JAUNDICE IN NEONATAL CARE - GCNC - CHW

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 clinical 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 of 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 transfusions.

CHANGE SUMMARY

- Updated references
- Amendments made to content
- Updated equipment information included
- Updated figure for phototherapy threshold

READ ACKNOWLEDGEMENT

- All clinicians working in Grace Centre for Newborn Care e.g. Registered Nurses, Clinical Nurse Specialists, Nursing Unit Managers, Clinical Nurse Educators, Registrars, Fellows and Neonatologists are to read the contents of this document.

Approved by:	SCHN Policy, Procedure and Guideline Committee	
Date Effective:	1st September 2017	**Review Period:** 3 years
Team Leader:	Nurse Educator	**Area/Dept**: Grace Centre Newborn Care CHW

Date of Publishing: 11 August 2017 12:32 PM Date of Printing: 11 August 2017

TABLE OF CONTENTS

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[1]. "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 fetal haemoglobin, and is due to increased production (accelerated red blood cell breakdown), decreased removal (transient liver enzyme insufficiency), and increased reabsorption (enterohepatic circulation)[2].

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[3].

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 fetal red cells, which is 40-70 days compared to 120 days in an adult, and an increased circulating red cell mass[3].

Bilirubin is produced by the breakdown of red cells where haemoglobin is phagacytosed by macrophages, and split into haem and globin. The globin portion, a protein, 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[4].

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 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 gluuronic 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 serobilinogen. As these compounds are now water-soluble, they can be excreted in the urine and stools[1].

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[6,7]. 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[8].

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.

Hemolytic 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[9].

Rhesus incompatibility

Occurs when Rh-positive fetal 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 an Rh-negative mother cause destruction of the Rh-positive fetal red cells[3]. 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 fetal-maternal blood transfusion during delivery or amniocentesis. During subsequent pregnancies the risk of fetal red cell haemolysis increases secondary to an elevated level of maternal anti-Rh antibodies[10].

With the advent of anti-D immunoglobulin Rhesus incompatibility is now a rare condition. Anti-D binds to fetal 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 fetus from Rh incompatibility resulted in the condition erythroblastosis (EBF) resulting in significant fetal anaemia[2].

ABO incompatibility

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 fetal red cells, causing haemolysis and the production of bilirubin.

Antibody mediated hemolytic disease can be diagnosed by examination of a blood film for signs of hemolysis 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[10].

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.

Galactosemia

The mechanism in galactosemia 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[11].

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[12].

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[6].
- Asian background (male): due to increased genetic predisposition to G6PD deficiency.
- Maternal immunoglobulin G (IgG) antibodies with rhesus incompatibility.
- Presence of cephalhematoma

Measurement of Jaundice

Clinical Examination

The assessment of jaundice improves with clinical experience, however, remains at best an estimate. Examination under natural light with attention to the sclera as well as the skin can be helpful. Babies with darker complexions as well as those with an increased red-cell mass can make interpretation more difficult. A number of clinical "rules" such as Kramer's rule have been recommended by some authors although there is little evidence to support their use, particularly as a means of deciding when NOT to perform a serum bilirubin.

Serum versus transcutaneous monitoring

Measure and record the bilirubin level urgently (within 6 hours) in all babies more than 24 hours old with suspected or obvious jaundice.

- Use serum bilirubin measurement for babies in the first 24 hours of life or who have a gestational age of less than 35 weeks.

- In babies who have a gestational age of 35 weeks or more and who are over 24 hours old use a transcutaneous bilirubinometer to measure the bilirubin level. f a transcutaneous bilirubinometer is not available, measure the serum bilirubin.
- If a transcutaneous bilirubinometer measurement indicates a bilirubin level greater than 250 micromol/litre, measure the serum bilirubin to check the result.
- Use serum bilirubin measurement if bilirubin levels are at or above the relevant treatment thresholds for their age, and for all subsequent measurements[13].

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[6].

Bilirubin Threshold

The following chart[14] gives the SBR level for a given day of life and gestational age at which to commence phototherapy in well babies with uncomplicated jaundice. Please note that this is not a guide to cease treatment.

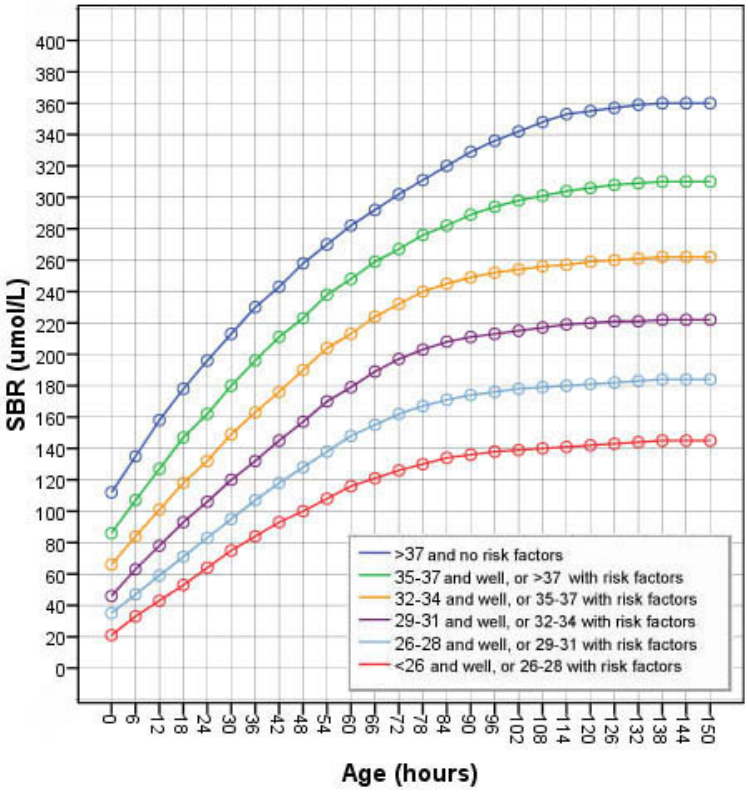


Image 2. Bilirubin threshold chart[14]

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 more and are more than 24 hours old, and who have a bilirubin level that is below the phototherapy threshold but within 50 micromol/litre of the threshold (see the threshold table and the treatment threshold graphs), 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.

In babies who are well, have a gestational age of 38 weeks or more and are more than 24 hours old, and who have a bilirubin level that is below the phototherapy threshold by more than 50 micromol/litre (refer to threshold table), do not routinely repeat the bilirubin measurement.

Do not use phototherapy in babies whose bilirubin does not exceed the phototherapy threshold levels in the threshold table and the treatment threshold graphs.

During phototherapy

- repeat serum bilirubin measurement 4–6 hours after initiating phototherapy
- repeat serum bilirubin measurement every 6–12 hours when the serum bilirubin level is stable or falling.

Stopping phototherapy

- Stop phototherapy once serum bilirubin has fallen to a level at least 50 micromol/litre below the phototherapy threshold (treatment threshold graph).
- Check for rebound hyperbilirubinemia with a repeat serum bilirubin measurement 12–18 hours after stopping phototherapy. Babies do not necessarily have to remain in hospital for this to be done[13].

Phototherapy

Phototherapy is a treatment of 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 wave length[3]. 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[4]. 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].

Equipment

NeoBlue mini led Phototherapy overview

The neoBLUE mini device is a portable phototherapy light 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. Blue LED's emit light in the range of 400-500 nm (peak wavelength 450-470nm). 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. Blue LED's do not emit significant ultraviolet (UV) or infrared (IR) radiation, so they can be placed close to the baby[14].

Surface area coverage and intensity

- The neoBLUE mini light covers a treatment area of 12.7 cm x 20.3 cm
- For infants >3 Kg either two neoBLUE lights are to be used to ensure adequate surface coverage or alternately Medwarm lights can be used for larger neonates
- Keep 30.5 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.
- Use with a bassinet: The neoBLUE mini light can be used to treat babies in bassinets, keep the light as close to the baby as possible

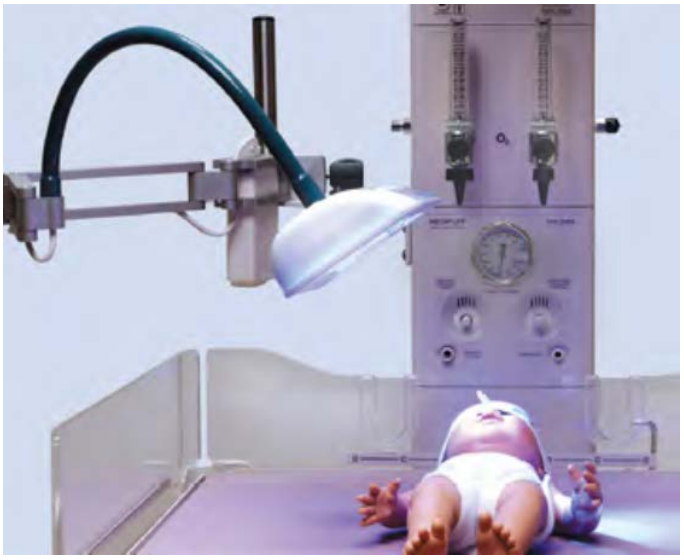


Image 3. Example of NeoBlue LED light in use on an open care system

- NeoBlue lights are stored on a fixed pole in the equipment storeroom.

Safety alert

To ensure adequate surface area cover for neonates >3Kg two NeoBlue LED phototherapy lights are used.

Medwarm LED Phototherapy lights

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

Image 4. Medwarm LED Phototherapy Light

Fibreoptic lights (Biliblanket)

- 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[16].
- The fibreoptic blanket can be used to provide the second source of phototherapy when double lights are ordered.
- Fibreoptic phototherapy blankets have been shown to be less effective in decreasing bilirubin levels than conventional phototherapy except in preterm infants. Combining a fibreoptic light with conventional phototherapy maybe more effective[13].
- Use a protective disposable cover on the fibreoptic 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.

Image 5 & 6. Example of Fibreoptic phototherapy blanket equipment and equipment in use

Care of the Neonate receiving Phototherapy

- Preterm infants are nursed semi naked with a nappy when under phototherapy[17]. 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.
- 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.
- Record an accurate fluid balance and measure the urinary specific gravity once a shift.
- Weigh infants at least 2nd daily.
- Dehydrated infants will require a regulated feeding regime and intragastric feeds to ensure their hydration is maintained. Demand feeding should only be considered if the serum sodium is less than 140mmol/L.
- Reflective material such as white linen can aid in additional phototherapy light exposure to the infant7.
- Exposure to phototherapy increases capillary blood flow and metabolic rate, which can cause an increased insensible fluid loss, particularly in the preterm infant[18,19].
- Monitor the axilla, skin and environmental temperature and record every four hours.
- Check the infant's buttocks for signs of excoriation and treat appropriately.
- Clean the buttocks with water only as oils and creams should not be used with phototherapy.
- 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 Coban and an opaque material such as Vellband as light interference may result in erratic or inaccurate saturation measurements.
- 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.
- 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.

Exchange transfusion

An exchange transfusion can prevent acute bilirubin encephalopathy and kernicterus by rapidly diluting the serum bilirubin and removing antibody coated red blood cells replacing it with blood with normal levels of bilirubin and antibody free cells. Exchange transfusion is not free of risk[20, 21, 22]. The commonest clinical problems are apnoea, bradycardia, cyanosis, vasospasm, and hypothermia. This procedure is now infrequently performed in the NICU and as such poses an added risk[21].

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 reconstitution with fresh frozen plasma (FFP) as required.

A 'double volume' exchange (85mL/kg x 2) is performed with 10mL syringes and the procedure should take around 1½ -2 hours. This removes about 85% of the infant's red blood cells. At the end of the exchange blood transfusion the bilirubin should be about 50% of pre exchange level. It will rebound at about 4 hours to 2/3 the pre exchange level.

The mortality risk is 0.5%.

The amount of fresh frozen plasma (FFP) to be added to a packed red blood cell (PRBC) unit to obtain the desired haematocrit (Hct 0.45) is calculated as follows:

Total exchange volume (mL)	**= Infant weight (kg) x 85 x 2**
Absolute PRBC volume	**= total exchange volume x 0.45** (desired haematocrit)
Actual PRBC volume	**= Absolute volume /Hct of the PRBC unit**
Volume of FFP	**= Total volume – actual PRBC volume**
***For example,* using a PRBC unit with a measured Hct of 0.56 in a 3500gm infant**	
Total exchange volume (mL)	**= 3.5 x 85 x 2 = 595mL**
Absolute PRBC volume	**= 595 x 0.45 (desired haematocrit) = 267.75mL**
Actual PRBC volume	**= 267.75 / 0.56 (as measured from unit) = 478mL**
Volume of FFP	**= 595 – 478 = 117mL**

The 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 and umbilical artery is commonly employed when available. A peripheral artery cannula and a peripheral venous cannula

can also be used. This technique has been found to be safe in haemo-dynamically unstable infants[22]. If using the peripheral cannula method it is recommended that as a precaution two venous cannulae 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.

Patient Safety

- Blood and blood products are not to be mixed or re-constituted in GCNC. Blood is supplied from the Blood Bank for 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.
- The doctor and nurse who start the procedure should finish the procedure.

Preparation of the infant

- Empty the infant's stomach prior to starting the exchange procedure.
- Use a pacifier for comfort and provide supportive wrapping to help contain the infant.
- Continuously monitor heart rate, temperature, respiratory rate and oxygenation during the procedure.
- Two are required for the duration of the procedure, one being a medical officer.
- 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); Infants SBR and electrolytes including calcium
  - **On maternal blood:** Indirect Coombs if ABO
  - **Other:** Group and Rh factor; Test for antibodies if Rh negative; Father's Rh factor
- Two-catheter technique:
  - A peripheral arterial line or an umbilical artery catheter is required with a good flow and connected to a pressure transducer.
  - A peripheral venous line or an umbilical venous catheter is required and patency checked in a free flowing vessel.
- One-catheter technique:
  - An umbilical venous catheter, firmly secured
  - A means of measuring the blood pressure, either inflating cuff or a pressure transducer connected to an arterial line (peripheral or umbilical)

The following calculator is to be used when whole blood is not available, and a substitute needs to be obtained by mixing packed cells and FFP. It assumes the blood components for the exchange transfusion are to be mixed in a standard 150ml burette, prior to filtering and warming. It takes into account the fact that the burette may be topped up a number of times, hence the need to specify the residual.

A calculator can be found at: www.sswahs.nsw.gov.au/rpa/neonatal

Go to resources then the Exchange Tx calculator

For exchanges transfusion step by step instructions refer to the Appendix.

Caveats to Guidelines

- A exchange transfusion using packed red blood cells at 30mL/kg may be performed as determined by the cause of the jaundice, the serum bilirubin concentration, the infant's gestational age and factors which increase the risk of bilirubin toxicity i.e. haemolysis, acidaemia, sepsis[13].

Potential complications

- Wrong blood
- Incorrect total leading to congested heart failure or anaemia
- Vascular complications
- Rebound hypoglycaemia
- Air or blood emboli
- Temperature instability
- Perforation of gut by umbilical catheter
- Necrotising enterocolitis

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

References

1. McGillvary, A., Evans, N. (2012). Severe neonatal jaundice: Is it a rare occurrence in Australia? Journal of Paediatrics and Child Health 48; 801-807
2. Evans, D. (2007). Neonatal Jaundice. British medical journal of clinical evidence, 12:319
3. Den, J., McKenna, K. (2010). Management of Haematological disorders. In: Boxwell, G. Neonatal Intensive Care Nursing 2nd edition: Routledge, London and New York; 205-212
4. Beachy, J.M (2007). Investigating jaundice in the newborn. Neonatal Network 26(5); 327-333
5. Bilirubin Metabolism Medscape http://emedicine.medscape.com/article/178841-overview
6. Bhutani, V.K. and Wong, R.J (2017). Hyperbilirubinemia in the preterm infant (less than 35 weeks gestation). Uptodate. Assessed in Februaury 2017
7. Wong, R.J., Stevenson, D.K., Ahlfors, C.E., and Vreman, H.J. (2007). Neonatal Jaundice: bilirubin physiology and clinical chemistry. Neonatal Reviews, 8;58-67
8. Truman, P. (2006). Jaundice in the preterm infant. Paediatric Nursing 18(5); 20-22
9. Blackburn, S.T. (1995). Hyperbilirubinemia and neonatal jaundice. Neonatal Network 14(7); 15-25
10. Hey, E. (1995). Neonatal Jaundice: how much do we really know? MIDIRS Midwifery digest 5(1); 4-8
11. Frank, C.G., Frank, H.F.(2006). Jaundice. In: Merenstein G.B. and Gardener, S.L. Handbook of neonatal intensive care. Sixth Edition, Mosby Elsevier, United states of America; 554-555
12. Calhoun, D.A. (2016). Postnatal diagnosis and management of hemolytic disease of the fetus and newborn. Uptodate. Assessed February 2017
13. NICE guidelines (Last updated: 2016). Jaundice in newborn babies under 28 days. National Institute for health and care excellence. Accessed June 2017
14. Sydney Local Health District (2011) Women and Babies: Jaundice in the Newborn Policy Directive http://www.slhd.nsw.gov.au/rpa/neonatal%5Ccontent/pdf/guidelines/RPAH_Jaundice_PD2011_047.pdf
15. Neoblue mini product manual www.natus.com
16. Maayan-Metzger A. Yosipovitich G. Hadah E. Sirota L. Transepidermal water loss and skin hydration in preterm infants during phototherapy. American Journal pf Perinatology 2001, 18:393-6
17. Maisels MJ, Watchko JF Treatment of jaundice in low birthweight infants. Archives of Disease in Childhood Fetal and Neonatal Edition 2003, 88:F459
18. Vreman HJ, Wong RJ, Stevenson DK. Phototherapy: current methods and future directions. Seminars in Perinatology 2004,28(5):326-33.
19. American Academy of Paediatrics-(Clinical Practice Guideline), Management of hyperbilirubinaemia in the newborn infant 35 weeks or more of gestation. Paediatrics 2004, 114 (1): 297-316.
20. Ahmed SM, Charoo BA, Iqbal Q, Ali SW, Hasan M, Ibrahim M, Qadir G.. Exchange transfusion through peripheral route. JK Practitioner 2005:12(3):118-120.
21. Patra K, Stoffer-Isser A, Siner B, Moore J, Hack M. Adverse events associated with neonatal exchange transfusions in the 1990s. Journal of Pediatrics 2004, 144(5):626-31.
22. de Waal KA, Baerts W, Offringa M. Systematic review of the optimal fluid for dilutional exchange transfusion in neonatal polycythaemia. Archives of Disease in Childhood. Fetal Neonatal Edition. 2006, 91:7-10.

Appendix

Exchange Transfusion Two Catheter Technique

Equipment

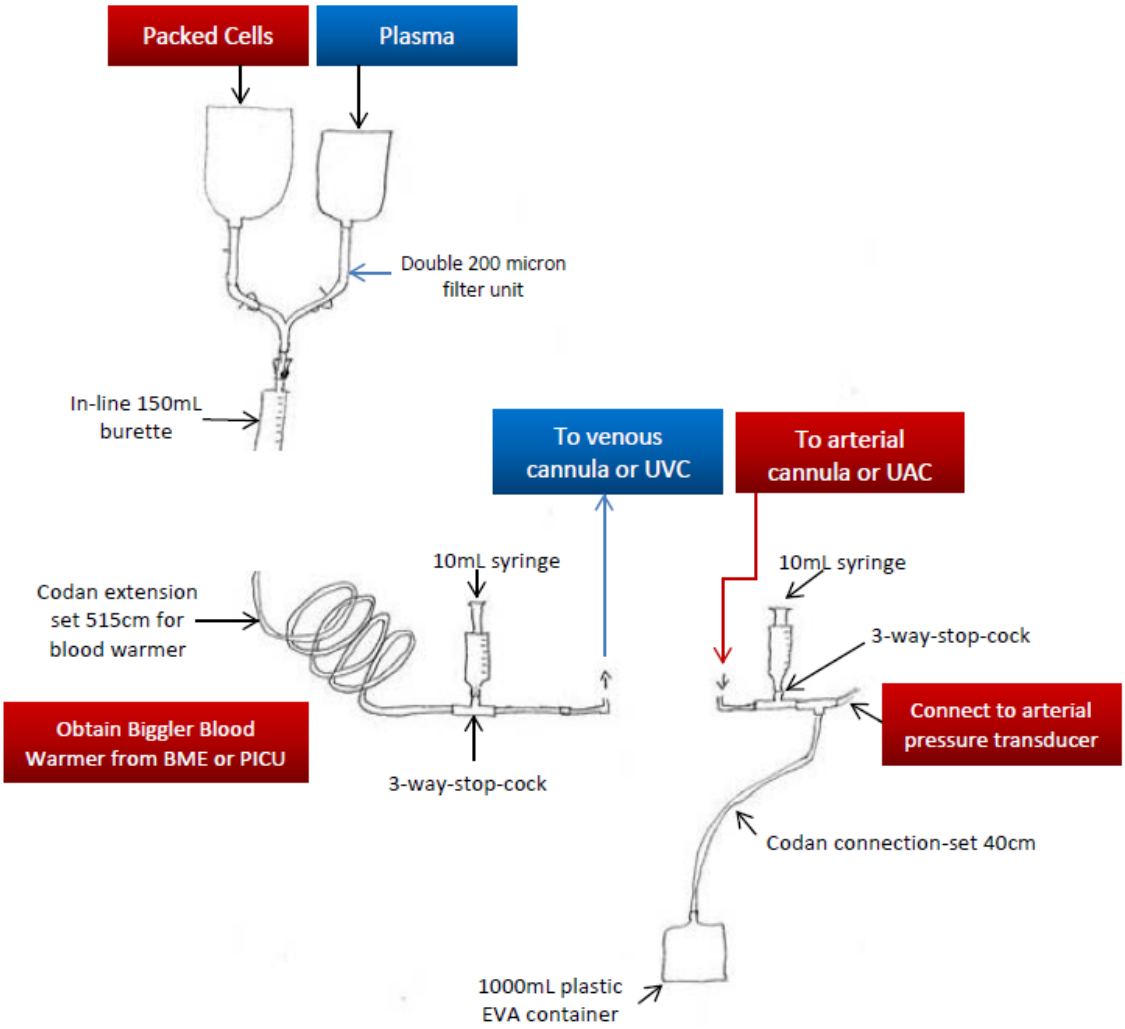
- Double 200 micron filter unit*
- In-line 150mL burette*
- Codan extension set 515cm*
- 2 Three 3-way taps* [BD connecta 360° luer-lok ref. 394600]
- Two 10mL syringes *
- Waste 1000mL EVA bag for removed blood*
- Extension tubing for waste bag – Codan connector set 40cm*
- Pressure transducer set-up or blood pressure cuff appropriate size
- Biggler Blood Warmer (obtained from BME or PICU)

Technique

1. Using packed cells and plasma connect the double micron filter unit to each bag.
2. Mix the packed cells and plasma in the burette as the desired ratio (see link above)
3. Coil the tubing around the warming tube set to maintain blood at body temperature (36.7 – 37°C).
4. The blood to be exchanged is calculated as twice the circulating blood volume at 85mL/kg.
5. 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.
6. Blood is aspirated by arterial syringe 10mL at a time, approximately 1 – 2mL/kg/min or 100mL exchanged every 15 minutes maximum.
7. Blood is injected by venous syringe at the same rate as withdrawal from arterial line.
8. Mix the blood and plasma in the burette at the desired ratio according to the infant's haematocrit and desired haematocrit
9. Gently rotate burette to ensure the blood and plasma are mixed – this is especially important at the end of the procedure
10. Avoid pauses in aspiration to avoid clotting in small cannula
11. Monitor BP every 15 minutes and ABG/BSL from output (artery) line every 30 minutes. Treat hypoglycaemia as necessary. Correct acidosis.
12. Record input and output on exchange transfusion chart or appropriate CCIS record. A dedicated person should be available to do this for the entire procedure.

13. Immediately following the exchange transfusion blood should be taken for SBR and Hb and repeated 4 - 8 hours later.
14. Blood sugar levels are measured hourly for four hours following completion of the procedure. Electrolytes and ABG may also require review.
15. Withhold feeds in sicker patients. Feeds may be reintroduced cautiously 12 hours post procedure.

Image 7. Two Catheter Exchange Transfusion set up



Exchange Transfusion One Catheter Technique

Equipment

- Exchange Transfusion Kit (located in store room) including:
  - Double 'stem cell' connector
  - Administration set and burette
  - Four-way stopcock
  - 10mL syringe
  - Waste product bag for removed blood
  - Extension set
- In addition you will require:
  - Blood warming tubing if required
  - Pressure transducer set-up or blood pressure cuff appropriate size

Technique

1. Prime the giving set with normal saline prior to priming the set with blood.
2. A blood warmer may be used to ensure the blood is injected at body temperature.
3. The blood to be exchanged is calculated as twice the circulating blood volume (double volume 170mL/kg).
4. Fresh frozen plasma (FFP) is added to the packed red blood cell unit and mixed in the burette.
5. A four-way stopcock is turned to regulate the input and withdrawal of blood.
6. Blood is aspirated by syringe 10 ml at a time, approximately 1-2 mL/kg/min.
7. The stopcock turned and the blood discarded into the waste bag.
8. 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.
9. Monitor BP every 15 minutes and ABG/BSL from output line every 30 minutes.
10. Record input and output on exchange transfusion chart or appropriate CCIS record.
11. Immediately following the exchange transfusion blood should be taken for ABG/SBR and Hb and repeated 4 - 8 hours later.
12. Measure the body temperature and adjust environment if required.
13. Blood sugar levels are measured hourly for four hours following completion of the procedure. Electrolytes and ABG may also require review.
14. Due to the perceived increased risk of necrotising enterocolitis post exchange transfusion, withhold feeds. Feeds may be reintroduced cautiously 12 hours post procedure.