusion and restriction of its movement across membranes.
- Following this reperfusion and energy restoration occur with influx of reactive oxygen species toxins, and an inflammatory cascade. During the reperfusion phase, some cells may get “overwhelmed” and undergo **secondary energy failure**, apoptosis, necroptosis, or inflammation. The goal of therapeutic hypothermia, sedation, and minimal handling initiated in the early reperfusion phase is to slow down the reperfusion and inflammation process to allow cells to recover.
- A **tertiary phase** when gliosis and impaired oligodendrocyte maturation occurs can last years

Therapeutic Hypothermia

- This is so far the only proven effective evidenced-based intervention as shown by multiple well-designed RCTs and is currently is only validated for babies born from 35 weeks of gestation.
- Cochrane 2013 showed a statistically significant and clinically important reduction in the combined outcome of mortality or major neurodevelopmental disability to 18 months of age
- To be effective, it needs to be initiated as early as possible (preferably 1–2 hours but up to 6 hours is deemed the therapeutic window of opportunity)
- Many adjunct therapies (e.g. erythropoietin, stem cells, xenon, melatonin) to therapeutic hypothermia are being studied but as yet none have strong evidence supporting these.

Preterm Infants <35 weeks

- The prognosis after HIE in preterm infants seems to be poorer than in term infants.
- The early mortality rate is high (25–33%), partly related to the high incidence of central grey matter and brainstem injury and also to the associated multiorgan failure
- Most survivors develop some degree of developmental impairment.
- A randomized control trial of cooling was undertaken in the USA (Preemie Hypothermia for Neonatal Encephalopathy) in preterm infants with signs of HIE, enrolling 168 infants between 33- and 35-weeks GA and weighing more than 1500 g. The trial, completed in 2022 with follow-up at 18–22 months, showed no benefit of the cooling treatment, Death or disability occurred in 35% of cooled infants and 29% of non-cooled infants.

Adverse Effects of Hypothermia

- Mild hypothermia appears to be well tolerated.
- Adverse effects such as sinus bradycardia, increased blood pressure and increased oxygen requirement are transient and reversible with re-warming
- There has been a median increase in FiO₂ of 10–15% reported in infants with severe respiratory failure (oxygen requirement greater than 80%) up to 6 hours of age and because of this they are not eligible for cooling.
- Increase in the rates of thrombocytopenia

Cerebral Function Monitor (Brainz Monitor)

- Amplitude-integrated EEG recordings with a “cerebral function monitor”, obtained continuously from two biparietal electrodes, have been shown to be useful in the early prediction of the severity of brain injury.
- The Brainz monitor should be placed early on any baby with HIE, encephalopathy or seizures
- A daily report should be documented on the [Hypoxic Ischaemic Encephalopathy Assessment and Management](#) form and the trace discussed with a SMO/Fellow and representative images saved to Celo under the patient's NHI on HCS
- The different types of trace on the aEEG are described below and examples of the traces can be found in the information booklet attached to the machine.:

CNV **Continuous normal voltage:** upper margin >10 uV, lower margin > 5 uV, continuous activity

DNV **Discontinuous normal voltage:** upper margin > 10 uV, lower margin < 5 uV, discontinuous activity

BS **Burst suppression:** upper margin < 10 uV with high amplitude bursts, discontinuous activity

LV **Low voltage:** upper margin < 5 uV, minimal activity

S/W **Sleep/wake:** narrow trace when awake or in active sleep, wider when in quiet sleep

SZ **Seizures:** rapid rise in baseline voltage with corresponding spike/wave raw signal lasting at least 10 secs

- During therapeutic hypothermia (TH), the recovery time taken to achieve a normal background pattern is the best predictor of good and poor outcomes. (Ref 1)
- Among infants who never gain a normal trace, all had poor outcomes and 72% died.
- High electrographic seizure burden (>40 min) is associated with abnormal long-term outcomes, independent of HIE severity or therapeutic hypothermia. (Ref 2)

(1) Thoresen M, Hellstrom-Westas L, Liu X, de Vries LS. Effect of hypothermia on amplitude-integrated electroencephalogram in infants with asphyxia. *Pediatrics*. 2010;126(1): e131–9.

(2) Kharoshankaya L, Stevenson NJ, Livingstone V, Murray DM, Murphy BP, Ahearne CE, Boylan GB. Seizure burden and neurodevelopmental outcome in neonates with hypoxic-ischemic encephalopathy. *Dev Med Child Neurol*. 2016;58(12):1242–8.

Hypothermia Protocol

Inclusion Criteria

- Infants ≥ 35 weeks gestation
- Evidence of moderate or severe encephalopathy (Sarnat 2 or 3)
- Evidence of intrapartum hypoxia, at least two domains as below:
 - Apgar score ≤ 5 at 10 minutes
 - Mechanical ventilation, CPAP **or** ongoing resuscitation at 10 minutes
 - Cord pH **or** arterial/capillary pH < 7.0, **or**, base deficit of ≥ 12, **or**, lactate ≥6mmol/ L within 60 minutes of birth

Exclusion Criteria

- Cooling cannot be started within 6 hours of birth
- Birth weight less than 1.8 kg
- Major congenital abnormalities
- Severe hypotension, pulmonary hypertension or coagulopathy unresponsive to treatment within 6 hours
- Infants requiring inspired oxygen >80% and not responsive to treatment within 6 hours
- Infants in extremis and not expected to survive

Cooling on Transport

- Cooling can occur on a retrieval as long as the case has been discussed with the NICU consultant and the management deemed appropriate for that baby.
- The referring peripheral unit should not start passive cooling (and should never do active cooling) until after a discussion has occurred with the NICU team. There is a passive cooling protocol to provide advice for the referring unit in the Transport handbook
- The cooling ice packs would need to be taken out on the retrieval so discussion with the consultant before departing would be prudent

Cord Blood Gases

- Should be requested for any delivery where the baby requires resuscitation of (> 2 minutes duration.)

Placental Histology

- Should be requested for any baby admitted with Apgar <6 at 5 mins or who you think may be considered for cooling.
- Remember to ask for the placenta to be held if the baby is to be retrieved from a peripheral centre

Documentation

- [Hypoxic Ischaemic Encephalopathy Assessment and Management](#) form is to be filled in by the clinician (NNP, Reg, SMO) making the decision to cool
- This can be found in the Neonatal Handbook folder under “other guidelines” and should be used as a decision tool to help deciding whether to cool or not
- This form also documents relevant information such as timing of cooling, grade of HIE, aEEG findings, dates for follow-up MRI and developmental exam

Sarnat Stages for HIE

Always discuss with a consultant when a baby meets criteria for HIE as Sarnat scoring can be difficult.

- Stage 1:** Hyperalertness, increased activity, hyper-reflexia, hypertonic, reactive pupils, normal heart rate, seizures uncommon
- Stage 2:** Lethargy, hypotonia, constricted pupils, bradycardia or irregular breathing, weak suck and Moro reflex. Seizures. EEG shows abnormal background activity
- Stage 3:** Stupor, flaccidity, small or deviated pupils which react poorly to light, decreased or absent reflexes, seizures often absent but may have decerebrate posturing

Management of Babies Commenced on the Hypothermia Protocol

The key concepts in the acute brain injury prevention are:

- early identification and referral
- optimal transition from fetal to neonatal circulation
- restore perfusion and oxygenation and glycemia as quickly and effectively as possible
- prevent fluctuations in physiologic parameters such as pCO₂, blood pressure, avoidance of hyperoxia, hypocarbia and hyperthermia
- minimal handling
- pain management
- clinical and electrical seizures should be treated quickly and effectively, and this means that aEEG monitoring needs to be instituted.
- early nutrition
- normoglycemia
- treatment of acidosis
- optimizing fluid and electrolyte balance including calcium
- evidence suggestive of infection should be sought (e.g. prolonged rupture of membranes, maternal fever, chorioamnionitis either from the history and directly in the baby) and treated until proven negative.
- A detailed discussion between the parents and consultant must occur prior to commencement of cooling.
- All infants should have venous and arterial catheters inserted if possible.

Cooling Protocol

- All infants will be nursed on an overhead.
- Core temperature to be lowered to 33.0°C–34.0°C.
- Temperature will be measured continuously by a thermistor inserted 5 cm into the rectum.
- Cooling will be started and continued for 72 hours.
- Cooling should preferentially be done with the cooling mattress which has a feedback mechanism from the baby's rectal temperature and the cooling machine.
- Cooling can also be achieved by using cool packs of around 10°C be applied to the back of the neck and head, and across the torso. Active cooling will be reduced when the rectal temperature falls below 34.5°C and stopped when below 34.0°C. If the temperature falls below 33.5°C, the heater output on the radiant warmer will be manually adjusted to maintain the target rectal temperature at around 33.5°C.
- Active cooling will be reduced if the inspired oxygen increases by more than 20%

- Cooling will be stopped if there is:
 - persistent hypoxaemia in 100% oxygen
 - life threatening coagulopathy
 - an arrhythmia requiring medical treatment (not sinus bradycardia)
- After 72 hours, rewarming will occur at a rate not exceeding 0.5°C every 2 hours and stopped when the core temperature is 37 degrees

Monitoring

For 72 hours infants will be carefully monitored by:

- continuous invasive blood pressure measurements if able to be sited
- oxygen saturation
- heart rate
- respiration rate
- urine output
- ECG
- aEEG

Fluids

Most babies will be fluid restricted:

- Day 1 - total daily fluids of 40-60 ml/kg/day
- Day 2 - 40-80 ml/kg/day
- Day 3 - maximum of 90 ml/kg/day unless decided by SMO in complex haemodynamic cases
- Reduced enteral feeding should be given with caution but is advisable unless gut perfusion is very compromised and should be discussed with the SMO during cooling.
- Generally no contraindications to trophic feeds as soon as EBM is available
- Not all cooled babies will need TPN and when fluid restricted it may not be practicable unless concentrated TPN is used. Could consider TPN over the first few days if feed intolerance becomes an issue

Sedation

- Dexmedetomidine is the preferred sedation option, especially in a non-ventilated baby
- Maximum dose of rate should be 0.2microgram/kg/hr as the drug accumulates during hypothermia and can cause severe bradycardia.
- Morphine can be used as an adjunct in a ventilated baby or in a baby who is not on invasive ventilation and is showing signs of distress/discomfort during the cooling period

Investigations

- Blood tests may need to be done daily and should be discussed on the ward round
 - blood gases, lactate, glucose
 - electrolytes, urea, creatinine, calcium, magnesium (NEON)
 - liver function tests (are not usually needed daily)
 - full blood count
 - coagulation profile (usually no need to repeat if the first one is normal)
- Hypocapnia (pCO₂ <35mmHg) has been associated with a worse survival and neurodevelopmental outcome so careful monitoring of pCO₂ during cooling is crucial and correct sample temperature should be entered on the blood gas analyser to correct hypothermia effect on analysis. If pCO₂ is volatile the use of transcutaneous CO₂ monitoring can avoid repeated blood sampling (especially in a baby that does not have arterial access)
- Head ultrasound scan before cooling if concerns about brain bleed or to exclude other cause of seizures (can be done as POCUS head scan if out of hours)
- Heart POCUS prior to cooling if hemodynamically unstable or if requiring inotropic support and to assess for pulmonary hypertension
- Early and late head MRI scans on day 4-5 after rewarming and on day 10-14 with discussion of the results with parents
- Formal continuous EEG to be discussed with SMO and neurophysiology department only if required
- Hammersmith neurological examination around day 7 by developmental physiotherapist

Brain MRI

- This is the gold standard for detecting and defining the extent of acute injury after perinatal asphyxia. Brain MRI is done shortly after rewarming to help with counselling families as soon as possible
- The **first MRI** is done between days 4–5 to take advantage of information from diffusion-weighted imaging (DWI)
- The **second MRI** is done around day 10 to see maximum injury on conventional MRI sequences. Occasionally this scan may be omitted if the initial MRI has shown no abnormalities, the aEEG trace was not concerning and the baby is progressing well with feeding and from a developmental assessment perspective
- A formal meeting should be held with the parents after each MRI either by the lead SMO or the SMO on service

Neonatal Seizures

Notify the consultant of the admission of any baby with suspected or proven seizures.

There are multiple possible causes, including:

- Birth asphyxia
- Intracranial haemorrhage eg: IVH, intracerebral, subarachnoid, subdural,
- Metabolic disturbance
 - Hypoglycemia
 - Hypocalcemia
 - Hypo/hyponatremia
 - Hypomagnesemia
 - Hyperammonemia
- Secondary to inborn errors of metabolism
- Infection
 - Viral eg. HSV
 - Bacterial
 - Protozoal eg. toxoplasmosis
- Anatomical abnormalities
- Intoxication (e.g. inadvertent injection of local anaesthetic into fetus)
- Drug withdrawal

Presentation

This may be quite subtle e.g. dusky spells, apnoea, or with obvious clonic or tonic-clonic movements.

The following table is from the ADHB guidelines.

Type	Physical Features	EEG
Subtle	<ul style="list-style-type: none"> • Eye signs - eyelid fluttering, eye deviation, fixed open stare, blinking • Apnoea • Cycling, boxing, stepping, swimming movements of limbs • Mouthing, chewing, lip-smacking, smiling 	<ul style="list-style-type: none"> • Often no EEG changes. • EEG changes most likely to occur with ocular manifestations
Tonic	<ul style="list-style-type: none"> • Stiffening • Decerebrate posturing 	<ul style="list-style-type: none"> • EEG variable
Clonic	<ul style="list-style-type: none"> • Repetitive jerking, distinct from jittering • Can be unifocal or multifocal 	<ul style="list-style-type: none"> • Usually changes identified
Myoclonic	<ul style="list-style-type: none"> • Rare • Sleep myoclonus is benign 	<ul style="list-style-type: none"> • EEG often normal • Background EEG can be abnormal

Investigations

- FBC, Electrolytes, Blood glucose
- Blood cultures, urine cultures, CSF (don't forget contraindications). Send sufficient specimen for viral studies, including HSV PCR. It may be helpful to send an extra tube of CSF and ask the lab to freeze it, especially if an infectious or metabolic cause is suspected.
- Throat swab, stool specimen for virology
- Aspirate and swab any skin lesions. Discuss with virology. In general they will send a vial of viral transport medium. A swab tip can be broken into this.
- Immunofluorescence specimens are collected by scraping the base of a vesicle and smearing the material onto a glass slide (supplied from virology). This slide should be transported in a rigid plastic container.
- Blood gases
- CXR, cranial ultrasound, urgent CT if suspicion of a subdural haemorrhage.
- Investigation of suspected inborn error as above.
- EEG / BRAINZ monitor
- It is not necessary to defer therapy until an EEG can be obtained.
- EEG may assist in confirming that subtle phenomena are seizures or to determine if a paralysed infant is having seizures.
- The interictal EEG (full 16 lead) may be useful in estimating prognosis particularly in HIE.

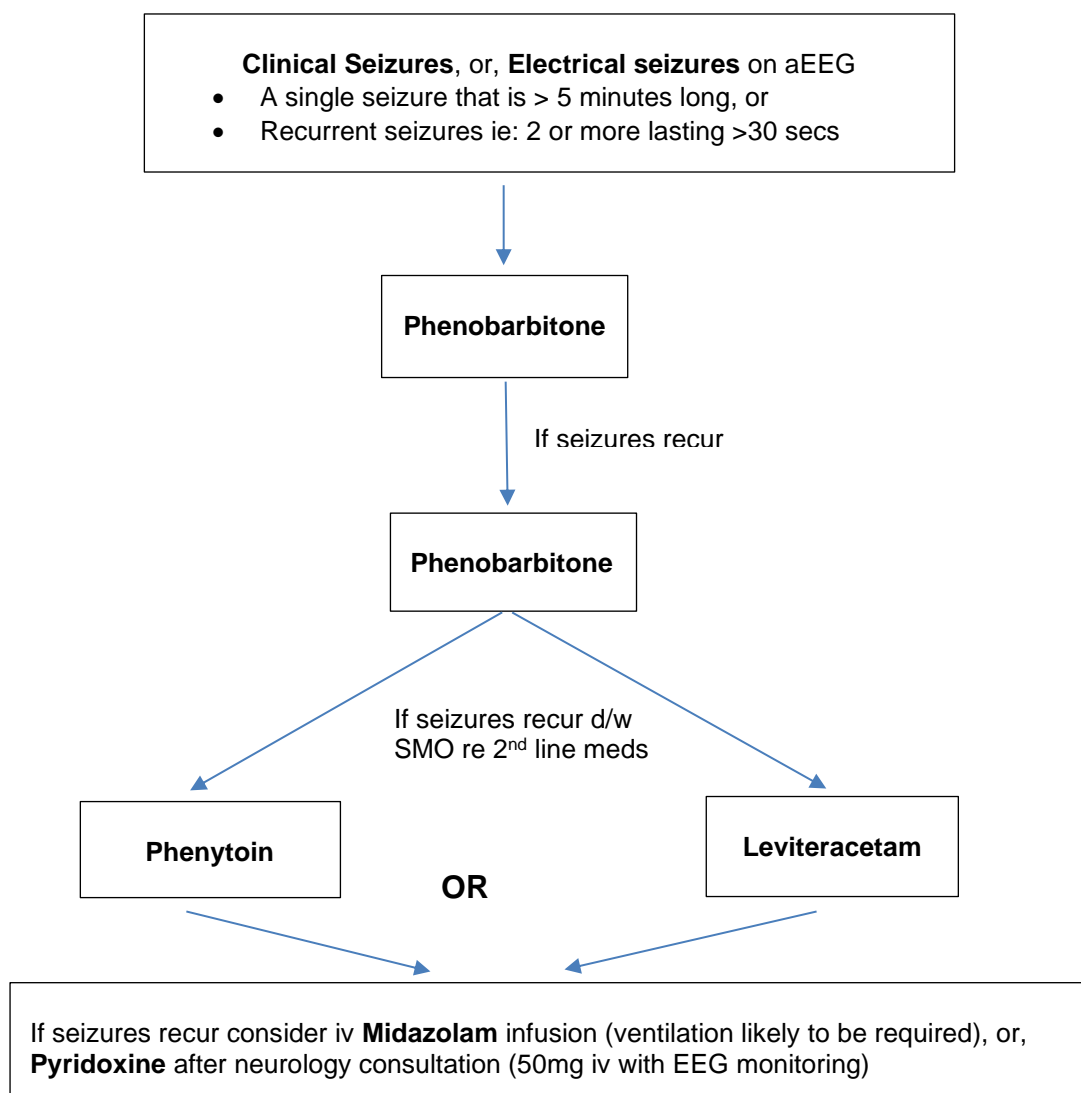
Diagnosis and Management

- Involves a full history and examination particularly with reference to the above aetiologies.
- Management directed to the cause if known.
- Avoid hyperthermia – see protocol. Maintain temperature within 35.5 to 36.5 °C
- Ventilation if apnoea or hypoventilation secondary to seizures or anticonvulsant therapy.

Anticonvulsants

- The commonest reason to need anticonvulsants in NICU is due to HIE, followed by cerebral infarcts or haemorrhage
- Aggressively treating aEEG seizures versus clinical seizures will reduce the seizure burden but does not necessarily lead to improvement in neurodevelopmental outcome
- If seizures are treated early and appropriately they are easier to control so we would advocate early use of anticonvulsants when seizures are present, although it can be hard to know if all electrical seizures need to be treated

Initial Management Flowchart (see next page)



- Note that the SMO may deviate from the above flowchart. For example:
 - Midazolam may be given earlier if the baby is already ventilated
 - Further phenobarbitone doses (to a maximum of 40mg/kg) may be suggested if already on two anticonvulsants to maximise drug levels prior to considering a third anticonvulsant
- The underlying cause of the seizures and likelihood of seizures stopping as the baby recovers need to be considered when giving repeated doses of sedating medications which may lead to oversedation and the need for increasing respiratory support
- Studies have shown that phenobarbitone remains the most successful anticonvulsant in neonates and leviteracetam is not superior to phenobarbitone (*Leviteracetam vs Phenobarbital for neonatal seizures: a RCT. Pediatrics 2020; 145.*) Leviteracetam may be used as a secondline agent and is an easier drug to use for longer term maintenance therapy
- Maintenance anticonvulsants and drug levels are not usually required
- Recommend anticonvulsants are discontinued before discharge after seizures stop irrespective of the MRI and EEG findings in most cases.
- Formal EEG may be helpful if the baby does not follow a typical course, if the seizures do not stop or if recommended by the Neurology team.

Brainz Monitor

- The BRAINZ monitor is a type of cerebral function monitor but does not give the same information as a standard 16 lead EEG.
- It does have the advantage of easy use in a neonatal intensive care situation and has been proven to be of use in the detection of neonatal seizures and significant cerebral dysfunction.

Indications

The following infants should be considered for BRAINZ BRM2 monitoring.

- Infants $\geq 34/40$ with:
 - Definite or possible seizures
 - Muscle relaxed infants at risk of seizures that may not be clinically apparent
 - Moderate perinatal asphyxia (Neonatal encephalopathy, Sarnat 2 or 3)
 - Unexplained apnoea
- Monitoring on other babies should not be commenced unless directed by a specialist.

Application

- Sensors to be applied by Newborn Medical and Nursing staff who have undertaken BRAINZ BRM2 training.
- See instructions on monitor and make sure to enter the correct date and time
- Needles
 - Clean the skin with 2% chlorhexidine and part the hair
 - Insert needles in the appropriate spots, attach the reference sensor on to the back
 - Dry the area around the needles and secure with a steristrip
- Electrodes – the key to good application is patience and a stepwise approach
 - Ensure the purple end has straight (not bent) connecting “teeth”
 - Warm the sensors in the incubator or under the radiant warmer
 - Use the ruler provided to ascertain where the sensors should be placed
 - Place them around any injury ie: cephalhaematoma and mirror the position on the other side
 - Prepare the skin by parting the hair and rubbing a small amount of abrasive gel 10-15 times over a larger area than is required to fit the sensor on
 - Place the sensor in the correct spot and hold it there firmly for 30 seconds to allow the hydrogel to warm and bond with the skin
 - Only add water from the outside of the sensor if needed if the hydrogel dries out
- See basic EEG atlas pictures of BRAINZ abnormalities on G: drive / brainz.

Documentation

- Assessment of the background activity, presence of seizures and R/L asymmetry are important to note.

Intraventricular Haemorrhage

- Incidence in babies <1500gm is up to 25%, and is highest in gestation < 26 weeks
- Caused by bleeding into the subependymal germinal matrix \pm extension into the ventricle or parenchyma
- The bleeding occurs mainly in the first few days after birth and can be detected by head US:

Day 1 – 50% detected

Day 2 – 75% detected

Day 3 – 90% detected

Grade 1 - Bleeding limited to the germinal matrix

Grade 2 - Blood extending into the ventricle but not distending the ventricle

Grade 3 - Blood extending into the ventricle and filling (over 50%) and distending the ventricle with blood, ventricular dilatation is present.

Grade 4 - Parenchymal bleeding with or without blood in the ventricle

Risk Factors

- Lower gestational age
- Lack of antenatal steroids
- Unstable haemodynamics
- PDA, Sepsis

Monitoring

- Head US scans on day 3-5, 7-10 and at 6 weeks in all <1500gm and <32 week gestation babies
- Head US scans on day 14 and 28 as well if significant abnormalities
- See checklist for babies <1500gm

Post Haemorrhagic Ventricular Dilatation

Definition

- Posthaemorrhagic ventricular dilatation (PHVD) is defined as progressive ventriculomegaly after an intraventricular haemorrhage (IVH).
- The ventricular width at the intraventricular foramen exceeds 4mm over the 97th centile for gestational age (see *Neonatal Intranet* under “Other Guidelines” – Levene index).
- The overall risk of PHVD after an IVH is about 25%. However, the risk increases with the severity of the IVH: (*Arch Dis Child Fetal Neonatal Ed* 2002;87:F37-41)

Grade 1 IVH	4%
Grade 2 IVH	12%
Grade 3 IVH	74%
Grade 4 IVH	71%

Pathogenesis

- CSF is produced by the choroid plexus and reabsorbed by the arachnoid villi and across the ependyma into small blood vessels. After an IVH there are multiple small blood clots that prevent CSF reabsorption. Plasminogen in the CSF attempts to fibrinolyse the blood but is often ineffective.
- Over time transforming growth factor $\beta 1$ (TGF $\beta 1$) is released into the CSF and causes deposition of extracellular matrix proteins and this can further inhibit reabsorption leading to communicating hydrocephalus.
- The extracellular proteins can also cause obstructive hydrocephalus by blocking the exit to the fourth ventricle.

Management

- Infants with progressive ventricular dilatation are managed with the aim of preventing secondary damage due to raised intracranial pressure and avoiding the need for a permanent shunt if at all possible.
- About 50% of infants will show resolution of their dilatation and not require surgery.
- Studies have reviewed a number of non-surgical treatment modalities and they have been shown to be ineffective or high risk procedures - these include repeated lumbar punctures or ventricular taps, diuretic therapy with acetazolamide and frusemide and intraventricular fibrinolytic therapy.

Surgery

- Surgical interventions for PHVD are the mainstay of treatment and are needed if the ventricular dilatation progresses and is associated with raised intracranial pressure.
- About 30% of infants with PHVD will need surgery.
- External ventricular drains can be placed subcutaneously in the scalp with a catheter in the ventricle and allow easy access for repeated drainage of CSF to remove blood and protein and to normalise intracranial pressure.
- The risks include infection, skin breakdown and blockage with blood clots.
- This is usually a temporary measure and be all that is required if the ventricular dilatation stops progressing.
- A permanent ventriculoperitoneal (VP) shunt is needed if the ventricular dilatation is unremitting.
- These can not be placed early due to risk of blockage if the protein component of the CSF is >1.5g/L.
- VP shunts carry a high risk of infection and blockage.

Outcome

- The outcome after PVHD is poor.
- About 20% of infants will die and those that survive have high rates of neurodevelopmental disability.

❖ METABOLIC / ENDOCRINE

Hypoglycaemia

Definition

- Data suggests that there may be sequelae from blood sugar values < 2.6 mmol/L (Lucas 1988), however, there is no clear consensus as to what threshold to use in treatment of hypoglycaemia. In a recent survey of all units in the Australia New Zealand Neonatal Network < 2.6 mmol/L was used in all units and is the cut off used in a New Zealand collaboration of clinical practice guidelines on treatment of neonatal hypoglycaemia with oral dextrose gel.
- If any baby shows symptoms that could be due to hypoglycaemia, a blood sugar level should be measured immediately

Background

- Healthy term infants are able to mobilise energy stores through a process known as counter regulation and are unlikely to suffer any ill effects if fed infrequently in the first 24-48 hrs. Some babies however are less able to mount this response and these babies are at greater risk of hypoglycaemia.
- Regular assessment and documentation of all infants should occur including assessment of feeding regardless of risk factors. All assessments should be documented on the neonatal observation chart if on the postnatal ward.
- Healthy term infants do not require routine monitoring of blood sugars but at risk babies need to be identified and monitored accordingly.
- Hypoglycaemia may be asymptomatic or symptomatic, but both can result in adverse outcome such as brain injury, neurodevelopmental delay and death.
- Symptoms are wide ranging and include poor feeding, altered level of consciousness, cyanosis, jitteriness, seizures, apnoea, tachypnoea, irritability, hypotonia, sleepiness and floppiness
- Hypoglycaemia needs to be suspected or prevented and actively investigated and treated in any unwell baby
- Please be aware that colostrum and milk mixture are not equivalent. Give whatever colostrum is available and recheck before considering infant formula. Women who have collected colostrum antenatally will have a limited resource available.
- Dextrose gel with milk feeds has been shown to be better than feeding alone to reverse neonatal hypoglycaemia in babies from 35 weeks gestation and under 48 hours of age. This in turn reduces maternal infant separation by reduced admission to the Neonatal Unit and encourages the establishment of breast feeding.

Infants at high risk of hypoglycaemia

- Preterm < 37 weeks
- Small for gestational age $< 9^{\text{th}}$ percentile (on UK-WHO growth chart Ref.2400521)
- Macrosomic babies $> 98^{\text{th}}$ percentile (on UK-WHO growth chart Ref.2400521)
- Baby of a mother with diabetes
- Hypothermic infants
- Severe intrapartum fetal distress or cord lactate > 5.8 mmol/L
- Asymmetric growth (weight centile more than 2 centile lines lower than head and length centile) in conjunction with another risk factor e.g. intrapartum fetal distress or meconium
- Unwell infants
- Sepsis
- Ultrasound abnormalities in utero such as agenesis of the corpus callosum, septic-optic dysplasia or absent cavum septum pellucidum (See Antenatal Ultrasound Abnormalities)
- Infants diagnosed or suspected of Beckwith Weideman Syndrome

Transient Hypoglycaemia

- Decreased glucose production or increased utilisation
- Asphyxia, starvation, sepsis, congenital heart disease, hypothermia, SGA
- Transient hyperinsulinism
- Infant of a diabetic mother, LGA, SGA, rhesus haemolytic disease, Beckwith-Weideman syndrome.

Persistent or Severe Hypoglycaemia

- Hyperinsulinism
- Congenital hyperinsulinism, pancreatic adenoma, leucine sensitivity.
- Decreased production of glucose
- Glucagon deficiency, congenital hypopituitarism, cortisol deficiency (CAH), inborn errors of metabolism.

RED FLAG: A baby with severe or persistent hypoglycaemia without a clear common cause such as, a baby of a diabetic mother, or being growth restricted should be an alert to a less common cause which could be endocrine or metabolic in origin

Management of Hypoglycaemia on Postnatal Wards (BSL <2.6 mmol/L)

Indication to Call Neonatal Team Immediately

- Apnoea
- Cyanosis
- Altered level of consciousness
- Seizures
- Abnormal tone
- Blood glucose <2.0mmol/L

Management

- Care to be provided on the postnatal ward unless the baby is symptomatic in which case refer and transfer to the neonatal unit (see flow chart below for babies ≥ 35 weeks gestation within 48 hours of birth),
- Infants at risk of hypoglycaemia should be fed as soon as possible, preferably within the first hour and then fed at least 3 hourly
- The first blood sugar should be checked pre-feed 3-4 hours after birth (this is to avoid the natural nadir in BSL levels) and should continue to have 3 hourly feeds until a total of 3 consecutive pre-feed measurements are ≥ 2.6 mmol/L
- If any recording of BSL <2.6 has occurred, feed the baby at least every 3 hours with blood sugars prior to feeds until there have been 3 subsequent and consecutive BSL's ≥ 2.6 and the baby is feeding well without supplemental feeds
- If a baby has not had low sugars but changes from breastfeeds with top-ups to fully breastfeeding a pre-feed BSL is recommended
- The Accu-chek monitors is used for blood sugar measurement and is accurate at low levels. If there is any concern regarding the result use the blood gas analyser as it is more reliable. The Maternity Clinical Coordinators are able to process blood samples through the blood gas analyser to confirm hypoglycaemia prior to giving iv glucose. **Do not delay treatment.**
- Give colostrum and recheck BSL before considering the use of formula
- If there are concerns about the adequacy of the first feed or concerns about milk transfer then discuss with the parents the option of EBM, harvested colostrum, pasteurised donor breast milk or infant formula
- Prior to any administration of infant formula, ensure mothers have had lactation support including LMC/Midwife or lactation consultant and are regularly expressing. Ideally babies should be skin to skin with their mother whilst feeding by any method
- If formula is indicated give 5-10ml/kg per feed and assess response
- Hypoglycaemia usually resolves in the first 24-48 hours depending on the cause
- The desired outcome from this treatment is that the blood glucose is restored quickly to the normal range without disruption to the establishment of breast feeding and maternal-infant bonding.
- Babies at risk of hypoglycaemia can discontinue blood glucose measurements when they are feeding well without the use of dextrose gel, and without additional supplementary feeds or top ups AND have three consecutive pre-feed blood glucose concentrations ≥ 2.6 mmol/L

Dextrose Gel

- To be used only in the first 48 hours after birth for well babies ≥ 35 weeks gestation
- 40% dextrose gel solution
- Dose is 200mg/kg (0.5mL/kg), prescribed by the neonatal team. Verbal order is allowed if there are delays in prescribing on the drug chart

- Use oral single use syringes to withdraw doses. See Neonatal Drug profile for further details.
- Use non-sterile latex free gloves, dry the baby's inner cheek with sterile gauze and then massage the dextrose gel into the buccal mucosa.
- Administration of dextrose gel should be at least 30min apart
- Maximum of 6 doses of dextrose gel in 48 hours

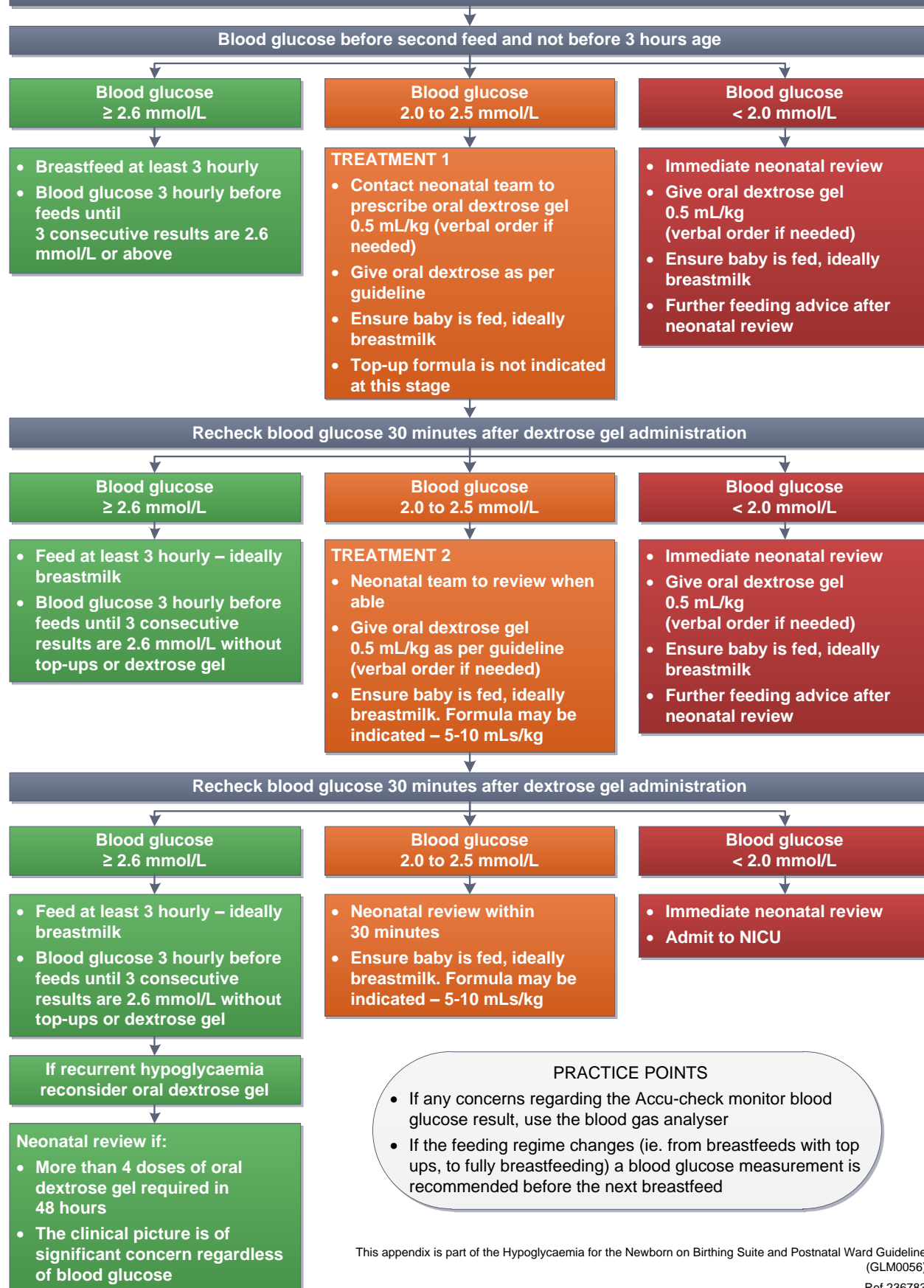
Referral Criteria for Neonatal Assessment

- If blood glucose is below 2.0 mmol/L at any stage to consider NICU admission
- If blood glucose is below 2.6 mmol/L after the second or third feed despite dextrose gel administration
- Any clinical signs of hypoglycaemia
- If more than 4 doses of dextrose gel are required in the first 48 hours
- Request neonatal daily review for babies who develop hypoglycaemia (2.0-2.5mmol/L) even if the post-feed BSL improves according to the feeding protocol
- If the clinical picture is of significant concern that may indicate the baby is unwell regardless of the blood glucose level

Babies at Risk of Hypoglycaemia Flowsheet

NOTE: Oral dextrose gel is used to treat neonatal hypoglycaemia ≥ 35 weeks and < 48 hours after birth

FEED IN FIRST HOUR THEN AT LEAST 3 HOURLY, KEEP WARM INCLUDING SKIN TO SKIN



Management of Hypoglycaemia in NICU

- If care on the postnatal ward cannot maintain the BSL's or baby is symptomatic admit to NICU
- Recheck the BSL on the gas analyser to confirm hypoglycaemia before making a management plan as glucometers are less accurate at lower blood glucose levels
- If severe hypoglycaemia and iv access is difficult or delayed consider using an im glucagon bolus (200 mcg/kg) to elevate the blood sugar whilst working on iv access as this can elevate the BSL for up to 2 hours
- **Dextrose gel is usually not appropriate for hypoglycaemic babies on NICU as they are too preterm, have already failed dextrose gel or are unwell with increased metabolic demands**

BSL <1.5mmol/L or symptomatic hypoglycaemia

- Immediate intervention is required with iv therapy
- If able, take the bloods for a hypoglycaemia screen at iv insertion but do not delay treatment if there is difficulty in obtaining the samples
- Give 2ml/kg 10% dextrose at 2mls/min - be aware of rebound hypoglycaemia
- A bolus must be followed by a continuous infusion of dextrose
- Start at 65ml/kg/day and increase up to 90ml/kg/day if the subsequent BSL remains < 2.6mmol/L
- If already on a dextrose infusion then the rate or concentration of the infusion needs to be increased after a subsequent bolus
- Recheck the BSL in 30 minutes
- Total fluid volume in day 1 should be limited to 100ml/kg/day otherwise issues arise with hyponatraemia from free water overload. Other options include increasing the dextrose concentration from 10% to 12.5% to 15% to maintain the BSL.
- Central iv access is required if concentration is $\geq 12.5\%$ but a peripheral iv with 12.5% can be used temporarily until central access is obtained
- Dextrose concentrations >25% should not be given

IV Glucose Infusion Calculator (courtesy of Dr Ben McConchie, Paediatrician, Timaru)

- Located on the Neonatal Intranet under Calculators tab
- This tool will be helpful in babies with unstable blood sugars or intractable hypoglycaemia requiring frequent adjustments of their dextrose infusions
- Two dextrose infusions will run simultaneously (10% and 50% dextrose) with a Y connector and the rates of each infusion are altered to achieve the overall dextrose % required that will enter the baby.
- This will remove the need to making up new fluid bags each time a change is requested
- The tool also calculates the glucose load in mg/kg/min so it is obvious what changes are being made
- To make it clear that the infusions are different strengths – run the 10% dextrose on the usual Alaris VP pump and the 50% dextrose on the Alaris CC pump (50% dextrose will be added to the guardrail library in 2024)
- This is a tool only and not a prescription. It does not need to be printed off.
- Wean the baby down to 10% or 12.5% dextrose and when stable change to a single bag of this to allow titration with enteral feeds in the usual fashion
- This tool is only for iv fluids and not for feed titration

Starship Glucose Calculator

- This is another calculator that can calculate the total glucose load of iv fluids and/or enteral feeds
- It is a great tool to use for babies who are grading up or down on 10% dextrose infusions, enteral feed volumes or polycal additives to be aware of the changes to the glucose load
- Calculate the glucose load in mg/kg/min with each alteration in fluid rate or concentration
- If manipulating dextrose concentrations and rates > 10 mg/kg/min are not sufficient to maintain BSL's then additional pharmacological management may be required after consultation with Endocrinology and a cause for the hypoglycaemia found
- Medications may include – glucagon infusion, diazoxide, hydrocortisone, octreotide
- To discuss on ward rounds with the SMO when it is safe to start weaning iv fluids – usually when BSL's have been stable for 12 hours and there is no feed intolerance
- Gradually wean and overlap to enteral feeds – be aware of the severity and persistence of hypoglycaemia to guide the rate at which to wean. If in doubt discuss with the SMO
- Use the glucose calculator as a guide to the drop in mg/kg/min when alterations are being made to ensure changes are not too aggressive

- Make sure to check the glucose intake if a drip tissues and a plan is made to increase enteral feeds faster and not replace the line as the glucose intake may be significantly lower running the risk of hypoglycaemia recurring
- BSL must continue to be monitored when weaning (see below)

BSL 1.5-2.5mmol/L

- If the baby is asymptomatic and has not responded to dextrose gel, breastfeeds or top-ups on maternity then place a nasogastric tube and feed enterally between 65-90ml/kg/day depending on their age and previous milk intake volumes as a 1-2 hourly feed volume
- Breastmilk volumes will likely be insufficient and so pasteurised donor milk (PDM) or formula will be required. PDM should be offered first but if this is declined then consent for formula will be needed or iv fluids used. If parents are concerned because of a family history of cow's milk allergy then Peptijunior or Neocate may be used in the short-term but this needs to be discussed with the SMO and dietitian.
- If BSL 1.5-1.9mmol/L - consider a 2ml/kg 10% dextrose at 2mls/min bolus and start an IV infusion of 10% dextrose at 65ml/kg/day or if already on a dextrose infusion increase the rate or concentration and recheck the BSL in 30 minutes
- If BSL is 2.0-2.5mmol/L consider increasing the feed volume if tolerated or start an iv infusion as above and recheck the BSL in 1 hour
- Calculate the glucose load in mg/kg/min with each alteration in fluid rate or concentration ([Click Here](#))
- Wean iv fluids when BSL have been stable for 12 hours as per the section above.

BSL Monitoring

- Every 30 minutes until $\geq 2\text{mmol/L}$, then,
- Hourly until $\geq 2.6\text{mmol/L}$, then,
- 4-6 hourly prefeed but this is very dependent on the clinical context and will be individualised
- Transient hypoglycaemia - stop BSL when there are 3 consecutive BSL $\geq 2.6\text{mmol/L}$ and
 - is off iv fluids
 - has transitioned to 3 hourly enteral feeds without additional caloric supplements
 - is not on medication to support the blood sugar level
- Persistent or Recurrent hypoglycaemia - BSL monitoring will need to be continued 4-12 hourly depending on the clinical scenario for a longer period and needs to continue until:
 - has transitioned to 3 hourly enteral feeds
 - nutritional supplements are weaned
 - is not on medication to support the blood sugar level
 - requires 3 consecutive BSL $\geq 3.5\text{mmol/L}$
 - a 6 hour safety fast is required before discharge

Indications for a Hypoglycaemia Screen

- Severe Hypoglycaemia - BSL $< 1.5\text{mmol/L}$
 - Not all babies with a one off/admission low BSL will need a screen - consider the clinical context and risk factors
- Hypoglycaemia associated with seizures
- Glucose requirement $> 10\text{ mg/kg/min}$
- Early onset hypoglycaemia - that persists or recurs after 72 hours despite adequate iv or enteral feed volumes
 - Take a screen even if the BSL is not significantly low ie: $< 3\text{mmol/L}$ as the results will still be helpful for the Endocrine team. These babies should have a BSL $\geq 3.5\text{mmol/L}$ at this age and so we should not accept BSL $< 3\text{mmol/L}$ as being normal.

Packs with the appropriate tubes and prewritten form are available in the Lab room along with a sticker for documentation of the results.

Check the blood sugar on a gas prior to taking "hypoglycaemia bloods" as glucometers are less accurate at lower blood glucose levels. Take the bloods before a feed or additional iv dextrose is administered but do not stop the current iv infusion.

Hypoglycaemia Bloods	Blood tube	Lab	Result Time	Blood Tube Summary
Formal Glucose	Green 0.6mL	Daily	2-3hrs	Minimum requirements: 3 full EDTA pink tubes (one on ice). A 4 th tube would be helpful if able 3 Li Heparin green tube 1 blood gas
Beta-hydroxybutyrate	Green 0.6mL	Daily	1-2hrs	
Cortisol	Green or Pink 0.6mL	M-F, not w/e or holidays	1-4 days	
Plasma Insulin	Pink 0.6mL on ice	M-F, not w/e or holidays	1-4 days	
C-peptide	Pink 0.6mL on ice	2x a week M-F, not w/e or holidays	3-7 days	
*Ammonia	Pink 0.6mL on ice	Daily	1-2hrs	
GH	Pink 1mL	2x a week M-F, not w/e or holidays	1-5 days	
Free fatty acids	Pink 1mL	M-F, not w/e or holidays	1-4 days	
Blood gas - lactate	Capillary tube	NICU	Immediate	
*TSH, T4 (Biochem)	2x Green 0.6mL	Daily	2-3hrs	
* Ammonia and TFT can be taken at a later date when not hypoglycaemic if it is hard to get enough blood at the time of the hypoglycaemia. Urine metabolic screen can be an additional test if the hypoglycaemia bloods do not point to an obvious cause. The urine does not need to be collected when a baby is hypoglycaemic				

These tests are to show what the baby's biochemical and hormonal response to hypoglycaemia. This may provide a diagnosis or guide further investigation.

Documentation of the results needs to be on the prepared results sticker and placed on the Investigation sheet for interpretation and sign off by the lead SMO. It also has advice for referral to Endocrine and the need for further tests such as MRI and a 6 hour fast pre discharge.

HYPOGLYCAEMIA SCREEN		Result	Normal range or comment	Interpretation by SMO
Date:	Time:			
Glucose			3.5-7.7 mmol/L	
Beta-hydroxybutyrate			< 0.3 mmol/L (fasting)	
Cortisol			170-500 nmol/L (between 6am to 10am hours)	
Insulin			10-80 pmol/L (absent in hypoglycaemia)	
C-peptide			350-750 pmol/L	
Ammonia			0-50 umol/L	
Growth hormone			< 3 ug/L is indicative of GH deficiency	
Free fatty acids			0.0-0.6 mEq/L	
Blood gas – lactate			0.5-2.0 mmol/L	
TSH			Assess in combination with T4	
T4 (Free) Gen Lab.			0-6 days 17-42 pmol/L > 6 days – 1 year 14-23 pmol/L	
SMO to review/sign off only after all results available		Outcome: <input type="checkbox"/> Normal <input type="checkbox"/> Refer to endocrine <input type="checkbox"/> MRI pituitary <input type="checkbox"/> Fasting protocol Other:		
Name:				
Date:				

Ref:2407146 Authorised by: Clinical Director Neonatal Services July 2020

Results in the normal range may not actually be normal for the clinical situation and reference ranges cannot be relied upon in these circumstances.

Results needs to be discussed with the SMO and Endocrinologist as they need to be interpreted along with the clinical situation

Criteria for Endocrinology Referral

1. Glucose requirement of >10 mg/kg/min
2. Severe hypoglycaemia - BSL <1.5 mmol/L at any time
 - Not all babies with a one off/admission low BSL will need a referral - consider the clinical context and risk factors
3. Persistent hypoglycaemia – BSL <2.6 mmol/L that persists past 72 hours age
4. Recurrent hypoglycaemia - BSL <2.6 that recurs after seeming to resolve
5. Hypoglycaemia in a baby with no obvious maternal or neonatal risk factors such as maternal diabetes, IUGR, LGA, perinatal stress
6. For interpretation of a hypoglycaemia screen result

Transient hypoglycaemia is common in the NICU but there will be a group of patients with an underlying condition such as a metabolic or endocrine disorder that present with severe, recurrent or persistent hypoglycaemia and these babies need specialist input and investigation

Endocrine - Hyperinsulinism, Hypopituitarism

Metabolic - Galactosaemia, Fatty acid oxidation disorders, Glycogen storage disease, Maple Syrup Urine Disease, Organic acidemia, Tyrosinaemia

Criteria for a Safety Fast

1. All the conditions listed above that warrant an Endocrine referral, plus
2. Confirmed hyperinsulinism, or
3. Confirmed hypopituitarism

- To be done 5-7 days prior to discharge, in the daytime
- No sucrose or milk to be given to the baby to settle them during the fast
- IV access is not required prior to the test

Time 0	Baseline BSL then breastfeed or bottle feed baby a 3 hourly amount
3hrs	BSL on gas machine
4hrs	BSL on gas machine
5hrs	BSL on gas machine
6hrs	BSL on gas machine

BSL <3.0 mmol/L at any time: take bloods for a hypoglycaemic screen, then STOP the fast, feed the baby and consider an im glucagon bolus depending on how low the glucose level is

BSL ≥ 3.0 mmol/L: continue the fast
after the 6 hour BSL feed the baby and no bloods are needed

Hyperinsulinism

- Rare but significant cause of severe, recurrent hypoglycaemia in infancy
- Insulin secretion is inappropriately high and poorly regulated
- Insulin inhibits: glycogenolysis, gluconeogenesis, lipolysis, ketogenesis, glucagon and cortisol responses
- Therefore the body is unable to use counter-regulatory hormones in the face of hypoglycaemia
- **The triad to diagnose hyperinsulinism includes – absent ketones and a detectable insulin level in the presence of hypoglycaemia**
- If this diagnosis is considered take blood tests listed above at the time of hypoglycaemia
- Caused mainly by mutations involving the SUR1 and Kir6.2 proteins in the K^+ ATP channel in the pancreatic beta cell membrane that regulates insulin secretion
- Mutation in the GLUD-1 gene causes activation of glutamate dehydrogenase that also causes an increased release of ammonia so it is imperative to check for ammonia if hyperinsulinism is being entertained
- Note that not all hyperinsulinaemic babies will be macrosomic

Diagnosis

- **BSL <2.6mmol/L**
- **Inappropriately high insulin** or C peptide for the glucose concentration (note the level of the insulin does not predict the severity of the hypoglycaemia)
- Increased glucose requirements >10 mg/kg/min
- Low free fatty acids
- Absent ketones
- Cortisol will be slightly lower than expected
- Rapid response to glucagon - expect a rise of >1.5mmol/L after administration

Management

- Secure good iv access with a central line
- Provide frequent feeds or iv dextrose as needed to maintain BSL's
- Aim to keep BSL >3.5mmol/L as these babies have no other energy source (ketones) for their brains
- Document the mg/kg/min of dextrose that is required to maintain BSL's
- Use glucagon 200 mcg/kg im if an iv tissues and there is difficulty re-siting another – it acts by glycogen being released in the liver into glucose to be utilised
- Diazoxide – start at **1mg/kg/dose 8 hourly** and increase to **2mg/kg/dose 8 hourly** if the blood sugars have not responded within 24-48 hours and in discussion with Endocrinology. Our maximum dose is usually 3mg/kg/dose 8 hourly.
- Diazoxide works by inhibiting insulin secretion. **Most responders will do so at the lower dose.** Higher doses will have the risk of more side effects such as fluid retention and oedema.
- Diazoxide is albumin bound so if a baby is hypoalbuminaemic be aware that the baby is at risk of excessive fluid overload
- Diazoxide can worsen pulmonary hypertension and so consider withholding treatment until a baby is stable and has transitioned appropriately
- Chlorothiazide – used as a diuretic to counteract the fluid retention caused by diazoxide but is also synergistic with diazoxide by inhibiting insulin secretion by other methods. Must be started any time diazoxide is used.
- Monitoring of BP, blood sugars, FBC and sodium levels are required when starting diazoxide and increasing the dose (see drug profile)
- Octreotide for sugars resistant to diazoxide
- Surgical treatment only if persistent – partial or 95% pancreatectomy

Subcutaneous Glucose Monitors

- Subcutaneous Continuous Glucose Monitors (CDM, Dexcom) and Flash Blood Glucose monitors (FGM, Libre Freestyle) are primarily designed for use in the setting of diabetes mellitus in older children and adults.
- Dexcom CGM is licensed for use in children over 2 and Libre Freestyle FGM is licensed for use in children over 4 years of age
- CGM/FGM measures the glucose concentration in the interstitial fluid.
- They are not licensed for use in neonates with hypoglycaemia, however, they may be used as an adjunct to blood gas glucose measurements in the management of babies with difficult to control hypoglycaemia under the guidance of the Paediatric Endocrine team
- Consider the CGM/ FGM as a tool to look at glucose stability and trends rather than point to point accuracy to assess a threshold of blood sugar level
- In babies, a sensor is inserted under the skin by the Paediatric Diabetes Outreach nurse usually in the lateral thigh and can stay insitu for up to 2 weeks.
- We need to be aware of the limitations of the subcutaneous sensors in neonates
 - Libre Freestyle FGM often reads low for up to 24 hours.
 - There are delays between diffusion of glucose from the blood to the interstitial fluid
 - They may be helpful in reducing the amount of heel pricks needed for a gas blood sugar reading although they almost universally under-read the glucose level in neonates so may not spare the baby many heel pricks if this is the case
 - Over time the sensor becomes less accurate and will need to be removed

- The benefits of a subcutaneous sensor are:
 - they can help show trends in patterns of blood sugar readings over time when they are downloaded retrospectively
 - the sensor can be swiped to assess the glucose level but if the level is $\leq 3.5\text{mmol/L}$ then a further glucose reading needs to be taken with a capillary sample to confirm or refute the level may be used to help wean a baby off supplements or diazoxide.

Discharge Planning

- If the hyperinsulinism has not recovered by the time of discharge and the baby is needing caloric supplements or diazoxide then a thorough discharge plan needs to be made
- Endocrine need to be contacted to advise on follow-up. They have limited ability to see babies in clinic for transient hyperinsulinism but are available to consult and provide advice.
- Babies can be discharged home on polycal supplements or diazoxide – both have pros and cons
- A plan needs to be made in conjunction with Endocrine for home blood sugar monitoring and/or a sensor monitor if the baby is going home on polycal or diazoxide
- Education will be needed from the Endocrine outreach nurse if home blood sugar monitoring needs to occur
- Parent information sheet from Endocrine
- Acute Care Plan and advice on when to present and who to call
- The feeding regime that the baby will have at home needs to be in place for around 2 days prior to discharge to ensure that the sugars are stable on the feeding plan for home to try to prevent early readmission

Hypopituitarism

- Another rare cause of persistent hypoglycaemia
- Can be seen in association with temperature instability, hypotonia, roving nystagmus, prolonged jaundice, conjugated jaundice, micropenis, undescended testes, midline defects such as absent corpus callosum or cavum septum pellucidum
- Consider this as a cause of persistent or recurrent hypoglycaemia if there are no clear risk factors in the maternal or neonatal history

Diagnosis

- Recurrent low glucose which but may not be severely low. Remember a BSL of $>3.0\text{ mmol/L}$ after a few days of age is not normal
- Low cortisol
- Low GH
- Low TSH
- Appropriately low insulin and C-peptide levels
- Normal ketones

Management

- This will be directed by the Endocrine team
- Hydrocortisone replacement must start 24 hours prior to thyroxine replacement
- Note there is a chance of diabetes insipidus after starting medical management. This would be detected by a large increase in the urine output.
- Thyroid function tests will need to be taken frequently and dose adjustments made as directed by the Endocrine team
- Referral to Ophthalmology to examine the optic discs which may be pale if there is an association with septo-optic dysplasia. They will usually prefer to see them as an outpatient.

Hyperglycaemia

- Blood glucose above 7 mmol/L are elevated.
- Very low birthweight infants are at risk of developing hyperglycaemia due to reduced glucose tolerance and insulin resistance.
- Hyperglycaemia is associated with increased fluid and electrolytes losses, IVH, sepsis and mortality
- Occurs in those usually <28 weeks or <1000g during periods of stress, sepsis, instability or when steroids are given
- Consider and investigate for sepsis as a cause of the hyperglycaemia rather than just putting it down to prematurity
- Management includes
 - reviewing the glucose intake to make sure it is not excessive ie: >9mg/kg/min (see glucose calculator ([Click Here](#))) and if so alter the fluid volume or change from 12.5% to 10%
 - change any extra infusions eg dopamine/morphine into 5% dextrose or saline
 - start insulin
 - decreasing dextrose concentration to 7.5% but this will impact on nutrition and growth
- When 2 consecutive blood sugars 4 hours apart are >10 mmol/L, and/or there is dextrose present in the urine, insulin should be commenced after discussing with the SMO.
- An arterial line for frequent blood sampling is advisable if there is hyperglycaemia.
- Blood sugars to be checked 3-4 hourly initially and if very stable then 4 hourly and never check less frequently than 6 hourly

Insulin Infusion

- Babies who receive insulin should be entered in the insulin computer for insulin dosing predictions
- Enter the baby on the computer prior to starting insulin – hyperglycaemia is not an emergency
- Chart insulin on the insulin infusion sheet
 - Commence at 0.05 units/kg/hr in most cases
 - If BSL >20mmol/L consider starting at 0.1 unit/kg/hr
- Occasionally in a very resistant baby the infusion will need to be made “double strength” to limit the volume
- The Registrar or CNS/ANP must be informed about every blood sugar that is taken when a baby is on an insulin infusion
- The aim is for a gradual weaning of the BSL below 10mmol/L and to stop glucose leaking in to the urine - it is more dangerous to have a low BSL than a high BSL
- The target range for the insulin computer is 4-8mmol/L
- The insulin infusion must always run through the same iv line as the dextrose infusions so that if the line tissues the infusions stop simultaneously
- If the baby's insulin dosing is not via the insulin computer then decrease the rate when the BSL is 5-8mmol/L and stop the insulin infusion when the BSL is <5.0mmol/L

Insulin Computer

- Stored in the laboratory room
- Always have it plugged in to save power
- Turn on and the **password pattern is the shape of an S**. Then select the STAR-GRYPHON icon
- STAR (StochasticTARrgeted) and GRYPHON (Glucose Regulation sYstem to Prevent Hyper and hypoglycaemia in Neonates)
- STAR setting – can choose between training mode and clinical mode for teaching purposes – ensure the training mode is OFF if using on a patient
- **The model is designed for preterm babies <1500g** so is not appropriate to use for term babies on insulin
- Select New Patient
- Enter all the fields, making sure that the times for the blood sugars, feeds and infusions are correct
- Working weight is the birth weight until it is surpassed
- Insulin concentration is automatically calculated from the working weight and will round down to 2 decimal points. The clock defaults to 30min after the blood sugar was taken to allow time for the infusion to be prepared – if there are further delays then update the time that the infusion is expected to start
- The first prediction is always 0.05units/kg/hr or 0.2mL/hr (if baby <1000g 0.05units/kg/hr will be 0.21mL/hr and the pump will also show this so do not worry). Choose when you want the next blood sugar to be taken in 2,3 or 4 hours time acknowledging that it takes 1-2 hours for the infusion to reach the baby

- When the next sugar is taken - click **Calculate Treatment** to be taken through the steps:
 - **Insulin** – check working weight is the same, if not update the weight and click Calc Conc to update the concentration and check that this working weight is being used for the insulin infusion recipe. If not then rechart the infusion with the new concentration and have a new bag prepared
 - **Parenteral Nutrition** – check the infusion rates of dextrose containing fluids are accurate. If there have been changes since the last sugar then adjust the nutrition rates and/or add a new infusion in
 - **Enteral Nutrition** – need to enter the feed regime each time as it can change frequently, ensure that the time of the next feed is correct. If there is no feed regime then click the ON button to say OFF
 - **Blood Glucose** – enter the latest value
 - **Recommendations** – options for dosing are given depending on when you want the next sugar to be taken. There is also an option for stopping insulin but that is usually left for when a baby is better and trialling off insulin. The graph shows 95% confidence intervals for where the blood sugar will be in the next 2,3 or 4 hours time to help you decide which option to pick. Chart the new dose and rate on the infusion sheet
 - Repeat the process with every blood sugar taken
- When to stop insulin
 - SMO decision taking into account the stability of the blood sugars, the rate of insulin (usually <0.05 units/kg/hr) and the clinical picture
 - When insulin is off, continue to monitor blood sugars in case the baby rebounds and needs insulin again
 - If within 8 hours of stopping insulin the baby starts insulin again then update the information on the current episode and continue
 - If insulin is needed after being off for more than 8 hours click “Start a new episode” which will autofill some data and allow you to quickly update the nutritional data

Inborn Errors of Metabolism

Background

- These are congenital metabolic disorders resulting from the absence/ abnormality of an enzyme, its cofactor, or, a gene product that modulates a metabolic pathway
- Results in a block to a metabolic pathway or a defect in transport of substances
- Can affect pathways of protein, carbohydrate or fat metabolism
- Newborn screen at 48 hours can detect some metabolic conditions but some babies will present prior to this result being available
- Acute encephalopathy from accumulation of toxic metabolites is the predominant presentation of metabolic disease in the newborn.
- Early consultant input and consultation with a metabolic paediatrician is essential in suspected cases as irreversible neuronal injury occurs rapidly.
- Contact Callum Wilson or Emma Glamuzina – Metabolic Specialists at Starship

Refer to the [Starship Guidelines - Metabolic Disease in the Newborn](#) for further information and links to the [British Inherited Metabolic Disease Group](#) with advice on emergency management

Presentation

This is usually non-specific and often have had a symptom-free period before deteriorating

- Poor feeding
- Lethargy
- Coma
- Vomiting
- Tachypnoea, deep breathing
- Seizures
- Hypotonia
- Liver dysfunction, hepatomegaly, splenomegaly

Think of the possibility of inborn errors of metabolism in the presence of:

- Consanguinity
- Family history of unexplained neonatal death, or a sibling with unexplained mental retardation
- Unexplained illness in a term baby, usually but not exclusively, after commencing feeding
- Sudden onset of overwhelming illness

Metabolic Conditions Presenting in Neonates

Aminoacidopathy	Maple syrup urine disease, phenylketonuria, tyrosinaemia
Organic Acidaemia	Methylmalonic acidaemia, isovaleric acidaemia, propionic acidaemia
Fatty Acid Oxidation Disorder	MCAD (medium chain acyl-CoA dehydrogenase deficiency)
Urea Cycle Defects	OTC (Ornithine transcarbamalase deficiency)
Pyruvate Metabolism Disorder	Pyruvate dehydrogenase deficiency
Mitochondrial Transport Chain Disorder	

Metabolic Acidosis

- Suspect if tachypnoea, grunting and apnoea with a normal CXR (Kussmaul breathing).
- Consider the **organic acidemias**.
- If acute encephalopathy with unexplained lactic acidosis consider disorders of **pyruvate** and **citric acid** cycles, disorders of **mitochondrial transport chain**, **congenital lactic acidaemias**.
- Defects in **gluconeogenesis** may also cause a raised lactate.

Hyperammonemia and Encephalopathy

- Consider **organic acidemias**, **urea cycle defects**, **transient hyperammonemia** of newborn

Intractable Newborn Seizures

- Consider **nonketotic hyperglycinemia**, **pyridoxine dependent seizures**, sulfite oxidase deficiency, molybdenum cofactor deficiency

Unexplained Hypoglycaemia.

- Consider defects in **gluconeogenesis**, **fatty acid oxidation disorders**, **glycogen storage disorders**

Jaundice, Hepatomegaly, Bleeding

- Consider **galactosemia**, **fructosemia**, and **tyrosinemia** type 1

Unusual Smells

- Consider **PKU**, **MSUD**, **isovaleric acidemia**.

Gram Negative Sepsis

- Consider galactosemia

Non-Metabolic Differential Diagnosis includes:

- Septicaemia
- Congenital heart disease eg. hypoplastic left heart.

Investigations

Discuss specimen collection with the laboratory (especially Chris Leaver, Head Technician in Special Biochemistry)
It is very important to try and make the diagnosis for the family for genetic counselling

Blood:

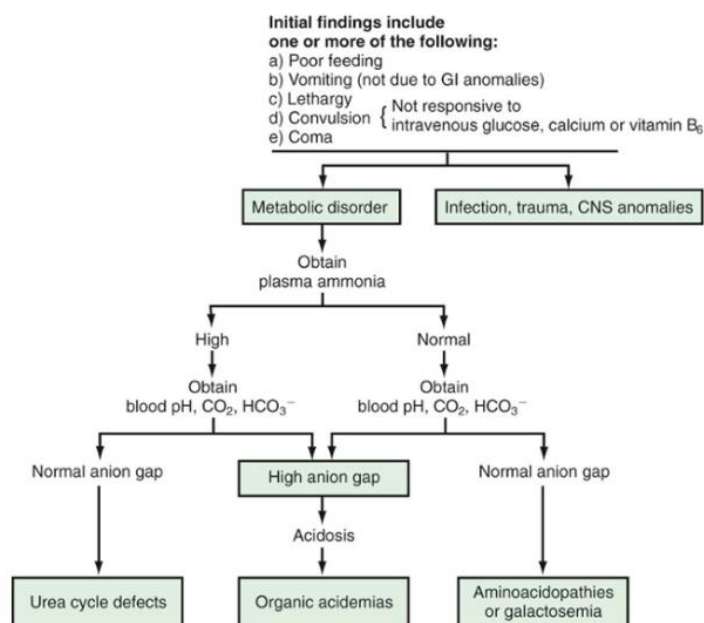
- Blood gases, lactate
- Urea and electrolytes, liver function tests
- Ketones – beta-hydroxybutyrate
- Glucose
- Ammonia
- Free fatty acids
- Acylcarnitine profile (blood spot on Guthrie card)
- Amino acids

Urine:

- Ketones.
- Amino acid screen
- Organic acids screen

Anion Gap:

- Calculating this can help further with the diagnoses
- Anion Gap = $(Na + K) - (Cl + HCO_3)$
- Normal range is 4-12mmol/L



If the infant dies, try to ensure appropriate specimens are taken:

- Plasma -deep freeze 5 mls in aliquots at -20 degrees.
- White cells - deep freeze for DNA.
- Urine - deep freeze 10 mls.
- Skin biopsy - store at 4 degrees.
- Liver biopsy - a needle or open biopsy: A needle biopsy may be taken for histology, EM and enzyme studies. This should be deep frozen (preferably snap frozen).

Initial Management in Suspected Metabolic Encephalopathy

- Stop protein feeds
- Stop catabolism (give IV fluids with 10% glucose)
- Enhance removal of toxic metabolites
- Specific medications and management as guided by metabolic paediatrician – this may involve transfer to Auckland PICU for haemofiltration

Metabolic Medications

- NICU will have a “**Metabolic Medication Box**” in the Pharmacy Room which will contain medications (and drug profiles) that may be recommended by the Metabolic Team.
- The indications are to reflect what might cause an acute presentation in a baby
- The dosing is often an initial dose to start with and further dosing to be determined by the Metabolic Specialist. There can be wide dose ranges.

- Biotin
- Levocarnitine
- Sodium phenylbutyrate
- Sodium benzoate
- Hydroxocobalamin
- Arginine
- Thiamine
- Folinic acid
- Pyridoxine
- Pyridoxal-5-Phosphate
- Co Enzyme Q10

Maternal Thyroid Disease

- Maternal stimulating or inhibiting thyroid antibodies may cross the placenta and transiently affect the baby
- Occasionally some of these infants will need treatment in the neonatal period.
- When there are more than two generations affected by thyrotoxicosis or more than one first degree relative consider the even rarer autosomally dominantly inherited activating mutations of the TSH receptor. This is important as the neonatal thyrotoxicosis is more persistent
- Any symptomatic baby needs a medical review
- Note that the Guthrie will only detect hypothyroidism

Maternal Hypothyroidism secondary to ectopic thyroid or thyroid aplasia

- There is only a slightly increased risk in the neonate and a Guthrie card test should suffice.

Maternal Graves' Disease

- In mothers with a history of Graves' disease will have circulating thyroid stimulating antibodies which can cause a transient hyperthyroid state in the neonate that may require treatment.
- This can occur even if the mother has been rendered hypothyroid by surgery or radioiodine treatment.
- Both carbimazole and propylthiouracil cross into breast milk but do not appear to affect the neonate if maternal doses are less than 15mg per day of carbimazole and less than 150mg per day for PTU
- Although rare neonatal thyrotoxicosis is associated with a high mortality.
- The incidence of Graves' is estimated to be about 0.2% and only 1-10% of infants will subsequently be affected. The highest risk is in those whose mothers are receiving antithyroid treatment at the time of delivery.

Maternal Hashimoto's

- In mothers with Hashimoto's thyroiditis there may be circulating stimulating or inhibiting antibodies that may transiently affect the neonate.

Investigations

- The optimum timing of **thyroid function tests** in the newborn is debatable.
- We know that there is a natural physiological surge in TSH and subsequently T4 at about 30 minutes post delivery. The TSH falls over the next 5 days with the T4 gradually declining over the next 2 weeks.
- Babies at **high risk** of (mothers with active Graves' in pregnancy, or family history of activating mutations of TSH receptor) or with symptoms of hyperthyroidism (tachycardic, weight loss, loose stools, increased temperature/hot, jittery/hyperactive) should have thyroid function tests done **at 2 days, in conjunction with the Guthrie** (or earlier if symptomatic) and repeated at 1 week with close observation for symptoms.
- Babies at **low but some risk** of hyperthyroidism (past history of Graves' disease or Hashimoto's thyroiditis) or hypothyroidism (Hashimoto's thyroiditis) should have thyroid function tests checked at **5-7 days** and parents advised of symptoms of thyroid disease.
- Babies at **low risk** (mothers with an ectopic or aplastic thyroid, or on thyroxine replacement with no antibodies) should simply have a Guthrie done
- Babies whose mothers are on thyroxine but have no thyroid antibodies only need a Guthrie
- TFT's (TSH, T4) are done in the biochemistry lab at Canterbury Health Lab for screening or as part of a prolonged jaundice screen. **Fill one green tube to the top line, this can be done by the midwife by heelprick along with the Guthrie.** Results available that day.

Process

- LMC identifies in pregnancy that the baby will need screening blood tests after birth
- LMC is responsible for ensuring the blood form is completed and their name on the form to check the result
- Liaison with the Neonatal team at any stage is appropriate but these babies are frequently discharged prior to any of these blood tests being taken and so needs LMC oversight.
- LMC to ensure the bloods are taken (if on day 2 then combine with the Guthrie and if in CWH then to be discussed with core staff about who will take the blood)
- Note: Very few babies need TFT checked on day 2.
- LMC is the primary person responsible for checking the result. If the results are normal then no more action is needed. If the results are abnormal then that is the time to contact the Neonatal team on 5039 (weekdays) or 5019 (weekends) for help in interpreting the result

Ambiguous Genitalia

- When you have a baby with ambiguous genitalia it can be difficult to know how best to approach the examination and discussion with the family.
- The [Starship Guideline - Differences of sex development - Atawhai Taihemahema](#) has helpful tips on how to manage this sensitively, how to discuss the differences in the genitalia with the family, examination and first-line investigations
- Refer to the Paediatric Endocrinologists as soon as able as they will guide further investigations and be involved with the family long term

❖ CARDIOLOGY

Murmurs

- The following recommendations are based on the fact that the majority babies will have an audible murmur (often quite transiently) some time in the first 24 hours, caused by closure of the ductus arteriosus or other circulatory changes related to the perinatal transition.
- The murmur of normal ductal closure in a well term infant is typically a systolic murmur with blowing or "whooshing" quality. It can be reasonably loud but should never be accompanied by a precordial lift or thrill, abnormal peripheral pulses, cyanosis. It is usually short, as opposed to the holosystolic or machinery murmur of a persistent patent ductus arteriosus in an older baby, presumably because the pulmonary vascular pressures are still relatively high. With experience, you will get used to these innocent murmurs and will distinguish them from murmurs that sound more pathological in origin.
- However, it is also important to recognise that several of the most serious congenital heart defects that present in the first week of life can be associated with soft or insignificant sounding murmurs. Thus, in excluding serious congenital heart disease, the rest of the cardiovascular examination is just as important as auscultating the heart.
- If the baby is well and has a normal examination, and is less than 24 hours old, re-examine in 24 hours.
- Examine the baby daily up to day 4 or until the baby is discharged. **If the murmur is still present on day 4 or at discharge:**
 - Perform pre (right wrist) and post ductal oxygen saturations (feet) prior to discharge. The oxygen saturation should be read once a satisfactory trace has been obtained (for at least 5 minutes)
 - Infants in whom the **oxygen saturation is <95%** on either of the recordings or where there is a significant difference ($\geq 3\%$) between the two readings should have an echo performed prior to discharge
 - Infants in whom the **oxygen saturation is <90%** or in whom there is clinical concern should be seen by the neonatal registrar/NNP and admitted to the NICU
 - Infants in whom the **oxygen saturation is $\geq 95\%$** on both of the recordings should be booked in to the Echocardiogram clinic on a Wed afternoon in CWH Radiology.
- Order a **heart US** by completing an electronic radiology request on Health Connect South and choose **US Chch Womens Hospital and in the order ask for a heart US**. Consultants will triage and arrange a Wed appointment within 1-2 weeks
- If an **echo** is requested by the Consultant to be performed by the **echo technicians from cardiology**, complete an electronic radiology request on Health Connect South and choose **Transthoracic echo**
- Perform CXR, ECG, 4 limb BP if baby unwell or echo indicates a significant shunt.
- When doing an ECG on a baby, place the leads as follows:

Use the:	VI lead as V4R	V2 lead as VI
	V3 lead as V2	V4 lead as V3
	V5 lead as V4	V6 lead as V6

Antenatal VSDs

- Babies with a **membranous VSD of any size or a muscular VSD of 3mm or more** should have an outpatient echo arranged (see above)
- If a VSD is ≥ 5 mm, discuss with the service consultant. In some cases they may elect to do an echocardiogram prior to discharge.
- Some small VSD's detected antenatally will close prior to birth.
- A baby with a small muscular VSD (< 3 mm) does not require neonatal attendance at birth, any further investigations or routine paediatric follow up. The advice to the parents and GP/LMC should be as follows:
 - Small VSD's will likely close on their own;
 - it is unlikely to have any clinical impact;
 - if there are any clinical concerns the baby should be referred for a paediatric review.
 - Symptoms and signs of cardiac failure may include - fast breathing when at rest or sleeping; sweating around the forehead; lethargy, and poor feeding
 - If a murmur is still present at 4 years of age the patient should be referred by their GP for a paediatric review.

Neonatal ECG Guide

Please note: many values are different to paediatric or adult guidelines

Each 1mm square on the ECG equates to 40ms or 0.04sec

- Rate: 1500/R-R interval (in mm)
- Rhythm: Sinus (if p waves present)
- P axis: 0-90°
- QRS axis: 60-180°
- T axis: 1st 72 hours: +ve in V1 and V4R.
After 72 hours: -ve in V1 and V4R
Similar progression in V2 and V3)
- P waves < 3mm in any lead, ≤ 0.08s
- QRS complex 0.06-0.08s
RS progression: gradual progression up to 3 yrs
"Neonatal pattern" (after 72 hrs): R>S in V1; S>R in V5 and V6
"Infantile/neonatal" pattern (after neonatal period): R may be > S in V1 as well as V5-6
S in V6 < 15mm by 1 wk; < 10mm by 6mths; < 5mm by 1yr
- Q wave May be present and normal in V1 and V4R.
Always less than 25% of R in same lead.
< 6mm in aVF and V5, < 5mm in V6, ≤0.03s.
- ST segments ST depression up to 2mm (precordial) may be normal
- PR interval 0.08-0.12s
- QT interval < 0.45s under 6 months, then < 0.44s, if >0.49s then needs urgent cardiology review

Corrected QT interval $QTc = QT / \sqrt{R-R}$ (all in seconds)

Condition	Rate/rhythm	P	QRS	ST	T	Other
HyperK ⁺	Ventricular arrhythmias	Small/flat	↑, small R	↓/↑	Tall, pointed	
HypoK ⁺	arrhythmias	↑	↑	↓	↓	U waves
RV Hypertrophy			R axis deviation R V1 > 30mm S V6 > 15mm R/S V1 > 6.5mm		Up in V1 >3days	
LV hypertrophy			S V1+R V6>30mm R V6 ≥ 15mm S V1 > 20mm			
Acute myocarditis	Frequent ectopics		Q waves	↓	flat	↑ QTc
Hypothermia	Sinus brady	↑ PR				↑ QTc J waves
ASD	Incomplete RBBB	↑	? RV hypertrophy Primum: Lt axis deviation Secundum: Rt axis deviation			
Hypothyroid	Sinus brady	↑ PR; ↓	↓	↓		U; ↑ QTc

Persistent Pulmonary Hypertension of the Newborn

Primary PPHN

- Primary dysfunction of the pulmonary endothelium
- Usually idiopathic

Secondary PPHN

- Birth asphyxia
- Meconium aspiration
- Diaphragmatic hernia
- Sepsis
- Severe hyaline membrane disease

Diagnosis

- A 20 mmHg difference between pre and postductal oxygen, if the ductus arteriosus is open
- Ultrasonographic presence of a right to left shunt at ductal level, through a patent foramen ovale, or more subtle echocardiographic signs (ie: TR, septal flattening in systole) can also indicate PPHN is present.

Management

- Establish adequate monitoring with pre and post ductal transcutaneous oximetry and arterial lines
- Liberal oxygen use as this is a pulmonary vasodilator, aim for a PaO₂ 100-120mmHg
- Avoid noxious stimuli and keep quiet
- Use analgesia as needed to calm the baby and achieve better matching of tissue oxygen supply/demand
- Maintain PCV > 0.35 to ensure good oxygen carrying capacity
- Aim for a normal pH 7.30-7.40.
- Use muscle relaxants if necessary to reduce metabolic demands and promote stability.
- Treat ventricular failure and maintain adequate systemic blood pressure with volume and pressors, e.g. dobutamine, milrinone, noradrenaline, vasopressin as necessary.
- A higher than normal systemic pressure may be needed to reduce right to left shunting and maintain pulmonary blood flow.
- Consultants will guide optimum MAP/ pCO₂/ pO₂ in each case.
- Inhaled nitric oxide should be used if there is evidence of PPHN and the baby is receiving maximal respiratory support and failing to oxygenate well (eg: oxygenation index 30-40)
- NO improves oxygenation markedly in primary PPHN
- Sildenafil can also be an adjunct to nitric oxide in severe pulmonary hypertension and is available po and iv with an iv infusion sheet available on the Intranet
- Prostaglandins may be required to maintain duct patency to offload right heart strain

$$\text{Oxygenation Index} = \frac{\text{MAP} \times \text{FiO}_2 \times 100}{\text{PaO}_2}$$

Normal Infant

Infant in 100% O₂, Paw; 25, PaO₂; 50

Infant in 21% O₂, Paw; 10, PaO₂; 95-100

Oxygenation Index

2.1 - 2.5

50

2.1 - 2.2

Nitric Oxide

- Inhaled nitric oxide (iNO) is currently the standard vasodilatory agent used for treatment of PPHN
- Multiple clinical trials conducted since 1992, including a Cochrane review in 2009, have demonstrated its benefit in treating PPHN
- Nitric oxide is recommended for use in the term and late preterm population.
- Its role in the extreme preterm infant is controversial but may be considered on a case by case basis for temporary management of acute hypoxaemia whilst awaiting other treatments to take effect. No long term benefit in CLD or mortality rates has been found in randomised studies when NO has been used in the preterm population.
- Caution in the presence of bleeding such as coagulopathy, IVH, GI bleeding pulmonary haemorrhage due to the effect of NO on platelet function

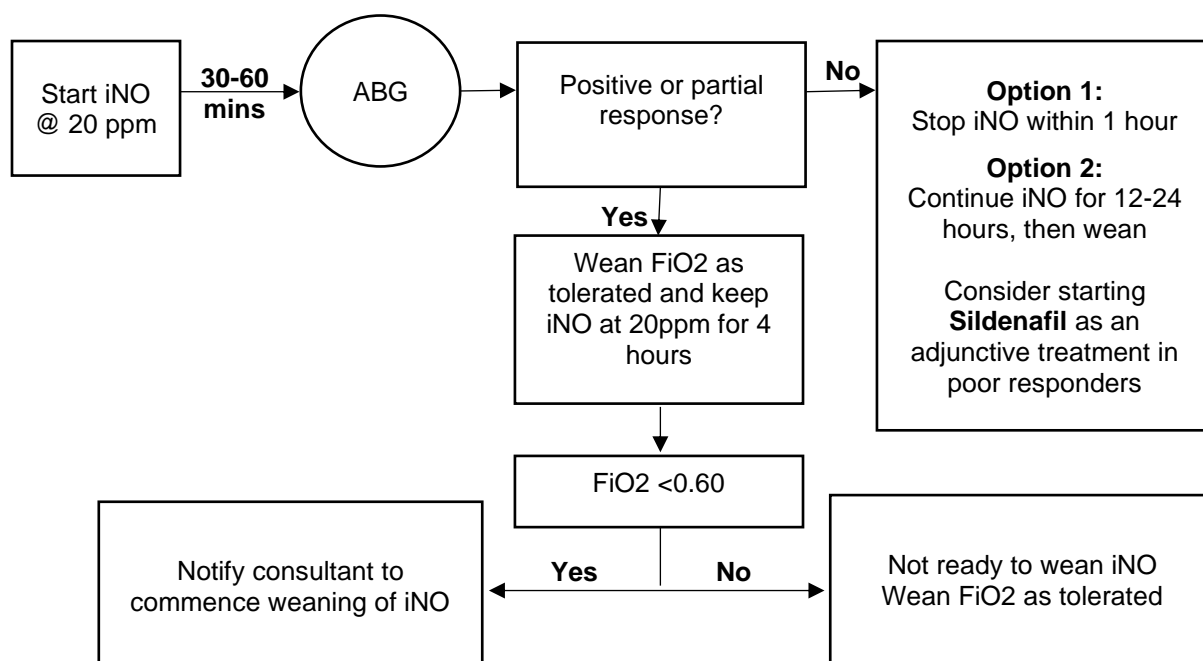
- Nitric oxide diffuses across alveoli and causes vasodilation by relaxing smooth muscle in pulmonary arterioles. This decreases pulmonary resistance and improves oxygenation
- The benefit of inhaled nitric is its ability to be delivered directly to the lungs with no or minimal systemic action, therefore no risk of systemic hypotension. However, prolonged, unnecessary use of iNO is not recommended
- Byproducts such as methemoglobin and nitrogen dioxide can have adverse and toxic effects.
- iNO is expensive drug so should be judiciously used and weaned as early as possible

Indications for commencing Nitric Oxide

- This is a consultant decision based on a clinical diagnosis of PPHN supported by echocardiography confirmation and an oxygen index of >20 (however consider nitric oxide at an OI of 15)
- Echocardiography can confirm high pulmonary arterial and right ventricular pressures based on tricuspid regurgitation, as well as exclude cyanotic congenital heart disease, a major differential diagnosis
- Ideally an echo should be done prior to starting iNO but in an emergency iNO should be started as soon as possible followed by an echo in 1-2 hours
- A chest X-ray should be done prior to ensure adequate lung recruitment

Commencing Inhaled Nitric Oxide

- After confirming the diagnosis of PPHN and taking baseline observations and blood gas (preferably arterial) iNO should be commenced at 20ppm. Higher doses have not been found to offer any additional benefit and carry increased risk of toxicity
- A repeat arterial blood gas should be taken after 30-60 minutes of commencing therapy to assess response. A positive response is suggested by an increase in $\text{PaO}_2 \geq 20$ mmHg, increase in sats by 10% or being able to drop $\text{FiO}_2 \geq 0.2$
- If a positive or partial response is not seen within the first hour, the options include immediately stopping the iNO, or continuing for 12-24 hours before weaning. This is in view of evidence suggesting that 35-40% of newborn infants may not respond to iNO
- It is unsafe to stop abruptly if iNO has been administered for longer than one hour due to the risk of rebound PPHN. If a positive or partial response is seen then iNO should continue for 4 hours, weaning FiO_2 as able
- Methaemoglobin (F MetHb) levels (%) are automatically measured and reported in all the gases. Levels should be reviewed on the first gas after commencing and then 24 hourly. Levels of MetHb up to 2.5% are considered normal and safe. Levels above that should be closely watched and iNO should be discontinued if levels $>10\%$.



Positive Response Indicators:

- $\uparrow \text{PaO}_2 \geq 20$ mmHg
- \uparrow Sats by 10%
- Able to wean $\text{FiO}_2 \geq 0.2$

Partial Response Indicators:

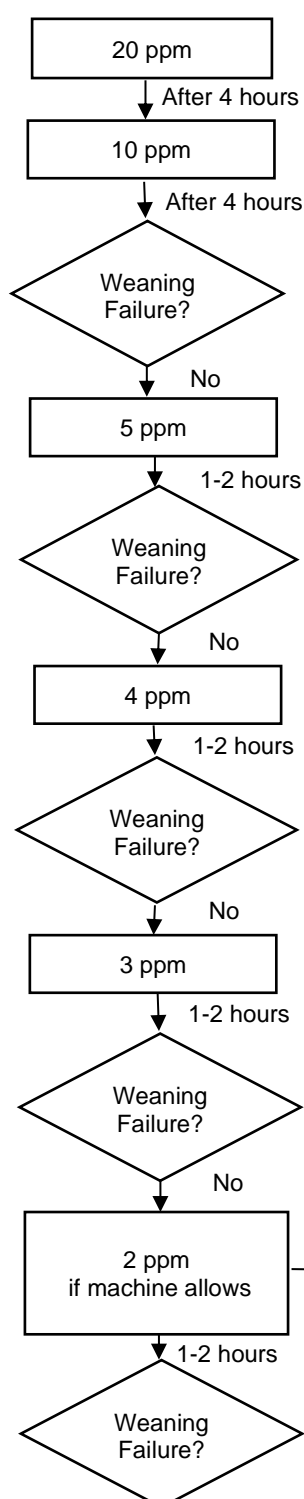
- $\uparrow \text{PaO}_2$ by 10-20 mmHg
- \uparrow Sats by 5-10%
- Able to wean FiO_2 by 0.1-0.2

Methaemoglobin:

- Obtain first level 30-60 mins after commencing iNO
- Obtain q24hr there after
- Level $\leq 2.5\%$ normal and safe
- Level $> 10\%$ discontinue, decrease iNO by 50% and repeat level

Weaning of Nitric oxide

- Once iNO has been commenced, consideration of timely and appropriate weaning is important
- Rebound pulmonary hypertension following prolonged use and abrupt withdrawal of iNO is a significant risk due to the down regulation of any endogenous NO production
- Weaning should be considered at four hours if FiO₂ is <0.6. Decreasing iNO from 20ppm down to 5ppm quickly has been found to be safe. This should be done by halving the iNO from 20ppm, to 10ppm to 5ppm, every 1-2 hours if the patient remains stable
- Indications not to wean include an increase in FiO₂ of >0.2, a decrease in oxygen saturations of >5% or a pre/post ductal saturation gradient of >10%. In this situation iNO should be returned to previous dose and continued for four hours until any further attempts at weaning are made
- Once the patient is stable at 5ppm iNO, weaning should occur in 1ppm steps, every 1-2 hours until off
- The Aeronox 2 system can wean to 2-3 ppm only then off
- At discontinuation, it may be necessary to increase the FiO₂ by 0.2 temporarily to counter rebound PPHN
- Again, if at any point there are criteria fitting weaning failure the iNO should be returned to the previous dose for four hours before attempting further weaning.
- If the patient remains on iNO at 96 hours, review of differential diagnosis is recommended.



Criteria for Weaning Failure:

- ↑FiO₂ by 0.20
 - ↓SpO₂ by >5%
 - Pre/post ductal SpO₂ gradient of >10%
- Stop weaning and return to previous dose of NO

Weaning Considerations:

- If weaning failure criteria are met, wait 4 hours before reattempting wean
- If >96 hours on NO consider repeat ECHO and consider differentials for pulmonary hypertension

Discontinue NO

At discontinuation it may be necessary to increase FiO₂ by up to 0.20

ECMO

This is only provided by the Starship PICU team and cannot be performed locally as an ongoing treatment. It can, however, be initiated by the Auckland ECMO team in Christchurch as part of a retrieval to Auckland PICU

This is used infrequently for babies with severe, but, recoverable lung disease, such as severe Meconium Aspiration Syndrome non-responsive to nitric and inotropes

[ECMO retrieval - preparation for referring centre prior to arrival](#)

[ECMO referring centre checklist.pdf](#)

Link to local Policy when completed

Patent Ductus Arteriosus

- The incidence of haemodynamically significant PDA (hsPDA) varies on the definition, the time of assessment and gestational age.
- In normal term infants, 90% of PDAs are closed by 48 hours and 98% by 96 hours.
- Closure can be delayed with increasing prematurity.
- The difficulty is determining in which babies closure will be delayed which may then lead to significant left to right shunting and adversely affect pulmonary function.
- Early prophylactic administration of indomethacin reduces the need for symptomatic treatment of PDA but in randomised controlled trials has not affected pulmonary or developmental outcome (TIPP study NEJM 344(26):1966-72).
- As a result we use targeted treatment of PDA's based on clinical features or echocardiogram diagnosis

Clinical signs to assess significance of PDA

- systolic murmur, full radial pulses
- active praecordium
- wide pulse pressure on invasive monitoring
- systemic hypotension.
- clinically significant but silent PDAs (no murmur) are common especially in the extremely premature baby and in the first 3-5 days of life
- late features (after day 3-5) include increasing ventilation requirements, cardiomegaly, hepatomegaly and pulmonary plethora on the CXR.

Echocardiogram

Gold standard for diagnosis and the following all contribute to the echo assessment of the PDA. Those in bold have more recently been used to determine haemodynamic significance.

- Increased LA dimension
- Increased LA:AO ratio
- Increased LV end diastolic dimension
- **Absent or reversed flow in the descending aorta**
- **Non-restrictive pattern on PDA doppler flow**
- **Turbulent main pulmonary artery peak diastolic flow >0.2m/sec**
- **Left pulmonary artery peak diastolic velocity >0.3m/sec**
- **Absolute dimension of Ductus Arteriosus.**

CWH Protocol

- Infants < 28 weeks' gestation will have an echo between day 1-3 depending on index of suspicion, hypotension and respiratory factors.
- Infants 28 weeks or more will have an echo based on clinical and respiratory features and index of suspicion eg. no antenatal steroids, hypotension, need for ventilation

Treatment

- Will be decided by the consultant after consideration of contraindications to medications
- Medications have better effect the earlier they are given

Paracetamol

- Has become our first-line option in most babies
- One course (3-6 days) to be given prior to day 28
- Check echo after 3 days to assess response and if to continue then check liver function tests

Indomethacin

- Rarely used now
- 3 dose course of 0.2mg/kg 12-24 hrly with echo review after course completion
- Need to monitor electrolytes, platelets and renal function prior to and during the treatment
- Contraindicated if the baby is concurrently on steroids, has pulmonary hypertension, platelets <80, renal impairment (oliguria or creatinine >120mmol/L) , bleeding or NEC

Surgical Closure of PDA

Surgical closure of a PDA may be required if the duct has not closed after two courses of indomethacin and the baby remains ventilator dependent.

When the decision has been made for surgical repair of a PDA it is the Neonatal Team's responsibility to prepare the baby appropriately for surgery. This will include:

- Liaison with the surgical team for the date and time of the procedure
- Liaison with the anaesthetist for any pre-op requirements and completing the [Neonatal and Anaesthesia Handover](#) form and emailing to paedanaesth@cdhb.health.nz
- A current group and hold
- Intubation, ventilation and stabilisation prior to surgery
- Ventilate on a machine with the capacity to deliver high frequency ventilation
- Arterial line access
- Dobutamine infusion prepared and commenced after d/w the Neonatal consultant and/or anaesthetist

Follow-Up

- Any baby who has a PDA that remains open at discharge needs Paediatric follow-up
- The PDA may have been detected on a heart scan at discharge or be a persisting murmur in a baby who has previously had a heart scan confirming a PDA
- Arrange for follow-up by the lead SMO in the Paediatric Outpatients clinic
- Note that all babies <32 weeks will already be followed up so it is babies 32 weeks and older where follow-up will need to be specifically considered

Hypotension

Hypotension is often broadly **defined** as a mean systemic BP < GA in the first few days (equates to about 10th%)

3rd% BP measurements for gestational age in a newborn at birth

(Mullaly R et al. Arch Dis Child Fetal Neonatal Ed 2023;0:F1-F8)

Blood Pressure Reference Ranges

Gestation	Sys 3 rd	Dias 3 rd	Mean 3 rd
24	32	15	26
25	34	16	26
26	36	17	27
27	38	17	27
28	40	18	28
29	42	19	28
30	43	20	29
31	45	20	30
32	46	21	30
33	47	22	30
34	48	23	31
35	49	24	32
36	50	25	32

BP increases with postnatal age so that by day 3 the MAP is usually GA + 5-10 mmHg.

Also take note of the systolic and diastolic BP as different conditions have different patterns

- Decreased afterload from a PDA or septic shock may have a normal mean BP but a very low diastolic BP
- Minimal change between systolic and diastolic BP due to a high diastolic BP may indicate pulmonary hypertension and increased afterload

Post Conceptual Age BP Ranges

(Flynn JT. Pediatric Nephrology 2000;14:332-341)

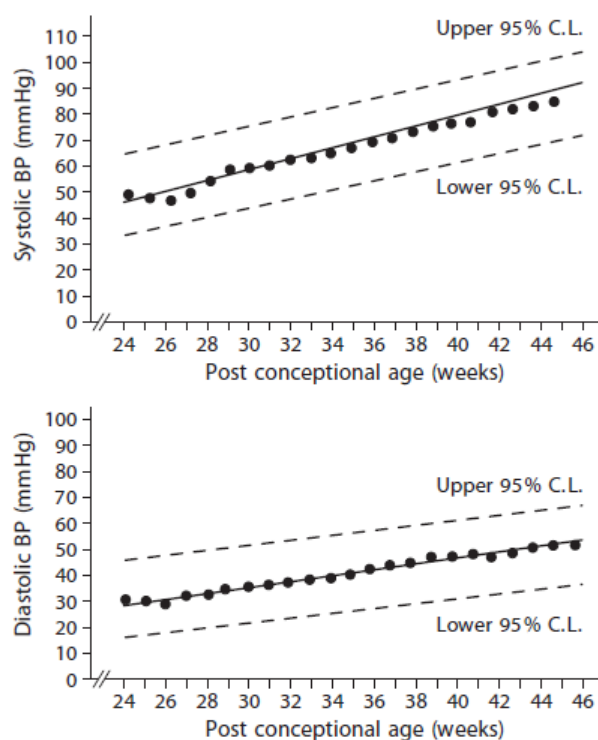


Fig. 3 Linear regression of mean systolic and diastolic blood pressures by postconceptual age in weeks, with 95% confidence limits (*upper and lower dashed lines*). Reproduced from Zubrow et al. [9], with permission from the copyright holders, Stockton Press, a division of Nature America

Causes of Hypotension

- Hypovolaemia
- Anaemia
- Haemodynamically significant PDA
- Sepsis
- Left ventricular dysfunction
- Adrenal suppression

Initial management

- Assessment of fluid balance, urine output, lactate
- Echocardiogram is an essential tool to check cardiac filling, cardiac output and myocardial function

Fluid Bolus

- The benefits of fluid boluses to treat hypotension have not been established.
- The underlying cause of the low BP needs to be investigated and the management tailored as appropriate
- If the baby is euvoletic then the BP will not respond but the heart will have an extra load of fluid to circulate
- Excessive fluid is associated with increase rates of PDA, BPD, NEC
- Fluid boluses may be indicated if there is concern for hypovolaemia ie: history of blood loss (APH, placental abruption) or hypovolaemia is confirmed on echo or there is septic shock with third spacing
- Normal saline (0.9%) 10ml/kg over 30 – 60 minutes. Note that poorly functioning myocardium may not cope with repeat boluses and that is why bedside echo is important

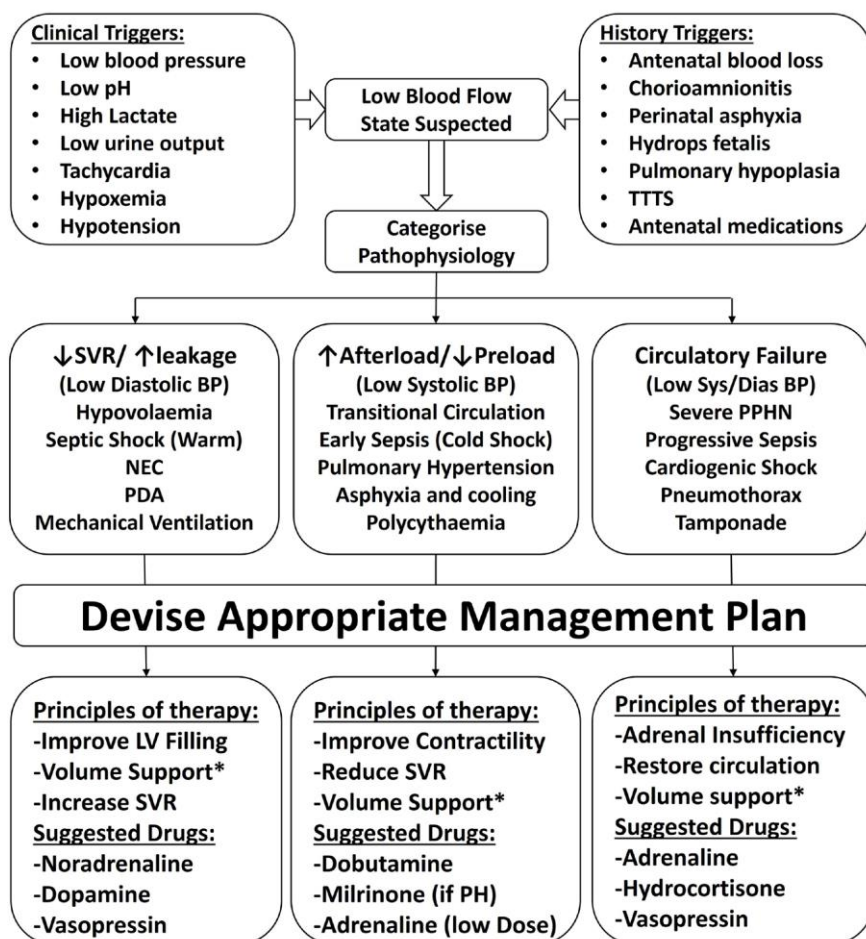
Medications

- Dobutamine
 - Inotrope
 - Helpful in situations where the cardiac output is low due to poor cardiac function and the baby needs inotropic support as well as blood pressure support ie: extreme prematurity, PPHN
 - Does not consistently raise the BP but should improve myocardial function
- Dopamine
 - Vasopressor
 - Commence at 5 to 10 mcg/kg/min, titrate to response.
 - Effective in septic shock where the peripheries are vasodilated
 - To manage diastolic hypotension in the setting of a significant PDA
 - Preterm infants often need an inotrope in conjunction with dopamine to support myocardial function
- Noradrenaline
 - Vasopressor
 - Helpful in the setting of pulmonary hypertension as it has less effect in the pulmonary vasculature
- Adrenaline
 - Inotropic effects at lower doses
 - Vasopressor effects at higher doses and babies may be quite sensitive to small dosing changes
- Hydrocortisone
 - Preterm infants may have a relative cortisol deficiency due to an immature hypothalamic-pituitary axis and a suboptimal response to stress
 - Hypotension is less common in neonates whose mother received a complete course of antenatal steroids
- Vasopresin
 - Vasopressor, rarely used

This flowchart is from a paper titled – **Haemodynamic assessment and management of hypotension in the preterm**. It proposes an approach to hypotension with suggested causes and management strategies.

This is not to be used as strict guideline for management of hypotension in our NICU but shows the framework of decision making that goes into considering the cause and potential medications required to help different clinical states.

Suggested Approach to Hypotension in Preterm Infants



Blood Pressure Reference Ranges

Gestation	Sys 3 rd	Dias 3 rd	Mean 3 rd
24	32	15	26
25	34	16	26
26	36	17	27
27	38	17	27
28	40	18	28
29	42	19	28
30	43	20	29
31	45	20	30
32	46	21	30
33	47	22	30
34	48	23	31
35	49	24	32
36	50	25	32

Vasoactive Drugs Mode of Action

	SV	SVR	PVR
Adrenaline	↑↑↑	↑↑↑	↑↑
Noradrenaline	↑/≈	↑↑↑	↓/≈
Vasopressin	≈	↑↑↑	↓/≈
Dobutamine	↑↑	↓/≈	≈
Milrinone	↑↑	↓↓	↓↓
Dopamine	↑	↑↑	↑↑↑

SV = stroke volume; SVR = systemic vascular resistance; PVR = pulmonary vascular resistance
 ↑ = increase; ↓ = decrease; ≈ = no effect

Practical Considerations:

- * Volume support should be considered in the presence of a history of blood loss and or the use of an inodilator agent
- Do not treat a single indicator of low blood flow state in isolation unless strong clinical evidence of an antenatal event
- Central intravenous access should ideally be obtained - some of the vasoactive medications can have cutaneous effects
- If central access is not achievable then a low lying UVC or a peripheral cannula can be used to restore circulatory integrity
- Ideally, invasive arterial access should be used to monitor blood pressure especially if there is no response to one agent
- Cuff BP should be interpreted with caution especially in very small infants
- Consider hydrocortisone if hypotension unresponsive to 2 therapeutic agents
- Early echo consult is advisable for severe hypotension / hypotension unresponsive to treatment / significant hypoxaemia
- Therapeutic algorithm may vary depending on pathophysiology as determined by echo consult (if available)

Mullaly R, El-Khuffash AF. Arch Dis Child Fetal Neonatal Ed 2023;0:F1–F8. doi:10.1136/archdischild-2022-324935

Supraventricular Tachycardia

Presentation

- 30-40% of SVT presents in the first few weeks after birth.
- The majority of SVT in neonates is due to a re-entrant rhythm (extra electrical connection)
- Often asymptomatic and tolerated for many hours
- Tachypnea, poor feeding, pallor, sweating, irritability, lethargy

Non-Pharmacological Management

- Only use this in patient who are haemodynamically stable and not in shock
- Cardiorespiratory monitoring in place
- Explain the procedure to the parents
- Wrap arms in a towel and immerse the whole face (including mouth and nose – no need to occlude these as the baby will hold its breath) in an ice water slurry in a bowl/bucket for 5 seconds (there is an ice machine on Birthing Suite)
- Reverts SVT in 90% cases

- If unable to dip baby into the water (often the case in NICU) place an ice cold facecloth (ie: a facecloth dipped into a bowl of water and ice) to the entire face covering the eyes, mouth and nose for 10 seconds
- The clinical situation when the SVT occurs and the baby's stability and tolerance to the SVT will determine when ice treatment is used and when medical staff need to be notified and will therefore be individualised.
- The medical team should be called immediately to assess the baby for the first episode of SVT. After this the medical team needs to clarify how long the period of SVT should be tolerated before ice treatment is to be used and when to call the medical team back for review

Pharmacological Management

- If ice has not been successful or contraindicated due to shock
- IV access in as large a vein as possible – antecubital fossa is preferred
- Place a 3-way tap
- Adenosine rapid bolus through one port then a rapid bolus of saline flush up to 5mL
- Adenosine temporarily blocks the AV node so asystole will be seen briefly before reverting to sinus rhythm
- Record the rhythm strip when giving adenosine
- Dose at 100mcg/kg then 200mcg/kg then 300mcg/kg and if still unsuccessful call the on-call Paediatric Cardiologist in Starship for further advice about adenosine doses (up to 500mcg/kg) or other drugs (amiodarone)

Electrical Cardioversion

- Treatment of choice if the baby is in circulatory shock and there has either been no response to iv adenosine or iv access has not been obtained
- This is rarely required and we have little experience with cardioversion
- A decision needs to be made at the time regarding stabilisation with intubation/ventilation and sedation with morphine and midazolam boluses (suggest 100mcg/kg dosing if airway is secured).
- If the baby is conscious they will need sedation and to do this safely the airway needs to be secured
- If the baby is unconscious then the time taken to intubate needs to be weighed up with stability of the baby
- Defibrillator is on Level 5 postnatal ward
 - Open the door on the right side of the machine
 - Press the ON button
 - Place the Paediatric electrodes over the apex of the heart and the second one either on the back or right upper chest
 - Connect the electrodes into the socket coming from the machine
 - Press the ANALYSE button
 - Press the SYNC button to make it a synchronous shock
 - Press the down arrow on the ENERGY SELECT Button (it defaults to 200J – adult shock)
 - The ENERGY SELECT button goes as low as 2J then in one joule increments to 10J
 - Aim for DC shock of 1J/kg and repeat at 2J/kg if unsuccessful
 - Press CHARGE button
 - Press RED button to deliver the shock

Ongoing Management

- Take a 12 lead ECG once back in sinus rhythm
- Half of the babies will have recurrence of SVT in infancy but 90% will have stopped by 1 year of age
- Consult Paediatric Cardiologist to discuss the need for ongoing medication and follow-up

Antenatal Diagnosis of Aortic Arch Hypoplasia/Coarctation

- These cases have had a potential arch abnormality detected on antenatal scans
- A referral will have gone to Cardiology Akld with the scans being reviewed and a plan made that it is appropriate to deliver in Chch
- Any fetus with a significant and likely duct dependent arch narrowing will have a plan made to deliver in Akld. However, the arch and PDA are dynamic structures so it is not always possible in borderlines/more mild cases to determine antenatally which cases will end up having a clinically significant arch narrowing that needs cardiology input soon after birth or prostaglandin to maintain systemic blood supply and which will have normal anatomy after birth.

Management

- Paediatric attendance at delivery is not required for this indication alone
- Keep baby with their mother on the postnatal ward if well and expect admission for a minimum of 3 days as monitoring and scans are required
- Daily Neonatal Team review and Neonatal Team to do the 24 hour baby check and to include pre and post ductal saturations at this time
- Monitor with newborn observations at 1,4,12 hours and then 12 hourly (including saturations) until the heart ultrasound is performed
- Lactate measurement 12 hourly until the heart ultrasound is done
- Heart ultrasound to be performed by NICU consultant day 2-3 or earlier if unwell
- The baby needs to remain an inpatient until the PDA closes and the aortic arch has been confirmed on scan as patent
- These babies may need a repeat scan at 6-8 weeks so discuss with Dr Alex Binfield (Paediatrician) regarding the requirement of this prior to the baby being discharged

Right Sided Aortic Arch

- Antenatal scans may diagnose a right sided aortic arch with the possibility of a vascular ring
- Right sided arches occur in 0.1% of the population and vascular rings are even less common
- A right sided aortic arch exits the heart and curves to the left but behind the trachea and oesophagus
- The branches of the aorta can run anteriorly to the heart or there can be a double aortic arch and therefore there can be blood vessels behind and in front of the trachea and oesophagus forming a vascular ring
- Vascular rings may be classified as complete or incomplete
- After birth the baby needs to be examined as part of their normal 24 hour newborn check
- If they are asymptomatic then the parents need to be informed of the potential symptoms of a vascular ring and given the parent information sheet (**Neonatal Intranet – Parent Information tab**– print in colour, or copies in the parent information cupboard in NICU) and a short discharge letter needs to be sent to the GP
- **An echo does not need to be arranged postnatally**
- Further investigations would only be required of the baby became symptomatic from a vascular ring and echo is not the investigation of choice

Symptoms of a Vascular Ring

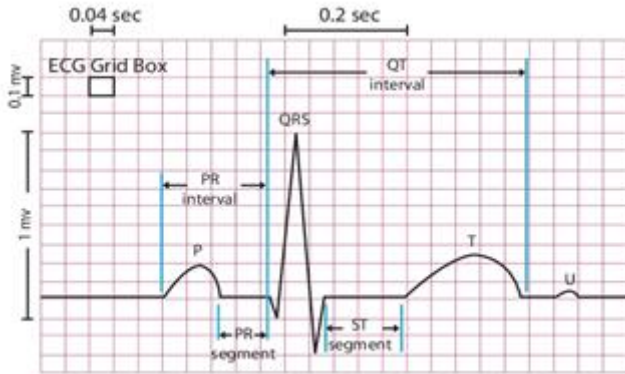
- Complete vascular rings are more likely to be symptomatic than incomplete
- Symptomatic children will usually present before a year of age and rarely in the neonatal period
 - Respiratory stridor, wheeze, cough, recurrent chest infections
 - Oesophageal difficulty swallowing food gets stuck, choking, vomiting, regurgitation of food worsening of respiratory symptoms when eating

Screening for Long QT Syndrome

- This is for well newborns where a parent has been diagnosed with long QT syndrome
- Long QT syndrome is an uncommon hereditary heart condition (1/2000) where there is abnormal electrical activity of the heart with the risk of sudden death
- The commonest form has an autosomal dominant inheritance pattern
- When a baby is born with a confirmed or suspected family history of long QT there is concern around whether the baby has inherited the condition as well
- ECG's are used to screen for long QT syndrome but they are not always diagnostic
- The best way to rule out long QT in the baby is with genetic testing if the specific mutation has been identified in a previous family member
- Only about 70% of families with LQTS have an identified gene defect.
- If a family have a known gene defect then they may already be known to CIDG (Cardiac Inherited Disease Group) and/or Genetics service and plans may have been made for genetic testing in the baby after birth. However this is always done after or in parallel with cardiological assessment.

Plan after Birth

- Request an ECG at 1 week and 1 month of age, and measure the QTc (corrected QT interval) carefully
- In a newborn the QTc should be <0.45 sec
- Arrange for urgent review if the QTc is significantly prolonged (>0.49 sec)
- Note that ECGs in the first 3-4 days often have a QTc which are difficult to interpret.
- Each square on the ECG is 40 milliseconds or 0.04 secs. Count the squares/time from the start of the Q wave to the end of the T wave. This time is the QT interval. It then needs to be corrected for the heart rate so calculate the time from one R wave to the next R wave in seconds and calculate the QTc using the formula $QTc = QT / \sqrt{R-R}$ (all in seconds)



- Check with Genetics or CIDG about their input with the family
- Refer to Dr Alex Binfield after the 1 week ECG for ongoing outpatient review, and he will discuss with Cardiology or the CIDG coordinator to arrange follow up and management. Cardiology will usually arrange to see the baby during the first few months.
- The infant should avoid QT prolonging medications until the condition is excluded (refer to Starship Guidelines - <https://www.starship.org.nz/for-health-professionals/starship-clinical-guidelines/>)
- If the mother is the gene carrier, reinforce the need for her to take beta blockers over the first nine months after delivery, it is a time of increased risk for her

❖ SURGICAL CONDITIONS

Liaison with Paediatric Anaesthetists

To communicate with the Paediatric Anaesthetists about planned surgeries you can complete this form - [Neonatal and Anaesthesia Handover](#) (also on the Neonatal Intranet under Neonatal Forms) and email it to paedanaesth@cdhb.health.nz to update them on the clinical situation, surgery planned and timeframe for the surgery to improve communication around our complex patients and to allow timely anaesthetic review prior to the surgery

Gastroschisis

Background

- Gastroschisis is a congenital defect of the anterior abdominal wall immediately to the right of the umbilicus.
- Small and large bowel protrude through the defect, and occasionally other abdominal organs eg: stomach, gonads
- 10% have a related gastrointestinal abnormality such as bowel atresia
- Other complications include bowel dilatation, ischaemia, and perforation
- Mortality is up to 10%, often related to septicaemia or the complications of gut dysmotility and/or short gut syndrome and parenteral nutrition.
- Reduction of the gut is best performed within a few hours of birth as the infant is at risk of fluid, protein and heat loss from the exposed bowel, and progressive oedema and dilatation of the bowel makes it increasingly difficult to reduce.
- In about 20% of cases reduction is not safely possible at the first procedure and in these a temporary silo is formed.
- Delay in establishing full enteral feeding is common with a median duration of around three to four weeks. TPN is required for most of this time.
- The median duration of hospital stay is around 6 weeks.

Repair

- The gastroschisis will usually be repaired in theatre under general anaesthetic
- Occasionally, the bowel can be reduced in the neonatal unit depending on the condition of the infant and the appearance of the bowel

Clinical Management

- Wrap the bowel in cling wrap, supporting it centrally on the baby's abdomen and avoiding any kinks in the bowel. The wrap decreases evaporative heat loss and prevents the bowel mesentery kinking
- Insert a large bore nasogastric tube (usually 8-10Fr) and place it on free drainage and frequent regular suction. The purpose is to keep the stomach empty of air and fluid.
- Cardiorespiratory monitoring
- Keep the baby warm and monitor temperature.
- Give IV Normal saline bolus 20ml/kg before transfer to theatre
- Monitor blood glucose
- Start amoxycillin and gentamicin
- Maintenance fluids are commenced at 90ml/kg/day and changed to TPN postoperatively
- A urinary catheter is inserted either before or during surgery to measure urine output
- A long line is required either by the surgical team at the time of the gastroschisis repair or in NICU

Babies with gastroschisis can be unstable in the first 24-48 hours after surgery with splinting of the diaphragm, high analgesic requirements, large 3rd space losses of fluid, persistent metabolic acidosis and dehydration.

- Analgesia: During theatre the babies are often given fentanyl. A loading dose of morphine (100mcg/kg) is given prior to commencing a morphine infusion (20mcg/kg/hr or more as required) before the NICU transport team bring the baby back to the unit. Further morphine boluses of 50mcg/kg are given if there are signs of pain.
- Fluids: A Normal saline bolus of 10-20ml/kg is often needed postoperatively as well if they remain hypovolaemic. Boluses of albumin 4% can be used instead of saline if the albumin is low (ie: <25). Nasogastric aspirates of >10mls in 4 hours should be replaced ml for ml with Normal saline over each subsequent 4 hour period.

Omphalocele

Background

- Omphalocele (or exomphalos) is a hernia within the umbilical cord where the contents are covered by a membrane (in contrast to gastroschisis where loops of bowels are completely exposed).
- Omphalocele minor only contains bowel whereas omphalocele major contains bowel as well as other organs, including the liver.
- Omphaloceles have a high rate of associated anomalies (50-70%)
- Chromosomal associations are seen in about 30% and include trisomy 13, 18 and 21.
- Beckwith-Weidemann syndrome is seen in up to 10% of cases.
- Cardiac and renal anomalies occur in 30-50% of cases.
- Thorough examination after birth is essential to detect associated anomalies

Repair

- Immediate management includes protection of the defect with cling wrap to lessen excessive heat, fluid and protein loss.
- The baby should be NBM, on iv fluids and antibiotics and have a large bore NG placed.
- The surgical team should be notified as soon as possible after delivery
- Warming Mattress should be used in theatre to prevent hypothermia
- Surgical management depends on the size of eviscerated contents, presence of an intact sac and associated anomalies.
- Treatment involves reduction of the herniated viscera.
- Surgical reduction may lead to transient respiratory and cardiovascular compromise, as well as occasionally bowel ischaemia.
- A staged reduction is the best method for large defects.
- A prosthetic silo is fashioned to allow daily reduction of abdominal contents back in to the abdominal cavity over a 5-10 day period
- A longline should be placed in theatre in most cases

Congenital Diaphragmatic Hernia

- This is a potentially life threatening congenital malformation caused by a defect in the diaphragm allowing abdominal contents to herniated into the chest
- 85% of cases are on the left and 2% are bilateral
- Seen in about 1:3000 live births
- Survival rate is 60-80% if born alive
- About 30% have associated anomalies ie: trisomy 13, 18, 21, cardiac, CNS, GU and GI malformations and these babies have a higher mortality rate
- Survival is determined by the severity of the pulmonary hypoplasia and pulmonary hypertension
- Treatment goals are to **achieve adequate oxygenation whilst minimise pulmonary volutrauma and overdistension** of hypoplastic lungs while maintaining adequate acid-base balance and blood gases

Determinants of a Poorer Prognosis

- Early antenatal diagnosis
- Delivery <37 weeks or <1500g birthweight
- Polyhydramnios (AFI >25cm)
- Liver in the chest
- Hydrops
- Multiple associated anomalies
- Right sided or bilateral lesions may also have a worse prognosis
- Lung to head ratio (the ratio of the area of the contralateral lung to the fetal head circumference):
 - this is a numeric estimate of the size of the lungs
 - ratio of <1.0 predicts survival is unlikely
 - ratio of >1.4 predicts a higher survival rate
- Severe pulmonary hypertension after birth

Delivery

- Antenatal steroids have not been proven to be of benefit beyond 34 weeks gestation but should be considered up to 39 weeks gestation if delivery is by elective caesarean section.
- Planned day time delivery at term is advisable
- Attendance at delivery by Registrar or NNP **and** Neonatal consultant
- Neuromuscular blockers such as pancuronium should not be used routinely as there is no data to prove that this improves survival rates
- Elective intubation without prior bag/mask ventilation
- Gastric tube to decompress the stomach and intermittent or continuous suction
- Target preductal saturations of 80-90%
- Aim to minimise PIP to <25cmH₂O
- Surfactant should not be given routinely in term babies

Admission Procedures / Investigations

- NBM
- Fluid restrict 40-65ml/kg/day
- TPN when electrolytes are stable
- Central double lumen IV access
- Arterial line (preductal/right radial is preferred but a UAC is easier to site initially)
- Transcutaneous CO₂ monitoring, pre and postductal saturations
- FBC, group and hold, arterial gas, coagulation profile
- CXR/AXR
- Urethral catheter to monitor urine output
- Head US – look for IVH (contraindication to ECMO)
- Echo –to assess pulmonary hypertension, right ventricular dysfunction, cause of hypotension and to rule out cardiac anomalies
- Renal US (not urgent) – for associated anomalies
- Maintain normal glucose, Ca, Mg, haematocrit, pH, temp so as to minimise pulmonary vasoconstriction
- Maintaining a normal systemic BP for gestational age
- If hypotensive give a 0.9% saline bolus 10-20ml/kg and consider inotropes if no improvement
- Start inotropes if there is hypotension, ventricular dysfunction or poor cardiac output
- Dobutamine is a better first-line inotrope in these babies as it has less effect on the pulmonary vasculature than dopamine
- Milrinone may be beneficial as an inodilator but can also cause systemic hypotension so may need to be given in conjunction with a vasopressor (noradrenaline, adrenaline, dopamine)
- Note that high doses (>10 mcg/kg/min) dopamine can cause increased pulmonary vascular resistance and may be counterproductive
- Hydrocortisone can be used as a second-line inotropic agent
- Give morphine for sedation and pain relief
- Neuromuscular blockade is not to be used routinely but may be required in unstable babies and should be discussed with the SMO prior to administering. Pain scores should be assessed first to ensure pain management is maximised.

Ventilation

- Improved survival has been shown with gentle ventilation:
 - spontaneous respiration
 - permissive hypercapnia (50-70mmHg)
 - minimal sedation
 - avoidance of paralysis
 - keeping the PIP <25cmH₂O or MAP <16 on HFOV, PEEP 3-5cm H₂O
 - targeting adequate pre-ductal saturations (85-95%) and post-ductal >70%
- Conventional ventilation is used initially but consider HFOV if needing to use higher PIP with conventional ventilation
- Do not use recruitment manoeuvres and avoid **overdistension** of the lungs which is easy to do
- If you are unfamiliar with HFOV then ask the Consultant for guidance about **any** changes to ventilation

Pulmonary Hypertension Management

- Inhaled nitric oxide does not always help - should only be used with echo proven pulmonary hypertension (right to left shunting across PFO/ PDA and suprasystemic pulmonary vascular resistance) after optimising lung inflation and LV function
- If inhaled nitric oxide is started use 10-20ppm and if it does not produce a clinical improvement then it should be discontinued
- Use nitric oxide cautiously in the presence of LV dysfunction as the increased preload can cause pulmonary congestion and worsening oxygenation
- Sildenafil can also be used in the setting of severe pulmonary hypertension
- If the ductus shuts in the presence of suprasystemic pulmonary pressures - commencing Prostaglandin E 10ng/kg/min to reopen the duct can reduce right ventricular strain and improve cardiac output
- ECMO is used rarely and only for rescue treatment and would be undertaken only in Auckland

Determinants of Severity

- Oxygenation Index = $\frac{MAP \times FiO_2 \times 100}{PaO_2}$
 - Modified Ventilation Index = $\frac{PIP \times RR \times CO_2}{100}$
- | | | | |
|--------|--------------|-------|--------------|
| < 6 | 98% survival | < 40 | 96% survival |
| 6-17.5 | 46% survival | 40-80 | 36% survival |
| > 17.5 | 0% survival | > 80 | 0% survival |
- Correlation between higher pH and lower CO₂ and increase in mortality

Surgery

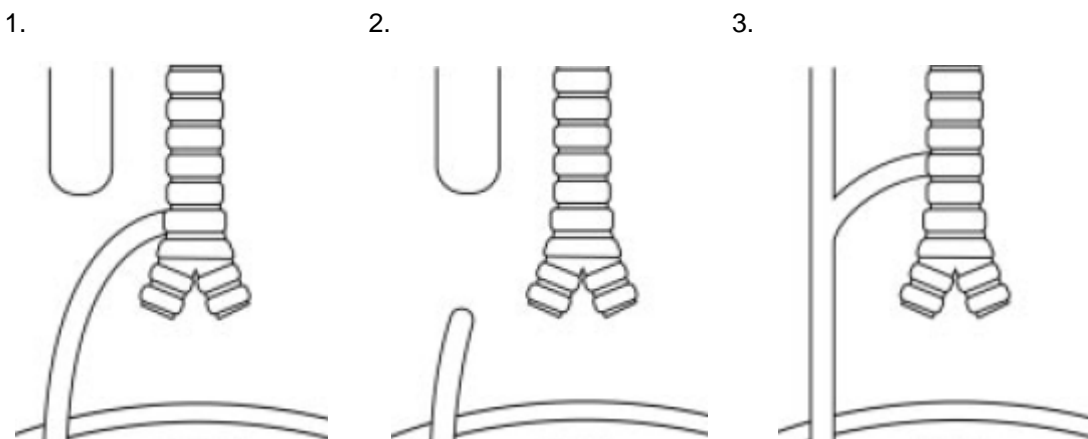
- This is undertaken only when the infant is stable.
- Parameters indicating stability – normal systemic BP, preductal sats >85%, oxygen requirement <50%, lactate <3, urine output >1ml/kg/hr
- In severe cases it is performed when there has been improvement in the pulmonary hypertension and more stable ventilation (usually around 2-3 days of age)
- The diaphragm is repaired with sutures or a synthetic patch

CDH EURO Consortium Consensus 2015: Neonatology 2016;110:66-74

Pediatric Pulmonary Hypertension Guidelines – American Heart Association 2015

Oesophageal Atresia

1. Oesophageal atresia with a distal fistula between the trachea and oesophagus occurs in 85%
 2. Oesophageal atresia alone occurs in 7%
 3. Tracheo-oesophageal fistula alone occurs in 4% - often late diagnosis
- Other variants including proximal fistula



Associations

- 50% overall have associated anomalies
- Most common is VACTERL: Vertebral/ Anorectal/ Cardiac /Tracheo-Esophageal/ Renal/Limb
- Also CHARGE: Coloboma/ Heart/ Atresia choanae/ Retarded growth/ Genital hypoplasia/ Ear
- Trisomy 18, 21 (7% have a chromosomal abnormality)

Diagnosis

- <10% diagnosed before birth with polyhydramnios or absent stomach, rarely see the upper oesophageal pouch antenatally
- Other antenatal anomalies may increase suspicion for oesophageal atresia
- Copious oral secretions unable to be swallowed, excessively “mucousy” baby
- Desaturations and respiratory distress
- Delayed diagnosis with choking with feeds (diagnosis should be made prior to feeding)
- Confirmation of diagnosis if unable to pass a 10G nasogastric tube 10cm beyond the gums in a term baby
- CXR shows the nasogastric tube coiled in the upper pouch at T2-T4
- CXR with bowel gas indicates presence of a fistula
- Gaseous abdo distension suggests preferential air entry through the fistula and is potentially dangerous

Investigations

- Echo for congenital heart disease and to describe the side of the aortic arch (right in 2.5%)
- Renal ultrasound if urine has not been passed, not required if antenatal scans are normal
- Vertebral or rib anomalies may be seen on initial XRays
- Karyotype / Microarray if baby is dysmorphic
- Spinal US if associated anorectal malformation or low spinal abnormality

Pre-op Management

- If born outside CWH the baby needs to be retrieved in a pressurised plane, low flying helicopter or by road to prevent trapped intra-abdominal gas distending causing splinting of the diaphragm
- 10F gastric tube into the upper pouch on continuous suction
- Regular oral suction to prevent aspiration
- NBM – iv fluids
- TPN later on depending on clinical situation and gestation
- Nurse head slightly up to reduce risk of aspiration of saliva
- Antibiotics – amoxicillin at anaesthesia induction (baby may already be on antibiotics for other indications)
- Ventilate if needed - if ETT tip can be placed beyond the distal tracheal fistula it will reduce the risk of gastric distension. Beware gas entering the fistula causing gastric dilatation

Gastric Perforation

- Risk of gastric perforation from air going from trachea through fistula to the stomach which can't be vented
- Gastric perforation can occur in any baby – ventilated or not, although it is more likely to occur in a preterm infant with HMD on assisted ventilation
- Presents with sudden deterioration – abdominal distension and tension pneumoperitoneum and despite increased ventilation, metabolic acidosis and difficulties with oxygenation occur
- Urgent needle paracentesis of the abdomen to deflate then proceed to laparotomy immediately
- Surgical preference is to prevent this complication by early ligation of the fistula in those with significant lung disease (HMD) with the oesophageal anastomosis occurring at the same time or later on depending on the patient's stability

Long Gap

- > 4 vertebral bodies as the gap between proximal and distal parts of the oesophagus
- This is usually not associated with a fistula
- Assess the length of the gap, exclude a proximal fistula and place a gastrostomy for feeding
- Repair of oesophagus at a later stage after a period of growth (usually 3 months)

Post-op Management

- Primary repair of the atresia and ligation of the fistula via a right thoracotomy
- Normally no trans-anastomotic NG tube (unless preterm or multiple anomalies)
- Normally no chest drain placed unless there are concerns about the anastomosis
- Start feeds when the baby has shown they can swallow saliva
- Sign on baby's incubator – do not remove/replace NG, do not suction orally past 7cm
- Antireflux meds will be required in the majority of cases

Complications/Long Term Issues

- Anastomotic leak (5%) can present rarely with tension pneumothorax, but are usually small and heal spontaneously
- Recurrent chest infections from pulmonary aspiration
- Tracheomalacia which causes the typical "TOF cough" and tends to improve with time
- Laryngeal nerve palsy detected by a hoarse cry sometimes seen after repair of an H fistula
- Feeding difficulties – related to oesophageal dysmotility stenosis, GORD, tracheomalacia
- Gastro-oesophageal reflux – treat aggressively to decrease the impact on stricture formation
- Recurrence of fistula is very rare
- Strictures needing dilatation (in up to 20%)
- Scoliosis and chest wall deformities

Bilious Vomiting or New Large Bile Stained Aspirates

Bilious vomiting or new onset of bile aspirate in an NG fed baby is a sign of **intra-abdominal pathology and must be taken seriously.**

Term babies present usually in the first month of life and many in the first few days on the postnatal ward or primary birthing unit. They can also present to CAA.

The bile colour indicator ranges from yellow to very dark green (spinach in the chart below)

Milk	Lemon	Mustard	Wasabi	Lime	Avocado	Spinach

- Some infants will have bilious aspirates that are bright yellow in colour in the initial phases
- Note that colostrum may appear yellow in colour.
- Remember milk can reduce the intensity of the "bile"

Differential Diagnosis

Bile and never tolerated feeds

- It could be the first sign of malrotation* with volvulus even if the abdomen is not distended and this is a surgical emergency. Check for anorectal malformations
- Assess for Hirschsprung disease
- Review the antenatal scans as bowel dilatation may suggest an atresia.

Bile after having tolerated feeds

The following causes should also be considered:

- NEC
- Malrotation with intestinal volvulus – these can present early and late.
- Intestinal obstruction – eg. bowel atresias, Hirschsprung disease, anorectal malformations, strictures, adhesions if previous NEC/surgery
- Strangulated inguinal hernia

Bile that may not be pathological

- Bilious aspirates occur frequently in the preterm infant on nasogastric feeds with feed intolerance in the first week as the gut motility develops.
- Similarly, post-surgical babies and those with ileus may have bilious aspirates in the recovery phase.

*In malrotation, the primary pathology is failure of the small bowel mesentery to attach to the posterior abdominal wall normally, such that there is a narrow "universal mesentery" with the superior mesenteric artery and vein supplying the whole of the mid-gut, (i.e., all the small bowel and much of the large bowel) enclosed within it. Twisting or torsion of this (called "volvulus") will lead to mid-gut ischaemia and necrosis, and sometimes a poor outcome (short gut syndrome or death).

Management

- Admit the baby to NICU (or HDU if presents to CEC)
- In some situations the baby < 1 month corrected may be more appropriate to be transferred to NICU. This is a SMO discussion/decision and reliant on bed state
- Take an accurate history of feeds and vomiting, as well as meconium and stool pattern.
- View the colour of the vomit if possible
- Examine the baby for abdominal distension, abdominal tenderness, bowel sounds and groin lumps
- Check the blood sugar (if they are obstructed they may not be absorbing enough milk to maintain blood sugars) and a capillary gas – checking pH, lactate, base excess
- AXR (AP and lateral).
- The Neonatal SMO must be informed and review the AXR with the on-site team at all times day and night. The Paediatric radiologist on-site or on call can also assist with the assessment.
- Consultation with the Paediatric surgeon on call at any time. It is best to notify them at the time of presentation / AXR.
- Initial management for the bile stained vomiting is to make the baby **NBM and start iv fluids and antibiotics** (amoxicillin/gentamicin or cefotaxime/vancomycin if later presentation or concern for NEC / peritonitis consider metronidazole as triple antibiotic cover)
- The gold standard for the radiological diagnosis of malrotation is an **upper GI contrast study #**. The Paediatric surgeon and neonatologist should discuss the ordering of the study taking into account the clinical status of the baby. It needs to be clear who will be calling the Radiology team after the contrast study is requested
 - In the day call the Paediatric Radiologist directly
 - After hours contact the On Call Radiology Registrar first and they will help liaise with the on-call Paediatric Radiologist
 - If volvulus is suspected, timing is urgent and will occur at any time of the day or night.
 - If the baby is stable and the contrast study is being deferred by the surgeons until the daytime then still order the test but inform the on call Radiology Registrar so that the Radiology team are aware of the need for the test and the reasons that it is not being done urgently
- Occasionally, depending on the clinical state of the infant surgery may be undertaken without prior imaging.
- Abdominal ultrasound should not be used as a first line investigation in suspected malrotation and volvulus unless the baby is too unstable to be moved to radiology for an upper GI study, and this should only be undertaken after discussion between the paediatric surgeon, neonatologist and paediatric radiologist. It can be performed at the bedside in the NICU.
- Ultrasound for malrotation/volvulus can be challenging depending on factors such as gaseous bowel distension and operator experience, and therefore may not always provide a definitive diagnosis.
- In addition to assessing for malrotation/volvulus (which is not always possible), abdominal ultrasound can also be used to assess for intramural gas, free fluid, perforation, collections and portal venous gas.
- If there is a clinical picture of malrotation, surgery will be required after the contrast study or US.
- Other indications for urgent surgery where malrotation has been excluded:
 - NEC with peritonitis typically with perforation,
 - Intestinal obstruction with compromised bowel
 - Irreducible inguinal hernia.

An upper GI study or barium meal, in malrotation will show the DJ flexure has failed to ascend to the same level as the pylorus, and is not to the left of the midline. Most of the small bowel will continue to spiral down in the right para-vertebral gutter.

Bowel Obstruction

A variety of conditions may present with similar signs and symptoms. Antenatal scans, history and careful examination should help in establishing a diagnosis. The higher the obstruction the earlier the vomiting with less marked abdominal distension. The lower the obstruction the later the vomiting and more marked the distension

Presentation

- Abdominal distension
- Tenderness or pain on examination of the abdomen
- Vomiting – often bilious
- Delayed passage of meconium or failure to pass meconium within 48-72 hours
- Maternal history of polyhydramnios may indicate a high obstruction

Differential Diagnosis

- Duodenal atresia
 - Commonly associated with Down syndrome
 - Double bubble on AXR (dilated stomach and duodenum)
- Malrotation with volvulus
 - An embryological anomaly leaves some small bowel attached by a narrow pedicle of mesentery with increased risk of volvulus leading to ischaemia and bowel necrosis
 - Symptoms can be intermittent as the bowel can twist and untwist
- Small bowel atresia – ileal and jejunal (often multiple atresias)
- Colonic strictures after NEC
- Meconium ileus
 - Antenatal scans may have shown echogenic bowel
 - Associated with Cystic Fibrosis – take a family history
 - Check immunoreactive trypsin result from Guthrie Card
 - May need to do further molecular testing for CF and refer to CF Team
- Hirschsprung Disease
 - Delayed passage of meconium with increasing abdominal distension and vomiting
- Hernia
 - Examine for groin lumps consistent with a strangulated hernia
- Anorectal malformations
 - Often as part of VACTERL association

Management

- Notify Paediatric Surgeons
- NBM, iv fluids or TPN
- Large bore gastric tube (8F) on free drainage as well as regular aspiration to decompress the bowel
- Ventilate if systemically unwell or if abdominal distension may cause diaphragmatic splinting and compromise spontaneous ventilation
- Broad spectrum antibiotics (amoxicillin and gentamicin) with consideration of the addition of metronidazole
- Replace extra fluid losses such as large aspirates or vomits with normal saline - usually replace if >10ml in 4 hours but the baby's birthweight, subsequent weights and electrolytes all need to be taken into account
- Pain relief – morphine bolus 25-50mcg/kg and an infusion of 10-20mcg/kg/hr if needed
- If not ventilated a morphine bolus of 25mcg/kg and an infusion at 10mcg/kg/hr should not cause apnoea
- If a strangulated hernia is the cause then the hernia needs to be reduced and if this is achieved then surgery can then be arranged electively
- Rectal washouts as directed by surgeons if Hirschsprung disease is a possibility – 10mL/kg 2-3 x a day
- Discuss with surgeons about likely timeframe to establish feeds postoperatively, if delay likely, consider Longline placement in theatre
- If born outside CWH the baby needs to be retrieved in a pressurised plane, low flying helicopter or by road to prevent trapped intra-abdominal gas distending causing splinting of the diaphragm

Investigations

- FBC, electrolytes, blood culture
- Group and Hold (cross match indicated if surgery is planned)
- Blood gas –metabolic acidosis marker of systemic illness and ischaemic bowel
- Coagulation profile if systemically unwell and bowel necrosis a possibility
- CXR/AXR
- Upper GI Contrast: malrotation – duodenojejunal flexure is to the right of vertebrae and lower than normal
- Lower GI Contrast: small bowel atresia / strictures/ meconium ileus / Hirschsprung disease – to identify the transition zone
- Rectal suction biopsy for suspected Hirschsprung disease
 - Done in NICU by Paediatric Surgical Team
 - Sucrose for pain relief although is a relatively painless procedure
 - Histology results in 2 days showing absent ganglion cells in the submucosa and increased staining for acetylcholinesterase

Necrotising Enterocolitis

Seen in < 5% of babies < 1500g with a mortality rate of up to 30%.

Unknown aetiology with a multifactorial pathogenesis including gut immaturity, bowel ischaemia, altered bacterial colonisation of the gut and enteral feeding.

Risk Factors

- Prematurity, IUGR
- Abnormal umbilical artery dopplers – absent or reversed
- Enteral feeding
- Formula feeding
- Lack of antenatal steroids
- Polycythaemia
- Term babies with severe hypoxia or cyanotic congenital heart disease

Presentation

This can be an evolving pattern or a sudden fulminant onset

- Bilious aspirates
- Abdominal distension, tenderness, discolouration
- Blood in stool
- Apnoea
- Temperature instability
- Metabolic acidosis
- Hypotension
- Falling platelets, neutrophils and Hb

Bells Criteria

- Stage 1 (suspected)
 - Unwell, apnoeas, aspirates, abdo distension, blood in stool
 - AXR nonspecific changes
- Stage 2 (definite)
 - Acidotic, abdominal tenderness, falling platelets
 - Pneumatosis or portal venous gas on AXR
- Stage 3 (advanced)
 - Hypotensive, DIC, peritonitis
 - Perforation and free gas on AXR

Investigations

- FBC, NEON, CRP, Blood culture, Coagulation profile
- Blood gas for acidosis, lactate, blood sugar (a high sugar is sign of sepsis)
- AXR – supine and lateral
 - Dilated bowel loops with thickened wall
 - Pneumatosis (air in the wall of the bowel)
 - Free gas seen as air accumulating under the liver in left lateral position
 - Stacking of loops on top of each other
 - Fixed bowel loops
 - Gas in the portal venous system seen as “black” air overlying the liver

Management

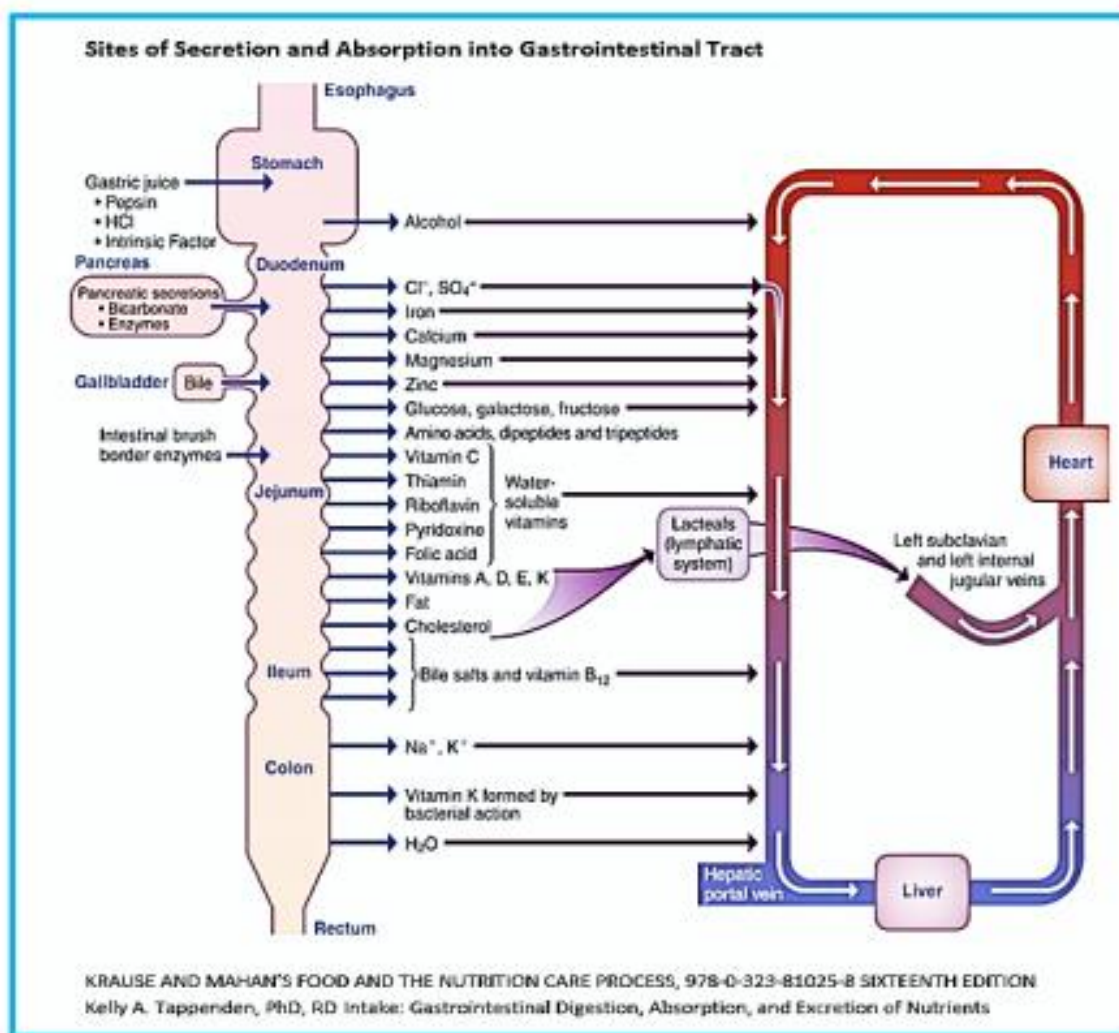
- Call neonatal consultant if you feel that clinically the baby may have NEC
- Babies developing NEC can deteriorate very quickly and require intubation, inotropes and volume support so it is best to inform the consultant early
- NBM for 7-10 days and large bore nasogastric for bowel decompression
- Start TPN and lipid after d/w consultant
- Broad spectrum antibiotics for 7-10 days to cover Gram +ve, Gram –ve and anaerobic organisms
 - Vancomycin, cefotaxime and metronidazole are an appropriate regime for neonates
 - Amoxycillin, gentamicin and metronidazole can be used in babies who have not been on antibiotics
- Pain relief with a morphine infusion
- Correct electrolyte imbalances
- Correct anaemia and low platelets according to protocol limits as discussed with the consultant
- Inform surgeons after d/w neonatal consultant (if definite AXR changes call them even if after hours)
- 40% require surgery either due to failed medical management, perforation or a fixed bowel loop
- Consider a contrast study 4-6 weeks later for stricture formation if there are symptoms of bowel obstruction

Prevention

- Breast milk – up to 10x decreased risk of NEC compared to formula
- No feeding regimes have been shown to be better than others to prevent NEC
- Fortification of feeds has not been proven to cause NEC
- Probiotics have been shown to decrease rates of NEC and the most appropriate choice of probiotics and dosing is still being researched

Ostomy or Significant Bowel Resection with Primary Anastomosis.

- Knowledge of the bowel anatomy after bowel resection including level of ostomy, remaining bowel length and remaining bowel condition is essential to understand the nutritional needs of the infant post-operatively.
- An initial ileus with minimal stoma output is common initially and often followed by a post-resection hypersecretory period that improves over weeks to months with intestinal adaption.
- Infants with resection and primary anastomosis are also at risk of increased intestinal losses. Assessing stool or stoma output regularly is important to minimise fluid and electrolyte abnormalities and optimise growth.



Post-operative care

- Careful fluid management is important in the post-operative period to avoid fluid overload and/ or electrolyte imbalance.
- 24 hour fluid balance monitoring should be initiated and urine output measured and recorded on the observation chart.
- Gastric losses above 20mls/kg/day should be replaced 1:1 with **0.9% saline + 20mmol KCl in 1000ml** (bags stocked in pharmacy room)
- Commence TPN as delays to establishing enteral feeding are expected, especially in preterm babies.
- Blood gases can be used to monitor electrolyte shifts and should be performed at least daily while on TPN with NEON twice weekly for additional nutritional parameters while enteral feeds are established then weekly thereafter

Establishing and advancing feeds

- Enteral feeds should start low and be progressed with consideration to the effect on stoma/ stool output and other indicators of feed tolerance.
- EBM should be the milk of choice initially but if there is ongoing feed intolerance consider the use of an extensively hydrolysed formula (Pepti-junior) or amino acid formula (Neocate)
- Starship has a guideline for advancing enteral feeds and this can be accessed here: starship.org.nz

Routine assessment as enteral feeds established

- Measure and record stoma output in mls/kg/day
- Measure and record urine output in mls/kg/hr
- Weigh alternate daily initially, then every 4 days when stable.
- Monitor growth (including length and head circumference with every second weight measurement/ 8 days)
- Weekly NEON with LFTS and conjugated bilirubin.
- Weekly urinary sodium – if <20 mmol/L is indicative of sodium depletion. Children with small bowel ostomy will require additional sodium supplementation, even if the serum sodium is in the normal range.

Calculation for estimated stoma Na losses:

$$\frac{\text{Ostomy output (mls/day)} \times 100\text{mmol/L}}{1000} \div \text{weight (kg)} = \text{est Na loss in mmol/kg/day}$$

*More proximal stoma's will have greater sodium losses. Jejunal losses range from 80-140 mmol/L.

- Infants with stomas and small bowel resection are at risk of micronutrient deficiency. Most common deficiencies include fat soluble vitamins (Vitamins A, D and E) and zinc, copper, selenium and iron.
 - If infant is still on TPN after 21 days they should have serum zinc, copper, selenium and ferritin levels checked along with fat soluble vitamins.

Managing high stoma outputs in infants already established on enteral feeds

- Output should be calculated as follows:
 - Neonates with stoma but no mucous fistula or 0% refeeding= stoma output only
 - Neonates with stoma and partial refeeding= stoma output – refed volume +stool output (if stool output can't be measured, consider >6 stools per day as excessive and consider also the consistency and volume.)
 - Neonates with primary anastomosis and no stoma or 100% re-feeding = stool per rectum
- A consensus on what constitutes a high output stoma is difficult to find.
- **A stoma output >20mls/kg/day** is a trigger to assess hydration, electrolyte and nutritional status.
- **Outputs > 40mls/kg/day** require urgent assessment of current status and management including assessment for dehydration and replacement of excessive losses.
- **If > 70mls/kg/day** and not being refed, consider reducing the rate of feeds, or withhold feeds for a period.
- NOTE: More proximal stomas eg, jejunal should have a lower threshold for replacement of losses and alteration of feeding regime (20 mls/kg/day)
- Some infants may require a period of partial parental nutrition to support growth and nutrition and allow further bowel recovery.
- Assess for nutritional compromise. Assess all growth parameters, iron and protein status and consider risk of micronutrient deficiency.
- Consider viral stool PCR to exclude infectious causes
- Consider loperamide to slow intestinal transit time (if sufficient time has elapsed since surgery ie, a few weeks). Start at lowest dose.
- Omeprazole reduces gastric hypersecretion and can also help manage excessive stoma losses.
- Consider change in milk (EBM > Pepti junior > Neocate)
- Consider continuous or slow bolus feeds to improve tolerance
- Small bowel stasis, with symptoms of poor growth, feed intolerance with vomiting and diarrhoea and abdominal distension, can be addressed with the use of enteral antibiotics (we typically use metronidazole and gentamicin.) There is no clinically useful diagnostic test for this condition but infants with small bowel stoma are at risk and treatment should be initiated only in discussion with Gastroenterology.
- For the most complex infants, Starship also have a guideline for managing nutrition and feed advancement for infants with chronic poor gut function and dependence on TPN (intestinal failure). [Intestinal rehabilitation \(starship.org.nz\)](https://www.starship.org.nz/intestinal-rehabilitation). These infants will be under joint care with gastroenterology.

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Fluid, electrolyte and Nutrition Management for Infants with an Ostomy or Significant Bowel Resection with Primary Anastomosis. The Hospital for Sick Children. Toronto, April 2023.

Bushra A Malik, Yuan Y Xie et al. Diagnosis and pharmacological management of small intestinal bacterial overgrowth in children with intestinal failure. Can J Gastroenterol. 2011 Jan; 25(1): 41-45

Neonatal Enterostomy Management Guidelines . UC Davis Children's Hospital. Sacramento. January 2024.

Urogenital

Undescended Testes

- Most undescended testes are evident at birth.
- Descent is unlikely to occur beyond 3 months post-term
- Newborn testes are not retractile
- If undescended testis suspected, refer to paediatric surgery/paediatric urology at 3 months post-term
- Inform the GP and tell the parents that an operation is likely to be necessary if the testis is confirmed to be undescended

Hypospadias

- Presents as a bent penis (chordee), with an incomplete foreskin (dorsal hood) and a urethral meatus in an abnormal position (proximal to where it should be)
- Check that the testes are descended and that the scrotum is not bifid (this may indicate a DSD (intersex) problem)
- Refer to the paediatric surgeon/urologist .
- Neonatal circumcision contraindicated
- If the abnormality is severe, obtain a renal USS.

Hydrocoeles

- Hydrocoeles need no treatment unless they persist
- Examine to be certain there is no inguinal hernia
- If hydrocoele alone, reassure parents that these almost always resolve spontaneously,
- Refer to paediatric surgeon if there is diagnostic uncertainty or if they persist beyond 2 years of life

Inguinal Hernias

- Usually appear as an intermittent lump at the external ring in the groin
- Always needs surgical correction
- Paediatric surgical referral before discharge.

Ovarian Cysts

Ovarian cysts diagnosed antenatally

- The vast majority of these are benign follicular cysts and if they contain solid elements consider the possibility of a cystic teratoma
- Cystic masses containing solid elements or symptomatic ovarian cysts should be surgically removed and histology performed
- Septated or debris filled cysts usually mean that the ovary is already dead from torsion and ischaemia and these frequently disappear on follow up ultrasound scans
 - All suspected ovarian cysts should be referred to the Paediatric Surgeons
 - An early postnatal scan should be arranged – discuss timing with the surgeons and arrange follow-up in the surgical clinic after the scan

❖ ORTHOPAEDICS

Developmental Dysplasia of the Hips

Risk factors for developmental dysplasia of the hips (DDH)

1. Breech or transverse lie in the 3rd trimester
2. First degree relative with history of DDH
3. Severe oligohydramnios of long duration

These infants should have a hip ultrasound at 6 weeks after their due date regardless of a normal hip examination (scans done before 6 weeks are hard to interpret due to immaturity and need to be repeated so details such as the EDD are crucial to get the correct timing of the scan)

The process for hip follow-up is a 3 step process and is described below:

1. DDH Form to be completed on HCS
2. Hip US referral to be made on HCS
3. Virtual Hip Clinic referral to be made on HCS so that there is a closed loop to ensure all referrals have their details and US reviewed and no patient is missed

Neonatal team to complete this process only for babies at Christchurch Womens Hospital

LMC referrals for hip dysplasia screening for babies in the community or after a primary birthing unit or home birth

- advise them to contact the DDH team directly by email: ddh@cdhb.health.nz or ph: 021 951 261

Step 1: DDH Referral

- There is a standard referral form for DDH at-risk follow-up: **Health Connect South - Add New Document – Developmental Dysplasia of the Hips.**
 - An encounter is needed and will be the NICU or Maternity admission
- The form includes information for the parents to understand why the scan is being requested and the follow-up required if the scan is abnormal
- The electronic referral sits in HCS and can be seen by the DDH Coordinator and NICU team.
 - It is sent directly to the GP electronically
 - Copies for the LMC and Parent need to be printed off
 - No form needs to be printed for the NICU ward clerk

Step 2: US Request Form

- The request form:
 - Click on Ultrasound CHC Hospital General; Hips
 - Put Team DDH CDHB as the responsible clinician (NOT the Neonatal SMO)
 - The EDD is to be written in the free text area for clinical details (not where there is an EDD box as this is for pregnant women). Any baby born ≥ 40 weeks should use their birthdate as the EDD
 - Add in the reason for the scan – breech, family history, transverse lie, oligohydramnios
 - Timeframe is 6 weeks corrected or you can calculate a planned target date
- All results are reviewed by the Orthopaedic DDH coordinator who triages results with the Orthopaedic surgeon and it is their responsibility to arrange follow up scans and clinic appointments
 - Borderline results involve arranging a repeat hip US in 6 weeks
 - Abnormal results are referred for an Orthopaedics clinic review within 4 weeks

Step 3: Clinic Referral for US Review

- To ensure the baby is booked into the DDH Virtual Clinic (Orthopaedic-Paediatrics) to follow up their scan results the following is needed
 - Open the referrals tab on HCS and Create Outpatient Referral in the same way other clinic appointments are made
 - Chose Orthopaedic-Paediatrics, clinic assessment at Christchurch Hospital
 - Reason for referral – DDH Virtual clinic, US ordered, HCS referral letter completed
 - Requestor is the SMO they are admitted under if in NICU or if on maternity then the Level 2 SMO for the week

Abnormal Hip Examination

Hips that are dislocated or dislocatable or there is a major risk factor such as neural tube defect or arthrogryposis

- Discuss the clinical findings with the neonatologist on service who may also examine the baby
- After discussion with the neonatologist refer to orthopaedics by completing the Urgent DDH Referral form (found in Neonatal Forms under the letter “R” on the Neonatal Intranet). Click “full screen” and then “Open in Word” to edit the form and then print (**do not save a copy**). Email a scanned copy of the form to the DDH Coordinator at ddh@cdhb.health.nz and to the NICU secretary nicuadmin@cdhb.health.nz to upload on to HCS.
 - The Coordinator can also be contacted on 021951261 if you have any questions
 - There is no need to phone the on-call Orthopaedic Registrar and no need to order an ultrasound as orthopaedics will arrange that after assessing the baby.
- The referral will be reviewed and booked within 3 days and an appointment made within 2 weeks
- If you are contacted by LMC’s with a baby with an abnormal hip examination please advise them to contact the DDH team directly by email: ddh@cdhb.health.nz or ph: 021 951 261.

Talipes

Positional talipes

- The foot can be brought into normal anatomical alignment when manipulated
- No need for Orthopaedic or Physio review. Give handout for Positional Talipes, by printing link <https://www.rch.org.au/uploadedFiles/Main/Content/ortho/factsheets/POSITIONAL-TALIPES.pdf>
- Advise if unchanged by 4-6 months, contact GP for Orthopaedic review.

Talipes calcaneovalgus

- The foot is pressed against the front of the shin is of no significance and needs no treatment.

Talipes equinovarus

- The foot is inverted, supinated and adducted distal to the talus
- Many babies are born with a minor degree of positional talipes equinovarus in which full ankle movements are possible and in these cases no treatment is necessary.
- Fixed talipes can be detected on antenatal scans and an antenatal referral may have gone to the Orthopaedic Paediatric Physio who should have met with the family to discuss the treatment after birth
- Babies on the postnatal ward with fixed talipes should be referred to the Orthopaedic team by completing a Referral letter (under Add New Document) and emailing to paediatricorthopaedic@cdhb.health.nz. Please include on this the Mothers NHI as the team may have met the family antenatally. A senior Orthopaedic Nurse will either visit the family in hospital or arrange to see them as an outpatient within 2 weeks to discuss the treatment required. There is no need to call the on-call Registrar.
- Babies in NICU with fixed talipes should have a Referral letter emailed to the Orthopaedic team paediatricorthopaedic@cdhb.health.nz when the baby approaches term (if born prematurely) as casting will not be done prior to this as it is not developmentally supportive.
- Treatment involves casting from about 2 weeks of age in term babies or around term corrected age in preterm babies. The casts are changed every week for about 6 weeks and then they proceed to a tenotomy and a further 4 weeks of casting before starting to wear John Mitchell boots and bars.

Erbs Palsy

- This is caused by injury to the brachial plexus often after a difficult delivery
- Typically the arm is held limply by the side, medially rotated and the hand in a “waiters tip” position
- Flexion at the elbow is diminished
- Look for associated clavicular and humeral fractures and Horner’s syndrome (ptosis, small pupil)
- Refer to Neonatal Physio (page 5119 or place a referral in her pigeon hole in NICU) who will review on the ward if available and at 2 weeks of age. If the palsy has not recovered then they will refer to the Child Development Service for ongoing follow-up and management

Other Orthopaedic Issues

- Occasionally other orthopaedic issues occur that need to be discussed with the Orthopaedic team, eg: fractured humerus or femur, dislocated joints, congenital skeletal abnormalities.
- If they are non-acute then a Referral letter to Orthopaedic Outpatients paediatricorthopaedic@cdhb.health.nz is all that is required. This will be reviewed by the Orthopaedic Paediatric Physio in the first instance who will liaise with the available Paediatric Orthopaedic Surgeon and a time will be arranged to review the baby
- If it is acute and within work hours then complete a Referral letter and contact the Charge Nurse on phone 80812 or mobile 0276890189 and she will liaise with the Paediatric Orthopaedic Surgeon available and arrange for the baby to be seen. Email referral to paediatricorthopaedic@cdhb.health.nz
- If it is an acute issue that is out of hours then call the Acute Orthopaedic Registrar as the first point of contact on 0272222723

❖ ENT/PLASTICS

NICU - Email addresses for referrals for inpatient review

- ENT Referrals – ENT.outpatients@cdhb.health.nz
- Plastics Referrals - plastics.secretaries@cdhb.health.nz
- Cleft Palate – see flowsheet below

Ear Deformities

- Deformational ear anomalies are not uncommon and occur in up 1:400 live births.
- There is a spectrum of deformation from anotia (the absence of external/internal ear components) to mild external ear deformations (Lop/Stahl Ear etc)
- Tanzer¹ has described a classification system according to the anatomical regions of the canal/external ear affected

BOX 7.1 Clinical classification of auricular defects (Tanzer)

- I. Anotia
- II. Complete hypoplasia (microtia)
 - A. With atresia of external auditory canal
 - B. Without atresia of external auditory canal
- III. Hypoplasia of middle third of auricle
- IV. Hypoplasia of superior third of auricle
 - A. Constricted (cup and lop) ear
 - B. Cryptotia
 - C. Hypoplasia of entire superior third
- V. Prominent ear

Nelligan – Plastic Surgery 3E Volume 3 Craniofacial, Head and Neck Surgery, Paediatric Surgery

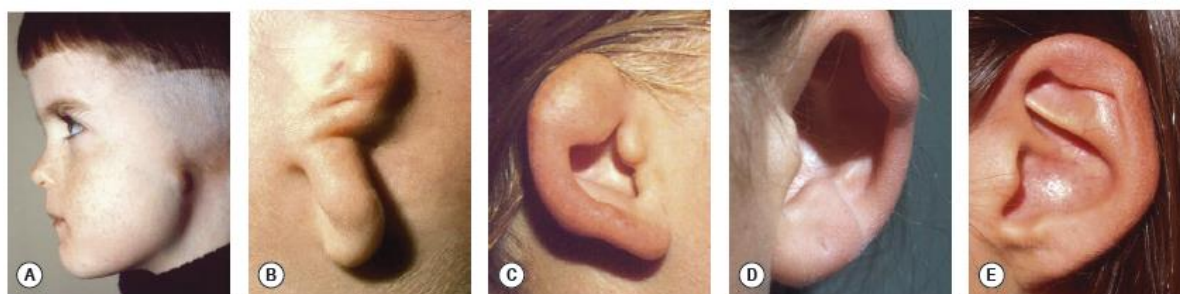


Fig. 7.4 Ear malformations, shown by severity. (A) Anotia. (B) Grade III microtia. (C) Moderate constriction. (D) Grade I constriction. (E) Lop ear.

- Microtia – or ‘small ear’ (up to 1/1500 live births in certain populations) is also associated with auditory canal atresia. Hearing assessment at audiology should always be assessed in these children **without** hearing screening. These babies will be directly referred to audiology as per Antenatal and Childhood UNHSEIP screening protocol.
- Management of congenital ear deformational anomalies ranges from complex staged surgical correction in Grade I – II to simple splinting measures in Grades IV and above.
- Tan et al ² have shown that early external splintage reduces long term auricular deformity and the need for later surgical correction.

Referral Process

- To ensure that it is only those babies who have an ear shape that is corrective the below picture describes what ear shapes can be corrected with taping. It is also to ensure that new parents are not coming to the hospital with their baby whose ear shape doesn't warrant reshaping.



TYPES OF EAR DEFORMITY

- The plastics ear clinic has asked that all those wanting to refer to the plastics OPD consider what is appropriate for referral as many ears will self-correct over the first few weeks of life. It is only the shapes above or an obvious mal-formed ear (e.g. microtia or atresia) that should be referred to plastics OPD. Microtia or atresia should be referred by the NICU team if the baby is an inpatient.
- If LMCs/referrers are unsure they need to take a photo of both the baby's ears and email these pictures along with the NHI of the baby with parental consent, to the UNHSEIP coordinator at: angela.deken@cdhb.health.nz. The coordinator if unsure of the ear shape will consult with the ear clinic nurses or the Plastic doctors to advise whether referral is deemed necessary and the LMC/referrer will be advised of the outcome. If referral is advised the UNHSEIP coordinator will refer the baby to the plastics outpatient's department.
- Refer by electronic referral to Plastics Outpatients. The baby will be reviewed by the Plastics Team at the Plastic Surgery Outpatients clinic a week after taping commences. More complex anomalies should also be referred and appropriate multidisciplinary team consultations (neonatal service) can be arranged.

Ear Splinting

- The technique of ear splinting used at Christchurch is as described by Manji et al ³; a small roll of thin DuoDerm is used to splint the anti-helical fold, secured with steri-strips and 3M Silicone tape to set-back the pinna.



- Ideally this would be performed as soon as the deformation is noted and within the first week of life to achieve the highest success of long-term correction in the shortest timeframe.
- Follow up will be performed 1 week after first splint application in Plastic Surgery Clinic then as required for the following weeks.
- At week 5, the splint is taken down for 24 hours and if the ear anomaly remains corrected after this time, one further week of splinting is applied then ceased.
- The simple splinting technique is taught to the parents/caregivers of the newborn and is performed by them weekly which is an effective non-invasive treatment method. If there are any questions, please contact the UNHSEIP coordinator on 027 3450 849 or angela.deken@cdhb.health.nz

1. Tanzer RC. The constricted (cup and top) ear. *Plast Reconstr Surg*. 1975, 55:406
2. Tan ST, Shibu M, Gault DT. A splint for correction of congenital ear deformities. *Br J Plast Surg* 1994;47:575e8
3. Manji, I. Durlacher, K. Verchere, C. Correction of neonatal ear deformities using DuoDERM: A simple technique, *Paediatrics and Child Health*. 2020 1, 1-4

Facial Nerve Palsy

These are generally caused by pressure from a forceps delivery.

Babies need review by Registrar/NNP on the postnatal ward or in NICU

Most facial nerve palsy presentations are self-limiting (resolve by 2 weeks)

Complex presentations include:

- Complete unilateral facial palsy
- Difficulty creating a seal for feeding – requires referral to Lactation Consultant
- If the eye is not closing, consult Ophthalmology regarding eye treatments
- Minimal change in the initial palsy presentation over 48 hours should raise concern over a possible transection (although this is very rare)

Suitable for discharge when oral feeding is no longer impacted by the palsy.

ACC form to be completed by the Obstetric or Neonatal Teams.

There is no pathway for referring babies for Outpatient Physiotherapy at the hospital. If parents wish to engage Private Physiotherapy with ACC funding, they can self refer to community Paediatric Physiotherapists

If palsy persists at 6 weeks of age then referral to Plastics Outpatients is appropriate

Differentiate facial nerve palsy from asymmetrical crying facies. In asymmetrical crying facies, the face appears symmetric with eye and forehead muscles unaffected. At rest the face is symmetric but becomes asymmetric with crying with the mouth pulled downward on one side

Stridor

This is relatively common in the neonatal population with causes being:

1. Laryngomalacia – common
 2. Vocal cord palsy occasionally
 3. Subglottic stenosis very rarely
- The airway in a neonate is more anterior and smaller and the anatomy lends itself to stridor in the setting of relatively bigger tongues, narrow epiglottis and hypotonia
 - Stridor may be associated with primarily an airway issue or a feeding issue or a combination of both
 - Not all babies with stridor need referral to ENT for a scope

Indications for SLT Referral

As per the Infant Feeding Referral Criteria refer to SLT in babies with stridor during feeding to:

- assess oral feeding
- provide clinical feeding assessments and feeding support
- arrange videofluoroscopy (VFSS) if indicated to formally assess swallow function and safety.

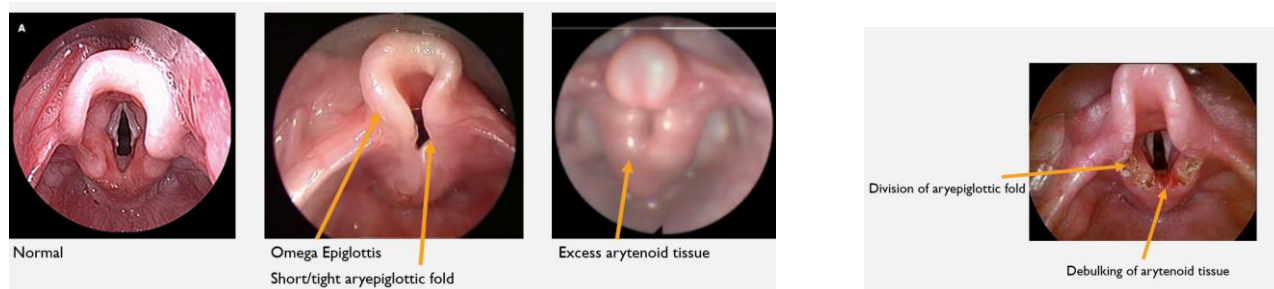
Indications For ENT Referral

This will need to be individualised but include:

- Airway concern
 - Abnormal cry
 - Aspiration/unable to protect the airway
 - Stridor in association with increased work of breathing and desaturations
- Feeding concern
 - A preterm or hypotonic baby with stridor whilst learning to feed may not need an immediate referral to ENT (see below)

Laryngomalacia

- This tends to develop over time and may not be present at birth
- Louder stridor is not necessarily a worsening airway issue. It will be more obvious with activity (crying, feeding) and may become more obvious when tone improves
- **Mild laryngomalacia** with stridor audible but without work of breathing needs no specific management or ENT referral
- **Moderate laryngomalacia** will have audible stridor as well as some increased work of breathing with feeding and crying. This can be managed with a period of observation, feeding support with SLT and consideration of management of concomitant gastro-oesophageal reflux prior to ENT referral.
- **Severe laryngomalacia** may present as increased work of breathing at rest and is more likely to be associated with other airway anomalies and requires a scope and consideration of a supraglottoplasty. This involves dividing the aryepiglottic folds, and trimming redundant tissue from the arytenoids.
- There is no benefit of serial scopes in a baby with a diagnosis of laryngomalacia, unless the clinical situation has changed significantly



After Supraglottoplasty

Vocal Cord Palsy

- Unilateral vocal cord palsy will present with an abnormal cry and needs evaluation by ENT
- Bilateral vocal cord palsy may not present with an abnormal cry but these babies cannot protect their airway safely and may present with aspiration, desaturation and feeding issues. These babies will be scoped every 1-2 weeks to assess for improvement in the palsy

Cleft Lip and Palate

Cleft Palate and/or Lip

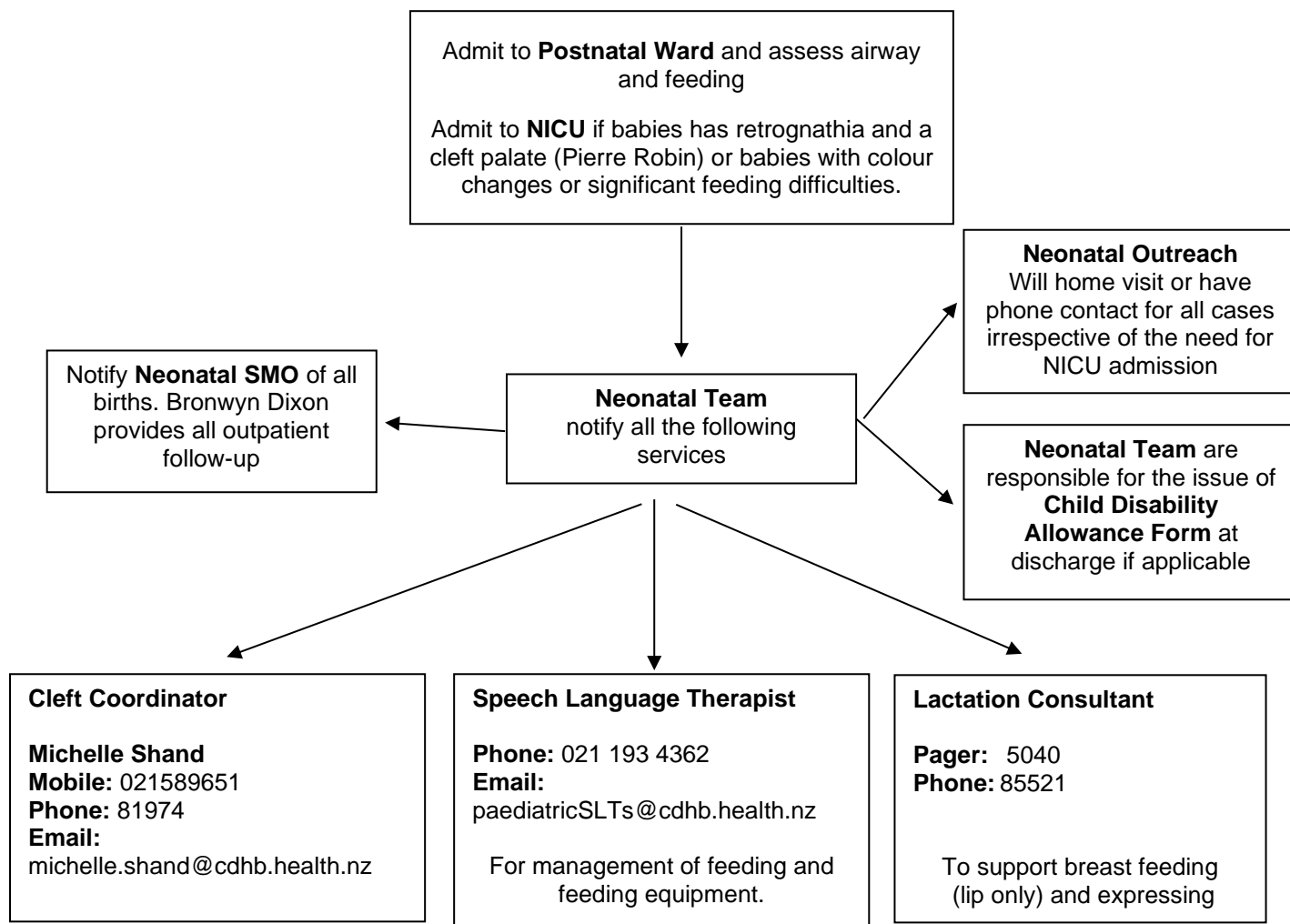
- May need admission but management on the postnatal ward is encouraged.
- All babies to be discussed with the SMO on service who will also need to approve readiness for discharge
- To stay in hospital until feeding is established or has a discharge feeding plan. This will take at least 4 days
- Encourage breast feeding or time at the breast , but breast milk feeding via a specialised feeding system is often used.
- Referrals needed (also see flow sheet below):
 - Cleft Nurse – works part-time but can act on referrals promptly. May have met the family antenatally. She will refer to Plastics as needed so NICU no longer need to do this referral.
 - Speech language therapist - will assess and provide appropriate specialised bottles. All babies need to be seen by SLT prior to discharge
 - Lactation consultant – may have met family antenatally, involve early
- There is a parent information booklet (The Blue Book) available to be given to the family
- A Child Disability Allowance form should be completed before discharge if the palate is involved and registration for the National Travel scheme
- Breast pumps are available for loan at no cost via Cleft NZ website

Pierre Robin Sequence

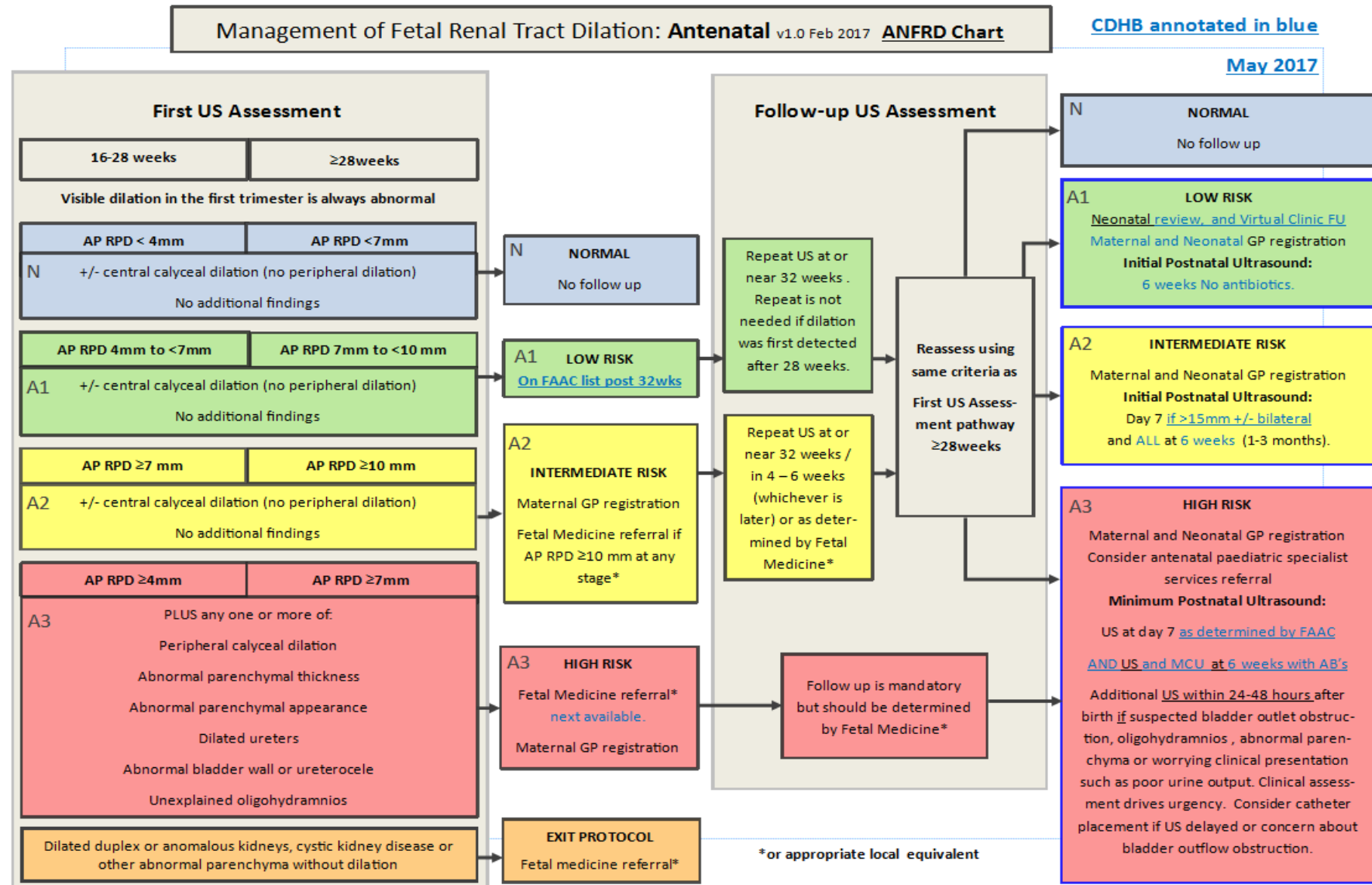
- Pierre Robin syndrome is characterised by micrognathia (small jaw), retrognathia (posterior displacement of the chin), glossoptosis (the tongue falls backwards) and u shaped cleft soft palate.
- The severity of the syndrome, which presents in the neonatal period with upper airway obstruction and feeding difficulties, varies widely.
- Upper airway obstruction presents at, or shortly after birth as a result of retrognathia and subsequent posterior position of the tongue. The airway can be managed in a number of ways from postural nursing with the infant prone, nasopharyngeal airway to tracheostomy
- **Admit to the NICU** for saturation monitoring if there is any suspicion of airway compromise.
- Referral pattern as per cleft palate pathway but may also need ENT review
- Consider investigation/follow-up for other features of (autosomal dominant) Stickler syndrome, especially if there is a positive family history of Robin sequence or eye abnormalities, usually with geneticist referral.
- Babies that benefit from nasopharyngeal airway will have had full assessment, including a sleep study, prior to NP airway insertion. The decision will be made by Consultants with consultation with parents
- Consider need for cardio-respiratory monitoring at home.
- See **Procedures section** for instruction on how to insert a **nasopharyngeal airway**

Cleft Lip and Palate Pathway

<p>At Birth Initial Assessment of airway by Neonatal Team</p>



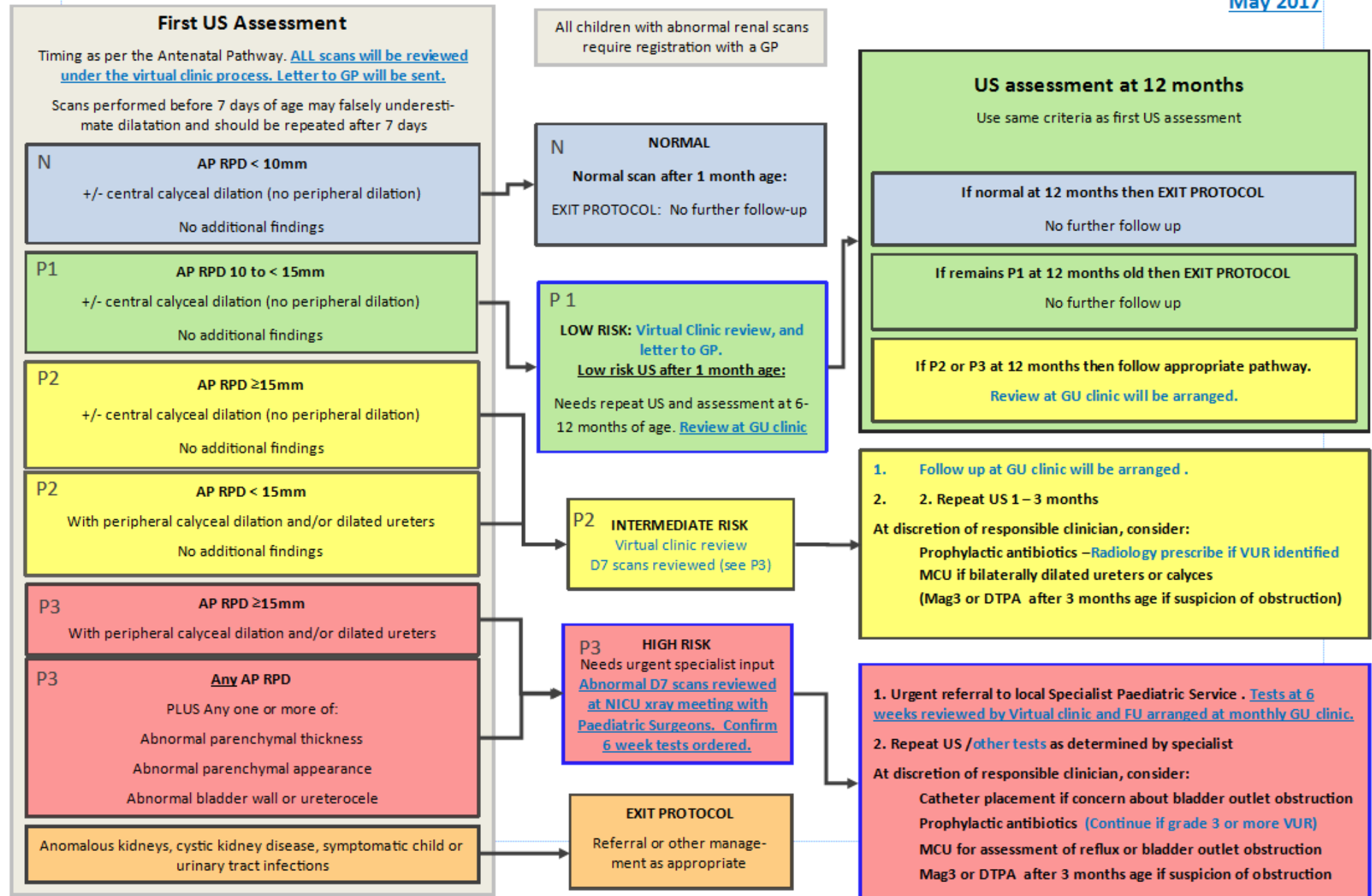
❖ RENAL



Management of Fetal Renal Tract Dilation: Postnatal v1.0 Feb 2017

CDHB annotated in blue

May 2017



Other Renal Issues

The flowcharts above only relate to antenatal renal dilatation, however, there are other antenatal renal anomalies that need follow up: Check the letters on HCS which contains the FAAC group advice. **Scans are done at corrected age** ie: 6 weeks corrected.

- **Single kidney and Unilateral Multicystic dysplastic kidney:**

- **US at 6 weeks** unless FAAC suggest otherwise which would be due to additional findings.
- Virtual clinic follow-up
- An MCU will be done if required after the US.

- **Horseshoe kidney or Pelvic kidney**

- without dilatation or dilatation less than 7mm: – **US at 6 weeks**
- If dilatation ≥ 7 mm or ureters seen, then **MCU and US at 6 weeks with antibiotic prophylaxis**
- Virtual clinic follow-up

- **Duplex kidney**

- No Antenatal dilatation and RPD < 4mm at 32 weeks - **No postnatal US required**
- Duplex with RPD ≥ 4 mm and central dilatation only – **US at 6 weeks**
- Duplex with peripheral calyceal dilatation / moiety dilatation – **US and MCU at 6 weeks with antibiotic prophylaxis**

- **Family History of High grade VUR** in parent or siblings, ie. first degree relatives:

- Parents should be made aware that despite normal antenatal ultrasound findings the infant is at increased risk of VUR and investigation are recommended.
- Incidence of VUR is 20-40% if a sibling is affected and 40-60% in offspring of mothers with VUR.
- Over the years the level of VUR at 6 weeks age when the postnatal renal US was normal is usually grade 3 or less and the need for other than US monitoring has not been required in the majority of cases.
- **US only if no antenatal dilatation and no antibiotics** are needed, however after discussion, acknowledge that the family may request an MCU due to their previous experience
- **US and MCU if antenatal RPD dilatation > 7mm** or ureters seen, regardless of peripheral calyceal involvement and **antibiotic prophylaxis**
- Family history of VUR with early UTI history in other family members and normal antenatal scans - some parents will prefer antibiotics from day 5 depending on their experience. Signs and symptoms of UTI are variable and subtle.

Antibiotic prophylaxis

- If an MCU is done < 7 days age give a dose of iv gentamicin prior to the MCU
- Prophylactic oral antibiotics can start from day 5
- Firstline choice is trimethoprim (2 mg/kg/dose once at night) and continue until the MCU result is known
- Any baby having an MCU are recommended to have prophylactic antibiotics by 5 days of age
- Parents are sometimes reluctant for their baby to be on antibiotics – they should be advised depending on the severity of the antenatal findings. If at the mild end of the spectrum commencing 2 nights before the MCU is adequate

Documentation

- Generic letter to be completed: **Health Connect South – Add New Document – Antenatal Renal – Select the Current Inpatient Encounter**
- To get the correct template (Antenatal Renal or Renal Family History) select the appropriate tick box at the top of the template. This letter will explain the process to parents, LMC, GP (enter the relevant names)
- Fill in the appropriate details as you move down the template
- At the bottom the responsible clinicians need to be manually entered and these should be **R Sinclair and E Anderson**
- Untick the “On behalf of” box
- The US and MCU are ordered electronically. The SMO for the investigations should **say R SINCLAIR** so that the results go to the appropriate person to act upon. Note they are to be requested on corrected gestation and not necessarily 6-8 weeks from birth.
- The requests must have the Maternal NHI written in free text for the Radiologists to be able to view the antenatal scans at the time of the postnatal investigations

- To ensure the baby is booked in to the Antenatal Renal Virtual Clinic (Paediatric Outpatients) to follow up their scan results the following is needed:
 - Open the **Referrals tab** on HCS and Create Outpatient Referral in the same way other clinic appointments are requested
 - Choose **Paediatric Medicine**, clinic assessment at Christchurch Hospital
 - **Reason for Referral** - request the Virtual Renal Clinic with Dr Ruth Sinclair in 6-8 weeks and add the date that the US \pm MCU has been requested for so that the clinic appointment can be booked at an appropriate time after the investigations have been done.

Renal Referrals if not an inpatient at CWH

- LMC's should contact the ward registrar or CNS-ANP/NNP on pager 5039 during working hours to arrange the necessary investigations and arrange prophylactic antibiotics if required
- Copies of the antenatal ultrasound will need to be faxed to 3644883 or 85883 internal or scanned and emailed if they are not available on Health Connect South
- Virtual clinic follow up is as above after the investigations at 6-8 weeks corrected age.

❖ POSTNATAL WARDS

Transfers from NICU to the Postnatal Ward

This is a guideline and there needs to be an element of flexibility around:

- the acuity of the Delivery Suite, NICU and Postnatal on a daily basis
- the individual clinical situation
- the best situation for the baby and family to avoid separation wherever possible

Communication

- ISBAR form to be completed by NICU staff and to document the expected management on the postnatal ward including the requirement for observations or length of antibiotic course
- NICU staff to contact Postnatal Ward Clinical Coordinator to discuss the potential transfer
- Baby's NICU folder to transfer to the postnatal ward with the baby and to be returned to NICU after discharge

General

- Maintaining temp 36.5-37.5 in a cot
- If a baby is <2.3kg they will be admitted to NICU at birth, however, if the baby is stable as per the criteria below then discuss on day 3 if the baby can transfer to the postnatal ward to be with the mother. Rare to transfer a baby back to postnatal ward if <2.2 regardless of performance
- Infants who are now well can complete their antibiotic course on the postnatal ward
- Observations will be required 4 hourly for 24 hours if the baby had been on CPAP or oxygen or is on antibiotics. The need for these to be continued past 24 hours to be discussed with the Neonatal team.

Respiratory

- Not requiring oxygen
- Respiratory rate <60/min
- If respiratory rate is 60-70/min but effortless and not impacting on feeding and needing no specific NICU treatment transfer should still be considered
- NEWS score of 1 for respiratory rate 60-70/min can be an accepted variation that needs to be documented in the ISBAR handover and maternity multi-care pathway to highlight that the respiratory rate has been recognised and will be reviewed daily.
- Babies who receive CPAP in delivery suite but this is stopped on or shortly after admission should return to their mothers as soon as possible
- Babies who have short term CPAP/oxygen for 1-2hours and then have transitioned well
 - 2-4 hours of sats monitoring in NICU off respiratory support
 - maintaining sats $\geq 95\%$ in air (review histogram for the past 2-4 hours off resp support)
- Babies who required CPAP/oxygen for >2hours
 - at least 6 hours of sats monitoring after coming off respiratory support
 - maintaining sats $\geq 95\%$ in air (review histogram for the past 2-4 hours off resp support)

Feeds and Blood Sugars

- Babies who have short term CPAP <2 hours should have one breastfeed prior to transfer but this may not always be able to occur in NICU depending on the mothers mobility postpartum
- If the baby was on iv fluids/NG feeds these need to have been halved or stopped for at least 6 hours prior to transfer and the baby to have fed twice with 2 pre-feed sugars $>2.6\text{mmol/L}$
- If top ups are required then a specific feeding plan should be documented prior to transfer

NICU Team Prioritisation of Neonatal Reviews on Postnatal Ward

- When covering the postnatal ward, print off a patient list in the morning
- The babies that need a check have NICU beside their name on Floview
- Make contact with the maternity co-ordinator (pager 5128) and maternity discharge facilitator (pager 5034) on arrival in the ward to discuss the prioritisation of the babies

- The patient list can be printed off Floview and once a baby has been seen update Flowview
- It is imperative to use this as a way of communication to maintain continuity of care as there are a number of staff covering the postnatal ward during the week and weekends.
- Midwives or GP's may contact the postnatal staff member for assistance with organising follow-up renal scans and prophylactic antibiotics if the baby was not born at Christchurch Women's. It is easier for us to arrange the tests and this ensures they will get appropriate follow-up if needed. For hip referrals advise the LMC to email the DDH coordinator.
- Before referring babies to consultants in other specialities we prefer that you discuss the abnormality with the neonatal paediatrician on call or on service. Referrals to clinics or for investigations should always take place in the context of a full discussion with the parent(s) and notification of the GP/LMC
- Electronically sign off the results of all babies reviewed by the Neonatal Team on the postnatal wards on a daily basis and at discharge

Newborn Early Warning Score (NEWS)

- Introduced 2015 as a quality measure to ensure babies in at risk groups have appropriate observations and a clear process to escalate care in concerning clinical situations
- All observations to be documented on the Newborn Observation Chart (C280106)
- After birth the baby needs their risk category to be reviewed and documented. This will dictate when they require NEWS observations and if oxygen saturations and blood glucose monitoring are also required.
- Refer to document C280106

Newborn Checks

Initial Newborn Check

- 0-2 hours to check for cardiorespiratory transition and for significant congenital anomalies
- Mainly completed by midwives
- Is not part of the resuscitation assessment
- If you do complete the examination fill in the column on the green sheet (QMR0044).

Full Newborn Check (at 24 hours)

- Involves reviewing the maternal notes to check blood and scan results and taking a history from the mother to check for any concerns in pregnancy, family history of newborn problems (heart, hips, kidney diseases)
- Column on the green sheet (QMR0044) for documentation and the Well Child Book
- Registrars and CNS/ANP to measure oxygen saturations on all babies when doing the full newborn check
- Midwives will check oxygen saturations on selected babies as documented in the NEWS
 - 1 and 4 hrs: intrapartum opioid analgesia, severe fetal distress
 - 1 and 4 hrs and prior to transfer: sepsis risk, meconium exposure
 - 12-24 hrs age - <37 weeks, <9th% weight, >98th% weight or infants of diabetic mothers
- Saturations to be checked on either foot until stable and should be ≥95%. If they are not then recheck a preductal reading on the right hand. If this remains <95% then assess and investigate for a cardiorespiratory cause for lower saturations.

Checks that are the responsibility of the Midwife

- NVD, uncomplicated instrumental deliveries
- Caesarean sections (all categories) where the Newborn Observations are normal and there are no additional concerns
- Babies of mothers with diabetes – refer for Neonatal input if there are blood sugar issues as per guideline
- Breech deliveries - Neonatal team to be consulted if there are concerns about unstable hips for a second opinion and to ensure the hip referral forms are completed but the Neonatal team do not need to complete the full examination and this can be done by the midwife prior
- Babies briefly in NICU for <4 hours who have normal Newborn Observations
- LMC's are responsible for ensuring that the initial and 24 hour check are completed
- If a midwife is not confident with performing this examination they should seek support from their midwifery colleagues or Neonatal Service ward Reg/NNP who can do the assessment with them.
- They can also seek further training from the midwifery educator at a convenient time.

Checks that are the responsibility of the Neonatal Team

- Antenatal consultation with the Neonatal Team
- Preterm delivery <37 weeks
- Congenital abnormality
- An LMC or core midwife can request a review by the Neonatal Team at any time if they have any concerns such as respiratory distress, abnormal exam findings, unstable hips, murmur, antenatal anomalies that need follow-up
- Babies admitted to NICU for >4 hours.
- Babies admitted to NICU for <4 hours should be reviewed by the NICU Team but the full baby check may be able to be done by the LMC if there are no ongoing concerns.
- Babies born to mothers with complex mental health issues where it has been identified antenatally by the Mothers and Babies team that Neonatal review would be beneficial

Transfers Out

The Neonatal Team is often asked to check that a baby is well enough for transfer either to home or a primary birthing facility. For this to occur the following needs to be clarified:

The initial check has been completed and documented by the LMC or midwife

- The baby has had a normal temperature (36.5 – 37.5) recorded between 1-4 hours of age
- The baby has fed well on one occasion as this is a good sign of wellness
- The baby has been reviewed to ensure that the cardiorespiratory status is stable and the baby has transitioned normally
- Remember that babies 37 weeks and 9-25% may need longer before transfer.
- **Prior to transfer to a primary unit before 24 hours of age a baby with risk factors must have a repeat NEWS of 0**

Babies who CAN Transfer LESS THAN 6hrs age if NEWS = 0

- Vaginal delivery with no risk factors
- Non-complex instrumental delivery (see definition on Newborn Observation Chart)
- Intrapartum analgesia or GA
- Maternal GBS/PROM/Sepsis risk and antibiotics given > 4hrs before birth

Babies who CAN Transfer FROM 6 hrs age if NEWS = 0

- Maternal GBS/PROM/Sepsis risk and no antibiotics or antibiotics given < 4hrs before birth (need for ongoing 4 hourly observations until 24 hours of age)
- Thick meconium, or thin meconium with Apgars at 5 minutes < 9 (need for ongoing 4 hourly observations until 24 hours of age)
- Intrapartum fetal compromise if repeat lactate at 3-4 hours is ≤ 3 mmol/L. However, the whole clinical picture needs to be reviewed with the Neonatal team and the lactate result not looked at in isolation.
- Weight > 98th% with no maternal diabetes require 3 normal blood sugars before transfer
- Maternal GDM diet controlled require 3 normal blood sugars before transfer

Babies who CAN Transfer FROM 24 hrs age if NEWS = 0

- Intrapartum fetal compromise if repeat lactate at 3-4 hours is > 3 mmol/L to stay 24 hours even if the lactate normalises subsequently.
- Type 1 Diabetics or poorly control Maternal GDM must also have had 3 normal blood sugars
- Clinical chorioamnionitis
- Maternal GA (baby may be ready prior to 24 hours so this indication is maternally driven)
- High risk instrumental category – time > 20 minutes, more than 3 pulls, 2 or more cup detachments, Apgar < 7 at 5 minutes.

Babies who CAN Transfer from Day 3 if NEWS = 0

<9th % for weight and ≥ 37 weeks gestation

Babies who CAN Transfer from Day 4 if NEWS = 0

- Premature babies <37 weeks gestation

Transfers In

- Babies born at a birthing unit are to transfer in to CWH Maternity if they are:
 - Preterm <37 weeks or,
 - Term ≥ 37 weeks but <3rd % for birthweight
- Babies born at a birthing unit may stay at the birthing unit if they are:
 - Term ≥ 37 weeks and 3-10th % for birthweight
 - As long as they are able to have newborn observations, blood sugar monitoring, 3 hourly feeds with feeding support and a weight at 72 hours as described in the section below
 - If they are <2500g then we would recommend supplementation with Vitamin D (for all) and Fe (if breastfed)

Maternity Babies for Daily Neonatal Review

Criteria

1. Preterm babies <37 weeks
 2. 37⁺⁰-37⁺⁶ weeks with birthweight <10th%
 3. ≥ 38 weekers with birthweight <3rd%
- Approximately 40% of babies born at 35 weeks and 70% of babies born at 36 weeks gestation remain on the postnatal ward (CWH audit 2013) and do not require admission to the neonatal unit.
 - 37 weekers who are SGA < 10th% have more challenges (ie: feeding, jaundice, multiples) and more likely to have maternal morbidity eg PET, than term babies 38 weeks and more and more likely to be LBW <2500g
 - These preterm or low birth weight (LBW) babies are at higher risk of issues with temperature control, jaundice, establishing feeding, maintaining blood sugars and gaining weight.
 - Parents should be informed of the unique characteristics of their preterm or LBW baby. For example, these babies may not wake spontaneously, may not feed effectively and may lack stamina to take adequate feeds
 - Consequently closer scrutiny of breastfeeding and protection of lactation by hand expressing and / or electric breast pumping is required to ensure lactation keeps pace with baby's caloric intake.
 - Babies ≥ 38 weeks with birthweight between 3-10% will have daily reviews by the midwifery team who will refer to the Neonatal Team if issues arise. We recommend they stay to Day 3 and are assessed for appropriateness for discharge after the Day 3 weight

These babies require:

- Daily review, whilst inpatient, by the Neonatal Team.
- Document findings on the **Small Baby Neonatal Care Plan** – Maternity on Cortex (see below)
- Neonatal team or LMC will perform the 24 hour baby check and document on Newborn Record (QMR0044)
- Standard NEWS observations at 1, 4, 12, 24 hours as well as oxygen saturations once within 12- 24hrs and blood sugar monitoring 3 hourly initially
- A blood sugar check prefeed 3-4 hours after birth (combine with lactate if required) and repeat sugar prefeed until there are 3 consecutive levels ≥ 2.6 mmol/L
- Referral and review by the Lactation Consultant team to formulate a feeding plan which will include cue based feeding with no longer than 3 hours between feeds with top-ups of expressed breastmilk (EBM) as available or donor breast milk (pasteurised or unpasteurised if applicable) or infant formula.
- Monitoring input and output that are consistent with postpartum age with clear documentation on Infant Feeding Record (Ref.2400431)
- Weight around 72 hours of age (Day 3) is required
- Clearance by the Neonatal Team prior to discharge/transfer
- Ensure a feeding plan is in place

- From 24 hours if a baby is ≥ 37 weeks and is 3-10th% they may transfer out to a primary birthing unit if that is desired but only normal if the NEWS score and BSL are normal and the baby is feeding well AND after discussion and review by the Neonatal team.
- If the baby stays at CWH then from 72 hours (Day 3) consideration can be made to the mother and baby's readiness for discharge or transfer with the following options available:
 1. Stay at CWH for 4 days – mandatory if preterm < 37 weeks at birth
 2. Require ongoing oversight but this could occur at a Birthing Unit from 72 hours onwards
 3. Be ready to be discharged home but would need a 72 hour weight prior to discharge to ensure that this is a safe decision
- It is recommended that Vitamin D is supplemented (from birth) if < 37 weeks or < 2500 g until 12 months age
- Iron to start from 4 weeks of age if they are breastfed and < 37 weeks or < 2500 g birth weight. This is recommended to continue until 12 months age
- Babies needing Vitamin D and Iron should get a prescription before discharge from the Neonatal Team.
- A discharge letter will be written after final review

Vitamin D Supplementation

There are high rates of Vitamin D deficiency in pregnant mothers in New Zealand and so supplementation of babies with Vitamin D should follow the NZ Ministry of Health guidelines.

Vitamin D should be given to babies on the maternity ward that are under review by the Neonatal team if they are:

- Preterm < 37 weeks
- Low birthweight < 2500 g
- ≥ 37 weeks if:
 - Partially or exclusively breastmilk fed
 - Breastmilk or formula fed with:
 - naturally dark skin
 - a mother with vitamin D deficiency
 - a sibling who has had rickets or hypocalcaemic seizures

Recommend that supplementation is for a year

Feeding Red Flags

If any consecutive breastfeeds are A-D do a full set of newborn observations and consider recording feeding concerns in NOC/NEWS

Red flags that would trigger a score for **feeding concerns** include a baby who:

A baby who:

- Is lethargic and too sleepy to feed
- Not had a first feed in the first hour, followed by no feed in the first 4 hours.
- Has an initial first feed, then not waking for a feed within the next 6 hours.
- Regular feeding for 12-24 hours is then not interested for 6 hours. When a baby stops feeding after previously doing well, this can be a sign of early onset sepsis (within the first 48 hours), severe hypoglycaemia, and in rare circumstances intra-abdominal problems
- Has hypothermia, which may also increase the risk of hypoglycaemia
- Babies with risk factors identified, who are not feeding well, have more potential to show early signs of infection or develop hypoglycaemia

If there are feeding concerns, then a blood glucose check may be warranted.

Consider the impact of maternal factors – eg; the reason for induction was poor growth at 37/38 weeks. Plus factors that delay lactation.

Some babies who run into difficulty have asymmetric growth and their birth weight plots at 9-25th centile, so are not initially in a NEWS risk group

It is useful additional information to plot the baby's birthweight on a customised antenatal GROW chart in the mothers notes if available.

Management of Babies with Excessive Weight Loss

7-10% Weight Loss

- Observe a full breastfeed
- Ensure effective positioning and attachment
- Observe for effective suckling pattern, observe for milk transfer and use breast compressions throughout the feed
- Ensure minimum of 8 feeds in 24 hours
- Skin contact to encourage breastfeeding
- Observe for change in frequency / amount of urine and stools
- If top-ups are felt to be needed consider half tops ups (15-30mls)
- Reweigh after 24 hours
 - If weight increasing, continue to monitor closely and provide support
 - If no weight gain or further loss refer to the next section below

10-12.5% Weight Loss

- Follow the plan above
- Refer to Lactation consultant and Neonatal Team
- Express breastmilk after each feed and offer to baby
- Feed according to feeding cues with no longer than 3 hours between feeds
- Offer full top-ups (30-60mls) after each feed
- Consider breast milk substitute if inadequate EBM
- **Reweigh after 24 hours**
 - If weight increasing, continue to monitor closely and wean top ups as able
 - If no weight gain or further loss will need NICU admission

>12.5% Weight loss

- Refer to NICU for admission and management

<https://www.starship.org.nz/guidelines/practice-recommendations-for-weight-loss-dehydration-and-hypernatraemic/>

Subgaleal Haemorrhage

- This is a rare but life-threatening condition and needs to be recognised early and managed aggressively
- A subgaleal haemorrhage occurs when there is rupture of the emissary veins between the dural sinuses and the scalp veins resulting in bleeding into the subgaleal space.
- A large amount of blood can collect in this space and lead to hypovolaemia, anaemia, coagulopathy and death if untreated.
- Risk factors include vacuum assisted deliveries (but it can also occur with NVD, forceps and caesarean)
 - Incorrect placement
 - Vacuum duration >20 minutes
 - More than 3 pulls
 - 2 or more detachments
 - Prematurity
- To support early identification the Newborn Observation chart has an assessment for babies following instrumental birth to recommend frequency of observations depending on the risk stratification
- Mean age of diagnosis is before 6 hours of age

Clinical Features

- Large, diffuse fluctuating mass crossing suture lines
- Generalised scalp swelling that is moveable, fluctuant, gravity dependent
- With the baby on their back feel for fluctuance at the occiput and try to push the swelling forward and if it does so freely then it is a subgaleal bleed
- Displacement of the ears
- Periorbital oedema
- Increased head circumference – late sign

To help differentiate from other head swellings:

Cephalhaematoma – will not cross a suture line, can be fluctuant but is localised

Caput – pitting oedema, superficial swelling that can be fluctuant

Management

- [Neonatal Subgaleal Haemorrhage Practice Recommendation - NZ Newborn Clinical Network 2018](#) has further information including an algorithm for detection and management
- Refer to the CDHB [Paediatric-Massive-Transfusion-Protocol-232679](#) if required around logistics and blood products supplied. To summarise this is the order of blood products recommended
 - 10ml/kg of each in order – RBC, FFP, RBC, Cryo
 - 0.45 mL/kg Ca gluconate
 - 10ml/kg of each in order – RBC, FFP, RBC, Platelets
 - 0.45 mL/kg Ca gluconate

Cortex Small Baby Care Plan - Maternity

- This template should be used for babies needing daily reviews due to being **preterm or small**
 - <37 weeks
 - 37⁺⁰-37⁺⁶ weeks with birthweight <10th%
 - ≥ 38 weekers with birthweight <3rd%
- The care plan should be used for all reviews of the baby once it has been started rather than use other progress notes. There is a progress note section in the Care Plan to use.
- It is for the Neonatal Team's documentation of the medical review – the midwifery team have their own templates for documentation
- Under the baby's NHI click + and choose Care Plan – Neonatology – Small Baby Care Plan Neonatal
- Save and sign every entry
- **The template can be updated many times in a day but as it is a living document the data is overwritten unless the template has a SNAPSHOT taken which saves a version in the patient's timeline.**
- Recommend that once a day or after all the necessary entries are made the Care Plan needs to have a **SNAPSHOT** to save all the days entries – the option to Snapshot only becomes available after the first initial save
- The template has been created to have some fields visible on certain days when they are relevant so it will not look the same day to day
- If a field is not necessary for your patient then you do not need to enter anything
- If entered fields are no longer relevant then they can be deleted to keep the care plan less cluttered
- There are mandatory fields which must be entered before you can save it
- If a heading has an "i" in a circle – click it and you get some hints
- When the baby is discharged you need to **END CARE PLAN** to close off the admission

Discharge Letter Criteria

- Discharge letters are required for the following babies on the postnatal ward:
 - Admission to NICU for > 4 hours prior to transfer to the postnatal ward
 - Received antibiotics
 - If they are <37 weeks or <2500g and have had neonatal input on the maternity ward
 - Babies do not specifically need a letter if they are just going home on Vit D due to identified risk factors such as darker skin, maternal Vitamin D deficiency or being breastfed over winter
 - Babies with congenital abnormalities eg Downs syndrome, Cleft lip and palate
- Check with consultant re:
 - need for outreach / discharge facilitation, physio assessment, early intervention after discharge, social work input, Child disability allowance
 - Referrals to other specialties have been made ie: ENT, Paediatric Surgeons, Plastics, Orthopaedics
 - Outpatient investigations have been made (excluding routine hip and renal scans)

- If any clinic follow-up appointments are necessary
 - Copies should go to the GP, LMC, Parents and other specialties involved in the care of the infant - this should be arranged by the postnatal ward admin staff
 - If a baby needs follow-up to be arranged then follow the HCS process outlined under the Discharge, Referrals and Follow-Up section of the Handbook. Note: Cortex referrals are no longer to be used

Antenatal Ultrasound Abnormalities

- **Borderline cerebral ventriculomegaly** (ventricles 10-15 mm)
 - Head circumference and careful physical exam
 - Ventricle/s > 10mm – postnatal head US if this is the advice from the Fetal Anomaly Committee
 - Head US as an inpatient has the benefits of rapid resolution of any parental concerns as the majority of these scans will be normal.
 - If the head US is done as an outpatient then arrange for the parents to receive the results – either by phone contact or review in clinic
- **Choroid plexus separation**
 - Physical exam including head circumference
 - Head US only if ventriculomegaly or structural abnormality (especially of corpus callosum) on later antenatal scan
- **Choroid Plexus cyst(s)** - Physical exam, if no abnormality, no investigation required
- **Isolated partial or complete agenesis of Corpus Callosum +/- absent Cavum Septum Pellucidum:**
 - Antenatal: Fetal MRI AND microarray
 - Postnatal:
 - Monitor blood glucose until 48 hours old, if < 2.6 mmol/L send hypoglycaemia panel immediately
 - Pituitary workup at 48 hours of age: T4, TSH, FSH, LH (inpatient)
 - Ophthalmology review (outpatient)
 - MRI if not obtained antenatally, microarray if not obtained antenatally
- **Isolated absent Cavum Septum Pellucidum after 20 wks GA:**
 - Antenatal: Fetal MRI, consider genetics only if additional anomalies found
 - Postnatal:
 - Monitor blood glucose for 48 hours, if < 2.6 mmol/L send hypoglycaemia panel immediately
 - Pituitary workup: At 48 hours of age, send T4, TSH, FSH, LH (inpatient)
 - Ophthalmology review (outpatient)
 - MRI if not obtained antenatally
- **Fetal cardiac echogenic focus** – physical exam, if no abnormality, no investigation
- **Abdominal calcifications**
 - Physical exam, if no abnormality, may need no investigation.
 - Consider TORCH screen if not done antenatally.
 - Make sure Guthrie card is done after 48 hours protein feeds

❖ PROCEDURES

If in any doubt, consult more detailed references and/or a more senior colleague. The consultants are proficient in these techniques and expect to undertake appropriate demonstration and supervision.

Procedure Note

For all 'major' procedures (arterial lines, central venous lines, intercostal drains, LP) we expect that irrespective of the success of the procedure there will be documentation of the procedure which should include:

- Time and date
- Name of the procedure, Indication
- Documentation of consent, (if needed)
- Antiseptic preparation and sterile drape
- Analgesic or anaesthetic (if any) technique
- Complications (e.g. blood loss), and
- Method used to judge success of the procedure (e.g. radiograph illustrating tip in correct position)
- Comment on position (whether satisfactory or not) and whether line was manipulated to a better position

For longlines, UVC, UAC this is to be completed electronically

- Open the patient on HCS.

Add New Document/ Click Treatment/Rehabilitation Record/Click on current admission/CDHB CVAD Insertion Form opens

- Complete the form as well as possible but note this is a DHB wide form so not all parts are relevant
- Enter in the free text boxes the **line length, tip position after XRay and any alteration to the line** so when reviewed it is obvious what has happened to the line after insertion
- A separate form is needed for each line ie: 2 are needed if UVC and UAC are inserted
- The date and reason why the line is removed needs to be entered in when this occurs and that can be entered by the Nurse or Registrar/NNP
- Finalise the form when completed after the line is removed.
- Update the Level 3 Patient Summary under Vascular Access with the line type, tip position, if this is appropriate and what management plan has been discussed if the line is malpositioned.
- The line type and FINAL tip position is to be documented on the central line sticker and placed on the Problem List

Sterile Technique and Skin Preparation

- Use meticulous sterile technique for all procedures.
- Cap, mask, sterile gown and gloves are needed for central vascular cannulation (i.e. umbilical lines and central venous lines).
- Gloves are strongly recommended for all other procedures where there is a risk of significant bodily fluid exposure, e.g. blood drawing and IV insertion
- Careful site preparation is an important step in preventing nosocomial infection. However:
 - alcohol can cause serious delipidation and damage to premature skin do not use alcohol only swabs
 - iodine can be absorbed across neonatal/premature skin in amounts sufficient to cause hypothyroidism so should not be used on the skin
- **Never** splash preparation solutions around carelessly
- Prepare the smallest area compatible with good hygiene.
- Use drapes intelligently to avoid having to prepare a large area of skin.
- < 28 weeks gestation, < 7 days old - use low strength chlorhexidine (0.1%, blue solution) especially for UAC, UVC and longline insertion to prevent burning to skin from stronger preparations
- < 28 weeks gestation and ≥ 7 days old – use chlorhexidine 2% swabs (alcohol free)
- ≥ 28 weeks gestation at any time - use chlorhexidine 2% swabs (alcohol free)
- Ensure the skin is allowed to dry before commencing the procedure
- Swabs containing alcohol 70% swabs are only to be used to clean iv ports and connections and **not on the skin** apart from when accessing a ventricular reservoir (see below)

Pain Relief and Sucrose

- Babies feel pain so before a painful procedure always consider analgesic options.
- Controlling a babies discomfort will improve your chances of success in the chosen procedure
- Don't forget the value in using an assistant to ensure the baby's comfort which may include swaddling or the use of a pacifier
- If a baby is ventilated this may include an increment of morphine. .
- Sucrose is a well studied drug that provides pain relief in babies
- Sucrose is effective for most painful procedures and should be used for the following:
 - Heel prick, im injection, venepuncture, iv line insertion, arterial line insertion, arterial stab, LP, NG insertion, tape or suture removal, bladder puncture or catheterisation, longline insertion or removal, chest drain insertion or removal, dressing change, ventricular tap, ETT suction, echo, eye exam
- See the sucrose drug protocol for instructions on dosing
- Sucrose should be given in the mouth 2 minutes prior to the procedure to be effective
- Contraindications to using sucrose include: postconceptual age <26 weeks, parental refusal, medical paralysis, unsafe swallow, oesophageal atresia, tracheo-oesophageal fistula and metabolic conditions

Capillary Samples

- Remember to use the correct site, i.e. on the lateral aspect of the heel.
- Prewarming the heel may help both collection and validity of results.
- Clean the skin with Chlorhexidine swab.
- Use special heel-prick lancets.
- Blood gases measured from arterialised capillary blood are useful for pH, pCO₂ and bicarbonate.

Venous Blood Samples

- "Broken Needle" technique often the easiest
- Use a 21-23 gauge needle specifically designed with plastic attachment or with the hub broken off to drip blood into the tubes
- Or collect (using careful sterile technique) from the hub at the time of insertion of IV.

Peripheral Venous Cannulation

- Wash hands and always wear gloves
- The cannulas most frequently used are 24 guage (yellow) and come in to different lengths
- After 2-3 unsuccessful attempts STOP and ask someone with more experience to try (this could be the nurse or NNP or a more senior Registrar).
- After 4 attempts by 2 people the SMO needs to be informed to decide if they need to try, if a UVC is needed or if the cannula is not required.
- Place some gauze under the hub to protect the skin from injury
- Secure well with steri-strips, Tegaderm™ and a back-board secured with brown tape

Arterial Puncture

- Radial stab - assess presence of the ulnar artery by palpation or by confirming perfusion of the hand when radial artery occluded.
- Fibre optic light is often helpful in the small baby.
- Use 24 gauge needle (either butterfly or straight needle), heparinised by drawing a small amount up and then thoroughly expelling it.
- Consider using 0.1 ml of 0.5% xylocaine without adrenaline subcutaneously for analgesia.
- Insert through the skin at 45 degrees, watching for a flashback.
- Press firmly on the site for two minutes after withdrawal.

Peripheral Arterial Cannulation

Indications

- Measurement of blood gases
- Blood pressure monitoring
- Frequent blood sampling

Contraindications

- Absent or blocked ulnar (if using radial) or radial (if using ulnar) artery
- Previously cannulated ulnar or radial artery
- Pre-existing circulatory insufficiency of the limb
- Local skin infection
- Malformation of the limb

Equipment

- Clean trolley
- Sterile gloves
- Chlorhexidine
- 24G IV cannula
- Heparinised saline syringe
- Extension set and SmartSite™
- Long splint
- Brown tape and Tegaderm™ dressing
- Transilluminator (Cold Light)

Technique

- Clean skin with chlorhexidine
- Suitable arteries to use are the radial or posterior tibial.
- Transilluminate to ensure patency of both radial and ulnar artery.
- Avoid excessive hyperextension of wrist
- Insert 24G cannula/needle slowly at 30 degrees until a flashback is seen
- Advance cannula into the artery
- Connect to a luer lock connector / extension that has a smart site connected with syringe attached,
- Flush with heparinised saline and secure with steri-strips and Tegaderm™
- The nurses will then connect this to the VAMP system and transducer to infusion pump.
- Use 1 U/ml heparin in 0.45% or 0.9% saline run at 0.5-1mL/hr to keep patent.

Complications

- Limb ischaemia, including gangrene of limb
- Blanching of hand or foot
- Skin ulcers
- Emboli
- Local or systemic infection
- Infiltration

Management of Ischaemia

- 0.2% glyceryl trinitrate ointment (note some references refer to 2% ointment but this is not available in NZ)
- Apply 4mm/kg/dose every 8 hours. Onset within an hour.
- Aiming to vasodilate to increase blood flow
- Watch for hypotension or tachycardia from systemic absorption

Central Line Associated Bloodstream Infection Bundle

- A CLABSI bundle was created to reduce central line infections rates
- The grouping of evidence based interventions which are known to individually improve care, results in significantly greater improvement when they are applied together
- In the NICU it refers to the insertion and care of UVC, UAC and percutaneous longlines

Bundle Elements

1. Five moments of hand hygiene - refer to page 5
2. Standardised sterile insertion pack – still requires additional items (see below)
3. Insertion practice
 - a. Use screens and signs – “sterile procedure in progress”
 - b. Use hat, face mask, sterile gown provided in the pack
 - c. Add sterile gloves, catheters, skin cleansing solutions and instruments
 - d. Nurse to remain with the baby throughout the procedure
 - e. Clean hands with surgical hand wash
 - f. Keep baby warm throughout procedure
 - g. Complete instrument inventory when returning items to the hospital aides for cleaning and resterilising as they are not disposable
4. Documentation
 - a. Health Connect South electronic form – Neonatal Central line
 - b. Insertion sticker for Problem List
 - c. Level 3 Patient Summary Sheet
5. Sterile access and line change practices – refer to Central Venous Access Device OPS PPN43
6. Quality improvements
 - a. Education to new medical and nursing staff
 - b. Audit of insertion documentation
 - c. IV link nursing activities

Link to an education session on appropriate placement and imaging of central lines in NICU by Dr Phillipa Depree (Paediatric Radiologist, March 2020)

<https://www.healthlearn.ac.nz/mod/page/view.php?id=14734>

Umbilical Artery Catheterisation

Indication

- For secure arterial access in an unwell or ventilated baby for blood pressure monitoring and blood sampling

Contraindications

- Evidence of local vascular compromise in lower limbs or buttocks
- Peritonitis
- Necrotising enterocolitis
- Omphalitis
- Omphalocele

Personnel

Babies <26 weeks should have their UVC/UAC inserted by the most senior person available, ie: SMO/Senior Reg/Fellow/NNP. They should not be inserted by junior staff who need supervision as the babies do not tolerate excessive handling.

Insertion

- Identify the 2 arteries and 1 vein – the vein is patulous and often lies superiorly, the arteries are thick walled and usually smaller. At the abdominal wall level the vein is at 12 o'clock and the arteries at 4 and 8 o'clock
- There are two techniques
 - either cut the cord aiming to bisect the vessel, or
 - clamp the end of the stump with a forceps and fold the cord stump over a forcep and cut with blade a lateral arteriotomy, cutting the artery half way through the wall leaving the rest of the cord attached for the meantime (this is the method we recommend if you are relatively inexperienced because it is often easier and it leaves the other vessels untouched if you are unsuccessful).
- Dilate the artery with fine iris forceps.
- Slow, gentle dilation results in smooth muscle relaxation, whereas, rapid stretch damages the endothelium and promotes spasm. Time spent in ensuring dilation before catheter insertion increases the chances of success.
- Pass the catheter to the previously measured distance, plus the length of the cord from insertion site to base.
- If the catheter doesn't pass with gentle pressure, never force it.
- As you try to get the catheter to pass from the umbilical cord to the intraabdominal umbilical artery (which runs down the anterior abdominal wall, it is often helpful to apply gentle traction on the cord in a cephalad direction (towards the head), so that the catheter doesn't have to make a right angle turn at this site.
- Take samples of the UAC as needed and flush the line and ensure an infusion is started prior to the XRay to prevent the line clotting

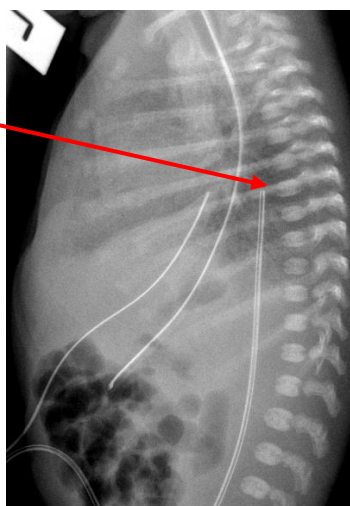
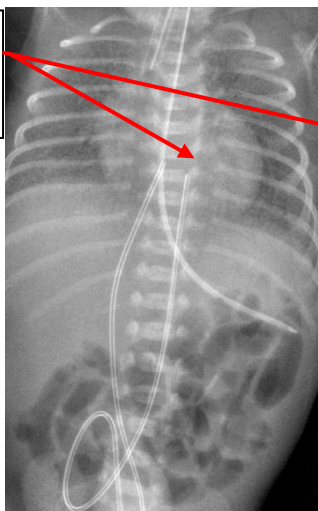
Securing the Catheter

- Secure the catheter with a suture through the edge of the Wharton's jelly, tied with reef knot, then wrapped carefully round the base of the catheter and tied securely again.
- Enclose the catheter and suture in a tape flag.
- Alternatively, attach a small tape "flag" to the base of the catheter and pass a suture through the edge of the Wharton's jelly, knot it and then pass it through the flag and knot again.
- Avoid elaborate architectural marvels with sutures and tape, including "argyle stocking" sutures. They are wonderful hiding places for microbes and rarely improve the security of the catheter.
- In bigger babies, whose skin will stand it and who can be expected to grab and tug on their catheters, consider the use of a simple set of 'football posts' made of zinc oxide tape and attached to the skin on either side of the umbilicus. Use another piece of tape to secure a loop of catheter between the posts.

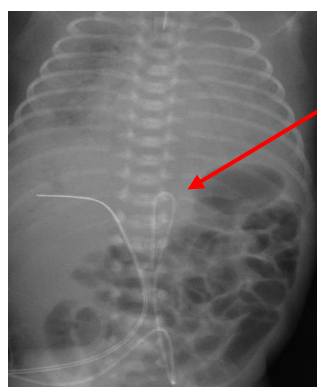
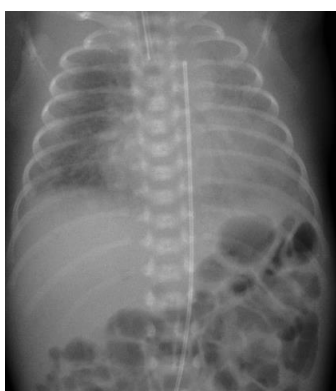
Appropriate Tip Position

- Satisfactory position is between T7-T9 (preferred), or in a 'low' position at the level of the L3 or L4 vertebra.
- Note areas to avoid are coeliac axis (T12), SMA (T12-L1), renal arteries (T1), bifurcation (L4-5)
- Remove if there is mottling of leg(s) or buttock(s), although discuss with consultant, it may be worth trying some volume first.

UAC well placed
at T8
(UVC too high)

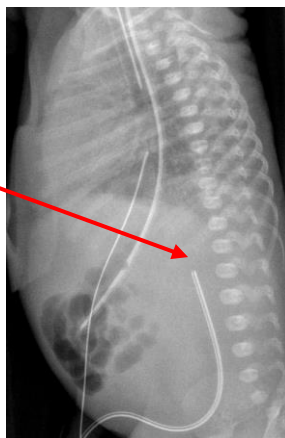
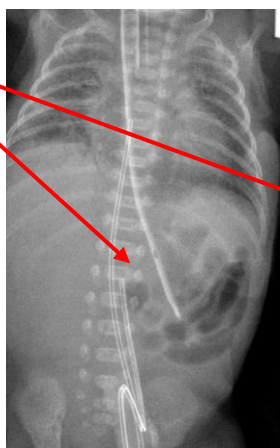


UAC too high at
T3 in the aortic
arch – withdraw to
a T7-9 position



UAC curled over
itself –remove and
resite in second
artery.
(UVC in the liver)

UAC in low
position at L2 –
withdraw slightly
to be at L3-4
level



Line Imaging

- Check position of the catheter with Chest and Abdo XRay - AP and Lateral
- If a UAC needs to be withdrawn to a more appropriate level then a Lateral alone is sufficient as this is also the best XRay to take to review a UVC after manipulation.
- Never insert the line in further after the sterile field has been removed, only withdraw if needed

Documentation

- Document the line insertion in Health Connect South (see page 137), Level 3 Summary Sheet and on the sticker for the Problem List
- Chart 0.45% (usually for <1500g babies) or 0.9% saline with 1unit/mL heparin
- Run the infusion at 0.5mL/hr

Risks of UAC

- Sepsis is a risk for any central line and needs to be managed with aseptic insertion technique and good quality nursing care after insertion
- Impaired lower limb perfusion may necessitate line removal
- Thrombosis, vasospasm, embolus, haemorrhage - see under peripheral arterial line for glyceryl trinitrate ointment dosing to manage vasospasm.
- Malposition and vessel perforation

Umbilical Vein Catheterisation

Indication

- Central access for parenteral nutrition or infusions in preterm infants ≤ 30 weeks or $< 1500g$
- Central access for parenteral nutrition for term infants with surgical conditions
- Central access for infusions in term babies with HIE, severe meconium aspiration or PPHN
- Exchange transfusion
- Infusion of hypertonic solutions eg: more than 10% dextrose for hypoglycaemia
- Urgent access at birth for resuscitation using volume expansion or adrenaline
- Unable to site a peripheral cannulae and access needed for antibiotics or fluids

Contraindications

- Peritonitis
- Necrotising enterocolitis
- Omphalitis
- Omphalocele

Length of Use

- If a UVC is well positioned at the IVC/RA junction then it will be reviewed on day 7 if still in-situ. The majority will then be changed for a longline if central access is still required. If a baby is likely to no longer require central access within a few days time then the UVC may remain in place until no longer needed.
- Note that 50% of UVC's migrate in or out in the first week and so we need to be keep vigilant about the line placement despite it being initially well positioned. Review the line on any subsequent XRay irrespective of the reason for the XRay. Repeat an XRay if there are concerns that the internal length of the line has altered.
- A UVC that is in a low position after insertion or after manipulation is not well placed and should be removed as soon as possible and definitely within 48 hours. Options are to use a peripheral iv line with peripheral TPN and not using the UVC at all, or only using 10% dextrose through the UVC to minimise any liver injury if extravasation into the liver occurs whilst a longline is being secured.
- Remember that TPN can be given peripherally so the risks of using a malpositioned UVC may outweigh the risks of TPN via a peripheral line.

Equipment

- [illegible]

Preparation

- Distance can be estimated using standard tables or formulas

Internal catheter length for UVC (in cm) = 1.5 x (B.Wt. in kg) + 5.5, or

Birth Weight (kg)	Internal Catheter UAC	Length (cm) UVC
0.5	10.95	6.35
1	12.2	7.1
1.5	13.45	7.85
2	14.7	8.6
2.5	15.95	9.35
3	17.2	10.1
3.5	18.45	10.85
4	19.7	11.6

Remember to add the length of the umbilical cord from site of insertion

- Prepare your equipment as much as possible prior – it is not the nurses job to do this for you
- A screen should be placed around the cot space prior to starting
- One nurse is required to stay with the inserter throughout the procedure
- Open up a central line pack on the procedure trolley
- Put on the cap and mask
- Scrub your arms and hands, putting on a sterile gown and gloves
- Use a 3.5 or 5 French double lumen catheter depending on the size of the baby
- Flush the catheter and SmartSites™ with heparinised saline 0.1U/mL
- See above under “Skin Preparation” as to which swabs to use to prepare the cord and surrounding skin
- Have a helper open up the separate pack with the tools on to the trolley
- Drape the baby
- Tie the cord tie around the base of the umbilical cord and loosely knot
- Cut the umbilical cord 1-2cm from the base and tighten the cord tie if it bleeds

Personnel

- Babies <26 weeks should have their UVC/UAC inserted by the most senior person available, ie: SMO/Senior Reg/Fellow/NNP. They should not be inserted by junior staff who need supervision as the babies do not tolerate excessive handling.

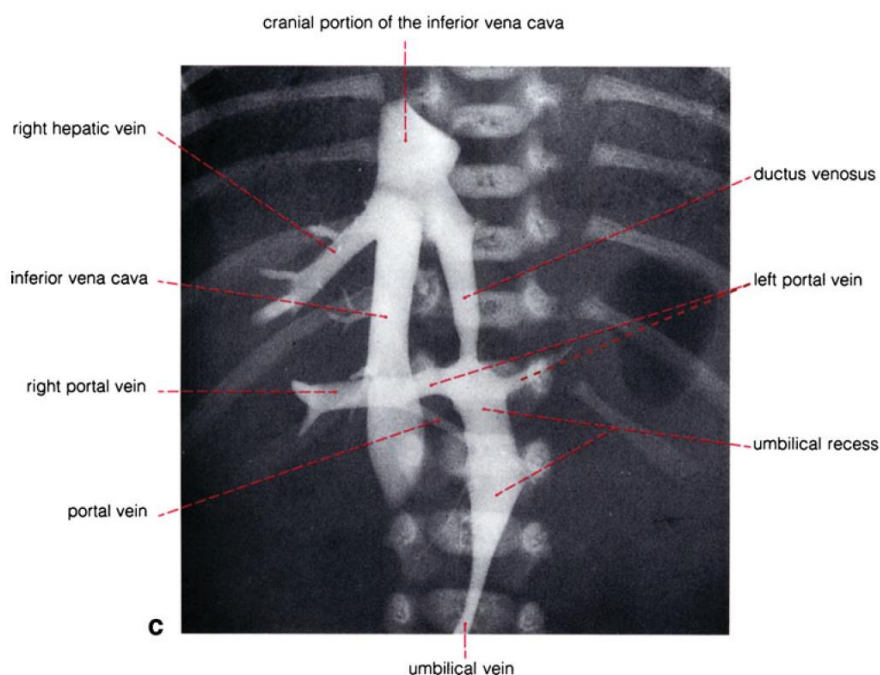
Insertion

- Identify the vein – it is patulous, has a thin wall and is often the vessel that bleeds when the cord is cut
- If the cord is cut at the base then the umbilical vein is found at 12 o'clock
- Hold the Whartons jelly with forceps and gently dilate the vein with the iris forceps
- Place the catheter in the vein opening and gently advance it which should only need slight pressure
- The umbilical vein turns cephalad inside the baby, so gentle caudad traction on the cord may help the catheter turn the corner.
- Catheters that either won't pass to the distances required or do not aspirate blood are likely to have passed into a branch of the portal vein, rather than traversing the ductus venosus into the IVC.
- If this has happened withdraw the line to a position where blood can be aspirated and the lines flushes easily. Never leave a line in that does not aspirate blood.
- Ensure that an infusion is started through the line prior to the XRay to prevent the line clotting

Securing the Catheter

- Secure as for UAC above

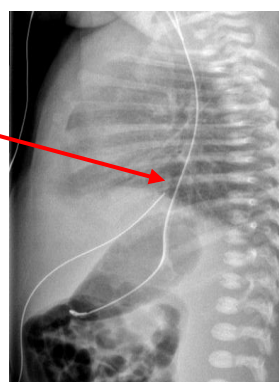
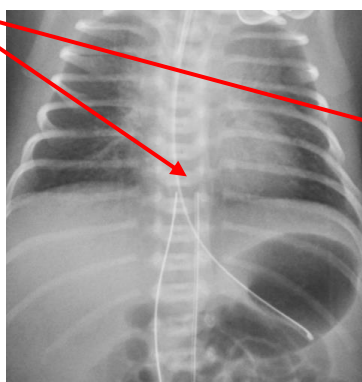
Anatomy



Appropriate Tip Position

- **A UVC in the ideal position** is the tip at the IVC/RA junction which usually correlates to the level of the diaphragm. Only about 50% of insertions will be appropriately positioned on the first attempt. The report will say the UVC tip is appropriately positioned at the expected location of the IVC/RA junction.

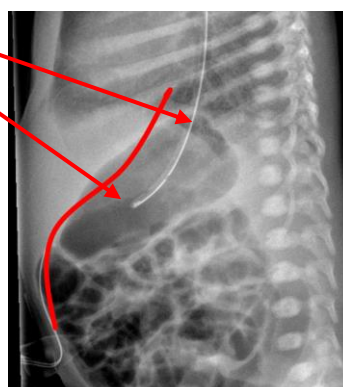
UVC (and UAC) well placed at T8-9 on AP and at the level of the diaphragm on lateral film



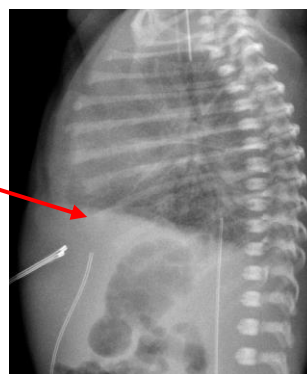
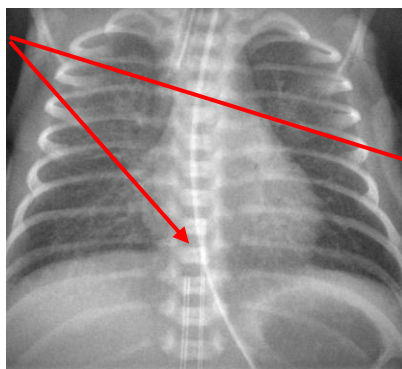
On lateral XRay the line takes a postero-superior approach along the axis of the stomach

On AP XRay the line may head straight up or to the patients right but the tip should never end up directed to the patients right but should come back into the midline

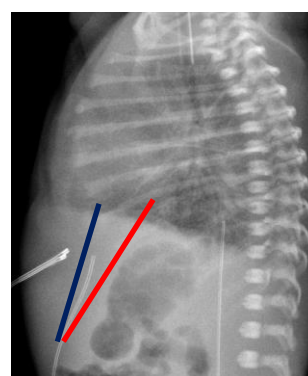
Anterior convexity then posterior convexity indicates line has passed through the ductus venosus and tip ends up anterior to the NG tube



Falsely reassuring AP film with UVC appearing to be at the diaphragm. Lateral confirms the low position of the UVC in presumably in the umbilical vein. Highlighting the value of a lateral film

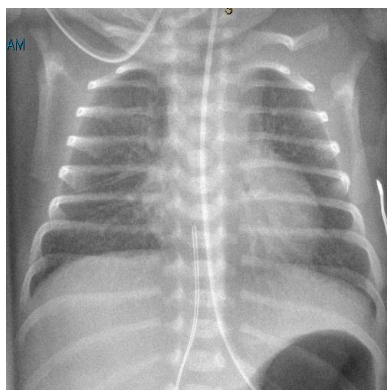


The angle of the UVC should follow the red line and not the blue line which is too anterior



- **A UVC that is high** and above the diaphragm is the only situation where you can be certain that the UVC has passed through the ductus venosus
 - Measure the distance from the tip to the level of the diaphragm (often easiest on the lateral) and withdraw the line to this distance
 - If the line is then at the IVC/RA junction then it is safe to leave in and use for 7 days before review assuming that there is no evidence or concern that the line may have migrated
 - If XRs are taken for any other reason then the tip position should be re-evaluated as up to 50% of lines migrate (in or out) in the first week

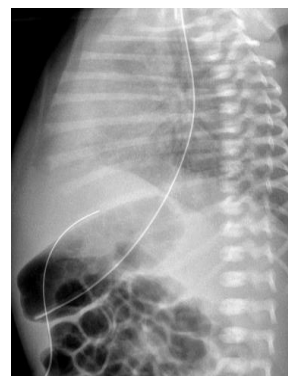
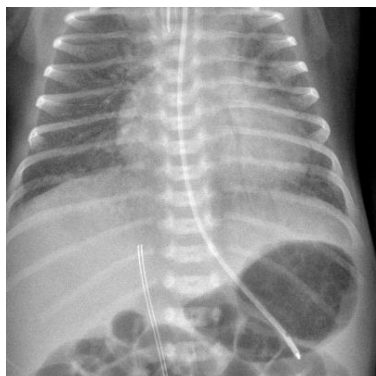
UVC too high in the right atrium – pull back to the level of the diaphragm



- **A UVC that is low** and is below the diaphragm may have the tip in the umbilical vein, portal vein or hepatic vein and are not ideal and need to be recognised and discussed with the SMO.
 - The UVC in this position can be used in the short term however should be preferably removed within 48 hours and a longline inserted or peripheral access used
 - If a longline is unable to be inserted and central access is required then an XRay every 48 hrs whilst the catheter remains in-situ can monitor for any migration or further malposition. Alternatively an US may help rationalise the tip position and risks associated with ongoing use.

- Consider running 10% dextrose through the line instead of TPN/Lipid to lessen the risk of extravasation injury
- Radiology will call NICU if the line is low and the report will say – the UVC tip is projected over the expected location of the umbilical vein/ductus venosus

UVC is low
presumably in
the umbilical vein
– remove within
48 hours

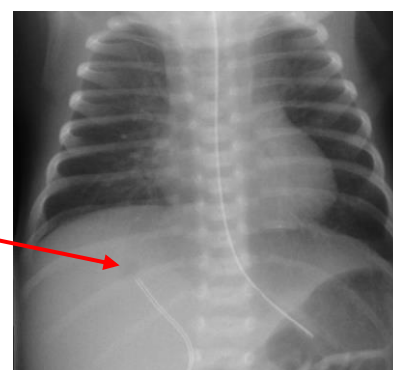
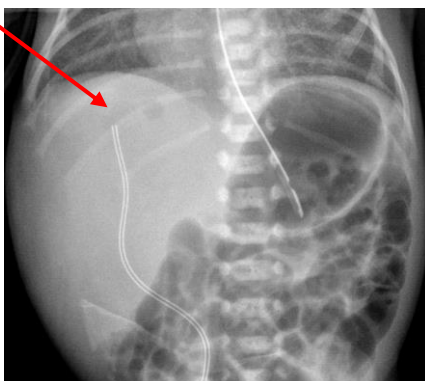


- **A UVC that is deviating** to the right or left will be in a portal vein, hepatic vein or umbilical vein branch
 - This line must be either removed immediately (preferred option) or repositioned
 - If the line is felt to be required in the short-term then measurement and withdrawal of the catheter into the midline should be done with a repeat Xray
 - The UVC in this position can be used in the short term however should be preferably removed within 48 hours and a longline inserted or peripheral access used
 - If a longline is unable to be inserted and central access is required then an XRay every 48 hrs whilst the catheter remains in-situ can monitor for any migration or further malposition. Alternatively an US may help rationalise the tip position and risks associated with ongoing use.
 - Radiology will call NICU if the line deviates and the report will say – the UVC tip is projected over the right/left liver, not in the expected location of the umbilical vein or ductus venosus and is therefore malpositioned.

UVC entered the portal vein. Preferably remove the line and use other sites for vascular access. If no other option then withdraw the line so it is out of the liver in a low position and remove within 48 hours when other access is obtained.



Radiolucency projected over the liver. Causes include: air being introduced at the time of insertion or extravasation. Consider US to exclude line extravasation.



Line Imaging

- Chest and Abdo XRay
 - All UVC's need an AP and Lateral at time of insertion
 - If the line is withdrawn from a high position above the diaphragm then only a lateral film is required
 - If the line is withdrawn from a low position such as a portal or hepatic vein (ie: has deviated to the right or left) and will remain in for immediate use then both an AP and lateral will be required to ensure that the line is straight as the lateral alone will not be sufficient
- Always discuss the line position with the consultant if it is not in an acceptable position
- Very minimal patient rotation will make it appear that the catheter has moved from target anatomical landmarks
- If there is a radiolucency present over the liver then consider if extravasation may have occurred and investigate with an abdominal ultrasound
- An ultrasound may also be able to help identify the tip placement in the IVC/ductus venosus or inappropriate placement in the heart or liver vessels. This is not standard practice but may be required to assess if a line is safe to remain in-situ and will be dictated by the SMO.
- An US can be performed by the Neonatologist and the images saved and reported on by the SMO if they have the appropriate skill and/or if the scan is needed acutely overnight.
- Alternatively an Ultrasonographer or Radiologist may be asked to perform the US during the day with the Radiologist reporting on the tip position.

Documentation

- Document the line insertion in Health Connect South, Level 3 Summary sheet and on the sticker for the Problem List.
- Continuous infusions through a UVC require 0.1U/mL heparin to maintain patency. A spare lumen needs to be flushed with 1mL of 0.1U/mL heparin 6 hourly

Risks of UVC

- Sepsis is a risk for any central line and needs to be managed with aseptic insertion technique and good quality nursing care after insertion
- Thrombosis is a risk but is uncommon. Avoid infusing platelets or clotting factors through a UVC unless there is no other option
- Haemorrhage
- Extravasation in the Liver
 - This occurs when the tip is in a smaller portal/hepatic/umbilical vein branch and is in a deviated/ low and/or anterior position on XRay and this is why these positions are not recommended for longer term use ie: more than 48 hours
 - Extravasation usually develops in the liver parenchyma with a fluid filled cyst which can track into the peritoneal cavity as ascites
 - Babies present with abdominal distension and can go on to develop coagulopathy, metabolic acidosis and need reventilation and fluid and blood product support
 - If there is any suspicion of a UVC extravasating then immediate management is to stop all infusions through the line, ultrasound the abdomen and remove the line
- Cardiac Tamponade
 - If the UVC tip is left in the heart the tip can work its way into the myocardium resulting in fluid infusing into the pericardium leading to tamponade - so a UVC should not be left in the heart
 - This is rare and more often seen with longlines but needs to be considered in a baby with acute cardiorespiratory collapse with no clear cause
 - Immediate management is to stop all infusions through the line, ultrasound the heart and remove the line. Pericardiocentesis may be required under ultrasound guidance

Percutaneous Central Venous Lines “Longline”

Indication

- Central access for parenteral nutrition or infusions in preterm infants <32 weeks
- Central access for parenteral nutrition for term infants with surgical conditions
- Infusion of hypertonic solutions eg: more than 10% dextrose for hypoglycaemia
- Prolonged course or antibiotics or antivirals
- **NOTE:** Longlines can be inserted 7 days a week if there is clinical need - a weekend should not be seen as a barrier to insertion given current staffing levels

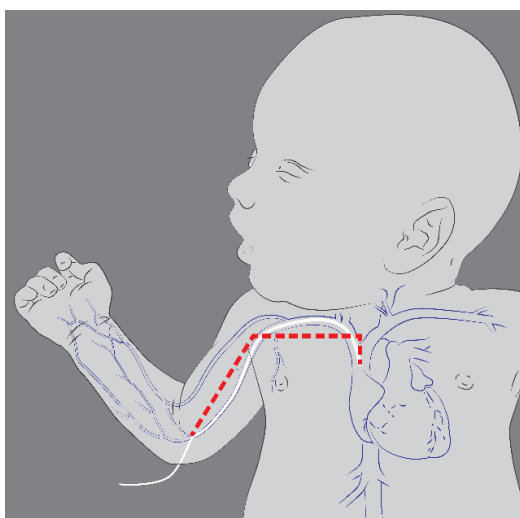
Equipment

- Sterile trolley, screen
- Sterile gloves
- Long line - There are 3 types of longlines
 - 24G catheter inserted via a butterfly in a prepared, sterile package
 - 28G can be used in babies <1000gm or in those with difficult veins, however, the larger size catheter is preferable in bigger babies as it blocks less often and tolerates bigger volumes
 - Double lumen longlines are available and should be considered in babies needing multiple medications. Both lumens are 28G and require a continuous infusion running to keep them patent.
- Central line pack with hat, mask, drapes, scissors, gauze, non reflux SmartSites™, syringes
- Sterile iris forceps and straight forceps for holding drapes together (a full instrument pack is not needed)
- Chlorhexidine
- Heparinised saline
- Steri-strips and Tegaderm™ to dress
- Measuring tape to measure distance from entry site to desired tip location

Aiming for optimal tip position

Note measuring correctly is key!

- **For insertions in the right arm**, measure from the insertion site along the predicted course of the vein, from the elbow crease to the anterior axillary line/armpit, across to the right sternal boarder and down to the level of the nipple line or third intercostal space (As pictured below).



- **For insertions in the left arm**, measure from the insertion site along the predicted course of the vein, from the elbow crease to the anterior axillary line/armpit, across to the right sternal boarder and down to the level of the nipple line or third intercostal space.
- It is likely that your measurement will be 1-2cm longer than the right.

- **For insertions into the leg**, measure from the insertion site along the course of the vein to the level of the umbilicus.
- An audit of final lengths gives the following guide for upper limb catheters into the antecubital fossa.

500-800g	7-8 cm
800-1200g	8- 9cm
1200-1500g	9-10cm
1500-2000g	11-12cm

Preparation

- Prepare your equipment as much as possible prior – it is not the nurses job to do this for you
- A screen should be placed around the cot space prior to starting
- One nurse is required to stay with the inserter throughout the procedure
- Open up a central line pack on the procedure trolley
- Put on the cap and mask
- Scrub your arms and hands, putting on a sterile gown and gloves
- There are 3 types of longlines
 - 24G catheter
 - 28G can be used in babies <1000gm or in those with difficult veins, however, the larger size catheter is preferable in bigger babies as it blocks less often and tolerates bigger volumes
 - Double and triple lumen longlines are available and should be considered in babies needing multiple medications. Both lumens require a continuous infusion running to keep them patent.
- Check that the silastic line will pass all the way through the butterfly, by feeding it from blunt end to fine end, then pulling it all the way through. NEVER pull it backwards, as you can cut it with the butterfly tip without intending to.
- Fit the metal section into the blue adaptor and screw tightly, the metal should be fully enclosed
- Flush the 24G catheter or double lumen(s) and Short Needle free minibore 14cm extension set (BC2042). with heparinised saline (0.1U/mL) and prefill the butterfly with saline or a yellow cannula if using this with the 28G
- Have a helper open up the separate pack with the tools on to the trolley
- If the baby is intubated and ventilated, a dose of systemic analgesic can be appropriate.
- In bigger babies who are ventilated, a dose of muscle relaxant such as pancuronium can also be useful
- See above under “Skin Preparation” as to which swabs to use to prepare the cord and surrounding skin
- Using a gauze square to hold the hand or foot, while you wash from shoulder to wrist or groin to ankle. Continue to hold the hand or foot up in the air while you wrap a sterile drape round the hand or foot and place another one under the limb.

Insertion

- A variety of sites can be useful, but antecubital veins or the long saphenous vein are reliable sites.
- A sterile gauze folded on diagonal can be helpful as a tourniquet if applied gently
- Make a venipuncture.
- Immediately release the tourniquet, if you are using one.
- Using fine non-toothed forceps, thread the silastic catheter into the vein for the pre-measured distance plus the length of the butterfly (just under 5 cm).
- The hardest part is getting the catheter to insert from the tip of the needle into the vein at about 4cm.
- Patience and perseverance are the keys to success
- Place your finger on the vein just above the butterfly/cannula to hold the line, then gently withdraw the butterfly/cannula
- The 28 G PICC lines insert using a 24G angiocath or the peelable butterfly included in the pack.
 - Once in your measured position, pull back the angiocath/butterfly and then remove the guidewire and flush with heparinised saline (0.1U/mL) using Short Needle free minibore 14cm extension set (BC2042).
- If using the larger catheter then feed it back and off the end of the catheter, unscrew the blue adaptor, remove the butterfly then reattach the blue adaptor to the catheter.
- If using a 28G with a yellow cannula then it cannot be removed but pull to the end of the line

- Gently aspirate, then flush (may not be able to aspirate a 28G line due to its small calibre)
- Ensure an infusion is started prior to the X-ray so that the line does not clot

Securing the Catheter

- Ensure that bleeding from the site has stopped (this can take several minutes of local pressure with a sterile gauze square)
- Place a Steri-strip close to the insertion site as an anchor
- Curl the catheter into several loops and secure with steri-strips.
- Place a small piece of gauze under the blue adaptor or cannula to prevent pressure sores
- The insertion site and the blue adaptor or remaining part of the cannula need to be dressed with Tegaderm™ but ensure it is not circumferential
- Make sure there are no kinks or places where the line will block off if the baby moves the limb (ie: at the wrist or foot) before placing the Tegaderm™ over the catheter as it is hard to remove once it is put on
- Provided it has been possible to draw back and flush the line, start a continuous infusion of saline via a T34 pump, while awaiting a radiograph to confirm position of the line. This is to prevent the line from clotting.

Line Imaging

Position verification upper limb

- In all upper limb PICC'S contrast is required.
- Remove the NG tube for the initial X-ray

Position verification lower limb

- For both sized catheters (24 and 28G) a lower limb long line **should have an AP and lateral film** taken without contrast in the first instance.
- If bowel gas obscures the line a repeat film with contrast will be requested after discussion between the radiologist and SMO.
- All long lines positions are to be re-checked by X-ray following any manipulation
- Radiographers can place the radiology plate in the incubator tray.
- All line placement to be confirmed with **Paediatric Radiology consultant** (may also involve registrar)
- Consider rechecking line internal length on X-ray to confirm tip position.

Appropriate Tip Position

Upper Limb Longline

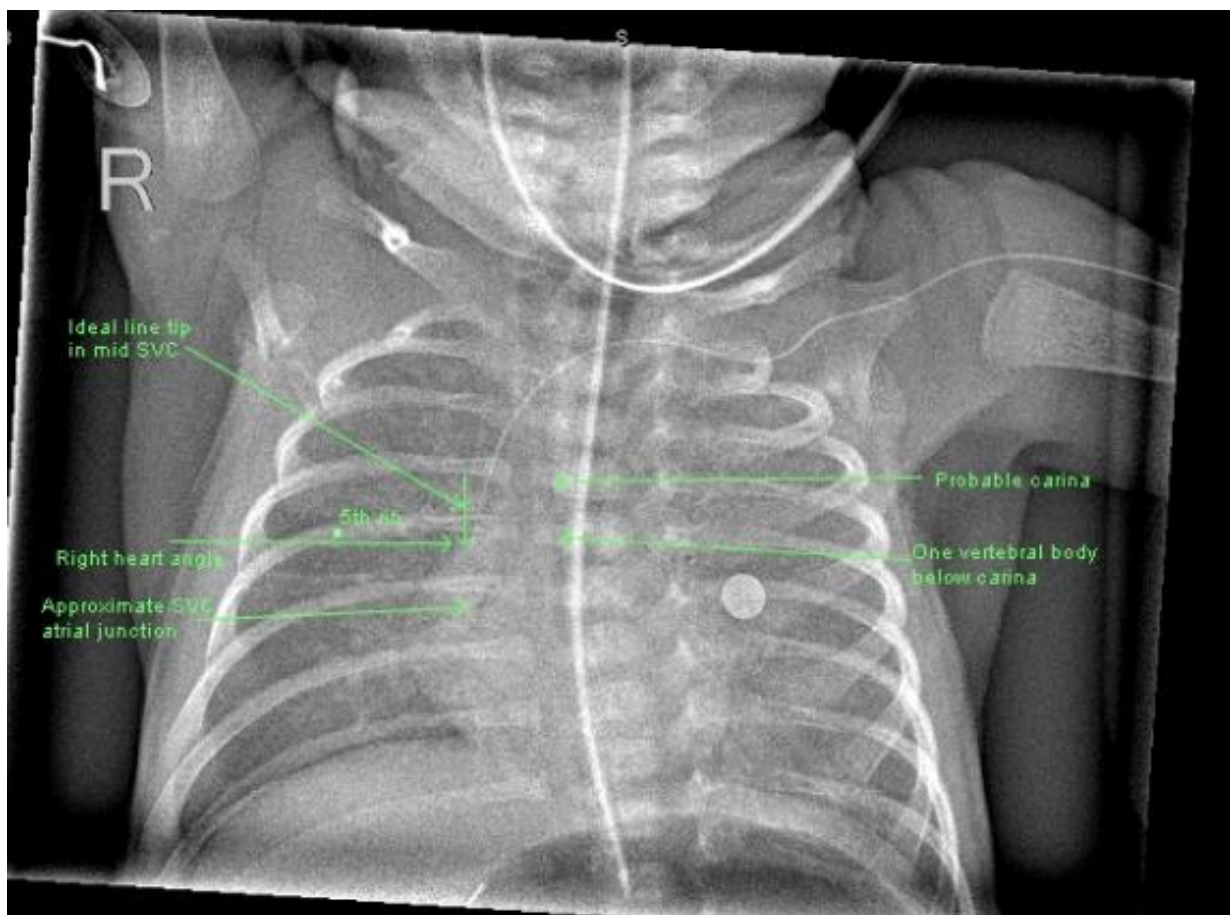
- **The ideal location for the catheter tip is parallel to the vessel wall in the superior vena cava, just proximal to the right atrial junction.**
- The suggested landmark on the chest X-ray is at the level of the carina or within one vertebral body below carina.
- This location is described as being 1 cm outside the heart in a premature infant and 2 cm outside the heart in a full-term infant.
- Insertion from the right is likely to lie more vertically than from the left due to the angle of the wall.
- A catheter tip with this orientation and in this location decreases the risk of vessel-wall irritation and allows the infusion to enter the bloodstream at the point of highest blood flow, maximizing the diffusion of infiltrates.
- When the line position is shorter – they can be used back to the axilla, but close monitoring for signs of phlebitis is required. A shorter duration of use is expected.

Lower Limb Longline

- The appropriate tip position is in the iliac vein or IVC
- In practice this means that the tip should preferably be above the groin and below the diaphragm

Note:

- Measuring distances on the images are inaccurate due to magnification and other factors, and this needs to be kept in mind when assessing distances for withdrawing lines etc.
- When upper and lower limb long lines are shorter than optimal, they can be used for TPN but use the **peripheral formulation** and closely monitor for signs of phlebitis. A shorter duration of use is recommended that is < 4 days.
- Shorter than optimal is assessed as follows:
 - Upper limb lines: Tip lateral to the medial end of the clavicle (i.e.: within subclavian or axillary veins)
 - Lower limb lines: Tip inferior to the position of the femoral head (i.e.: within femoral vein)

**Radiology reporting**

- Radiologist reports will state where the line tip is thought to be.
- Any inappropriate positioning will be reported and phoned to the NICU requester (default is pager 5025), or neonatal SMO.
- After hours line insertion will be reviewed by the inserter with the radiology registrar in the first instance. NICU SMO must be advised so they can review the films. A Paediatric Radiologist SMO is available at all times to review as required (On-call Paed Rad SMO can be called after-hours via switch).
- Given there is still some uncertainty about the ideal position, the radiologists are not expected to advise RMOs/Nurse specialists whether a line is ok to use, this needs to be approved by the NICU SMO.

Documentation

- Document the line insertion in Health Connect South, Level 3 Summary sheet and on the sticker for the Problem List. It is important to put in the final measurement if they have been manipulated for auditing in the future.

Risk of a Longline

- Sepsis is a risk for any central line and needs to be managed with aseptic insertion technique and good quality nursing care after insertion
 - Longlines are kept in for as long as they are needed are not routinely replaced.
 - If there are concerns that a longline may be a source of an infection then it should be discussed with the SMO whether it should be removed.
- Extravasation
 - This occurs most often when the longline has been unable to be inserted as far in as possible and the tip is either in the groin or the shoulder. Consider extravasation if the limb is becoming swollen or the pressure on the pump rise significantly. Remove the line.
- Cardiac Tamponade
 - Longlines with the tip in the heart can burrow in to the myocardium and eventually infuse fluid into the pericardium and so a longline should not be left in the heart
 - This is rare but needs to be considered in a baby with acute cardiorespiratory collapse with no clear cause
 - Immediate management is to stop all infusions through the line, ultrasound the heart and remove the line. Pericardiocentesis may be required under ultrasound guidance

References

PICC Placement in the Neonate

Amy S. McCay, N.N.P.-B.C., Elizabeth C. Elliott, N.N.P.-B.C., and Marlene Walden, Ph.D., N.N.P.-B.C. N Engl J Med 2014;370:e17. DOI: 10.1056/NEJMvcm1101914

Central Line Imaging and Contrast

Type of Line	At Insertion			After Initial Insertion if a line check is clinically required		
	AP	Lateral	Contrast	AP	Lateral	Contrast
UVC	✓	✓	✗	✗	✓	✗
UAC	✓	✓	✗	✗	✓	✗
Upper Limb Long Line	✓	✗	✓	✓	✗	✓
Lower Limb Long Line	✓	✓	✗ routinely ✓ if plain XRay not diagnostic	✓	✓	✗ routinely ✓ if plain XRay not diagnostic

Contrast Procedure for Long Lines

- Inject Omnipaque contrast via the **non-reflux smart site** on the end of the long line (these are stocked in the procedure trolleys in Drawer 4 by the long lines)
 - Premicath 28 g line = 0.3mL
 - Larger 24 g line = 0.7mL
- This site is preferred for consistency, to accurately deliver the amount of contrast required and to minimise the risk of tubing becoming occluded.
- When the Radiographer is in NICU and preparing the baby for the X Ray, contrast to be injected with sterile technique via the non-reflux smart site
- No specific timeframe is mandated but avoid giving the contrast at the time of the Xray or the contrast will be visible exiting the line and make reporting the line tip challenging, and avoid it dwelling in the line for longer than a few minutes.
- After the XRay flush the smart site and long line with saline to clear the line of contrast to reduce the chance of it blocking



If at any time a long line tip is not able to be clearly visualised on an X Ray (which may be incidental and not being done for line placement) use contrast and re-X Ray

Intraosseous Lines

Indications

- Emergency access to circulation when other routes have failed
- Administration of resuscitation fluids, blood products, and medications

Equipment

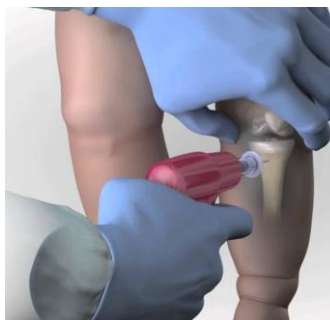
- 15 G intraosseous needle set
- Intraosseous drill

Procedure

- Clean and drape skin
- Attach needle to IO drill
- Insert needle at 90 degrees to the skin into anterior medial aspect of tibia, 1-2cm below tuberosity (see picture below)
- After reaching bone, squeeze trigger and drill through the cortex
- Remove stylet, place stabilizer over catheter hub, connect extension tubing
- Aspirate to confirm position and flush with normal saline
- Administer fluid or medications as indicate
- Remove as soon as alternative access is

Complications

- Fracture
- Damage to growth plate
- Infection
- Extravasation
- Compartment syndrome



Midlines

- Drugs and infusions that can run through a peripheral iv line can go via a midline, including blood products
- Can stay in for up to 4 weeks
- They are \$55 a midline so there needs to be a clear indication for their use over and above a peripheral iv line. If in doubt discuss with the SMO

Indications

- Prolonged antibiotic courses >5 days
- Peripheral iv lines tissing frequently or difficult to insert
- When reliable peripheral access is required eg: unstable blood sugars when PIV tissues
- If on 12.5% dextrose and no central access is available
- For TPN that is safe to run peripherally if central access is not indicated and length of TPN anticipated to be <7 days (ie: Start, Peripheral and term TPN bags)
- After unsuccessful longline insertion attempts but need secure access for TPN and the decision has been made to continue TPN (Starter, Peripheral Preterm and Term bags only). Note that the preference is for central access and central TPN bags when at all possible

Equipment

- Vygon – leaderflex pack
 - 22 gauge line with line length of 4cm and 6cm
 - Guidewire
 - 21G needle for insertion
- Trolley
- Dressing pack
- Drape
- Chlorhexidine
- Sterile Gloves (gown, mask and hat are not required)



Preparation

- Measure the limb
- Choose the appropriate length of catheter depending on the size of the baby and where the line will be inserted
- Ensure the tip remains in a peripheral position ie: distal to the shoulder or the femoral heads and the tip not ending at the knee or elbow joint

Procedure

- These do not need to be inserted or accessed in a full sterile manner but use sterile gloves
- Prime the catheter with saline
- Modified Seldinger technique
- Clean the skin and drape the limb
- Insert the needle into the vein and get a flashback of blood
- Insert the guidewire through the needle – this should advance without any resistance.
- If there is resistance then withdraw the needle and guidewire simultaneously – do not withdraw the guidewire through the needle as it could be damaged
- Ensure after guidewire insertion that there is enough remaining so that when the catheter is threaded over it there is enough guidewire exposed to exit the catheter hub
- Hold the guidewire in place and remove the needle



- Insert the catheter over the guide wire with a twisting motion
- Remove the guidewire

Securing the catheter

- Secure the line in a similar way to a longline - place a Steri-strip close to the insertion site as an anchor
- Place a small piece of gauze under the white plastic wings to prevent pressure sores
- The insertion site and white plastic wings need to be dressed with Tegaderm™ but ensure it is not circumferential

Line Imaging

- No CXR is needed routinely as the tip should lie in a peripheral vein
- If on XRay the line is in further than thought and is in a central position it should be withdrawn into the desired peripheral position. This is because midlines are not inserted or accessed with strict sterile conditions as a central line would be

Accessing the Line

- Do not use syringes <5mL as pressure placed in the line will be too high
- When the line is accessed - **“Scrub the Hub”** process should be used to reduce the chances of line sepsis

Documentation

- Health Connect South electronic form to be completed
- Complete and place the sticker below on the Problem List

MIDLINE INSERTION Date: _____
 Type: Leaderflex 22 gauge
 Catheter Length: 4cm 6cm
 Estimated Tip Position: _____

Complications

- Extravasation
- Occlusion with clot
- Infection although the risk is lower than with longlines

Chest Needle Aspiration

- For emergency aspiration of a suspected pneumothorax possible diagnosed after transillumination
- While setting up for formal chest drain insertion, drain with a 22G butterfly connected via a three way tap to 10 ml syringe.
- Put on gloves.
- Clean the skin with an appropriate antiseptic, then insert needle in the midclavicular line in the second intercostal space, perpendicular to the skin.
- Remember that the neurovascular bundle runs just beneath the inferior border of the ribs.
- Avoid the nipple area.
- You will usually feel a change in resistance as the needle penetrates the pleura.
- Draw back on the syringe, then turn the stopcock and depress the syringe plunger to expel the air.
- Repeat the process as often as necessary, until chest drain is inserted, or until it becomes clear that the pneumothorax is not reaccumulating.
- If you are not experienced in the technique of chest drain insertions, drainage with a butterfly will always suffice until a more experienced colleague can get there to assist you.
- If the baby improves significantly with needle drainage, and you are uncertain as to whether a chest drain is necessary, the end of the butterfly can be put into a small bottle of sterile water to create a temporary underwater drain (that will relieve a tension pneumothorax if it reaccumulates) until the baby's situation can be fully assessed over 10-20 minutes.
- This is also the technique used for emergency drainage of a pneumopericardium, (if there is cardiac tamponade), except that the needle is cautiously inserted just to the left of the xiphisternum, with the tip pointing towards the tip of the left scapula. Draw back frequently as you insert the needle, and have someone keep a watch on the ECG trace on the monitor. The same technique can also be used for emergency drainage of a large tension pneumomediastinum.
- After removing the needle dress with a Tegaderm™

Chest Drain Insertion

Indications

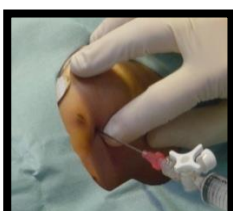
- Pneumothorax in a baby with significant respiratory distress or is ventilated
- Tension pneumothorax
- Pleural effusion

Equipment

- Clean trolley
- Sterile gloves, gown, hat, mask
- Chlorhexidine
- Chest drain (small, medium or large baby)
- Sterile central line pack
- 3 way tap
- 1% Xylocaine and 1ml syringe

Insertion of Chest Drain by Seldinger Technique – Cook Pigtail Drain

- Position the baby with the affected side up and the arm fully adducted.
- Open a cutdown tray and use cap, mask, gown and gloves.
- Use midaxillary line if possible.
- Prepare the area with antiseptic - see above under “Skin Preparation” as to which swabs to use
- Drape the area
- Remember analgesia i.e. use lignocaine 1% for all babies and additionally morphine if required and respiratory depression is not a concern
- Attach a 3 way tap and 10ml syringe to the needle and insert the needle and syringe into the 4th to 5th intercostal space mid or anterior axillary line and advance through the chest wall aspirating until air is aspirated and you are in the pleural space.
- It is important to aim anteriorly as that where the air will be.
- If the drain is for a pleural effusion then the drain should be aimed posteriorly



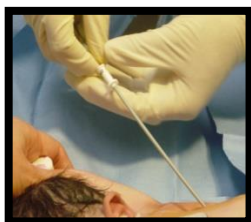
- Remove the syringe and 3 way tap and attach the guide wire introducer.
- Insert the guide wire through the introducer into the pleural space.



- Hold the guide wire and remove the needle, leaving the guide wire in place.



- Advance the dilator over the guide wire to enlarge the track through the chest wall then remove the dilator.



- Slide the chest drain over the guide wire, advance it through the dilated track until all side holes are in the chest.



- Hold the drain and remove the guide wire.
- Attach the supplied connector to the chest drain and attach to the underwater seal drain tubing.
- The drain does not require any suturing but should be held in place with Tegaderm™.
- Avoid heavy dressings that can restrict chest wall movement and obscure surveillance of the site
- Request AP and lateral chest radiographs. Use -10 pressure suction

Continuous bubbling in the underwater seal can indicate that:

- There is a very rapid air leak.
- Try reducing the ventilator pressures (especially PEEP) as blood gases allow, and/or switching to high frequency ventilation.
- Lung was perforated, (other clues to lung perforation are return of blood from the chest tube, suggestive location of tube tip and increased density around the tip of the tube on radiograph).
- Side hole is outside chest wall, (check radiograph)
- There is a leak in the system (check all the connections).

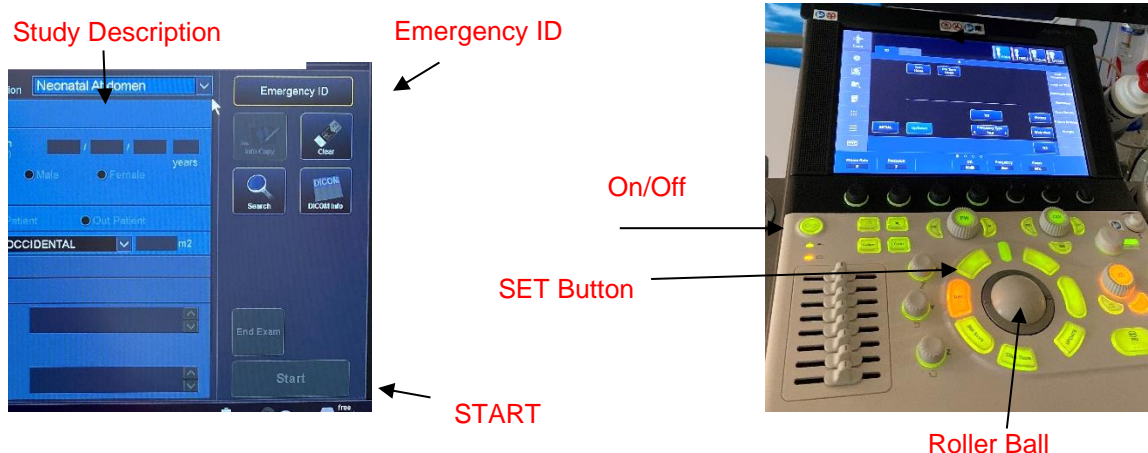
Failure of the tube to bubble intermittently can mean that:

- The pneumothorax has resolved (check by transillumination and/or radiograph)
- The tube tip isn't in the pleura (e.g. in the chest wall or mediastinum check radiograph)
- The tube is blocked (it may respond to being gently aspirated or flushed with 1-2 ml of air - do the above manoeuvres first)
- The air is loculated and the tube tip isn't reaching it. This should also be evident from the chest films. The first thing to do is to try repositioning the baby so that the air is near the tube tip, but sometimes reinsertion of the drain is necessary.

Bladder Ultrasound

- Unplug the machine and coil up the cords so you don't run over them
- Remove the brake by pushing the pedal at the bottom to the middle position
- Manoeuvre to the bedside and plug in
- Turn on the machine by pressing the **On/Off** button on left of machine
- Use the **Roller ball** to **Study Description** arrow, click **SET**, choose **Neonatal Abdo**
- Move the **Roller ball** to "**Emergency ID**" on right of screen and click **SET**
- Move the roller ball to **START** and click **SET**
- You do not need to enter any patient details as these scans will not be kept
- On the touch screen touch **Neonatal General** 11MC4 (ignore the numbers)

- On the next screen tap the **LINEAR** box **i18LX5**
- Take the large linear probe (straight edges) labelled **i18LX5**
- Use a single gel packet and put gel on the probe
- Place probe horizontally across the abdomen above the pubic bone in skin crease
- The top of the picture on the machine is where the probe is looking from
- A bladder will be a black round space at the top of the picture
- When finished turn machine off with the **On/Off** button at left hand side
- Then move roller ball to **SHUTDOWN** and click **SET**
- Wipe the baby's skin dry
- Clean the probe with the wipes in the basket below.
- Put the machine back in its parking slot, put brakes on and plug it in at the wall



Bladder Aspiration

- Use the ultrasound to confirm the presence of urine before attempting an aspiration
- This is the most commonly used technique to obtain a sterile urine sample in a neonate where sepsis is suspected. Urine should be sent for microscopy, culture and sensitivities and group B strep antigen
- Urine should be sent for fungal elements where systemic fungal infection is suspected in extreme preterms
- Urine samples sent for CMV PCR, or biochemistry need not be sterile.

Contraindications

- Recent voiding or dehydration where chances of success are low
- Superficial skin infection over site
- Significant genitourinary abnormality
- Distended bowel or abdominal mass

Equipment

- Sterile gloves
- Sterile dressing pack
- Chlorhexidine
- Ultrasound to check there is urine in the bladder
- Small syringe
- 23g blue needle
- Specimen jar

Procedure

- Explain procedure and indication to parents
- Position infant supine with arms and legs gently restrained by assistant
- Prepare skin with chlorhexidine - see above under "Skin Preparation" as to which swabs to use
- Insert 23G (blue) needle 1-2cm perpendicular plane in midline just superior to pubic bone
- Aspirate
- If no urine obtained retry later when bladder is more distended.

Complications

- Bleeding
- Perforation of abdominal organ
- Infection

Urinary Catheterisation

The ultrasound machine can be used to assess the presence of urine in the bladder prior to catheterisation. See the instructions attached to the ultrasound machine on how to do this.

Indications

- Urinary retention if bladder expression unsuccessful. Consider this in heavily sedated infants.
- Low urine output – no urine in 6 hours, or < 0.5 ml/kg/hour.
- Urethral valves with urinary retention
- Surgical infants who are at high risk of high intra-abdominal pressure postoperatively, ie: gastroschisis

Contraindications

- Abnormal bladder or urethra (except hypospadias)
- Abnormal perineum or ambiguous genitalia

Complications

- Perforation of the urethra or bladder.
- Knotting of catheter, causing trauma on removal (the risk of this is minimised by avoiding use of feeding tubes as catheters and inserting to correct length).
- Possibly increased by using feeding tubes instead of umbilical catheters or Foley catheters

Equipment

- **Term:** >3kg babies 8Fr or 6Fr Foley catheter (3ml balloon)
- **Preterm:** <1kg 3.5Fr umbilical catheter, >1kg 3.5Fr or 5Fr umbilical catheter if 6Fr Foley too large
- **Only use the Cook catheter which has no introducer**
- Chlorhexidine to clean skin - see above under "Skin Preparation" as to which swabs to use
- 10 ml syringe, Urine collection system, Sterile gloves
- Dressing pack, KY jelly

Insertion distance (approximate)

- Term: Male 6cm, Female 5cm
- Preterm: <750g Male <5cm, <750g Female <2.5cm
- The balloon extends 2.5cm back from the tip on the 6Fr catheter and 3cm on the 8Fr catheter – you will get urine draining back before the catheter is sufficiently in the bladder
- If the balloon is to be inflated it is advised that the Cook catheters are inserted to the hub before the balloon is inflated then withdraw to the above length
- If the catheter meets resistance do not inflate the balloon
- As a general rule place a purpose built urinary catheter (Cook catheter)
- Use the smallest catheter possible

- If the 6Fr catheter is too large the next best option is to insert a UAC into the urethra
- **Avoid using feeding tubes** as these may increase the risk of complications.
- **No introducer to be used**
- Balloon should not be inflated unless under ultrasound guidance in daylight hours – this is because of prior cases of balloons being inflated within the posterior urethra
- If the baby repeatedly passes the catheter when they empty their bladder despite adequate taping the balloon will need to be inflated – discuss with Neonatal SMO before proceeding. Consideration should be taken about whether these infants still need the catheter

Insertion Technique (Females)

- Place infant supine, with the thighs abducted.
- Put on sterile gloves.
- Separate labia, clean area around the meatus with antiseptic solution using anterior-to-posterior strokes
- Drape the area using a plastic backed paper sheet with central “hole”
- Apply sterile KY lubricant to tip of the catheter.
- With non-dominant hand spread the labia and identify the urethra.
- Gently insert catheter until urine is visible in catheter tubing.
- If catheter is accidentally inserted into vagina, leave in place, insert new catheter anterior to the first
- Connect to closed urinary collection system. Secure the catheter by taping to infant’s leg.
- No catheter balloon to be inflated until after radiology has confirmed the catheter is 3cm beyond the posterior urethra (formal US scan)

Insertion Technique (Males)

- Place infant supine, with the thighs abducted.
- Put on sterile gloves.
- Clean the penis with antiseptic solution starting at meatus and moving down the shaft of the penis.
- Drape the area using a plastic backed paper sheet with central “hole”.
- Apply sterile KY lubricant to catheter tip.
- Stabilise the penis with non-dominant hand, perpendicular to the body.
- Gently insert the catheter into the meatus until urine is seen in the catheter.
- Slight resistance may be felt as the catheter passes through the external sphincter. Hold the catheter in place with minimal pressure – generally spasm will relax after several minutes allowing easy passage.
NEVER FORCE THE CATHETER – if they are going to be held up it will be in the posterior urethra
- Connect to closed urinary collection system.
- To prevent dislodgement, tape catheter securely to lower abdomen, rather than the leg to help decrease stricture formation caused by pressure on the posterior urethra.
- No catheter balloon to be inflated until after radiology has confirmed the catheter is 3cm beyond the posterior urethra (formal US scan)

Lumbar Puncture

- This is an important procedure and essential to diagnose meningitis in a neonate which usually has few if any localising clinical signs in a neonate.

Contraindications

- Lumbosacral abnormalities
- Skin infection at site
- Respiratory or cardiovascular instability (start antibiotics and delay until stable)
- Coagulopathy (including thrombocytopenia)
- Signs of raised intracranial pressure (decreased level of consciousness, bulging fontanelle, papillary abnormality or other focal neurology) or known non-communicating hydrocephalus or structural abnormality (discuss with consultant regarding need for imaging)
- Actively convulsing

Equipment

- Sterile trolley
- Gloves, gown, hat, mask
- Chlorhexidine
- EMLA patch if LP is not urgent in a term baby
- Sterile dressing pack
- 25 gauge spinal needle for small babies, 22G for term infants
- Sterile LP sample tubes

Procedure

- Wear a sterile gown and sterile gloves , hat and mask
- Remember the inferior end of the spinal cord lies opposite the **body of the third lumbar vertebra** at birth and with growth it recedes to be at L1-2 in the adult.
- Explain procedure and indication to parents
- Ensure the infant is stable enough to tolerate procedure
- In term infants apply an EMLA patch 45-60 minutes prior to procedure unless this delay is unacceptable.
- If the infant is ventilated consider giving an increment of morphine prior to procedure.
- Local anaesthetic is not routinely used.
- Prepare using an LP kit and scrub for procedure
- Have the assistant position the infant in a lateral decubitus position with back perpendicular to the side of the bed. Be aware that neck flexion may cause apnoea in this age group.
- Prepare skin with chlorhexidine - see above under "Skin Preparation" as to which swabs to use
- Drape the area with sterile drapes
- Palpate the L3-4 interspace (at the imaginary line joining the iliac crests) and use this space or one below
- Insert the LP needle slowly withdrawing stylet when a slight "pop" is felt.
- If resistance is felt stop, withdraw and reposition
- Collect 10 drops in to each sterile pottle and send for microscopy, culture, Group B Strep Antigen, sensitivities, biochemistry and if indicated HSV PCR. Remember to number the samples and indicate to lab if baby has been on antibiotics.

Complications

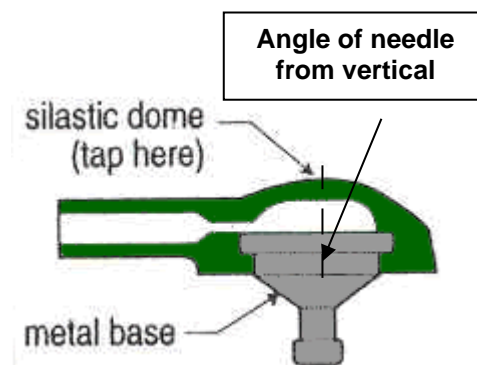
- Hypoxaemia, apnoea, bradycardia related to positioning
- Headache: difficult to be objective in newborn
- Infection: strict aseptic technique needed
- Nerve penetration: ensure midline puncture and no higher than L3-4
- Traumatic tap: more likely if advance needle too far: an insensitive sign of intraventricular or subarachnoid blood
- Intra-spinal epidermoid tumour: formed if epithelial tissue is introduced into the spinal canal by a needle without a stylet

Ventricular Reservoir Tap

Indications

Clinical symptoms of increased intracranial pressure.

- Apnoea, bradycardia, hypertension
- Poor feeding
- Lethargy
- Hypotonia
- Ultrasound evidence of progressive ventriculomegaly.
- Rapid increase in head circumference (>1.5cm a week)
- Tense fontanelle



Contraindications

- Low circulating blood volume
- Cellulite or abrasion over reservoir site
- Sunken fontanelle

Aims of Treatment

- To decrease progressive ventriculomegaly.
- To allow head growth at a rate of < 1cm per week.

Equipment

- **2% chlorhexidine + 70% alcohol swab to clean skin**
- 25 gauge butterfly needle or a brown 26 gauge needle
- 5ml syringe
- Standard sterile pack, mask, gown, gloves
- Additional sterile drapes as needed for maintenance of a sterile field



Precautions

- Maintain strict asepsis – wear sterile gloves and a sterile gown, hat and mask
- Monitor and correct serum electrolytes every other day if more than 10ml removed daily.
- Be prepared to provide rapid fluid replacement should the infant not tolerate large volumes being removed. Replace fluid removed with intravenous normal saline.
- If skin breakdown occurs, select an insertion site away from broken area.
- Do not place IVs on same side of scalp.

Technique

- Consider the use of sucrose for analgesia although at operation the area is denervated
- Place the infant with head in neutral position in anticipation of a 20 to 25 minute procedure.
- Cut any long hair that interferes with the surgical area but do not shave operative area.
- Wear sterile gloves.
- Clean skin with chlorhexidine/alcohol over the reservoir and surrounding skin with a diameter of 4cm.
- Allow to completely dry for 2 minutes.
- Position the sterile drape to maintain a sterile field.
- Attach the syringe loosely to the butterfly needle or brown needle (as you will need to disconnect it throughout the procedure)
- Insert needle through the skin just into the reservoir bladder.
- Select an insertion site different from the one most recently used.
- Angle needle not more than 30 degrees from vertical (see picture above)
- The base of the reservoir is metal so it cannot be punctured.
- Withdraw the required amount of CSF (fluid must be withdrawn no faster than 1ml/kg/minute)
- Once the syringe is full detach it from the needle leaving the needle in place and discard the fluid and reconnect the needle to the syringe.
- Limit the total volume of CSF drained at each tapping to no more than 30ml or 15ml/kg (whichever is less).
- The initial puncture should not exceed 10ml in volume and can be increased on sequential taps at a rate of not more than 5ml/day.
- It is sometimes advisable to tap twice a day at 15mls each time to avoid events.
- Sample CSF for culture, cell count, glucose and protein at least every three days.
- If fluid is blood-stained (from old haemorrhage), biochemical analysis may not be helpful.
- Culture dark fluid at least every three days.
- Remove needle and hold firm pressure for 2 minutes or until CSF leakage from skin stops.
- Repeat drainage at intervals dictated by clinical response +/- ultrasound markers. Repeat once a day but as often as twice daily. Aim to increase daily volume sufficient to prevent progressive ventriculomegaly.

- The volume taken off each day should result in an initial concavity of the fontanelle, with some overlapping of the cranial sutures.
- If the sutures are still overlapping and the fontanelle concave the following day, the interval between aspirations should be lengthened appropriately.
- Follow the response with daily head measurements and cranial ultrasound scans as required.

Complications

- Local skin breakdown
- Hypovolaemia, hypoproteinaemia, hyponatraemia (check electrolytes every 2-3 days)
- Wound or reservoir infection
- Ventriculitis
- CSF leak from puncture site
- Obstruction of ventricular catheter
- May precipitate further haemorrhage if large amounts of CSF removed

Nasopharyngeal Airway Insertion

Equipment

- Pulse Oximeter
- Appropriate sized soft (Ivory) Endotracheal tube, cut to enable fixation.
Commonly 2.5mm, 3.0mm, 3.5mm Portex Ivory tubes
- Comfeel base tape x3, Tegaderm, cut to shape.
- Sucrose

Technique

- Ensure that baby has been assessed and will benefit from nasopharyngeal tube placement.
- Attach oxygen saturation monitor if not already present.
- Measure length of NP airway required (distance from lateral nostril to tragus of ipsilateral ear or see chart below).
- Cut ETT to length and longwise to facilitate taping (see pictures).
- A fresh tube (ivory tracheal tube, Portex, UK) is prepared by cutting at the measured length plus 5 cm (fig 1). The tube is then cut down the midline of the underside of the tube to the measured length - this is the inside curve of the tube. Two cuts are made to each side of the midline to create two thin strips 3 mm wide, which are used for anchoring the tube to the child's cheeks. A further cut is made creating two additional strips on the top. One of these top strips shortened to the measured length plus 2 cm, is used for anchoring the tube to the dorsum of the nose. The remaining top strip is cut off at the measured length. The wedge that is cut off depends on whether the nasopharyngeal tube is used for insertion into the right or left nasopharynx (fig 2). (Masters et al, ADC 1999, 80 (2): 186-7)
- Coat tube with lubricant jelly
- Insert tube into nare along base of nose, you will feel resistance at the back of the nose. Rotate the tube and gently advance around the back of the nasopharynx. Advance forward to the point previously measured. Hold in place.
- Apply Comfeel to above infant's upper lip on each side and on dorsum of nose. Secure strips from tube to skin with Tegaderm™
- Ensure tube is in the nare comfortably. Care must be taken with edge of cut tube on nare.
- Suctioning should be performed initially after each feed but may be able to be less often
- Change nasopharyngeal airway weekly or sooner if frequently obstructing.
- Consider gentle nasal irrigation with normal saline drops and suctioning if baby appears snuffly.

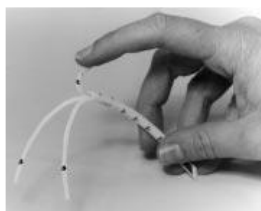


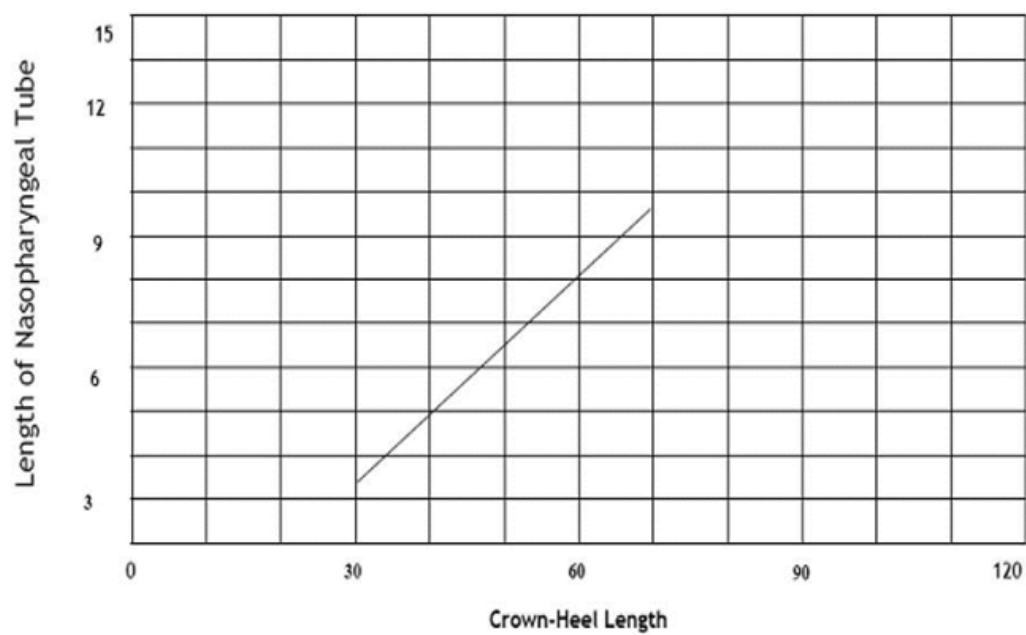
Fig 1



Fig 2

<http://adc.bmj.com/content/80/2/186.full.pdf>

(both images Masters et al, ADC 1999, 80 (2) 186-7)



<http://www.gosh.nhs.uk/health-professionals/clinical-guidelines/nasopharyngeal-airway-npa#Appendices>

❖ IMMUNISATION

Immunisation Schedule and Timing (March 2023)

6 weeks	Day 42	Rotarix (or by day 104)	Infanrix-hexa	Prevenar	
3 months	Day 91	Rotarix (or by day 174)	Infanrix-hexa	Prevenar (high risk only)	Men B Bexsero
5 months	Day 151		Infanrix-hexa	Prevenar	Men B Bexsero

6 weeks

- Immunisations should be given to babies as close as possible to 6 weeks postnatally, regardless of birth gestation. See below for exclusions to this.

3 months

- Immunisations to be given at 3 months age (13 weeks, day 91), irrespective of when the initial immunisations were given as long as there has been a minimum of 4 weeks since the 6 week imms

5 months

- Immunisations to be give at 5 months age (22 weeks, day 151). There is a target of this being given not earlier or later than 4 days around 5 months of age.

Practicalities

- There may be reasons to give an immunisation outside the fixed times
- Delayed - until a month after steroids, waiting for a baby to be well enough, waiting for the parents consent, if immunisation will hold up discharge then they may be delayed until a week after discharge to be done at the GP practice
- Early – to ensure discharge is not delayed with a family or a clinical situation where it is better to immunise early and be monitored than risk immunisation not happening in the community or being potentially unsafe

Immunisations

- The discharge letter and plunket book must state what has been given and when
- Immunisations should be given to babies as close as possible to 6 weeks postnatally, regardless of GA
- Immunisation should be deferred if the baby is very small and sick or unstable or is on corticosteroids.
- Discuss with the consultant if in any doubt.
- Some consultants prefer to vaccinate babies when they are still on CPAP to have that respiratory support around the time of potentially provoking apnoeas
- The presence of a progressive brain lesion is the only contraindication to vaccination (pertussis) likely to be of relevance in the NICU.
- IVH and most other intracranial lesions are not contraindications to pertussis vaccination, but if any doubt discuss with a consultant and document specific explanation to parents, for medicolegal reasons.
- The pneumococcal vaccine **ALL infants is Prevenar at 6 weeks and 5 months** (from Dec 2022)
- High risk babies** to receive an additional **Prevenar 13 at 3 months** (2017)
 - < 28 weeks gestation
 - Chronic lung disease
 - Cardiac disease with cyanosis or failure
 - Down Syndrome
 - Renal failure or Nephrotic syndrome
 - Intracranial shunts
 - Primary immune deficiency / HIV
 - Asplenia (anatomical or functional)

- Previous immunoglobulin infusions are not a contraindication to having their 6 week, 3 month or 5 month vaccines (including Rotavirus)
- The Nurse, Registrar or NNP should discuss immunisations with the family when they are due and the baby is medically stable to have them
- Verbal consent must be obtained and this needs to be documented by any staff member and signed for on the multicare pathway. Only then should the immunisations be prescribed
- The immunisations should be given in the presence of the parents if that is their preference
- It is not uncommon for babies to have mild temperature instability, increased apnoea, or irritability.
- It can be difficult to be sure whether these changes are due to the vaccine, or due to sepsis and it may be necessary to do a sepsis work-up, but keep in mind that immunisation can cause temporary elevation of the CRP and 'left shift' of the white cells.
- Apnoea monitoring for 24-48 hours after immunisation is appropriate if the baby is not on any monitoring

Rotavirus

- Rotarix is a live attenuated vaccine given orally at recommended ages of 6 weeks and 3 months
- The first dose must be given by 15 weeks (**Day 104**) chronological age and the second must be completed by 25 weeks (**Day 174**)
- Doses can be given no closer than 4 weeks apart
- Protection probably lasts 3 yrs and provides cover for infants when they are vulnerable to dehydration.
- The vaccine has been shown in Australia to reduce hospitalisation for young children with Rotavirus gastroenteritis by 70%.
- Reasons not to administer the vaccine at 6 weeks chronological age would be if the baby was unable to take the 1.5mL volume orally or if the medical team felt the baby was too unwell/unstable to be vaccinated.
- It is preferred to give the vaccine orally rather than via nasogastric tube to allow exposure for viral replication on the oral mucosa. The manufacturers specifications and the Medsafe data sheet do not support anything other than administration by mouth
- If the vaccine is not given at 6 weeks of age then administer either at discharge or with the second immunisations (whichever is earliest)
- If in rare cases a baby is approaching Day 104 and is still not safe to have anything orally then default to NG administration so as to not miss the opportunity to start the vaccination schedule
- See below for advice after exposure to steroids
- Standard universal precautions apply when looking after the NICU baby post-vaccination ie: handwashing and using gloves when changing nappies.
- The risk of this causing transmission to nearby un-immunised hospitalised babies is extremely low and the benefits of vaccination outweigh this risk (*Ref: Immunisation Handbook 2014, Peds 2014:133: e1555-1560*)
- There is a possibility of an increased risk of the rare condition of intussusception after the first dose of the vaccine although not all large data collections have this finding.
- The vaccine has been given in the USA since 2006 with no reported increase in intussusception rates

Meningococcal Vaccine

- From March 2023 Men B Bexsero® was added to the immunisation schedule to be given at 3 months, 5 months and 12 months chronological age with a minimum of 8 weeks between doses
- It is a very immunogenic vaccine and so it is recommended that paracetamol is given prior to the vaccination and at least 2 doses afterwards to reduce fever and the incidence of desaturations
- There is no evidence that the vaccination causes any more adverse effects than the other longstanding vaccinations as part of the schedule
- Refer to the drug profile for more information

Live Vaccines

Blood Products

- Live vaccines such as Varicella and MMR vaccine need to be delayed after certain blood products or immunoglobulins have been given (see Immunisation Handbook). **Does not apply to Rotavirus vaccine.**
 - Hep B Ig – withhold live vaccines for 3 months
 - Varicella ZIG – withhold live vaccines for 5 months
 - Packed RBC – withhold live vaccines for 5 months
 - Whole blood (exchange transfusion) – withhold live vaccines for 6 months
 - Platelets – withhold live vaccines for 7 months
 - IV Immunoglobulin (Intragam) – withhold live vaccines for 10 months

Steroids

- If a baby has received a course of **dexamethasone**
 - Delay Rotavirus (live vaccine) for 4 weeks after the completion of the course but ensure it is given by Day 104 (even if within the 4 week timeframe) to ensure they do not become ineligible
 - Other immunisations (Infanrix, Prevenar, Bexsero) can be given directly after completion of the steroid course
 - In consultation with Tony Walls (Infectious Diseases) our plan in Christchurch is to delay all immunisations until 4 weeks after the dexamethasone course for simplicity but note this can be individualised if required
- If a baby is on a course of **prednisolone** (usually for chronic lung disease)
 - If on < 2mg/kg/dose (usual situation) there is no reason to delay any immunisations (Infanrix, Prevenar, Bexsero, Rotavirus) and they should be given when due even if still on the prednisolone course
 - If on ≥ 2mg/kg/dose (rare)
 - Delay Rotavirus for 4 weeks after the end of the course, if possible, but give within this timeframe by Day 104 to ensure they do not become ineligible
 - Consider delaying other immunisations (Infanrix, Prevenar, Bexsero) until closer to term/discharge. The reason is because the immune response to the vaccine will be dampened and if this is left to closer to term corrected the baby may either be off steroids by then or the immune response may be better. This is infrequent and can be individualised for the patient's clinical situation. It is best to get immunisations started prior to discharge even if still on prednisone
- No need to delay any immunisations if on hydrocortisone for physiological replacement

Congenital Heart Disease

- Live vaccines need to be delayed for 8 months after cardiac bypass.
- This does not apply to the Rotavirus vaccine

Maternal Hepatitis B Carrier (HBsAg positive)

- The risk of mother passing the virus to her baby during delivery is high, and if not infected at birth, the baby remains at risk of hepatitis B infection from mother during the first five years.
- Although the baby's infection may be mild or even asymptomatic, chronic hepatitis occurs in up to 90% of infants who acquire the virus at birth.
- Thus, infection early in life results in a much higher risk of chronic hepatitis than in adulthood.
- Chronic hepatitis puts the baby, later in life, at high risk of transmitting the virus to others such as sexual partners and offspring, and of death from chronic liver disease or hepatocellular carcinoma.
- Recognition and counselling of mothers who are hepatitis B carriers should begin early in antenatal care.
- All pregnant women should be screened.

- Pacific Islanders, Africans, Asians and New Zealand Maori are high risk groups for chronic Hepatitis B carriage (this is presumed to be mostly due to perinatal acquisition).
- Carriage is also more common in people who have occupational or social exposure to human blood.

Management

- Wearing disposable gloves (to protect yourself) when handling the baby at birth and until they are bathed
- **Early bathing** of the baby to remove maternal blood and body fluids in warm water only
- Before any im injections the skin is to be cleaned with an aqueous chlorhexidine (alcohol-free) swab
- As soon as possible after birth, the infant should receive **Hepatitis B Immunoglobulin (HBIG)** 100 IU IM and **Hepatitis B vaccine** 0.5mL IM at separate sites
- Vaccine and HBIG are likely to be fully effective when given up to 12 hours after birth, and will protect some infants even when given after that, but there is no advantage in delay.
- If the father or a household contact has Hepatitis B it may be appropriate for the baby to receive the Hep B vaccination at birth (this is not on the immunisation schedule but discuss with Tony Walls on a case by case basis). Immunoglobulin is only indicated to prevent transmission from the mother during birth
- The baby will need subsequent hepatitis B immunisations as per the National Immunisation Schedule
- If a HBsAg positive mother has cracked, bleeding nipples and is breastfeeding the advice is that breastfeeding can still continue. Hep B does not transfer through breastmilk and there is additional protection after receiving the immunoglobulin and vaccine at birth.
- Infants of HBsAg positive mothers should be tested for HBsAg and antibodies to HBsAg one and three months after completion of the vaccine series. This will identify those few infants who have become chronically infected despite immunisation and will aid in their long term medical management. It will also identify infants who lack antibody and who should receive further doses of vaccine.
- If mother's HBsAg status is unknown at the time of delivery, maternal blood should be sent for testing.
- However, prophylaxis needs to begin immediately to be effective, so if she belongs to a **high risk group**, you should follow the protocol above for infants with know positive mothers without waiting for the results.
- If the mother proves to be negative the usual hepatitis B vaccine can be given at 6 weeks, 3 months and 5 months, and the serology testing after completion of the vaccine schedule can be omitted.
- We advise immunisation against Hepatitis B for all health care workers who are at risk of exposure to blood or bodily fluids. We also advise obtaining serologic proof that immunity has developed.

BCG Vaccine

- High rates of TB exist in New Zealand among population groups from Asia, Africa and the Pacific, particularly in recent immigrants.
- The role of vaccination is to protect individuals at high risk of exposure.
- BCG was introduced for neonates in 1976 and is effective in preventing extra pulmonary disease
- The LMC needs to assess the risk of TB in pregnancy and plan for vaccination after birth.
- In babies admitted to the Neonatal Nursery the Neonatal Staff also have the responsibility of considering eligibility for BCG vaccine.
- Preterm delivery or being of low birth weight are not contraindications to vaccination but babies should wait until they are >34 weeks before being vaccinated in order to ensure an adequate response.
- If eligible can be referred to the Public Health Nursing service by completing the [referral form](#) and emailing to bcbg@cdhb.health.nz . Phone number is 383 6863 if there are any issues.
- See Immunisation Handbook 2011 (www.moh.govt.nz/immunisation) for further information

Neonatal BCG Eligibility Criteria

- Living with a person with current TB or a past history of TB
- Living with one or more people who within the last 5 years lived for a period of ≥ 6 months in countries with a rate of TB ≥ 40 per 100,000
- During their first 5 years they will live for ≥ 3 months in a country with a rate ≥ 40 per 100,000 and are likely to be exposed to those with TB

Areas with rates of TB ≥ 40 per 100,000: Africa, South America, Russia, India, China (not Hong Kong), South East Asia (not Singapore), Pacific (not Cook Islands, Fiji, Niue, Samoa, Tokelau, Tonga)

❖ OPHTHALMOLOGY

Retinopathy of Prematurity

- With advances in monitoring and oxygen delivery systems, immaturity and very low birth weight are a greater risk factor than oxygen
- All babies with birthweight < **1250g** or < **30 weeks** should have an ophthalmology referral for screening for **retinopathy of prematurity (ROP)**
- Babies ≥ 30 weeks or ≥ 1250g may need screening for ROP (SMO discretion) if they have had
 - Hydrops
 - Grade 3 or 4 IVH or post haemorrhagic hydrocephalus
 - Severe sepsis
 - Nitric oxide for PPHN
 - Twin to twin transfusion syndrome
 - Prolonged period of high inspired oxygen

ROP – Patient Identification

- When a baby is admitted and fulfils the criteria for screening they should be entered into the ROP folder in reception by the ROP programme lead or ward clerk. The date for the first eye screen calculated by the ROP programme lead

ROP Screening (aligned with UK schedule)

Birth Gestation	First screening examination
< 27 weeks	31 - 31 ⁺⁶ weeks post menstrual age
27 – 29 ⁺⁶ weeks	4 weeks postnatal age between 31-34 weeks post menstrual age
≥30 weeks with birthweight <1250g	4 weeks postnatal age and by 36-36 ⁺⁶ weeks post menstrual age

- Timing of further reviews should not be longer than 2 weeks apart and sooner if there are concerns on the eye examination
- Assessment must continue until the retina is fully vascularised (minimum of 38 weeks, before screening can stop), OR, 40 weeks postmenstrual age in Zone 3 without any ROP
- If the regular ophthalmologist is on leave an alternative check will be arranged by the ROP programme lead to ensure no deferments occur.
- If treatment for ROP is required it should happen with 48-72 hrs of diagnosis

Eye Examination Process

- ROP programme lead gives parents information and obtains verbal consent prior to the first eye examination so they can be aware of the process and why it is required
- Eye drop stickers are available in the ROP programme lead office or NICU pharmacy cupboard to help prescribing – these need to be put on the drug chart and signed for prior to being administered
- Micro drops are 0.25% cyclopentolate + 2.5% phenylephrine drops – administered 60 min pre-exam
- Sucrose should be administered prior to installation of the eye drops and prior to the examination

RetCam Screening for Retinopathy of Prematurity

Binocular Indirect Ophthalmology (BIO) has been the gold standard in screening for ROP. However, in addition to BIO, wide field digital imaging which includes the RetCam, has been used for over 2 decades and has shown to be beneficial in supporting the screening and disease management of ROP in addition to an educational tool.

ROP screening in Neonatal Intensive Care Unit (NICU) Christchurch Women's Hospital takes place in a weekly clinic with BIO and RetCam imaging.

- Infants who fit screening criteria to have RetCam imaging between 34 - 38 weeks. Preferably around 36 weeks, which is the most likely time of diagnosis of Stage 1 and 2 ROP, i.e. when plus disease may be present.
- If born <26 weeks gestation to have RetCam imaging at 35-36 weeks and repeat at 38-39 weeks. Some babies may be fully vascularised in zone 3 and therefore able to be discharged.
- Monitoring of disease progression e.g. changes in vessel calibre. If Stage 2 or more, RetCam more frequently until resolution.
- ROP present, and treatment required (images can then be reviewed by Ophthalmologists, Neonatologists and ROP programme lead prior to and after treatment). Weekly RetCam screening post treatment until discharged from ROP screening.
- Babies ≥ 30 weeks or ≥ 1250 g may need screening for ROP if they have been severely unwell, for example PPHN requiring nitric oxide. Aim to RetCam these babies at 4 weeks or as soon as clinically stable.

Follow-Up after ROP Screening

- ROP screening sheets to be filed under Screening in the clinical notes and uploaded to HCS at discharge from the ROP screening programme
- RetCam images are uploaded to HCS after each Ret Cam imaging
- If a transfer to another centre is planned before 36 weeks corrected, before routine checks are completed or before 38/39 weeks in those < 28 weeks, Neonatal lead SMO/ROP programme lead contacts the accepting unit to identify that an ophthalmologist is contacted and available in that area for ongoing checks or transfer will need to be delayed.
- Timaru have an Ophthalmologist Khalid Mohammed who can perform ROP checks but the default should be that babies < 28 weeks must complete ROP screening at CWH prior to transfer as they are higher risk
- Babies who required screening for ROP should be seen at 12 months of age by the ophthalmologist as they have a higher risk of other eye issues. A referral process has been developed post ROP screening.
- Outpatient follow-up requests to be sent to Mark Elder for Chch and Ashburton patients, Logan Robinson for West Coast patients and Khalid Mohammed for South Canterbury patients.
- Babies who require laser treatment for ROP should be seen at 3 months by the ophthalmologist
- Babies who require Avastin treatment for ROP should be seen regularly until 54 weeks while on NICU or by the ophthalmologist in outpatients from 2 weeks post discharge.

Risk Factors for Eye Disease (apart from ROP)

- Examination of the eyes is an essential component of each check during infancy, and certainly each discharge examination. The examination should include a check that baby:
can fix and follow, has a full range of eye movements, has normal pupils and red reflexes (exam requires an ophthalmoscope) and equal orbit size
important to note that the red reflex in babies with Trisomy 21 as they have a 4% incidence of congenital cataract

Ophthalmology Consults for Conditions other than ROP

- Complete a Referral letter and email to eye.service@cdhb.health.nz where the referral will be triaged by Dr Antony Beddgood. His booking clerk is Deborah Long (deborah.long@cdhb.health.nz, extension 81600) and the eye outpatient administrator Keri Sulz (keri.sulz@cdhb.health.nz, extension 86055)
- Indicate on the referral our sense of urgency and whether the baby needs to be seen in NICU or if they can travel to the Eye Department (where they can get a more thorough assessment)
- These consults will usually be seen at a separate time to the ROP rounds

Urgent Referrals

- Absent Red Reflex – may be due to a cataract or retinoblastoma. Get a second opinion from an experienced colleague before referring especially in babies with darker skin as the reflex will be different. Note the 4% incidence of cataracts in babies with Trisomy 21.
- Red eye – due to infection or cellulitis (not routine conjunctivitis that is responding to treatment, or sticky eyes that are usually due to blocked tear ducts that resolve over the first year of life)
- Trauma to the eye – not isolated conjunctival haemorrhage
- Symptomatic, unwell baby with CMV or Toxoplasmosis – potential to consider acute treatment

Less Urgent Referrals

- Eye Malformations – colobomas, proptosis
- Abnormal eye movements – nystagmus, not fixing and following
- Work up for septo-optic dysplasia
- Close relative with a history of retinoblastoma or congenital eye abnormalities that may affect vision. Note that 90% of cases of retinoblastoma are sporadic and will not have a family history
- Suspected or confirmed CMV or Toxoplasmosis in an asymptomatic well baby
- Inborn errors of metabolism – risk of cataracts or other ocular signs
- Trisomy 21 – to be seen at 6 months – risk of congenital cataracts (4%), strabismus (27%), nystagmus (20%), and refractive error – both myopia (22%) and hyperopia (13%).

❖ AUDIOLOGY

- In 2009 a national newborn hearing screening programme commenced in Canterbury with automated ABR (aABR) or automated otoacoustic emissions
- From July 2015 this has changed so that all babies are screened with aABR and the risk factors for those requiring ongoing hearing surveillance have been modified
- For babies in NICU the risk factor sheet should be completed by the nurses, NNP or Registrars prior to screening (at around 36 weeks corrected gestation or 48 hrs prior to discharge)
- The risk factor form is then available for the hearing screeners who will make the necessary referral to audiology if required.
- The timing of the hearing surveillance through audiology will differ depending on the risk factor

Risk Factors for Hearing Loss Requiring Surveillance

- Craniofacial anomalies – pinna, ear canal, cleft palate (not an isolated cleft lip)
- Syndromal diagnosis with known association with hearing loss (such as Trisomy 21, CHARGE, Stickler syndrome, Goldenhar, Pierre Robin, Wardenburg, Pendred)
- Proven congenital CMV, Rubella or Toxoplasmosis infection (not herpes or syphilis)
- Ventilated for > 5 days
- Nitric oxide requirement
- HIE Grade 2 or 3 or received cooling
- Ototoxic medications with levels outside the therapeutic range
- Grade 4 IVH with post-haemorrhagic hydrocephalus
- Head trauma

Not Screened Direct Refer to Audiology

- Aural Atresia
- Meningitis and meningoenitis confirmed or strongly suspected
- Basal skull/Temporal bone fracture

Specific Situations

- Any baby who does not pass the aABR will be offered a repeat screen and only then referred to audiology for a diagnostic ABR
- Babies with Trisomy 21 will be referred for a diagnostic aABR with audiology even if they pass their screening test
- Babies who have severe jaundice will be screened or rescreened (if already done prior to the jaundice) first and will not be automatically referred to audiology for hearing surveillance
- A family history of hearing loss is no longer a risk factor – these children will all have their hearing screened at the B4 school check

Reasons for an ENT Referral

- Structural ear and facial anomalies
- Remediable middle ear disease may contribute to the hearing problem.

❖ NEONATAL SUBSTANCE WITHDRAWAL

There is a range of maternal medications and substances taken in pregnancy that can impact the behaviour of babies. This is usually in the first 2 weeks of life.

In 2022 the Eat, Sleep, Console (ESC) programme was introduced specifically for babies exposed to opiates antenatally. Babies exposed to other drugs may require supportive care for withdrawal but not using the ESC framework

Poor Neonatal Adaptation (PNA)

This describes a collection of symptoms seen in some infants exposed to maternal medications, such as:

- antidepressants, SSRI's and other psychiatric medications (eg prozac™, citalopram, escitalopram, quetiapine, venlafaxine,)
- benzodiazepines (eg. diazepam and temazepam)
- gabapentin
- other substances including tobacco, methamphetamines, ethanol, stimulants and marijuana*

Timing of withdrawal and symptoms vary but may include:

- chance of delayed transition/pulmonary hypertension and need for resuscitation at birth with SSRI's
- irritability, jitteriness or lethargy and low tone
- poor feeding, vomiting, diarrhea
- temperature instability
- nasal congestion
- tachypnea
- hypoglycaemia
- withdrawal from these substances without opioid exposure as well is generally more mild and usually resolves without intervention by 72 hours but can last up to 2 weeks
- Studies suggest up to a third of infants exposed to antidepressants may develop PNA, but in the majority of infants, symptoms are mild and self-resolve, usually within 72 hours.

Management

- these infants can be monitored on the postnatal ward
- supportive care should include an explanation of the infant's symptoms to the mother, support for feeding, swaddling/skin to skin cuddles and pacifier use for settling.

Resources

- Maternity guideline on Substance abuse in Pregnancy
<http://edu.cdhb.health.nz/Hospitals-Services/Health-Professionals/maternity-care-guidelines/Documents/GLM0067%20Substance%20Abuse%20in%20Pregnancy.pdf#search=psychotropic>
- Advice for Health Professionals Caring for Pregnant Women Taking Psychotropic Medicines and Infants Exposed to Psychotropic Medicines In Utero and while Breastfeeding
[Psychotropic Medications for Mothers and Babies](#) (Ref.2407235)

Maternal Opioid Use

- Mothers in the Nga Taonga Pepi programme (Previously Methadone in Pregnancy Programme (MIPS) who will also have attended the OG3 High Risk Antenatal clinic will have babies identified antenatally as being at risk of opioid withdrawal.
- The clinic uses two forms of treatment for Opiate Substitute Treatment (OST). Both are long acting opioids that occupy the mu opioid receptors and decrease opioid withdrawal symptoms and cravings.

Methadone

- oral daily dose with a wide range prescribed - mean dose in previous cohort through our unit was 60mg/day.
- Low doses < 50mg / day are less likely to be associated with withdrawal, high doses \geq 80mg are more often associated with withdrawal.

Buprenorphine with naloxone (Subutex)

- starting at 4-8mg/day and adjusted as needed.
- 12-24mg/day is often an adequate maintenance dose with a ceiling effect at high doses (24 to 32 mg)
- if a woman is not well controlled at doses approaching 32mg/day, a decision may be made to switch over to methadone.

- Buprenorphine is less sedating and gives less euphoric effect than methadone.
- Methadone has an increased risk of respiratory depression, and interactions between methadone and other respiratory depressants such as alcohol, benzodiazepines and the newer non-benzodiazepine hypnotics (Z-drugs), other sedatives or tricyclic antidepressants may be additive.
- Women on OST are often on additional prescribed medications and effects described under poor neonatal adaptation may also be seen.
- Infants can also have opioid withdrawal if the mother is on other opiates such as **tramadol, oxycodone, morphine, fentanyl and codeine**. These may be prescribed or used illicitly. If NEWS scores indicate withdrawal on PN then consider admission where they will be assessed with the ESC tools (see below).

Neonatal Substance Withdrawal (NSW)

This is the postnatal drug withdrawal syndrome that can be exhibited by neonates with antenatal exposure to certain drugs.

Opioids are the only antenatal substance exposure associated with acute potentially life-threatening withdrawal effects. Infants with in utero exposure to opioids are closely monitored and treated as needed.

Timing of withdrawal and symptoms vary but may include :

- For short-acting opiates (codeine and oxycodone) these may start in the first 6 hours of life and generally appear by 48 hours
- For long-acting opiates (methadone and buprenorphine) these generally occur at 36 - 72 hours of life but may be delayed until 5 to 7 days of age. Onset as late as 4 weeks has been reported.
- Factors that influence the timing and severity of neonatal withdrawal include length of exposure to the substance, dosage, genetics, other medications (such as antidepressants or benzodiazepines) and gestational age (full term infants have more withdrawal symptoms than preterm infants).
- Infants who are full term are more likely to have significant withdrawal than preterm infants
- Polysubstance use is common among opioid users and may worsen or alter the timing of opioid-withdrawal symptoms, particularly with benzodiazepines.
- Substances and medications noted to cause poor neonatal adaptation* may change the timing of withdrawal and/or lead to more severe withdrawal symptoms when in conjunction with fetal opioid exposure.
- Symptoms include tremors, irritability, excessive crying, lethargy, hyper/hypotonia, poor feeding, tachypnoea, temperature instability, nasal congestion, hypoglycaemia, sneezing, vomiting and diarrhoea and poor sleep.
- Never assume that irritability, lethargy, jitteriness, poor feeding are solely due to maternal medications/substance exposures. Significant medical aetiologies for these signs and symptoms must be assessed and investigated appropriately. **This is a diagnosis of exclusion!**

Monitoring Infants at Risk for Neonatal Substance Withdrawal

All babies with a risk of any substance withdrawal can be managed on the maternity ward assuming there are no other medical conditions necessitating a direct admission to NICU

- These babies will be **monitored using the NEWS score**.
- On the Risk Assessment section of the NEWS – Tick, Other risks/concerns and name the medications/substances used antenatally.
- Initial NEWS is within two hours of birth and then 6 hourly

- NSW symptoms are covered by the assessment of Behaviour/Feeding which includes assessment of tone (low tone/floppy, jittery/ irritability) and feeding
eg: If they became jittery / irritable (score=1) + feeding concerns eg If consecutive feeds are A-D (score=1a) = NEWS 2
A NEWS score of 2 or higher would trigger escalation via a phone call to the Neonatal team and a review within 30 minutes
- Non-pharmacological interventions on PN include low lights, quiet environment, swaddling and skin-to-skin contact should be used with all neonates antenatally exposed to drugs, nicotine and alcohol

Infants Exposed to Non-Opiates

- Remain on maternity ward with their mother if they are well
- Review by the Neonatal Team if there are concerns
- Guidance to determine if the baby is ready for discharge:
 - ability to eat ≥ 30 ml by day 3 PDM/MM or breastfeed well
 - sleep undisturbed ≥ 1 hour,
 - and be consoled within 10 minutes of crying.
 - Weight should be done at 72 hours (either in hospital or at home). Follow the maternity pathway if $> 8\%$ weight loss.
- The birth plan may have identified a 72 hour stay due to maternal mental health complexity. Check with the LMC, Social worker or mental health team if they are involved.

Infants Exposed to Opiate Substitute Therapy (methadone or buprenorphine)

- Because withdrawal from long-acting opioids generally occurs after 24 hours of life, infants at risk for withdrawal may stay with their mother on maternity for the first 24 hours of life if they have no other issues requiring an increased level of care.
- Should be admitted to the NICU after 24 ± 6 hrs of age (ie: between 18-30hrs of age when it is appropriate) for further monitoring and treatment as needed. The ACNM will advise when a bed is available for the mother if she is cleared from maternity.
- Our current policy is to encourage breastfeeding and have the mother in a parent room when the mother can be discharged from maternity.

Neonatal Meconium Drug Screens

- Meconium starts to develop in the second trimester and any drugs that the fetus is exposed to will accumulate in the meconium. When the baby passes meconium after birth it can be analysed. This provides a long window of detection for drug exposure for at least the 3rd trimester and even possibly earlier.
- There are certain clinical situations where a meconium drug screen may be beneficial to the baby's care
- Discuss with the parents that the reason for the meconium sample is to ensure the baby is receiving the appropriate care that they need
- Placing on the Eat Sleep Console programme is beneficial to nonpharmacologic care and a baby may transition to the ESC programme from results from the meconium screen
- Opioids may be associated with the need for treatment for withdrawal, benzodiazepines are associated with need for higher treatment dose requirement or second line medication and a longer duration of treatment

Examples of Situations to consider Meconium Collection:

- Maternal history of drug use or suspected drug use and an unwell baby where drugs may be a contributing factor – such as neonatal abstinence syndrome or neonatal substance withdrawal symptoms, unexplained neurological symptoms
- Maternal behaviours suspicious for intoxication
- Maternal history of drug use but denying drug use in pregnancy
- No antenatal care
- Request from Oranga Tamariki for a drug screen for care and protection decision making

If a mother is open about drug use in pregnancy, especially if monitoring results are available electronically then a meconium screen does not need to be taken to confirm this. Discuss with the NICU SMO involved.

Meconium Sample and Testing

- Screens are done on meconium and not transitional stool or faeces so a sample does need to be taken early in the first day or two.
- Contamination with blood means the test cannot be run
- A “pea size portion” of meconium is required for the analysis in the laboratory. If multiple samples are needed to make up enough sample, then the sample should be held in the fridge in the Blood gas room.
- Turnaround time is typically within 48 hours Monday to Friday. The sample is likely to be run on the day that it is delivered to Toxicology

Consent

- Parental/Caregiver consent is required before sending the sample.
- The sample can be collected and kept in the fridge until parental consent is obtained.
- In some cases where Oranga Tamariki have been involved and consent has been obtained before the baby is born, this will be documented in the Social Work care plan under the mother on HCS. Always confirm with the mother.
- Where a baby is symptomatic for withdrawal, care and protection issues are present and the parent has not consented or has self-discharged the SMO should discuss further with the social work team ± legal team about how to proceed.
- If the sample is required to optimise the baby’s care then the sample should be taken and sent to the lab for analysis as the above issues are worked through.

Drug Testing Panel

- A standard drug screening profile, which includes approximately 300 narcotics, drugs of abuse and therapeutic drugs. The testing can be tailored to detecting specific compounds outside the standard panel where this may be indicated.
- A negative result does not necessarily mean that a drug was not ingested in pregnancy – it may be in lower levels than detectable on the assay or be due to the meconium sample size.
- Urine samples are less helpful as urine is not in ample supply in the early days and collection is fiddly or invasive. Urine only gives an overview of the past 2-3 days. If this is still helpful then a small sample of approximately 2 mL is all that is needed to perform a drug screen.
- Typically, the laboratory will give preference to NICU samples and run these as acute samples with results available as soon as possible.

Eat Sleep Console (ESC) Assessment

- The ESC tool has replaced the Finnegan score previously used.
- It was developed as a simplified, “functioning-based” method of assessing an infant’s symptoms of withdrawal
- **Infants of mothers on OST in the Nga Tonga Pepi clinic will always be evaluated using this pathway**
- Focus is on involving the family as both the primary care giver and as a participant in decision making for their child
- Commence the Eat Sleep Console assessments 3-4 hourly on admission to NICU
- Resource folder in Room 6 contains
 - Eat Sleep Console assessment guide (ref 2408553)
 - ESC Assessment Tool (2408554)
 - Huddle worksheets (ref 2408555)

Eat Assesses if the infants feeding is appropriate or affected by substance exposure. Breast feeding is encouraged unless there are medical contraindications because it can delay the onset and decrease the severity of withdrawal symptoms as well as decrease the need for pharmacological treatment.

- **Effective Feed** – has effective latch and milk transfer, 8-12 feeds/24 hours, tolerating volumes, co-ordinated suck/swallow, able to co-ordinate feeding within 10 mins of showing hunger cues, good weight gain, good output
- **Ineffective Feed** – poor latch, uncoordinated suck/swallow, ineffective transfer, unable to co-ordinate feeding within 10 mins of showing hunger cues, poor weight gain

Sleep Assesses if sleep duration is affected by substance exposure. They should be able to sleep for more than 1 hour undisturbed.

- Observe for – fussiness, restlessness, increased startle, tremors, excessive sucking.
- Note: cluster feeding affecting sleep pattern could be normal dependent on GA/post-natal age

Console Is the infant unable to be consoled within 10 mins due to symptoms caused by substance exposure

- Consolability Scale/Soothing Support:
 1. soothes with little support (consistently self-soothes or soothes easily)
 2. soothes with some support (soothes fairly easily with skin-to-skin, rocking, pacifier, etc)
 3. soothes with much support or does not soothe in 10 minutes

Non-Pharmacologic Measures

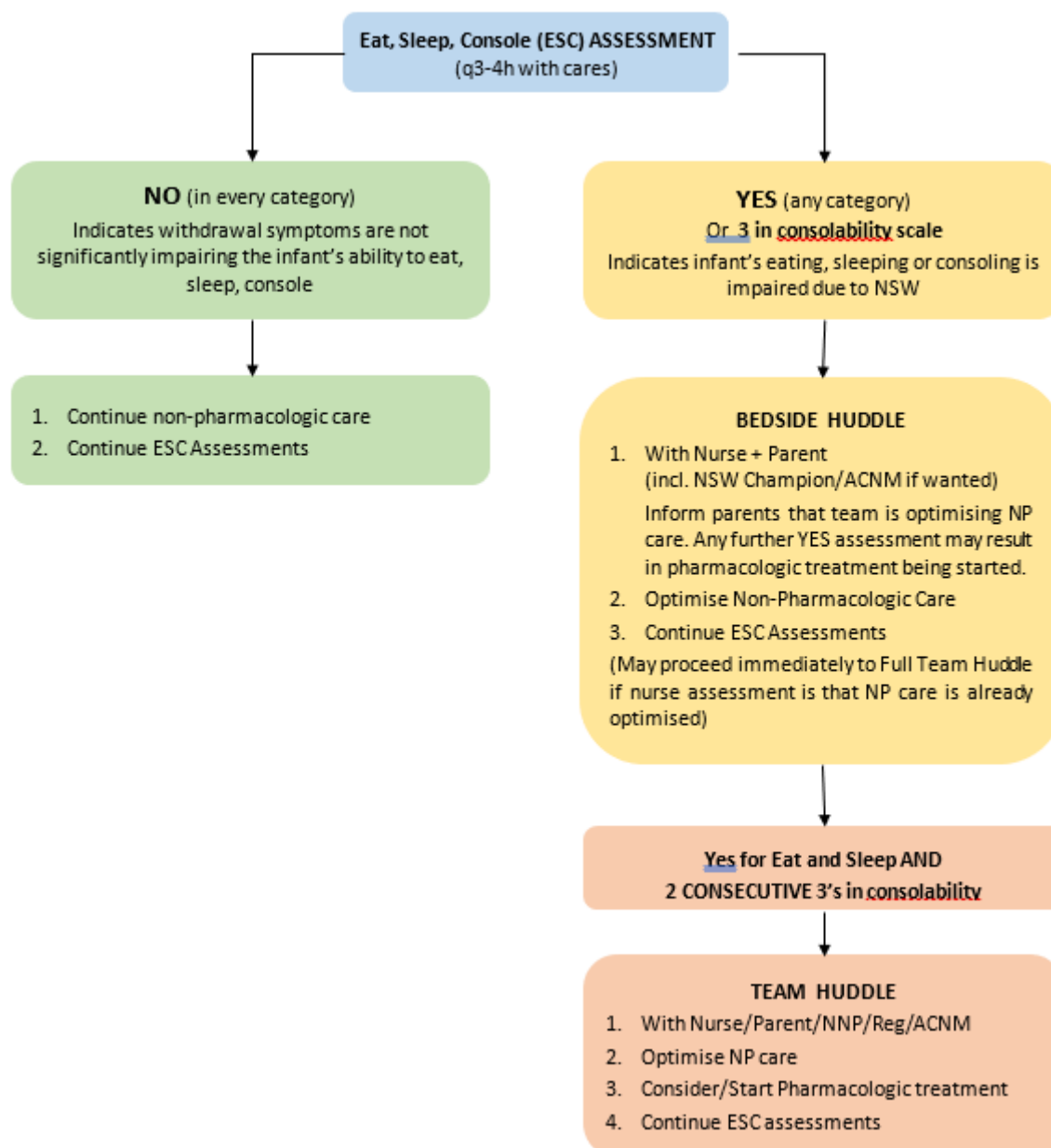
Fall into 2 categories with parent presence wherever possible.

Environment includes:

- Lighting – keep it low
- Avoiding noise - quiet and calm, avoid alarms
- Positioning in the room away from high traffic areas and sinks
- Limiting visiting

Handling includes:

- Speaking softly and talking before touch
- Gentle handling
- Skin to skin
- Slow rhythmic movements such as swaying
- Encouraging hand-to-mouth sucking or use of a pacifier for non-nutritive suck
- Clustering cares.



(Ref 2408553)

Criteria to Consider Pharmacologic Management

If these findings are present then follow the steps below:

Eat – yes response, OR

Sleep – < 1 hour, OR

Consolability – “3” in the consolability scale

- Bedside huddle with Nurse, parent (in person or over the phone) and ACNM to check if non-pharmacological areas can be improved

Eat – yes response, AND

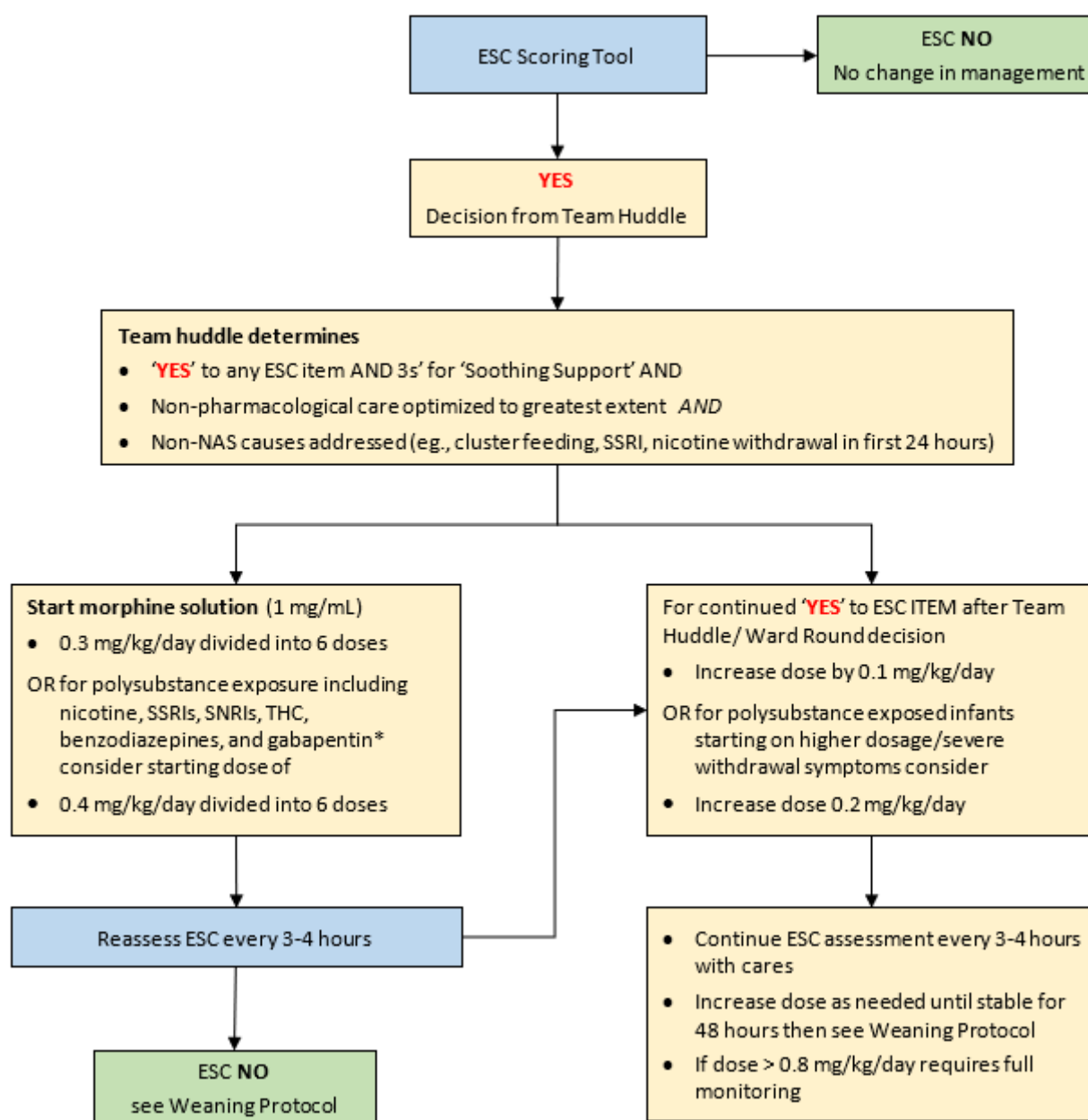
Sleep - < 1 hour, AND

Consolability – 2 consecutive “3’s” in the consolability scale

- Team huddle is held with the RMO/NP/CNSANP or SMO where the baby is considered to have met criteria to commence morphine and with parent consent

Morphine Dosing

- To treat neonatal substance withdrawal we use oral morphine solution (1 mg/ml). (see drug proforma)
 - **Initial dosing** 0.3 mg/kg/DAY in 6 divided doses (ie: 4 hourly)
An SMO may determine a starting dose of 0.4mg/kg/day if the mother is on high dose methadone and polypharmacy especially benzodiazepines and a heavy smoker > 10/day
Chart using the premade sticker for Morphine for NSW to make charting easier and less prone to error.
 - **Increasing the dose:** by 0.1mg/kg/DAY eg to 0.4 mg/kg/day, 0.5mg/kg/day etc. 3-4 doses are needed to reach a steady state and dose increases are discussed on the daily ward round.
The SMO may consider escalation dose increase of 0.2mg/kg/day.
- * If the dose required is greater than 0.8mg/kg/day then the baby must have a cardiorespiratory monitor.
- * Phenobarbitone is considered if dose needs to be increased above 0.8mg/kg/day. There is usually a high dose of OST and polypharmacy. Phenobarbitone is given in the evening at 3-4mg/kg/day without a loading dose.



(Ref 2408959)

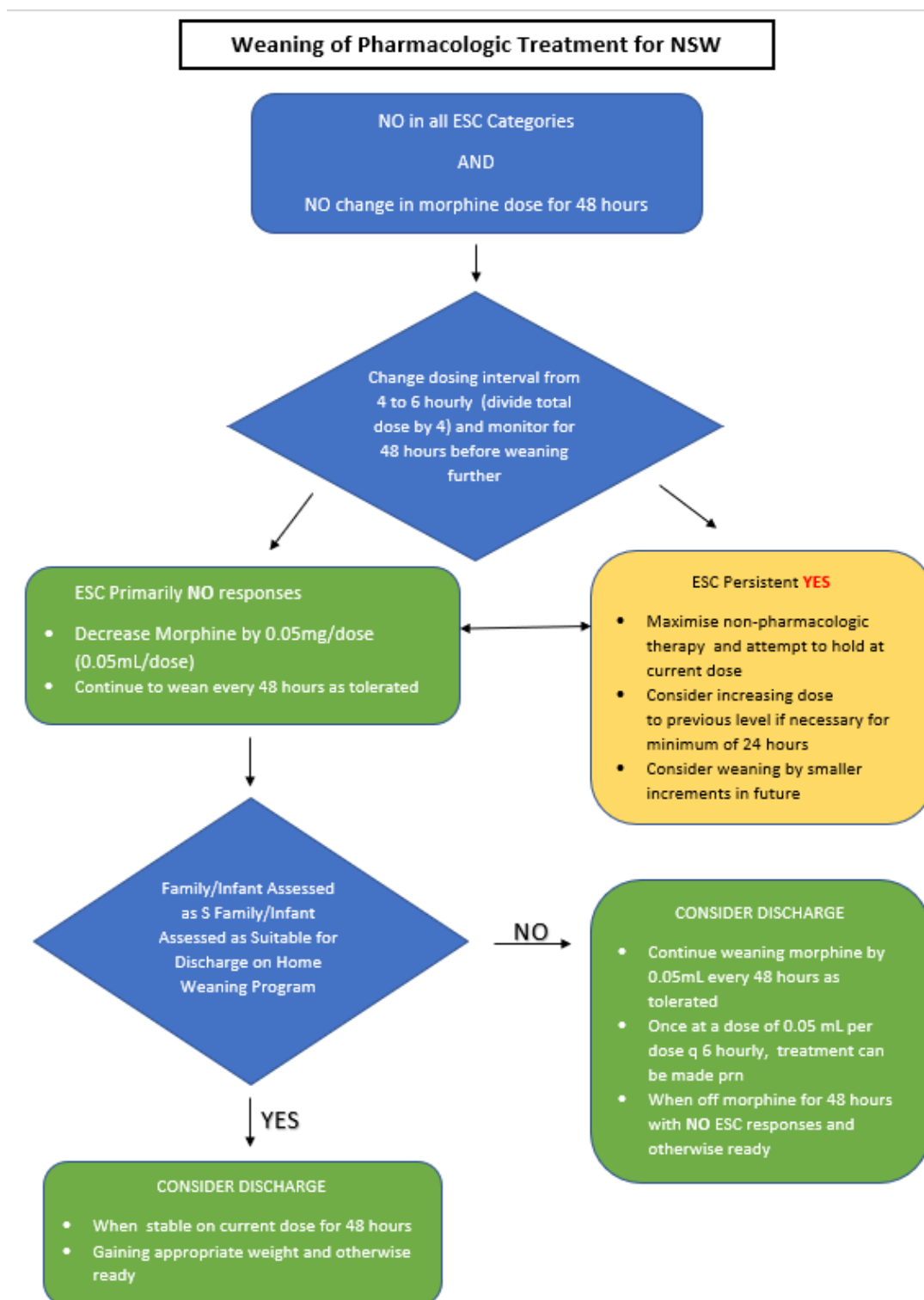
Morphine Weaning

- Once ESC scores have fallen (No for Eat and sleep and consolability 1 or 2) the dose of morphine can be changed to 6 hourly. Use the current total dose/day and divide by 4. This is not a change in overall dose per day but a change in interval

For example a baby on 0.5mg/kg/day given 4 hourly @ 3kg will be getting 0.25mg 4 hourly. They will change to 0.37 mls 6 hourly.

- If stable on 6 hourly dosing the dose can be reduced every 48 hours. The usual increment that the dose is dropped by is 0.05mls (0.05mg) per dose however at times the decrease will need to be smaller (by 10% suggested).

For example a baby on 0.5mL every 6 hours will be reduced to 0.45mL every 6 hours for the next 48 hours before the dose is reviewed again.



(Ref 2408960)

Discharge Planning

- Discharge planning needs and suitability for the “morphine at home programme” will be done in all cases of babies exposed to opiates antenatally whether or not they have needed treatment
- Discharge planning will involve SW, Discharge facilitator, Outreach nurse, SMO
- If infants are assessed as suitable for early discharge and continued morphine management for withdrawal at home, they can be discharged if they have successfully had a dose reduction without escalation of withdrawal symptoms. If they are on more than 0.5mg/dose more than 2 reductions before discharge are required.
- Once the dose is at 0.05 mg/dose, the treatment can be changed to prn

- If the baby is not suitable for morphine at home then once the baby has needed no treatment for 48 hours, he/she can be discharged home and/ if all care issues have been addressed
- If a baby was at risk for withdrawal but does not meet threshold for morphine management they can be discharged after 5 days as long as all care issues have been addressed

Follow-up

- Babies who have required NSW treatment will attend the Wednesday morning clinic at Christchurch Women's Hospital Outpatients. Ask the NICU ward clerks to book the baby's appointment. It does not require an ERMS referral to POPD for an appointment in the same way as other outpatient referrals
- Referral to Early Start and Neurodevelopmental follow up is on a case by case basis (they will usually have been assessed by the physiotherapist and SLT)
- If Oranga Tamariki have been involved ensure the named social worker is included in documentation. The social worker involved will assist with the discharge letter information.
- A section on agreed engagement with the family will be included in the discharge letter.
- If maternal Hepatitis C status is positive, it should be checked at 18 months

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DOI: <https://doi.org/10.1542/hpeds.2017-0128>

❖ Babies of Mothers with Mental Illness

General considerations

- Mental illness combined with the stress of post-partum period may impair a mother's ability to comprehend or retain information and make decisions.
- Communicate with compassion and document clearly. Consider written information and ideally have a support person present when conveying complex or distressing information about their baby.
- Involve the father in discussions about the care of his infant however be mindful that there may be complex relationship issues, as well as legal and confidentiality issues.
- Babies of mothers with mental illness are more likely to have exposure to smoking, alcohol and substance misuse, poverty, social adversity and family violence so there may be care and protection considerations.
- Mothers with mental illness may struggle to bond with their infant and care should support the mother-infant relationship and minimise periods of separation.
- Encourage breastfeeding if no contraindications but support formula feeding or mixed feeding if it is the mother's informed decision or best way to protect maternal/infant wellbeing. Lack of sleep is a common precipitating factor for a relapse of severe psychiatric illness.

Birth care plans for women with complex needs

- Women living with complex mental illness will have a complex needs birth plan (usually completed by 32 weeks gestation). A copy is placed in a confidential folder in the locked Neonatal ACNM office and should be consulted if her infant needs neonatal assessment.
- A FloView notification and a psychosocial support plan sticker on the front sheet of a woman's notes alerts practitioners that the woman has a complex needs birth plan.

Birth Considerations

- The decision for place of birth in women with a history of mental illness will take into account factors such as the medicines a woman is on, her current mental state, any co-existing medical or obstetric conditions, the risk of a postnatal deterioration, and the support that is available at home.
- **Women with mild mental illness, on single medicines, and with an uncomplicated pregnancy can birth at a primary birthing unit or at home providing there is someone present who is trained in newborn life support** and that oxygen and an ambubag is available.
- Persistent Pulmonary Hypertension of the Newborn (PPHN) is a rare complication where the fetal circulation persists at birth and will present with cyanosis. The risk is slightly increased with maternal antidepressants. If the infant is delivered and given immediate skin to skin contact, it is important that the infant's colour and breathing is closely checked. If any concern oxygen should be administered, pulse oximetry checked, and the neonatal team called.
- **The Neonatal Team do not need to routinely attend the birth of infants exposed to psychotropic medicines unless there is concern about potential need for resuscitation**, e.g. Lithium exposed infants, compromised pregnancy, high dose medicines that can cause respiratory depression close to the time of birth, complex polypharmacy, or coexisting substance abuse. LMCs who are unsure whether neonatal attendance is advised can discuss this with the Neonatal Team.

Poor Neonatal Adaptation and Neonatal Withdrawal

See the section above

Babies Exposed to Lithium

- **Lithium has a narrow therapeutic index and requires close monitoring to avoid toxicity.**
- Lithium levels can fluctuate during pregnancy and at the time of birth.
- Lithium crosses the placenta freely. Babies exposed to Lithium *in utero* may be at mildly increased risk (data is conflicting) of Ebstein's anomaly or other cardiac defects (first trimester exposure) and **should have had a fetal anatomy scan.**
- Infant lithium levels are likely to be highest at birth and in the first 2 days. Some exposed infants exposed may be hypotonic and require initial breathing support after birth and the **Neonatal Team should be present at the birth.**
- **Infant's may be at risk of Lithium toxicity in the immediate postpartum if they become dehydrated.** Extra monitoring and support with feeding may be needed.
- Some infants exposed to high levels of Lithium may experience side effects immediately after birth such as hypotonia, lethargy, poor sucking, tachypnoea, tachycardia, respiratory distress syndrome, cyanosis, and rarely arrhythmias. **For this reason, it is recommended the Neonatal Team should do the 24hr check.**
- Infant Lithium levels should be measured after birth and close attention paid to preventing dehydration. The initial lithium level can be done on cord blood and then if 'high', or there is clinical concern, rechecked 24-48 hours later with a neonatal blood test. There is no consensus on what level should be considered 'high' for an infant. Any level associated with symptoms of lithium toxicity should be considered 'high'. The authors of this guide recommend rechecking a neonatal level on any infant with a cord blood level >0.5 .
- As lithium freely crosses the placenta levels completely equilibrate between mother and foetus. Therefore, the cord blood level is likely to be the highest serum level in the infant with lithium levels declining after birth even if there is exposure through breastmilk.
- If at any time there is concern an infant may be showing **signs of Lithium toxicity** (lethargy, hypotonia, poor feeding) a **Lithium level, electrolytes, and renal function should be checked.** Neonatal renal function should ideally be checked after 24 hours of age as an earlier creatinine tends to reflect maternal creatinine.
- As **Lithium can also affect thyroid function**, it is important to ensure exposed infants have their newborn screening test.

Breastfeeding is currently not recommended by Medsafe for women on Lithium

- Lithium is excreted into breast milk in variable amounts (up to 50%) and there is a risk of neonatal toxicity, particularly if the baby is unwell or premature or maternal levels are high.
- There is a paucity of data on long term outcomes however there is little evidence of harm.
- It is likely that the risk of high lithium levels and symptoms of toxicity occur predominantly within the first few days of life or in the context of ongoing exposure to high levels in breastmilk in an infant who is dehydrated.

- If a mother decides to breastfeed on Lithium the risks and uncertainties need to be carefully explained to the mother, and there needs to be careful clinical oversight by a Perinatal Mental Health Team with infant blood monitoring.
- In Christchurch we recommend blood tests on cord blood, day 2, and day 7 and then 3 monthly while breastfeeding for Lithium level, urea, creatinine, electrolytes. Thyroid function should be checked on newborn screening test and at 3 and 6 months.
- Additional lithium testing should be done if baby becomes unwell or if maternal levels are high, and considered if maternal dose is increased (allow 5 days before testing for steady state drug level to be reached).
- An initial feed with colostrum can be offered if the mother wishes
- If baby stops breastfeeding or is predominantly formula milk fed, then this monitoring is not needed.
- If the baby is mixed feeding (formula/solids) and levels have been low discontinuation of monitoring can be considered.
- It is important to emphasise that this monitoring does not guarantee the infant will not suffer adverse effects.

Lithium level <0.6	Lithium level 0.6-1.2	Lithium level >1.2
<ul style="list-style-type: none"> - support demand feeding - do not allow baby to go > 4 hours without a feed 	<ul style="list-style-type: none"> - ensure adequate hydration - support feeding - do not allow baby to go > 3 hours without a feed - monitor lithium levels - check renal function 	<ul style="list-style-type: none"> - consider admission to neonatal unit for cardiorespiratory monitoring - support hydration - monitor lithium levels - check renal and thyroid function

KEY POINTS

1. Neonatal team to attend delivery of all babies of mothers on lithium
2. Cord blood to be taken for lithium level in all exposed infants (neonatal team to review result)
3. Close observation of baby after birth with feeding support to avoid dehydration
4. Neonatal team to do 24 hour check (including pulse oximetry check due to increased risk of cardiac defects).
4. Breastfeeding not recommended. If mother chooses to do so blood test monitoring of baby required.

Additional Resources:

New Zealand Formulary (www.nzf.org.nz)

Medsafe (www.medsafe.govt.nz)

Bumps (www.medicinesinpregnancy.org)

MotherToBaby (www.mothersandbabies.org)

Lactmed (<https://toxnet.nlm.nih.gov/newtoxnet/lactmed.htm>)

You can also contact the Mothers and Babies Service Liaison Paediatrician for advice and the Hospital Drug Information Service. There is also a Health Pathways Guideline – Mental Health Medications: Pregnancy and Breastfeeding June 2023

❖ BABIES < 32 or < 1500GM BIRTH WEIGHT GUIDE

AGE	ACTION
Day 1	Attach baby name label to transfusion form (Ref.2404015) Start vitamins IV with lipid
Day 2	Parents receive information regarding Probiotics Start Probiotics the day after birth
Day 3-5	US Head (scan earlier only if directed to by the SMO) Check Phosphate Day 3 and 5 for refeeding syndrome – treat if <1.8 mmol/L
Day 7	Start oral Vitamin A and Vitamin D for all and Micelle E (if <1250g or <30wks) when lipid stops US head routine D 7-10 Parents receive information regarding HMF Check Phosphate for refeeding syndrome – treat if <1.8mmol/L Start Folic acid if <1500g and will not receive HMF long term
Day 14	US head if significant abnormalities on 1 st scan(s) Check Phosphate for refeeding syndrome – treat if <1.8mmol/L
Day 28	1 st eye exam due if 26-29 ⁺⁶ weeks at birth Start Iron (check drug profile for exclusions) Vitamin D level if <28 weeks at birth and repeat 2 weekly if deficient US head if significant abnormalities on earlier scan(s)
Day 42	1 st eye exam due if <26 weeks at birth US head 1 st vaccine (discuss with consultant) not weight dependent Review need to start Fe if not already done so
34 weeks	Vitamin D level if <28 weeks (if not already having 2 weekly levels due to deficiency)
>36 weeks gestation	Full examination including hips and eyes (if no ROP check) Review nutrition with dietitian Review Probiotics at 36 weeks Stop Vitamin A if off respiratory support Review medications for discharge Repeat Gurthrie card Lung function SHIFT test if born <28 weeks Late head US if < 28 weeks gestation - discuss timing with SMO Review if an echo is required before discharge

❖ TUBES FOR LAB TESTS

- Intranet/Divisions/Canterbury Health Lab/Testing information will provide you with the blood volume and tube required for all tests done at Canterbury Health Labs
- Green tube = Lithium heparinised
- Pink tube = EDTA
- Red tube = Plain tube

BLOOD TEST	VOLUME	TUBE	COMMENTS	LAB	TESTED
Amikacin levels	0.6mL	Red – gel free		80397	Daily
Amino acids	0.6ml	Green or Red	On ice	80118	Mon-Fri
Ammonia	0.6ml	Pink	On ice	80397	Daily
Caffeine level	0.5ml	Call the lab to send over a Paediatric size non-gel green tube		80322	Tues and Fri
Chromosomes	0.6ml	Green		80881	Mon-Fri
Chrom. microarray	1-2ml	Pink – 2 full tubes minimum	Do not send if clotted Write clinical details	80881	Mon-Fri
Cortisol	0.6ml	Pink, Green, Red		80888	Daily
CRP	0.6ml	Green		80397	Daily
Cystic Fibrosis screen	0.5ml	Pink		80548	Mon-Fri
Full Blood Count	0.25ml	Pink		80373	Daily
Ferritin	0.6ml	Green or Red		80397	Daily
Gentamicin level	0.25ml	Green		80397	Daily
Group and Coombs	0.25ml	Pink		80375	Daily
Group and Hold	0.25ml	Pink	Handwrite label	80310	Daily
Immunoglobulin	0.4ml	Green, Red, Pink		80334	3 x week
JAUN screen	0.6ml	Green		80397	Daily
Lactate:Pyruvate	1ml	Special tube	Call 89761 for tube	80118	Mon-Fri
NEON	0.6ml	Green		80397	Daily
Phenobarbitone	0.6ml	Green		80397	Daily
Phenytoin	0.6ml	Green		80397	Daily
TSH/T4 at Biochem	0.6ml	Green or Red		80397	Daily
Vancomycin	0.6ml	Green		80397	Daily
Vitamin A and E	0.5ml	Red, Green, Pink	Protect from light	80332	Fortnightly
Vitamin D	0.6ml	Red	Changed from green top March 2023	80397	Daily
Zinc – needs to be separated within 4 hrs so do not send after hours	1ml	Green		80317	Mon-Fri

❖ RADIOLOGY

NICU Radiology Ordering and Reporting

- A Paediatric Radiologist SMO is available at all times to review films Monday – Friday 0800 to 1700, then they are on call. Contact them via the operators.
- NICU has a priority Xray (Chest and Abdomen) service from a radiographer Monday to Friday 0800-1630. Contact on Pager 5082 for urgent xrays after submitting an electronic order on HCS.
- After 1630 weekdays and on weekends/public holidays contact Pager 8937 after submitting the electronic order. The radiographer comes across from Chch Hospital.
- If the pager is not being answered call 80777 for Chch Radiology or 81854 for ED Radiology for assistance.
- The NICU SMO must be advised when xrays are taken so they can review the films. Ideally this should be electronically by Inteleviewer in hospital or remotely. The NICU SMO must have reviewed the films prior to requesting
- After hours the Radiology registrar can be asked to review the film. They have varying experience and so direct referral to the Paediatric Radiologist SMO is appropriate and preferably by the NICU SMO if able.
- Out of hours and weekend radiology for other investigations such as US, contrast studies, MRI
 - Consider the highest level of urgency when requesting the test on HCS and follow-up with a phone call. Discuss the timing with the Paediatric Radiology SMO, especially if the Paediatric surgeon also needs to assess eg: upper GI contrast study.
- For further information on radiology reporting of UVC/UAC/Longlines please refer to the Procedures section of the Handbook

Electronic Radiology Ordering

Refer to documents on **G:drive/NIC/Neonatal Handbook/Other Guidelines/Electronic Radiology** for more detailed information

Principles

- The only time when a paper form can be used is when a baby needs an urgent XRay prior to being allocated an NHI or if the systems are down
- All results will come through electronically even if ordered on paper
- Reg/CNS/NNP to sign off radiology results only for inpatients they are directly caring for
- **Inpatient** ordering should be **linked to the current inpatient encounter**
- **Outpatient** ordering should be done **without an encounter** as it does not relate to the current admission
- When ordering inpatient tests change the **responsible clinician to the NICU SMO on-service** so that the report goes to them for viewing ± sign off
- No radiology should be ordered with the LMC as the responsible clinician
- Any outpatient results need to be left for the SMO to view, act on and sign off
- **Renal** investigations – **Ruth Sinclair must always be the responsible clinician**, add maternal NHI to the form for ease of reviewing antenatal scans
- **Hip US** – **Matthew Wallenstein must always be the responsible clinician**
- If you need to add any information free text in the “Other Booking Information” section
-

Approval For Radiology Requests and Sign Off

NICU service	RMO	CNS-ANP or NNP	SMO
PLAIN XRAYS			
Chest radiograph with lateral view	Request and Sign off	Request and Sign off	Request and Sign off
Abdominal xray with lateral or decubitus view	Request and Sign off	Request and Sign off	Request and Sign off
Skeletal survey	Request after consultation with SMO and Sign off	Request after consultation with SMO and Sign off	Request and Sign off
Skull XRay	Request after consultation with SMO and Sign off	Request after consultation with SMO and Sign off	Request and Sign off

NICU service	RMO	CNS-ANP or NNP	SMO
ULTRASOUND			
Head Ultrasound	Request and Sign off	Request and Sign off	Request and Sign off
Renal US Outpatient	Request	Request	Request and Sign off
Hip US Outpatient	Request	Request	Request and Sign off
Abdominal US Renal US Inpatient	Request after consultation with SMO and Sign off	Request after consultation with SMO	Request and Sign off
Spine US	Request after consultation with SMO and Sign off	Request after consultation with SMO and Sign off	Request and Sign off
US cysts/lumps/collection joints/thyroid	Request after consultation with SMO and Sign off	Request after consultation with SMO and Sign off	Request and Sign off
Heart	Request on paper radiology form	Request on paper radiology form	Request and Sign off
INTERVENTION TESTS			
Barium swallow, small bowel follow-through or barium enema	Request after consultation with SMO and Sign off	Request after consultation with SMO and Sign off	Request and Sign off
Micturating cystourethrogram	Request after consultation with SMO	Request after consultation with SMO	Request and Sign off
NEUROIMAGING			
CT	Request after consultation with SMO	Request after consultation with SMO	Request and Sign off
MRI	Request after consultation with SMO	Request after consultation with SMO	Request and Sign off
NUCLEAR MEDICINE			
Nuclear medicine tests	Request after consultation with SMO	Request after consultation with SMO	Request and Sign off

❖ DISCHARGE, OUTREACH, REFERRALS AND FOLLOW-UP

DISCHARGE LETTERS

- Discharge summaries are needed for every baby and are completed on Health Connect South
- There are 2 discharge letter formats – complex and non-complex
- An interim letter for babies who have lengthy stays on the unit should be typed by the level 3 or 2 registrar. These babies will be <28 weeks or have had a complicated course and discharge is not expected for wks
- Most babies only need 5 copies printed
- Copies of letters should go to:
 - GP – majority will be sent electronically but HCS will state if this needs to be printed and posted
 - LMC – paper copy externally posted by ward clerk
 - Parents – paper copy hand delivered at discharge
 - Outreach Nurses – paper copy filed in their folder at discharge
 - Well Child Provider – paper copy filed in a folder at discharge and Outreach deliver them
 - File copy – paper copy filed
 - Other specialties eg: Fetal Medicine, Obstetrician, Surgeon, Neurosurgeon, Genetics etc depending on their involvement and follow-up of the patient. Paper copy to be internally posted

CHRISTCHURCH HOSPITAL PAEDIATRIC OUTPATIENT CLINIC

Babies followed up by a **designated Neonatal Paediatrician** at 6 weeks after discharge unless stated otherwise in the multidisciplinary care plan.

- All babies <32 weeks
- All babies <1500g at birth
- Some babies ≥ 32 weeks on home caffeine (refer to respiratory section)
- Home oxygen
- Seizures or abnormal neurology
- Grade 2 or 3 Hypoxic Ischaemic Encephalopathy
- Congenital abnormalities
- Syndromes
- Congenital infection (ie: toxoplasma, CMV)
- Cardiac conditions – including a patent PDA at discharge
- Metabolic conditions
- Endocrine conditions
- Erbs palsy not recovered
- **Or any baby at the lead SMO's discretion**

REFERRALS FOR INPATIENT REVIEW

For the team to know that a referral request has been actioned there needs to be written evidence in the notes under the Communication tab. This may be done by filing the:

Yellow consult sheet, or
Email correspondence

- Orthopaedics - paediatricorthopaedic@cdhb.health.nz
- Orthopaedics for Hip dysplasia only – ddh@cdhb.health.nz
- ENT – ENT.outpatients@cdhb.health.nz
- Plastics - plastics.secretaries@cdhb.health.nz
- Craniofacial, Charles Davis (Wellington) – info@craniofacialsurgery.co.nz
- Ophthalmology – eye.service@cdhb.health.nz
- Paediatric Surgery - paedadmin@cdhb.health.nz
- Genetics - genetic.servicenz@cdhb.health.nz
- Cleft coordinator – michelle.shand@cdhb.health.nz
- SLT – paediatricSLTs@cdhb.health.nz
- Paediatric Anaesthetists - paedanaesth@cdhb.health.nz to email the Neonatal and Anaesthesia Handover form for planned surgeries

ARRANGING OUTPATIENT FOLLOW-UP

- It is the responsibility of the Reg/CNS/NNP/SMO to ensure that a follow-up appointment has been requested via HCS. Open the icon below for information on setting up and requesting outpatient clinic follow-up. If there are any set-up issues contact service.desk@cdhb.health.nz



**HCS Outpatient
Referrals**

- Please document on the Multicare Plan that a referral was sent and when
- On HCS we now have visibility of: the referrals you have made, if they are accepted and what clinics are waitlisted or booked which is extra reassurance that the referral has been received and acted upon

Appointments for Paediatric Clinics held in Paediatric Outpatients – Chch or Ashburton

eg: Neonatal, Endocrine, Cardiology, Neurology, Gastroenterology, Renal, Infectious diseases, Haematology, Respiratory, Metabolic, General Paediatrics, Craniofacial, Paediatric Surgery

- Open the Referrals tab and Create Outpatient Referral
- Select **Canterbury DHB**
- Service – type in **Paediatric Medicine** or **Specialist Paediatric Surgery**
- Referral type – choose clinic assessment for clinic review but there are other options
- Routine Referrer Priority – will be scheduled when space is available in your clinic (ie: may be later)
- Routine Referrer Semi-urgent/urgent - nondeferrable and will be scheduled within the requested time frame
- Encounter – choose the current inpatient encounter
- Reason for Referral – this is where you free text the reason for referral, who the patient is being referred to (specific SMO or it can be a team if it is not SMO specific) and the timeframe
- There is the option of being able to attach a pdf document as well such as a discharge letter

Clinic admin will receive the referral and allocate it to the referred SMO

This will be visible on the SMO's HCS homepage under the Referrals heading

SMO will review the referral and triage it.

The SMO can add specific information as to when they want to see the patient, if they need bloods at the time or a scan arranged or even to schedule them as the last patient in case they DNA.

Clinic admin will then waitlist the patient as requested

Appointments for Clinics held in Christchurch but outside Paediatric Outpatients

- eg: Orthopaedics, Ophthalmology, Plastics, ENT, Dermatology, Dental, Neurosurgery
Same process as above but you will have to ensure you search for the correct specialty under Service
- For **Genetics** continue to use the genetics email genetic.servicenz@cdhb.health.nz

Appointments for Clinics held in Greymouth

- Open the Referrals tab and Create Outpatient Referral
- Select **West Coast DHB**
- Service – type in **Paediatric Medicine**
- Referral type – choose clinic assessment for clinic review

Appointments for Nga Taonga Pepi Clinic (NSW) held at Chch Women's Hospital Outpatients

- Ask the NICU Ward Clerks to book the baby into the next Wed morning clinic and if any question discuss with the Neonatal Outreach nurses

Referrals From Neonatal Follow-up Clinic to another Specialty (mainly for SMO's)

- If it is a short referral then the process is the same as above, ensure you choose the appropriate service. This removes the need for a referral letter to be dictated, typed, signed off then sent.
- If it is more complex and a dictated letter is required (this should be done if the Neonatologists are referring a patient on to Paediatrics for ongoing care) then the letter needs to be dictated, typed, put into pdf format by admin and emailed back to the SMO. The SMO then needs to follow the outpatient referral process as already outlined and attach the pdf document. Note: the dictated letter will not be sent by admin as there is no visibility of the process doing it this way

NEONATAL OUTREACH

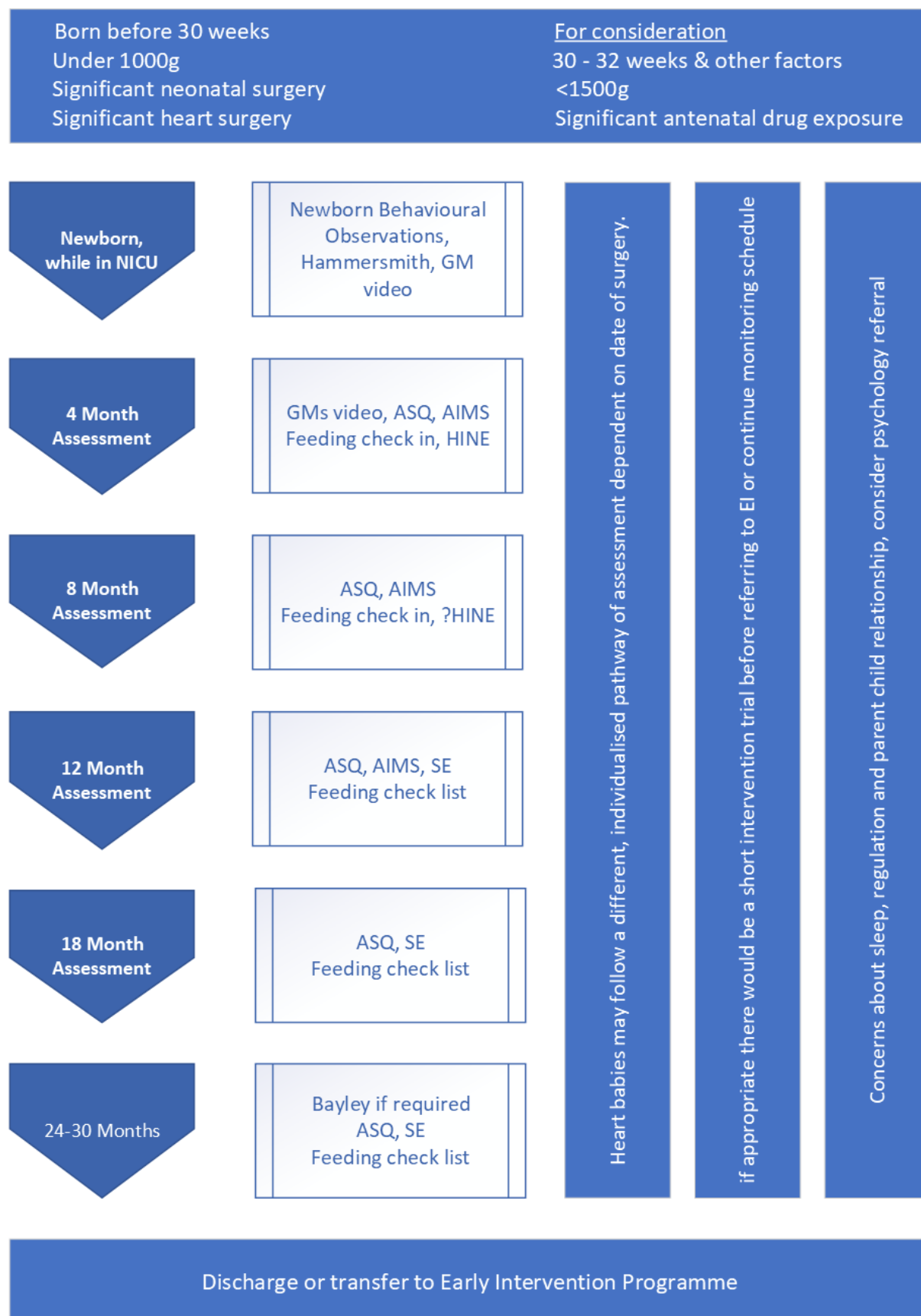
Criteria for referral:

1. Babies <34 weeks at birth
 2. Babies <2300g at discharge
 3. Complex babies eg: home oxygen, long term enteral feeding, genetic conditions, cleft palates
 4. Discharge on Tubes (DOTS) programme
 5. Babies with Neonatal Substance Withdrawal
 6. Babies discharged on caffeine
 7. Babies on caloric supplements
- The area that the Neonatal Outreach team cover ranges from Amberley down to Ashburton and inland to Darfield
 - The area covered for the DOTS programme is the Greater Christchurch area only
 - Babies and families will either be seen
 - at clinics based in areas such as – Amberley, Rangiora, Rolleston, Central Chch, Ashburton
 - at home
 - this will be individualised for the family and the care they require
 - the frequency and length of outreach provided will also be individualised
 - Neonatal Outreach will transfer some babies to Childrens Outreach at an appropriate time

DEVELOPMENTAL FOLLOW-UP

- Babies < 30 weeks and/or <1000g and/or following significant neonatal or heart surgery (not GA dependent) and considered “at risk” of developmental disability can be referred for **Assessment and Monitoring**.
- Babies 30 – 32 weeks and/or <1500g plus other “at risk” factors should also be considered for **Assessment and Monitoring**. Other factors may include:
 - Significant antenatal drug exposure
- Babies < 30 weeks and/or <1000g and/or following significant neonatal or heart surgery with signs of developmental disability prior to discharge can be referred for **Early Intervention (EI)**
- Babies ≥ 30 week with identified developmental disability or deemed at high risk can be referred for **Early Intervention. For example:**
 - Chromosomal abnormalities or syndromal diagnoses
 - Grade 2/3 HIE
 - Neurological abnormalities i.e. severe IVH, MCA infarct, hydrocephalus, seizures
 - Complex surgical babies i.e. diaphragmatic hernia, oesophageal atresia/fistula, gastroschisis.
- All babies who have spent time in NICU will be offered Little Miracles support group which includes neonatal physiotherapist twice a term.
- A decision is made by the time of the MDT discharge planning meeting based on the clinical course, head ultrasound/MRI results and physiotherapy assessments. This is to be documented on the multi-care pathway.
- Services are provided by 5 services, with the Child Development Service working in conjunction with the Ministry of Education for EI.
- Each service is set up differently, but most services have core staff in a role, or contract out to other services as required for the following therapists:
Physiotherapist, Conductor (for Conductive Education) Occupational Therapist, Speech Language Therapist, Social Worker, Family Support Worker, Kaiwhakapuawai, Psychology, Early Intervention Teacher, Education Support Worker
- All providers support whānau in a range of settings in their local community, including Early Childhood Centres, but most of the service delivery is as follows:
 - Champion Centre – Centre based service (Burwood).
 - CCS Disability Action – Home and community-based service
 - Conductive Education Canterbury – Centre based service (Addington)
 - Child Development Service – Home, early childhood centre and clinic-based service
 - Ministry of Education – Home and early childhood centre based service

Assessment and Monitoring Pathway for Infants at Risk of Developmental Disability (Early Intervention Children follow a different pathway)



❖ CHILD DISABILITY ALLOWANCE ELIGIBILITY

The Child Disability Allowance is a non-taxable payment made to the main carer of a child with a serious disability in recognition of the extra care required.

The child must require constant care and attention for at least 12 months because of their disability over and above that of a child of a similar age.

Medical practitioners completing these forms are randomly audited to ensure practice meets these guidelines.

For consistency for our patients the list below explains what conditions make the baby eligible for a child disability allowance. There will be conditions that occur rarely that will not be on this list.

- Syndromes with life-long disability eg: Trisomy 21, chromosomal abnormalities, spina bifida
- Cleft palate, tracheostomy, nasopharyngeal airway
- Chronic renal failure
- Discharged on home oxygen and enteral feeds by nasogastric or gastrostomy
- Home TPN
- Discharged on home oxygen alone for chronic lung disease of prematurity or known pulmonary hypoplasia for example in association with congenital diaphragmatic hernia.
- Major brain anomalies eg: hydrocephalus, migrational disorders, significant bleeding or clots, Grade 2 or 3 HIE with abnormal MRI findings with the expectation of ongoing disability
- Complex heart disease or in heart failure eg: Tetralogy of Fallot, Transposition, left or right heart hypoplasia, need for surgery in the first year of life
- Chronic skin conditions eg: epidermolysis bullosa, ichthyosis
- Severe musculoskeletal conditions eg: Larsen syndrome, severe contractures limiting mobility

Babies that are not eligible for a child disability allowance include:

- Short-term nasogastric feeding at home
- Short-term oxygen after meconium aspiration
- Uncomplicated small membranous or muscular VSD's
- High health needs are expected to improve before a year of age
- Referral to Early Intervention alone is insufficient
- Being born preterm is not a criteria - there need to be additional health needs lasting more than 12 months

❖ DRUG PRESCRIBING

- All medications in the unit should be prescribed in a consistent manner to avoid errors in dosing and administration.
- The following format is the preferred prescribing for all drugs and those where the dose is calculated from a formula mg/kg/day.
- If there is a dilution required different to the stock issued by pharmacy this should be documented.
 - Date and Time of Charting
 - Working weight documented
 - Drug NAME in CAPITALS
 - Indication for the drug
 - Concentration eg: (mg/ml)
 - Dose eg: (mg/kg/day)
 - Dose in mg
 - Frequency
 - Specify time period if it is an infusion eg: over 30 minutes
 - If the drug is infused through a pump with guardrail limits then the dose/kg/time period ie: mg/kg/hr, mcg/kg/hr, mcg/kg/min etc is also required (see drug protocols)
 - Prescribers NAME in CAPITALS

Discharge Prescriptions

- These can be generated in Health Connect South with the discharge letter and preferably electronically sent to the pharmacy or alternatively be printed off.
- Some drugs and formulas need Special authority numbers from the Health Benefits centre before a long term prescription can be continued. If in doubt ask the pharmacists.
- Most consultants have access to on-line approval of special authority numbers so there does not always need to be a delay in prescribing
- Dietitians now can obtain special authority numbers for nutritional supplements and arrange the prescriptions
- At the weekly sit down ward round on Thursday discharge planning issues should be undertaken – this realistically begins on moving to level 2. The discharge facilitator or dietitian will indicate when this needs to be done.
- The most common discharge medications are Vitamin D and Ferrous sulphate (from 4 weeks postnatal age, if breast fed). Copies of parent information sheets can be printed off to be handed to the parents at discharge. Do a script for 3 months.
- Micelle E (continued in CF or cholestasis), folate and Zinc are usually stopped at discharge.
- If the baby will be on complicated or multiple medications ask the pharmacist to meet with the parents before discharge to review details and give the parents a medication yellow card.

Electronic Prescriptions

- These are the preferred method for prescriptions from July 2020.
- A paper copy does not need to be sent to the pharmacy with the exception of scripts for Class C controlled drugs (codeine and benzodiazepines).
- Morphine still needs to be prescribed in triplicate on paper
- Caffeine still needs to be on paper

Preparation

1. Register with ERMS Online by going to <https://erms.health.nz>
2. Click Enter
3. Click Forgot Password
4. Enter your username which is your CDHB Username followed by .cdhb
5. Set a password
6. Keep a note of your password safely somewhere as it will be a complicated one
7. Do this now so you don't have to do it later when you are trying to discharge someone.
8. In HCS - click on User Settings and enter your MCNZ number/Nurse Practitioner number if it is not entered and update preferences

Prescription

1. Arrange with the patient which pharmacy they want to collect their medications from
2. Choose the Canterbury pharmacy from the drop-down menu
3. If the pharmacy is not in Canterbury (covers Chch, Ashburton) or the West Coast then the options are to print the script and give it to the parents or email the script to the out of area pharmacy
4. Enter the medicines on the prescription (the Supply box must be ticked) and click Finish

❖ MULTIDISCIPLINARY CARE PLAN (MCP)

- Multidisciplinary Care Plan replaces the Multidisciplinary Care Pathways that was introduced to the Neonatal Service in March 1999. It is a tool to assist the entire neonatal team with the holistic management of infants and families within the Neonatal Service.
- All infants are commenced on the MCP on admission
- The MCP is designed to be continued throughout the infant's stay in the Neonatal Service, and all disciplines are encouraged to continue their contribution until discharge.
- The plan provides an overview of care received, a record of referrals, a summation of assessments and results, and is also a prompt for management of clinical care and discharge planning.
- It is divided into 5 sections: Admission, Parental Information/Teaching, Clinical Care, Referrals and Assessments, Discharge Planning.
- Clinic follow-up plans can and should be documented on the last page and can be referred to when completing the discharge letter to ensure the baby gets seen at the right clinic in the right timeframe
- The MCP is easy to complete, a date and signature against the relevant information when the task has been completed is all that is requested in most cases.
- Of particular note for medical clinicians are sections within clinical care. Setting of parameters such as oxygen saturations and blood pressure mean are within this section as is the checklist for Babies < 32 weeks or < 1500gms
- Documentation in both the clinical notes and on the MCP may still be required in some instances. For example, expansion on discussion in Multidisciplinary meetings or results of infant assessments. Documentation in the MCP allows people to locate more quickly within the clinical notes details of these.
- Try not to be offended if nursing staff remind you of your duty to complete the MCP. They have been asked to do this.
- Documentation is very important. "If it has not been signed – it has not been done" is the presumption

❖ TRANSFERS AND RETRIEVALS

TRANSFER OF NICU PATIENTS TO PAEDIATRICS

Long Term Complex Patients

Transfer required either to Paeds ward for ongoing care, or, baby will be discharged from NICU but likely to have frequent admissions and needs a lead paediatrician – general / subspecialty

Aim to facilitate comprehensive transfer by:

- Each baby will need individualised plan
- If needs subspecialist alone – lead NICU SMO to discuss with relevant SMO
- If needs lead general paediatrician - discuss with Tom Townend (TT will discuss with the Paediatric team for allocating) and will communicate back to lead NICU SMO

For transfer to Paediatric ward

- Outstanding investigations completed / upcoming surgery completed / not requiring level 3 care - clear that Paeds can provide level of care baby needs
- Hold professionals MDT with lead Neonatologist and Paediatrician present along with nursing, social work, etc outlining reason for transfer, medical needs, follow up care required before discharge to Ward A7/High care
- Need detailed handover of social situation (includes Maori health worker if involved).
- Physiotherapy handover to Play therapy team and referral to early intervention completed by the neonatal team if required.
- New lead Paediatric SMO to meet with parents in NICU with appropriate NICU staff
- Detailed NICU discharge summary at time of transfer, including social situation
- Neonatologist hands over care completely at time of transfer but remains available for any queries

For transfer of care as outpatient

- as above without elements that relate to ward transfer
- Professional meeting held as above.
- Lead Paediatric SMO meets the family before discharge and becomes responsible for Neonatal outreach calls
- All follow up requirements eg Early intervention will be made and documented.

Complex babies being discharged from NICU will receive an Acute Care Plan and tour of CEC and the Children's ward as part of discharge planning.

Outreach involvement will be determined for each baby – for those being discharged home from NICU, neonatal outreach will be provided with planned transfer to Paediatric Outreach in line with usual practice.

Transfer when NICU Over Capacity

“Rapid” transfer if NICU is full and there is a need to transfer **agreed** babies to Paediatric ward. Discussion must first be with Neonatal SMO (on service) and Paediatric medical SMO (on call) and nursing staff/charge nurse A7

- Target late preterm and term gestation, NG feeding, not complex and discharge anticipated in at least 5-7 days' time.
- ACNM identifies suitable babies in discussion with the NICU SMO and discharge facilitator.
- ACNM initiates discussion with CNM A7 on 021583784 Mon-Fri, or afterhours Nurse in Charge A7 0275410741 (and the after hours Clinical Nurse Coordinator Mon-Fri after 1530 and weekends 021939893)
- Medical handover (including social situation), NICU SMO (either L3 or L2) to acute Paediatric SMO of the day of transfer.
 - Detailed discharge summary is completed and finalised on HCS at the time of transfer
 - Physical transfer of babies must occur in the morning to allow admission by medical staff in Paediatrics
- Bedside nursing handover at the time of transfer.
 - Monitoring requirements recorded for each baby e.g. continued monitoring for 7 days after caffeine has stopped, frequency of observations (usual 6 hourly in well level 2 baby). Rad 7 Monitors will be appropriate in this situation.

- A7 will record observations on patient track as well as the NICU level 2 Observation chart for recording breast feeding and weaning oxygen under 0.1L/min.
- Growth chart to accompany the baby.
- Note if a car seat trial is required.
- Medication review and supply of all medications at transfer with the patient.
- On arrival Paediatric registrar will admit into Cortex under the Paed SMO of the day and enter medications on Medchart.
- Care will be completely transferred to the Paediatric SMO but the Neonatal SMO will be available for any queries
- Infant feeding team notified if continued feeding support likely to be required. A7 nurse can contact Infant feeding support according to ward round review.
- Discharge facilitator team leader is informed of the transfer so that usual follow-up by neonatal outreach can be noted and arranged.
 - WCTO provider form will be disseminated when the baby's notes return
 - If Home education needed Discharge facilitator will co-ordinate.
 - Eg CPR, Blue card, NG insertion teaching.

BACK TRANSFERS

- Most of our back transfers are for babies who live on the West Coast or Timaru and they require nurse escort for admission to their local hospital for ongoing care.
 - Most babies from the West Coast will discharge straight home but if they are being admitted to Grey Base Hospital they will have a medical flight back transfer prior to discharge home
 - Most babies from Timaru will have an ambulance transfer back to Timaru hospital prior to discharge home
- Families of babies born <30 weeks or <1250g need to be advised early in the admission that consideration for back transfer can only occur after the ROP screens are completed at around 38-40 weeks. Note that occasionally a baby in Timaru may be able to have their last check locally if the Chch Ophthalmologists are in agreement and there is an Ophthalmologist in Timaru at the appropriate time to complete the check.

Criteria For An Escorted Back Transfer

- The need for ongoing hospital care prior to discharge
- Prematurity <37 weeks corrected gestation
- History of respiratory issues (excluding brief support for TTN/delayed postnatal transition)
- PPHN
- Chronic lung disease
- On oxygen
- On NG feeds
- On iv medications
- After major surgery
- The need to link in with local services for support and follow-up
- By road if <3 hrs but flight preferred if >3hrs travel time

Timaru Transfers

- Timaru is staffed by Paediatricians and nurses
- Timaru has speech language therapists who work across adult and paediatric caseloads. They are not primarily paediatric speech language therapists with neonatal expertise
- Timaru can accept:
 - Timaru ≥ 34 weeks
 - Babies on NG feeds who have been assessed by the infant feeding team (lactation consultant/CNS neonatal infant feeding and/or speech language therapist) in Christchurch and are felt to be safe to feed but lack stamina or have an established and reviewed feeding plan in place with a pathway of how to progress
 - Low flow oxygen but no higher levels of respiratory support
 - Babies on caffeine with a plan of when and how to wean

West Coast Transfers/Discharges

Staffing

- Greymouth has a maternity ward with midwives (Midwife Manager – Dawn Kremers) and Rural Health Specialists who provide medical oversight and rotate on a daily basis and so do not oversee an inpatient for a “whole admission”
- Greymouth does not have a dedicated, staffed Paediatric Ward with Paediatric nurses or Paediatrician onsite cover
- There is no Child Development Service or Paediatric Outreach nurse role
- Services required for any baby transferring to Greymouth or being discharged to the West Coast need to be individualised as per the community supports available at the time
- The NICU Discharge team and Outreach nurses can be a resource to help with arranging consumables and equipment if a baby is nasogastrically feeding at home if there is not an available person able to do that locally.
- The NICU Outreach Nurses can be a point of contact for advice on progressing oral feeding if required.

Inpatient Transfers To Greymouth Hospital

- This would be for individualised circumstances only and after discussion and acceptance by the local team (Midwifery and Rural Health Specialists) before the possibility is raised with families
- Need to be <6 weeks old to be within midwifery scope
- They can help with short-term transition to breastfeeding from nasogastric feeding in well babies without comorbidities but it is outside their scope to support transitioning to oral feeding for older patients after a longer NICU admission.
- Greymouth has a speech language therapist who work across adult and paediatric caseloads. They are not primarily paediatric speech language therapists with neonatal expertise
- A transfer to Grey as a step to home to sort out community supports is not really viable and if they are ready for home then this should be set up from NICU
- There needs to be a very clear discharge letter with the diagnosis and the plan for the local team and what they specifically need to do
- The baby is admitted under the Rural Health Specialists and not the visiting Paediatricians (John Garrett or Wendy Miller)
- The Paediatricians (if required) will pick up the patient in the outpatient clinic

Discharge Directly Home

- Ashburton and Kaikoura do not have local services so babies will need to be well enough to be driven home with their family when they are discharged home
- It is uncommon to have a baby from the West Coast or Timaru drive home, however, babies born at term or near-term who are ready for discharge can be driven home in a car seat with adult supervision and advice on the need for regular breaks.
- A car seat trial may be helpful to assess their stability for the car ride, especially if still <37 weeks corrected
- Take into consideration the length of the trip and whether a medical flight and hospital admission or commercial flight to home is warranted due to the travel distance alone
- A commercial flight is reserved for babies who have no requirement for admission to their local hospital the travel time by road is felt to be too long or if there are logistical issues with the family's ability to have car transport.

Associated Document Links: [ACNM Back Transport Coordination Initiating Back Transport of a Neonate](#) [Nurse Checklist for Back Transfer](#)

RETRIEVALS

The [Transport Handbook](#) contains all the information required for neonatal retrievals in one place

- Transport team composition
- Catchment area
- Clinical Guidelines
- Processes – [Initial Phone Call Checklist](#) [Retrieval Processes](#)
- Modes of transport
- Triaging urgency of transports
- Transport equipment