Yorkshire and Humber ODN (South)
Clinical Guideline

Title: Exchange Transfusion

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The review date for this guideline has been extended to a 5 year review **(September 2025)** as agreed by the Y&H Neonatal Executive Group at the Executive Meeting held 30 March 23

This clinical guideline has been developed to ensure appropriate evidence-based standards of care throughout the Yorkshire and Humber Neonatal ODN (South). The appropriate use and interpretation of this guideline in providing clinical care remains the responsibility of the individual clinician. If there is any doubt discuss with a senior colleague.

Best practice recommendations represent widely used evidence-based practice and high-quality standards that all Neonatal Units across the Network should implement. Subsequent suggested recommendations may be put into practice in local units. However, alternative appropriate local guidelines may also exist.

A. Summary page

Aim of guideline

This guideline covers the indications for full exchange transfusion and also partial exchange transfusion for neonates.
It offers 4 techniques for performing the exchange, which will vary depending of the intravenous access obtained in the infant, in addition to the personnel and expertise available.

B. Full guideline

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1.0 Introduction

Exchange transfusion is performed on a baby for a number of reasons. Common indications are:

1. To treat hyperbilirubinaemia when bilirubin reaches toxic levels in red cell incompatibility e.g. rhesus haemolytic disease, ABO incompatibility, anti-Kell antibodies
2. To manage babies with severe anaemia at birth e.g. twin to twin transfusion (consider single volume exchange)
3. To reduce packed cell volume in polycythaemia in which case a partial plasma exchange is performed

The procedure is not without risk. It has a recognized morbidity and mortality profile. In general, the overall mortality related to the exchange transfusion depends on the premorbid condition of the baby[1]. Published mortality rates vary from 0.53-3.3% per infant[6].

Please refer to the NICE guideline *Jaundice in newborn babies under 28 days (clinical guideline 98 CG98)* for a more comprehensive account on the management of jaundice.

Before proceeding to do an exchange transfusion **IT IS ESSENTIAL** that each case is discussed first with the consultant on duty.

2.0 Antenatal planning

When possible, all high-risk pregnancies should have been identified and an agreed care pathway prepared prior to delivery.

If an infant is expected to have significant haemolytic disease and require exchange transfusion, **it is the responsibility of the obstetric team** to ensure that blood bank is aware that an exchange transfusion is anticipated.

If the units required are scarce and may not be needed immediately it may be reasonable to arrange irradiation and transfer of the red cells to the unit after the birth and following early assessment of the baby.

2.1 Division of responsibilities

Clear division of responsibilities between obstetricians and neonatologists is important to ensure specific tasks are carried out efficiently and without duplication.

Obstetricians	*Neonatologists*	*Rationale*
• Inform Neonatologist and NICU at the earliest opportunity of a high-risk pregnancy and/or imminent delivery.		• Allow respective teams time to plan for the delivery and agree on the likelihood of the emergency need for red cells to be available at the time of delivery.
• Obtain fresh maternal sample prior to delivery		• Maternal sample needed to prepare bloods for exchange transfusion
• Liaise with blood bank prior to delivery and inform of possible exchange transfusion	• Check blood bank is aware that red cells maybe/are needed for exchange transfusion	• Help blood bank anticipate the need of bloods specifically for exchange transfusion
• Obtain cord bloods after delivery for DAT, X match FBC, SBR	• Check that cord bloods have been sent and chase the results	• Helps to ensure red cells for exchange can be prepared without delay

3.0 Donor red cell issues

Discuss with the blood bank early and please remember to specify **the actual volume in mls** of red cells needed. See section 7.0. When doing this remember to account for the dead space in the giving set and blood warmer. Please note that 1 unit of red cells contain approximately 250-300mls. An average term infant will require at least 2 units of red cells..

Red cells suitable for neonatal exchange are irradiated and 'fresh' (before the end of day 5 following donation), with a 24-h shelf-life post-irradiation in order to reduce the risk of recipient hyperkalaemia. They have a controlled haematocrit of 0·5–0·6 in order to reduce the risk of both post-exchange anaemia and polycythaemia .They are negative for high-titre anti-A and anti-B antibodies.[17]

3.1 Blood bank preparation time

Blood bank needs time to prepare red cells for an exchange transfusion. On average it takes approximately 1 hour to issue suitable red cells.

However in the presence of complex maternal antibodies ,blood bank may take considerably longer to prepare a "least incompatible" unit.

3.2 Haematocrit and red cells

The actual haematocrit will be noted on the bag provided. Please check with the neonatal consultant if the haematocrit of the red cells provided is > 0.6. This is rare.

In the event that the red cells provided have a high haematocrit .i.e. >0.60, the exchange transfusion can still be carried out using red cells and fresh frozen plasma. The red cells and plasma will be given in a ratio of 3 to 1 respectively. In this situation, every fourth aliquot that is given to the baby should be given as fresh frozen plasma (or 4.5% HAS if there is going to be a significant delay getting FFP) and this should be clearly documented.

Be aware that unlike blood, fresh frozen plasma must not be put through the blood warmer. It can be infused into the line which is infusing the packed cells via an additional three-way tap.

3.3 Irradiation of red cells

Irradiation of red cells prohibits T-lymphocytes proliferation and hence lowers the risk of graft versus host disease.

Irradiation of red cells **IS ESSENTIAL** if the infant has had a previous intrauterine transfusion. If the infant has not had an intrauterine transfusion, ideally red cells used should also be irradiated. However, this is not essential especially if this would lead to a clinically significant delay[7].

The current time needed to irradiate red cells is 10-15 minutes. Once irradiated the unit of red cells MUST be used within 24 hours.

3.4 Use of buffer solutions

The pH of a unit of red cells is around 7.0. This does not contribute to acidosis in the infant. 'Correction' of pH to physiological levels by the addition of buffer solutions is not indicated[2].

However, in the rare situation that the donor red cells are difficult to obtain and is more than 7 days old, it may be worth checking the pH of the red cells and if it is less than 7.0 then consider correction with a base. Please discuss with the neonatal consultant on duty before doing this.

4.0 Drug replacement following exchange transfusion[14]

Neonates undergoing exchange transfusion may also require concomitant drug therapy. The percentage of lost medications is extremely variable.

One study found that around 10% of Gentamicin, Phenobarbitone and Vancomycin are lost after a two volume exchange.

Consideration should be given to re-medication following exchange transfusion depending on the clinical condition of the baby, timings of the drugs in relation to the exchange transfusion and following determination of drug levels where appropriate. This hypothetical drug loss should also be considered when interpreting levels.

5.0 Prior to exchange

- Admit baby to the NICU.
- If there is hyperbilirubinaemia, immediately start quadruple phototherapy including a bilibed and **continue throughout exchange transfusion.** Ensure adequate exposure of baby to phototherapy to maximize effect.
- When plotting the SBR, use **total** serum bilirubin (do not subtract direct or conjugated bilirubin)
- Stop feeds and insert IVI to ensure that the baby receives hydration for the duration of the procedure.
- Aspirate stomach contents and leave nasogastric tube on free drainage. Keep nil by mouth.
- Check with blood bank that they are aware of a possible exchange transfusion.
- Once a decision to perform an exchange transfusion is made by the neonatal consultant, phone blood bank again so that the red cells can be irradiated.
- Explain treatment to parents and obtain **written consent**[11]. Document the discussion in the notes.

5.1 Monitoring

- Ensure appropriate continuous monitoring in situ including ECG, temperature probes, blood pressure and oxygen saturation monitoring. Heparin infusions should continue to run through arterial lines during the procedure.

5.2 Diagnostic samples

- Obtain a 'pre transfusion' blood spot for neonatal screening. If the baby has had an intrauterine transfusion follow national guidance from Public Health England about timing of blood spots[12].
- Consider the need to take diagnostic samples including storage of samples for later investigations Please refer to separate guidance depending on the aetiology.
- If appropriate, consider requesting a Kleihauer test to detect fetal-maternal hemorrhage.

5.3 Obtain early vascular access

Although, UAC and UVC are the preferred options peripheral veins and arteries can also be used in different combinations. The UVC must be in the IVC. The catheter tip **must not** reside in the liver.

- A UVC and a UAC (the preferred method)
- A UVC and a peripheral arterial cannula
- A UVC on its own
- 2 peripheral cannula and a UAC
- 2 peripheral cannula and a peripheral arterial cannula

5.4 Immunoglobulin

- Intravenous immunoglobulin (IVIG) acts by preventing the destruction of sensitised erythrocytes. Results have shown a significant reduction in the need for exchange transfusion in those treated with intravenous immunoglobulin[6].
  - ✓ Use IVIG as an adjunct to continuous multiple phototherapy in cases of haemolytic disease of the newborn when the serum bilirubin continues to rise. IVIG can be started while preparations for exchange transfusion are being made.
  - ✓ Always discuss with the neonatal consultant on call regarding the use of IVIG.

6.0 Set up

6.1 Personnel

- The consultant on duty must be notified of a possible/impending exchange transfusion
- Make certain that there will be at least 1 doctor/ANNP and 1 nurse to do the exchange transfusion for a dedicated period of 3 hours.
- Delegate and reallocate the workload.

6.2 Equipment needed

Consider having prepared boxes of equipment.

- IV cut down pack
- Selection of disposable sterile syringes and needles
- 3-way stopcock x 2
- UAC/UVC catheters and/or peripheral cannulas
- Red cell infusion set with appropriate filters
- Blood warmer (only used when infusion given at a constant rate).
- Drainage bag.
- Blood bottles including clotting, biochemistry, EDTA and glucose bottles
- Nasogastric tube

6.3 Blood warmer

Exchange transfusion should not be undertaken with red cells straight from 4°C storage, and an approved/CE marked blood warming device can be used to avoid hypothermia. However, use of a blood warmer is only appropriate if the infusion is given at a constant rate (warming is not suited to the intermittent bolus nature where the ‘push pull’ cycle method is used). Red cell warming should not be uncontrolled, e.g. infusion lines exposed to a radiant heater (because of the risk of red cell haemolysis). [17]

7.0 Calculating volume to be exchanged

- Usually a double volume exchange transfusion is performed. This removes 90% of the initial red cells and up to 50% of available intravascular bilirubin.
- A 'single-volume exchange' will only remove 75% of red cells and this may be insufficient. However, 'single-volume exchange' may sometimes be indicated in an extremely sick or anaemic infant or in preterm infants. If indicated, please discuss with the neonatal consultant on duty.
- Neonatal blood volume = 70-90 ml/kg for term and 85-110 ml/kg for preterm infants.
- For the purpose of simplicity an approximate blood volume of 90mls/kg will be used for both term and preterm infants in this guideline.

7.1 Double volume exchange

- Unless otherwise indicated, target the total **exchange volume at 180 mls/kg of blood**

7.2 Aliquot size

Weight (grams)	*Aliquot size (ml)*
< 1000	5 ml
1000 - 2000	10 ml
> 2000	15 ml

- Aliquots up to 20mls can be used in larger term babies after discussion with the neonatal consultant on duty.

8.0 Duration of exchange

- Aim to complete the exchange transfusion over 2 to 2.5 hours.
- Each cycle should take about 3 to 5 minutes in total to complete.

9.0 Procedure

- We recommend that individual units prepare photographs of their equipment and a step-by-step set up guide to support preparation. This can be very useful when a procedure is not performed frequently.
- Assemble equipment in an aseptic manner.

9.1 Blood samples needed during exchange transfusion

- Blood samples must be obtained from the baby on **3 separate occasions** i.e.
  - before starting
  - in the middle of the transfusion
  - upon completion of the procedure.
- Send bloods for FBC, U&E's, SBR, Albumin, Ca^{2+} , Mg^{2+} and clotting
- In addition, measure blood gases on the gas machine including glucose, ionized calcium, potassium and lactate before starting and half hourly during the exchange.
- Blood tests are required to attain a baseline and to monitor electrolytes and haematological derangements that may occur as a result of the procedure.

9.2 Observations and monitoring

Action	*Rationale*
• Continuously monitor HR, RR, oxygen saturation and BP. Record observations every cycle of the procedure.	• Observe for any deviation from baseline. This may indicate a reaction to the red cells or procedure
• Measure temperature half hourly	• Deviation in temperature from baseline, may indicate a reaction to the red cells
• Closely observe baby during procedure	• Look for cyanosis, pallor, abdominal distension and vomiting or bloody diarrhea. Watch ECG trace for arrhythmias
• Keep accurate timed record of blood removed & red cells transfused during the procedure.	• To allow ongoing assessment of overall condition and fluid balance

9.3 Techniques

- There are 3 main methods that can be used depending on;
  - Number of people available to do the exchange transfusion
  - Number and type of access available
  - The clinical condition of the infant[1]

There are no trials to suggest that any technique is superior to the others.

An isovolumetric exchange is when red cells transfused in, are matched by blood removed on a milliliter by milliliter basis. It is the preferred technique for anaemic and hydropic infants but requires at least 2 operators – see technique 3.

9.3.1 Technique 1: One person push and pull technique with a single vascular access

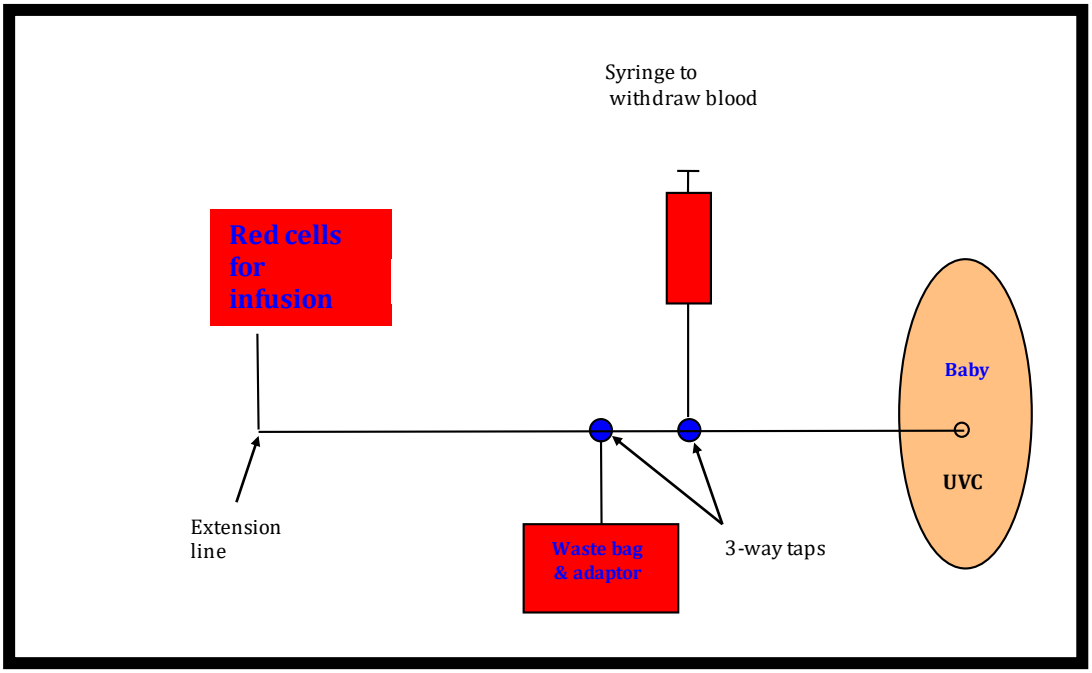
Personnel: Minimum of one doctor/ANNP and one nurse to record observations
Access: Ideally an umbilical venous catheter (UVC)

Action	*Rationale*
• Doctor/ANNP connects the umbilical venous catheter to the red cell giving set via two separate 3 way taps.	• To ensure a closed system.
• On the 3 way tap nearest to the baby a 20 or a 50 ml syringe is attached. On the other 3 way tap a drainage bag is connected. See diagram 9.3.1.	
• The exchange transfusion proceeds by withdrawing the aliquot of blood and replacing it with same amount of donor red cells. See below.	• Procedure **starts with the withdrawal** of blood in order that baby's circulation is not overloaded.

- A standard cycle involves:
  - **Blood withdrawn from baby,** turn tap
  - Blood pushed into waste bag, turn tap
  - Red cells withdrawn from donor red cell bag, turn tap
  - Red cells transfused to baby

Diagram 9.3.1.

One person push and pull exchange transfusion set up via a UVC



9.3.2 Technique 2: Infusion of donor red cells at a constant rate with simultaneous withdrawal of aliquots of blood from the baby

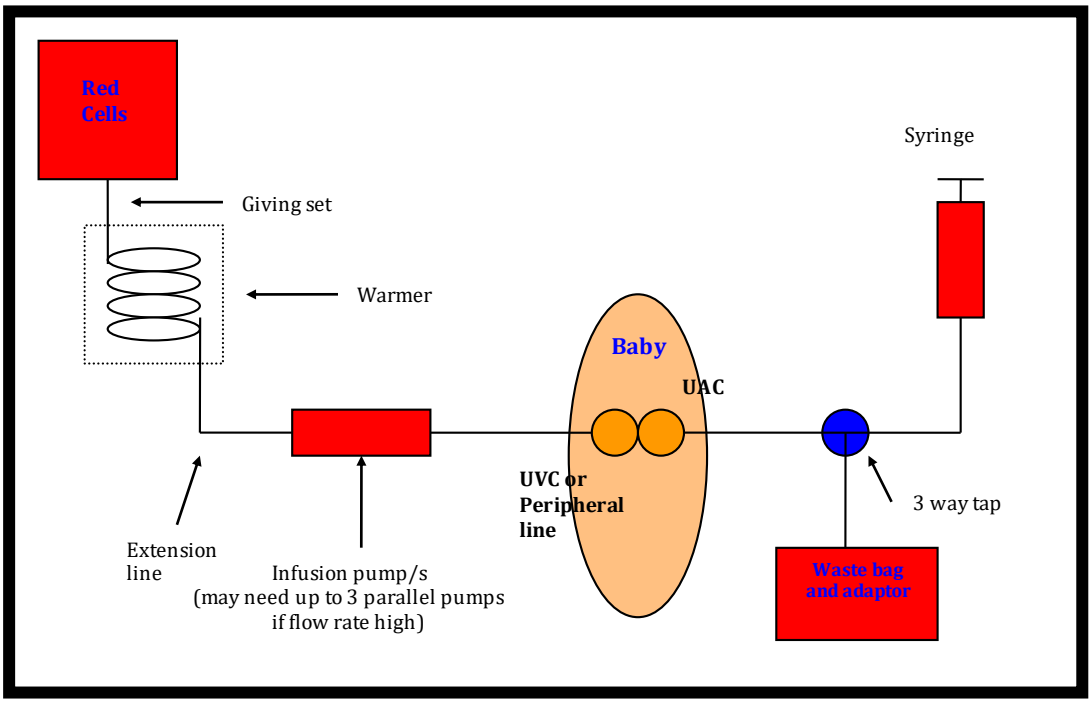
Personnel: **Minimum of one doctor/ANNP and one nurse to record observations**

Vascular access: **The following combinations can be used:**

- A UVC and a UAC (the preferred method)
- A UVC and a peripheral arterial cannula
- Peripheral cannula and a UAC
- Peripheral cannula and a peripheral arterial cannula

- Red cells should be infused into a vein and blood withdrawn via an arterial line.
- In this technique, donor red cells are infused at a constant rate through a catheter whilst simultaneously withdrawing blood in timed aliquots through the other catheter.
- In the set up shown in diagram 9.3.2, red cells are infused to the baby at a constant rate using either one or more infusion pumps via the UVC. At the same rate, blood is then pulled out of the baby via the UAC.
- It is important to note that peripheral arterial lines often do not sample as well as UACs.
- If the procedure is halted or the arterial line stops sampling, it is essential that the infused donor red cells are stopped immediately to avoid hypervolaemia. Similarly, if red cells are not infusing, the procedure needs to be stopped immediately to avoid inadvertent removal of blood leading to hypovolaemia.
- A red cell infusion pump can infuse red cells at a maximum rate of 60mls/hour. If the rate calculated is too large for the infusion pump parallel infusion sets can be used to achieve the desired rate of infusion. For term babies three parallel sets may be required.

Diagram 9.3.2. Infusion of donor red cells at a constant rate with simultaneous withdrawal of aliquots of blood from the baby



9.3.3 Technique 3: Isovolumetric 2 person push & pull technique with at least 2 vascular accesses

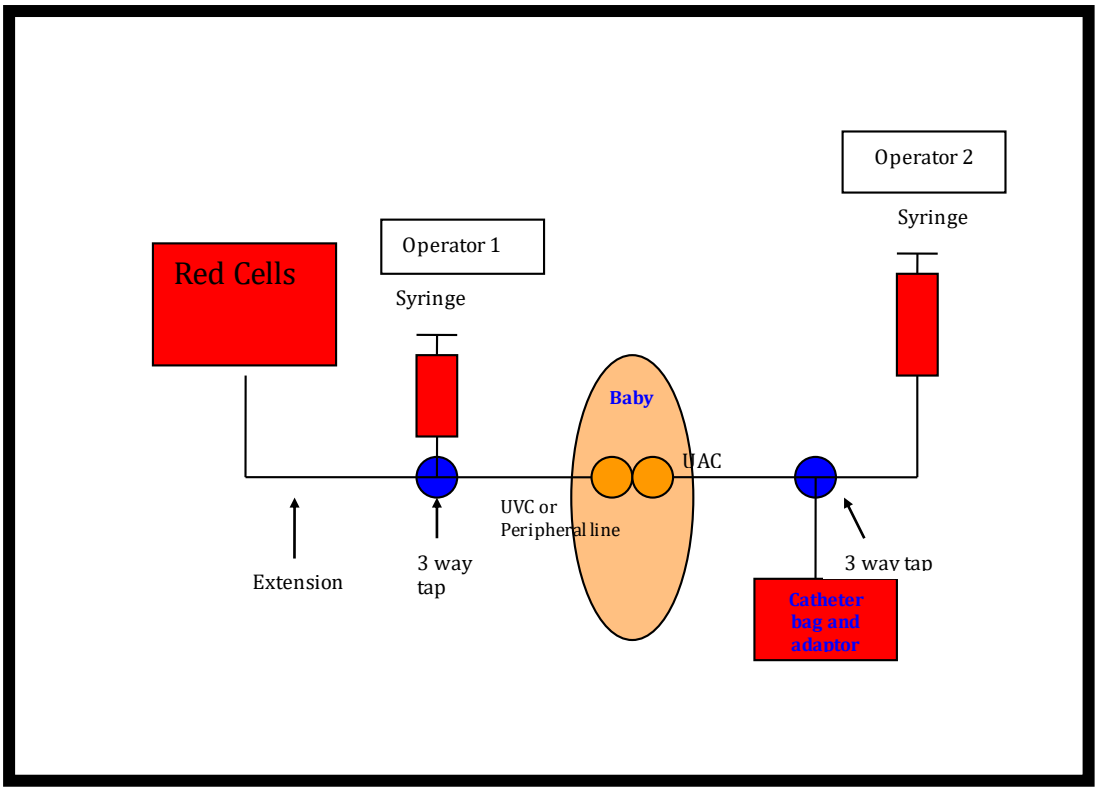
Personnel: **Minimum of two doctors/ANNPs and one nurse to record observations**

Vascular access: **The following combinations can be used:**

- A UVC and a UAC (the preferred method)
- A UVC and a peripheral arterial cannula
- Peripheral cannula and a UAC
- Peripheral cannula and a peripheral arterial cannula

- Red cells should be infused into a vein and withdrawn via an arterial line. If possible, red cells should not be infused into an arterial line.
- In this technique, an operator pushes an aliquot of red cells into the baby through a vein while simultaneously and at the same rate another operator pulls blood out via an arterial line.
- Red cells infused in, are matched on a milliliter by milliliter basis with blood that is removed.
- In the set up shown in diagram 9.3.3 below, red cells are infused into the baby by an operator using a UVC and simultaneously blood is pulled out of the baby via the UAC.

Diagram 9.3.3: Two-person isovolumetric technique with a UAC and UVC



9.4 Intentional deficit in hydropic or very sick babies

In hydropic or very ill neonates, it may be appropriate to leave an intentional deficit i.e. the final cycle of the exchange transfusion consists of withdrawing an aliquot of blood from the baby without replacing this volume with donor red cells. This may lessen the risk of inadvertent overload. This should be a consultant decision.

10.0 After the transfusion

- Leave lines in until confident that no further exchanges are required
- Continue multiple phototherapy
- Measure serum bilirubin level within 2 hours
- Monitor blood glucose hourly for 4 hours as exchanged red cells may have high glucose levels and rebound hypoglycaemia can occur following the exchange
- Keep nil by mouth for 24 hours after the procedure

11.0 Complications of exchange transfusion

Cardiac	arrest, arrhythmias, volume swings
Haematological	thrombocytopenia, coagulopathy, polycythaemia
Hypothermia	cardiac arrhythmias
Infection	bacterial and viral
Metabolic	↑K+,↓Ca^{2+},↓Mg^{2+} ,↑Na+, hypoglycemia, acidosis
Respiratory	volume swings, acidosis
Vascular	air or clot embolism
Gastrointestinal	ischaemia/perforation of intestine, portal vein thrombosis

11.1 Calcium

- Red cells used in the exchange transfusion contains citrate that binds to the baby's calcium. This may cause hypocalcaemia and hypomagnesaemia. Often this is transient and the ionized calcium rises spontaneously and rapidly.
- Check calcium and magnesium at the beginning, middle and end of the exchange (see section 10.1)
- If calcium or magnesium levels are low, discuss with the neonatal consultant on duty as to whether to treat or wait for a spontaneous increase.
- If the decision is to treat use the doses in the neonatal pharmacopoeia.
- If given, calcium needs to be given separately and not mixed with the aliquots of red cells.

12.0 Dilutional exchange transfusion

- This is performed to reduce the haematocrit in a polycythaemic infant.
- Before proceeding to do a partial exchange transfusion IT IS ESSENTIAL that the case is discussed with the consultant on duty.

12.1 Polycythaemia

Polycythaemia is a relatively common finding in the neonatal period but only a small proportion of babies develop clinical signs attributable to hyperviscosity.

At risk infants:

- Intrauterine growth retardation

- Infant of diabetic mother
- Twin-twin transfusion
- Delayed cord clamping

Signs of polycythaemia

These will often evolve over the first 24 hours as the haematocrit rises with the physiological decrease in plasma volume. The infants appear plethoric and can become cyanosed, particularly when active.

Other features:

- Lethargy
- Poor suck
- Vomiting
- Irritability
- Tachypnoea
- Tachycardia
- Heart failure
- Jaundice
- Hypoglycaemia

Hyperviscosity can result in sludging and microthrombi formation in small vessels.

Cerebral vascular occlusion	Convulsions, permanent neurological sequelae
Renal vein thrombosis	Haematuria, oliguria
Intestinal vascular occlusion	NEC
Platelet consumption	Thrombocytopenia

12.2 Indications for partial exchange transfusion

Please refer to local guidance on polycythemia.

12.3 Procedure

- 20mls/kg of blood is withdrawn and replaced with 0.9% sodium chloride.
- Any of the 3 techniques used for an exchange transfusion can be used.
- This can be done via peripheral or umbilical lines.

13 Audit points

- Time form decision to commencing exchange transfusion
- Whether double volume exchange transfusion was completed

14.0 References

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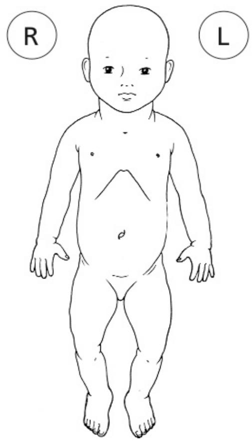
Appendices

A – Exchange Transfusion Observation chart

B - Example of unit-specific equipment set- up guide

Exchange Transfusion Observation Record



Date: ______________________

Baby's Name: ______________________ Date of Birth: ______________

Hospital Number: ____________ Room Number: ________ Space Number: ______

Birth Weight: ________________ (g) Working Weight: ________________ (g)

TIME	Axilla Temp.	Heart Rate	Respiratory Rate	Non inva. BP	SAO_2	Colour	Blood volume IN	Line site	Pump no	Pump press	Blood warmer temp.	Blood volume OUT	Line site	Blood volume balance	Blood glucose	Hb	Blood unit changed	Nurse signature
___:00																		
___:05																		
___:10																		
___:15																		
___:20																		
___:25																		
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Appendix B Example of unit-specific equipment set- up guide

Infusion of packed red cells and withdrawal of blood aliquots using one -person push-pull technique via UVC

Set-up and priming for blood infusion and blood aliquot withdrawals:
(This technique does not require the use of blood warmer)

- Empty equipment onto a sterile field
- Flush both BD Connecta 3-way taps with 0.9% Sodium Chloride
- Attach both BD Connecta 3-way taps to each other in series
- Attach Vygon Syringe adaptator to the distal 3-way tap at 'T' junction
- Spike the blood bag directly using the Codan transfusion set S93/B93, and prime. *Note: the giving set does not connect to a pump*
- Attach the Codan transfusion set S93/B93 to the distal end of the 3 way taps
- Attach the proximal end of the 3 way taps to the UVC
- Attach bile bag or urine collection bag to the Vygon Syringe adaptator to use as blood waste
- Attach BD Plastipak Luer-Lok 20ml syringe to the proximal 3-way tap at 'T' junction

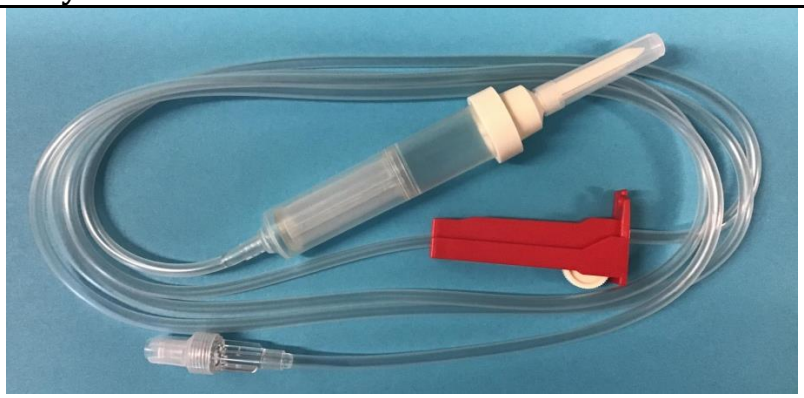
Blood requirements for priming of equipment:

	Blood requirement
Codan Transfusion set S93/B93	20mls
Total Required for priming of equipment:	**20mls**

Equipment required for packed red cell infusion and blood aliquot withdrawal:

Item	**Quantity**	**Location**
Codan Transfusion set S93/B93 (Priming volume = 20mls)	1	Exchange transfusion box
BD Connecta 3-way tap	2	Exchange transfusion box
Bile Bag (350ml capacity) or urine collection bag (1L capacity)	Bile bag = 2 (changed midway) Urine collection bag = 1	Exchange transfusion box
BD Plastipak Luer-Lok 20ml syringe	1 + spare	Exchange transfusion box
BD Plastipak Luer-Lok 10ml syringe	1	Exchange transfusion box
0.9% Sodium Chloride	10 mls	NICU
Red blunt fill needle	1	NICU
Sterile field	2	NICU
Vygon Syringe adaptator	1 + spare	Exchange transfusion box
Equipment to obtain 3 sets of blood samples (FBC, U&E's, SBR, Albumin, Ca2+ , Mg2+ and clotting) and initial blood gas + half hourly blood gases	X3 sets of blood sample bottles Minimum 7 gas capillary tubes	NICU

Images of non-routinely used items:

Codan transfusion set S93/B93 (Priming volume = 20mls) *Note: filter present in chamber for blood transfusions*	
Vygon Syringe adaptator	

Images for assisting setup:

Photo showing set-up of 3-way taps used in blood infusion and blood aliquot withdrawal	[photo to be taken]
Diagrammatic representation of set-up