Surgical Considerations for Pediatric Anesthesia

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The "little" patients
should not be considered
"miniature adults".

Neonatal Surgical Diseases

- Congenital diaphragmatic hernia
- Esophageal atresia/ Tracheoesophageal fistula
- Abdominal wall defects
  - Omphalocele
  - Gastroschisis
- Pyloric stenosis
- Hirschsprung's disease
- Post-tonsillectomy hemorrhage
- Cleft lip & cleft palate
- Myelomeningocele
- Lobar emphysema
- Necrotizing enterocolitis

Smith's, Anesthesia for Infant and Children, 9th ed.,2017.

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

Congenital diaphragmatic hernia

- **Incidence** of CDH = 1:2,500-3,000 live births
- Male to Female ratio = 1:1.8
- The most common & largest diaphragmatic defect (75-85%) → left posterolateral pleuroperitoneal canal (foramen of Bochdalek)

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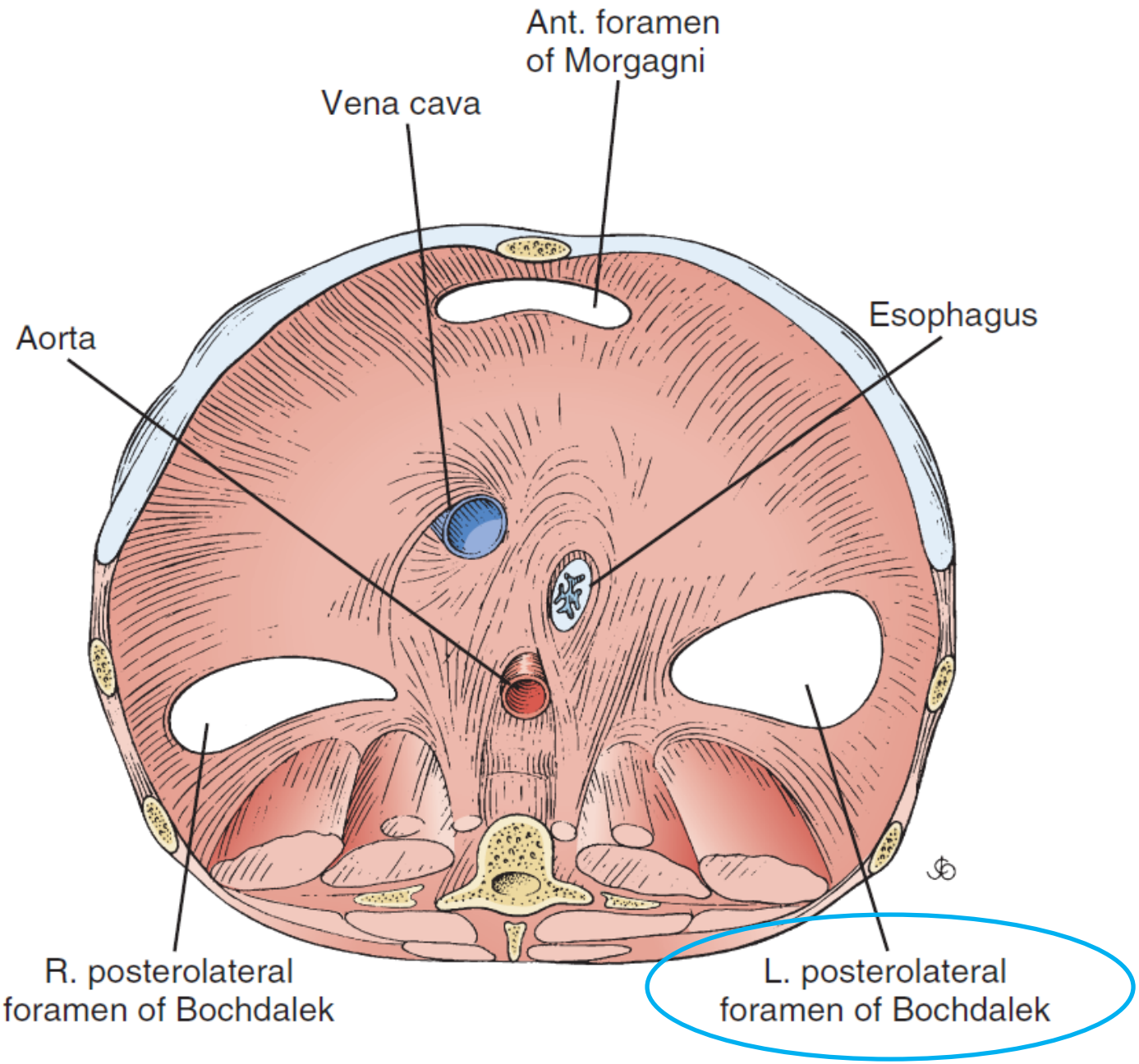

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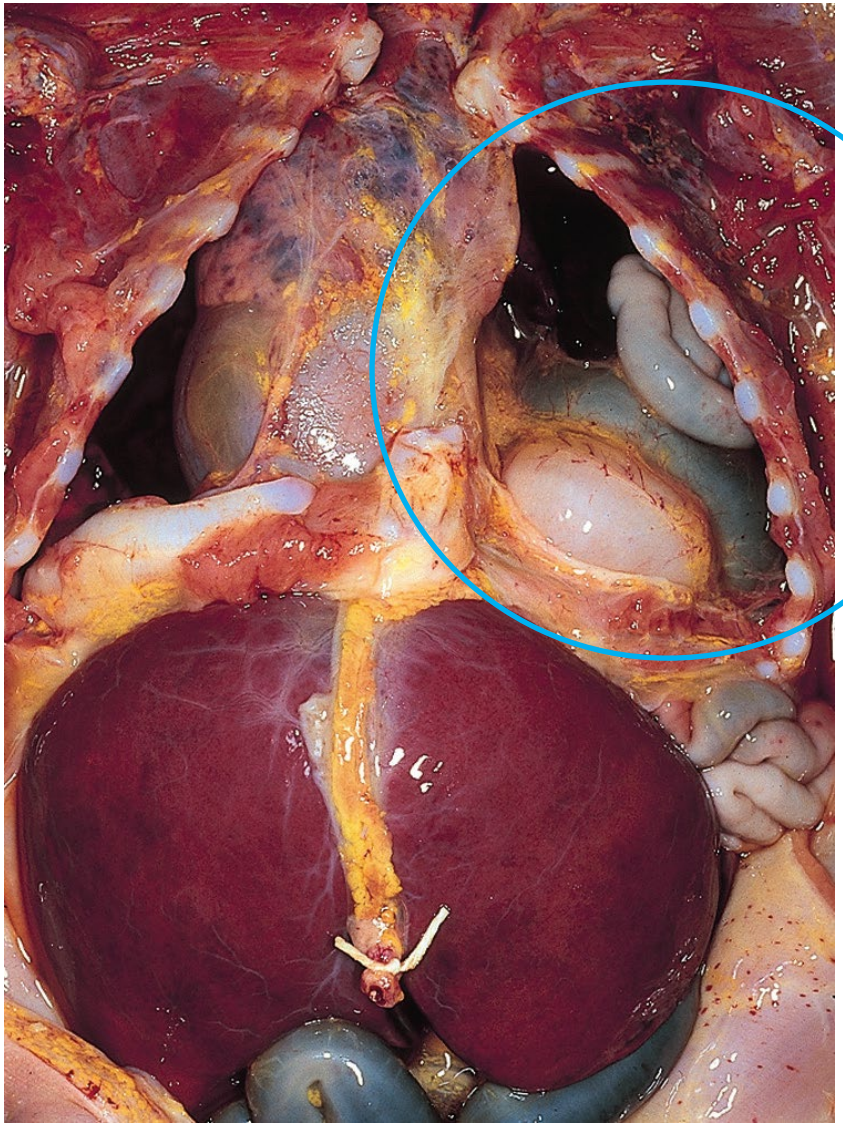

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CDH is associated with the following:

- Varying degrees of bilateral lung hypoplasia
- Pulmonary hypertension → Rt-Lt shunt → Hypoxemia
- Congenital anomalies ;
  - CNS (28%); neural tube defects, hydrocephalus, sensorineural hearing loss
  - Cardiac (25%); VSD, ASD,TOF, HPLS
  - Gastrointestinal (20%); undescended testis, hypospadias
  - Genitourinary (15%); gastrointestinal malformations
  - Trisomic (10%)
  - Skeletal

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- **Signs & symptoms** (soon after birth)
  - scaphoid abdomen,
  - barrel-shaped chest,
  - detection of bowel sounds during auscultation of the chest,
  - profound arterial hypoxemia

- Classic triad of CDH consists of
  - Cyanosis
  - Dyspnea
  - Apparent dextrocardia

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- **Diagnosis**
  - Prenatal (20 GA);

    ultrasonography→ findings that correlate with poor prognosis include polyhydramnios, displacement of the stomach above the diaphragm

    - degree of pulmonary hypoplasia estimated by calculating the lung-to-head ratio

high ratio (>1.4) indicates good lung size & good outcome compared to a low ratio (<1.0)

  - Postnatal, assessed the degree of pulmonary hypoplasia by
    - Degree of respiratory distress
    - Hypoxemia
    - Acidosis
    - PPH

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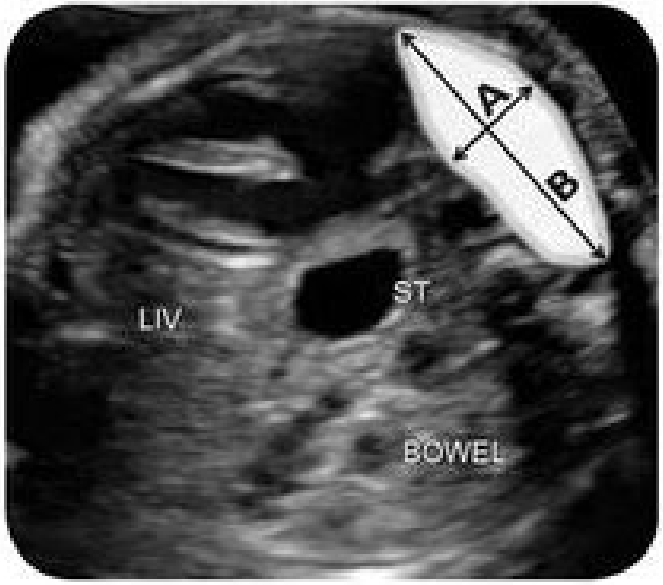
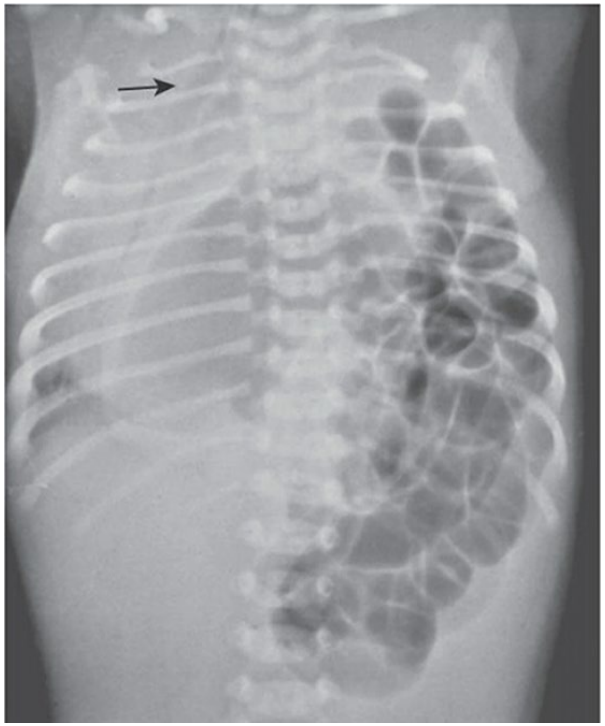


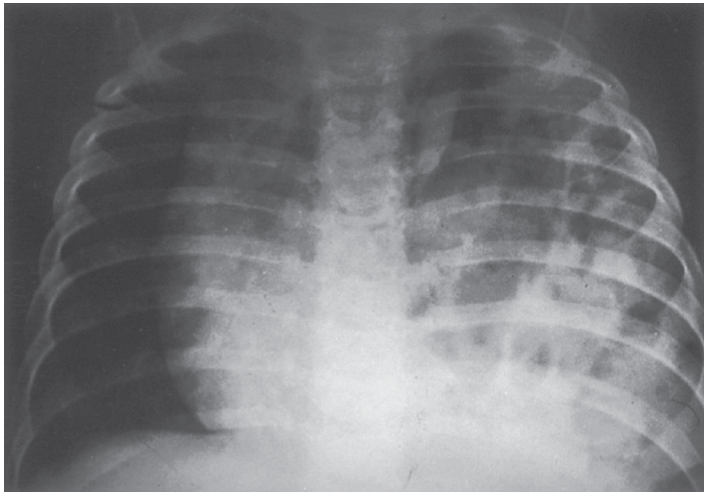
$$\text{LHR} = \frac{\text{Length A (mm)} \times \text{Length B (mm)}}{\text{Head circumference (mm)}}$$

$$\text{O/E LHR} = \frac{\text{Observed LHR}}{\text{Expected LHR}}$$

Severity	O/E LHR	LHR	Liver	Survival
Extreme	<15%	<0.4	–	0%
Severe	15–24%	0.4–0.84	Up Down	30%
Moderate	25–34% 35–44%	0.85–1.3 1.35–1.75	Up Down Up	50–70%
Mild	35–44% >45%	1.35–1.75 >1.8	Down Up –	75–100%

- **Diagnosis**
  - CXR showing loops of bowel or bowel gas pattern in the chest along with mediastinal shift





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- **Treatment**

a) Immediate treatment

- Decompression of the stomach with an orogastric or nasogastric tube
- Supplemental O_2
- Early tracheal intubation
- PPV < 25 cm H_2O
- FIO_2 adjusted preductal arterial saturations > 85%
- ECMO → survival 50%

b) do <u>not</u> require immediate surgery

- Must correct pulmonary hypoplasia 5-15 days

→ until decreased PVR & maintained ventilation with low PIP (<25 cm H_2O) & FiO_2 =0.5, correction of metabolic acidosis

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Surgical intervention when optimized cardiorespiratory status ;

- Arterial pressure normal for GA & stable for specific patient for 12 - 24 hours
- Preductal SaO_2 at least 85%, preferably 90-95%, with an $FiO_2 < 0.50$
- No acidosis ; lactate < 3 mmol/L
- Urine output 1 - 2 mL/kg/hour

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- **Prognosis**
  - Survival 42% - 75% → restrictive lung dz & reactive airways
  - related to the degree of pulmonary hypoplasia & associated anomalies
  - **Factors associated with a poor prognosis** ;
    - severe pulmonary hypoplasia
    - herniation to the contralateral hemithorax
    - onset of symptoms in the first 24 hours of life
    - severe Rt-Lt shunt that requires ECMO
    - associated major developmental anomalies
    - delivery in a nontertiary center

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- **Management of Anesthesia**
  - Awake tracheal intubation following preoxygenation
  - Preductal arterial cannulation (Rt radial)

  for monitoring SBP, blood gases, pH
  - N_2O should be avoided
  - PPV < 25 - 30 cm H_2O to minimize the risk of pneumothorax
  - Hypothermia must be avoided
  - After CDH reduction, an attempt to inflate the hypoplastic lung is not recommended
  - Maintenance fluid therapy & replacement loss

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Goals of ventilation & oxygen delivery in OR

- small tidal volume
- minimal PEEP (2 - 4 cm H_2O) to avoid atelectasis & trauma from shear stress (low-volume injury)
- adequate oxygenation without hyperoxia (SpO_2 90% - 95%)
- permissive hypercapnia ($PaCO_2$ 60-65 mmHg)
- maintaining adequate pH >7.25

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- **Postoperative Management**
  - remain intubated
  - no effective treatment for pulmonary hypoplasia
  - postoperative course characterized by
    - rapid improvement
    - tension pneumothorax
    - inferior vena cava compression
    - followed by sudden deterioration with profound arterial hypoxemia, hypercapnia, acidosis

      → reappearance of fetal circulation patterns

      → death

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Preoperative

Intubation and ventilation with permissive hypercapnia
Avoid bag-and-mask ventilation
Nasogastric tube for stomach decompression
Broad-spectrum antibiotics
Sedation/anesthesia

Intraoperative

Standard monitoring
Right upper-extremity pulse oximeter (preductal sat 90 to 95)
Lower-extremity pulse oximeter
Arterial catheter Rt.RA
Central venous pressure catheter
Anesthetic agents
High-dose opioids (50 mcg/kg fentanyl)
or
Low-dose inhaled agents with moderate doses of opioids (10 to 20 mcg/kg)
Nondepolarizing muscle relaxant
Ventilation
Permissive hypercapnia; peak pressures <25 cm/H_2O. Use PEEP 2 to 4 cm/H_2O
Temperature $PaCO_2$ 60-65 mmHg
Forced-air warmer

Postoperative

Consider regional anesthesia for postoperative pain
Continue postoperative ventilation

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Esophageal atresia / Tracheoesophageal fistula

- **Incidence** of EA/TEF = 1 : 3,000-4,500 neonates
- 50% of EA associated with
  - VATER (vertebral defects, imperforate anus, tracheoesophageal fistula, cardiac, radial & renal dysplasia)
  - VACTERL (VATER + cardiac & limb anomalies)
- 20% of EA → co-existing CVS anomalies (VSD, TOF, Coarctation of the aorta, ASD)
- 30% - 40% → Preterm

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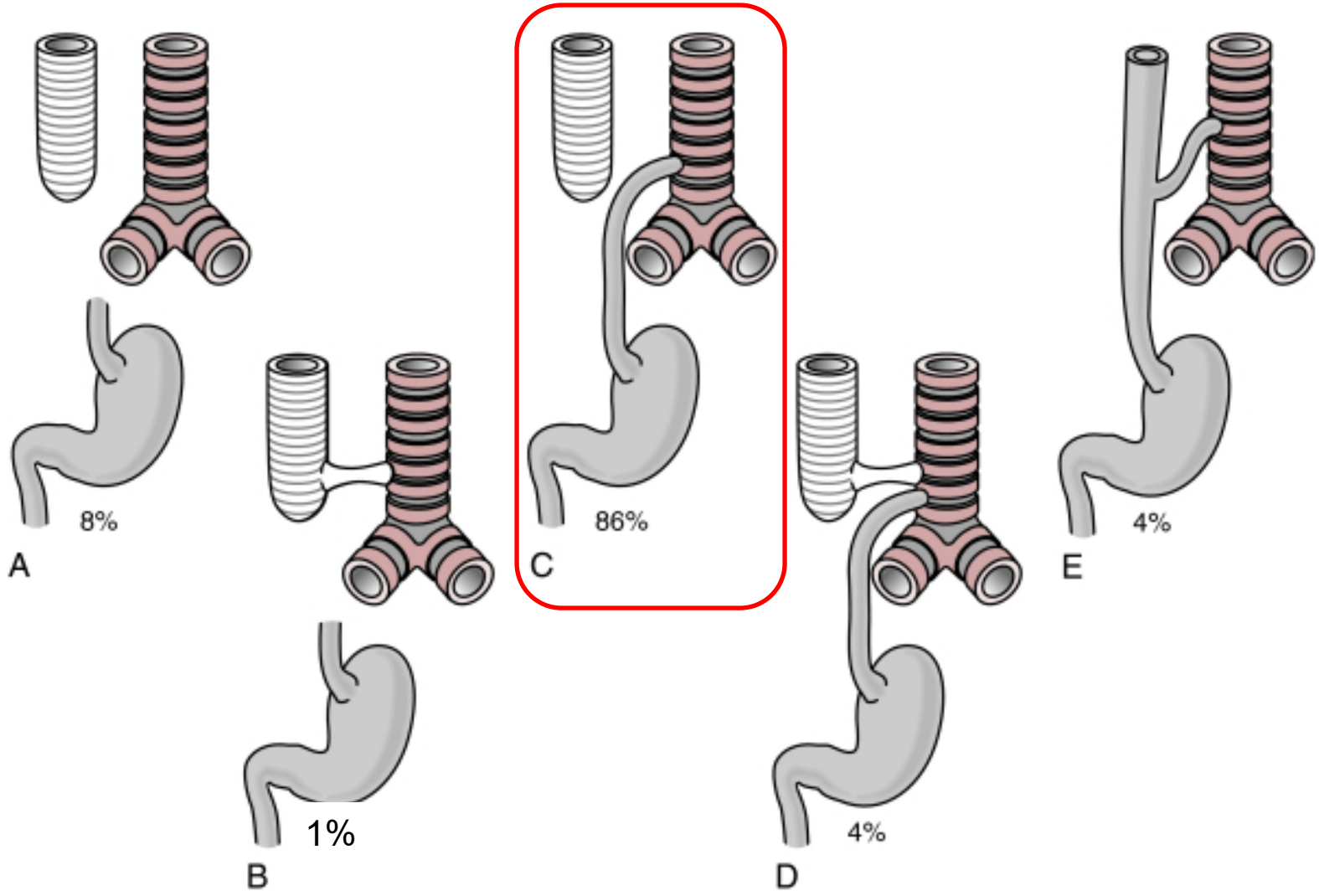
Types of EA/TEF



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- **Signs and Symptoms**
  - In TEF; - inhaled air bypass the lungs → hypoventilation & gastric distension

    - stomach contents reflux → aspiration pneumonitis
  - In EA; - proximal portion → drooling

    - distal portion → coughing, choking with feeds

- presents with respiratory distress associated with
  - Coughing
  - Cyanosis
  - Frothing at the mouth & nose
- Infants with isolated TEF in the absence of EA may elude diagnosis until later in life → recurrent pneumonias & refractory bronchospasm

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Spitz Classification → survival of TEF

Spitz group	Birth weight (Kg)	Major cardiac disease	%Survival
I	>1.5	-	96
II	<1.5	-/+	79
III	<1.5	+	38

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- **Diagnosis**
  - Prenatally; suspected EA if polyhydramnios
  - After birth;
    - oral catheter cannot passed into the stomach
    - cyanosis, coughing, choking during feedings
  - Plain radiographs of the chest & abdomen → coiling of a NG tube in the esophageal pouch
  - pure EA → airless, scaphoid abdomen

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Preoperative management : protect the lungs from aspiration pneumonia

- Avoiding feeding, IV fluid replacement
- Upright, semiprone positioning of the infant to minimize gastroesophageal reflux (Head up 30 degree)
- Intermittent suctioning of the upper pouch
- Administration of antibiotics

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- **Treatment**
  - maintain patent airway & prevent aspiration
    - Stopped feedings
    - head-up position to minimize regurgitation
    - Continuous suctioning of the proximal esophageal segment
  - avoided ET intubation
  - Type C→ Primary repair without gastrostomy
  - Delayed Sx (3-6 mths)→ Ligated fistula with inserted gastrostomy
  - Significant associated anomalies → staged surgical approach with initial gastrostomy

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- evaluation for associated anomalies; Rt-sided aortic arch (require Lt thoracotomy approach)
- Repair may be transpleural or extrapleural

- **Prognosis**
  - pathologic finding in EA is decreased tracheal cartilage→ tracheal collapse after tracheal extubation
  - Esophageal stricture → require dilatation
  - Chronic gastroesophageal reflux & dysphagia

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Management of Anesthesia

- awake intubation with spontaneous ventilation

  or fentanyl (0.2-0.5 mcg/kg)

- inhalation induction → intubated without muscle relaxants
- **RSI intravenous induction** → ventilation to minimize PIP (before Fistula ligation)
- Proper placement of ET tube is critical;

  above the carina but below the TEF

- ET tube advanced into Rt main bronchus then withdrawn until bilateral breath sounds are present (bevel facing forward)
  - avoid excessive airway pressures
  - anesthetic technique depends on physiologic status → Low-dose volatile + air/O_2/opioids

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- Intraoperative fluid losses replaced with crystalloid 6 - 8 mL/kg/hr
- Blood loss replaced with 5% albumin & blood → Hct ≥ 35%
- Avoid hypothermia
- During surgery, lung retraction may impair ventilation & surgical manipulation of the trachea → airway obstruction
- Frequent tracheal suctioning
- Excessive neck extension & reintubation → compromised new anastomosis
- tracheomalacia is common (up to 78%), clinically significant in only about 10% of patients

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Monitors

Standard monitoring

Upper- and lower-extremity pulse oximeter

Arterial access if hemodynamically unstable, congenital heart disease, or significant lung disease preoperatively

Anesthestic

Inhaled induction with sevoflurane

Establish intravenous access

Maintain spontaneous ventilation

If bronchoscopy is performed prior to surgical repair:

- Glycopyrrolate
- Topicalize vocal cords and trachea with lidocaine
- Titrate inspired anesthetic concentration
- Proporol or ketamine PRN

If fistula is 1 cm or more above carina, intubate (bevel ETT anterior) (inflate cuff if cuffed tube)

- If fistula below carina, then left mainstream intubation

Neuromuscular blockade after lung isolation

Position left lateral decubitus for right thoracotomy (no right aortic arch)

Fentanyl for analgesia

Consider regional anesthesia

Temperature: forced-air warmer

Postoperative

Postoperative ventilation, minimize neck extension

Regional anesthesia for pain

Multimodal analgesia including regional anesthesia

Abdominal wall defects

- **Omphalocele**
  - external herniation of abdominal viscera
  - abdominal contents contained within sac formed by peritoneal membrane internally & amniotic membrane externally
- **Gastroschisis**
  - hernial sac does not cover the herniated abdominal viscera
  - male preponderance

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Comparison of Gastroschisis & Omphalocele

	Gastroschisis	Omphalocele
Incidence	1: 10,000	1: 4,000–7,000
	Intact umbilical cord and evisceration of bowel through a defect in the abdominal wall right of the cord	Herniation of bowel and liver thorough umbilical wall covered by membranes unless ruptured liver and other organs
Sac	No membrane covering (sac absent)	Present
Associated Organs	No	
Associated Anomalies	Intestinal atresia 25%	Chromosomal anomalies
	Cryptorchidism 31%	Trisomy 18, 13, 15, and 21
		Beckwith-Wiedemann syndrome
		Pentalogy of Cantrell
		Prune belly syndrome
Maternal Age	< 25 yr	Older
Smoking and Alcohol Use	Yes	No
Teratogens	Acetaminophen, aspirin, pseudoephedrine use in pregnancy: Yes	No
Congenital Heart Disease	12%	24%
Prematurity	40%-67%	10%-23%

- **Diagnosis**
  - Prenatal; by fetal ultrasonography

- **Treatment**
  - Gastroschisis requires urgent repair
    - lower body & exposed intestine immediately place into a plastic bowel bag reduces → evaporative fluid and heat loss
  - Omphalocele requires urgent corrective surgery, preoperative cardiology evaluation & echocardiography
  - Staged closure is very successful & avoids increased abdominal pressure

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- Primary closure → cause
  - respiratory compromise
  - decreased venous return
  - circulatory dysfunction
  - Lower extremity congestion & cyanosis
- Primary closure is not recommended if
  - inspiratory pressures > 25 - 30 cm.H_2O
  - Intravesical/Intragastric pressures > 20 cm.H_2O

- **Prognosis**
  - survival rate for gastroschisis ≥ 90%
  - survival rates for omphalocele 70% - 95%

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- **Preoperative Management**
  - prevention of infections
  - minimization of fluid & heat loss
    - Covering exposed viscera with moist dressings & plastic bowel bag & maintaining neutral thermal environment
  - decompressed stomach with orogastric tube
  - Fluid;
    - Volume 2-4 times of daily maintenance requirement (≥8–16 mL/kg/hour)
    - 5% albumin = 25% of replacement fluids
  - Hypovolemia is indicated by hemoconcentration & metabolic acidosis

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- **Management of Anesthesia**
  - preservation of body temperature & continuation of fluid replacement
  - decompression of the stomach and preoxygenation
  - N_2O is avoided
  - Monitoring airway pressure
  - Direct monitoring of ABG & pH is helpful for guiding fluid therapy
  - Need mechanical ventilation for 24-48 hours

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Preoperative

Adequate hydration
Maintenance of temperature, prevention of heat loss
Evaluation for congenital heart disease and other associated abnormalities
Broad-spectrum antibiotics
Measure electrolytes

Intraoperative

Rapid-sequence induction
Avoid mask ventilation and abdominal distension
Muscle relaxation (nondepolarizing muscle relaxants)
Inhalational agents as hemodynamically tolerable
Opioids for analgesic
Consider regional anesthesia for intraoperative and postoperative care.
Monitors: standard monitors, arterial catheter if hemodynamically unstable
Consider central venous catheter for both intraoperative monitoring and post-operative nutrition
Monitor inspiratory pressures during defect closing
Right upper-extremity pulse oximeter (preductal)
Pulse oximetry on lower extremity. Used for postductal saturation and perfusion of lower extremity during abdominal closure.
Prevent hypothermia; forced air warmer

Postoperative

Mechanical ventilation unless defect small
Regional anesthesia encouraged unless prolonged intubation expected

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Pyloric stenosis

- **Incidence** 1 in every 300 live births
- Males > Female 4 times

- **Signs and Symptoms**
  - nonbilious projectile vomiting at 2 - 5 weeks of age
  - symptoms may develop - 1st week to 5th month of life
  - vomiting occurs within 30 to 60 mins after feeding
  - hypokalemic, hypochloremic primary metabolic alkalosis with a secondary respiratory acidosis
  - Hypovolemia, Hypokalemia, Hypocalcemia
  - Compensatory respiratory acidosis → resulting from hypoventilation & periodic apnea

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- **Diagnosis**
  - olive-like mass → palpated in the epigastrium
  - upper GI contrast studies (barium swallow)
  - Ultrasonography sensitivity 95% & specificity 100%
- **Treatment**
  - Pyloromyotomy → definitive treatment
  - not a surgical emergency
  - Fluid resuscitation guided by serum electrolyte →
    - serum chloride > 100 mEq/dL
    - serum bicarbonate < 28 mEq/dL
  - Metabolic alkalosis must be corrected prior to surgery to prevent postoperative apnea

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- **Prognosis**
  - Surgical treatment is curative
  - Feedings within 4 - 6 hrs following surgery

- **Management of Anesthesia**
  - full stomach → risk of aspiration; upper GI contrast studies
  - Prevent by
    - premedication with atropine
    - large-bore orogastric catheter

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- **Postoperative Management**
  - Postoperative depression of ventilation by
    - CSF alkalosis
    - intraoperative hyperventilation
  - Apnea monitoring for the first 12 hours after surgery
  - hypoglycemia may occur 2 - 3 hrs after surgery due to inadequate liver glycogen stores & cessation of intravenous dextrose infusions

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General Anesthesia Guidelines for Pyloric Stenosis

Premedication: not generally indicated
Monitors: standard anesthesia monitoring, gastric decompression
Anesthetic induction: intravenous rapid sequence
Propofol 2 mg/kg and rocuronium 0.5 mg/kg
or
Atropine 20 mcg/kg, propofol 2 mg/kg, and succinylcholine 2 mg/kg
or
Atropine 20 mcg/kg, propofol 3 mg/kg, and remifentanil 1 to 2 mcg/kg
Airway: endotracheal tube
Anesthetic maintenance: air/oxygen/sevoflurane or isoflurane
Anesthetic adjuncts: ondansetron
Intraoperative and postoperative pain management:
- Acetaminophen: intravenous 15 mg/kg or rectal 30 to 40 mg/kg initial dose
- Wound infiltration with local anesthetic agent

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Hirschsprung's disease

(congenital aganglionic megacolon)

- **Incidence** 1 in 5000 live births
- male predominance
- characterized by → absence of parasympathetic ganglion cells in the large bowel
  - aganglionosis extends proximally from anus usually limited to rectum & sigmoid colon

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- **Signs and Symptoms**
  - Constipation → dilatation of the proximal bowel & abdominal distention
  - enterocolitis with associated signs of bowel obstruction
  - explosive diarrhea following a rectal examination

- **Diagnosis**
  - suspected in any full-term neonate with delayed passage of stool
  - classic radiographic finding → presence of transition zone between normal dilated proximal colon & narrow, spastic distal colon segment
  - Rectal biopsy is the diagnostic gold standard → absence of ganglion cells and the presence of hypertrophied nerve bundles that stain positively for acetylcholinesterase

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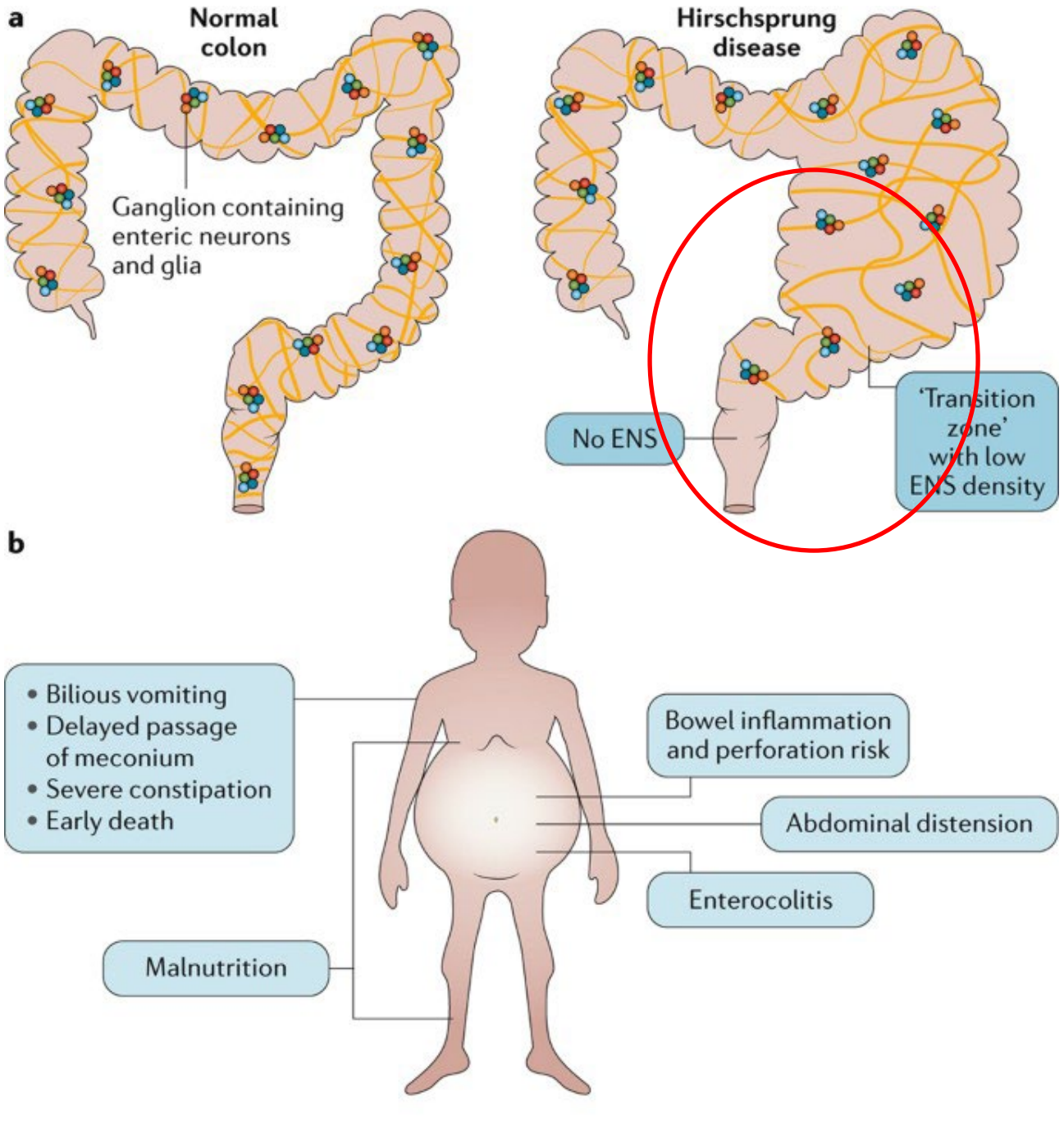
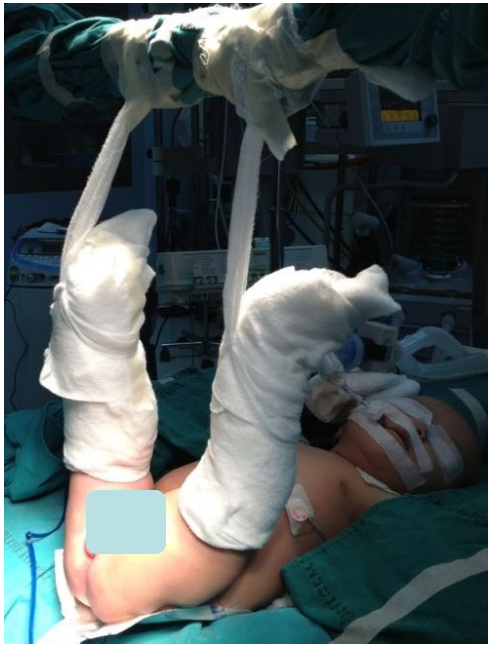

a
Normal colon
Ganglion containing enteric neurons and glia
Hirschsprung disease
No ENS
'Transition zone' with low ENS density
b
• Bilious vomiting
• Delayed passage of meconium
• Severe constipation
• Early death
Malnutrition
Bowel inflammation and perforation risk
Abdominal distension
Enterocolitis

- **Treatment**
  - Surgical treatment aimed at bringing ganglionated bowel down to the anus
  - primary endorectal **pull-through procedure**
  - decompressive colostomy is indicated in infants presenting with severe enterocolitis



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- **Prognosis**
  - require reoperation in
    - retained or acquired aganglionosis
    - severe strictures
    - dysfunctional bowel
    - intestinal neuronal dysplasia

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- **Management of Anesthesia**
  - IV catheters should be placed in upper extremities
  - Epidural anesthesia provides excellent intraoperative & postoperative analgesia
  - Extubation at the end of surgery

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Post-tonsillectomy hemorrhage

2 Indications for tonsillectomy in children:

- Sleep disordered breathing (SDB)
- Infection; recurrent tonsillitis, chronic tonsillitis, peritonsillar abscess (Paradise Criteria)

- Obstructive sleep apnea syndrome (OSAS)

AHI	Severity
1-4	Mild
5-10	Moderate
>10	Severe

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Post-tonsillectomy hemorrhage occurs 3.5% , can be a surgical emergency

- Primary bleeding occurs within 24 hours
- Secondary bleeding POD 5-7

Risk factors

- age; > 12 yrs. = Primary (1.5 เท่า), Secondary (3.3 เท่า)
- male sex
- history of recurrent tonsillitis/peritonsillar abscess
- coagulopathies

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Preoperative assessment

- Alert and Airway maintaining?
- Active bleeding?, Aspiration risk
- Adequately resuscitated?, Anemia

Preparation

- Blood transfusion tubing along with a fluid warmer
- Double suction set up with Yankauer suction tips
- Multiple sizes of stylet cuffed endotracheal tubes
- Backup laryngoscope blades/handles
- Emergency airway equipment (McGrath videolaryngoscope, GlideScope, fiberoptic intubation equipment)
- Resuscitation medications
- Tracheostomy set
- Avoid hypothermia

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Intraoperative

- Adequate preoxygenation
- Rapid sequence induction with cricoid pressure (Sellick maneuver)
- Suction catheter → directed into the midline of the oropharynx, avoiding the tonsillar fossae
- Gastric contents should be suctioned
- Caution with IV narcotics
- IV acetaminophen (12.5 mg/kg)
- Antiemetics; ondansetron (0.15 mg/kg), dexamethasone (0.15 mg/kg)
- Awake extubation

Yao, Anesthesiology, 9th ed., 2021.

PACU Discharge Criteria for the Pediatric (< 13 Years of Age)

Infant <1 Year

Optimal Pain Relief Achieved	□ YES	□ NO	
1. BP within Pre-op Value/Age-specific range	□ YES	□ NO	
2. HR 120-160	□ YES	□ NO	
A. Unchanged from Pre-op Rhythm?	□ YES	□ NO	□ N/A
3. LOC: Awake or at Pre-op Baseline	□ YES	□ NO	
4. Temp 36-38 Centigrade	□ YES	□ NO	
5. Respiratory Rate 30-60	□ YES	□ NO	
A. O2 Sat ≥ 94% or at Pre-op Baseline (if < 94%)	□ YES	□ NO	
6. Dressing Dry	□ YES	□ NO	□ N/A
7. Urinary Output Adequate for Size	□ YES	□ NO	□ N/A

Age 1 to 5 Year

Optimal Pain Relief Achieved	□ YES	□ NO	
1. BP within Pre-op Value/Age-specific range	□ YES	□ NO	
2. HR 80-150	□ YES	□ NO	
A. Unchanged from Pre-op Rhythm?	□ YES	□ NO	□ N/A
3. LOC: Awake or at Pre-op Baseline	□ YES	□ NO	
4. Temp 36-38 Centigrade	□ YES	□ NO	
5. Respiratory Rate 20-30	□ YES	□ NO	
A. O2 Sat ≥ 94% or at Pre-op Baseline (if < 94%)	□ YES	□ NO	
6. Dressing Dry	□ YES	□ NO	□ N/A
7. Urinary Output Adequate for Size	□ YES	□ NO	□ N/A

Yao, Anesthesiology, 9th ed., 2021.

PACU Discharge Criteria for the Pediatric (< 13 Years of Age)

Age 6 to 12 Year

Optimal Pain Relief Achieved	□ YES	□ NO	
1. BP within Pre-op Value/Age-specific range	□ YES	□ NO	
2. HR 60-130	□ YES	□ NO	
A. Unchanged from Pre-op Rhythm?	□ YES	□ NO	□ N/A
3. LOC: Awake or at Pre-op Baseline	□ YES	□ NO	
4. Temp 36-38 Centigrade	□ YES	□ NO	
5. Respiratory Rate 12-20	□ YES	□ NO	
A. O2 Sat $\geq$ 94% or at Pre-op Baseline (if $\leq$ 94%)	□ YES	□ NO	
6. Dressing Dry	□ YES	□ NO	□ N/A
7. Urinary Output Adequate for Size	□ YES	□ NO	□ N/A

Yao, Anesthesiology, 9th ed., 2021.

Postoperative

- Transfer with left or right lateral position
- Supplemental oxygen
- Emergency airway equipment
- Emergency medications
- Monitoring equipment

Postoperative complications

- fever
- intravascular volume depletion
- airway edema
- coagulopathy
- Anemia
- electrolyte disturbances
- rebleed

Yao, Anesthesiology, 9th ed., 2021.

Perioperative management for OSA

- moderate - severe OSA not be appropriate for outpatient surgery if the surgery involves the airway or Age ≤ 3 yrs.
- severe OSA who use CPAP or BiPAP → available in recovery & ward
- ⬇ Opioids analgesia
- ⬆ Nonopioid analgesia ; regional anesthesia

Smith's Anesthesia for Infants and Children, 9th ed., 2017.

Cleft lip & cleft palate

- cleft lip with or without a cleft palate is more common in boys
- isolated cleft palate is more common in girls

prevalence of

- a cleft lip with or without a cleft palate is 9.92 per 10,000
- a cleft lip is 3.28 per 10,000
- cleft lip and palate is 6.64 per 10,000

Yao, Anesthesiology, 9th ed., 2021.

Functional goals of cleft palate surgery are

- Normal speech
- Hearing
- Maxillofacial growth

early cleft palate repair (before 24 months of age) & delayed closure (after 4 years)

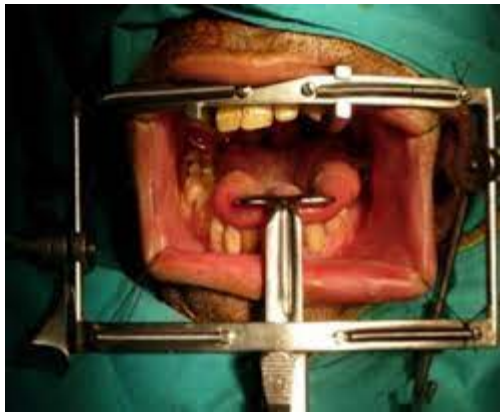
Most common

- repair a cleft lip when the baby is 6 - 10 weeks old
- repair a cleft palate at 6 - 12 months of age

Yao, Anesthesiology, 9th ed., 2021.

Intraoperative

- Standard monitoring
- Inhalation or IV induction
- ETT should exit the mouth in the midline without facial distortion
- pharyngeal pack of moistened ribbon gauze before “Dingman gag”



Complications

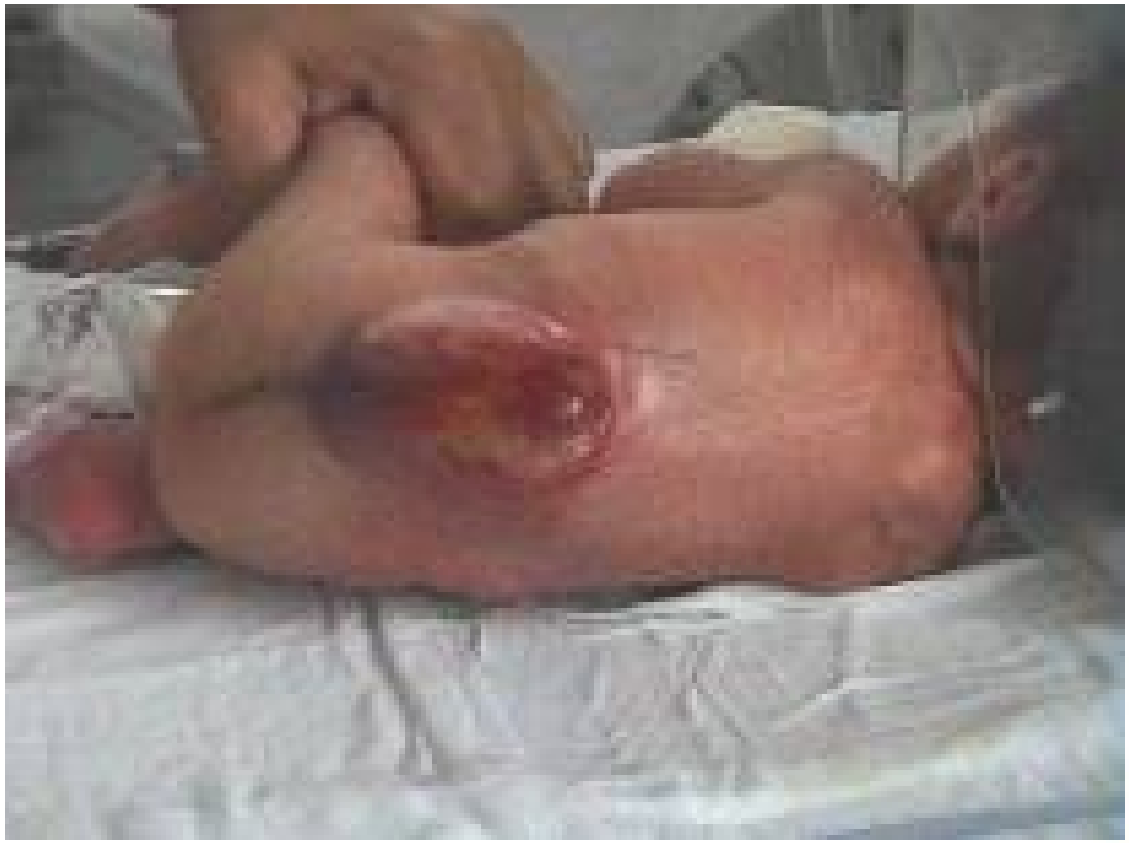
- Airway obstruction
- Bleeding
- Neurosensory disturbance
- Hypothermia

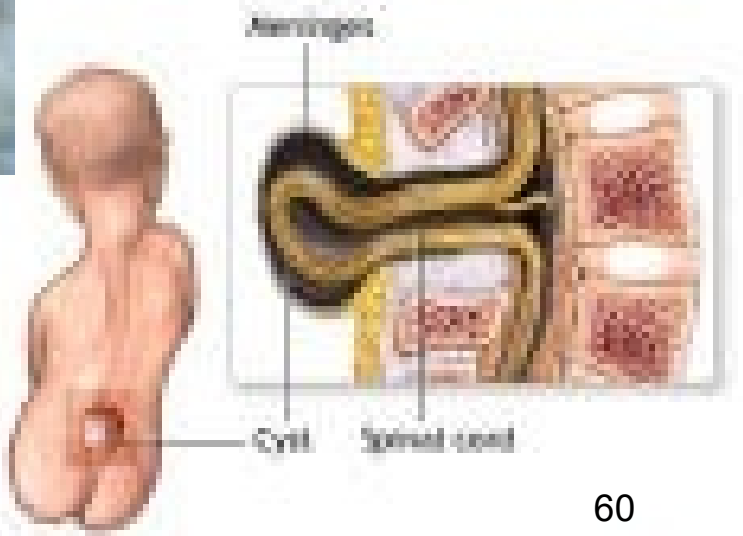
Yao, Anesthesiology, 9th ed., 2021.

Myelomeningocele

Problems

- Associated with Hydrocephalus
- Fluid & Blood loss from defect
- Cranial nerve palsy → inspiratory stridor
- Potential Brainstem herniation
- Latex allergy precaution




Cyst

Lobar emphysema

- rare cause of respiratory distress
- Pathologic causes
  - collapse of bronchi due to hypoplasia of supporting cartilage
  - bronchial stenosis
  - mucous plugs
  - obstructing cysts
  - vascular compression of bronchi
- most frequent site of involvement
  - left upper lobe (40%–50%)
  - right middle lobe (30%–40%)
  - right upper lobe (20%)
- Acquired lobar emphysema result from barotrauma associated with the treatment of bronchopulmonary dysplasia.
- increased incidence of CHD; VSD, PDA

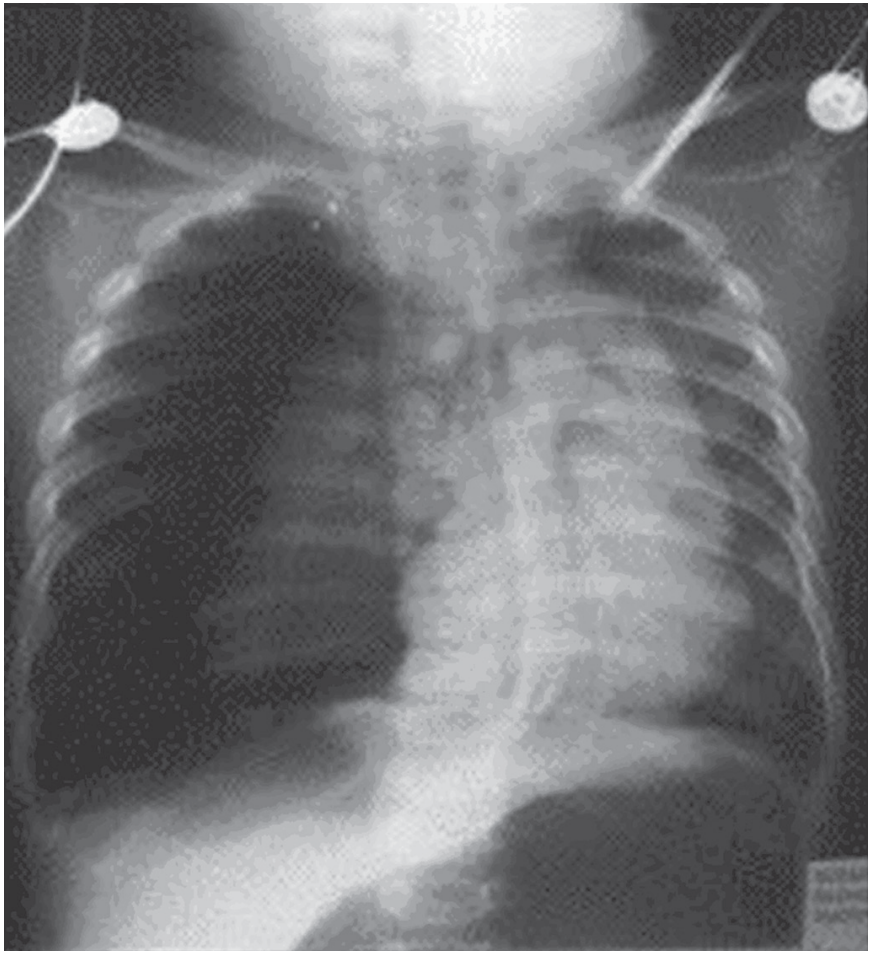
Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

- **Signs and Symptoms**
  - appear in neonatal period;
    - at birth 25%
    - 1 month of age 50%
  - mild tachypnea
  - wheezing
  - severe dyspnea
  - Cyanosis

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

Diagnosis

chest radiography, CT, ventilation/perfusion scan → radiolucent lobe & mediastinal shift



Smith's, Anesthesia for Infant and Children, 9th ed.,2017.

- **Treatment**
  - Resection of the diseased lobe → treatment of choice for symptomatic, progressive lobar emphysema

- **Management of Anesthesia**
  - greatest risk during induction as PPV before chest is opened may cause abrupt, exaggerated expansion of emphysematous lobes (gas enters but cannot leave due to a ball-valve effect)→ sudden mediastinal shift & cardiac arrest
  - tracheal intubation without muscle relaxants & maintenance of spontaneous breathing with minimal positive airway pressures
  - Nitrous oxide should not be used
  - Severely decompensated → require emergency needle aspiration or thoracotomy

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

Necrotizing enterocolitis ± bowel perforation

- **Incidence** & case fatality rates inversely related to GA & birth weight
  - greatest risk → GA < 32 wks, weight < 1500 g
- most frequently in terminal ileum & proximal colon
- most common neonatal surgical emergency
- Etiology of NEC
  - Perinatal asphyxia -- patent ductus arteriosus
  - systemic infections -- cyanotic CHD
  - umbilical artery catheterization -- Hypotension
  - RDS -- aggressive hyperosmolar formula feedings
  - exchange blood transfusions

Smith's, Anesthesia for Infant and Children, 9th ed.,2017.

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

- **Signs and Symptoms**
  - Early clinical findings; recurrent apnea, lethargy, temperature instability, glucose instability, shock
  - Specific signs of NEC ;
    - abdominal distention
    - high gastric residuals after feeding
    - bloody or mucoid diarrhea
  - Metabolic acidosis due to generalized peritonitis & hypovolemia
  - Neutropenia & thrombocytopenia

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

- **Diagnosis**
  - plain abdominal radiographic findings → Pneumatosis intestinalis (air in intestinal wall)
  - Pneumoperitoneum indicates intestinal perforation

- **Prognosis**
  - Medical management fails in approximately 20%
  - 25% of pneumatosis intestinalis may die
  - extensive intestinal resection → short-bowel syndrome
  - complications related to central venous catheters for total parenteral alimentation, cholestatic jaundice

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

Indications for Abdominal Surgery in NEC

Absolute Indications

Pneumoperitoneum

Intestinal gangrene (positive results of paracentesis)

Relative Indications

Clinical deterioration

Metabolic acidosis

Ventilatory failure

Oliguria, hypovolemia

Thrombocytopenia

Leukopenia, leukocytosis

Portal vein gas

Erythema of abdominal wall

Fixed abdominal mass

Persistently dilated loop

Nonindications

Severe gastrointestinal hemorrhage

Abdominal tenderness

Intestinal obstruction

Gasless abdomen with ascites

Smith's, Anesthesia for Infant and Children, 9th ed.,2017.

- **Treatment**
  - Medical treatment;
    - cessation of feeding
    - gastric decompression
    - intravenous fluids
    - Antibiotics
    - Mechanical ventilation
    - Hypotension → treated with crystalloid & blood product, Dopamine
  - Surgery;
    - reserved for medical management fails ~ 50%
    - bowel perforation
    - sepsis (peritonitis)
    - progressive metabolic acidosis

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

- peritoneal drainage procedures in interventional radiology

Robert S. Holzman, A Practical Approach to Pediatric Anesthesia, Chapter 17,1st Ed. 2008.

- **Management of Anesthesia**
  - fluid resuscitation with crystalloid & colloid before induction
  - Blood & platelet transfusions
  - rapid fluid administration to preterm neonates → intracranial hemorrhage or reopening of PDA
  - Need mechanical ventilation prior to surgery
  - full stomach precautions
  - maintain normothermia
  - Postoperative mechanical ventilation

Roberta L. Hines, Stoelting's Anesthesia and Co-Existing Disease, Chapter 24:Pediatric Diseases, 5th ed.2008.

Preoperative

Optimize hemodynamic and coagulation status
Check blood product availability
Check placement of endotracheal tube and catheters
Know acceptable hemodynamic parameters (BP, PSO_2, FiO_2)
Adequate venous access

Intraoperative

Standard monitoring and arterial catheter
Maintain hemodynamic stability
Consider vasoactive support (dopamine or epinephrine gtt)
Opioids or low-dose inhaled anesthetic agent with neuromuscular paralysis
Check glucose levels and electrolytes
Fluid resuscitation: fresh-frozen plasma, cryoprecipitate, and pooled red blood cells
Careful attention to temperature homeostasis – Forced air warmer

Postoperative

Mechanical ventilation
Sedation and analgesia

Smith's, Anesthesia for Infant and Children, 9th ed.,2017.

Bowel obstruction

- procedure to relieve the obstruction;
  - pyloromotomy for pyloric stenosis
  - bowel resection for atresias, stenoses, or webs

Robert S. Holzman, A Practical Approach to Pediatric Anesthesia, Chapter 17,1st Ed. 2008.

Gastrointestinal obstruction

1. Mechanical causes

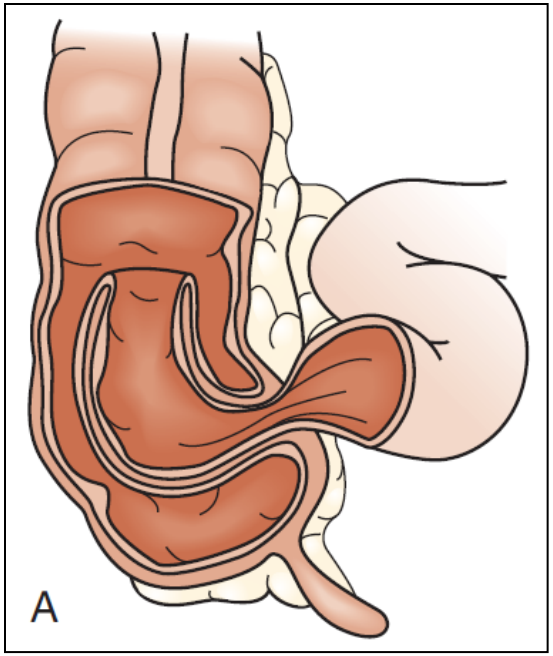
a) Congenital

- Intrinsic ;
  - Atresia, stenosis, webs
  - Meconium ileus
  - Duplications
  - Imperforate anus
- Extrinsic ;
  - Peritoneal bands
  - Midgut volvulus with malrotation
  - Volvulus around omphalomesenteric remnant
  - Annular pancreas
  - Mesenteric cysts/other tumors
  - Incarcerated hernias
  - Preduodenal portal vein

Robert S. Holzman, A Practical Approach to Pediatric Anesthesia, Chapter 17,1st Ed. 2008.

b) Acquired ;

- Necrotizing enterocolitis
- Adhesions secondary to prenatal perforation
- Mesenteric thrombosis
- Intussusception



2. Functional causes

– Hirschsprung disease

– Ileus ;
Peritonitis
Gastric/cecal perforation
Necrotizing enterocolitis

– Segmental colonic dilatation

Robert S. Holzman, A Practical Approach to Pediatric Anesthesia, Chapter 17,1st Ed. 2008.

Recommended General Anesthesia Guidelines for Intussusception

Premedication: as clinically indicated
Monitors: standard anesthesia monitoring
Vascular access: 1–2 large-bore catheters, arterial and central venous catheters if hemodynamically unstable
Anesthetic induction: intravenous propofol 2 mg/kg (if unstable ketamine 1 to 2 mg/kg) and rocuronium 1 mg/kg
Airway: endotracheal tube
Anesthetic maintenance: air/oxygen/sevoflurane or isoflurane. Avoid nitrous oxide
Anesthetic adjuncts: ondansetron
Intraoperative and postoperative pain management:
- Acetaminophen: intravenous 15 mg/kg
- Opioids: morphine 0.05 to 0.1 mg/kg or fentanyl 1 to 2 mcg/kg
- Dexmedetomidine 0.5 to 1 mcg/kg upon emergence
- Regional anesthesia depending on the surgical approach and clinical condition (tap block, rectus sheath block, epidural block, paravertebral block)

Smith's, Anesthesia for Infant and Children, 9th ed.,2017.

References

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