

**PEDIATRIC NEWBORN  
MEDICINE CLINICAL  
PRACTICE GUIDELINES**

**Exchange Transfusion and  
Partial Exchange**



Implementation Date: May 15, 2016



<b>Clinical Guideline Name</b>	Exchange Transfusion
<b>Effective Date</b>	May 15, 2016
<b>Revised Date</b>	
<b>Contact Person</b>	Medical Director, NICU
<b>Approved By</b>	Newborn Clinical Practice Council <u>3/10/16</u> CWN Policy Procedure and Guideline Committee <u>4/13/16</u> BWH Standards Policy and Procedure Committee <u>4/20/16</u> Nurse Executive Board <u>4/25/16</u>

This is a clinical practice guideline. While the guideline is useful in approaching the care of the neonate who requires an exchange transfusion, clinical judgment and / or new evidence may favor an alternative plan of care, the rationale for which should be documented in the medical record.

**I. Purpose**

The purpose of this clinical practice guideline is to (1) describe the indications for exchange transfusion and (2) outline the exchange transfusion procedure.

**II.** All CPGs will rely on the [NICU Nursing Standards of Care](#). All relevant nursing PPGs are listed below.

- Epic tip sheet: [Neonatal Double Exchange Transfusion](#)
- Epic tip sheet: [Neonatal Partial Exchange Transfusion](#)
- [NICU B.4 – Administration of Blood and Blood Products](#)
- [NICU C.5 Assisting with Umbilical Vessel Catheterization and/or Peripheral Arterial Line Placement and Removal](#)

**III. Background/Summary Information**

- Exchange transfusion is primarily performed in the setting of severe hyperbilirubinemia due to isoimmune hemolytic disease in order to remove antibodies and excess bilirubin, but other indications exist and are discussed below.
- Overall, the need for exchange transfusion has declined due to improvements in bilirubin surveillance, use of phototherapy, and antenatal immunoprophylaxis with RhoGAM (Rho(D) immunoglobulin).
- Complications of exchange transfusion include:
  - i) Blood-borne infection
  - ii) Thrombocytopenia and coagulopathy
  - iii) Graft vs. host disease
  - iv) NEC
  - v) Portal vein thrombosis
  - vi) Electrolyte abnormalities (i.e. hypocalcemia and hyperkalemia)
  - vii) Cardiac arrhythmias



- Please refer to “Evaluation and Management of Hyperbilirubinemia in the Newborn Nursery and NICU” CPG for details regarding evaluation and management of hyperbilirubinemia.

#### IV. Patient population

Exchange transfusion should only be performed in the neonatal intensive care unit (NICU) because of associated risks and the need for continuous monitoring. Infants in the newborn nursery with bilirubin levels at or approaching the threshold for exchange transfusion should be transferred to the NICU for further evaluation and treatment.

#### V. Definitions

- An exchange transfusion involves removing aliquots of blood from an infant and replacing with donor blood while maintaining adequate circulating blood volume.
- Depending on the clinical scenario, exchange transfusion may refer to double volume exchange, single volume exchange, partial/reduction exchange with saline, or partial exchange with packed red blood cells (pRBCs).
- Single volume exchange (1x circulating blood volume) removes ~65% of infant’s circulating red blood cells.
- Double volume exchange (2x circulating blood volume) removes ~88% of infant’s circulating red blood cells and can be expected to reduce bilirubin levels by ~50%.
- Typical circulating blood volume for term infants is 80-90 ml/kg. Typical circulating blood volume for preterm infants is 90-100 ml/kg.

#### VI. Indications

##### Exchange Transfusion to Lower Bilirubin

1. **Isoimmune hemolytic disease** (Rh isoimmunization, blood group incompatibility):
  - a. The most common reason for exchange transfusion
  - b. A double volume exchange (160-200 ml/kg) is performed
  - c. Removes circulating bilirubin to prevent bilirubin encephalopathy (i.e. kernicterus)
  - d. Replaces antibody-coated red blood cells with antigen-negative red blood cells
  - e. As bilirubin is removed from plasma, extravascular bilirubin rapidly equilibrates and binds to albumin in exchanged blood
    - i. bilirubin levels return to 60% of pre-exchange levels within 30 minutes after procedure
2. **Severe unconjugated hyperbilirubinemia** with risk of bilirubin encephalopathy:
  - a. When intensive phototherapy is unsuccessful or insufficient
  - b. A double volume exchange (160-200 ml/kg) is performed



### **Exchange Transfusion to treat Severe Anemia**

3. **Severe acute anemia** with normal or increased circulating blood volume:
  - a. Perform partial exchange transfusion with pRBCs to limit fluid intake
  - b. Must obtain hematocrit of “blood bank” pRBCs for accurate calculations
  - c. To calculate volume of pRBCs (ml) for partial exchange =
 
$$\frac{(\text{Wt (kg)} \times 90 \text{ ml}) \times (\text{desired Hct} - \text{infant's Hct})}{\text{Hct pRBCs} - \text{infant's Hct}}$$
4. **Severe chronic anemia** (eg. hydrops fetalis), chronic fetal-maternal transfusion:
  - a. Perform single volume exchange (90 ml/kg)
  - b. Note that fetal transfusion has become standard of care for fetuses with severe anemia

### **Partial Exchange to treat Polycythemia**

5. Typically a partial/reduction exchange transfusion with saline is performed for symptomatic infants with venous hematocrit > 65% or asymptomatic infants with hematocrit > 70%
  - a. More common in setting of SGA (IUGR), LGA, infants of diabetic mothers, trisomy 21, twin-twin transfusion, Beckwith-Wiedemann syndrome and otherwise healthy infants who receive an excessive placental transfusion
  - b. Remove whole blood and replace with normal saline (alternatives include 5% albumin or FFP but these contain proteins that increase viscosity) to lower hematocrit to ~55%
  - c. To calculate volume of saline (ml) for partial/reduction exchange =
 
$$\frac{(\text{Wt (kg)} \times 90 \text{ ml}) \times (\text{infant's Hct} - \text{desired Hct})}{\text{infant's Hct}}$$

### **Other indications**

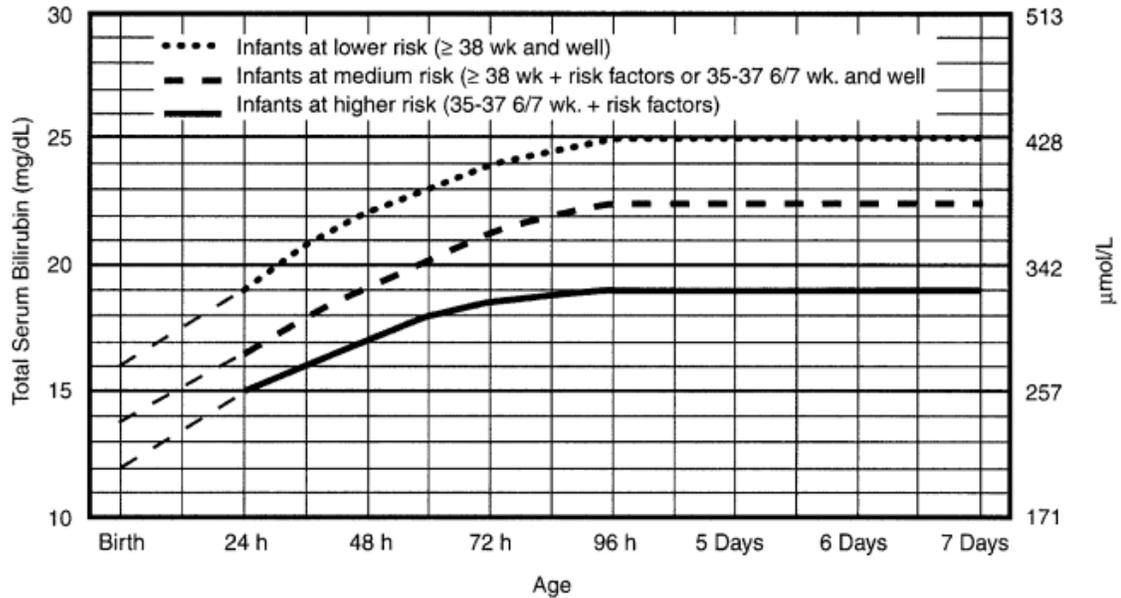
6. Less commonly, exchange transfusion may be performed because of severe disturbances of body chemistry or due to antibodies from maternal autoimmune disease

## **VII. Exchange Transfusion for Severe Hyperbilirubinemia**

1. Infants  $\geq$  35 weeks gestation
  - a. Consider exchange transfusion:
    - i. after 6 hours of intensive phototherapy unless there is evidence of acute bilirubin encephalopathy (significant lethargy, hypertonia, neck hyperextension, opisthotonos, high-pitched cry)
    - ii. OR if the total serum bilirubin (TSB) is  $\geq$  5 mg/dL above exchange level
  - b. Note that it may take several hours to prepare blood for double volume exchange; therefore, contact blood bank ASAP (2-7290) if exchange transfusion is anticipated. Ensure intensive phototherapy is administered in the meantime.



**Exchange transfusion nomogram (infants ≥ 35 weeks gestation)**



- c. Risk factors include:
  - i. Hemolysis
  - ii. G6PD deficiency
  - iii. Asphyxia
  - iv. Neurological signs including significant lethargy or irritability
  - v. Temperature instability
  - vi. Confirmed or suspected sepsis
  - vii. Acidosis
  - viii. Hypoalbuminemia (< 3 g/dL in near term and term infants)

2. Preterm infants < 35 weeks gestation

- a. Sick preterm infants are more likely than term infants to experience serious complications (including death) from exchange transfusion.

**Exchange transfusion guideline (infants < 35 weeks gestation):**

Gestational age	Total serum bilirubin (mg/dL) levels for exchange transfusion
<28 0/7	11–14
28 0/7–29 6/7	12–14
30 0/7–31 6/7	13–16
32 0/7–33 6/7	15–18
34 0/7–34 6/7	17–19



- b. Use lower levels for infants with any of the following risk factors:
  - i. Hemolysis
  - ii. Asphyxia
  - iii. Neurological signs (including significant lethargy or irritability)
  - iv. Temperature instability
  - v. Confirmed or suspected sepsis
  - vi. Acidosis
  - vii. Hypoalbuminemia (< 2.5 g/dL in premature infants)

### VIII. Technique

Exchange transfusions are performed using either one catheter push-pull method or two catheter continuous method.

1. One catheter push-pull technique: performed using single lumen UVC.
  - a. The four-way stopcock from exchange transfusion kit is used to connect (1) tubing from the donor blood, (2) the umbilical venous catheter, (3) the discard bag, and (4) an appropriately-sized syringe (syringe is connected to the port in the stopcock handle which points to the OPEN port).
  - b. Predetermined aliquot is withdrawn from umbilical venous line over ~1.5 minutes, cleared to discard bag, and equal aliquot donor blood (or normal saline) is subsequently administered over ~1.5 minutes.
  - c. Each aliquot should take ~3 minutes to complete.
  - d. Allow 30 second pause between removal and administration of blood, then draw subsequent aliquot from infant.
2. Two catheter continuous technique (requires 2 lines and 2 operators):
  - a. Predetermined aliquot is withdrawn from arterial line (umbilical or peripheral) while donor blood (or normal saline) is infused via venous line (umbilical or peripheral) at the same rate.
  - b. This method may be preferable for smaller infants as infant remains mostly euvolemic during the procedure.
  - c. Donor blood is hung with tubing passing through the blood warmer. A three-way stopcock is used to connect (1) umbilical venous line, (2) tubing from the donor blood, and (3) an appropriately-sized syringe.
  - d. Another three-way stopcock connects (1) umbilical arterial line, (2) syringe, and (3) the discard bag.
  - e. The aliquots are simultaneously withdrawn and infused; each aliquot should take ~1.5 minutes to complete.
  - f. The total exchange transfusion procedure should require at least 1 hour. Smaller aliquots and a slower rate place less stress on the infant's cardiovascular system.



### Determining aliquot volume:

- a. Each aliquot should be about 5% of the circulating blood volume, or 4 ml/kg.
  - i) Minimum aliquot volume is 5 ml for actual exchange to take place
  - ii) Maximum aliquot volume should not exceed 10% of infant's estimated blood volume

Weight	Aliquot volume
< 1500 grams	5 ml
1500-2500 grams*	10 ml
2500-3500 grams*	15 ml
> 3500 grams*	20 ml

\* In term infants, 10-20 ml aliquots may be used. For infants >2000g, begin with 10 ml and increase to 20 ml if well tolerated (i.e. stable vital signs)

### IX. Key Points

- Notify the blood bank (2-7290) ASAP that an exchange transfusion is being considered, and again when the decision is made to proceed.
- Moisten umbilical stump with gauze soaked in sterile water if umbilical access is anticipated.
- Licensed Independent Provider (LIP) will secure appropriate access for the procedure. Options, in order of preference, include:
  - UAC for withdrawal, UVC for replacement
  - Double lumen UVC – withdraw via primary port, replace via secondary port
  - Single lumen UVC – use one catheter push/pull technique
  - UVC/UAC for withdrawal, PIV for replacement
- Assure PIV is in place for administration of fluids and medications.
- DO NOT call for delivery of blood until lines are placed and confirmed via x-ray, as blood may expire in the interim.
- Blood should be as fresh as possible (< 72 hours old).
- For double volume exchange only, blood should be warmed to 37 degrees to prevent hypothermia in infant.
- During exchange procedure, gently agitate the blood bag every 10-15 minutes to prevent red cell sedimentation.
- If calcium gluconate is ordered for hypocalcemia, DO NOT administer via UAC or if heart rate is < 100 bpm.
  - Administer slowly over 10-15 minutes while closely observing HR and rhythm.
  - Flush line with normal saline before and after administration of calcium gluconate.



- An attending/fellow/NP must be present at the bedside at all times during exchange transfusion procedure.
- RN must remain at infant's bedside throughout exchange transfusion procedure.
- Monitor and record vital signs (heart rate, respiratory rate, blood pressure, and oxygen saturation) q 10 minutes, aliquots in/out, and total volume replaced using Neonatal Exchange Transfusion Flowsheet in EPIC.

## X. Equipment

- |  |  |
|--|--|
| 1. Radiant warmer  | 9. Povidone/Chlorhexadine  |
| 2. Flow inflating bag with manometer                                 | 10. Sterile water  |
| 3. 10% calcium gluconate and D10W readily available                  | 11. Softnets and safety pins   |
| 4. Hotline® blood warmer and tubing                                  | 12. Tape   |
| 5. Cardiorespiratory, oxygen saturation, and blood pressure monitors | 13. Needleless IV port adaptor(s)  |
| 6. Umbilical catheter insertion tray                                 | 14. T-connector  |
| 7. Exchange transfusion tray   | 15. Syringes, and tubes for collection of pre- and post-exchange lab tests |
| 8. Appropriate blood product or heparinized normal saline            | 16. Bedside glucose meter  |
|  | 17. Sterile gloves   |

## XI. Procedure

**NOTE: Partial volume exchange transfusions are performed with normal saline and do not require a blood warmer. Information and procedures below related to preparation of infant, aliquot volumes, care of infant during and post procedure are the same for both partial exchanges and double volume exchange transfusions.**

### Pre Double Volume Exchange Transfusion

1. The attending/fellow/NP will determine type and amount of blood product (or IV solution) needed (see "Indications" section above).
  - a. When placing order, specify that blood is for an exchange transfusion.
  - b. RN will double check the calculated volume of blood to be exchanged.
  - c. Add an additional 40 ml to calculated volume to account for priming the blood filter and tubing.
2. Notify the blood bank (2-7290) about exchange transfusion. Request that blood be as fresh as possible. Ask blood bank to calculate hematocrit of blood.
3. Obtain informed consent from parents. If parents cannot be reached and timing is critical, proceed with exchange transfusion and document attempts to contact parents in medical record.
4. RN will prepare blood warmer machine.
  - The blood must be pre-warmed to prevent hypothermia due to rapid infusion of large blood volume over short periods of time: usually 45-60 minutes

- a. HOTLINE ® warmer:
  - Check that the water level is above the minimum level mark on the tank. Add sterile water to the tank through the fill port if required.
  - Plug into power outlet.
- b. Set-up the HOTLINE ® warming set:
  - Plug the Twin-Tube Connector into the socket on the right side of the HOTLINE ® warmer.
    - Tubing must be connected to HOTLINE ® warmer before unit is turned on



- c. Activate the Power Switch on the left side of the warmer.
  - The green system operational light on the display panel will illuminate and the circulating water bath temperature display will begin to increase.



- d. Inspect the infant end of the tubing for leaks to confirm the integrity of the IV pathway.
    - The circulating water path will automatically prime when the HOTLINE ® warmer is turned on.
5. Perform time-out with all team members prior to start of procedure.
  6. Have resuscitation equipment, 10% calcium gluconate, and D10W at bedside.
    - a. Place infant on radiant warmer with total accessibility and continuous cardiorespiratory monitoring (cardiac monitor, blood pressure machine, oxygen saturation). Apply temperature probe to assure thermoregulation.
    - e. Infant should be continuously monitored for any precipitous complications including, but not limited to: cardiac arrhythmias, hypovolemia, fluid overload, arrest, etc

7. Secure infant's arms and legs.
8. If possible, infant should be NPO and the stomach contents aspirated prior to the procedure.
9. Ensure PIV is in place for administration of fluids and medications.
10. LIP will insert umbilical lines (if not already in place).
11. Open exchange transfusion kit using sterile technique and remove the blood filter, discard bag, stopcock, and one 20 ml syringe. Prepare the set-up while the umbilical lines are being placed.
  - a. Remove and insert filter (from exchange tray) into the bag of blood from Blood Bank.
  - b. Connect the IV administration set to the blood bag by:
    - Connecting the IV administration set to the HOTLINE Warming Set®.
    - Fully priming the IV administration set and the HOTLINE Warming Set®.
      - It may be necessary to secure the blood warmer tubing to the infant's bed as the tubing is thick and heavy
  - c. Monitor Hotline ® Warming Set temperature:
    - If the temperature does not reach between 37-42°C, do not proceed.
    - Turn off machine and call Biomed.
      - The circulating water bath temperature display will reach 37°C in approximately 4 minutes.



- d. Monitor patency of Hotline ® warming tubing.
    - Do not kink the blood warmer set tubing.
12. Attach 4 way stopcock from the exchange transfusion kit to:
    - a. Blood tubing.
    - b. Waste blood bag tubing.
    - c. Umbilical venous line to infant, turn stopcock off to infant.
      - The pointer on the stopcock in the exchange transfusion kits points to what is OPEN and available to withdraw or infuse (e.g., if stopcock pointer is pointing towards Blood tubing the blood may be drawn from blood bag).



13. Once the lines are placed and confirmed by x-ray, RN will acknowledge blood product order and release blood product in EHR. Inform UC to fax order to blood bank. Blood will be sent via pneumatic tube.
14. Verify blood product per protocol.
15. Draw pre-transfusion blood work (total/direct bilirubin, CBC, glucose, total/ionized calcium, state screen). Consider need for blood culture, electrolytes, and/or chromosome studies.

### **During Exchange Transfusion**

16. LIP will perform exchange transfusion in predetermined aliquots using push-pull or continuous technique (see “Technique” section above)
17. Record all documentation on the Neonatal Exchange Transfusion Record in electronic health record.
  - Blood warmer temperature must always be 37-42°F.
18. Monitor and record TPR & BP q10 minutes.
  - Complications and reactions can be precipitous.
19. Closely observe and record the amount of blood removed from and administered to infant.  
Document:
  - Amounts of each aliquot
  - Times
  - Temperature of blood warmer
    - Blood removed and administered should be in minimum aliquots of 5mL to pass through catheter for actual exchange to take place.
    - Maximum blood in and out should never exceed 10% of estimated blood volume of infant.
    - For term infants 10–20 mL aliquots can be used.
    - For infants weighing more than 2kg: begin with 10 mL then increase to 20 mL if tolerated well.
20. Closely observe for air in tubing going to infant.
  - To prevent air emboli.
21. Halfway through exchange, check glucose, cbc and ionized calcium.
  - a. Correct hypocalcemia if needed. Signs of hypocalcemia include change in QT interval, jitteriness, tetany.
  - b. Administer calcium gluconate 100-200 mg/kg/dose (dilute to maximum concentration of 20 mg/ml) IV over 10-30 minutes for EKG changes or symptomatic hypocalcemia (jitteriness or tetany). Do not give calcium gluconate if HR is <100 bpm. Flush tubing with 0.9% NaCl before and after calcium infusion. Observe heart rate and rhythm for side effects (profound bradycardia) during infusion.



22. Mix blood in bag by GENTLY squeezing blood bag and rotating in hand(s) after every 100 ml of exchange.

- RBC's and serum tend to separate. Vigorous mixing can result in cell damage.

### **Post Exchange Transfusion**

23. Following completion of exchange transfusion, flush line with 1-3 ml normal saline and reconnect to existing IV fluid or discontinue as necessary.

24. Draw post-transfusion blood work (total/direct bilirubin, CBC, glucose, total/ionized calcium, electrolytes, culture, type and cross).

25. Unsecure infant.

26. Discard blood per hazardous waste policy.

27. Document procedure in Neonatal Exchange Transfusion Flowsheet in EHR.

28. Place blood warmer in dirty utility room for cleaning.

- Unit Assistant will empty water from tank and clean blood warmer per manufacturer's instructions.

29. Observe for complications during and after the procedure.

- a. Hypoglycemia is most likely to occur post-transfusion. Monitor blood glucose levels for the first several hours after exchange.
- b. Serum bilirubin concentration rebounds to ~halfway between the pre- and post- exchange levels by two hours following exchange transfusion. Monitor serum bilirubin levels two to four hours after exchange and subsequently every three to four hours.

30. Feedings may be resumed two to four hours following completion of exchange transfusion procedure.



## XII. References

1. American Academy of Pediatrics Subcommittee on Hyperbilirubinemia. Management of hyperbilirubinemia in the newborn infant 35 or more weeks of gestation. *Pediatrics*. 2004; 114(1):297-316
2. Maisels MJ, Watchko JF, Bhutani VK, Stevenson DK. An approach to the management of hyperbilirubinemia in the preterm infant less than 35 weeks of gestation. *J Perinatol*. 2012 Sep;32(9):660-4
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4. Wong RJ, Bhutani VK. (2015). Treatment of unconjugated hyperbilirubinemia in term and late preterm infants. In: *UpToDate*. Kim MS (Ed), UpToDate, Waltham, MA. [www.uptodate.com](http://www.uptodate.com). Accessed December 31, 2015.
5. Hotline Blood Warmer Manufacturer's Instructions, Smiths Medical ASD, Inc. Rockland MA.