# JAUNDICE IN NEONATAL CARE

## PRACTICE GUIDELINE ©

## KEY POINTS

- Jaundice in the newborn period is a common clinical feature where approximately 50% of term and 80% of preterm newborns have visible jaundice.
- These infants may be at risk since the presence of jaundice may be a feature of a more serious, yet potentially treatable, disorder and, if the level of bilirubin is sufficiently elevated, there is a risk of neurological damage.
- Phototherapy is the first line treatment for hyperbilirubinemia. The decision to commence treatment is dependent on a number of factors including the level and rate of increase in the serum bilirubin as well as the infant's gestation, birth weight, post-natal age and the underlying cause of the hyperbilirubinemia.
- If phototherapy is not able to control hyperbilirubinemia exchange transfusion can prevent acute bilirubin encephalopathy and kernicterus by rapidly diluting the serum bilirubin.
- A double volume, two catheter technique is preferred for exchange transfusion.





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| **Approved by:** | SCHN Policy, Procedure and Guideline Committee | |
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# CHANGE SUMMARY

- This network guideline replaces the departmental CHW guideline *Jaundice in Neonatal Care GCNC CHW*.
- *Phototherapy for Neonatal Jaundice - CICU – SCH* (2022-111 v1) will be rescinded.
- Inclusion of Bilirubinometer, Mini Neo Blue light
- Deletion of IV administration of GALD
- Updated references
- Amendments made to content and procedure specifically related to exchange transfusion.
- Photos for exchange transfusion updated
- **01/10/24:** Minor review. Subheading in two-catheter technique updated

# READ ACKNOWLEDGEMENT

- All clinicians caring for neonates at risk of jaundice e.g. Registered Nurses, Clinical Nurse Specialists, Nursing Unit Managers, Clinical Nurse Educators, Nurse Practioners, Registrars, Fellows, and Neonatologists are to read the contents of this document.

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# What is Jaundice?

Jaundice, described as a yellow discolouration of the skin and sclera, is a common physiological occurrence in the newborn and is reported to occur in approximately 50% of newborns within the first week of delivery. “Physiological jaundice” starts to rise after the first 24 hours, peaks at 72hours and then reduces by day 7. This condition reflects the immaturity of the liver and the breakdown of foetal haemoglobin and is due to increased production (accelerated red blood cell breakdown), decreased removal (transient liver enzyme insufficiency), and increased reabsorption (enterohepatic circulation).

Mostly benign, elevated levels commonly do not require intervention and resolve spontaneously. Unconjugated bilirubin levels that rise above the threshold of albumin binding and clearance may then be taken up by the central nuclei in the brain leading to bilirubin encephalopathy and kernicterus. These conditions are irreversible leading to choreoathetoid cerebral palsy and if untreated death.

### *Physiology of bilirubin production*

In utero, the placenta is responsible for the excretion of unconjugated bilirubin which, after delivery, is assumed by the neonatal liver. The prominent source of bilirubin is the breakdown of haemoglobin accounting for 70-80 per cent of bilirubin production. Infants produce higher rates of bilirubin than adults as a result of the shortened lifespan of foetal red cells, which is 40-70 days compared to 120 days in an adult, and an increased circulating red cell mass.

Bilirubin is produced by the breakdown of red cells where haemoglobin is phagacytosed by macrophages and split into haem and globin. The globin portion is degraded into amino acids and plays no role in jaundice. Two reactions then take place in the Haem molecule. The first oxidation reaction is catalysed by the microsomal enzyme haem oxygenase and results in biliverdin (a green coloured pigment), iron and carbon monoxide. Biliverdin is then broken down by biliverdin reductase to form bilirubin.

### *Bilirubin metabolism and excretion*

The unconjugated bilirubin is transported to the liver through the bloodstream. However, as bilirubin is not water soluble, it is transported through blood bound to albumin. Once bound, the bilirubin enters the smooth endoplastic reticulum of the hepatocyte in a carrier-mediated process with the help of carrier proteins Y (ligandin) and Z. In the liver, a series of reactions occur, catalysed by the enzyme uridine diphosphate glucuronyl transferase (UGT) resulting in the joining of bilirubin with two molecules of glucuronic acid to produce bilirubin diglucronide or conjugated bilirubin. Conjugated bilirubin enters the small intestine via the common bile duct, and during its passage through the intestinal tract, bacterial enzymes convert bilirubin into urobilinogen and stercobilinogen. As these compounds are now water-soluble, they can be excreted in the urine and stool.

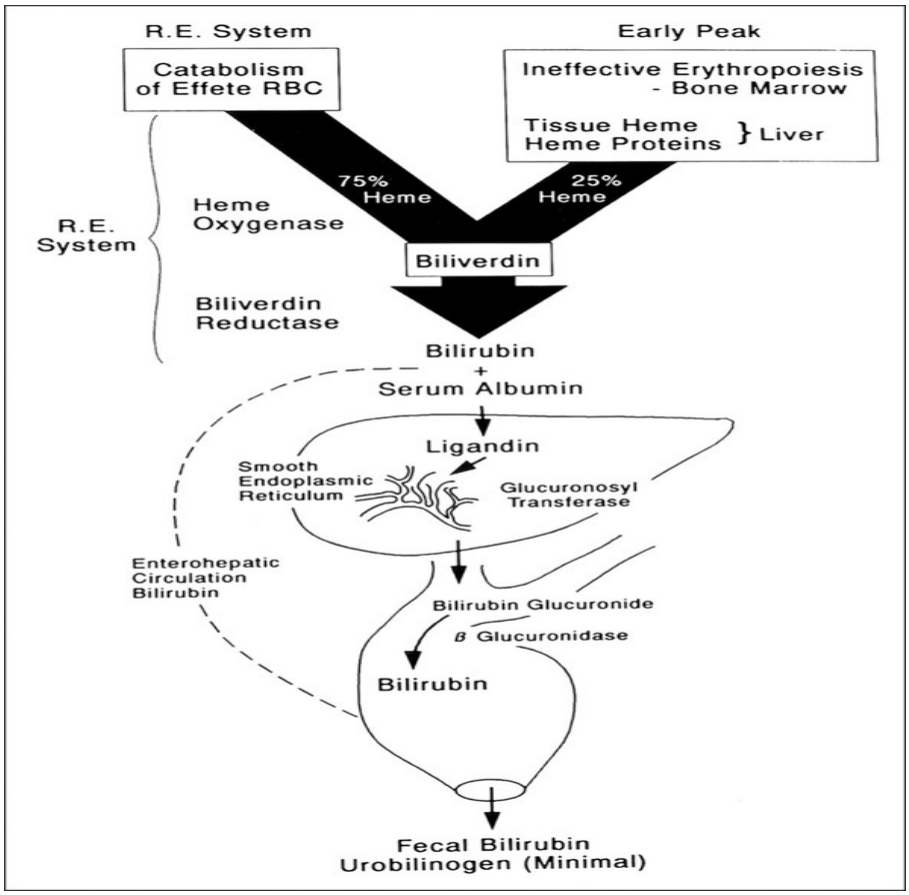



*Image 1. Bilirubin Metabolism*[5]

## Physiological Jaundice

A number of factors predispose newborns to developing jaundice, including increased bilirubin production, decreased bilirubin clearance and increased enterohepatic circulation. Physiological jaundice may be exacerbated by prematurity, administration of albumin-bound medications, bruising, polycythemia, the relatively short life span of fetal red blood cells, inadequate oral intake, delayed passage of stool and breastfeeding.

## Other causes of Jaundice

While physiological jaundice is a naturally occurring phenomenon, and accounts for the most common cause of increased bilirubin, jaundice may occur for other reasons, and may be the result of various disease processes.

### *Haemolytic disease*

Haemolytic disease of the newborn, due to blood group incompatibility, is an important cause of hyperbilirubinemia with significant morbidity in the neonatal period. Haemolytic disease, with resultant red cell haemolysis and overproduction of bilirubin, occurs with blood group incompatibilities such as Rhesus and ABO, as well as more rare disorders such as Anti E, Anti C, Kell and Duffy.

### *Rhesus incompatibility*

This occurs when Rh-positive foetal cells are passed into the Rh- negative maternal circulation. This results in an immune response leading to the production of anti-Rh antibodies. During this Rh-isoimmunisation, antibodies from a Rh-negative mother cause destruction of the Rh-positive foetal red cells. Because it takes time for the mother to mount this immune response, first born infants are often not affected, unless there have been previous miscarriages or termination, or after foetal-maternal blood transfusion during delivery or amniocentesis. During subsequent pregnancies the risk of foetal red cell haemolysis increases secondary to an elevated level of maternal anti-Rh antibodies.

With the advent of anti-D immunoglobulin, Rhesus incompatibility is now a rare condition. Anti-D binds to foetal cells and promotes their destruction prior to the initiation of a maternal immune response, providing passive protection from further sensitisation. Prior to this treatment, severe haemolysis in the foetus from Rh incompatibility resulted in the condition erythroblastosis (EBF) resulting in significant foetal anaemia.

### *ABO incompatibility*

This is now the most frequent cause of haemolytic disease of the newborn. ABO incompatibility occurs in the following situations:

- Maternal blood type O and infant's blood type is A (most common type) or B (most severe type)
- Maternal blood type is B and infant's blood type is A or AB
- Maternal blood type is A and infant's blood type is B or AB

Naturally occurring maternal antibodies attach to the antigens on the incompatible foetal red cells causing haemolysis and the production of bilirubin.

Antibody mediated haemolytic disease can be diagnosed by examination of a blood film for signs of haemolysis along with the direct antiglobulin test (DAT or Coombs) which is positive in the presence of antibody coated red cells.

### *G6PD Deficiency*

Glucose-6 phosphate dehydrogenase is an enzyme responsible for the maintenance of red cell membrane integrity. A deficiency of this enzyme causes a susceptibility to haemolysis due to cell liability. This condition has a sex-linked recessive inheritance pattern, which means that heterozygous females are carriers and males are affected. Triggers include ingestion of or exposure to oxidants such as naphthalene (moth balls), sulphonamide medications, Fava beans (broad beans) or during periods of infection.

### *Hypothyroidism*

Although not well understood, hyperbilirubinemia in the presence of hypothyroidism is thought to be due to the need for thyroxine in hepatic clearance of bilirubin. Jaundice may be prolonged, in the absence of other signs or symptoms of hypothyroidism.

### *Galactosaemia*

The mechanism in galactosaemia may be related to a lack of substrate for glucuronidation and the accumulation of abnormal metabolic by-products that are hepatotoxic. It is an autosomal recessive disorder characterised by increased jaundice in infants fed breast milk

or lactose-containing formula. The presence of non-glucose-reducing substrates in the urine suggests galactosemia. There is also an association with E coli sepsis.

***Breastfeeding***

Breast milk jaundice occurs in a small percentage of breastfed infants. It is a benign condition resulting in prolonged levels of mild to moderate jaundice caused by a factor in human milk resulting in increased enterohepatic circulation of bilirubin[3]. Although maternal antibodies are present in the breast milk, very little antibody is absorbed. Thus, mothers should be encouraged to breastfeed without restriction.

## Who is at higher risk?

- Premature infants (less than 35 weeks): Due to the increased immaturity of the red blood cells (RBC'S), liver and gastrointestinal tract, as well as delay in enteral feeding, which may limit intestinal flow and bacterial colonisation, resulting in further enhancement of the enterohepatic circulation.
- Asian background (male): due to increased genetic predisposition to G6PD deficiency.
- Maternal immunoglobulin G (IgG) antibodies with rhesus incompatibility.
- Presence of cephalohematoma
- Infants with intestinal ileus or obstruction — Ileus or anatomic causes of intestinal obstruction increase the enterohepatic circulation of bilirubin and result in jaundice. Bilirubin levels are frequently higher with small bowel than with large bowel obstruction.

# Measurement of Jaundice

Measurement of bilirubin is indicated to ensure appropriate and timely treatment of hyperbilirubinemia and prevent risk of bilirubin encephalopathy, hearing loss and kernicterus.

**Clinical Assessment**
Visual assessment for jaundice should occur for all neonates from birth and includes assessment of blanched skin, sclera, and gums. Those identified as jaundiced should have the appropriate serum or transcutaneous bilirubin measurement as visual assessment alone does not provide an accurate measurement.

It is recommended that neonates with increased risk factors are identified early and must have increased assessment for neonatal jaundice (see Appendix A for risk factors). Any neonate with visible jaundice <24 hours should have urgent medical review and investigation, refer to section 2.3 NSW guideline Neonatal - Jaundice Identification and Management in Neonates ≥ 32 Weeks Gestation [GL2016_027].

### Serum Bilirubin (SBR) Measurement

SBR measurement remains the 'gold standard for jaundice treatment decisions.

An SBR should be measured if the neonate is clinically jaundice on examination and:

- Unwell
- < 35 weeks gestation at birth

- < 24 hours of age
- Undergoing phototherapy or has undergone phototherapy (there is insufficient evidence to recommend the use of TcB after phototherapy)
- The TcB measurement is ≥ 250 micromol/L, or the result is on, or within 20 micromol/L of the phototherapy threshold line for gestation at birth

***All measurement should be plotted on the appropriate NSW Health Neonatal Jaundice Treatment Threshold Graph for gestational age at birth (charts available from 32 weeks to ≥38 weeks gestation). See Appendix B***

These threshold charts identify at what serum bilirubin level (SBR) the neonate should commence phototherapy, the level is determined by gestational age and day of life.

In the intensive care unit eRIC is used to determine accurate phototherapy management including commencement or discontinuation of treatment
If total SBR is rapidly rising or total SBR is at or above the exchange transfusion threshold an **urgent medical review** must be initiated, and relevant treatment and additional investigations initiated.

Note: Bilirubin measured via a blood gas analyser may result in underestimation and lead to under-recognition of neonatal jaundice that meets treatment thresholds. It is recommended that blood gas bilirubin results approaching the decision limit should be confirmed by a formal laboratory total serum bilirubin.

When taking blood turn off the phototherapy lights. Blue light may interact with bilirubin pigments in the blood sample, giving inaccurate results.

When performing a heel prick or venous stab for blood sampling administer sucrose as per Sucrose - Management of Short Duration Procedural Pain in Infants

**Transcutaneous Bilirubin Monitoring**

Transcutaneous bilirubin (TcB) devices use multi-wavelength spectral reflectance from the skin surface and can be used to non-invasively estimate transcutaneous bilirubin.
TcB measurement may be used to identify which infants require formal serum bilirubin testing. TcB readings are instant and may also be used to avoid delays in treatment while awaiting serum results.
***TcB are not used as a standard measurement in the intensive care units, as serum bilirubin is the gold standard. It may be measured in ward areas with the following criteria:***

- Transcutaneous bilirubinometer measurement may be used for the well jaundiced neonate >35 weeks gestation at birth and > 24 hours old.
- Transcutaneous bilirubin monitoring is **NOT** recommended in infants with a gestational age under 30 weeks gestation for the following reasons:
- Variations in tissue bilirubin binding which may lead to inaccuracies in detecting transcutaneous levels.

- Tissue optical properties vary with postmenstrual age in preterm infants and therefore cannot be systematic in determining levels.
- Transcutaneous bilirubin monitoring has not been found definitively reliable in the preterm group 31-34weeks gestation however some studies have seen consistent results in this age group and could be effectively used on this group without risk factors, following consultation with medical team.

*See Appendix A for instructions on using the Draeger JM105 Bilirubinometer.*

**Measuring and monitoring bilirubin thresholds before, during and after phototherapy**

**Before starting phototherapy**

In babies who are well, have a gestational age of ≥38 weeks or and are > 24 hours old, and who have a bilirubin level that is below the phototherapy threshold but within 50 micromol/litre of the threshold, repeat the bilirubin measurement as follows:

- within 18 hours for babies with risk factors for neonatal jaundice
- within 24 hours for babies without risk factors.

**During phototherapy**

- repeat serum bilirubin measurement 4–6 hours after initiating phototherapy or as indicated by the treating consultant/neonatologist.
- repeat serum bilirubin measurement every 6–24 hours when the serum bilirubin level is stable or falling, as indicated by the treating consultant/neonatologist.

**Stopping phototherapy**

- Stop phototherapy once serum bilirubin has fallen to a level at least 50 micromol/litre below the phototherapy threshold (treatment threshold graph).
- Repeat serum bilirubin measurement 12–24 hours after stopping phototherapy to detect any rebound hyperbilirubinemia, or as indicated by treating consultant.

## Phototherapy

Phototherapy is a treatment for hyperbilirubinemia in the newborn that involves the exposure of the infant's skin to light between the wavelengths of 400-500 nanometres (peak wavelength at 460nm). Bilirubin absorbs light at this wavelength. This light is visible as blue light and contains little or no ultraviolet light. Unconjugated bilirubin in the skin absorbs the blue light and is mobilised by structural isomerisation to a water-soluble form (lumirubin) that can be excreted in the urine. This bypasses the need for the liver to conjugate the bilirubin for excretion in bile.

The aim of phototherapy is to decrease the level of unconjugated bilirubin in order to prevent bilirubin encephalopathy, hearing loss and kernicterus. The decision to commence phototherapy is dependent on the level and rate of increase in the serum bilirubin, as well as

the infant's birth weight, post-natal age and gestational age and the underlying cause of the hyperbilirubinemia[3].

### Indications for phototherapy

Bilirubin threshold charts identify at what serum bilirubin level (SBR) the neonate should commence phototherapy. The level is determined by gestational age and day of life. The neonates SBR will be plotted on the graph on the Jaundice Tab on ERIC and if they sit above the acceptable level therapy will commence. See Appendix B for Neonatal Jaundice Treatment Threshold Graph.

Consideration should be given for starting phototherapy at a lower SBR if the neonate is <24 hours, has risk factors for neonatal jaundice or is unwell. Consider the requirement for single or double lights as per the indication below (NSW Health).

Ensure a medical officer has documented the need for phototherapy treatment in the patient's medical record, specifying the use of either single or double lights.

**Use single light phototherapy if:**

- SBR is at or above the phototherapy treatment threshold line

**Use multiple light phototherapy if:**

- SBR is rising rapidly (>8.5 micromol/L per hour)
- SBR is <50 micromol/L below the **RED** exchange transfusion line
- SBR fails to respond to single light phototherapy

***If the SBR is rapidly rising or approaching the RED exchange transfusion treatment threshold line and urgent medical review should occur***

**Contraindications to phototherapy** include:

- Neonates with congenital porphyria
- Family history of porphyria
- Concurrent treatment with photosensitising drugs

## Equipment

***NeoBlue and neoBLUE mini–LED Phototherapy overview***

The neoBLUE LED (Standard size) and Neoblue mini-LED are portable phototherapy light devices that delivers a narrow band of high-intensity blue light via light emitting diodes (LED's) to provide treatment for neonatal hyperbilirubinemia in the hospital setting.

NeoBLUE LED's emit light in the range of 450-470nm). NeoBLUE LED devices deliver a narrow band of high intensity blue light between 450-475nm with a peak wavelength 458nm. This range corresponds to the spectral absorption of light by bilirubin and is thus considered to be the most effective for the degradation of bilirubin.

NeoBLUE LED's do not emit significant ultraviolet (UV) or infrared (IR) radiation, so they can be placed close to the baby.

### *Neo BLUE LED phototherapy light* (Standard size)

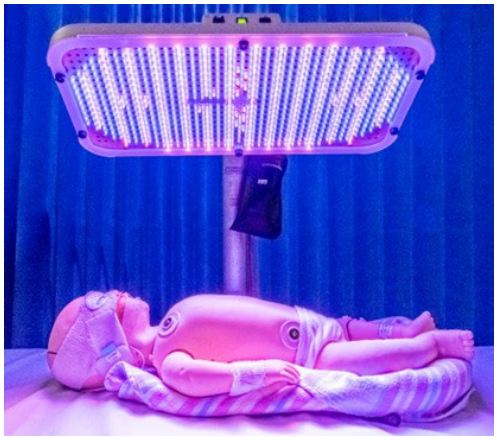



*Image 2. Examples of NeoBlue LED device (standard size)*

- The neoBLUE LED covers a treatment area of 50 x 25cm
- It has 2 different settings to switch between - standard (15 μW/cm²/nm) and intensive (35 μW/cm²/nm). Commence with intensive light.
- Ideally, the neoBLUE LED should be positioned directly above the infant. The light can be adjusted both horizontally and vertically using adjustment screws on the stand. **Do not place the light directly under a radiant warmer.**
- When using an infant warmer, the NeoBlue LED should be positioned to the side of the infant and tilted at a 40-degree angle. This prevents the phototherapy unit overheating and prevents the disruption of heat to the infant. The NeoBlue LED is tilted by grasping either side of the unit and tilting in an upwards motion.
- Be aware that tilting the light will increase the distance to the infant and reduce the light intensity. **The light must be no further than 30cm from the infant**.
- If necessary, the neoBLUE LED can be placed directly on top of an incubator. The rubber feet on the bottom of the unit provide stability and enable sufficient. Be aware that the distance from the infant may be too great to achieve intensive phototherapy.
- Turn on the power switch. This is the green switch in the centre of the front panel.
- Press the target illumination switch (right hand side of front panel) on the neoBLUE LED to position the lights correctly. The red target illumination light should be focused over the infant's torso. The default is to select the high setting for intensive phototherapy or unless the low setting for standard phototherapy as specified by the medical officer (control switch is on the left side of front panel).
- Measure and document the level of irradiance (light intensity) delivered by the phototherapy lights.

## Measuring light irradiance (intensity)

- Light irradiance is measured with the neoBLUE radiometer.
- The neoBLUE radiometer should only be used to measure irradiance on the neoBLUE LED phototherapy light
- To measure light irradiance using the neoBLUE radiometer, ensure that both the phototherapy light and the radiometer are turned on.
- Hold the radiometer under the phototherapy light near the infant's skin (over the torso). Press and hold the button on the front panel whilst waiting for the reading to stabilise. Release the button to lock the final reading.
- Measure the light irradiance on a daily basis during treatment and document the phototherapy dosage on the observation chart.

### *NeoBlue Mini LED Phototherapy*

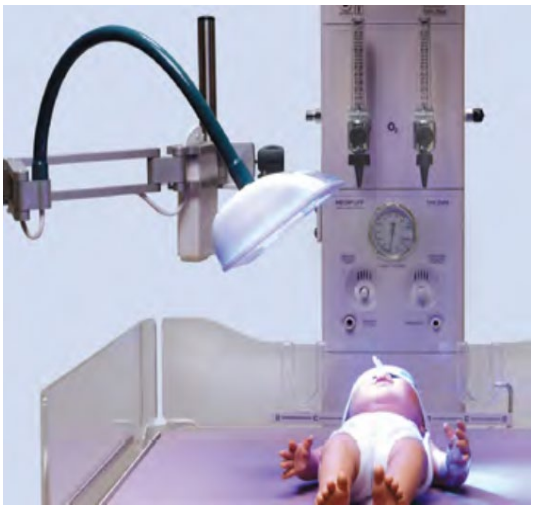


*Image 3. Example of NeoBlue mini light in use on an open care system*

- The neoBLUE **mini** light covers a treatment area of 12.7 cm x 20.3 cmFor infants >3 Kg either two neoBLUE mini-LEDs are to be used to ensure adequate surface coverage or alternately Med warm lights can be used for larger neonates. This will provide single phototherapy.
- Keep 30 cm from the light enclosure to the baby. This measurement is taken from the central area of the effective surface area for phototherapy.
- The intensity of the light is inversely related to the distance from the light source to the baby.
- When placing the light at an angle, you may be increasing the distance between the light and the baby, thereby decreasing the intensity.

**Use with different bed types:**

- Use with an incubator: the neoBLUE mini light can be placed on top of the incubator or can be tilted to the side
- Use with a radiant warmer: when used with the radiant warmer, care must be taken to angle the light and position it to the side of the heat source. The enclosure must be placed out of the path of the radiant heat source.

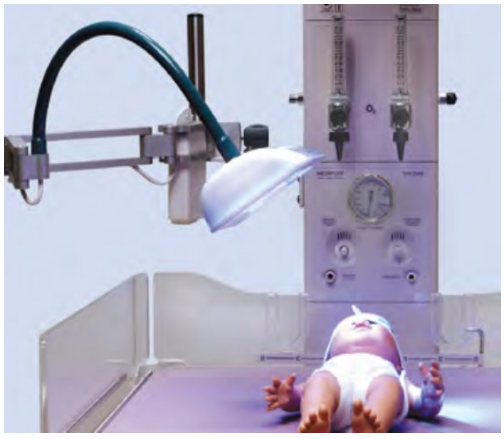



*Image 4 & 5 - Examples of NeoBlue equipment and equipment in use*

**Medwarm LED Phototherapy lights**

*Image 6. Medwarm LED Phototherapy Light*

The Medwarm LED Phototherapy lights can be used for term or preterm neonates. It has five different light intensity levels that can be changed during treatment.

- Unless otherwise specified by the treating neonatologist select the highest level of light intensity.
- The distance between the patient and the Medwarm LED phototherapy light should be 30cm.
- Instructions for use can be found in the equipment manual.

***Bilisoft (Biliblanket-fiberoptic)***

- Delivers narrow band of high intensity blue light between 430-490nm and provides an irradiance between 35 µW/cm²/nm (large pad) and 50 µW/cm²/nm (small pad).
- Position the connecting cable end so as not to cause pressure to the infant's skin.
- Inspect the skin every at least every four hours as burns have been documented especially with extremely low birth weight infants.
- The fibre-optic blanket can be used to provide the second source of phototherapy when double lights are ordered.
- Fibre-optic phototherapy blankets have been shown to be less effective in decreasing bilirubin levels than conventional phototherapy except in preterm infants. Combining a fibre-optic light with conventional phototherapy maybe more effective.
- Use a protective disposable cover on the fibre-optic blanket and place the probe next to the infant's skin.
- Do not use clothes or wraps as this will reduce the effectiveness of the phototherapy.
- Ensure that a new protective cover is used for each infant. The covers are single patient use and slide over the BiliSoft fibre optic pad. The cover should be changed if it becomes soiled.
- There are two sides to the BiliSoft LED blanket. ***Ensure that the illuminated area (brightest side) faces upwards and is in direct contact with the infant's skin.***
- The BiliSoft LED blanket is x-ray compatible therefore the infant is not required to be removed from the blanket for an x-ray

*Image 7 & 8. Example of Fibreoptic phototherapy blanket equipment and equipment in use*

### *BiliCocoon (NeoMedLight)*

BiliCocoon® is a medical device by NeoMedLight It is targeted at treating neonatal jaundice without compromising the relationship between the parent and the newborn.

- For maximum effectiveness, it offers an intensive and homogeneous irradiance (35 microW/cm²/nm),
- A large coverage of body surface area (1200 cm²)
- It is emitting light in the absorption spectrum of bilirubin: from 430 to 490 nm, facilitating the reduction of bilirubin concentration in the blood
- Light- emitting surface of 40x30cm²
- Suitable for use in infants with a weight >1kg
- Do not use clothes or wraps as this will reduce the effectiveness of the phototherapy.

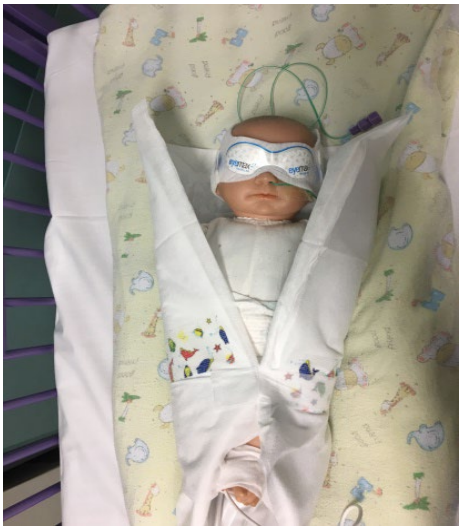


*Image 9&10. Example of Bilicoon and equipment in use*
https://www.medicalexpo.com/prod/neomedlight-sas/product-120913-843597.html

- Bilicocoon cover to be placed over equipment prior to use
- Protective eye wear to be worn at all times while light is emitting
- Oxygen saturation probe to be used to monitor throughout treatment with webrill cover for more accurate oxygen saturation recording

## Light source intensity

| Light Source | Distance from infant (cm) | Intensity (uw/cm²/nm) | Weight (kg) | Surface area (cm) | Classification |
|---|---|---|---|---|---|
| **NeoBLUE mini-LED** | 30cm | 30-35 | <2.7kg | 20.3-12.7cm | Single |
| **NeoBLUE LED (standard)** | 30cm | High 35<br>Low 15 | <4.5kg | 50x25cm | Single at high setting |
| **Medwarm** | 30cm | Setting:<br>**1** 17-23<br>**2** 37-43<br>**3** 57-63<br>**4** 77-83<br>**5** 97-103 | Not specified | 50x30cm | Setting 1-3 Single<br>Setting 4-5 Double |
| **Bilicocoon** | Direct contact | 35 | From 1 to 10kg | 40x30cm | Double |
| **Bilisoft** | Direct contact | 35 (large pad) | Not specified | 25x30cm | Single |

# Care of the Neonate receiving Phototherapy

### Surface area

- Infants are nursed semi naked with a nappy when under phototherapy.
- In extreme hyperbilirubinemia, the nappy is removed so that maximum expose to the light is obtained to avoid the necessity for an exchange transfusion. Their position is changed regularly to gain full benefit of the light exposure.

### Fluid and hydration

- Record an accurate fluid balance (which includes weighing of nappies) and measure the urinary specific gravity once a shift.
- Weigh infants at least 2nd daily.
- It is important to maintain adequate hydration and urine output during phototherapy since urinary excretion of lumirubin is the principal mechanism by which phototherapy reduces bilirubin levels. Thus, during phototherapy, infants should continue oral feedings by breast or bottle. There is no evidence that intravenous (IV) fluid supplementation provides significant additional benefit beyond adequate oral hydration. However, IV hydration is a potential option to correct for dehydration, hypovolemia, and/or hypernatremia in infants with significant volume depletion whose oral intake is inadequate, or in cases of very high SBR close to exchange level where interruption to phototherapy is not advisable.
- Exposure to phototherapy increases capillary blood flow and metabolic rate, which can cause an increased insensible fluid loss, particularly in the preterm infant.

- Breastfed infants whose intake is inadequate, who have excessive weight loss (>10 percent of birth weight), or who have evidence of hypovolemia should receive supplementation with human. Formula may be used if these preferred sources of human milk are not available. If breastfeeding is interrupted, it should be resumed as soon as possible.
- Assess and record stools. Phototherapy can cause loose, dark green stools. Pale stools may indicate obstructive jaundice which requires further investigation.

**Eye Care & Skin care**

- Protect the infant's eyes with 'phototherapy shades' to minimise the potential for retinal damage. The protective eye wear needs to be secure to prevent dislodgement, exposing the eyes to the harsh light or obstructing the airway.
- Remove phototherapy shades at least every four hours to check the infant's eyes for discharge. If required clean the eyes with normal saline. The phototherapy shades are changed every 24 hours. Check for appropriate size and tightness.
- Always turn the phototherapy lights off before performing eye care.
- Use warm water to clean the infant and dry afterwards to help maintain skin integrity. Creams and oils should not be used on exposed skin during phototherapy.
- Check the infant's buttocks during nappy changes for signs of excoriation. Creams may be applied to the nappy area as this area is not exposed to the lights. If the nappy is removed during intensive phototherapy, ensure that any creams are also removed.
- Turn off phototherapy lights when collecting blood for SBR levels as the phototherapy light will affect the sample.

***Patient Safety***

- Oxygen saturation monitoring is required as the blue lights may mask the infants' colour and the presence of cyanosis.
- When using saturation monitoring cover, the probe with an opaque material light interference may result in erratic or inaccurate saturation measurements.
- Turn off phototherapy lights when collecting blood for SBR levels as the phototherapy light will affect the sample.
- Protect the infant's eyes with 'phototherapy shades' to minimise the potential for retinal damage. The protective eye wear needs to be secure to prevent dislodgement, exposing the eyes to the harsh light.
- A skin temperature probe is used to continuously monitor the infant's temperature particularly when nursed on an open care system.

***Developmental and Family Care***

- Explain the use of phototherapy and the care of the infant to the parents.
- If the level is not extreme and medical permission has been obtained, turn off the phototherapy lights and remove goggles for short periods when parents are visiting.
- Arrange time for parents to take the infant out of phototherapy treatment so they can have periods to nurse the infant. For most infants this will be at feeding times.
- Provide comfort measures such as a dummy or positioning. If the infant is unsettled, and when cardiorespiratory monitoring is applied, the infant may be nursed prone.
- For additional developmental care information refer to the Developmentally supportive care for newborn infants practice guideline.

## Gestational alloimmune liver disease (GALD)

Gestational alloimmune liver disease (GALD) is a disease process causing severe fetal liver injury, due to transplacental passage of IgG as early as 12 weeks gestation from the mother to the fetus. It is difficult to diagnose newborns with GALD as there are not truly discriminating clinical, biochemical, radiologic, or histologic features.

Most patients with GALD-NH show signs of fetal liver disease including intrauterine growth restriction and oligohydramnios. Some will have evidence of cirrhosis on prenatal ultrasound, such as ascites. Many are prematurely born.

Patients with GALD present with signs of liver failure within hours of birth, hypoglycemia, bleeding, edema (anasarca, hydrops), and general sickness (culture negative sepsis).

Laboratory results indicative of GALD include:

- Hyperbilirubinemia (bilirubin exceeding 500umol/L) with elevated conjugated unconjugated portions
- Elevated INR on coagulation profile
- Aminotransferases rarely exceed 100 IU/L
- Very high a-fetoprotein levels (100,000–600,000 ng/mL)
- High serum ferritin levels (>800 ng/mL), low transferrin levels and high iron saturations

Prognosis for severe GALD without intervention is very poor. Combination of double-volume exchange transfusion to remove existing reactive antibody followed immediately by administration of high-dose intravenous immunoglobulin (IVIG) (1 g/kg) to block antibody induced complement activation has been the proposed as current treatment strategy.

# Exchange transfusion

**Exchange transfusion is a high-risk procedure which should only be carried out in a critical care unit with appropriately experienced clinicians and equipment.**

Exchange transfusion should be considered a **medical emergency procedure** and is time critical. If a newborn has serum bilirubin levels closer to the exchange transfusion threshold or above the exchange transfusion threshold ICU clinicians should initiate the following **four KEY** steps:

1. The on-call consultant/ neonatologist should be contacted without delay and confirm decision.
2. Obtain consent from parents for the procedure explaining the possibility of long-term complications because of high jaundice levels, the need for exchange transfusion, benefits of the procedure in minimising complications and risks involved with the procedure.
3. Communicate with blood bank. Send blood group and crossmatch and inform blood bank regarding **urgent** need for 1 to 3 units of packed RBCs (as per calculation explained below) and 15ml/kg of fresh frozen plasma for exchange transfusion.
4. Inform NUM/TL, ACCESS nurse and bedside nurse to start preparation for exchange transfusion. Continue intensive phototherapy with maximum exposure of body surface except for nappy and eyes.

**Aim:** Exchange transfusion can prevent or minimize the severity of acute bilirubin encephalopathy and kernicterus by rapidly diluting the serum bilirubin, thus removing antibody coated red blood cells replacing it with blood with normal levels of bilirubin and antibody free cells.

**Risks of procedure:** Exchange transfusion is not free of risk. The commonest clinical problems are apnoea, bradycardia, electrolyte imbalance and hypothermia. This procedure is now infrequently performed in the NICU and as such poses an added risk.

Due to the rarity of this procedure Australian Red Cross is no longer storing whole blood. This necessitates the use of packed red blood cells (PRBC) and fresh frozen plasma (FFP) as required.

### Blood Volumes

The volume of blood for exchange is calculated using an estimate of the neonate's circulating blood volume:

- Term infants 80ml/kg
- Preterm infants 100ml/kg

### Single volume exchange transfusion

Single volume exchange is considered when aetiology is not Haemolytic Disease of the Newborn. 1 x circulating blood volume (for example, for a term infant 80ml/kg) and this replaces approximately 60% of the blood volume.

### Double volume exchange transfusion

Double volume exchange transfusion commonly used for removal of bilirubin and antibodies,

2 x the circulating blood volume (for example, for a term infant 2 x 80ml/kg = 160ml/kg).

Replaces approximately 85% of the blood volume and this will cause an approximate reduction of 50% of the pre-exchange bilirubin level (but can be expected to rebound 4 hours post transfusion to approximately two thirds of pre-exchange level). The mortality risk is 0.5%.

**Ordering of Red Blood Cells (RBC) and Fresh Frozen Plasma (FFP):**
A request for blood products for an exchange transfusion is an ***urgent request.*** The blood products (RBCs and FFP) should be ready within 1-2 hours of the request, provided antibody testing has been completed. RBCs should be CMV negative and irradiated as is with all neonatal blood product transfusions. To ensure timeliness of the process, ensure consistent communication with Blood Bank. CHW Blood Bank- ext 52284. SCH Blood Bank- ext 23232.

**Volume of RBCs and FFP to be ordered:**
Red Blood Cells: When ordering red blood cells for an exchange transfusion, remember the priming volume of the exchange circuit is approximately 50mL, so additional RBCs should be ordered to accommodate this. A double volume exchange (80mL/kg x 2) is required for established hyperbilirubinemia or to prevent hyperbilirubinaemia.

- *Estimated double blood volume = 160 mL x weight (kg) + priming volume*
- *Fresh Frozen Plasma: Order 15mL/kg of FFP*

## Preparation of the infant

- Anticipate the potential need for respiratory support in self-ventilating patients
- All babies are to be placed on an open care system servo mode and skin temperature maintained at 36 – 36.5C (*Refer to Thermoregulation policy)*
- Continuously monitor cardio-respiratory, oxygen saturation, and NIBP during the procedure. Record baseline observations as indicated on the Exchange Transfusion page in the ‘Jaundice’ tab on eRIC.
- Aspirate gastric contents through a 6Fr or 8Fr feeding tube prior to starting the exchange procedure.
- Position small nappy (to maintain maximum exposure to phototherapy) and change as necessary to keep area as clean as possible
- Place urine bag or cotton balls in nappy, or IDC to monitor urine output
- Confirm correct identification of the baby with the MO performing the procedure

- Ensure the newborn screening test (NBST) is attended prior to transfusion
- Continue phototherapy lights throughout the procedure
- Ensure a functioning peripheral cannula is in place for FFP infusion
- The volume of RBCs and FFP to be administered must be prescribed on eRIC prior to commencing the procedure
- Resuscitation trolley nearby
- Use a pacifier for comfort and provide supportive wrapping to help contain the infant
- Blood tests prior to exchange:
  - **On cord blood:** Direct Coombs; Hb, SBR
  - **On baby blood:** ABO and Rh factor; Direct Coombs (If not done on cord blood); SBR, ABG, NBST, EUCs including calcium, LFTS, FBC, BGL, coags and hold samples for other tests as indicated (e.g. G6PD deficiency, viral infection, hereditary spherocytosis, or metabolic studies)
  - **On maternal blood:** Indirect Coombs if ABO
  - **Other:** Group and Rh factor; Test for antibodies if Rh negative; Father's Rh factor

## Procedure

The exchange transfusion technique can be performed using either a one-catheter or two catheter technique for the removal of blood.

One catheter is used when only the umbilical vein is available as long as the UVC is at the diaphragm and not in the liver. Exchange transfusion via the portal system is not recommended.

A two-catheter technique using the umbilical vein (blood in) and umbilical artery (blood out) is commonly employed when available. A peripheral artery cannula and a peripheral venous cannula can also be used. This technique is preferred and has been found to be safe in haemodynamically unstable infants. If using the peripheral cannula method, it is recommended that as a precaution two venous cannulas should be inserted prior to commencing the procedure so that if the input line blocks or the cannula dislodges, the procedure is ceased and recommenced with a new line.

For exchange transfusion step by step instruction are provided below.

# Exchange Transfusion using One Catheter Technique

### *Equipment*

- Exchange Transfusion Kit:
  (Located in ET box in storeroom at GCNC. For SCH obtain transfusion kit from RHW NICU)
  - Vygon Exchange Transfusion Kit
  - Blood administration set
  - Blood warming tubing
  - Blood warmer set at 37°C
  - BBraun Pump (for higher rates of blood infusion required, labelled in ET box)
  - 50mL syringes
  - 10mL syringes
  - Blood sampling tubes
  - BBraun pump for FFP administration
  - Fresh frozen Plasma (FFP)
  - Blood specimen tubes/sampling syringes
  - Resuscitation trolley nearby

### *Technique*

1. Use the prepacked Vygon exchange transfusion kit, see diagram below.
2. A blood warmer should be used to ensure the blood is injected at body temperature. Coil the tubing around the warming tube set to maintain blood at body temperature (set at 37°C). Blood warming extension set should be threaded into blood warming coil while set unprimed and the extension set to be secured to the blood warmer using clear tape.
3. Prime the giving set with blood and make sure that there is no air in the line.
4. The blood to be exchanged is calculated as twice the circulating blood volume.
5. Fresh frozen plasma (FFP) to be infused separately via PIVC. For every 90 mL of PRC infusion, administer 10mL FFP. Continue administering 90ml of PRC, after which 10mL FFP is administered again. Continue this process until the exchange transfusion is completed. i.e., replace 100ml of patient's blood with 90mL of PRC and 10mL of FFP.
6. A four-way stopcock is turned to regulate the input and withdrawal of blood.
7. Blood is aspirated by syringe 10ml at a time, approximately 1-2mL/kg/min.
8. The stopcock turned and the blood discarded into the waste bag.
9. Using a 10mL syringe blood is withdrawn from the bag, stopcock turned, and blood injected into the umbilical vein at a rate of 1 – 2mL/kg/min.
10. Continue process until the end of pre-calculated exchange volume.
11. The bedside nurse is responsible for recording in and out blood volumes. Each cycle in and out should take approximately 4-5 minutes.

12. Monitor BP every 15 minutes and collect an SBR, blood gas, BGL, FBC and coagulation screen halfway through the exchange transfusion or as indicated by the neonatologist.
13. Record input and output in the patient's electronic medical record.
14. Immediately following the exchange transfusion bloods should be taken for a blood gas with a BGL, SBR, EUC, CMP, FBC, coags and crossmatch for a potential subsequent exchange transfusion, and repeated at 2 hours, 6 hours, and 12 hours.
15. Measure the body temperature and adjust environment if required.
16. Blood sugar levels are measured hourly for four hours following completion of the procedure. Electrolytes and ABG may also require review.
17. Due to the perceived increased risk of necrotising enterocolitis post exchange transfusion, withhold feeds. Feeds may be reintroduced cautiously 12 hours post procedure.

*NB: The exchange transfusion should not commence until the medical and nursing staff agree that the circuit set is correct and ready to commence the procedure.*

**Image 8:** Single Catheter exchange transfusion equipment and set up:

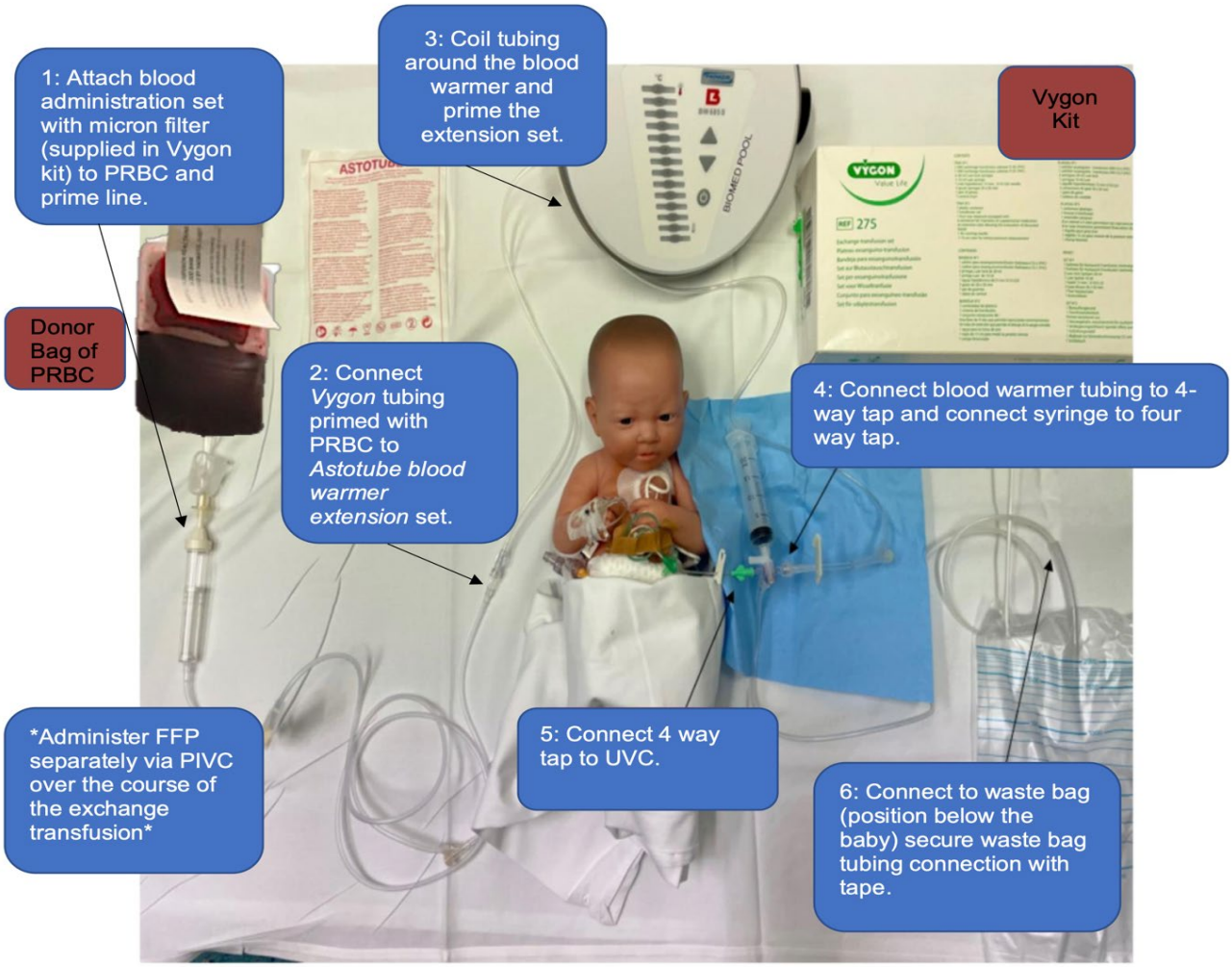
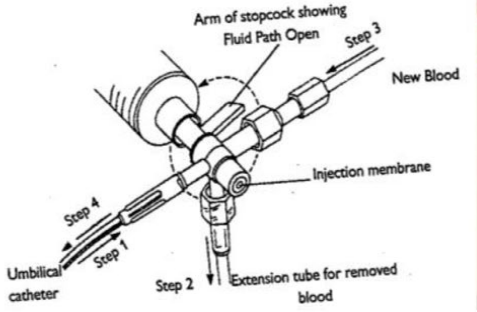
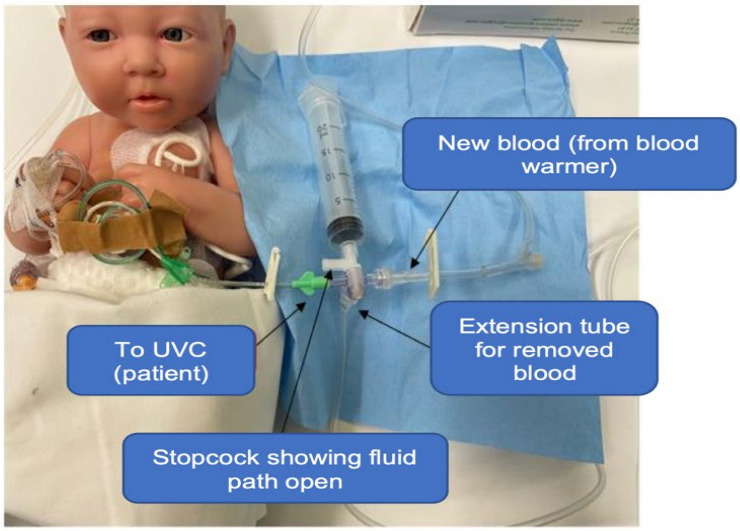



**Image 9:** Close up of four way tap set up:



# Exchange Transfusion Two Catheter Technique

### *Equipment*

- Vygon Exchange transfusion kit
- 1-2 bags of packed red blood cells (PRBC)
- Blood administration set
- B Braun pump (for higher rates of blood infusion required, labelled in ET box)
- 50ml syringes
- 10ml syringes
- Blood sampling tubes
- Blood Warmer set at 37°C
- Blood warming tubing
- Fresh frozen plasma (FFP)
- Blood specimen tubes/sampling syringes
- Resuscitation trolley nearby

### *Technique*

1. Use the prepacked Vygon exchange transfusion kit
2. Connect the blood administration set to the bag of PRBCs as shown in the image below.
3. Coil the tubing around the warming tube set to maintain blood at body temperature (set at 37°C). Blood warming extension set should be threaded into blood warming coil while set unprimed.
4. Prime the giving set with blood and make sure that there is no air in the line.
5. The blood to be exchanged is calculated as twice the circulating blood volume.
6. Two operators are required – a medical officer who controls the withdrawal of blood and a registered nurse who manages the input of blood. Where possible a third team member is involved in the essence of education.
7. Blood is aspirated by arterial syringe 10mL at a time, approximately 1 – 2mL/kg/min or 100mL exchanged every 15 minutes maximum.
8. Blood is injected by venous syringe at the same rate as withdrawal from arterial line.
9. Fresh frozen plasma (FFP) to be infused separately via PIVC. For every 90mL of PRBC infusion, administer 10mL FFP. Continue administering 90ml of PRBC, after which 10mL FFP is administered again. Continue this process until the exchange transfusion is completed. i.e., replace 100ml of patient's blood with 90mL of PRBC and 10mL of FFP.
10. Avoid pauses in aspiration to avoid clotting in small cannula.
11. Continue process until the end of pre-calculated exchange volume.

**12.** Monitor BP every 15 minutes and collect a SBR, blood gas, BGL, FBC and coagulation screen halfway through the exchange transfusion or more frequently as indicated by the proceduralist to manage electrolyte and metabolic derangements.

**13.** Record input and output in the patient's electronic medical record. A dedicated person should be available to do this for the entire procedure.

**14.** Immediately following the exchange transfusion bloods should be taken for a blood gas with a BGL, SBR, EUC, CMP, FBC, coags and crossmatch for a potential subsequent exchange transfusion, and repeated at 2 hours, 6 hours, and 12 hours or as indicated by the treating physician

**15.** Measure the body temperature and adjust environment if required.

**16.** Withhold feeds in sicker patients. Feeds may be reintroduced cautiously 12 hours post procedure.

**17.** The proceduralist should document the exchange transfusion procedure in the progress notes.

NB: *The exchange transfusion should not commence until the medical and nursing staff agree that the circuit set is correct and ready to commence the procedure.*

**Image 10:** Exchange Transfusion Set Up - Two Catheter Technique *(option using a 3-way tap)*

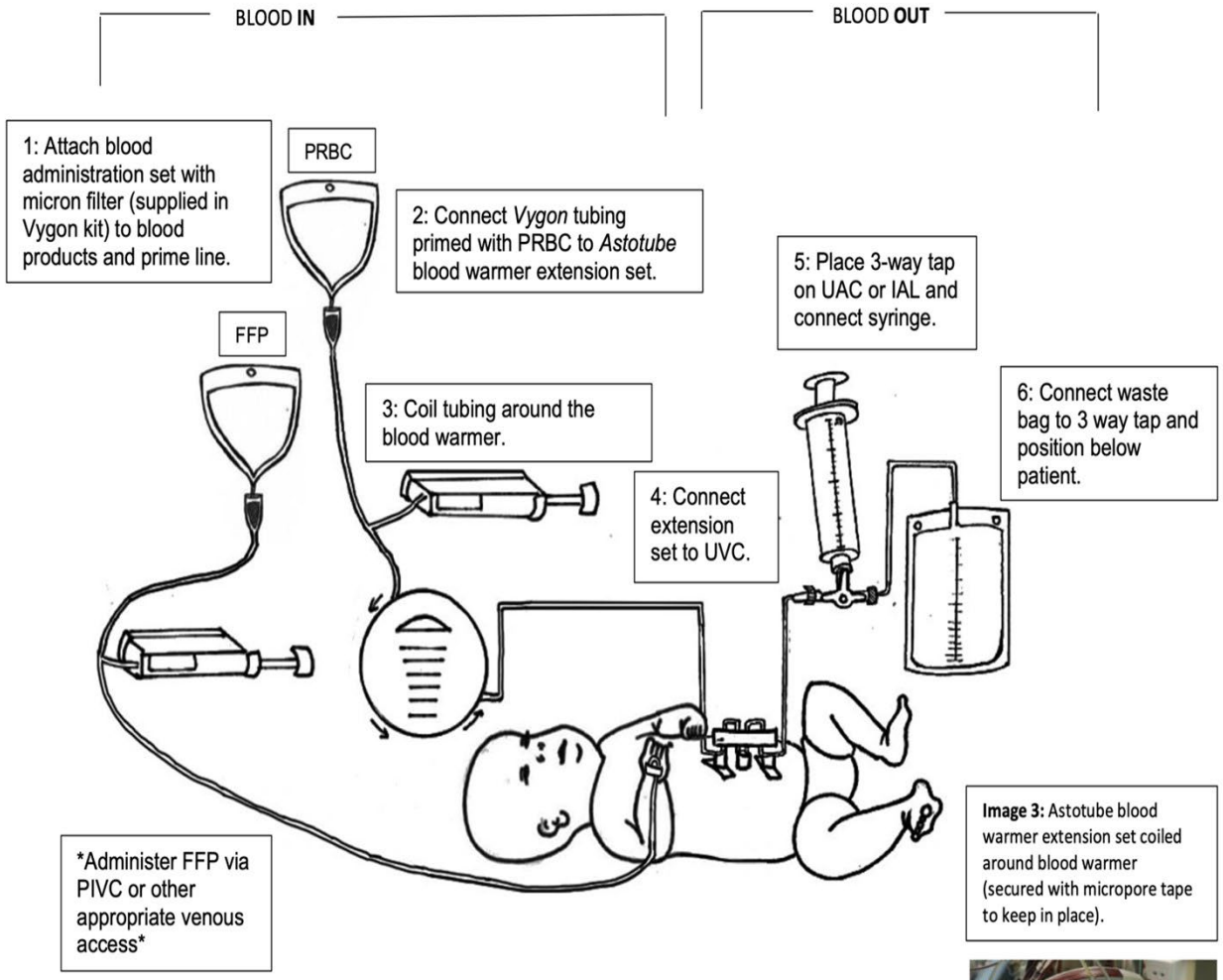



**Image 3:** Astotube blood warmer extension set coiled around blood warmer (secured with micropore tape to keep in place).

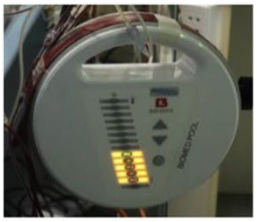
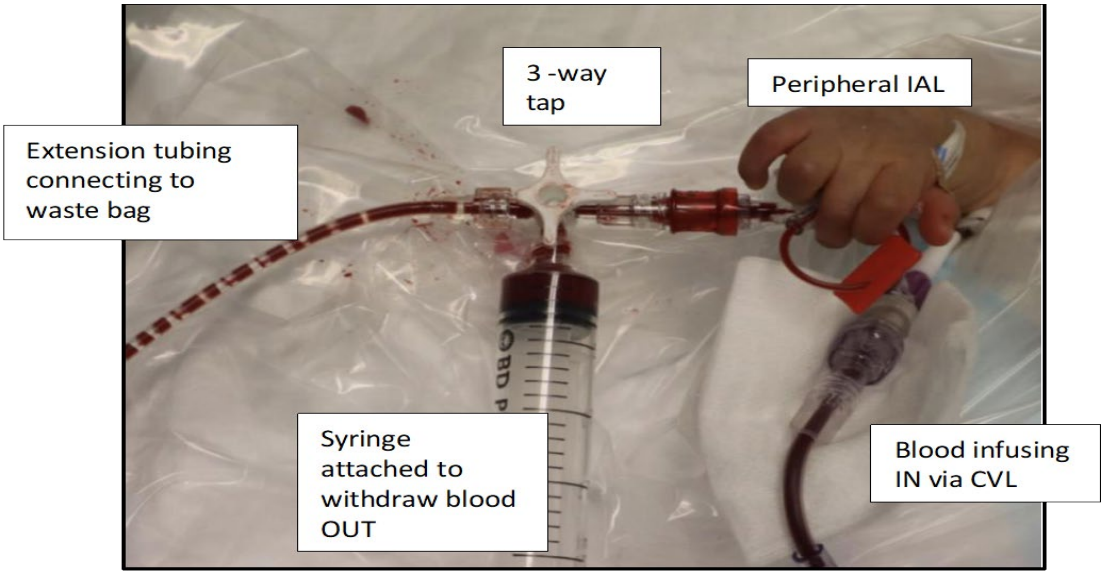


**Image 11:** Close up of BLOOD OUT set up using a 3-wap tap instead of the 4-way tap included in the Vygon package via a peripheral IAL.




## Patient Safety

- Blood and blood products are not to be mixed or re-constituted. Blood is supplied from the Blood Bank for the procedure.
- Continuous cardio-respiratory monitoring including NIBP, and observations recorded every 15 minutes during the procedure.
- The procedure is performed in an incubator or under a radiant heater.
- Resuscitation equipment must be available for use during the procedure.
- Universal precautions should be observed throughout the procedure including the use of protective eye wear and gloves.
- Record input and output in the patient's electronic medical record.
- The doctor and nurse who start the procedure should finish the procedure.

**In case of adverse reaction during the procedure**

- Stop the procedure
- Resuscitative measures
- Flush catheter
- Keep blood batch number of blood products and complete IIMS

## Post procedure care

- Continue phototherapy post procedure, till SBR results are reviewed by the consultant
- Repeat SBR at 2 hours, 6 hours, and 12 hours or as indicated by the treating physician
- Continuous monitoring post procedure and document 30minutely for first 4 hours and then routine hourly observations continued for 24 hours
- Observe the catheter site for bleeding or signs of infection
- Withhold feeds in sicker patients. Feeds may be reintroduced cautiously 12 hours post procedure. Keep NBM post procedure for at least 4hrs
- Monitor glucose, EUC, LFT, FBC, coags and CMP
- Monitor for signs of NEC and observe for signs of feed intolerance when feeding is recommenced
- Monitor urine output
- Document the procedure in eRIC.

## Potential and rare complications during or post-procedure include:

- Administering incorrect blood
- Incorrect total leading to congested heart failure or anaemia
- Vascular complications
- Rebound hypoglycaemia
- Catheter related (air or blood emboli, thrombosis, haemorrhage)
- Temperature instability (hypo/hyperthermia)
- Perforation of gut by umbilical catheter
- Necrotising enterocolitis
- Haemodynamic (hypo/hypertension), electrolyte imbalance (hypocalcaemia, hyperkalaemia, acidaemia)
- Other related potential complications could include Arrhythmias, bradycardia, neutropenia, dilutional coagulopathy, feed intolerance, NEC, septicaemia, and blood born infection

### *NSW Health Policy*

Additional information relating to Jaundice and its management can be found in the NSW Health policy at the following link: Neonatal - Jaundice Identification and Management in Neonates ≥ 32 Weeks Gestation

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# Appendix A: Transcutaneous Bilirubin Monitoring

Transcutaneous bilirubin (TcB) devices are widely utilised in well near/full-term babies to estimate bilirubin levels alongside total serum bilirubin (SBR) levels.

TcB measurements provide immediate results, expediting treatment and avoiding discharge delays, and indicating the necessity for formal serum bilirubin measurement.

***Instructions for Use***

All clinicians require appropriate training in the use of Drager JM 105 and the relevant Jaundice guidelines.

The Dräger Jaundice Meter JM-105 is intended for use as a screening device for jaundice in the newborn and can be used before, during and after phototherapy. It provides a transcutaneous measurement of bilirubin in µmol/L.

**Taking a TcB Measurement**

1. Clean the measuring probe with an alcohol swab.
   - If the green Ready LED is on, the measurement can be taken.
2. Select MENU→ Select MEASURE→ Press OK
   - The letters AVE with the number of measurements selected will appear in the display.
3. Place measuring probe perpendicular to measuring point.
   - Forehead (inpatient) or sternum (outpatient)
   - Place probe tip flat against the baby's skin, not at an angle, and press lightly until you hear a click.
   - Lift the Jaundice Meter JM-105 from the skin between measurements and pause until the green READY light illuminates again.
   - Repeat the testing procedure until the required number of measurements (3x times).

4. Document the TcB results in patient's medical records.
   - JM-105 has a measurement range of 0.0 µmol/L to 340 µmol/L. If - >340 - blinks in the measured value field, the measured value is outside the display range.
5. Clean the probe with an alcohol swab after use.

## Documentation of TcB results

- TcB result should be plotted on the appropriate gestation age Neontal Jaundice Treatment Threshhold Chart
- The TcB measurement is ≥ 250 micromol/L, or the result is on, or within 20 micromol/L of the phototherapy threshold line for gestation at birth, an SBR should be measured.

## References:

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- https://www.draeger.com/Content/Documents/Content/JM-105-Device-Operation-QRGv1.pdf

# Appendix B