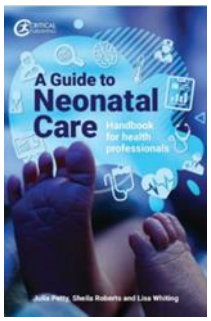
Chapter 11 Important practices in the neonatal intensive care unit



A Guide to Neonatal Care - Handbook for Health Professionals
Petty J, Whiting L and Roberts S (2024) Critical Publishing

Supplementary information

Neonatal resuscitation

Refer to book chapter 11 for information on newborn resuscitation and an overview of various topics relevant to the neonatal intensive care unit, namely ventilation strategies (including continuous positive airway pressure), blood values and taking / giving blood, blood gas analysis, cardiovascular care (including blood pressure monitoring) and drug administration. The web companion adds further detail to this content.

Resuscitation of the newborn

Ensuring a safe and patent airway and adequate breathing thereafter is an essential priority in any area of health care. Strategies may be required for managing the airway in the event of the neonate being unable to do so themselves. A standardised approach is necessary {see the newborn life support [NLS] guidance link below] for any resuscitation using a structured method to guide practice. The order of the algorithm is very important and re-assessment for a response (increase in heart rate and visible chest movement) after each stage or intervention is essential in order to move on through the algorithm.

EXTRA READING

Read the Newborn resuscitation and support of transition of infants at birth Guidelines (2021) for a full summary of how to support the transition and resuscitate newborns, including the full algorithm that can be downloaded.

Preparing for resuscitation in neonatal care

Anyone who could potentially need to care for a neonate requiring resuscitation should be familiar with their own emergency trolley or Resuscitaire®. The table below presents what should be available on a Resuscitaire® and /or emergency trolley. Preparation and equipment checking [Figure 11.1] in resuscitation practice is essential at least on a daily basis to ensure readiness for emergency and unexpected events.

Figure 11.1 Resuscitation equipment

- Attached to air/oxygen blender and gas source*
- Power source on* Overhead heater* Stop clock*
- T-piece connector and tubing connected to pressurised gas source, preferably with valve to give positive pressure ('PEEP' valve) *
- Bag-mask valve (BVM) (for manual ventilation)
- 2 towels.
- Stethoscope.
- Face masks.
- Suction catheters (wide bore: minimum 10fr)
- Laryngoscope with infant straight blade.
- Airway adjuncts (e.g., iGels).
- Sterile endotracheal tubes (ETT) (2.5, 3.0, 3.5, 4.0 of each size)
- Sterile cord scissors and umbilical clamp.
- Magills forceps Introducer(s) ETT fixators. Scissors.
- Hats of varying sizes
- Plastic bags or sheets (for preterm neonate)
- Umbilical venous catheters and umbilical catheterisation pack Sutures
- Emergency drugs: Adrenaline 1:10,000, Sodium Bicarbonate 4.2%, Dextrose 10%.
- 0.9% saline for flushing drugs.
- Syringes and needles.
- 20g cannula.
- Nasogastric tubes
- Chest drainage equipment (Heimlich valve).
- Non-sterile gloves

***Note: Items marked * are relevant to the Resuscitaire® only**

Stop and think

Remember ABCD in that order. (Airway- Breathing- Circulation- Drugs). Most newborns require A and B only, due to the primary reason for resuscitation in this age group. Only a few require C and D.

Resuscitation in the neonatal unit

The NLS algorithm applies to all neonates including those at birth and those subsequently nursed within other areas. Within the special unit or on postnatal ward, resuscitation measures may be required in cases for example, where a neonate stops breathing or displays a significant drop in saturations and/or heart rate, with no response to initial intervention – ie stimulation and increasing oxygen. Resuscitation is also required when a ventilated neonate in intensive care suddenly deteriorates; eg chest stops moving, sudden desaturation, colour change, drop in heart rate.

Intubation and subsequent mechanical ventilation are only necessary if absolutely necessary and for the shortest possible time in line with protective lung strategies, when good quality resuscitation by the above measures have not secured the neonate's airway and / or when surfactant is required in a premature neonate (See Chapter 7). This may necessitate ongoing support and insertion of an artificial airway, for the least time possible. Figures 11.2 and 11.3 include important elements of assisting with intubation in the neonate. Optimal endotracheal tube [ETT] placement is essential to provide adequate ventilation and minimise injury or harm to the neonate (Cerone and Pinheiro, 2022).

Figure 11.2 Guide for endotracheal tube [ETT] sizing

Width (2, 2.5, 3, 3.5, 4, 4.5)

General guide <1kg: 2-2.5 / 1-2kg: 2.5-3 / 2-3kg: 3-3.5 / 3-4kg: 3.5-4 / >4kg: 4.5

Length (Kempley et al, 2008)

Corrected Gestation (weeks)	Weight (kg)	ETT length at lips (cm)
23-24	O.5-0.6	5.5
25-26	0.7-0.8	6.0
27-29	0.9-1.0	6.5
30-32	1.1-1.4	7.0
33-35	1.5-1.8	7.5
36-37	1.9-2.4	8.0
38-40	2.5-3.1	8.5
41-43	3.2-4.2	9

Length is for oral intubation. Add 1 cm for nasal intubation.

Figure 11.3: Assisting with intubation and ETT fixation

- ❖ Prepare and administer appropriate sedation prior to intubation as prescribed by the medical staff.
- ❖ Prepare equipment.
- ✓ Ensure correct size endotracheal tube (ETT) -sizing correlates well with gestational age and birthweight. – see Figure 11.2 and the reading below.

EXTRA READING - Recommendations on ETT sizing are provided by Ebenebe et al (2022) – see article and sizing guide and another guide using weight is provided by Liu et al (2021)

Equipment

- ✓ Laryngoscope (check light) with straight blade
- ✓ Stethoscope
- ✓ Suction with size 8-10 catheter
- ✓ T-piece circuit (check pressure) or bag-valve-mask in working order.
- ✓ ETT holder and fixation method
- ✓ Correct size hat (with ties each side) if used to secure ETT to the holder.
- ✓ Gauze to protect cheeks.

- ❖ Position neonate appropriately
- ❖ While doctor / ANNP intubates, ensure that suction and bedside resuscitation equipment are available.
- ❖ Observe vital signs and raise an alert if oxygen saturations / heart rate drop.
- ❖ Watch neonate's temperature during exposure ensuring they are kept covered.
- ❖ Once intubation complete, the ETT position can be confirmed by……
- ✓ **Clinical assessment**- Chest movement & air entry should be bilateral.
- ✓ **Chest X-ray (CXR)** for confirmation of ETT position.
- ✓ ETT tip should be between 0.2 and 2 cm above the carina. The most common malpositioning is in the right mainstem bronchus.
- ✓ **Caliometric end tidal CO2 (EtCO2) detector** can be used prior to CXR, a disposable ETT connection containing a pH sensitive indicator. If carbon dioxide is detected in the expired breaths, this is an indication the ETT is in the lungs. An absence of color change suggests that the tube is not in the trachea.

Stop and think

Close observation is a vital nursing role during the intubation procedure to support whoever is carrying this out, particularly of the heart rate and oxygen saturation levels.

Ventilation in the neonatal unit

A healthy baby with an open airway will be able to breathe spontaneously without problems. However, in neonatal care, respiratory management to support a neonate's breathing is often necessary. While intubation for full ventilation support may be required in the intensive care setting, this should only be done if absolutely necessary. Non-invasive means of airway and breathing support is always preferable to avoid the potential long-term damage to lungs from mechanical ventilation.

The ultimate aim is to wean any support as soon as possible and for the neonate to breathe on their own without support. A non-invasive respiratory support therapy is CPAP which is administered non-invasively by a Flow driver via two short nasal prongs or a mask over both nostrils (see book chapter 11). The Flow driver offers a selection of modes to avoid the need for intubation / re-

intubation and to assist in weaning the neonate from mechanical ventilation. One CPAP level can be given or two (bi-phasic).

Stop and think

CPAP should always be considered before more invasive models of intubation and full ventilation in line with a protective lung strategy.

Sometimes referred to as intermittent positive pressure ventilation (IPPV), mechanical, mandatory or artificial ventilation, this term applies to the whole spectrum of ventilation modes that deliver positive pressure via an ETT according to parameters set on a ventilator. Figure 11.4 provides an overview of ventilation modes.

Figure 11.4 A Guide to ventilator modes
(Petty, 2013)

EXTRA READING
Read the paper on Ventilation strategies and modes by Petty (2013) for an overview and…….For the most recent guidance- refer to the NICE guidance on respiratory support of the preterm neonate (2019)

Key headlines from the NICE (2019) guidance

- For preterm babies who need non-invasive ventilation, consider nasal CPAP or nasal high-flow therapy as the primary mode of respiratory support.

Invasive ventilation techniques in the neonatal unit

- For preterm babies who need invasive ventilation, use volume-targeted ventilation (VTV) in combination with synchronised ventilation as the primary mode of respiratory support. If this is not effective, consider high-frequency oscillatory ventilation (HFOV).
- For preterm babies who need invasive ventilation but VTV and HFOV are not available or not suitable, consider synchronised intermittent mandatory ventilation (SIMV).
- Do not use synchronised pressure-limited ventilation such as assist control (AC), synchronised intermittent positive pressure ventilation (SIPPV), patient-triggered ventilation (PTV), pressure support ventilation (PSV) or synchronised time-cycled pressure-limited ventilation (STCPLV).

Mode	Definition
Target tidal volume (TTV)	***or Volume guarantee (VG)*** A desired tidal volume (Vt) is set that is guaranteed and delivered at the lowest possible pressure. TTV is turned on in conjunction with an existing mode
Synchronised intermittent mandatory ventilation (SIMV)	SIMV synchronises the set breaths with the neonate's breathing. A rate is set but the breaths are delivered 'in-tune' with the neonate's efforts by detecting these and synchronizing the delivery
High frequency oscillation ventilation (HFOV)	A non-conventional mode of ventilation that uses breath rates or rather 'oscillations' known as frequencies, at rates much greater than normal physiological breath rates. This causes the chest to "bounce" or vibrate

The following modes are now outdated or not recommended- the terms may still be used in the literature.

Continuous mandatory ventilation (*CMV*)- mandatory ventilation which does not allow the neonate to breathe between ventilator breaths.

Pressure support ventilation (PS)- In PS, breathing efforts are supported with a ventilator breath set to a desired pressure; similar to PTV but the neonate determines their own rate *and* inspiratory time (Ti). A mode in its own right or used in conjunction with SIMV where any breath that the neonate spontaneously delivers is pressure supported to a percentage of the peak pressure set.

Proportional assist ventilation (PAV)- PAV gives assistance that is proportional to the neonate's effort, whereby the applied pressure increases in proportion to the VT and flow generated by the neonate, with the frequency, timing, and rate of lung inflation being controlled by the neonate.

NB: The actual terminology used may differ between makes and models of different ventilators.

Stop and think

Protective lung strategies are vital to minimise risk to the neonate's lungs – i.e., keep volume, pressure and oxygen as low as possible (Ozer, 2020).

In addition, it is important to learn about ventilation terminology in order to grasp and eventually fully understand what is observed and recorded each hour throughout the neonate's stay in intensive care. See book, chapter 11 for the ventilator setting and parameters used.

Making changes to ventilation

Ventilation should be delivered in a dynamic fashion and should continually be reviewed with the aim to reduce requirements as soon as possible. Changing ventilation therefore is important to understand the following and the guide in Figure 11.5.

General principles:

Manipulating oxygenation

MAP controls oxygenation.
So, oxygenation can be influenced by changing any of the variables that alter MAP.
(PIP, PEEP, Ti and Te)

Manipulating CO2 elimination

Minute volume (Vmin) controls C02 elimination.
CO2 levels will be influenced by any changing measure which affects Vmin i.e., manipulating the rate, Vt or both will alter the Vmin.
(Remember- Vmin = Vt x rate)

Stop and think

Evaluation is an essential component of clinical decision making following any change in order to know the effectiveness of any interventions.

Suggested actions and changes to ventilation should be based on assessment of the individual neonate.

The intention to wean along with any weaning strategy should be in place as soon as a neonate is started on any means of ventilation support, being mindful of limiting pressure, volume and oxygen.

(Logan et al, 2022; Ozer, 2020; Sweet et al, 2023)

Figure 11.5 A Guide to weaning ventilation

AIM: to wean as soon as possible, in line with a protective lung strategy

Is the neonate making spontaneous efforts to breath?

If no, the neonate may not be ready to wean. If yes

CONSIDER;

- Have the blood gas values normalised?
- Consider possible changes to ventilation during weaning in line with oxygenation or CO2 elimination or both.
- Has the oxygen requirement improved, preferably below a Fi02 of 0.6 (60%) Wean down oxygen as tolerated.
- Has the compliance of the lungs improved, good chest expansion / lung fields?
- If on TTV / VG, is the PIP needed to reach the target volumes decreasing?
- Have any opiates/sedatives that could affect respiratory drive been stopped?
- Has the neonate been started on respiratory stimulants (Caffeine)?

If no to any of these questions, the neonate may not be ready to wean. If yes

Continue to wean parameters in stages appropriate to the mode of ventilation. Evaluate the effect of each change.

Prior to extubation, are the ventilator settings low enough to be close to the neonate's physiological parameters.

Extubate when appropriate based on the above requirements.

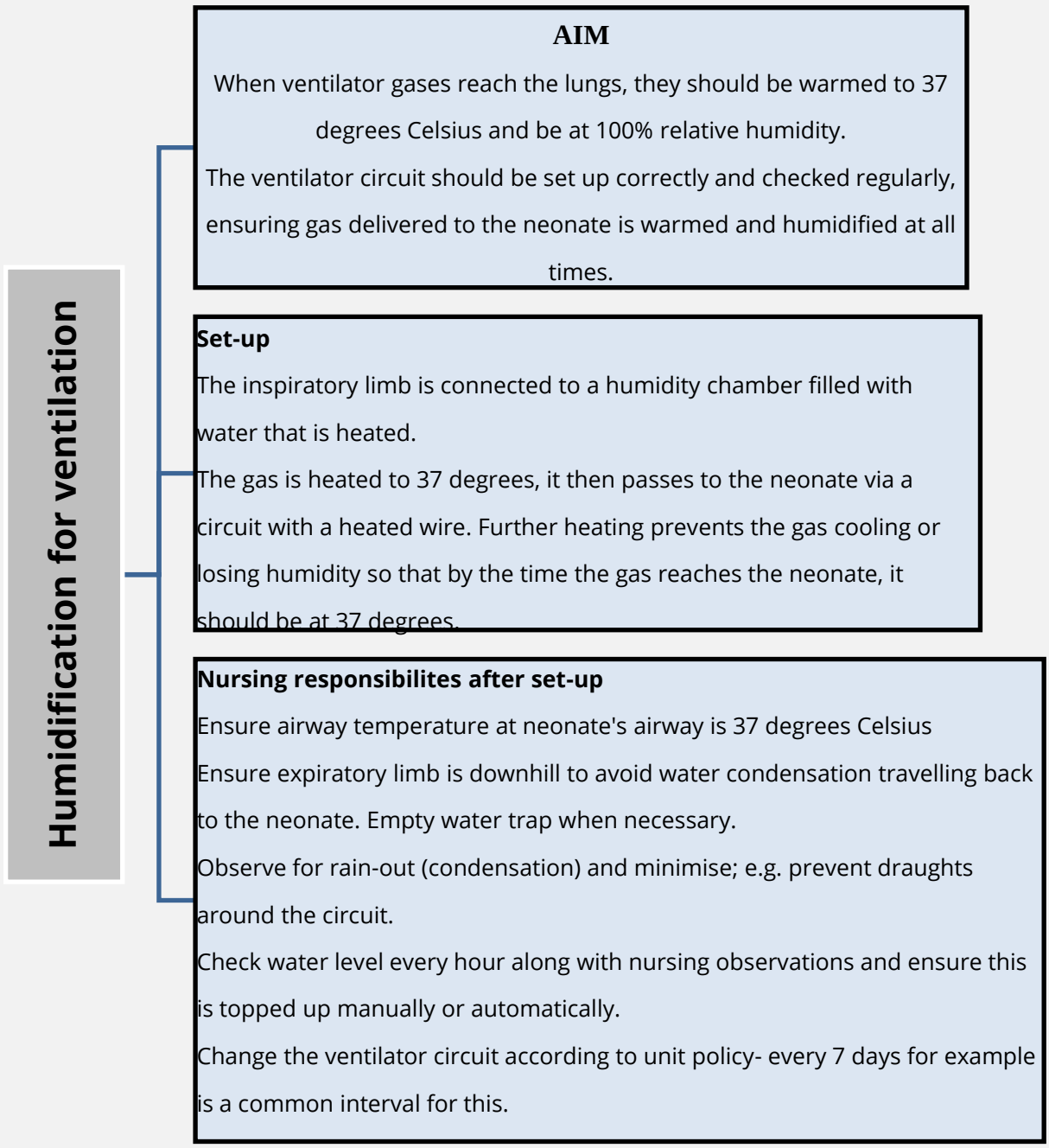
Following extubation, continue to assess and evaluate regularly.

EXTRA READING – read the paper by Sangsari et al (2022) for further information Weaning and extubation from neonatal mechanical ventilation: an evidenced-based review

Other care practices in ventilation

There are many areas to consider when caring for a neonate on artificial ventilation by any means. Ventilation requires gases delivered to the lungs to be warmed and humidified to prevent adverse consequences for the vulnerable airway such as drying and thickening and poor clearance of secretions and increased risk of infection. Suctioning the airway is performed to maintain its patency by safe removal of secretions. In neonatal practice, suctioning can be undertaken via the nasopharyngeal (NP), oropharyngeal (OP) or endotracheal tube (ETT) route. At birth it may be necessary to clear thick meconium, blood or vernix (rarely) to ensure an open airway during the early minutes of life when breathing is being established. In the case of the non-ventilated neonate in the unit, suction may be required to clear copious, thick oral or nasal secretions when they are unable to clear these themselves. Suctioning the ETT in the ventilated neonate can be performed when indicated to clear secretions and prevent a blocked tube. Overall, to ventilate effectively, the ETT must remain patent and regular checks should be made to ensure the adequacy of ventilation. Care and checking of equipment are also necessary including the flow sensor. There are of course times when other adjuncts are required in the very sick neonate such as chest drain insertion and the use of inhaled nitric oxide. The figures 11.6 to 11.10 below give further information to add to the brief content in the book on airway humidification, suctioning, chest drain care and inhaled nitric oxide.

Figure 11.6 Humidification in ventilation practice



Stop and think

Any artificial ventilation mode delivering gas to the airway and lungs must deliver warmed humidified gases to avoid any potential damage.

Figure 11.7 Oral and nasopharyngeal suctioning

Assess the *need* for suction and refer to care plan / documentation

Diminished chest movement? Increased oxygen requirement?

Increased visible and/poor audible secretions?

Any previous suctioning required? Frequency?

Select appropriately sized catheter

At birth or in an emergency- use a Yankeur sucker or *no less than* an 8 to 10 Fr (depending on size / gestation)

Neonatal period- Use 4 to 10 Fr depending on size / gestation that should be passed freely without resistance.

At birth

- Suction under direct vision only using a light source to visualise the OP.
- Newborn Resuscitation guidelines recommend a laryngoscope blade to depress the tongue down and view the back of the OP.
- Do not suction further than what is visualised.

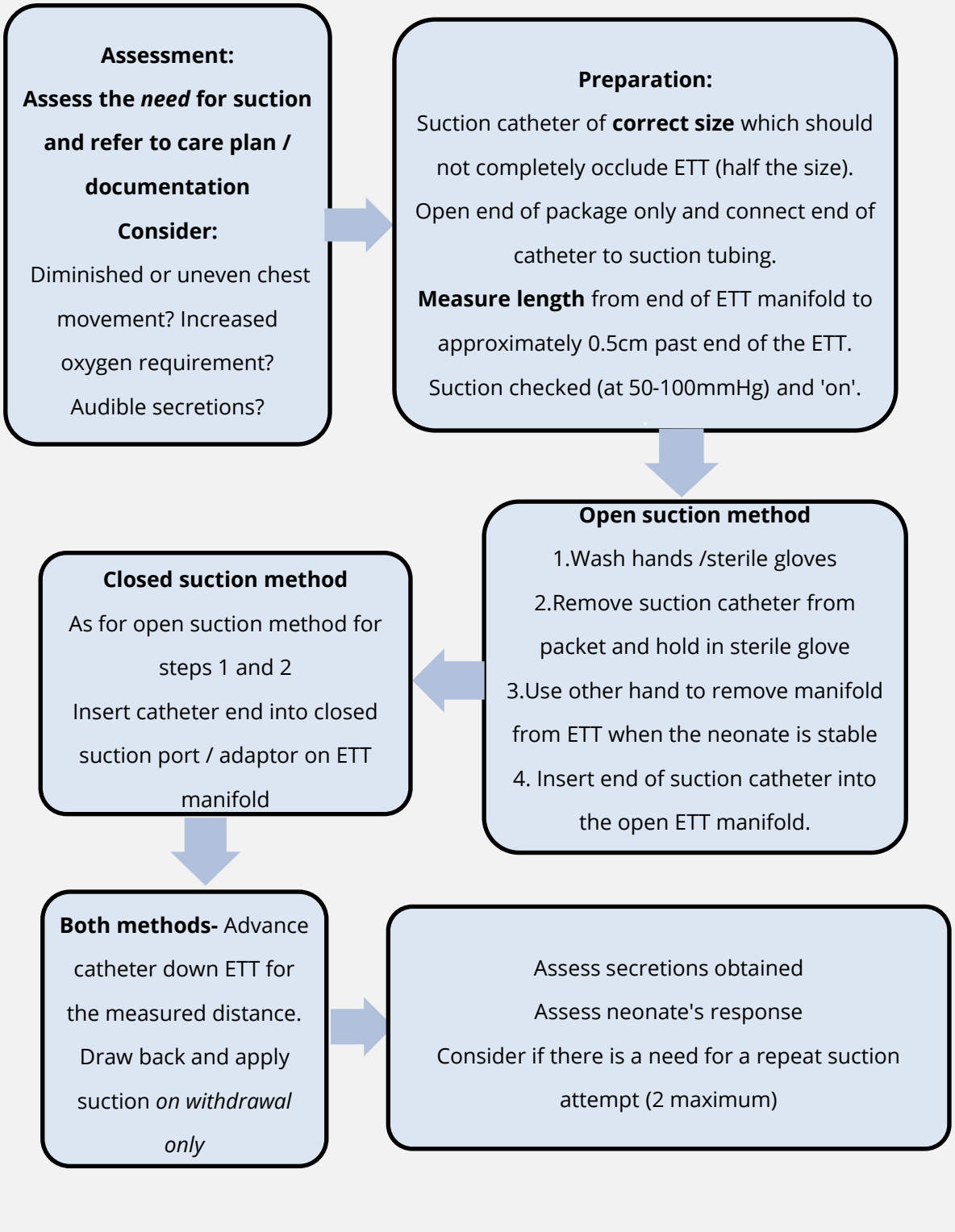
- **In the neonatal period**
- Suctioning should not be done blindly.
- A catheter should be passed into the mouth or nose just to the back of the OP or NP but no further.
- No force should be applied.
- Withdraw catheter once inserted and apply suction *when drawing back only* taking no more than 5 seconds as a rule.

Observe and monitor throughout the procedure.

Stop and think

Suctioning by any route is associated with potential complications that include stimulation of gag reflex (OP or NP suction) sudden fluctuations in oxygenation status, hypoxia, bronchospasm, bradycardia and tissue or tracheal damage which may not be well tolerated by fragile preterm neonates. Suctioning should be carried out with these above potential risks in mind.

Figure 11.8 Endotracheal (ETT) suctioning



Stop and think

Suction by any route should not be done routinely and must be carried out following assessment of clinical condition with caution. Assessment should determine the frequency of the procedure tailored to the individual neonate.

Suction catheter size

ETT diameter	Catheter size
2.0 mm	4FG
2.5 mm	5FG
3.0 mm	6FG
3.5 mm	7FG
4.0 mm	8FG

Stop and think

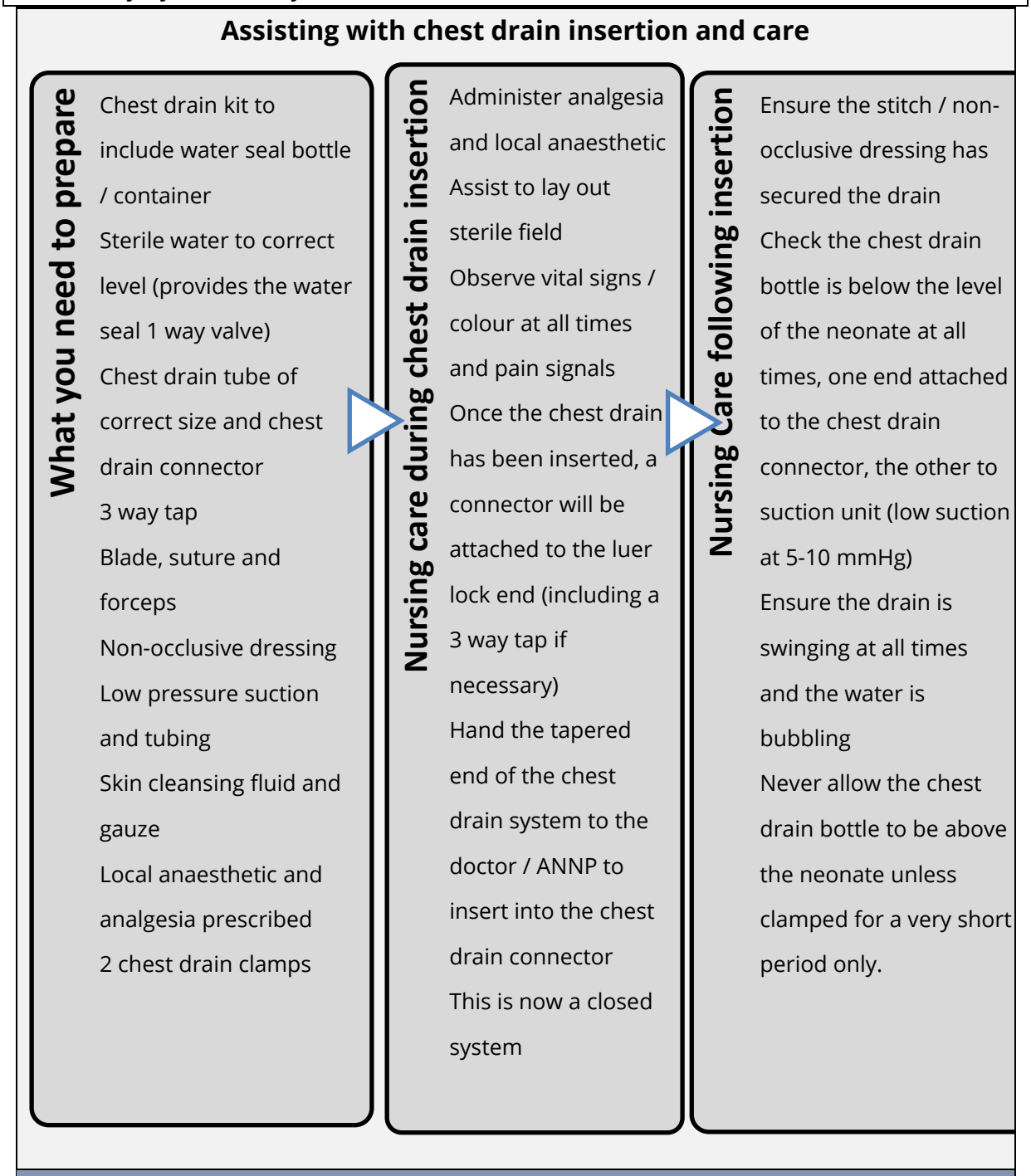
ETT suction occludes the airway for a given period. Therefore, it should be done swiftly and smoothly lasting less than 5 seconds, with an appropriately sized catheter.

Additional practice points

- Due to potential complications associated with disconnecting the neonate's ventilator, *closed* suctioning as the preferred method and has been shown to have short-term benefits.
- Pre-oxygenation has also been shown to assist in maintaining oxygenation and can be considered: However, this should not be routine, and oxygen should not be increased by any more than 5 – 10% for 1 minute prior to suctioning.
- Routine normal saline (0.9%) instillation prior to suction is not supported by evidence. Consideration can be given when secretions are very thick, purulent, and hard to clear.
- If secretions are thick, ensure adequate humidification is being delivered by the ventilation or CPAP circuit.
- Suctioning pressures are within the range 50-100 mmHg as a rule.
- **Standard precautions alert.** Care must be taken during suction not to introduce infection by using aseptic non-touch technique and sterile gloves. Ensure that each catheter used is inserted once only (single use) and discarded.

Figure 11.9 Chest drain care

Chest drain insertion is undertaken to remove unwanted air in the presence of an air leak such as a pneumothorax or to drain fluid in the case of a pleural effusion. Diagnosis of air leak is carried out using either a cold light (chest transillumination) or definitively by chest X-ray.



Stop and think

Tension pneumothorax is an emergency: ensure access to the cold light source and equipment for rapid 'butterfly' aspiration of gas prior to chest drain set-up. Insertion of a chest drain is an extremely painful and invasive procedure- therefore adequate and timely pain relief must be prescribed and administered.

Figure 11.10 Inhaled nitric oxide nursing guide	
Safety aspects	**Rationale**
Nurses must be trained in the set-up and use of Nitric Oxide.	The set up for giving iNO therapy involves integration of the gas into the inspiratory limb of the ventilator circuit as well as a sampling monitor attached to the circuit. Neonates are sensitive to iNO and will deteriorate quickly with sudden discontinuation – this may cause rebound pulmonary hypertension.
A backup NO cylinder should be available with emergency manual ventilation system attached.	
Every effort should be made to avoid disconnection.	
Closed circuit suctioning should be instituted by an adaptor added to the ETT manifold.	
Monitoring	**Rationale**
Monitor oxygen requirement and the pre and post ductal saturation difference. Oxygenation index can also be calculated.	Response to iNO is indicated by reduction in oxygen requirement (Fi02 and/or oxygenation index) and pre and post ductal saturation difference normalising. Toxic effects include; increased airway reactivity, altered surfactant chemistry, epithelial hyperplasia, inflammation, pulmonary oedema, and production of methaemoglobin, a by-product of iNO metabolism. Methaemoglobin cannot carry oxygen.
Hourly blood gases should be taken when treatment is first commenced as part of assessing response. Four hourly blood gases should subsequently be satisfactory if the neonate is stable on treatment unless clinically indicated.	
Methaemoglobin should be checked	
The NO and Nitrogen Dioxide (N20) levels should be continuously monitored and documented.	
Weaning iNO	**Rationale**
iNO is started at 20 ppm.	Weaning from iNO should be considered when a neonate shows clinical improvement and when oxygen requirement starts to reduce.
Neonates should be weaned as quickly as possible if their condition allows, preferably within 24 hours of starting therapy.	
iNO is decreased in increments until iNO administration is 5 ppm.	
Discontinue iNO, depending on the ease of weaning.	
Stop and think As for ventilation, iNO should be weaned and discontinued as soon as possible once a response is ascertained, titrated to response of the neonate.	

Blood

Taking blood

Sampling blood by varying means for analysis, screening and/or diagnosis is a very common practice in neonatal care. It is therefore important to understand normal blood parameters (see book, chapter 11). Understanding blood values specific to the neonatal group is important as there are some physiological differences in this group compared to the older child and adult.

In addition, a vital and common investigation for assessment of the sick or compromised neonate in clinical care is blood gas analysis which gives valuable information regarding a neonate's respiratory, oxygenation and metabolic status along with the response to changes to management, such as ventilation changes, administration of oxygen and fluid. Normal values as well as a systematic approach to analysis can be seen in the book, chapter 11. A systematic approach to working through the different aspects of a blood gas analysis result is useful, always considering the pH *as a priority* and then leading on to working out what has contributed to the change in pH. it should be remembered that exceptions to 'normal', 'textbook' values apply, depending on the individual situation- for example, permissive hypercapnia, compensated values, site of sampling. These must be considered in the interpretation of blood gases.

Stop and think

Caution should be taken in how much blood is taken for repeat tests. This should be monitored particularly in very small neonates whose blood volume can easily be depleted.

Giving blood

A blood transfusion may be required in the neonate for the prevention of anaemia secondary to prematurity or blood loss, when the haemoglobin (Hb) drops to an operational threshold level (subject to local guidelines on low acceptable values). Blood products and some general information on blood administration can be seen in the book, chapter 11. Figure 11.11 below gives some additional considerations.

Figure 11.11 Additional practice points for giving blood

Checking

The prescription of blood and blood components must be completed special requirements for neonates, e.g., irradiated or CMV negative.

- The blood unit and compatibility slip should be checked by two nurses to ensure correct neonate against their ID band and inspected for integrity of blood and pack before connection to the blood transfusion giving set.
- The expiry date of the blood must not be exceeded.

Procedural aspects

- *Aseptic non-touch technique* (ANTT) should be utilised for connection of the transfusion.
- A sterile *blood transfusion* giving set must be used to filter and run through the blood for administration. A sterile platelet giving set may be used for transfusion of platelets and cryoprecipitate.
- Drugs must never be added to blood.
- Transfusion must be completed within 4 hours.
- Blood should only be warmed using a blood transfusion warmer.
- The empty bag must be disposed of according to local policy.
-

References: British Committee Standards in Haematology (2004), UK Blood Transfusion and Tissue Transplantation Service (2013)

Stop and think

Any neonate receiving a blood transfusion should be monitored.

Cardiovascular care

A healthy baby who has clear airway and is breathing effectively will be well perfused with a cardiovascular system [CVS] able to deliver all essential nutrients and oxygen to the body. However, in the sick neonate who does not have the compensatory mechanisms to cope with compromise, support for the CVS is often necessary, as seen in the book, chapter 7. Figures 11.12 to 11.15 elaborate further on some aspects of CVS care including cardiac failure considerations.

Managing blood pressure and volume

In intensive acre, careful and regular assessment is necessary when the CVS is accessed by the arterial system for blood sampling and monitoring of the circulation. When / If an arterial system is not in place, blood pressure in NICU will be monitored manually / electronically.

Stop and think

Caution should be applied when administering fluid volumes to a neonate as kidney function is immature. The risk of overload should be guarded against.

The potential risks of drugs used to increase blood pressure should be considered and close monitoring undertaken. For inotrope administration, care should be taken titrating doses to avoid rapid swings in blood pressure that can affect the brain perfusion. Caution should be applied with the administration of sodium bicarbonate and steroid use due to the potential serious side effects.

Figure 11.12 Monitoring arterial blood pressure in neonates

- Assist with arterial line insertion and safe securing - via umbilical artery or other peripheral artery access. See Umbilical cord care and catheterisation.

- Set up infusion system with heparinised saline through an arterial giving set including a transducer. ORDER= Saline syringe attached to giving set & transducer, attached to a three-way tap, attached to the arterial line cannula

- Ensure the correct waveform scale is chosen for blood pressure on the monitor.

- Calibrate the system to zero (see 33b below) prior to commencing monitoring.

- Arterial alarms should be checked on set up and at the beginning of each shift along with calibrating the transducer to zero.

- If there is no arterial access, take regular cuff readings (hourly or as indicated by the neonate's condition), manually or automatically timed.

Stop and think

Safety: Close and regular observation of article lines should be maintained to prevent the associated risks such as bleeding, blockage by a blood clot and the effect on perfusion. Check/observe limbs for perfusion- colour, circulation, pulse, and temperature of extremity distal to puncture site. The line may need to be removed if perfusion is compromised.

Cardiac Failure

CVS care is also relevant to the neonate who presents with *cardiac failure* either from congenital heart disease (CHD) or less commonly, from non-structural causes. A neonate presenting with cardiac failure for whatever reason presents with a characteristic set of signs and symptoms requiring specific management.

Figure 11.13 Classification of congenital heart anomalies*- summary table

(Source Merck and co. © - Baffa, 2014)

Classification	Examples *In decreasing order of frequency.
Cyanotic	
Right to left shunt	Tetralogy of Fallot Transposition of the great arteries Tricuspid atresia Pulmonary atresia Persistent truncus arteriosus Total anomalous pulmonary venous return
Acyanotic	
Left to right shunt	Ventricular septal defect Atrial septal defect Patent ductus arteriosus Atrioventricular septal defect
Obstructive	Pulmonary stenosis Aortic stenosis Coarctation of the aorta Hypoplastic left heart syndrome (often also manifests with cyanosis, which may be mild)

11.14 Cardiac failure – overview

Cardiac failure: initial presentation in first few days

- Heart murmurs on routine screening.
- Tachycardia.
- Breathlessness
- Tachypnoea
- Difficulty feeding
- Failure to thrive.
- Cyanotic episodes (especially during feeding).
- Sudden collapse

Congestive cardiac failure (CCF): later presentation

- Tachycardia
- Cardiac enlargement
- Tachypnoea, intercostal retractions, grunting, flaring, dyspnoea, rales and cyanosis.
- Gallop rhythm
- Mottling / decreased perfusion (capillary refill) and decreased pulses.
- Decreased urine output and oedema.

Management overview of cardiac failure

Recognise clinical signs and symptoms (See above)

Diagnosis – provisional based on signs or definitive via Echocardiogram / Chest X-ray (CXR)

Request a Cardiac Team consultation.

Initial management

- Pre-ductal ABG to check Pao2 (right arm) in room air and hyperoxia test by pre and post ductal saturation (Sa02) monitoring.
- Treat metabolic acidosis and poor perfusion with inotropes, fluid bicarbonate as appropriate.
- Four limb BP - an upper to lower limb systolic difference of > 10mmHg is significant.
- Prostaglandin E1 (PG) infusion if a duct dependent cardiac disease is suspected.

Congestive cardiac failure [CCF]

- Treat the cause (eg CHD or cor pulmonale due to chronic lung disease)
- Diuretics (such as frusemide) help to decrease total body water.
- Monitor vital signs. Watch for tachycardia, arrhythmias, decreasing Sao2 and dyspnoea, apnoea or tachypnoea.
- Maintain adequate calorific requirements.

Referral and transportation to tertiary centre if necessary

Stop and think

Any neonate on a prostaglandin infusion should be monitoring closely for potential side effects: apnoea. Differentiating cardiac from respiratory causes is essential as soon as possible for prompt referral and transfer to a cardiac centre.

Figure 11.15 The preterm neonate with patent ductus arteriosus (PDA)

The presence of a PDA in a preterm neonate is due to a failure of the *ductus* to close.

Recognise clinical signs.

- Signs and symptoms of congestive heart failure, increased need for oxygen and inability to wean from ventilator.
- Widened pulse pressure / low diastolic pressure, bounding peripheral pulses and tachycardia with or without a gallop.

- **Diagnosis by echocardiogram**

- Medical management with fluid restriction and diuretics
- Continually assess pulse, heart rate, pulse pressure, perfusion, and auscultation for the presence of a murmur.
- Indomethacin or Ibuprofen (dosage depends on weight, gestation and renal function).
- Assess after indomethacin for ductal closure, decreased urine output and thrombocytopenia.
- Referral and surgery (ligation) may be necessary if medical treatment is not effective.
- Teach and reassure parents.

Stop and think

Any neonate on receiving non-steroidal anti-inflammatory drugs (e.g., ibuprofen, indomethacin) should be monitoring closely for potential side effects (eg bleeding, reduced urine output).

Drug administration

Comprehending the principles of drug administration is one of the core components of the Nursing and Midwifery Council Education Standard proficiencies. It is an essential part of safe nursing practice to be able to

calculate and administer drugs correctly and to understand their dosage, indications and side effects. This is particularly important in neonatal care as we are dealing with a distinct group of smaller, more vulnerable patients. Here offers guidance on some useful formulas in relation to drug units and calculations (Figures 11.16 to 11.20).

Stop and think

Neonatal drug dosages are more likely to be prescribed and given in microgrammes than larger units, compared to older age groups. Certain drugs are also given in nanogrammes. It is very important to understand how to convert larger units to smaller units for accuracy and to avoid errors in administration.

Figure 11.16 Understanding strengths and units - summary table

a- Converting grammes to milligrams to micrograms to nanograms. (Multiply by 1000 to convert larger unit to smaller units)

Grammes (g) to milligrammes (mg) - multiply by 1000.

Milligrammes (mg) to microgrammes (mcg) - multiply by 1000.

Microgrammes (mcg) to nanogrammes (ng) – multiply by 1000.

Converting nanogrammes to microgrammes to milligrammes to grammes

(Divide by 1000 each time, to convert smaller to larger units)

b- 1 in 1000 1 in 10,000

(Parts of an active drug in a given volume)

1 in 1000 means 1g in 1000mls (1000mg in 1000mls = 1mg per ml)

1 in 10,000 means 1g in 10,000mls (i.e., less concentrated)

1000mg in 10,000mls = 1mg in 10mls
c- Mmols…. eg for sodium bicarbonate, electrolytes Molarity refers to atomic weight. 1 mole is the molecular weight for a drug. Mmol is one thousandth of a mole
d- Units of activity E.g., for drugs from natural sources such as heparin (1000 units in one ml), insulin (100 units in a ml) or hormones
e- How many grammes in a certain % Strength as a percentage means the number of parts per hundred. 5% glucose is 5 parts glucose in 100 parts of volume (5g in 100 mls) 10% glucose is 10 parts glucose in 100 parts (10g in 100mls)

Figure 11.17 Calculating drug dosages – flow chart

Prior to drawing up….

CHECK- Right medication, right dose, right patient, right time, and right route.

How much do I need to draw up?

Volume needed =

$$\frac{\text{What you want}}{\text{What you've got}} \times \text{volume the drug is in}$$

EXAMPLE ….

The required dose of a drug is 60mg.
The elixir contains 50mg in 10ml.

$$\text{Volume needed} = \frac{60\text{mg}}{50\text{mg}} \times 10\text{ml}$$

$$\frac{60\text{mg}}{50\text{mg}} \times 10\text{ml} = \frac{6}{5} \times 10 = \frac{6}{1} \times 2 = 12\text{ ml}$$

Remember; to cancel a fraction, choose a number that divides exactly into the top and the bottom.

Stop and think

You should check that both the dose prescribed, and the drug being used are the same in units (eg milligrams). Safe prescribing is essential.

Drug infusion formulas

The following section gives some useful formulas for calculating drug *infusion* dosages starting with how to check how much drug is being administered from a given infusion rate.

Figure 11.18 Calculating doses from infusion rates

This should be done at the start of every shift and after infusions have been set up or changed. This formula checks what dose is being given by the infusion rate.

Quantity of drug put into syringe (in mcg or ng) * (see note below*)

Divided by the volume in the syringe.

Divided by the neonate's weight ** (See note below**)

Multiplied by the infusion rate running.

This gives you the dose in <u>mcg/kg/hour</u> (being given by the current rate of infusion)

* Convert mg to mcg first (multiply mg x 1000 to get the drug in mcg)

Or convert to ng by....

**NB if the drug (e.g., inotropes) is given in mcg/kg/*<u>minute</u>* SO ALSO divide by 60 at this point **

<u>IN other words –</u>

The initial dose (mcgs) *divided by* the weight (kg) *divided by* the volume (mls) gives you *the dose* ***per kg per hour*** *in 1 ml.* You then multiply by the final figure by the current rate of infusion.

Divide this by 60 (minutes) to give you the dose ***per kg per minute.***

Stop and think

Some drug infusions are calculated in mcg/kg/hour while others are in mcg/kg/minute depending on the half-life of the drug being given It is important to know this when checking the prescription and calculate accordingly.

Changing the concentration of a drug

It may be necessary to change the concentration of a drug prior to drawing up the final volume for many reasons; For example, diluting a drug (adding *more volume* to a given dose) changes the concentration of a drug to make the end volume larger and this assists in accuracy when drawing up very small doses. Conversely, changing the concentration by adding *more drug* to a given volume is useful in relation to drug infusions when a neonate is very volume restricted whereby the same dose can be delivered in less volume.

Stop and think

Always refer to the specific drug monograph as to *how* a drug should be prepared, over how long it should be administered and whether it requires further dilution. For any drug, one must understand why it is being given (indication) and the associated side effects. Always check the BNF for Children and/or local policies /drug monographs for dosage, recommended method of administration and a full list of associated side effects or contraindications.

Figure 11.19 Diluting drugs

Diluting a drug is necessary to make is *less concentrated.*

Example 1- A drug which comes in a 500mg vial which needs to be given as a 5mg in 1ml concentration

Example 1 – Vancomycin- Dose required is 15mg.

Make up Vancomycin 500mg to a concentration of 500 mg in 10mls (which is 50 mg in 1 ml)

Take out 1ml (which is 50mg) and put into 9 mls of normal saline or water for injection (WFI)

This makes 50 mg in 10 mls which is **5mg in 1 ml.**

Calculate the required dose from this 5mg in 1 ml solution.

Dose = 3 mls

Then attach IV giving set and run through the solution to leave 3 mls in the syringe (or leave more in the syringe but *ensure you set the Volume to be infused* at 3 mls)

Example 2- 'Double diluting a drug E.g., SODIUM BICARBONATE

The dose …. 1.5 mls needed – double dilute with WFI to 3 mls.

However, you will 'lose' within the line during priming.

SO, draw up double of everything in 1 syringe – i.e., 3 mls of sodium bicarbonate and 3 mls WFI and run through IV line until 3 mls is left in syringe.

(Or leave more in the syringe but *ensure you set the Volume to be infused*)

The above principles can be applied to any drug that needs further dilution to administer it.

Figure 11.20 Administering drugs when you need to give very small amounts

Example: Ranitidine (Preparation is 50mls in 2 mls = 25mg in 1ml)

1mg prescribed which means 0.04 mls is required which is a very small quantity to work with

Therefore, Take out 1ml (=25mg) from the vial of drug

Add to 4 mls of saline or WFI.

This makes 25mg in 5mls (5mls in 1 ml) –

Work out your dose (1mg) from this solution to enable you to give a greater volume.

New volume after dilution = 0.2mls which is much easier to draw up

NB- you can alter the volume that the drug is diluted into as long as you always use the standard drug formula to work out how much you need to draw up finally. The above principles can be applied to any drug where you need to draw up a larger volume to administer it safely.

Making drugs more concentrated for infusion

To make a drug infusion more concentrated in volume restricted neonates A larger initial dose of the drug is added to the syringe in the first instance in the same volume, e.g., double the drug amount will give desired dose in half the volume. The formula is then used in the same way. In other words, adding more drug gives the same dose but in a smaller volume. The above principles can be applied to any drug infusion where you need to restrict volume but keep the drug dosage the same.

Surgical nursing practices

Knowledge of the nursing care practices relating to the surgical neonate is a substantial topic and to go through each surgical condition particularly the whole repertoire of congenital structural anomalies, is beyond the scope of this book and web companion. However, some common practices can apply more broadly to any surgical case, namely, identification of acute gastrointestinal tract (GIT) obstruction, pre- and post-operative checklist, gastric decompression, replogle tube care, stoma care, fluid / feeding issues for the surgical infant and Necrotising Enterocolitis [NEC] as a specific surgical neonatal condition [Figure 11.21 to 11.26].

Figure 11.21 Assessment and management of acute gastro-intestinal tract (GIT) obstruction

Common / classic signs

- Bilious vomiting / increased aspirates
- Abdominal distension
- Failure to pass meconium / stool ('ileus')
- Absent bowel sounds

- **Immediate interventions:**
  - NBM
  - Gastric decompression
  - IV fluids
  - ? antibiotics (if NEC)

- **Then .....**
  - Referral to surgical team
  - Pain control / NBM / gastric decompression
  - Respiratory support
  - Cardiovascular support
  - Parent care

Stop and think

Bilious vomiting indicates pathology

The bowel becomes compromised when its blood supply is decreased before or following birth and bacteria that are normally present in the bowel invade the damaged area, causing more damage Management should commence as early as possible once any suspicion of NEC or acute intestinal obstruction arises.

Stop and think

Optimum preparation both prior to surgery and in the post-operative period aims to ensure that the neonate is safe, physiologically ready to cope with anaesthesia and surgery and family is psychologically prepared.

Figure 11.22 Pre and post -operative care for the surgical neonate

Pre-operative checklist

The following should be completed and documented:

- Patient details and assessment overview. Consider the systems.
- Baseline observations including temperature.
- Blood results as applicable (Full blood count, clotting)
- Assessment of pain
- Record of any previous events in surgery
- Pre-operative fasting information (When NBM started)
- Pre-operative safety checklist
- Discussion with parents
- Consent formed signed following clear discussion.
- Risk assessment to ensure transfer to and from theatre- see below.

Specific conditions: some examples

- Acute intestinal obstruction including NEC – Gastric decompression (NGT in place), observe for perforation.
- **Signs of intestinal obstruction- abdominal distension, bilious vomiting, absent bowel sounds, failure to pass meconium or stool.**
- Oesophageal Atresia- Replogle tube drainage.
- Gastroschisis- Cling film wrap / protection of exposed.
- Congenital Diaphragmatic hernia– Stabilisation prior to theatre

(Leeuwen and Fitzgerald, 2014)

Post-operative checklist

The following should be completed and documented:

- As above, ensure safe transfer back to unit by risk assessment.
- Recovery assessment details following procedure and anaesthetic.
- Post-operative observations – ascertain frequency.
- Respiratory management post-operatively and oxygen requirement
- Prescription chart with appropriate analgesia / nurse-controlled analgesia / assess pain.
- Fluid / feeding management (varies depending on neonate and condition plus how much bowel is compromised) (Brasher et al, 2014)
- Wound Care plan- see previous unit (2S(i) Skin Care (Figure 86)
- Summary of operation, signed/ dated by surgeon with clear post-operative instructions including any potential risks (blood loss, significant changes to vital signs)
- Explanations to parents

Specific conditions

Follow post-operative instructions for individual conditions, Some examples:

- Resection for acute intestinal obstruction including NEC – continue gastric decompression, if applicable stoma assessment
- Oesophageal Atresia- ensure trans-anastomotic tube (ngt that passes the surgical oesophageal wound) is not dislodged.
- Gastroschisis- Care of the silo sac over the abdominal Congenital Diaphragmatic hernia– Ventilation management included.

Risk assessment for transfer to and from theatre

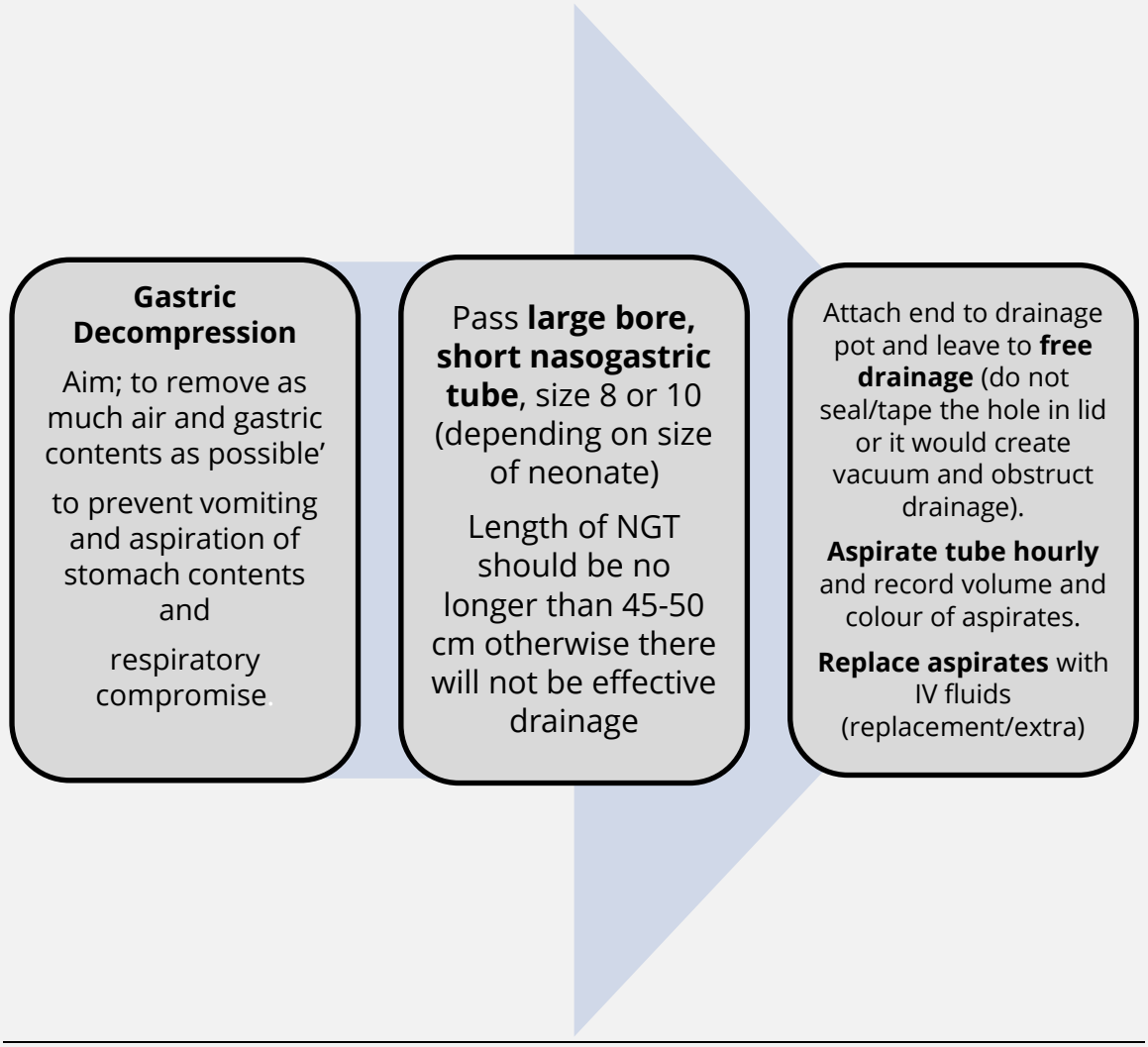
Low risk: No oxygen therapy, good oxygen saturations in air, alert and clinically stable
Medium risk: Oxygen requirement and signs of respiratory distress
High risk: Oxygen therapy >40%, requiring ventilation support.

Assessment of risk will determine who may be required to accompany neonate for transfer and equipment: transfer bag, suction, oxygen cylinder.

Gastric decompression

One of the most important, and yet simple, procedures to undergo in the surgical neonate is insertion of a short, wide-bore gastric tube for free drainage, gastric decompression and prevention of abdominal perforation. This is vital for any neonate with abdominal distension or suspected obstruction for whatever cause.

Figure 11.23 Gastric decompression



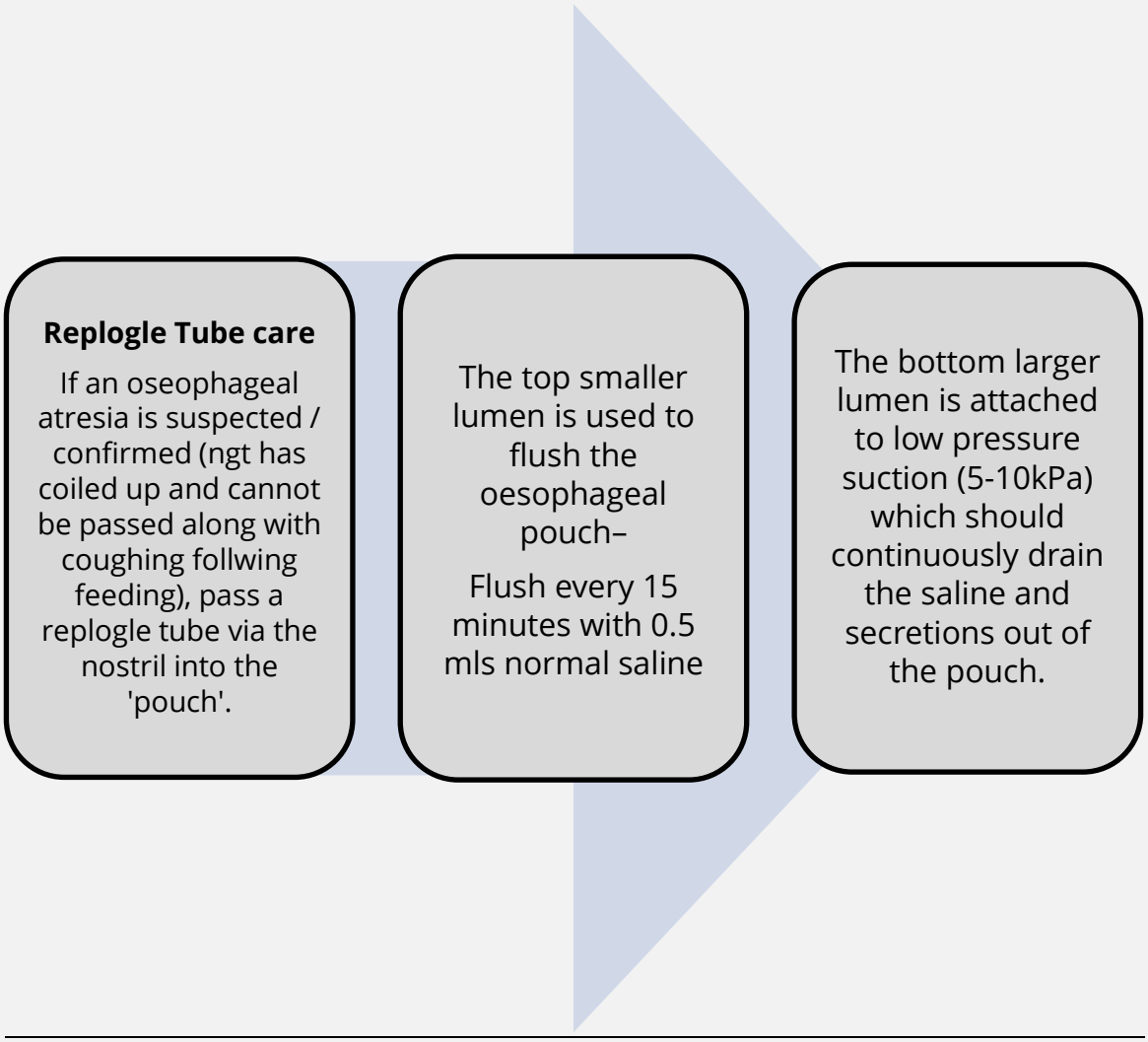
Stop and think

For *any* suspicion of acute intestinal obstruction from any cause, it is essential to remove the feeding tube and immediately insert a short, wide bore nasogastric tube on full drainage.

Replogle tube care

A replogle tube, which sits in the pouch blind end) of the oesophagus (in the case of oesophageal atresia) is a double lumen tube used to remove secretions from the upper GIT and prevent aspiration.

Figure 11.24 Replogle tube care



Stop and think

Continuous suction is necessary to ensure adequate clearance of secretions from the upper GIT and prevent them from entering the lungs.

Stoma care

A stoma may be formed following resection of any part of the small or large bowel when a primary anastomosis is not possible. The bowel is therefore bought out to the surface of the abdomen either as a loop or as two ends comprising a proximal, functioning stoma (top of the bowel exiting which eliminates stool) and a distal 'mucous fistula' (which leads to lower part of bowel to the anus).

Stop and think

Observation of both the stoma and the surrounding skin is an essential part of post-operative assessment.

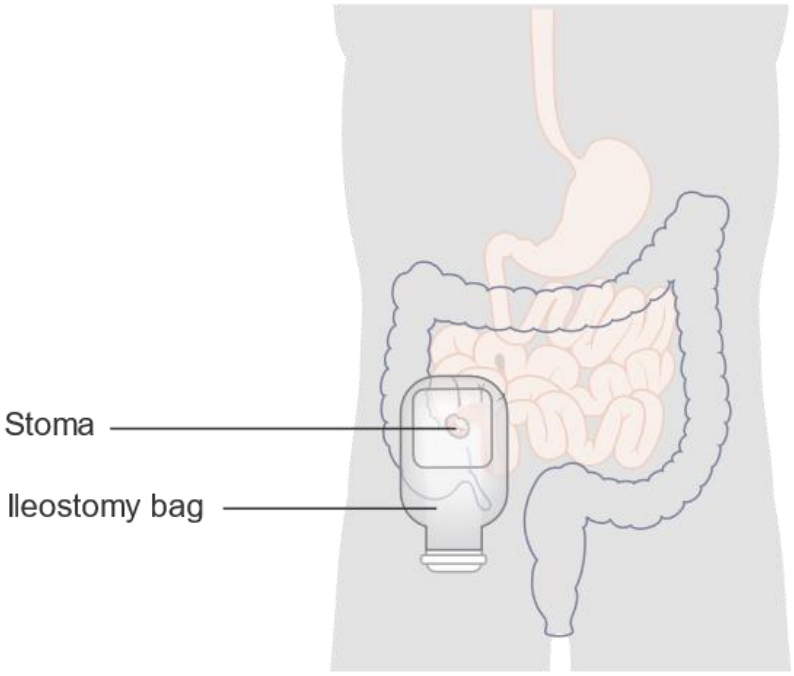


Figure 11.25 Neonatal stoma care

Assessment

- Colour of stoma (should be deep red/pink)
- Position of stoma (should be slightly raised).
- Report / refer if: the stoma bleeds excessively, prolapses out or retracts in, turns dark or bluish in colour and/or if the stoma losses become increasingly watery.
- Observe the skin for signs of excoriation/ rashes/ epidermal stripping.

Care principles

- Routine Stoma Care includes: emptying of stoma bag of stool/ flatus, change of stoma bag, care of peristomal skin.

Stoma bag care

- Cover stoma with petroleum impregnated gauze (jellonet) then a dry gauze over layer.
- When the stoma becomes active, a stoma bag should be fitted.
- Depending on the condition of the baby and the stoma, the volume of output and other obstacles to bag adhesion, acceptable time intervals for stoma change may vary.
- After initial formation, the stoma will decrease in size, so it will be necessary to re-measure the stoma size as each new stoma bag is applied.
- Angle the bag to encourage the contents to drain away from the stoma.
- Consider oral sucrose for pain/ discomfort management, pacifier for non-nutritive sucking and holding the neonate during stoma bag changing and care.

Documentation

- All stoma losses - colour, consistency and indication of amount.
- Complete stoma care and assessment record.
- If stoma losses are fluid, the volume in millilitres should be measured and recorded.
- Refer / liaise and formulate stoma care plan with stoma nurse specialist for advice on bags, skin care and use of adjuncts such as any liquid barrier film, frequency of changing stoma bag.

Parental considerations

- Inform parents about and involve them in the care of their neonate's stoma. If discharged home, careful discharge planning will be required. This will include;
- Parental teaching, assessment of parental competence to provide stoma care, supply of stoma appliances for discharge, arranging GP provision of stoma appliances in the community and community support.

Fluid therapy and feeding the surgical neonate

Due to compromise to the bowel from surgery, surgical neonates have specific care needs regarding fluid requirements and feeding regimes.

Figure 11.26 Fluid therapy and feeding the surgical neonate

Fluid requirements: Fluids (maintenance) are restricted in the immediate post-opertaive period for varying lengths of time due to the effects of anaesthesia and potential for overload. Increase as condition / recovery allows.

Fluid replacement: Output lost from the bowel should be measured (from gastic or stoma losses that are discarded or insensible loss via an abdominal well defect)

Replace losses with IV infusion (usually saline with potassium) as extra to maintenance either on a 'ml for ml' basis OR when losses reach a certain threshold agreed by the unit team.

Feeding: Resume feeds when the bowel is able to tolerate and has recovered from surgery.

Feeding readiness: Meconium or stool passing, bowel sounds, reduced / absent nasogastric losses that are clear

Milk: Feed preferably breast milk or if required, special hydrolysed formula: contain pre-digested protein for enhanced absorption and tolerance.

Specific cases

In Short gut when signiicfant bowel has been resected, long-term absorption may be affected

Long-term / home TPN may be required with trophic 'priming' of the bowel via small amounts of milk (may be continuous)

Gastrostomy feeding

Stop and think

Compromise to the bowel may persist for a significant period depending on the quality of bowel resected or the post-operative response.

Necrotising enterocolitis (NEC) assessment

NEC most commonly affects premature neonates and is essential that anyone working in this field is mindful of the potential and implications of this potentially devastating disease. The bowel becomes compromised when its blood supply is decreased before or following birth and bacteria that are normally present in the bowel invade the damaged area, causing more damage. Prognosis is dependent on the amount of bowel affected and co-morbidities. Vigilant assessment and supportive therapy are therefore essential.

Stop and think

Having a framework in which to assess a potentially devastating condition such as NEC assists in guiding appropriate management.

Management should commence as early as possible once any suspicion of NEC or acute intestinal obstruction arises.

Figure 11.27 Necrotizing enterocolitis (NEC) and Bell's (modified) staging criteria

Adapted from http://www.medicalcriteria.com/criteria/ped_nec.htm

Stage	Systemic signs	Abdominal signs	Signs on X-ray	Treatment
IA Suspected	Temperature instability, apnoea, bradycardia, lethargy	Gastric retention, abdominal distension, emesis, heme-positive stool	Normal or intestinal dilation, mild ileus	NBM, antibiotics
IB	Same as above	Bloody stool	Same as above	Same as IA
IIA Definite, mildly ill	Same as above	Same as above, plus absent bowel sounds with or without abdominal tenderness	Intestinal dilation, ileus, pneumatosis intestinalis	NBM, antibiotics for longer period than above
IIB Definite, moderately ill	Same as above, plus mild metabolic acidosis and thrombocytopenia	Same as above, plus absent bowel sounds, definite tenderness	Same as IIA, plus ascites	NBM, antibiotics for longer period than above

IIIA Advanced, severely ill, intact bowel	Same as IIB, plus hypotension, bradycardia, severe apnoea, mixed acidosis, DIC, and neutropenia	Same as above, plus signs of peritonitis, marked tenderness, and abdominal distension	Same as IIA, plus ascites	NBM, antibiotics for at least 10 days, fluid resuscitation, inotropic support, ventilator therapy, paracentesis
IIIB Advanced, severely ill, perforated bowel	Same as IIIA	Same as IIIA	Same as above, plus pneumo-peritoneum	Same as IIA, plus surgery
DIC: disseminated intravascular coagulation NBM- Nil by mouth				

Neurological care

A healthy baby will display signs of an intact central nervous system (CNS) such as normal reflexes, behaviour and responses to stimulation. The CNS of the sick and/or preterm neonate however is more vulnerable to the effects of hypoxia, infection, trauma or any other event that can potentially damage the developing CNS. The following content provides some of the assessment tools that are used in neonatal practice to diagnose or manage neurological conditions (Figures 11.28 to 11.32).

Intraventricular haemorrhage (IVH) grades - Intraventricular haemorrhage (IVH) is a major complication of prematurity. IVH initiates in the fragile germinal matrix, a richly vascularised area lining the ventricles in the developing brain affected by disturbances in the cerebral blood flow (CBF). Papile's grading is the most commonly cited tool used as depicted below.

Figure 11.28 IVH gradings

- **grade I**
  - restricted to subependymal region / **germinal matrix**. Overall good prognosis
- **grade II**
  - extension into **normal** sized ventricles and typically filling less than 50% of the volume of the ventricle. Overall good prognosis
- **grade III**
  - extension into **dilated** ventricles. ~ poor outcomes* likely.
- **grade IV**
  - grade III with **parenchymal (tissue**) haemorrhage. Higher rates of poor outcomes*

***Poor outcomes include complications (post-bleed hydrocephalus**,

- Preterm neonates will have a head ultrasound carried out early and then regularly.
- PVL is another neurological condition seen in the preterm brain.

Stop and think

Gentle handling and caution with care procedures should be considered to safeguard the vulnerable brain and prevent haemodynamic instability which is associated with IVH.

Hypoxic-ischemic encephalopathy (HIE)

Hypoxic-ischemic encephalopathy (HIE), previously known as perinatal asphyxia is characterised by acute or subacute brain injury due to asphyxia systemic hypoxaemia and/or reduced cerebral blood flow (CBF) before or at birth.

Figure 11.29 Hypoxic ischaemic encephalopathy (HIE) grades Sarnat staging system – HIE (adapted from Zanelli, 2013)

	Stage 1	**Stage 2**	**Stage 3**
Level of consciousness	Hyperalert	Lethargic or obtunded	Stuporous
Muscle tone	Normal	Mild hypotonia	Flaccid
Reflexes			
Suck	Weak	Weak or absent	Absent
Moro	Strong; low threshold	Weak; incomplete; high threshold	Absent
Eye movement reflex	Normal	Overactive	Weak or absent
Tonic neck	Slight	Strong	Absent
Need for ventilation	No	Yes	Yes
Heart rate	Tachycardia	Bradycardia	Variable
Feeding problems	Mild	Moderate	Severe
Seizures	None	Yes	Yes - early
Duration	1-3 days	2-14	Hours to weeks

Stop and think

The stage of HIE influences the care given and the long-term developmental outcome.

Therapeutic cooling

Evidence supports the use of therapeutic hypothermia for term newborn infants with Moderate to-severe hypoxic ischaemic encephalopathy reduces the combined outcome of death or long-term neurodevelopmental disability at 18 months (Jacobs et al, 2013; Witt, 2013). Criteria for Cooling needs to be clear so that neonatal staff understand the process of referral for cooling.

Stop and think

Therapeutic cooling is undertaken in specific neonatal units to which neonates are referred and transferred. However, passive cooling can be commenced in *any neonatal uni*t once referral for 'active' therapeutic cooling is decided and can be done by simple measures such as turning off incubator temperature, leaving portholes open and leaving only a nappy on the neonate.

Figure 11.30 Therapeutic cooling

(A +B)

A. Neonates *>36 weeks gestation with at least one of the following*:
Apgar score of <5 at 10 minutes after birth.
Continued need for resuscitation, including endotracheal or mask ventilation, at 10 minutes after birth.
Acidosis within 60 minutes of birth (pH <7.00).
Base Deficit 16 mmol/L within 60 minutes of birth.
Infants who fulfil the A criteria should be assessed for whether they fulfil the B criteria.
B. *Moderate to severe encephalopathy, consisting of altered state of consciousness (lethargy, stupor or coma) AND at least one of the following:*
hypotonia.
abnormal reflexes including oculomotor or pupillary abnormalities.
an absent or weak suck.
clinical seizures, as recorded by study personnel.

- Cooling started within 6 hours (continued for 72 hours)

TOBY guidelines NPEU (2010)

Figure 11.31 Therapeutic cooling - nursing overview

Preparation

- In a cooling unit, prepare equipment (cooling blanket or bed)
- If in a non-cooling unit, arrange neonatal transfer.
- Any unit, start passive cooling and take temperature regularly (every 15 minutes)
- Parental consent

Cooling

- Body is cooled to 33-34 degrees Celsius (no lower than 33)
- Central / rectal temperature via probe is taken continually
- Cerebral function monitoring is undertaken during cooling along with all vital signs. Observe heart rate baseline which may be lower than previous.
- Ensure CO2 does not drop below 5 on blood gas analysis (cooling can cause alkalosis)
- Coagulation is checked
- Fluids restricted
- Observe for pain and discomfort. Morphine given and sedation if required.
- Observe skin for integrity / tissue viability (? fat necrosis)

Re-warming

- Re-warm 0.5 degrees every 2 hours is a suggested rate
- When central temperature is at an agreed value, switch cooling off
- Observe carefully during re-warming (blood pressure may drop)
- Follow-up, scans and referral to the central register

Stop and think

Re-warming should be done carefully and slowly avoiding large, sudden increases in the central temperature.

Cerebral function monitoring (CFM)
(aEEG: amplitude integrated electroencephalogram)

aEEG monitoring allows the ability to view activity of the brain over long periods of time at the bedside. Neonates considered for CFM include: any neonate who has likely HIE, is receiving hypothermia for HIE, is suspected or at high risk of having seizures &/or abnormal movements and neonates with unexplained neurological signs.

Figure 11.32 CFM

Application

- Sensor / electrode application on the scale; see manufacturer's instructions.
- Hydrogel or low impedance needle electrodes. Hydrogel electrodes are preferable to avoid discomfort and they adhere better in warm conditions. Water can be used to rehydrate hydrogel electrodes.
- Electrodes must be a minimum of 2 mm apart for correct tracing to be recorded. Low impedance is necessary for a 'clean' trace while the presence of impedance may artificially interfere with the trace.
- Care should be taken to prevent electrodes from becoming accidentally dislodged.

Record events

- Nursing care and procedures undertaken in the care of the neonate receiving CFM should be recorded. This is used when interpreting the data.

Ongoing assessment

- Observe /assess clinical signs displayed by the neonate during CFM and document / report accordingly – for example: vital signs, abnormal movement and tone.

Stop and think

Interpretation of CFM data is carried out by a health professional who is trained in classifying aEEG traces, experienced with the expected patterns exhibited, both normal and abnormal.

Neonatal abstinence syndrome

Neonates born to drug addicted mothers may become dependent on those drugs themselves during pregnancy and then withdraw from that drug after birth. These are said to have neonatal abstinence syndrome (NAS). NAS may develop in newborns exposed to narcotics in utero. Although NAS is more typically seen in opiate withdrawal, similar symptoms are seen when withdrawing from benzodiazepines, barbiturates and alcohol. Several abstinence scoring systems can assist nurses and physicians in assessing the severity of NAS withdrawal and providing appropriate therapy. Figure 11.33 outlines an overview of the common features of an assessment tool for NAS used to identify the extent to which a neonate is withdrawing from the passive effects of drugs. Finally, any simple and effective nursing intervention used may help to reduce stress for these vulnerable neonates and their families.

Stop and think

Assessing the neonate for the presence of NAS or to decide whether to start treatment is open to interpretation due to the subjective nature of assessing neonatal behaviour consistently by different practitioners and at different times of the day. Attempts should be made to increase objectivity by measures such as providing consistency of allocated nurses if possible and ensuring any confounding factors are limited.

Figure 11.33
Assessing the neonate for neonatal abstinence syndrome (NAS)

Neurological features	**Gastrointestinal features**
Tremors	Poor feeding
Irritability	Uncoordinated and constant sucking
Increased wakefulness	Vomiting
High-pitched crying	Diarrhoea
Increased muscle tone	Dehydration
Hyperactive deep tendon reflexes	Poor weight gain
Exaggerated Moro reflex	
Seizures	
Frequent yawning and sneezing	
Other	**Autonomic signs**
Fever	Increased sweating
Mottling	Nasal stuffiness
Temperature instability	

Scoring: key points

Various versions of tools exist but most are based on an original tool by Finnegan and Kaltenbach (1992). Whatever tool is used however, there are some common elements.

- Scoring tools lists symptoms that are most frequently observed in NAS.
- Each symptom and its associated degree of severity are assigned a score, and the total abstinence score is given.
- The first abstinence score on admission should be recorded as baseline.
- Following the baseline score, scoring is done at intervals decided and agreed according to the individual neonate symptoms, whether treatment is required.
- In a term neonate, scoring should be performed after a feed, before they fall asleep. A crying neonate should be soothed and quietened before assessing muscle tone, Moro reflex and respiratory rate. Modification may be required for preterms.
- Multiple drug misuse alters the pattern of withdrawal.
- The optimal threshold score for starting pharmacologic therapy for NAS is also subject to local unit policy.

Transportation of the neonate

This section focuses on neonatal transportation. It is vital that accessibility to a tertiary NICU be available for all unstable newborn infants. Maternal antenatal transfer provides more favourable outcomes for ill newborns and adverse events have been associated with ex-utero (Ratnavel, 2013). However, some infants will inevitably need to be transported acutely to. In reverse, it is equally important to have a good system in place to facilitate the transfer of these patients back to their hospital of booking. Figures 11.34 and 11.35 deal with stabilisation and equipment checking. Stabilisation of the sick neonate prior to transporting them is essential to ensure best outcomes. While waiting for the retrieval team, to prepare for transfer, a checklist for stabilisation and equipment can be useful.

Stop and think

Time taken to stabilise a neonate and optimise their condition is time well spent prior to transporting them to another centre.

Figure 11.34 Stabilisation prior to transfer

Airway management • establish a patent airway, • evaluate the need for oxygen, or an artificial airway • security of the airway – (ETT) must be secure to prevent intra-transport dislodgement • chest X-ray – to check position of the ETT.

Breathing The need for intra-transport ventilation must be assessed: • oxygenation, • ABG, • tachypnoea and expected respiratory fatigue, • recurrent apnoeic episodes • Consider if it safer to intubate for transfer.

Circulation • heart rate and perfusion (capillary refill) are good indicators of CVS status, • blood pressure • intravenous access (at least 2 cannulae) • If dehydrated, the neonate must be rehydrated before leaving.

Communication • Good communication between the different teams will help better coordination of the transfer. • inform the receiving specialist unit, • patient details, • history/ physical findings/provisional diagnosis/investigations, • current management and status of the baby. • mode of transport • Use of SBAR

Drugs as required • antibiotics, • analgesia/ sedation: especially if neonate is intubated, • inotropes, • vitamin K.

Documentation • history including antenatal and birth history/ physical findings/ diagnosis, • input/output charts, • investigation results/ X-rays, • parents' contact telephone numbers.

• **Environment** • Neutral Thermal Environment, • optimal temperature for the neonate (axilla) • prevention of heat loss- Incubator heated and transwarmer ready unless passive cooling is required.

Equipment: - Check all equipment.

Fluid therapy resuscitation fluid, maintenance fluid, other ongoing or anticipated losses in the surgical neonate, eg intestinal obstruction, gastroschisis.

Gastric decompression • An orogastric tube will be required in surgical neonates with 4 hourly aspiration and free flow of the gastric contents.

Immediately before departure

CHECK clinical condition and vital signs, positioning, pain and stress levels, secure the neonate and all tubes, function of equipment.

Re-communicate with receiving unit about current status and expected time of arrival.

PARENTS – include as part of stabilisation process and consider their needs.

Preparing for transportation

Even for staff who are not part of a dedicated team, transfers may still occur within the hospital to and from delivery suite, x-ray dept. and other; in addition, non-urgent back transfers may also be carried out by neonatal staff. A transport incubator checklist therefore can be useful to promote safety and preparation.

Figure 11.35 Checking the transport incubator

Transport incubator

- Check function before leaving the hospital.
- Ventilator working without any leaks, gives pressure.
- Monitors: cardiorespiratory and pulse oximeter
- Infusion pumps with adequately charged batteries.
- Suction device functions properly
- Oxygen cylinders – ensure adequacy for the whole journey.

Equipment

- Intubation and ventilation equipment and ETTs of varying sizes
- (Laryngoscope, Magill forceps, batteries with spares)
- Manual resuscitation (BVM) bags and masks of appropriate size are available and in working order.
- Suction apparatus and catheters /tubing
- Oxygen tubing
- Anticipated medication and water for dilution and injection
- IV fluids, giving sets. Pre-draw fluids or medication into syringes if required Intravenous cannulas of various sizes.
- Needles of different sizes
- Syringes and tubing
- Suture material
- Adhesive tape, scissors
- Gloves, gauze, swabs (alcohol and dry)
- Stethoscope, thermometer
- Nasogastric tube
- Transwarmer mattress
- Chest clamps (if water seal chest drain is present)

Stop and think

As for any essential equipment, being familiar with the presence and working of the transport incubator maximises safety.

Umbilical care and catheters

In the healthy, term, near term or healthy preterm neonate at birth, evidence supports the recommendation to delay cord clamping for at least one to two minutes prior to clamping and cutting (two minutes for term, one minute for preterm). Once clamped and cut, the cord is then kept clean and is observed until the stump separates. In the sick or high-risk neonate who requires admission after birth to neonatal care, the cord is clamped and cut immediately leaving a long stump which is then catheterised. Figure 11.36 deals specifically with the care issues around umbilical vessel catheterisation.

Stop and think

The timing of cord clamping now supported a delayed cord clamping strategy [DCC].

If used for catheterisation, any umbilical catheter has associated risks which should be observed on at least an hourly basis and documented. Catheters should be removed if any concern arises.

Figure 11.36 Umbilical catheter care - overview

Use of umbilical cord at birth

- At birth, the cord can be used for blood sampling and once cut, the umbilical vein can be used for catheterisation when emergency resuscitation drugs are required.
- In an unstable, sick neonate who requires admission to intensive care, both an umbilical venous catheter and arterial catheter can be inserted (UVC / UAC)

UVC: For fluid and drug administration
UAC: For arterial monitoring and blood sampling.

Positions for umbilical catheters

- There are two potential positions for the UAC. These are described as "high" or "low" and confirmed on Chest X-ray (BAPM 2018)
- The high position is at the level of thoracic vertebral bodies T6-T9- "above the diaphragm" The low position is at the level of lumbar vertebral bodies L3-L4. Both avoid points that may interfere with perfusion to vital organs. (References: BAPM 2018*).*

Care of UAC / UVC s

- UACs- The same principles apply as for care of arterial lines in general and blood sampling from arterial lines (See also cardiovascular care; book, chapter 11).
- There are some specific issues around umbilical catheterisation that are relevant here as these are central vessels.
- Neonates with UACs/UVCs are not placed prone.
- Lower limbs need to be closely observed for perfusion.
- The stump should be well secured and observed for bleeding and redness/ infection.
- Remove the catheters when vessels are no longer patent, or complications / concerns arise.

Stop and think

Any umbilical catheter has associated risks which should be observed on at least an hourly basis and documented. Catheters should be removed if any concern arises.

Glossary

Albumin: A protein found in blood plasma responsible for ensuring fluid does not leak from blood vessels into surrounding tissues.

Alkaline phosphatase: A group of isoenzymes (when two or more molecules of enzyme are closely related but not identical to each other) located on the outer layer of the cell membrane. Abnormal levels can be caused by liver or bone conditions.

Ammonia: Produced by cells throughout the body, especially the intestines, liver, and kidneys. Most ammonia is used by the liver to make urea.

Amylase: An enzyme (type of protein) that helps the body to break down carbohydrates.

Aspartate transaminase: An enzyme (type of protein) that is released when the liver or muscles are damaged.

Bicarbonate: A base (a substance that can neutralise acid by reacting with hydrogen ions); it helps keep a normal acid-base (pH) balance.

Bilirubin: Bile pigment produced by breakdown of haem from red blood cell metabolism which is measured from analysing blood serum.

BiPAP (Bilevel positive airway pressure): BiPAP machines can switch between inhalation and exhalation pressures (whereas CPAP provides a constant pressure).

Bradycardia: Slow heart rate.

Calcium (ionised): The amount of calcium in the blood that is not attached to proteins. Calcium is an electrolyte that helps to build and maintain bone strength; it also plays an important role in nerve and muscle function.

Calcium (total): A measure of the calcium level in the blood. Calcium is an electrolyte that helps to build and maintain bone strength; it also plays an important role in nerve and muscle function.

Capillary refill time: The length of time taken for the skin colour to return to a capillary bed after pressure has been applied to the skin and caused blanching.

Cardiac output: The amount of blood pumped out of the ventricles.

Chloride: An electrolyte that plays an important role in the regulation of body fluids, electrolyte balance, electrical neutrality and acid-base status

Conjugated bilirubin: Bilirubin which is water soluble and able to be excreted via the urine.

Continuous positive airway pressure (CPAP): A constant positive airway pressure either set at one level or two alternating levels, is applied to the airway of a spontaneously breathing neonate to maintain adequate functional residual capacity within the alveoli and prevent atelectasis.

C-reactive protein (CRP): A protein made by the liver; increases in times of infection.

Creatinine: A compound produced because of the metabolism of creatine (mainly located in the brain and muscles) and excreted in urine.

Ductus arteriosus: Small blood vessel connecting the pulmonary artery to the aorta in order to bypass pulmonary circulation during foetal development.

Electrolytes: A substance that ionizes when dissolved in suitable solvents such as water (for example: Sodium, potassium, magnesium, calcium).

Endotracheal tube (ETT): Small plastic tube that is inserted through the nose or mouth down through the larynx and into the trachea for full mechanical ventilation.

Fibrinogen: A glycoprotein that is produced by the liver and helps blood to clot.

Full blood count (FBC): A blood test that measures the number and status of different types of blood cells, including red cells, white cells, and platelets.

Globulin: Plays an important role in liver function, blood clotting, and fighting infection.

Glucose: Provides the body with energy and is essential for all cells of the body. It supplies the 'fuel' for respiration which generates adenosine triphosphate (ATP), the energy source for all cells.

Haematocrit: The packed cell volume (PCV) expressed as a percentage. Newborns have a higher haematocrit than adults and older children.

Haemoglobin (Hb): A protein found in the red blood cells that carries oxygen in the body and gives blood its red colour.

Hypercapnia: Higher than normal levels of carbon dioxide in the circulating blood.

Hyperthermia: Body temperature above the normal range**.**

Hypotension: Lower than normal range of blood pressure (Mean blood pressure <40mmHg in term/<30mmHg in a preterm baby).

Hypothermia: Body temperature below 35 degrees Celsius.

Iatrogenic: Illness caused by medical intervention or treatment.

Insulin: A hormone made in the pancreas that helps to regulate blood glucose levels.

Intermittent positive pressure ventilation: The use of a mechanical ventilator to deliver controlled pressures of gas (primarily oxygen) to the lungs.

Intubation: Insertion of a tube, via the nasal or oral passages, to the trachea.
Iron: A mineral that is required for growth and development. Iron is also used to make haemoglobin.

Jaw thrust: A means of opening the airway of an unconscious person.

Lactate: A by-product of anaerobic metabolism when oxygen delivery to the tissues is insufficient to support normal metabolic demands.

Laryngeal mask: An airway device that, when inserted, forms a seal on top of the glottis – the opening between the vocal cords; (endotracheal tubes pass through the glottis to the trachea).

Lymphocytes: A type of white blood cell; there are two main forms: B cells and T cells. The B cells produce antibodies that attack invading bacteria, viruses, and toxins; T cells destroy the body's own cells that have been taken over by viruses or become cancerous.

Magnesium: An electrolyte that plays an important role in protein synthesis, muscle and nerve function, blood glucose control, and blood pressure regulation.

Meconium: Foetal stool. The thick, sticky and dark green substance forming the first faeces of a newborn baby.

Metabolic acidosis: An increase in hydrogen ion concentration in the systemic circulation; this results in a low bicarbonate level.

Monocytes: A type of white blood cell. Monocytes turn into macrophage or dendritic cells when an organism (such as bacteria) enters the body.

Nasopharyngeal: The upper part of the pharynx (throat) that lies behind the nose.

Neonatal intensive care unit: Specialises in the care of babies who are critically ill; they may have been born prematurely, have low birth weight or have a medical diagnosis that requires specific care and management.

Neutrophils: A type of white blood cell that act as the immune system's first line of defence.

Oliguria: Low urine output (as calculated according to the weight of the infant).

Oropharynx/oropharyngeal: The soft palate, the pharynx (throat), the tonsils, and the rear of the tongue.

Oxygen saturation: Measures the percentage of haemoglobin that is bound to oxygen.

Oxygenation index: Assesses the degree of hypoxic respiratory failure and persistent pulmonary hypertension of the newborn.

Partial thromboplastin time (PTT): Measures the length of time taken for blood to clot.

Persistent pulmonary hypertension of the newborn: A condition in which the pulmonary arteries remain constricted after birth.

Phosphate: An electrolyte that is essential for the production of energy, muscle and nerve function as well as bone growth.

Plasma osmolarity: A measure of the different solutes (dissolved substances) in plasma.

Platelets: a small colourless disc-shaped cell fragment without a nucleus, found in blood and involved in clotting.

Pleural effusion: The accumulation of fluid in the pleural cavity (in between the parietal and visceral pleura).

Pneumothorax: Collapse of part, or all of a lung.

Potassium: An electrolyte that helps to maintain the levels of fluid inside cells (intracellular). It also facilitates muscle contraction and supports normal blood pressure.

Pre-ductal SpO2: Arterial saturation in the vessels that originate from the aorta before the ductal orifice.

Preterm/premature: Relates to babies who are born alive before 37 weeks gestation.

Protein (total): Measures the amount of protein in the blood.

Prothrombin: Helps blood to clot.

Pulmonary haemorrhage: Bleeding into the lung(s).

Pulse oximetry: A non-invasive method to measure oxygen saturation levels.

Retinopathy of prematurity: Abnormal blood vessels grow in the retina and can lead to blindness.

Respiratory distress syndrome: A condition in which an infant's lungs cannot provide their body with enough oxygen.

Sodium: An electrolyte that helps to maintain the body's fluid balance as well as nerve and muscle function. It maintains normal fluid levels outside of cells (extracellular).

Surfactant: A substance that reduces the surface tension within the lung alveoli allowing them to expand in normal breathing.

Tachycardia: Rapid heart rate, above the normal expected range.

Thrombin: a proteolytic enzyme (breaks down proteins) that is formed from prothrombin and helps blood to clot.

Thromboplastin: Aids blood clotting by facilitating the conversion of prothrombin to thrombin.

Thrombin time (TT): The length of time that it takes for the blood's plasma to form a clot.

'T-piece' inflation: Used to provide positive pressure ventilation.

Urea: a colourless crystalline compound that is the end product of the metabolic breakdown of proteins; it is excreted in urine.

Vernix: A thick, greasy substance made of water, fatty acids, and proteins, which creates a moisturizing and protective barrier for a baby's skin.

VTV (volume targeted ventilation): A more recent mode of ventilation that is designed to reduce the lung damage that can be caused by more standard ventilation methods.

White blood count (WBC): The number of white cells per microlitre of blood.

White cells: Form part of the body's immune system. They help to fight infection. Types of white blood cells are: Granulocytes (neutrophils, eosinophils, and basophils); monocytes and lymphocytes (T cells and B cells).

EXTRA READING

For additional guidance, refer to the following guidelines:

- NICE (2019) **Specialist neonatal respiratory care for babies born premature**
- British Association of Perinatal Medicine (2024) **Management of Bilious Vomiting in the Newborn Period and Radiological Support for Neonatal Services - A DRAFT BAPM Framework for Practice.**
- British Association of Perinatal Medicine (2018) **Use of Central Venous Catheters in Neonates (Revised 2018) A BAPM Framework for Practice**
- UK Resuscitation Council (2021) **Newborn resuscitation and support of transition of infants at birth Guidelines**

Also read the following papers:

- El-Radhi (2015) **Management of common neonatal problems**
- Sweet et al (2023) **European Guideline Consensus on the Management of Respiratory Distress Syndrome**
- Gupta and Adler (2016) **Management of an Unexpected Delivery in the Emergency Department.**