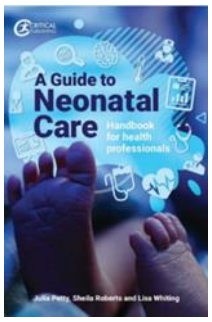
Chapter 8- Important principles of care in the neonatal unit



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

Supplementary information

Neonatal Thermal Care

Refer to the book chapter 8 for information on thermal care, heat loss methods, maintaining an optimum thermal environment and how to keep neonates warm. To add further detail to this content, neonates who experience temperature stability demonstrate enhanced growth, decreased oxygen requirements, reduced mortality, and reduced morbidities associated with hyperthermia and hypothermia (Wood et al, 2022). The neutral thermal environment (NTE) is an environment in which the neonate maintains a normal body temperature in order to minimise energy expenditure and oxygen consumption. The recommended normal temperature ranges for neonates depend on factors such as maturity and weight. For term neonates, axillary temperatures, range from 36.5°–37.5°C, preterm neonates 35.6°–37.3°C, and very low /extremely low birth weight neonates 36.7°–37.3°C (Hodson, 2018). The use of double-walled incubators is the optimum method of providing NTE in the first instance, at a time when thermal control is limited. Other key interventions such as use of plastic wrapping bags in preterm babies, skin-to-skin and thermal mattresses should also be considered (McCall et al, 2018; Smith, 2016). Age and gestation must be considered in order to set the desired incubator temperature. This assists to combat radiant heat loss with an inner, warmer wall equal to that of the ambient air temperature inside the incubator, providing a barrier that protects the preterm neonate from cooler exterior surfaces (Wood et al, 2022). The majority of modern incubators have a servo mode function and this is the preferred method for neonates requiring assisted thermoregulation. Servo control maintains the neonate's temperature within a specific range by adjusting

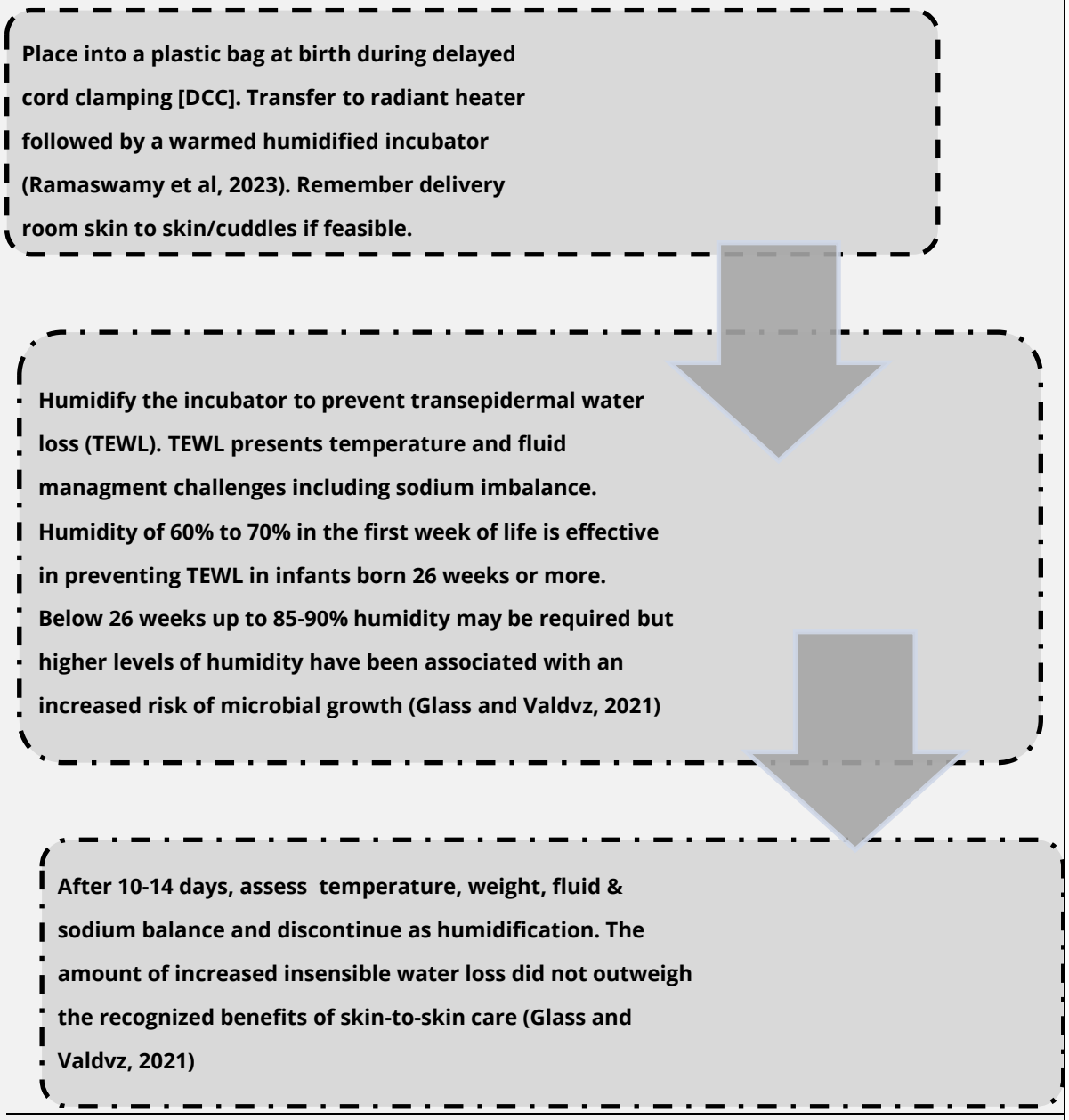
heat output to achieve a pre-set skin probe temperature. Optimal temperature probe placement is on the abdomen for a supine neonate or on the back over the flanks if positioned prone. The probe should be resited and continually observed. It is recommended that axillary temperature checks 4-8 hourly by nursing staff are undertaken (Joseph et al, 2017).

Humidification

Current consensus amongst healthcare professionals supports the use of incubator humidification as a method of preventing trans-epidermal water loss (TEWL). It is suggested that minimizing the water gradient between the internal environment of the neonate and the external environment of the incubator will minimise evaporation through the skin (Rizk et al, 2022). However, recent studies have demonstrated that microbes and toxins thrive in humid conditions thus increasing the risk of infection (Glass and Valdez, 2021). Furthermore, there is a current lack of robust evidence to support specific guidelines and no study has directly compared different percentages, durations, and weaning practices of humidification to one another in a controlled manner which has resulted in variations in practice (Rizk et al,2022). Generally, a neonate < 26-30 weeks, < 1kg in weight and in the 1st 7-10 days should be nursed in 60%- 70% relative humidity via a closed incubator to provide their optimum NTE. For neonates below 26 weeks gestation it is common for humidity up to 95% to be utilised. However more research around incubator humidity of neonates less than 26 weeks' gestation is required. Weaning high humidity levels should begin after 1 week of life and unnecessary incubator humidity discontinued once the neonate has developed a skin barrier at approximately 2 weeks' postnatal age (Turnbull and Petty, 2013; Glass and Valdez, 2021). See Figure 8.1 for a summary.

 **EXTRA READING –** Read more about this topic……Liu, J., Wu, S., & Zhu, X. (2022). Advances in the Prevention and Treatment of Neonatal Hypothermia in Early Birth. *Therapeutic Hypothermia and Temperature Management*, *12*(2), 51-56.

Figure 8.1: Humidification in thermal care



Stop and Think

A neonate's temperature along with fluid and electrolyte status should be monitored when administering humidity.

Fluid balance & electrolytes

The management of fluid and electrolyte therapy is an important area because many neonates in the NICU will require intravenous fluids. The prematurely born neonate has relatively low cellular mass and water is the main constituent of the body (Goyal and Banerjee, 2020). During post-natal adaption, fluids, electrolytes and nutrients previously supplied by the placenta are removed and this has an immediate impact. The body experience shifts of fluids between intracellular, extracellular, and vascular compartments resulting in changes in daily requirements during the first 7-14 postnatal days (Moss, 2022).

Electrolytes are required for optimum cellular function and DNA synthesis for repair and growth. In the unwell or prematurely born neonate, imbalances of fluid and electrolytes are common, which may be further aggravated by NICU treatment procedures (Fusch and Jochum, 2014). The neonate does not tolerate conditions of excess or deficiency well, therefore, careful attention to fluid and electrolyte *balance* is required to avoid harmful fluctuations (Goyal and Banerjee, 2020).

Refer to the information on calculating fluids, electrolytes and daily allowances (see book; chapter 8), glucose and electrolyte requirements and administration (Figure 8.2) and intravenous infusion (IV) care (Figures 8.3 and 8.4), summarised below. Optimum fluid management is about ensuring a balance between input and output. Neonatal fluid management will change and adapt based on age, weight, maintenance needs, deficits, and ongoing losses. It is a vital part of neonatal care and is not always straightforward in a sick and/or preterm neonate (Moss, 2022).

Figure 8.2 Glucose and Electrolyte requirements and administration

ESPGHAN/ESPEN/ESPR/CSPEN Guidelines (Jochum et al, 2018)

Electrolyte Requirements

Sodium (Na+) mmol/kg/day	Day 1	Day 2	Day 3	Day 4	Day 5
Term neonate	0-2	0-2	0-2	1-3	1-3
Preterm neonate >1500g	0-2	0-2	0-3	2-5	2-5
Preterm neonate >1500g	0-2	0-2	0-5	2-5	2-5
Potassium (K+) mmol/kg/day	0-3	0-3	0-3	2-3	2-3
Chloride (Cl) mmol/kg/day	0-3	0-3	0-3	2-5	2-5

- *Glucose:* On day 1, 10% Glucose. Higher concentrations may be required if neonate is hypoglycaemic, fluid restricted or requiring multiple IV infusions. However, this should not delay the initiation of PN if PN is indicated.
- Electrolyte intake is varied according to plasma values, but the following is a guide.
- *Sodium:* Needed once the neonate develops a natriuresis (evidenced by increased urine output, falling weight, and sometimes falling serum sodium). Excretion occurs primarily through urine. In cases of high urinary Na losses, the need for Na supply may exceed 5 mmol/kg/day.
- *Potassium:* Should not normally be given on the first day of life. Should only be started once there is good urine output, considering the potential for the development of nonoliguric hyperkalaemia. Serum potassium <5mmol/l and satisfactory creatinine. Start at 2-4mmol/kg/day.
- *Chloride (Cl):* intake should be slightly lower than the sum of Na and K intakes (Na + K-Cl = 1–2 mmol/kg/d) to avoid excessive Cl intakes and risk of iatrogenic metabolic acidosis
- *Calcium:* Hypocalcemia is more common in preterm / low birth weight neonates because their parathyroid glands immature. Calcium may be needed on the first day of life (start at 1mmol/kg/day).
- *Replacement of GI losses (surgical):* losses may be increased under pathological conditions i.e. bowel obstruction, ileostomy, pleural effusions, peritoneal drainage, and external cerebrospinal fluid drainage. These should be replaced with 0.9% Sodium Chloride with Potassium Chloride added.

Stop and think.

- Care must be taken when administering electrolytes intravenously as they are *hypertonic* solutions, potentially causing significant damage to the tissue if there is any extravasation. Observe the IV site regularly and record the information.
- Electrolytes should be prescribed and administered according to individual need and evaluated on a regular basis. Always check prescriptions individually and ensure that you are satisfied that the baby is receiving the correct amount of electrolytes prescribed.

Intravenous infusion (IV) Care

The importance of vigilance with IV devices and assessment must be emphasised to prevent both infection and damage to fragile veins and IV sites, particularly in relation to the fragile vascular system in the neonatal population (Dioni et al, 2014). For long-term IV infusions, the use of percutaneous inserted central catheter (PICC) is commonplace (Linakis et al, 2016). However, peripheral venous cannulas need to be used frequently for drugs and so risk prevention is essential. Two frameworks can be applied to this: 1- IV Care bundle and 2- IV site assessment tool [Figures 8.3 and 8.4 respectively].

Figure 8.3 Intravenous Infusion Care Bundle- Checklist (Aziz, 2009)

- ✓ Handwashing
- ✓ Assess need for IV cannula / PICC line.
- ✓ Site inspection hourly and document
- ✓ Use VIP score (see Figure 8.5) and document.
- ✓ If lines are not required, remove.
- ✓ Access – use aseptic non-touch technique (ANTT)
- ✓ Clean all ports with alcohol swab and allow to dry.
- ✓ Administration set replacement – depends on local policy and the solution being administered.

Stop and think.

Care bundles are groups of three to five evidence-based interventions that, when performed together, produce better outcomes than if performed individually (International Society for Infectious diseases [ISID], 2019). They provide a way to ensure that the minimum standard of care is delivered. Care bundles are an effective tool for healthcare providers to improve the quality of care they deliver to their patients. (Garcia et al 2022; Lavallée et al 2017)

EXTRA READING – Read more about care bundles from the International Society for Infectious diseases https://isid.org/guide/infectionprevention/bundles

Figure 8.4 Visual Infusion Phlebitis scale

Adapted from Higginson and Parry (2011)

Appearance	Score	Stage of Phlebitis
IV site appears healthy Action: observe cannula	**0**	No signs.
One of the following signs is evident ● Slight pain near IV site or ● Slight redness near IV site Action: observe cannula	**1**	First signs.
Two of the following are evident ● Pain at IV site ● Redness ● Swelling Action: resite cannula	**2**	Early stage.
All the following signs are evident ● Pain along path of cannula ● Redness around site ● Swelling Action: resite cannula and consider treatment	**3**	Medium stage.
All the following signs are evident/extensive ● Pain along path of cannula ● Redness around site ● Swelling ● Action: resite cannula and consider treatment	**4**	Start of advanced stage.
All the following signs are extensive ● Pain along path of cannula ● Redness around site and swelling ● Extravasation**	**5**	Advanced stage.

Action: initiate treatment*/resite cannula

**Treatment: Stop infusion, remove IV device, elevate limb, apply comfort measures, for peripheral site extravasation injury; follow local policy and consider subcutaneous irrigation.

Stop and think.

Extravasation injury can arise rapidly if administering hypertonic drugs, glucose or electrolyte concentrations (Dioni et al, 2014). All intravenous devices / sites should be assessed regularly and documented.

Gastrointestinal care and feeding

Refer to the book chapter 8 for information on feeding methods and nutritional requirements in the neonatal unit. To add further detail to this content, the aim is always to feed a neonate *as early as possible* if their physiological condition, gestation and ability to tolerate enteral feeding allows (Tume et al, 2020). Breast feeding with a mother's own milk is the preferred feeding option for any neonate. In the preterm neonate, benefits are further pronounced as it lowers the risk of complications such as necrotising enterocolitis and infection and improves long-term health outcomes such as chronic lung disease, metabolic syndrome and neurodevelopment outcomes. Prematurity raises barriers for the initiation of mother's own breast milk feeding and its continuation as mother and baby are separated due to the need for medical intervention and sucking and swallowing is immature. The expression of breast milk is therefore necessary for several weeks before the baby is able to breast feed (UNICEF, 2016; Heller et al 2021). In addition, not all mothers continue to produce milk for varying reasons, or they may choose to feed using formula preparations when discharged home. The use, handling and preparation of expressed breast milk is outlined in Figures 8.5 and 8.6 that address the making up of breast milk preparation and powdered formula milk respectively.

Stop and think.

- Any specific nutritional advice should be discussed with the neonatal dietician as an important member of the multi-disciplinary team.
- Another important of the multi-disciplinary team is the feeding specialist or someone allocated to supporting and advising on feeding, for both staff and parents. Advice includes how to prepare and store milk for feeding.

Figure 8.5 Handling and storage of expressed breast milk

(NICE, 2006, Rhodes, 2012)

Expressing

- All mothers in the hospital setting should be taught how to express, label, and store their milk in line with the local Trust standard.
- Each neonate should have a designated space in the fridge and milk refrigerated immediately.
- Tips for mother: the aim is to start expressing within six hours from delivery, express at least once between midnight and 6am, hand pumping is useful to collect colostrum followed by electric pump and express 8-10 times per 24-hour period until milk supply established avoiding long gaps than 6 hours (Fewtrell et al, 2016)

Making up feeds

- In line with local policy and using Standard precautions to prevent infection, feeds should be made up in sterile syringes or bottles to suit the desired qualities and feeding pattern for each neonate. Fortifier to be added as per local guideline.

Labelling

- Labelling should include neonate's hospital number and name; date and time milk was expressed/defrosted.

Storage

- Milk should be used within recommended. A general guide is– 4 hours at room temperature, 96 hours in the fridge, 24 hours from time removed from the freezer and frozen for 6 months.

- Unused breast milk is discarded if not used after these time periods.
- The fridge temperature should be 0°C - 4°C and freezer -20°C.
- Parents storing milk in their fridge at home should store it towards the back and not in the fridge door, to maintain a cooler temperature.
- Never re-freeze milk, as this may increase the risk of bacterial growth.
- Unused expressed breast milk must be discarded after 3 months.
- This guide is based on hospital-based care. Guidelines for home storage differ.
- At home, breast milk can be stored in a sterilised container: in the fridge for up to five days at 4°C or lower, for two weeks in the ice compartment of a fridge and for up to six months in a freezer.

Defrosting

- Frozen milk should be thawed in the fridge.
- Use milk within 24 hours after the start of the defrosting process.

Administration

- Remove a maximum of 4 hours' worth of milk from the fridge.
- Milk should be used in order as was expressed for first 14 days to ensure baby gets all colostrum.
- After 14 days, use the freshest milk available, and fresh milk in preference to frozen milk.

Reference: Royle et al (2019)

Stop and think.

Formula milk may be required if EBM supplies exhaust and donor milk is not available. In hospital, sterile pre-packed nutrient enriched preterm formulations are provided. All are single use bottles and remaining milk discarded once the desired volume has been given. The same rules apply as EBM regarding time left out at room temperature once opened.

Figure 8.6 Making up powder Formula feeds.

The aim is to ensure that when staff or parents make up powdered infant formula it is prepared safely.

Points of note: Powdered infant formula is not a sterile product so if the feed is not prepared safely, bacteria can cause infection. Formula should be made up with water at a temperature of 70 degrees Celsius, which will kill these bacteria. It is recommended to make up a fresh bottle for each feed.

Making up a feed:

1. Clean, disinfect the work surface, wash hands.
2. Use a sterile bottle.
3. Fill kettle with fresh tap water allow to boil using kettle provided.
4. Allow kettle to cool no longer than 30 minutes.
5. It is important the water is still hot, 70 ◦C, otherwise the bacteria in the milk powder may not be destroyed.
6. Pour the correct amount of water as per instructions into the sterile bottle.
7. Loosely fill the scoop and level it off using the leveler provided.
8. Add the number of scoops of milk powder as per instructions to the water.

9. Place lid on the bottle and shake the bottler until the powder is dissolved.
10. Always take care as 70-degree water is still hot enough to scald.
11. To cool milk, once powder is dissolved, hold the bottle under cold running water.
12. Place sterile teat onto bottle if to be used.
13. Test temperature of milk before giving it to the intended neonate.
14. Empty out the remaining water left in the kettle down the sink.

(References: Royle et al 2019; British Dietetic Association, 2019).

Total parenteral nutrition (TPN)

The aim of parenteral nutrition is to provide adequate nutrition to prevent catabolism and to promote growth, for those neonates who are unable to tolerate enteral feeds. Parenteral nutrition (PN) is vital for premature and certain term neonates, but carries risks such as infections, liver damage, and complications. Nutritional management should prioritize establishing enteral feeds, except in cases where it carries a potential risk. In some neonates, PN may supplement inadequate enteral intake, but for many it will constitute their only nutritional source. Figure 8.7 provides an overview of TPN, including the formulas for when it is reduced / titrated once enteral feeding is increased.

Figure 8.7 TPN overview

When?

- TPN should be started within 1-8 hour of birth.
- For preterm babies born before 31+0 weeks
  For preterm babies born at or after 31+0 weeks, start parenteral nutrition if sufficient progress is not made with enteral feeding in the first 72 hours after birth.
- In older neonates, following intestinal surgery or when enteral feeding is not possible.

What?

- TPN should be introduced over a period of a few days with glucose concentrations gradually increasing to avoid the complication of hyperglycemia.
- It will eventually provide *balanced nutrition of* **carbohydrate, amino acids, and lipid.**

- If urea levels are low, nitrogen (amino acid) may be increased and growth is inadequate and there is no lipidemia, fat may be increased.
- Supplementation with vitamins and trace elements will be provided, for example, magnesium and phosphate. Iron supplements are not given for neonates receiving TPN.
- It is recommended to provide both fat soluble and water-soluble vitamins.
- Follow the NICE (2020) guidance on TPN for the required dosage and titration rates for all nutrients including .....
- Ratios of non-nitrogen energy to nitrogen, and carbohydrates to lipids...

Monitoring in TPN

- Measure blood glucose 1-2 hours after starting PN and 1-2 hours after change of PN bag.
- Measure glucose more frequently of hypoglycaemia or hyperglycaemia present.
- Daily urea & electrolyte estimation (incl. calcium) and glucose
- Blood pH
- Serum triglycerides
- Regular albumin & phosphate estimations
- Regular weighing
- Regular monitoring for infection (FBC or CRP)
- Regular checks on serum bilirubin
- Weekly alkaline phosphatase + LFT's
- Observe for potential complications: Line infection, thrombus and extravasation, hyperglycaemia, unconjugated hyperbilirubinaemia (? cholestasis)

NICE (2020) / Madabhushi & Ahmed (2022)

Practice points:

- Central venous line (e.g., PICC) is necessary for TPN administration.
- Use of aseptic technique for care of central lines for TPN
- Break line as little as possible.
- TPN is not mixed with any drugs.
- Always use an infusion pump with a pressure alarm
- If hyperglycaemic or glucose >1% in urine, insulin therapy is required.
- Protect from light.

Stop and think.

TPN should be titrated / reduced as enteral feeding is advanced carefully according to the neonate's response and tolerance.

Trophic feeding and advancement of feeds

Beginning and achieving full enteral nutrition is a key step in the care of preterm neonates, particularly very low birth weight (VLBW) neonates. As is true for many organ system-specific complications of prematurity, the gastrointestinal tract must complete in utero development ex utero while concurrently serving a physiologic role reserved for after completion of full-term development (Salas and Travers, 2023).

Buccal colostrum

It has become common practice to place a small volume of colostrum directly onto the buccal mucosa (cheeks) of preterm neonates during the early neonatal period. Colostrum, the fluid secreted by the mammary glands over the first few postnatal days, is rich in biological protective factors that are present in higher concentrations in the colostrum of mothers who have delivered preterm neonates. Oropharyngeal administration of mother's own colostrum to her preterm neonate consists of placing a small amount (0.1 to 0.5 mL) of colostrum directly onto the buccal mucosa at least once and usually repeatedly within the first 48 hours of life. Human colostrum and milk are known to contain significant levels of anti-infective agents and there are some studies that have suggested that it is a safe, feasible prophylactic measure against sepsis, NEC, and ventilator-associated pneumonia (Nasuf et al, 2018).

Minimal enteral feeding and feed advancement

Minimal enteral feeding refers to the administration of a small amount of feed to preterm newborns (often referred to as gut priming) usually calculated at 10-20ml/kg/day. Neonates with a low gestational age, intrauterine growth restriction and antenatal absent, reversed diastolic flow are considered high risk Necrotising Enterocolitis (NEC) and previously a cautious approach to initiating and increasing milk feeding in this population was adopted. The SIFT Trial found

no clear advantage for important outcomes in high-risk neonates when milk feeds were advanced in daily volume increments compared to 30 ml/kg/day or 18 ml/kg/day (Dorling et al, 2019).

Feed advancement is a critical and controversial issue. Slow advancement of enteral milk feeds has traditionally been used because of concerns around feed intolerance and necrotizing enterocolitis (Yang et al, 2022). Current World Health Organization (WHO) recommendations are that feed volumes can be increased by up to 30 ml/kg per day under careful monitoring for feed intolerance. A 2021 Cochrane systematic review compared slow feed increment (#24 ml/kg per day) with fast increment (>24 ml/kg per day) in VLBW neonates and included 13 trials. The results demonstrated no difference between slower versus faster feed advancement on the risks of mortality and necrotizing enterocolitis. It also found that necrotizing enterocolitis, invasive infection, and feeding intolerance were reduced in the fast increment group. Figure 8.8 provides a guide for the commencement of trophic feeds and advancement thereafter.

Figure 8.8 Advancing enteral feeds.
WHO, Royle (2019), Yang et al (2022)

- Advise mothers to hand express as soon after delivery as possible (ideally within 1 hr.)
- **Initiate administration of buccal colostrum as soon as colostrum available (ideally within 2 hr. of birth)**
- Place 0.3 mL (0.15 mL per side) colostrum in buccal cavity by syringe/ gloved finger at 3-hrly intervals for the first 48 hr. of life
- At 24 hours, commence trophic feeds of Mothers Own Milk/Donor EBM and increase at a rate of 30mL/kg/day (or as tolerated).

Working weight	Trophic feeds (10 to 20ml/kg/day)	2 hourly feeds increase (approx. 30ml/kg/day)
500g	0.5ml 2 hourly	1 ml every 24 hourly
600g	1ml 2 hourly	1ml every 12 hourly
700g	1ml 2 hourly	1ml every 12 hourly

800g	1ml 2 hourly	1ml every 8 hourly
900g	1.5ml 2 hourly	1ml every 8 hourly
1000g	1.5ml 2 hourly	1ml every 6 hourly
1100g	1.5ml 2 hourly	1ml every 6 hourly
1200g	2ml 2 hourly	1ml every 6 hourly
1300g	2ml 2 hourly	1ml every 6 hourly
1400g	2ml 2 hourly	2ml every 12 hourly
1500g	2.5ml 2 hourly	2ml every 12 hourly
1600g	2.5ml 2 hourly	2ml every 8 hourly
1700g	2.5ml 2 hourly	2ml every 8 hourly
1800g	3ml 2 hourly	2ml every 8 hourly

Stop and think.

- Full enteral feed volumes are subject to individual need and weight gain. If weight gain is adequate, a neonate can be fed on 150mls/kg/day increasing to 180mls/kg/day in cases where such gain is poor. This, however, should not usually be required if the neonate receives fortified EBM or preterm formula.
- Minimal enteral nutrition or trophic feeding is extra to fluid requirements; when to include the volume should be done according to ongoing and regular assessment tailored to individual needs.

Insertion and checking nasogastric and orogastric tubes.

Neonates born prematurely or who are unwell at birth will frequently have a nasogastric [ngt] or orogastric tube [ogt] inserted and are widely used for enteral feeding, medication or for gastric decompression (Dias et al, 2017). Therefore, it is essential that tubes are passed and tested safely according to national guidance from the National Patient Safety Agency (NPSA), 2011) [see Figure 8.9].

Figure 8.9 Inserting and checking gastric tubes.

- An appropriately sized ngt/ogt should be chosen – e.g., 5 FG 6FG or 8FG for feeding.
- Measure according to local policy. Two commonly used methods of measuring for NG tube placement are ● Nose-earlobe-xiphoid (NEX); and ● Nose-earlobe-midline of the umbilicus (NEMU) (Lawson-Wood and Hucker, 2022).
- Markings enable accurate measurement of depth and length.
- Aspirate stomach contents with a 10ml syringe and look for an acid response using pH paper. **pH should be 5.5 or less.**
- Ensure you work through the NPSA (2016) flowchart and record all actions.
- If there is no aspirate, the neonate can be re-positioned or a chest Xray taken.
- Consider factors that can contribute to a high gastric pH (6) -Presence of amniotic fluid in a newborn, milk in stomach, particularly if receiving 1-2 hourly feeds, use of medication to reduce stomach acid.
- Once correct position of tube ascertained, secure to face with approved method.
- Check tube position using pH following initial any tube insertion, before administering feeds or medication, following vomiting, if there is evidence of tube displacement (e.g., if tape loose or visible tube appears longer or kinked).
- If on continuous feeds, synchronise tube checking with syringe changes.

Stop and think.

- Measuring the correct length of ngt / ogt prior to passing a tube is essential.
- Testing is carried out using pH paper or x-ray confirmation only and should not be done by the 'whoosh' test (auscultation of injected air entering the stomach) (NPSA, 2011).
- If confirmation of tube position is not possible by the above methods (pH or x-ray), do not feed and remove the tube.

Vomiting and reflux

Many neonates vomit at some time. In most cases this is unimportant. However, there are circumstances when the type of vomiting is important to observe and therefore having a guide to this may be useful to inform practice. Figure 8.10 covers an overview of the types of vomiting and implications for practice.

Figure 8.10 A Guide to the neonate who is vomiting.

Key messages

- In most cases, vomiting is insignificant- for example, 'posits' that are small but frequent.
- Of most concern is the presence of blood or bile.
- Any neonate who is sick, has deteriorated, who fails to thrive, has reflux or projectile vomiting is a cause for concern.

Type of vomit	Practice points
With blood	May have swallowed maternal blood during labour or the neonate may be bleeding: e.g., clotting deficiency, stress ulceration caused by steroids or indomethacin? Observe colour and consistency closely, document and ascertain cause.
Bilious vomiting	Green vomit. Is a common symptom and can indicate pathology. Obstruction is always presumed until otherwise confirmed by contrast study and surgical review (BAPM, 2023) Pass wide bore nasogastric tube and aspirate. May need a surgical referral. Bilious vomiting in preterm neonates have a larger differential diagnosis due to their additional co-morbidity
Projectile	May be a sign of duodenal obstruction or pyloric stenosis if after 2-3 weeks of life. As above, treat as for surgical emergency if these conditions are suspected.
The neonate who is unwell	A sign of infection or metabolic disorder. Observe closely, document and ascertain cause.
Significant Reflux with or without failure to thrive	Effortless vomiting especially when lying flat. Elevate head of bed, position neonate in prone or left lateral position*, thicken feeds and feed more frequently with smaller volumes. Antacid and/ or anticholinergic drugs. Minimal handling after feeding. Observe for potential aspiration. *The prone or left lateral position reduces acid reflux. As these positions increase the risk of cot death, they should only be utilised on the neonatal unit where cardio-respiratory monitoring is in place. Parents should be advised to place neonates in the supine position when discharged home. References: Corvaglia et al (2013) Ratnayake and Kim (2014), BAPM (2023).
With concurrent diarrhoea	Possible gastroenteritis. Requires investigation into cause of infection, stool specimens, rehydration, intravenous *if necessary*

Stop and think.

Bilious vomiting is a common symptom in the newborn and can indicate pathology. There are concerns that there could be malrotation / volvulus which can present with no other symptoms (BAPM, 2023)

Renal assessment

Refer to the book chapter 8 for information on renal monitoring and urinalysis. To add further detail to this content, acute kidney injury (AKI) is a common occurrence in the neonatal intensive care unit (NICU). It is typically defined as the drop or sudden loss of kidney function and is characterized by accumulation of waste products, loss of fluid and electrolyte balance, and alteration of acid-base homeostasis which is traditionally defined by an increase in serum creatinine (Pantoja-Gomez et al 2022). Neonatal AKI has been shown to be associated with adverse outcomes including increased length of mechanical ventilation, prolonged length of stay, and rise in mortality. Those who develop AKI in the neonatal period may be at increased risk for the development of chronic kidney disease (CKD) (Coleman, 2022).

Neonatal kidneys are particularly susceptible to hypoperfusion and ischemia secondary to the dynamic changes in renal blood flow that occur postnatally. These alterations are driven by changes in the renin-angiotensin system and prostaglandins making neonates susceptible to nephrotoxic medications such as angiotensin-converting enzyme (ACE) inhibitors and non-steroidal anti-inflammatory drugs (NSAIDs).It is important to monitor neonatal renal function which is still progressing at birth and the kidneys are still developing (Moss, 2022). Serum Creatinine is currently the “gold-standard” of biomarkers to identify AKI, but there are a multitude of challenges with Creatinine as a biomarker as it serves as a measure of kidney function, rather than injury (Coleman et al, 2022). Careful attention to serum creatinine and urine output is required in newborns of any gestational age admitted to the NICU, especially between 2 and 9 days of life, which is the period during which AKI more frequently develops (Pantoja-Gomez et al 2022). Serum Creatinine is currently the “gold-standard” of biomarkers to identify AKI, but there are a

multitude of challenges with Creatinine as a biomarker as it serves as a measure of kidney function, rather than injury (Coleman et al, 2022).

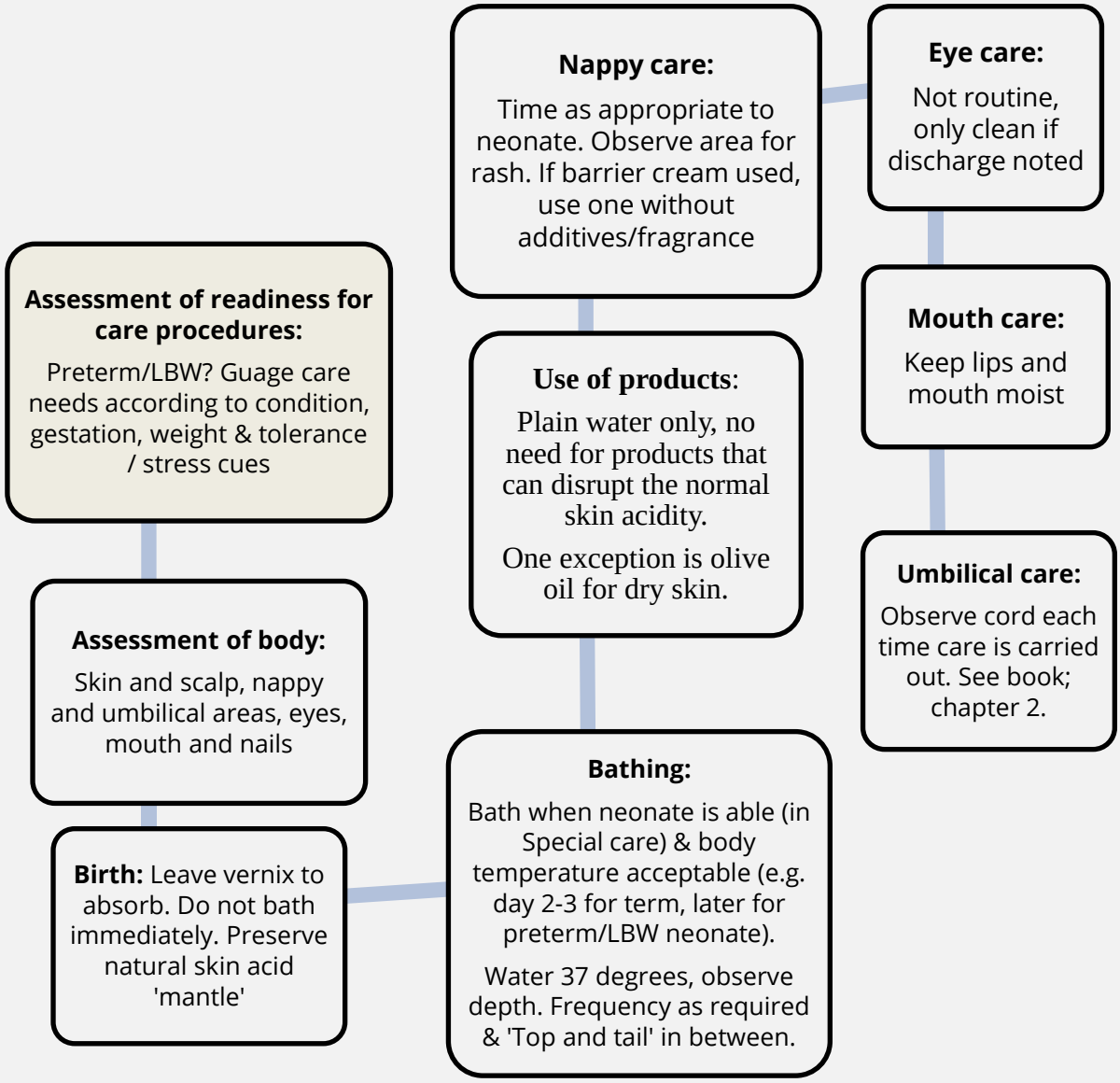
Stop and think.

Ward based urinalysis provides useful information on hydration levels, potential infection, and tolerance to glucose. It should not be overlooked when a neonate is sick in intensive care and used along with key laboratory testing, as necessary.

Skin care and tissue viability

The skin of a newborn particularly if born preterm has a relatively poor barrier function with a greater risk of injury from pressure and shearing forces then older infants and children (Oranges et al, 2015). This can increase the risk of infection, discomfort, excoriation or epidermal stripping particularly if the skin is immature or oedematous because of illness. Skin care can therefore be challenging (Johnson, 2016). Refer to the book chapter 8 for information on general skin assessment and nursing actions. Figures 8.11 through to 8.18 outline the important practice points for skin care in relation to hygiene in the neonatal unit, and more detailed guidance on assessing tissue viability risk, prevention / management of pressure sores and wound management as a whole.

Figure 8.11 Principles of neonatal unit hygiene care



Stop and think.

Encourage parents to bring in their own products. They should be advised that products should have a neutral pH. In the hospital setting, generally water is used alone with products being prescribed only if necessary- for example, in the case of nappy rash or skin excoriation.

Presence of vernix, lanugo hair (<34 weeks gestation), xerosis (in post-term) and harmless rashes (e.g., milia, erythema toxicum) are normal findings.

Figure 8.12 Assessing tissue viability risk.

(i) Skin viability assessment tool 1

Source: Ashworth and Briggs (2011) Neonatal Tissue Viability Assessment tool based on adapted Braden Q scale

Intensity / duration of pressure				
Score-	**3**	**2**	**1**	**0**
Physical condition	Gestation < 28 weeks	28-32 weeks	>33 - <38 weeks	>38 weeks
Mobility	Immobile	Very limited	Slightly limited	No limitations
Activity	No activity	Very limited	Slightly limited	No limitations
Sensory perception	Completely limited	Very limited	Slightly limited	No impairment
Skin tolerance and structure				
Moisture	Constantly moist	Very moist	Occasionally moist	Rarely moist
Friction	Significant problem	Problem	Potential problem	No problem
Nutrition	Very poor	Inadequate	Adequate	Excellent
Tissue perfusion and oxygenation	Extremely compromised	Compromised	Adequate	Excellent

Scores

0 – 5: Low risk 6 – 10: At risk 11-19: High risk >20: Very high risk

For complete tool and detail on assessment criteria- see Ashworth and Briggs (2011)

(ii) Skin viability assessment tool 2

Source: Adapted Glamorgan Pressure Ulcer Risk Assessment Scale (Healthcare Improvement Scotland (HIS), 2020)

Risk Factor	**Score**
Neonate cannot be moved or deterioration in condition / under general anaesthetic >2 hours	20
Unable to change position without assistance /cannot control body movement	15
Some mobility	10
Normal mobility for age	0
Equipment / objects / hard surfaces pressing or rubbing on skin	15
Significant anaemia	1
Persistent pyrexia	1
Poor peripheral perfusion (cold extremities/ capillary refill > 2-3 seconds / cool mottled skin)	1
Inadequate nutrition	2
Low serum albumin	1

Scores

0 : No risk >10: At risk >15: High risk >20: Very high risk

Stop and think.

Regular skin assessment including any areas of concern, risk or actual skin damage must be incorporated into a neonate's care plan.

Figure 8.13 Nursing actions according to skin viability risk	
Category	**Suggested action**
Not at risk / low risk	Continue to reassess daily and every time condition changes.
At risk	Inspect skin with all care procedures. Relieve pressure by regular position changes. Resite probes more frequently, use of protective dressing under cannula, ETTs, loosen tapes, regular checks of areas.
High risk	Inspect skin with each repositioning / care episode as above. Use of adjuncts to relieve pressure- e.g. gel mattress. Seek advice from Tissue Viability nurse.
Very high risk	Inspect skin at least hourly if condition allows. More regular probe changes. Avoid adhesive tapes. Refer to Tissue Viability Nurse.
Ashworth and Briggs (2011) / Johnson (2016)	

Stop and think.

For all risk categories, assessment should be clearly documented and handed over from shift to shift.

EXTRA READING – Read more about the Braden Q Scale (2003), a Neonatal Tissue Viability Assessment Tool; eight different criteria assess the neonate's risk of threats to skin integrity

Figure 8.14 Prevention and management of pressure ulcers in the neonate- Source: Adapted from NICE Guideline 179 (2018)

ASSESSMENT OF SKIN AND RISK OF PRESSURE ULCERS

- Perform Skin assessment.
- Perform risk assessment – Use a tool validated and adapted for this population such as the Braden Q or Glamorgan scale –
- Use tools to support clinical judgement.
- Document findings

PREVENTION

- Regular and documented skin assessment.
- Take note of skin changes in the occipital area, ears and heels.
- Note skin temperature and any blanching erythema or skin discoloration.
- Reposition neonate every 4 hours or more frequently if required.
- Relieve pressure on the scalp/ head, heels, ears and knees if prone.
- Use a foam cot mattress or overlay for at risk neonates.
- Consider a pressure redistributing device / pillow for neonates at risk of occipital pressure ulcers.
- All above should be part of an individualised care plan.

MANAGEMENT

- Document the surface area and depth of any pressure ulcer.
- Categorise any pressure ulcer using the NPUAP-EPUAP (2009) classification system (grades 1 to 4)
- Assess fluid balance and ensure hydration is optimised.
- Consider using specialist support devices.
- Use dressings that promote a warm, moist healing environment to treat grade 2, 3 and 4 pressure ulcers.
- Debridement (autolytic) may be necessary with a chosen dressing – seek advice from Tissue Viability nurse.
- Antibiotics may be required for infected pressure ulcers.

EXTRA READING – NICE Pressure sore prevention guideline 179 (2018) - 1.2 & 1.5 Prevention & management: neonates, infants, children and young people

Figure 8.15 European Pressure Ulcer Advisory panel (EPUAP) and National Pressure Ulcer Advisory panel (NPUAP) Pressure Ulcer Classification System (2024)	
Category/Stage I: Non-blanchable erythema	Intact skin with non-blanchable redness of a localized area usually over a bony prominence.
Category/Stage II: Partial thickness	Partial thickness loss of dermis presenting as a shallow open ulcer with a red / pink wound bed, without slough. May also present as an intact or open/ruptured serum-filled or serosanguinous filled blister. Presents as a shiny or dry shallow ulcer without slough or bruising.
Category/Stage III: Full thickness skin loss	Full thickness tissue loss. Subcutaneous fat may be visible, but bone, tendon or muscle is *not* exposed. Slough may be present but does not obscure the depth of tissue loss.
Category/Stage IV: Full thickness tissue loss	Full thickness tissue loss with exposed bone, tendon, or muscle. Slough or scarring may be present.

EXTRA READING – EPUAP/NPUAP (2019 Prevention and Treatment of Pressure Ulcers/Injuries: Clinical Practice Guideline

Stop and think.

Neonates considered to be 'at risk' of pressure ulcers are identified after assessment using clinical judgment and/or an agreed risk assessment tool (NICE, 2018). 'High risk' factors include limited mobility, immaturity, nutritional deficiency, previous or existing areas of skin breakdown and numerous invasive IV sites or tubes.

Figure 8.16 Neonatal wound assessment
(August et al 2022)

Classification of wound can be undertaken by observing the colour which indicates the stage of wound healing and/or any presence of infection.

Wound colour

Pink: New growth of skin
Red: Granulating, new vascular connective tissue
Yellow: slough (dead cells)
Green/ yellow: Infected
Black: Necrotic tissue

Wound site	Document site (s) and indicate on care plan where the wound is
Wound size	Width, breadth, and depth- record all. Possible drawing in care plan of shape and size.
Thickness / depth	Partial thickness- damage epidermis and dermis Full thickness- also involves subcutaneous tissue and below
Exudate	Serous fluid, blood, or pus
Odour	None to mild to obvious
Skin integrity	Surrounding skin- assess colour, moisture, breakdown, oedema, pain, rash, skin changes, infection
Skin maturity	Gestation- observe presence of translucency, friability, and integrity
Pain	Present all the time or at dressing change only

Stop and think.

A systematic assessment of any wound is vital as this provides baseline information on which to assess healing and effectiveness of management given.

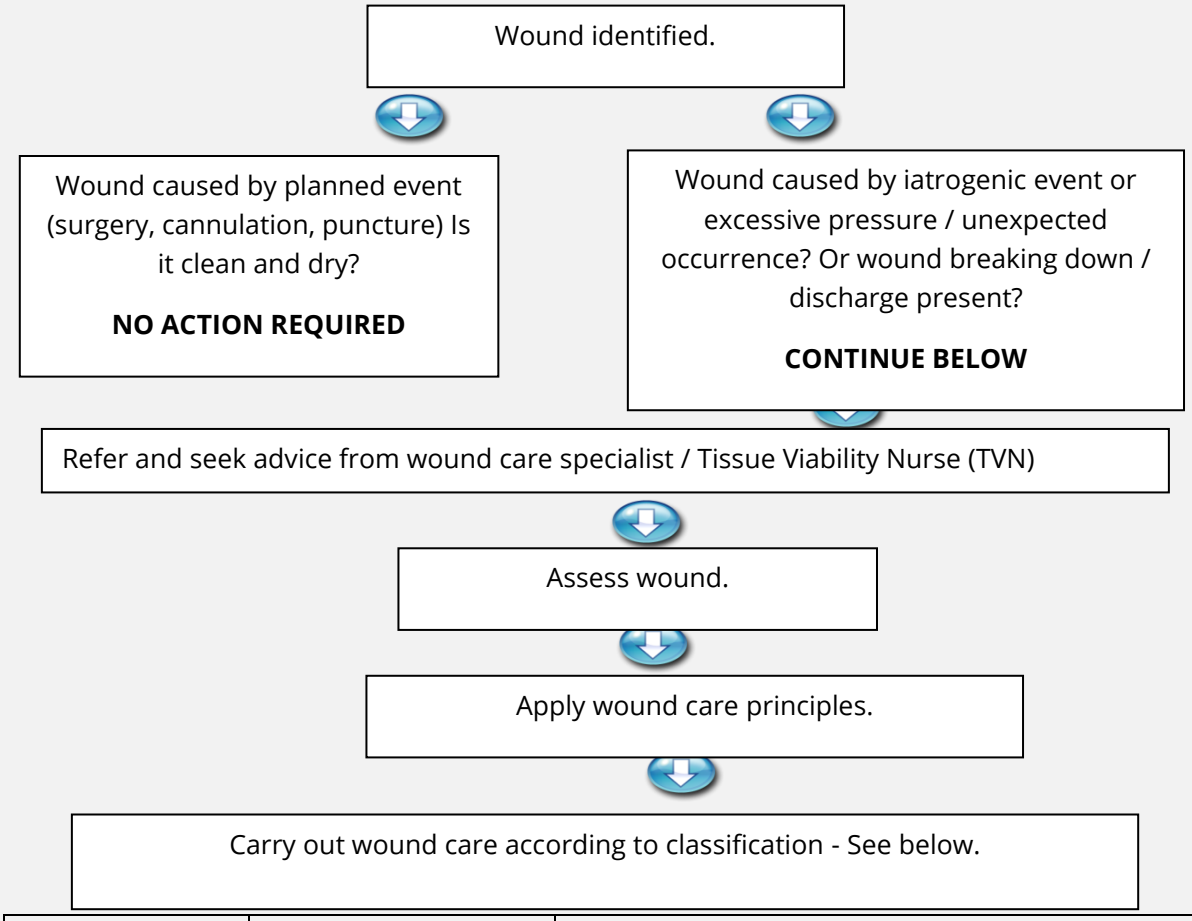
Figure 8.17 Neonatal Wound care principles

- Causes of wounds in the neonate: trauma (epidermal stripping, tearing), surgical incisions, contact excoriation (chemicals, moisture, urine / stool), extravasation, thermal injury, pressure ulcers CPAP prongs/mask, ischemia and congenital (epidermolysis bullosa, gastroschisis, myelomeningocele)
- Protect any wound from trauma with non-adherent dressing / covering.
- Deeper, more significant wounds that are granulating heal better with moist wound healing and a dressing that promotes this. This promotes the optimum environment for epithelialisation and growth of new skin tissue and the prevention of trauma from the wound drying out.
- Use a dressing that maintains an ideal environment for wound healing (low adherent, vapour permeable). Dressing choice will depend on type and depth of wound and level of exudate.
- Superficial wounds (e.g., skin excoriation) can be exposed to air.
- Wound cleansing may be necessary in the presence of debris, bacteria, or necrosis. Routine cleansing of all wounds however is not necessary.

Stop and think.

Whatever the cause, the aims of wound care are the same; to protect the wound area, to promote optimum healing and resumed skin integrity, to prevent breakdown and if necessary, provide gentle cleansing and treatment in the presence of infection.

Figure 8.18 Wound care Overview



Classification	Aim of care	Suggested Dressing (s)
1.Pink (epithelialising)	Keep wound moist/warm and protect	Hydrocolloid sheets are self-adhesive, absorb fluid and are impermeable to bacteria and /or soft, non-adherent silicone layer
2.Red (granulating)	Keep wound moist/warm, protect, promote granulation, and manage exudate	Amorphous hydrogel with semi-permeable non-occlusive dressing.
3.Yellow (sloughy)	Debridement and manage exudate	As for 1 and 2 above
4.Green (infected)	Prevent any further infection	Hydrocolloid fibrous dressing with foam
5.Black (necrotic)	Debridement and manage exudate	As for 1 and 2 above

Devise plan of care and frequency of dressing change with TVN and document. Review wound appearance and care with each dressing change until healing has been achieved.

Infection control

Refer to the book chapter 8 for information on recognising infection, risk factors and the septic screen in brief. To add further detail to this content, while many aspects of infection prevention and control (IPC) mirror institutional efforts, optimisation of IPC practices in the neonatal unit requires careful consideration of its unique population and environment. Immaturity and illness make neonates vulnerable to infection which are associated with increased mortality, increased length of stay and healthcare costs, and risk of neurodevelopmental disability among survivors (Johnson et al, 2021). It is therefore imperative that measures are taken to prevent it.

Standard precautions must be always adhered to which includes hand hygiene, protective clothing, sharps and waste disposal, management of care equipment and environment and the safe care of linen including uniforms. It is worth re-iterating that thorough hand washing is vital. The World Health Organization's (WHO, 2009) Five Moments for hand hygiene should be followed.

5 Moments
Before touching a patient
Before clean and aseptic procedures
After contact with body fluids
After touching a patient
After touching patient surroundings

Understanding neonatal sepsis and the septic screen

Early diagnosis and treatment of the neonate with suspected infection are essential to prevent long-term complications associated with systemic sepsis and to treat appropriately with antibiotics, if necessary, in a timely fashion (NICE

2021). It is essential to have an understanding of risk factors, clinical signs as well as the haematological markers (NICE, 2021). Diagnosis and the decision to start antibiotics is based on a combination of all factors and is undertaken on an individual basis. For well appearing babies the Kaiser Permanente Risk Calculator may be utilised and is endorsed by NICE (2021).

Early-onset sepsis (EOS) is generally caused by the transmission of pathogens from the female genitourinary system to the newborn or the fetus. These pathogens can ascend the vagina, the cervix, and the uterus, and can also infect the amniotic fluid. Typical bacterial pathogens include Group B streptococcus (GBS), Escherichia coli, coagulase-negative Staphylococcus, Haemophilus influenza, and Listeria monocytogenes. Maternal factors that increase the risk include chorioamnionitis, GBS colonization, delivery before 37 weeks, and prolonged rupture of membranes greater than 18 hours (Simonsen et al, 2014).

Late-onset sepsis (LOS) usually occurs via the transmission of pathogens from the surrounding environment after delivery, such as contact from healthcare workers or caregivers. A percentage of LOS may also be caused by a late manifestation of vertically transmitted infection. Neonates requiring intravascular catheter insertion, or other invasive procedures that disrupt the mucosa, are at increased risk for developing LOS (Simonsen et al, 2014).

It is the immature immune system that is the major contributing factor for increased neonatal susceptibility to sepsis. Signs and symptoms of neonatal sepsis can range from nonspecific or vague symptoms to hemodynamic collapse. Early symptoms may include irritability, lethargy, or poor feeding. Others may quickly develop respiratory distress, fever, hypothermia or hypotension with poor perfusion and shock. However, neonates with

bacteraemia can be asymptomatic and have a normal physical examination.

Laboratory Tests

laboratory testing plays an important role in diagnosis. In a neonate with suspected sepsis, blood culture should be immediately drawn alongside a full blood count and a C-reactive protein (CRP). CRP levels start rising within 6 to 8 hours during an infectious episode in neonates and peak at about 24 hours therefore it is recommended that a further CRP is taken 18-24 hours following initial screen (NICE, 2021). In selected babies a Lumbar Puncture may be performed to obtain a cerebrospinal fluid sample if it is thought safe to do so and if there is a strong clinical suspicion of infection or are clinical symptoms or signs suggesting meningitis. For babies who require an antibiotic course longer than 36-48 hours, a Gentamicin Level will be checked prior to 2nd or 3rd dose (refer to local guidance).

Antibiotics

Empiric treatment with IV antibiotics should be started as soon as sepsis is clinically suspected and always within 60 minutes of the decision to treat (NICE 2021). Length of course will depend on clinical and laboratory findings.

Stop and think.

In any neonate that deteriorates, infection should always be considered as a potential diagnosis and a septic screen commenced as soon as possible. Antibiotics should be given within 60 minutes of the decision to treat (NICE, 2021)

EXTRA READING – Read more about the NICE guidance (2021) Neonatal infection: antibiotics for prevention and treatment. NICE guideline [NG195]

Jaundice

Jaundice, the well-known term for hyperbilirubinaemia, manifests as yellowish discoloration of the skin, sclera, and mucous membrane. It is cited that up to 60% of all neonates will exhibit clinical signs of jaundice in the first few weeks of life (Mitra and Rennie, 2017) and this number increases to around 80% in the preterm population due to immaturity of bilirubin metabolism. Refer to the book chapter 8 for information on types of jaundice, assessment and phototherapy devices. Further detail to this content is outline below with some additional information on exchange blood transfusion therapy required when phototherapy is no longer effective as a treatment option [Figure 8.19].

Measuring and assessing bilirubin levels

Serum bilirubin measurement (SBR) is not recommended routinely for those neonates without visible jaundice. However, within the neonatal unit, neonates are more likely to be jaundiced and so bilirubin measurement is commonly done. Severe hyperbilirubinemia can cause bilirubin-induced neurological dysfunction and, if not detected or treated adequately, may lead to bilirubin encephalopathy (Bhutani and Wong, 2015).

Stop and think.

Visible inspection alone should not be used to estimate a neonate's bilirubin level (NICE, 2010). The oral mucosa should be assessed and the sclera of the eyes, rather than the skin, due to difficulties in identifying yellow colouration in darker skin tones. Refer to the guidance from the NHS Race Observatory [NHSRO] on assessing babies with Black and brown skin (NHSRO, 2023).

Assessing types of jaundice

Jaundice is usually a mild, transient, and self-limiting condition and resolves without treatment. It is referred to as "physiological jaundice." However, it is imperative to distinguish this from a more severe form known as "pathological

jaundice" as severs hyperbilirubinemia can cause bilirubin-induced neurological dysfunction (BIND) and, if not treated adequately, may lead to acute and chronic bilirubin encephalopathy (Ullah et al, 2016). There are two distinct types of Neonatal hyperbilirubinemia: Unconjugated hyperbilirubinemia is the most common type and can be either physiological or pathological. Physiological jaundice accounts for 75% of neonatal hyperbilirubinemia and results from a physiological alteration in neonatal bilirubin metabolism.

Unconjugated hyperbilirubinemia is the most common type of jaundice seen in neonates, but some infants with jaundice have conjugated hyperbilirubinemia, which is always pathological and signifies an underlying medical or surgical cause (Ullah et al, 2016)

Conjugated hyperbilirubinemia, also referred to as neonatal cholestasis, is characterized by elevation of serum conjugated/direct bilirubin and is due to impaired hepatobiliary function. For prolonged jaundice, distinguishing conjugated from unconjugated hyperbilirubinemia is critical because cholestatic jaundice/conjugated hyperbilirubinemia is almost always pathologic and warrants prompt evaluation and treatment (Fawaz et al, 2017). Prolonged jaundice may be indicative of a serious disease that requires treatment. Therefore, assessment and monitoring are vital. However, breast-milk jaundice should be a consideration in the presence of prolonged jaundice which is not due to a disease process.

Phototherapy

The main treatment for significant jaundice is phototherapy, which converts unconjugated bilirubin to a conjugated, safe form that can be excreted. Double or triple phototherapy should be attempted where high levels of SBR are present to avoid an exchange transfusion being administered. There is no evidence to prove that one form of phototherapy is more effective than another.

Whatever device is used, the neonate must be cared for and monitored the same (NICE, 2010).

Neonatal Exchange Blood Transfusion

Neonatal Exchange Blood Transfusion is a specialist procedure with associated risks and is now infrequently performed in most neonatal units mainly as a result of the reduction in HDN following routine antenatal anti-D prophylaxis for D-negative women. It must take place in an intensive care setting, with intensive physiological and biochemical monitoring carried out by staff trained in the procedure following written informed parental consent (New et al, 2016).

Figure 8.19 Exchange blood transfusion (EBT)

EBT is used for treatment of severe hyperbilirubinaemia above the "exchange line" on relevant charts where bilirubin levels continue to rise steeply despite double and triple (NICE 2010) The aim of EBT is to reduce the unconjugated bilirubin to a **safe level.**

Obtain written parental consent.

↓

Preparation and Equipment

Insertion of lines: umbilical (or peripheral) arterial and venous catheters
Equipment: Blood warmer, blood (prescribed) warmed to 34-35^{0}c. 10-20 ml syringes, three-way taps X 2, sterile pack, waste bag, sterile gown /gloves, IV tubing X2
Investigations: May include FBC, U&Es, LFTs split bilirubin, glucose, blood gas, clotting

↓

The procedure

Nurse in an open incubator in ITU. Ensure NBM with a NGT inserted and kept on open drainage. Maintenance fluids and electrolytes should be commenced.
Two-catheter method; donor blood infused slowly through one catheter whilst the neonate's blood is removed via the other vessel in timed aliquots of 5mls/kg.
Alternative method ('push-pull' / one catheter method): 5mls/kg of blood is aspirated slowly over 2 minutes, and then discarded. The same amount of blood from donor bag is pushed slowly into neonate (over 2 minutes). This completes a cycle.

↓

Monitoring and Documentation

- Fluid balance (input and output) should be maintained.
- Record baseline temperature, heart rate, respiratory rate, oxygen saturation and blood pressure (invasive or cuff). Record heart rate, respiratory rate every 15 minutes. Note any changes from the baseline.
- Document exact time exchange commenced, and volumes infused and removed.
- Check blood pressure half hourly.
- Check blood gas, calcium, and blood glucose regularly throughout.
- Continuously monitor pulse oximetry and ECG
- Record all observations on the EBT chart with exact times.
- It is essential that all events are carefully documented Lines – assess

⇩

Post transfusion Management

Check SBR, FBC, Clotting, and U&E, Blood gas, calcium, and glucose, continue to monitor vital signs hourly, keep neonate nil by mouth for at least 24 hours, monitor SBR 4 hourly, keep lines in situ with heparin running through the arterial line.

New et al, British Committee for Standards in Haematology (2016)

Stop and think.

Exchange blood transfusion is a very invasive procedure with potential complications such as circulatory overload or hypovolaemia, hypothermia due to unwarmed blood, cardiac arrythmias (from hyperkalaemia), electrolyte disturbances, air embolism, catheter problems, NEC. In the event of a sudden collapse, stop the transfusion. Doctor/ANNP with a nurse providing one-to-one care carries out the exchange.

Figure 8.20 Performing a dilutional exchange transfusion.

The aim of the dilutional exchange is to reduce the packed cell volume (PCV) to **50-55%** in the case of symptomatic polycythaemia. The neonate should be admitted to HDU or ITU and cardiopulmonary monitoring commenced.

⇩

Ensure all relevant blood tests have been done- to include blood glucose and bilirubin.

⇩

Obtain venous access. An UVC is the easiest option.
Alternatively, a peripheral cannula inserted in a large vein and a peripheral arterial line. Normal saline is the replacement fluid of choice because it is inexpensive and effective.

The volume of blood to be diluted is calculated according to a formula. An example of one that could be used is below:

$$\text{Estimated blood volume (85mls x weight in kg)} \times \frac{\text{Observed PCV-Desired PCV}}{\text{Observed PCV}}$$

The exchange should be done aseptically, and aliquots of 5mls/kg delivered and replaced over 2-3 minutes. Blood is removed through the arterial line and saline replaced via the peripheral cannula. If only a UVC is in place, the 'push-pull' technique can be used.

Post-exchange, monitor vital signs for at least 24 hours and keep NBM. Check blood glucose, bilirubin, clotting screen and electrolyte levels.

Stop and think.

Exchange transfusions are associated with risk and are invasive procedures. Therefore, *informed* consent should be obtained from parents.

Glossary

Apnoea: The absence of breathing.

Aseptic Non-Touch Technique (ANTT): A method by which precautions are taken during clinical procedures to prevent the transfer of microorganisms to the patient by the avoidance of touching key parts that come into direct contact with them.

Asphyxia: An insufficient supply of oxygen to the body.

Bag-Valve-Mask (BVM): A self-inflating bag, which is a hand-held device, used to provide positive pressure ventilation to neonates who are not breathing adequately.

Blanching: Skin that remains pale for longer than normal when pressed.
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.

Deoxyhaemoglobin: The form of haemoglobin without oxygen.

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

Enteral: Refers to the intake of food and liquid via the gastrointestinal tract (whether this is orally or via a tube).

Epidermal stripping: Removal of one or more layers of the stratum corneum (outer layer of the epidermis) of the skin following removal of adhesive tape or dressings.

Exchange blood transfusion (EBT): A type of blood transfusion in which some of the neonate's blood is removed in small aliquots and replaced with donor blood; sometimes used to treat severe jaundice. May be used for hyperbilirubinaemia, haemolytic disease of the newborn and removal of toxins/drugs as in sepsis, inborn errors etc.

Excoriation: Abrasion of the skin where it may be torn and damaged.

Extravasation: The leakage of intravenous drugs/fluids from the vein into the surrounding tissue.

Haemolytic Disease of the Newborn (HDN): A condition where the infant's red blood cells break up more quickly than what is considered normal.

Hyperglycaemia: A whole blood glucose concentration of >8 mmol/l.

Hyperbilirubinemia: High levels of circulating bilirubin in the blood. Bilirubin is produced from the breakdown of haemoglobin (Hb) in red blood cells. May be conjugated (bound to albumin) or unconjugated (unbound and so able to cross the blood-brain barrier and cause brain damage).

Hypoglycaemia: Low blood sugar level, below 2.6mmol/litre in a neonate.

Hypothermia: Body temperature below 35 degrees Celsius.

Intrapartum asphyxia: Oxygen deprivation occurring during labour or delivery of the infant.

Jaundice: The yellowing of the skin, mucous membranes, and the whites of the eyes that occurs when the body does not process bilirubin as it should resulting in hyperbilirubinaemia.

Neurodevelopmental disability: Conditions that affect how the brain functions.

Neutral Thermal Environment: The environmental temperature at which a neonate uses minimal rates of oxygen consumption and expends the least energy.

NICE: The National Institute for Health and Care Excellence produces evidence-based guidelines for health and social care.

Oedema: An excess of fluid in the cavities or tissues of the body.

Oxygen toxicity: A condition that arises from inhaling too much supplementary oxygen.

Oxyhaemoglobin: The form of haemoglobin which is oxygen loaded.

Pathological jaundice: Due to a disease process appearing with a rapid onset on day 1 of life.

Phototherapy: Treatment for jaundice, involving placing a neonate under blue, fluorescent lights, sometimes called bili-lights.

Physiological jaundice: Due to the normal process of red blood cell breakdown appearing after 3 days of life.

Polycythaemia: A condition that causes "sluggish" circulation due to an abnormally high number of red blood cells (high packed cell volume (PCV)).

Prematurity: Relates to babies who are born alive before 37 weeks gestation.

Prolonged jaundice: Lasting more than 14 days in term babies and more than 21 days in preterm babies. may still be indicative of a potential and serious disease condition such as biliary atresia, choledochal cyst, neonatal hepatitis, metabolic disorders (galactosaemia) or a complication of TPN.

Total Parenteral Nutrition (TPN): The administration of a nutritionally complete solution given intravenously when it is not possible to feed enterally.

Unconjugated bilirubin: unbound bilirubin which is able to cross the blood-brain barrier and cause brain damage.

EXTRA READING

- Read this open access paper – Moncrieff G (2018) **Bilirubin in the newborn: Physiology and pathophysiology**. BJM.

- Read the NICE (2010) guidance**; Jaundice in newborn babies under 28 days**, and…

- The clinical knowledge summary [CKS]; **Jaundice in the Newborn**.

- British Association of Perinatal Medicine (2019) **Improving Normothermia in Very Preterm Infants A Quality Improvement Toolkit.**

- British Association of Perinatal Medicine (BAPM) (2024) **Identification and Management of Neonatal Hypoglycaemia in the Full Term Infant (Birth – 72 hours).**

- British Dietetics Association (2019) **Guidelines for the Preparation and Handling of Expressed and Donor Breast Milk and Specialist Feeds for Infants and Children in Neonatal and Paediatric Health Care Settings.**

- National Institute for Clinical Excellence (NICE) (2020) **Neonatal Parenteral Nutrition.**

- Plus, also read the guidance on assessing babies with non-Caucasian skin tones from the National Health Service (NHS) Race and Health Observatory (2023). **Review of neonatal assessment and practice in Black, Asian and minority ethnic newborns: Exploring the Apgar score, the detection of cyanosis and jaundice**