Society for Pediatric Anesthesia
education • research • patient safety

EXPLORATORY LAPAROTOMY (BEDSIDE NICU)

Surgical Specialty:	Pediatric General Surgery
Authors:	Ruchika Gupta MD, University of Michigan Ann Arbor, MI Jina Sinskey MD, University of California, San Francisco, CA

Background:

- General Considerations
  - Bedside surgery in the neonatal intensive care unit (NICU) is often considered for urgent or emergent cases in unstable neonates at high risk for transport to the operating room (OR)[1,2]
  - Due to urgency, there may be limited time for a preoperative workup. A thorough handoff from the NICU team is essential.
  - These surgeries are most often performed for necrotizing enterocolitis (NEC) or abdominal washout with the need for bowel resection. On occasion, other surgeries, such as congenital diaphragmatic hernia or obstruction from volvulus, may also be performed at the bedside. In addition, assistance from an Anesthesiologist for less critical cases, such as simple silo placement or reduction for omphalocele and gastroschisis, may be requested.
  - Considerations for Non-Operating Room Anesthesia (NORA)[3]
    - Unfamiliar environment: Communication with the surgical and NICU team members is critical.
    - There is typically no anesthesia machine at the bedside; thus, volatile agents are unavailable, and intravenous anesthetics must be used.
    - The patient may be on a NICU ventilator or receiving high-frequency oscillatory ventilation (HFOV).
    - Monitors will also likely be in a different space with different configurations and frequencies.
    - The Anesthesia team is responsible for bringing additional OR anesthesia equipment and medications to the bedside.
    - No immediate anesthesia help
      - Request possible anesthesia tech or designate a NICU nurse and/or NICU respiratory therapist for additional support.
  - The patient is often far away from the anesthesiologist. Prepare diligently for lack of patient access due to space constraints and the need for surgical access.

- Patient Considerations
  - Patients who receive bedside surgery in the NICU are generally sicker than those who can be transported to the OR; they are often on HFOV or multiple vasopressors and often too hemodynamically unstable to transport[1,2]
  - Neonates have disproportionately higher perioperative morbidity and mortality. This higher mortality has been attributed mainly to the degree of preoperative illness, the complexity of the surgeries (e.g., cardiac surgery), and infant physiology.[4]
  - Preterm neonates are at higher risk of intraventricular hemorrhage, bronchopulmonary dysplasia, patent ductus arteriosus, bradycardia, and NEC.
  - Associated Comorbidities/Syndromes
    - Patients may have associated congenital abnormalities such as congenital heart disease. Always review the echocardiogram preoperatively. Patients with a patent ductus arteriosus (PDA) will have excessive pulmonary circulation at the expense of oxygen delivery.

Anesthetic Planning:

- Pre-Anesthetic Evaluation
  - Due to time constraints, the preoperative evaluation often consists of a chart review and good communication with the primary team.
  - Assessment of adequate vascular access, including peripheral intravenous (IV) catheters, arterial, and central lines. If vascular access is inadequate, consider the placement of a PICC line if time allows.
  - Additional labs/tests indicated during work-up
    - Complete Blood Cell count: hemoglobin and platelets
    - Type and screen
    - Coagulation tests: Prothrombin time and International Normalized Ratio
    - Electrolytes, specifically glucose and calcium
    - ABG/VBG/CBG (depending on the vascular access)
    - Review echocardiogram and chest X-ray
  - Discussions to have with surgeon/family
    - Code Status: patients are almost always intubated; discuss code status, goals, and progression of care
    - ECMO Candidate: discuss with family and surgeons
- Specific or Unique Room Set-up Requirements
  - Airway: Most patients are already intubated. If not, discuss with the NICU team who will intubate the patient. In addition, NICU babies often have an uncuffed ETT. Discuss whether the uncuffed ETT is adequate or should be changed to a cuffed ETT to manage respiratory requirements during surgery.
    - Have airway equipment available based on the patient's age and weight
    - Video and direct laryngoscopy size Mil 00,0,1: a non-angulated video laryngoscope is recommended.[6]
    - ETT size 2.5-3.5 cuffed or uncuffed: the same size as current ETT and 0.5 smaller ETT is recommended
    - Oral airway 40mm-50mm
    - Mask size 1 or 2
    - Appropriately sized supraglottic airway for rescue (usually a size 1)

- Drugs/Infusions
  - Continue all the medications that are currently being administered.
  - Continue the glucose or total parenteral nutrition infusions to prevent hypoglycemia, although surgical stress can increase catecholamine response and lead to hyperglycemia.
  - Draw up all medications in smaller syringes 1 mL to 3 mL, or unit-dosed syringes.
    - Be vigilant when dosing and concentrating medications.
  - Inotropes:
    - 1 mcg/mL epinephrine for IV push, 10 mcg/mL epinephrine for IV push, atropine unit dose syringe, and an inotrope infusion, such as dopamine at appropriate concentrations for neonates.
  - Anesthetic and analgesic agents: fentanyl (diluted if possible 10mcg/mL unless volume is an issue), midazolam, ketamine. NICU patients are often already on opioids and may need higher doses for operative analgesia.
  - Non-depolarizing muscle relaxants (such as rocuronium or vecuronium)
  - Calcium gluconate (or chloride if central access is available)
  - Other medications may include sodium bicarbonate, hydrocortisone, antibiotics, and albumin.
  - Consider giving non-emergent medications via an infusion to prevent hydrostatic gradient changes in various compartments (i.e., blood-brain barrier) leading to intraventricular hemorrhage.
  - As there is no drug cart, bringing urgently needed medications is critical, as well as making sure these are organized and promptly available during an emergency.
- Monitors
  - Standard American Society of Anesthesiologists monitors
    - Electrocardiogram
    - Appropriately sized non-invasive blood pressure (NIBP) cuff volume adjusted for neonates.
    - Pre- and post-ductal pulse oximetry
    - Continuous temperature monitoring
    - End-tidal CO_2 monitoring is often difficult in the ICU, especially in patients on HFOV. Be aware of the capabilities at your institution. Consider frequent blood gas measurements or transcutaneous CO_2 monitoring. In addition, side stream $EtCO_2$ often draws too much volume (150mL/min) to be beneficial. Mainstream $EtCO_2$ monitoring may be an option. One may need to request this from the respiratory therapist.
  - Arterial line, if indicated
- Blood Availability
  - Have blood products crossmatched and available in the NICU, including packed red blood cells and fresh frozen plasma. Designate how they will be brought to the bedside and administered with a warmer. Often, the ICU will have a storage fridge or cooler. Determine if they need to be in the room or just readily available on the floor.
  - Critically ill and septic patients may already have coagulopathies and may need vitamin K

- Other Indicated Resources
  - A respiratory therapist for ventilator management during the case, especially if the patient is on an HFOV.
  - Warming device for fluids, if indicated for the patient, including heat lamps, gel warmers, and forced air blankets.

Intraoperative Considerations:

- General
  - Patients are often critically ill with high morbidity and mortality
  - Confirm intravenous and arterial access: umbilical catheters are common
    - IV Access: assess all IV access to patient, ensure patency and ability to push medications. Note the dead space required to get medication to the patient; use the proximal access and thinner lower-volume tubing.
    - Strongly consider dedicated intravenous access for medications, fluids, and blood products.
    - Minimize fluids and account for all flushes given as total fluids administered.
- Induction
  - Patients are often already intubated: confirm the depth of ETT. Confirm availability of emergency airway equipment, including appropriately sized suction catheters and the appropriate depth for suctioning.
  - Administer IV anesthetic and analgesic agents, including paralytics, which are beneficial for exploratory laparotomies. Timing should be coordinated with the surgical staff and the beginning of the surgical portion of the case. Communication is imperative.
- Positioning
  - Patient may be far away: Ensure route of access to patient's head in case of emergency (e.g., accidental extubation)
  - Confirm access to IV tubing, including multiple options, in case of failure after the patient is draped.
- Maintenance
  - Medications as above
- Hemodynamic/Physiologic goals
  - Avoid hypotension and hypertension with appropriate medications to treat.
  - Discuss oxygen saturation goals with the NICU to avoid hypoxemia and oxygen toxicity.
  - Discuss CO_2 goals and permissive hypercapnia or CO_2 trends
  - Anticipate hypocalcemia as a cause of hypotension if blood products are given and treat appropriately
- Surgical Considerations (such as neuromonitoring, muscle relaxation, anticipated blood loss)
  - The use of a muscle relaxant is recommended throughout the case
  - Avoid hypothermia (use plastic drapes, light warmers, warming pads under the baby, and warm irrigation fluids)
  - Although there is often not a large amount of blood loss in patients with NEC, resuscitation with blood products is often necessary.
- Emergence/Disposition
  - Patients are often kept intubated with postoperative ventilation and remain in the NICU.
- Post-op Care
  - Provide a thorough postoperative handoff to the NICU team

Case-Specific Complications/Pitfalls

- Cardiovascular collapse
  - Decompression of the abdomen can lead to cardiovascular collapse; be prepared with pressors, crossmatched blood products, and ventilatory mechanic changes.
  - Intraoperatively, hypoxia, acidosis, and hypothermia can lead to shunt reversal in premature infants with a PDA.
- Coagulopathy
  - Increased risk of coagulopathy in neonates with NEC due to sepsis, hypothermia, and dilution of coagulation factors.
- Hypoxemia
  - Patients are prone to respiratory complications, with premature neonates at the highest risk.
  - Patients with NEC often also have tense abdomens with high ventilatory requirements that often change during the case, affecting lung compliance, ventilation, and oxygenation.
  - Small ETTs are likely to be obstructed by secretions and may affect oxygenation and/or ventilation.
  - A respiratory therapist and NICU faculty should be readily available for ventilator management during the case.
  - Have an oxygen source with a neonatal Ambu bag, Neo-puff, or Jackson-Rees circuit available.
- Accidental extubation
  - Accidental extubations are one of the most common adverse events in the NICU.[6]
  - Airway equipment should be available: laryngoscope, ETT, face mask, oral airway, suction, and appropriate-size catheters.
  - An oxygen source with a neonatal Ambu bag or Jackson-Rees circuit should be available.

References

1. Kumar Sinha S, Neogi S. Bedside neonatal intensive care unit surgery- myth or reality! J Neonatal Surg. 2013;2(2):20. PubMed Link
2. Wang YL, Jeng SF, Tsao PN, Chou HC, Chen CY, Hsieh WS. Operating Room Within the Neonatal Intensive Care Unit--Experience of a Medical Center in Taiwan. Pediatr Neonatol. 2015;56(4):220-225. PubMed Link
3. Shih G, Bailey PD Jr. Nonoperating room anesthesia for children. Curr Opin Anaesthesiol. 2020 Aug;33(4):584-588. PubMed Link
4. Houck CS, Vinson AE. Anaesthetic considerations for surgery in newborns. Arch Dis Child Fetal Neonatal Ed. 2017;102(4):F359-F363. PubMed Link
5. Peyton J, Park R, Staffa SJ, et al. A comparison of video laryngoscopy using standard blades or non-standard blades in children in the Paediatric Difficult Intubation Registry. *Br J Anaesth*. 2021;126(1):331-339. PubMed Link
6. Sharek PJ, Horbar JD, Mason W, et al. Adverse events in the neonatal intensive care unit: development, testing, and findings of an NICU-focused trigger tool to identify harm in North American NICUs. Pediatrics. 2006;118(4):1332-1340. PubMed Link

Reviewed by:

Reviewer #1: Meenakshi Atteri, MD, Arkansas Children's Hospital

Reviewer #2: Vikram Patel, MD, University of Tennessee

Reviewer #3: Marc Parris, M.D., MPH, Children's Hospital of Philadelphia

Senior Editor: Debnath Chatterjee, MD, FAAP, Children's Hospital Colorado

Created:8/16/2022 Last revised:01/19/24