Tiny preemie for an X-lap - and they want to do it in the NICU!

Peter A. Chin, MBBS
Jenny Dolan, MD

Department of Anesthesiology
University of Miami,
Miami FL

Objectives

At the end of this discussion, the participant should be able

1. To understand the unique physiology of the extremely premature baby
2. To discuss and appreciate the different anesthetic techniques that may be appropriate
3. To appreciate the pros and cons between surgeries performed in the Intensive Care Unit and the Operating Room
4. To discuss the appropriate monitors and equipment that might be needed in the Neonatal Intensive Care Unit

A 2-week-old premature baby boy, born at 23 weeks of gestational age, is scheduled for emergent Exploratory Laparotomy due to Necrotizing Enterocolitis. Abdominal X-ray is positive for free air in the abdomen.

Birth weight was 610 grams, but he currently weights 556 grams. He was intubated at birth due to respiratory distress syndrome, and remains intubated, refractory to surfactant treatment. Hospital course since birth has been complicated by presumed sepsis, currently under empiric antibiotic treatment, and a grade III intraventricular hemorrhage. Echocardiography had revealed a patent ductus arteriosus, since treated with indomethacin. The renal ultrasound was normal. Patient also being treated for a skin break down with cultures positive for pseudomonas.

Physical examination reveals a very small and fragile male infant, intubated, with ETT# 2.5 taped at 7cm at the lips. Auscultation of the lungs reveals scattered rales and rhonchi with decreased sounds in both bases. No audible heart murmurs are present. Abdomen is tense and distended, with absent bowel sounds. Intravenous access consists of a right arm peripherally inserted central catheter (PICC) line. An umbilical arterial line is present and chest x-ray confirms location at the tip at T11. Current infusions include dopamine 8mcg/kg/min, hydrocortisone and hyperalimentation.

Laboratory investigations: WBC 30,000; Hct 27%, platelets 80,000; Na 141; K 5.3; Creatinine 0.9; Glucose 76. Arterial blood gas pH 7.28, $PaCO_2$ 56, PaO_2 58, HCO_3 30, base deficit –6, Sat 90%. Ventilator settings are IMV 30/min, FiO2 60%, PIP 20 cmH2O, peep 6, with tidal volumes of 5-7 ml/kg. Vitals BP 48/20, HR 168/min, SpO2 90%, temp 36.2C

Are any further investigations needed?

The surgeon has booked this case as an emergency, and wishes to perform the surgery at the bedside.

What are the advantages and disadvantages of surgery at the bedside, compared with the Operating Room?

Surgery is planned for the bedside.

What monitors and equipment do you wish to transport from the Operating Room?
Do we need additional vascular access?
Do you require blood products at the bedside? If so, what products, and how much?
What emergency medications should be available?

An additional left arm 24G IV cannula is placed. After suitable preparation and application of monitors, anesthesia is induced.

What are the options for anesthesia techniques in an extremely low birth weight infant?

Anesthesia is induced with atropine 0.02mg/kg, fentanyl 1mcg/kg, rocuronium 1mg/kg, and patient remains hemodynamically stable.

Patient is positoned, prepped and draped. Surgery begins.

Surgical finding include a perforation at the ileum, and friable bowel tissue. Blood loss continues, and increases rapidly so that an estimated 40cc is lost within 5 minutes.

What type, and how much blood products do you give?

Fifty milliliters of packed cells is given, but patient remains hypotensive. Heart drops to 60-80/min.

What do you do?

Atropine 20mcg/kg and epinephrine in escalating doses is given. A nurse looks under the drapes to check on the peripheral IV being used, and notes a massive tissue infiltration.

What are your options now for drug and fluid administration?

Can you use an umbilical arterial line for volume and pressor administration?

What about intraosseus fluid and drug administration in an ELBW infant?

Volume resuscitation in continued very cautiously through the umbilical arterial line, and the dopamine is increased to 20mcg/kg/min and an epinephrine infusion started through the PICC line.

Surgical control of blood loss is obtained, and the infant becomes hemodynamically stable on dopamine 20mcg/kg/min and epinephrine 0.1 mcg/kg/min. Arterial blood gas shows pH of 7.25, PaO_2 66, $PaCO_2$ 55, HCO_3 15, and base deficit of -12, with a Hct of 18. Additional blood, and bicarbonate are given.

What is the optimal amount and method of bicarbonate administration?

Surgery ends, and report is given to the neonatologists. Examination of the infiltration shows a very large area of indurated tissue extending up the entire left upper extremity and onto the left trunk.

How do you address this issue with the parents?

The infant is followed over the next several weeks. No compartment syndrome develops, but skin breakdown occurs over the trunk and is successfully managed conservatively. Three month follow up showed no lasting sequelae from the infiltration.

Topics of discussion

Location of surgery
Monitoring in NICU
Anesthetic requirements for ELBW infants
Use of umbilical lines and peripherally inserted central catheters
Indications for irradiated and CMV-negative cellular components
Discussion and disclosure with the parents

Reading list

Anesthesia for Neonates and Premature Infants (Chapter 16, pp 559-565) in Smith's Anesthesia for Infants and Children 7Ed. Editors Motoyama EK, Davis PJ. Mosby 2005
Anesthesia for Premature Infants (Chapter 14) in Pediatric Anesthesia 4Ed. Editor Gregory GA. Churchill Livingstone 2002
Anesthesia in the Neonate (Chapter 31) in Neonatal-Perinatal Medicine: Diseases of the Fetus and Infant 7Ed. Editors Martin RJ, Fanaroff AA. C.V. Mosby. 2001
Hazards of Transfusion (Ch 36) in Pediatric Hematology 2Ed Editors Lilleyman JS, Hann IM, Blanchette VS. Churchill Livingstone 1999
Kinouchi K. Anaesthetic considerations for the management of very low and extremely low birth weight infants. Best Pract Res Clin Anaesthesiol. 2004 Jun;18(2):273-90.
Medications (Chapter 6). Neonatal Resuscitation Textbook 4Ed. American Heart Association/American Academy of Pediatrics 2000.
Hobgood C, Tamayo-Sarver JH, Elms A, Weiner B. Parental preferences for error disclosure, reporting, and legal action after medical error in the care of their children. Pediatrics. 2005 Dec;116(6):1276-86.

Model Discussion

There has been a marked improvement in the survival rates of the smallest of pediatric sub-populations, the extremely low birth weight (ELBW) infant, that is, those weighing less than 1,000gm. Within ELBW infants, there are marked differences, with survival of the smallest (450-600gm) being about 40%, and the larger ones (901-1000gm) about 90%[i]. Despite these improvements, morbidity rates have not changed, and there has been a corresponding increase in surgical procedures done on these tiny patients. The most common surgical procedures in this weight group (under 1000gm) are patent ductus arteriousus (PDA) ligation and for necrotizing entericolitis (NEC)/bowel perforation[ii].

The spectrum of co-existing morbidity in ELBW infants is diverse. All organ systems are profoundly immature, and this will alter the pharmacokinetics and pharmacodynamics of drugs. Some of more common co-morbidities include intraventricular hemorrhage, retinopathy of prematurity, patent ductus arteriousus, and respiratory distress syndrome.

The site of surgery for these infants will often be dictated by local custom, availability of suitable equipment and supplies, as well as hospital layout. There are of course, advantages and disadvantages of surgery in the Operating Room (OR) versus the Neonatal Intensive Care Unit, but the decision at each institution must be take into account unique hospital characteristics. In addition, there may be individual clinical considerations that dictate one site over another (such as the use of High Frequency Ventilation). Advantages of the OR may include faster access to anesthesia assistance, greater familiarity with

equipment and monitors, capability of deliver anesthetic gases, and possibly less risk of infection, and faster access to lab tests, and blood banking services. Disadvantages of the OR will include the risks associated with transport including vascular line and endotracheal tube dislodgement, hemodynamic instability, and hypothermia. Surgery in the NICU may avoid these problems, but the lack of familiarity with equipment can be a concern. If surgery is undertaken in the NICU, it is imperative that the anesthesiologist becomes familiar with the location and function of the equipment that he or she may need. It will often be useful to have NICU personnel immediately available (neonatologist, nurses, respiratory therapists) to help troubleshoot problems as they arise.

Many anesthesiologists do not have experience in obtaining or managing invasive vascular lines in ELBW infants. Percutaneous central venous catheters (PCVC's) are commonly used in ELBW infants for the delivery of hyperalimentation, and allows for a reduction in the number of catheters/cannulas needed throughout the hospital stay. A Cochrane review in 2004 did not show an increased risk of infection[iii] with PCVC's. Peripherally inserted central catheters (PICC) are a sub-group of PCVC's that are inserted in peripheral veins in the extremities, with the tip lying at the atrio-caval junction. These lines have much smaller and longer lumens than catheters placed directly into the internal jugular, subclavian or femoral veins. Thrombosis is a common complication of these lines, and use of heparin-bonded catheters and/or continuous heparin infusion has been shown to decrease this risk in adults.

The most common site for arterial lines in ELBW infants is the umbilical artery. Umbilical artery catheters (UAC's) may be used for infusion of fluids and medications as well as continuous blood pressure monitoring, and blood sampling. Its tip is located in the descending aorta either high (T6-T10) or low (L3-L5). UAC's are associated with clinically significant risks including infection, thrombosis and vasospasm. If severe enough, these can lead to bowel, renal or spinal cord injury, or gangrene of an extremity. A Cochrane Database Review from 2000[iv] concluded that high catheters were associated with less risk and should be used exclusively.

Intraosseous lines have been used for resuscitation in babies as small as 515gm, when conventional vascular access failed[v]. In this series there were no long-term complications due to intraosseous access in the survivors.

Red cell transfusions in ELBW infants pose similar risks as in older, larger infants, including hyperkalemia, acidosis, citrate intoxication, hypothermia, transfusion reactions, volume overload and transmission of infection. ELBW infants are also at particular risk from cytomegalovirus (CMV) infection and transfusion associated graft versus host disease (TA-GVHD). CMV infection may be prevented by leukocyte filtration, or use of CMV-negative donor blood. Gamma irradiation of all cellular transfusion products (whole blood, packed red cells, and platelets) is effective in preventing TA-GVHD[vi].

Anesthesia requirements for ELBW infants are not clearly defined. There is no doubt that term neonates experience pain, and that they benefit from the provision of anesthesia for surgical procedures and attenuation of the stress response. The gestational age at which fetuses (and perhaps ELBW infants) begin to experience pain is, however, a matter of intense scientific and political debate. Some articles have suggested as early as 18 weeks gestation, while others, as late as 28 weeks. Balanced anesthesia techniques may be feasible when using an anesthesia machine capable of delivering volatile agents. Otherwise, an opioid-based technique can also be used. Spinal anesthesia and regional nerve blocks have also been described.

Sodium bicarbonate is not routinely indicated during resuscitation. It is very caustic and hypertonic and must be given slowly (no faster than 1mEq/k/min), in a large vein, with adequate ventilation assured. The recommended does in neonatal resuscitation is 2 mEq/k given as 4.2% solution[vii].

Disclosure to the parents is essential from an ethical standpoint. It would be ideal to address resuscitation and other end-of-life issues prior to the administration of anesthesia for a critically ill infant. Other severe complications, such as this infiltration, must be disclosed to the parents. A recent study has clearly demonstrated that parents wished to be informed of error, and may decrease the likelihood of legal action[viii].

---

[i] Meadow W, Lee G, Lin K, Lantos J. Changes in mortality for extremely low birth weight infants in the 1990s: implications for treatment decisions and resource use. Pediatrics. 2004 May;113(5):1223-9

[ii] Limpert JN, Limpert PA, Weber TR, et al. The impact of surgery on infants born at extremely low birth weight. J Pediatr Surg. 2003 Jun;38(6):924-7

[iii] Ainsworth SB, Clerihew L, McGuire W. Percutaneous central venous catheters versus peripheral cannulae for delivery of parenteral nutrition in neonates. Cochrane Database Syst Rev. 2004;(2):CD004219.

[iv] Barrington KJ. Umbilical artery catheters in the newborn: effects of position of the catheter tip. Cochrane Database Syst Rev. 2000;(2):CD000505.

[v] Ramet J, Clybouw C, Benatar A, Hachimi-Idrissi S, Corne L. Successful use of an intraosseous infusion in an 800 grams preterm infant. Eur J Emerg Med. 1998 Sep;5(3):327-8.

[vi] Mentzer WC, Glader BE. Erythrocyte Disorders in Infancy In: Taeusch HW, Ballard RA, Gleason CA, eds. Avery's Diseases of the Newborn. Philadlephia: Elsevier Saunders 2005

[vii] Neonatal Resuscitation Textbook. Ch 6 p6-12. American Heart Association/American Academy of Pediatrics

[viii] Hobgood C, Tamayo-Sarver JH, Elms A, Weiner B. Parental preferences for error disclosure, reporting, and legal action after medical error in the care of their children. Pediatrics. 2005 Dec;116(6):1276-86.

Syllabus / Questions

1. What are the advantages and disadvantages of surgery performed in the Neonatal Intensive Care Unit, compared with the Operating Room?
2. What are the anesthetic and analgesic requirements of the extremely premature infant?
3. How is fluid management and vascular access different between an extremely low birth weight infant, and an older child?
4. What is appropriate monitoring and equipment for off-site anesthesia?
5. What special precautions should be taken for blood transfusions in extremely premature infants?