

Necrotizing Enterocolitis

Necrotizing enterocolitis is a neonatal gastrointestinal emergency characterized by ulceration and necrosis of the small bowel and colon resulting in peritonitis and if left untreated, can progress to septic shock.

ANESTHETIC CONSIDERATIONS:

1. Emergency surgery with little/no time for preoperative optimization
2. Neonatal/premature patient and associated physiologic, anatomic and pharmacologic changes.
3. Sepsis and septic shock may require aggressive resuscitation with fluids and inotropes/vasopressors.
 - a. ARDS
 - b. DIC
 - c. Renal and hepatic failure
4. Rapid sequence induction and precautions to prevent perioperative aspiration
5. Distended abdomen – restrictive lung disease, increased A/W pressures
6. Fluid, electrolyte and metabolic disturbances (lactic acidosis, hyper/hypoK, hyper/hypoNa, hypoglycemia)
7. Temperature instability – warm room

ANESTHETIC GOALS:

- Preoperative optimization vs. proceed to OR for emergency surgery if failure of medical therapy
- Aggressive fluid and inotropic/vasopressor resuscitation
- Maintain intraoperative hemodynamic stability
 - Septic neonate is very sensitive to depressant effects of anesthetics
- Facilitate surgical intervention by providing abdominal muscle relaxation
- Postoperative disposition: NICU/PICU

HISTORY

- Clinical findings are often non-specific
- Early signs
 - Irritability, lethargy, temperature instability
 - Increased work of breathing
 - Feeding intolerance (high gastric residuals, vomiting)
- Later signs
 - Abdominal distention, bloody/mucoid stools
 - Hypotension, recurrent apneas
 - Thrombocytopenia, coagulopathy
 - Multiorgan system failure
- Metabolic acidosis very common

PHYSICAL

- Vital signs – BP (hypotension), HR, RR, SpO₂, T (fevers)
- CNS – irritability, lethargy
- Airway
- Respiratory – recurrent apneas
- CVS – cool extremities, mottling,
- Abdo – distended abdomen, diffuse tenderness, peritoneal signs

INVESTIGATIONS

- Labs
 - CBC/D (anemia, dilutional or blood loss; thrombocytopenia and neutropenia associated with gram-negative sepsis)
 - Lytes (dehydration, hyperkalemia)
 - Cr, urea (prerenal ARF)
 - Glucose (hypoglycemia)
 - INR, PTT, Plts, fibrinogen (coagulopathy, DIC)
 - ABG (metabolic acidosis)
 - Blood cultures
- Imaging
 - AXR – bowel edema, pneumatosis intestinalis, portal venous air, free intraabdominal air
 - Air in intestinal wall represents gas produced by bacterial fermentation that penetrates the damaged mucosa and enters submucosal region
 - Pneumoperitoneum indicates intestinal perforation
 - Abdominal U/S
 - Bowel wall with a central echogenic focus and a hypoechoic rim (the pseudo-kidney sign) may indicate necrotic bowel and imminent perforation.
 - Contrast enema – contraindicated (risk of bowel perforation with leakage of contrast into peritoneum)

OPTIMIZATION

- Airway management
 - Early airway management in setting of distended abdomen, sepsis, clinical deterioration
- Fluid resuscitation

- Avoid rapid fluid administration in preterm infants; risk of ICH or reopening of ductus arteriosus
- Begin antibiotic therapy

ANESTHETIC OPTIONS

- **No anesthesia (cancel case)**
 - Consider if no potential for surviving operation
- **General anesthesia**

ANESTHETIC SETUP

- **Drugs**
 - Standard emergency drugs
 - Vasopressor/inotrope infusions available (epinephrine, dopamine)
 - Calcium gluconate, stress dose steroids
- **Monitors/Equipment**
 - Standard CAS monitors
 - Arterial line for hemodynamic monitoring
 - Central line for hemodynamic support
 - Time to place lines weighed against need for urgent laparotomy
 - Multiple iv access
 - Consider need for ICU ventilator
 - Foley catheter
 - Forced air warmer, fluid warmer
 - Blood set
- **Other**
 - Blood products (PRBCs, FFP, Plt, cryo, albumin)

MANAGEMENT OF ANESTHESIA

- **Induction**
 - Caution: critically ill patients very sensitive to depressant effects of anesthetics
 - Fluid resuscitation prior to induction
 - For patients not already intubated
 - Full stomach precautions (awake intubation vs RSI)
 - Ketamine induction
 - Succinylcholine – avoid if hyperkalemia 2° to necrotic bowel; substitute high dose rocuronium
 - Intubate with ETT to allow ventilation with PIP >20 cmH2O in setting of ↑ intraabdominal pressures with ↓ pulmonary compliance
- **Maintenance**
 - Opioid-based/midazolam technique or ketamine preferred if hemodynamically unstable
 - Fentanyl 20-50mcg/kg + midazolam 0.1mg/kg + muscle relaxant
 - Ketamine 4mg/kg/hr + muscle relaxant
 - Low-dose inhalational anesthetic agent if patient condition improves
 - Fentanyl 5-10mcg/kg + inhaled anesthetic + muscle relaxant
 - Volatile agents cause significant hypotension in setting of sepsis + hypovolemia
 - Avoid N2O due to gas pockets in abdomen
 - Hemodynamic support – vasopressor/inotrope infusions as indicated
 - Monitor ABGs (pH, lactate, Hct, lytes, glucose)
 - Fluid management
 - Expect massive volume requirements
 - Large intraoperative losses from surgical + 3rd space losses; replace with full-strength balanced salt solution to maintain BP and U/O in addition to maintenance requirements.
 - Warm fluids to maintain normothermia
 - Transfusion often required
 - PRBCs to maintain Hct >30%, Hb >100; replace blood losses
 - FFP, Plts, cryo as indicated (goal is Plts >100, normal INR and PTT)
- **Emergence**
 - Transfer intubated to ICU for ongoing resuscitation and monitoring

DISPOSITION & MONITORING

- **ICU**
 - For ongoing mechanical ventilation, hemodynamic support, fluid resuscitation, antimicrobial therapy, and monitoring for complications
 - Postop analgesia
 - Fentanyl 1-3mcg/kg/hr
 - Morphine 0.1mg/kg q4-6h

COMPLICATIONS

- Hyperkalemia
- Septic shock
- Short-bowel syndrome (postop)
- Complications related to central lines
- Complications related to TPN
- High mortality rates
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PATHOPHYSIOLOGY

- Epidemiology
 - Most common neonatal surgical emergency
 - Incidence among VLBW infants: 5-15%
 - Mortality rates for neonates <1500g: 25-50%
- Risk factors
 - Prematurity (< 32 wks)
 - Very low birth weight (< 1500g)
 - Perinatal asphyxia, respiratory distress syndrome
 - Congenital heart disease – persistent PDA, cyanotic CHD
 - Systemic infections
 - Umbilical artery catheters
 - Early rapid feeding with hyperosmolar formula
 - Exchange blood transfusions
- Pathology
 - Terminal ileum and proximal colon most common
 - Lesions may be mucosal or transmucosal, continuous or discontinuous
- Pathophysiology
 - Immature distal small bowel/large bowel has ↓absorptive capacity → stasis
 - Pooling of fluid
 - Bacterial proliferation → local infection → intestinal wall necrosis → perforation → gangrene
 - Ischemia → fluid loss, peritonitis, sepsis, DIC
 - Persistent metabolic acidosis with hyperkalemia suggests presence of necrotic tissue
 - Gram negative sepsis
 - Thrombocytopenia – endotoxin binding to platelets
 - Neutropenia
 - NEC predisposes to
 - Hypovolemia, cardiac and respiratory failure, capillary leak syndrome, DIC, hypoglycemia
- Management
 - NEC is primarily a *medical* disease
 - Airway/respiratory support
 - Consider if ↓LOC or abdominal distention contributing to hypoxia and hypercapnia
 - Hemodynamic support to improve CO and bowel perfusion
 - Fluid and electrolyte therapy
 - Vasopressors/inotropes
 - Antibiotics
 - NPO + OG tube decompression
 - +/- peritoneal drain
 - Remove umbilical artery catheters to avoid compromising mesenteric blood flow
 - TPN often required
 - Surgical intervention
 - Required in 50% of cases
 - Indicated for bowel perforation or unresponsive to medical management (worsening of peritonitis, metabolic acidosis, and sepsis, or bowel perforation as markers of bowel necrosis)
 - Exploratory laparotomy with resection of gangrenous bowel, enterostomies, primary anastomosis vs ileostomy
- Outcomes
 - Long-term survival based on degree of prematurity, associated congenital anomalies, degree of surviving bowel, total length of affected bowel, subsequent complications
 - Intestinal obstruction 2° to adhesions may occur weeks to months after a relatively benign course

REFERENCES

- Miller p.2677-78
- Barash p.1199-1200
- Coexisting p.600-01
- Cote p.742-43, 763
- Up To Date “Necrotizing enterocolitis”

Modified bell staging criteria for necrotizing enterocolitis (NEC)

Stage	Classification of NEC	Systemic signs	Abdominal signs	Radiographic signs
IA	Suspected	Temperature instability, apnea, bradycardia, lethargy	Gastric retention, abdominal distention, emesis, heme-positive stool	Normal or intestinal dilation, mild ileus
IB	Suspected	Same as above	Grossly bloody stool	Same as above
IIA	Definite, mildly ill	Same as above	Same as above, plus absent bowel sounds with or without abdominal tenderness	Intestinal dilation, ileus, pneumatosis intestinalis
IIB	Definite, moderately ill	Same as above, plus mild metabolic acidosis and thrombocytopenia	Same as above, plus absent bowel sounds, definite tenderness, with or without abdominal cellulitis or right lower quadrant mass	Same as IIA, plus ascites
IIIA	Advanced, severely ill, intact bowel	Same as IIB, plus hypotension, bradycardia, severe apnea, combined respiratory and metabolic acidosis, DIC, and neutropenia	Same as above, plus signs of peritonitis, marked tenderness, and abdominal distention	Same as IIA, plus ascites
IIIB	Advanced, severely ill, perforated bowel	Same as IIIA	Same as IIIA	Same as above, plus pneumoperitoneum

DIC: disseminated intravascular coagulation.
Adapted from *Neu J. Pediatr. Clin North Am* 1996; 43:411, 1996.