

Neonatal Exchange Transfusion

Introduction

Double volume exchange transfusion is mainly used for the management of hyperbilirubinaemia and haemolytic disease of the newborn, when other methods of treatment such as early and intensive use of phototherapy have been ineffective.

The aim of an exchange transfusion is:

- To lower the serum bilirubin level and reduce the risk of brain damage (kernicterus);
- To remove the infants' affected red blood cells and circulating maternal antibodies to reduce red cell destruction;
- To correct anaemia and treat any potential for heart failure whilst maintaining euvolaemia.

Haemolytic disease: Indications for exchange transfusion

1. Cord Hb < 12 mg/dl and/or cord SBR > 80: immediate exchange transfusion
2. Exchange transfusion if rate of rise in SBR is such that SBR is likely to reach 300 micromol/L (aim to keep SBR below 340 micromol/L)

Informed Consent

- Before the commencement of any blood or blood product infusion the medical officer or registered nurse administering the blood product must ensure that parents have given an informed consent for the procedure. *Refer to the RPA PD2006_040 - Informed Consent for Transfusion of Blood and Blood Derived Products.*
- *Benefit versus risk* - In otherwise well babies the risk of exchange transfusion are usually small but in preterm babies who are unwell the risks of exchange transfusion are increased and the procedure must be balanced the high morbidity associated with bilirubin encephalopathy.

Collection of blood samples and ordering of Red Blood Cells and FFP:

- Liaise with the obstetric team and notify blood bank of a possible exchange transfusion before the delivery of an Rh- affected fetus. *Refer to the RPA 2007_047 Pre Transfusion Testing and administration of Blood Products.*
- Stored red blood cells (RBCs) have a predictable packed cell volume of 60% (+/- 2%) so measurement of haematocrit levels is no longer necessary. In order to dilute the RBCs by 10% you will also need to order Fresh Frozen Plasma (FFP) of suitable type.
- A request for RBCs for exchange transfusions is normally considered an urgent request. The RBCs should be ready within 2 hours of request provided antibody testing has been completed. To ensure timeliness of the process, you should always communicate with the RPA Blood Bank (ext 58033).

Types of Red Blood Cells

1. Rh haemolytic disease of the newborn: RBCs less than 5 days old are used.
 - O Rh negative RBCs do not have major blood group antigens so they are not haemolysed by maternal antibodies that may still be present in the infant's circulation.

- If the RBCs are made available before delivery of the sensitised infant the RBCs must be O Rh negative and cross matched against the mother. If the RBCs are sourced after delivery the RBCs must be cross matched against the infant.
2. **ABO incompatibility:** Use group O, Rh specific RBCs. These RBCs contain low levels of antibodies and lack antigen that could trigger any circulating maternal antibodies in the newborn.

Subsequent transfusions should be done with RBCs that are compatible with that of the mother and infant.

Volume of RBCs and FFP to be ordered

The volume required is dependent on the reason for exchange and is determined by the formula below.

1. **SINGLE VOLUME EXCHANGE** (*anaemia with normovolaemia*)

Estimated blood volume depends gestational age and timing of cord clamping ranging from 53 - 105 ml/kg/min. Mean blood volume was 70 ml/kg (early cord clamping) versus 90ml/kg (delayed cord clamping for infants weighing 480-2060g).

Estimated single blood volume = 85ml x weight (kg)

2. **DOUBLE VOLUME EXCHANGE** (*for established hyperbilirubinaemia or to prevent hyperbilirubinaemia*)

Estimated double volume to be exchanged (ml) = estimated blood volume x 2 x infant weight (kg)

Preterm/Term infant = 85ml x 2 x weight (kg) = 170 ml x weight (kg)

Double volume exchange 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 2/3rds the pre-exchange level.

Ordering blood (SSWAHS PD2009_05)

A cross match request form MR175 must be hand written (addressograph labels are not acceptable) and collection witnessed and signed by a second MO / RN. Specimen must be labelled by hand (addressograph labels are not acceptable).

When ordering red cells for an exchange transfusion, remember the priming volume of the exchange circuit is *approx 50ml* so additional RBCs should be ordered.

Always communicate with blood bank ext 58033

Collection of blood and plasma from Blood Bank

Blood Bank will notify the nursery when the RBCs and FFP are ready to be collected. The Ward Assistant will need **both** the *Intravenous Infusion Order Form (MR665A)* and the *RPA Blood Product Issue Form* to collect the blood products from Blood Bank.

The Procedure

Access for procedure:

Usually a 5 FG umbilical catheter is inserted to a level that allows free flowing withdrawal of blood please see central line protocol for insertion and management of UVCs and UACs.

Isovolumetric exchange

The preferred method in this nursery is the *isovolumetric or simultaneous exchange* where access is via an umbilical venous catheter (blood in) and an umbilical arterial catheter (blood out).

If either umbilical vessel is not available then the *RBCs* can withdrawn via a peripheral arterial cannula and donor RBCs / FFP infused through a venous cannula.

Using this method the RBCs are slowly withdrawn from the umbilical arterial catheter (or peripheral arterial line) in pre-determined aliquots with simultaneous replacement of donor RBCs / FFP through the umbilical venous catheter (or peripheral venous line) using the same aliquot size.. The process should not be hurried and should take a minimum of 2 hours or more depending on the volume of the exchange.

Push pull method

When using the same catheter that is the RBCs / FFP are pushed in and pulled out through the same umbilical venous catheter. The minimum time for this procedure is 2 hours or more depending on the volume of blood to be exchanged.

Rate of exchange

A suggested rate is 30 aliquots over 2 hours that is, 4 minutes each cycle. This is irrespective of whether the isovolumetric or push-pull method is used.

Aliquot volume for double volume exchange:

Aliquot volume (ml)

= estimated blood volume x 2 x infant weight (kg) / number of aliquots in 2 hours

= 85ml x 2 x weight (kg) / 30

Equipment

Clean Equipment	Sterile Equipment
<ul style="list-style-type: none">• Clean dressing trolley with Lemex solution, leave one minute & wipe dry• Blue sterile plastic sheet to place under sterile drape.• IV infusion pump (Allaris Signature)• Infusate such as 10% dextrose - if exchange delayed• Biegler™ Blood Warmer• tape measure• masks• protective goggles if open care.• 4 ampoules heparinised saline (50units / 5ml)• unopened solutions for skin preparation (aqueous chlorhexidine)• Comfeel®• Leukoplast® (brown tape)	<ul style="list-style-type: none">• single lumen UVC (Argyle)<ul style="list-style-type: none">◦ 5 Fg infants 1000g and 28 weeks◦ 3.5 Fg infants <1000g or <28 weeks• sterile gown and two sets of sterile gloves• sterile green drapes (one fenestrated)• dressing pack• umbilical drip insertion set (scalpel blade / sutures included)• L3 Exchange pack• 3.0 silk suture• sterile linen cord tie• additional gauze swabs• assorted needles / 5 ml syringes• Arterial line pack (optional)

Emergency equipment

- Check T-piece positive pressure & suction equipment (8/10Fg catheter)
- Emergency trolley is checked, stocked and in close proximity

Preparation of the infant

- Infants greater than 33 weeks gestation are placed on an open care system on servo mode to maintain skin temperature at 36-36.5 oC - see Thermoregulation Guideline.
- Infants less than 34 weeks are usually managed in an isolette

- The infant will require cardio respiratory and saturation monitoring set alarm limits
- Temperature probe in situ set alarm limits
- NIBP & cuff for blood pressure recording (if arterial line not insitu)
- Evacuate gastric contents through a 8FG feeding tube and leave on free drainage.
- Place urine bag (infants > 30 weeks gestation) or cotton balls to collect and monitor urine output. This also assists with maintaining a clean dry environment
- Have oral sucrose & pacifier available to settle infant if needed

In addition

- Ensure informed consent has been obtained from parents
- Confirm infant ID with the medical officer performing the procedure
- Check blood and plasma with medical officer / second RN and sign the RPA Transfusion Sheet
- Phototherapy using the Biliblanket (Ohmeda) should be continued during procedure
- Organise pathology forms and containers for haematology (full blood count), biochemistry (sodium, potassium, magnesium, calcium, SBR, glucose) x 3 of each (for use during the procedure).
- NBST card labeled (NBST needs to be collected prior to transfusion)
- Use i-stat for ABGs during the procedure
- The volume of RBCs and FFP to be exchanged must be prescribed on the Intravenous Infusion Order Form (MR665A) and documented on the Neonatal Exchange Blood Transfusion Record (MR 529) before commencing the procedure.
- Temperature
- ECG and SpO2%
- Respiration rate and effort
- Blood pressure non invasive BP or invasive
- Screening Blood glucose level
- Girth measurement
- Urinalysis and specific gravity
- Note infants colour tone and behaviour
- Record these baseline observations on the Neonatal Exchange Blood Transfusion Record (MR 529)

Priming the Circuit

1. ***Simultaneous exchange*** - see *Figure 1* for priming of the venous access (blood in) and *Figure 2* for set up of the arterial access (blood out).

Load the blood in burette with 135 ml of RBCs and 15 ml of FFP that is a 10% dilution and prime the lines. Re-load the burette with a 10% dilution when necessary that is add 126ml RBCs and 14ml FFP to the 10ml residual volume in the burette. This is to ensure the HCT of infused red cells is consistent throughout procedure.

Both clinicians (MO and RN) are to wear gloves and protective goggles.

- Withdraw first aliquot slowly; announce volume (x-ml) 'out', the RN records volume and uses this waste sample to take FBC, creatinine, sodium, potassium, magnesium, calcium, glucose, SBR, ABGs and NBST (if not already taken).
- The RN to ask a third colleague to organise transport of specimens to pathology and record NBST on appropriate forms (Neonatal Weight Chart MR550, Blue Book, Newborn Care Discharge Risk MR46/5 and Neonatal Exchange Blood Transfusion Record (MR 529).
- At the same time as the aliquot is being withdrawn, the medical officer, having drawn the aliquot volume from the burette into the syringe, pushes blood into the umbilical venous catheter and announces volume (x-ml) 'in'.
- The RN records both volume out and in, including running totals
- Repeat the sequence, at all times ensuring that volume being removed is kept at the same rate as volume being given.
- The RN should report the cumulative volumes every 100 ml
- Gently rotate both the RBC pack and the burette every 10 minutes to ensure an even mix of plasma and RBCs.

Set up and priming of the simultaneous exchange circuit

Figure 1: Blood in - venous access

Figure 2: Blood out - arterial access

Vital signs must be recorded at 15 minute intervals from baseline, including;

- o heart rate & rhythm
- o oxygen saturation
- o skin temperature
- o respirations (rate and effort)
- o NIBP/ invasive BP every 15 minutes
- o infants colour, tone & behaviour
- o document blood warmer temperature maintain at 37degrees C

Investigations: Attend blood tests every 10 cycles: use waste blood to perform FBC creatinine, sodium, potassium, magnesium, calcium, glucose and ABGs.

- o Continue process till end of pre-calculated exchange volume
- o RN to report end balance and on last aliquot of blood (arterial line) use waste blood to take FBC, creatinine, sodium, potassium, magnesium calcium, glucose, SBR and ABGs. Again ask a third colleague to organise transport of specimens to pathology.

2. **Push and pull method** (Single vessel exchange) see *Figure 3* for priming of the single vessel (umbilical venous catheter circuit).

Load the blood in burette with 135 ml of RBCs and 15 ml of FFP that is a 10% dilution and prime the lines. Re-load the burette with a 10% dilution when necessary that is add 126ml RBCs and 14ml FFP to the 10ml residual volume in the burette. This is to ensure the HCT of infused red cells is consistent throughout procedure.

Both clinicians (MO and RN) are to wear gloves and protective goggles.

- o Withdraw first aliquot slowly; announce volume (x-ml) out, the RN records volume and uses this waste sample to take FBC, creatinine, sodium, potassium, magnesium, calcium, glucose, SBR, ABGs and NBST (if not already taken).
- o *The RN to ask a third colleague to organise transport of specimens to pathology and record NBST on appropriate forms (Neonatal Weight Chart MR550, Blue Book, Newborn Care Discharge Risk MR46/5 and Neonatal Exchange Blood Transfusion Record (MR 529).*
- o After the first aliquot is being withdrawn, the medical officer, having drawn the aliquot volume from the burette into the syringe, pushes blood into the umbilical venous catheter and announces volume (x-ml) in.
- o The RN records both volume out and in, including running totals
- o Repeat the sequence, at all times ensuring an even pace the procedure may have to be slowed if not well tolerated. The RN should report the cumulative volumes every 100 ml
- o Gently rotate both the RBC pack and the burette every 10 minutes to ensure an even mix of plasma and RBCs.

Vital signs must be recorded at 15 minute intervals from baseline, including;

- o heart rate & rhythm
- o oxygen saturation
- o skin temperature
- o respirations (rate and effort)
- o NIBP/ invasive BP every 15 minutes
- o infants colour, tone & behaviour
- o document blood warmer temperature - maintain at 37degrees C

Investigations Attend blood tests every 10 cycles: use waste blood to perform FBC creatinine, sodium, potassium, magnesium, calcium, glucose and ABGs.

- o Continue process till end of pre-calculated exchange volume

- o RN to report end balance and on last aliquot of blood (arterial line) use waste blood to take FBC, creatinine, sodium, potassium, magnesium calcium, glucose, SBR and ABGs. Again ask a third colleague to organise transport of specimens to pathology.

Figure three: Push and pull method

**Insert blood warmer in the circuit and position before the 4 way tap.

Post Exchange Care

- Remove the exchange circuit and prime new intravenous infusion set
- Commence intravenous / arterial fluids as ordered on the *Intravenous Infusion Order Form (MR665A)*.
- Ensure all intravenous and arterial connections are secure, the infusion pump is zeroed and alerts are set.
- Check all infusions, volumes and rates with a second RN and document on the *Intravenous Infusion Order Form (MR665A)* and the *Intensive Care Chart (MR581)* or *High Dependency Chart (MR582)*.
- Ensure infant is clean and dry and repeat all observations
- Notify parents that the procedure has been completed and their infant is comfortable
- Perform blood glucose levels and ABGs (if indicated) 30 minutes after exchange and as appropriate to keep BGLs > 2.5mmol/l and to stabilise respiratory / metabolic condition.
- Repeat FBC, creatinine, sodium, potassium, magnesium, calcium, glucose and SBR as indicated post exchange.
- Monitor infant for abnormal signs and possible complications including thrombocytopenia, bleeding, signs of infection, feed intolerance or abdominal distension see *Table 1*.
- High intensity phototherapy needs to be continued and reviewed in relation to SBR results
- Follow up should be arranged with attending staff specialist as requested

Possible Complications These are unusual if the exchange is performed slowly and often the best management is to slow down or pause the exchange. Any of the following can happen.

Table 1: Complications

Complications	Prevention & Management
Hypothermia - if babys skin temperature falls below 36°C.	Confirm placement of temperature probe and take axilla reading. Confirm blood warmer is at 37°C Turn up the servo control or isolette and slow the exchange.
Hyperglycaemia donor blood is preserved in dextrose.	Blood glucose levels can be elevated during the exchange and generally resolve without intervention.
Hypoglycaemia: may occur during and shortly after the exchange.	If baby's reagent strip blood glucose is less than 2.5 mmol/L give slow push of 2 ml/kg of 10% dextrose (via peripheral line or flush catheter dead space before & after dextrose injection). Repeat screening blood glucose level on next cycle. Continue to monitor glucose levels.
Hyperkalaemia: unlikely to happen with red blood cells less than 5 days old but is more likely to happen with a sick preterm infant <i>refer to hyperkalaemia protocol</i>	If K^+ > 6.0mmol/L give calcium gluconate if Ca <2.0 mmol/L and recheck K^+ frequently. Stop exchange if K^+ >7.0 mmol/L and treat until K^+ < 6.0 and then restart exchange. Peaked T waves / widened QRS / VEBs can be seen with hyperkalaemia.
Hypocalcaemia: This is rare with the preservative	If Ca^{++} drops to < 1.5 mmol/l then flush catheter

anticoagulants used now and will rarely need treating.	dead space with normal saline and give Urgent IV Correction: 0.23-0.46mmol/kg (1-2ml/kg of calcium gluconate 10%) by slow IV injection of diluted solution over 10 minutes. Do not give into a peripheral vein. Prolonged QT interval can be seen with hypocalcaemia.
Metabolic acidosis: Mild metabolic acidosis is common and usually doesn't need treating. Correct hyperkalaemia / hypocalcaemia before giving H ₂ CO ₃ .	If baby's base excess falls below minus 10mmol/l then flush catheter dead space with normal saline, and Half correct with 4.2% sodium bicarbonate (mmol of bicarbonate = [body weight x base excess x 0.3]/2). If acidosis worsens or persists, then consider stopping exchange.
Thrombocytopenia: Stored red cells are platelet depleted, so the platelet count will tend to fall during the exchange transfusion. This rarely needs intervention.	If the platelet count falls to < 50,000 consider stopping exchange and arrange a platelet transfusion through a peripheral vein.
Air Embolus:	Ensure lines are set up and primed correctly. Observe lines for presence of air during exchange & ensure 3-way taps are closed to the infant when filling or expelling contents of syringe.
Anaemia/Polycythaemia:	Ensure HCT of RBCs / FFP infusion is kept consistent throughout procedure. Gently agitate burette at frequent intervals to prevent separation of red cells and FFP.
Necrotising Enterocolitis: Ensure the UVC is in correct position.	Perform isovolumetric exchange transfusion or use small aliquots if single lumen technique used.

References

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