A Practical Algorithm-Based Guide

for Early Decision-Making in Pediatric Surgery

Yinna Urquiza, MD
Nubia Ruiz, MD
Pediatric Cardiovascular Surgeon

Pediatric Surgery in Algorithms

A Practical Guide for Early Clinical Decision-Making

Authors Information

MD. Yinna Leonor Urquiza Suárez
Médico General Universidad Autónoma de Bucaramanga

MD. Nubia Dakeisa Ruiz Nieto
Cirujano Cardiovascular Pediatra Universidad Autónoma de México

Table of Contents

Preface

Pediatric surgery requires timely recognition, thoughtful clinical judgment, and decisive management. For students, general physicians, and early surgical trainees, however, the first steps in evaluating pediatric surgical conditions can often feel overwhelming. The complexity of clinical presentations, combined with the urgency that often accompanies pediatric surgical disease, demands a structured, practical approach to decision-making.

This book was developed to simplify that process. Rather than serving as a traditional comprehensive textbook, it is designed as a practical, algorithm-based guide that provides clear visual frameworks to assist clinicians in the early recognition and management of common pediatric surgical conditions.

The concept for this book emerged from my own journey in medicine. As a medical student, I often found the most helpful learning tools were those that transformed complex clinical reasoning into simple, structured pathways. Later, during my training and clinical experience in pediatric surgery, I saw how essential rapid

decision-making is when caring for children with surgical conditions. In many situations, having a clear mental algorithm can make the difference between uncertainty and confident clinical action.

The algorithms presented in this guide aim to provide exactly that: structured decision pathways that help clinicians navigate common pediatric surgical scenarios. Each chapter combines concise clinical explanations with visual algorithms designed to facilitate understanding, recall, and practical application.

This book is intended for medical students, general physicians, and surgical trainees who seek a practical tool for approaching pediatric surgical problems with clarity and confidence. We hope that these algorithms will serve not only as a study resource but also as a quick reference to support clinical reasoning and ultimately improve care for pediatric patients.

How to Use This Book

Pediatric surgical emergencies often require rapid recognition and timely decision-making. However, for students, general physicians, and surgical trainees, navigating the initial evaluation and management of these conditions can be challenging.

This book was designed as a practical, algorithm-based guide to support early clinical decision-making in pediatric surgery. Rather than providing extensive theoretical discussions, it focuses on clear visual frameworks that simplify complex diagnostic and management pathways.

Each chapter follows a consistent structure:

Algorithm

A visual flowchart guiding the initial evaluation and management of the condition.

Clinical Overview

A concise summary of the key clinical features and pathophysiology.

Diagnostic and Management Approach

A brief explanation of the recommended diagnostic steps and treatment strategies.

Clinical Pearls

Key points intended to reinforce essential concepts and facilitate quick clinical recall.

The goal of this book is not to replace comprehensive surgical textbooks but to provide a concise decision-making tool to assist learners and clinicians in recognizing and managing common pediatric surgical conditions.

By integrating structured algorithms with concise clinical insights, this guide aims to support efficient clinical reasoning and improved patient care.

List of Abbreviations

- **ABCDE:** Airway, Breathing, Circulation, Disability, Exposure (Initial Assessment)
- **AHT:** Abusive Head Trauma
- **ARM:** Anorectal Malformation
- **ASD / VSD:** Atrial Septal Defect / Ventricular Septal Defect
- **CDH:** Congenital Diaphragmatic Hernia
- **CML:** Classic Metaphyseal Lesion (in NAT)
- **EA / TEF:** Esophageal Atresia / Tracheoesophageal Fistula
- **FAST:** Focused Assessment with Sonography for Trauma
- **HPS:** Hypertrophic Pyloric Stenosis
- **IBD:** Inflammatory Bowel Disease
- **LNBW / VLBW:** Low Birth Weight / Very Low Birth Weight
- **NAT:** Non-Accidental Trauma

- **NEC:** Necrotizing Enterocolitis
- **NOM:** Non-Operative Management
- **NPO:** Nil Per Os (Nothing by mouth)
- **OG / NG Tube:** Orogastric / Nasogastric Tube
- **PAS:** Pediatric Appendicitis Score
- **RUQ / LUQ:** Right Upper Quadrant / Left Upper Quadrant
- **SBO:** Small Bowel Obstruction
- **SMA:** Superior Mesenteric Artery
- **TBSA:** Total Body Surface Area (in Burns)
- **UAST:** Upper Airway / Soft Tissue

General Principles

Initial Surgical Assessment

Clinical Core: The pediatric surgical evaluation begins with a rapid, systematic approach to identify life-threatening conditions. Unlike adults, children have a high physiological reserve but can decompensate quickly once their limits are reached.

- **The Pediatric Assessment Triangle (PAT):** Appearance, Work of Breathing, and Circulation to Skin. This 30-second visual assessment determines the urgency of care.
- **History:** Focus on the "Onset-Duration-Progression" of symptoms. In surgery, the timing of the first emesis or the migration of pain is diagnostic.

Neonatal Stabilization

- **Clinical Core:** "A neonate is not just a small infant." Their thermoregulation and glucose metabolism are fragile.
- **Thermoregulation:** Use radiant warmers. Hypothermia leads to metabolic acidosis and increased oxygen consumption.

- **Glucose Management:** Monitor for hypoglycemia (target >45-50 mg/dL). Infants have limited glycogen stores.
- **Fluid Resuscitation:** Initial bolus of **10-20 mL/kg** of Isotonic Crystalloid (Normal Saline or Ringer's Lactate).
- **Decompression:** Immediate placement of a **Replogle or Sump tube** (10-12 Fr) for any suspected bowel obstruction or CDH.

Pain Management in Children

Clinical Core: Inadequate pain control increases the stress response and delays recovery.

- **Assessment:** Use age-appropriate scales (FLACC for infants/non-verbal, Wong-Baker FACES for children >3 years).
- **Multimodal Analgesia: * Step 1:** Non-opioids (Acetaminophen/Paracetamol 15mg/kg and NSAIDs like Ibuprofen 10mg/kg).
- **Step 2:** Regional anesthesia (Caudal blocks or local infiltration).
- **Step 3:** Opioids (reserved for severe trauma or post-op, carefully titrated to avoid respiratory depression)

Antibiotic Therapy

(Prophylaxis vs. Treatment)

Clinical Core: Antibiotics should be targeted and timely.

- **Surgical Prophylaxis:** Administer within **60 minutes before** skin incision. Usually, a 1st- or 2nd-generation cephalosporin (Cefazolin).
- **Therapeutic (Infection/Perforation): * Appendicitis/ NEC:** Broad-spectrum coverage for Gram-negatives and Anaerobes (e.g., Piperacillin/Tazobactam or Ampicillin + Gentamicin + Metronidazole).
- **Duration:** Prophylaxis should usually be discontinued within 24 hours post-operatively.

Referral and Transfer Criteria

Clinical Core: Knowing when and how to refer is a critical surgical skill.

Stabilize before Transport: Ensure the airway is secure, IV access is established, and the stomach is decompressed (NPO/OG tube).

• **Referral Criteria:**

1. Hemodynamic instability despite resuscitation.
2. Suspected Midgut Volvulus or Necrotizing Enterocolitis.

3. Specialized care needed (ECMO for CDH, Pediatric ICU).

• **Communication:** Always provide the receiving surgeon with the "Triple Report": Clinical status, Imaging results, and Fluids/Meds administered.

Fluid Management in Pediatric Surgery

Clinical Core: Dehydration and electrolyte imbalances can be life-threatening in surgical neonates and children. Precise fluid calculation is mandatory to avoid fluid overload or inadequate perfusion.

A. Maintenance Fluids (The 4-2-1 Rule / Holliday-Segar Method)

Used for children who are NPO (Nothing by Mouth) but hemodynamically stable.

- **0–10 kg:** 4 mL/kg/hour
- **10–20 kg:** 40 mL + 2 mL/kg for every kg above 10.
- **>20 kg:** 60 mL + 1 mL/kg for every kg above 20.

- **Example:** A 25 kg child requires 65 mL/hour (40 + 20 + 5).

B. Fluid Resuscitation (The "Bolus")

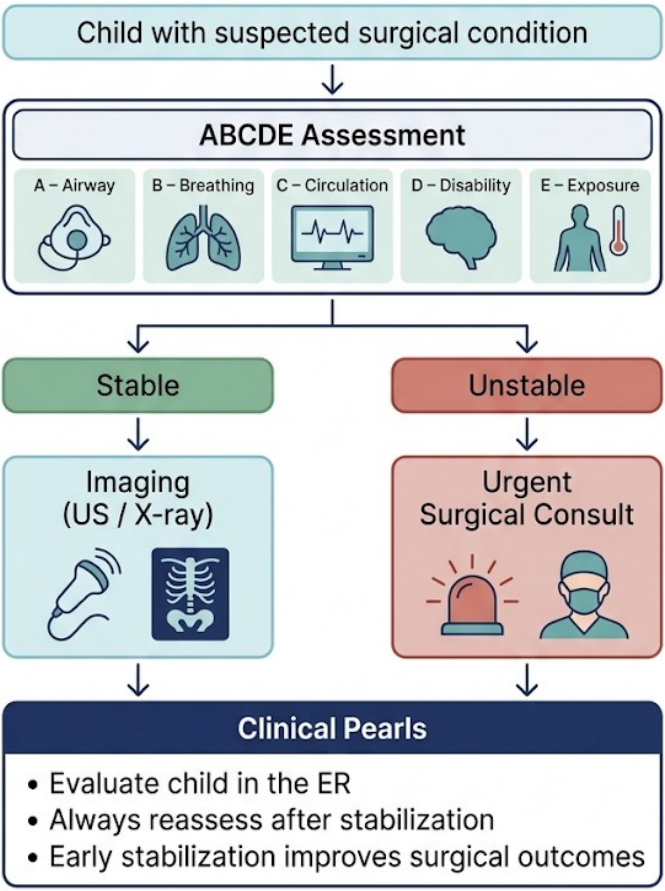
Used for patients in shock, severely dehydrated, or with ongoing surgical losses.

- **Isotonic Crystalloid:** Normal Saline (NS 0.9%) or Ringer's Lactate (LR).
- **Standard Dose: 20 mL/kg** over 10–20 minutes.
- **Neonatal/Cardiac Dose: 10 mL/kg** (to avoid volume overload).
- **Goal:** Restore peripheral pulses, improve mental status, and achieve adequate urine output.

C. Targeted Urine Output (The Best Monitor of Perfusion)

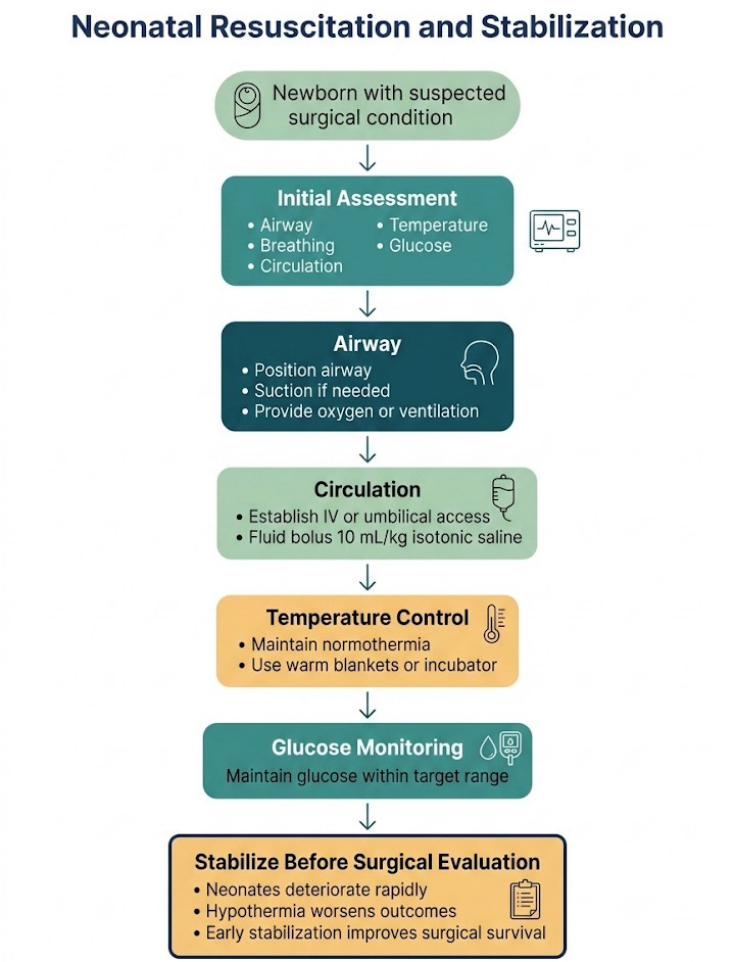
- **Neonates/Infants:** 2 mL/kg/hour
- **Children:** 1 mL/kg/hour
- **Adolescents:** 0.5 mL/kg/hour

Initial Surgical Assessment

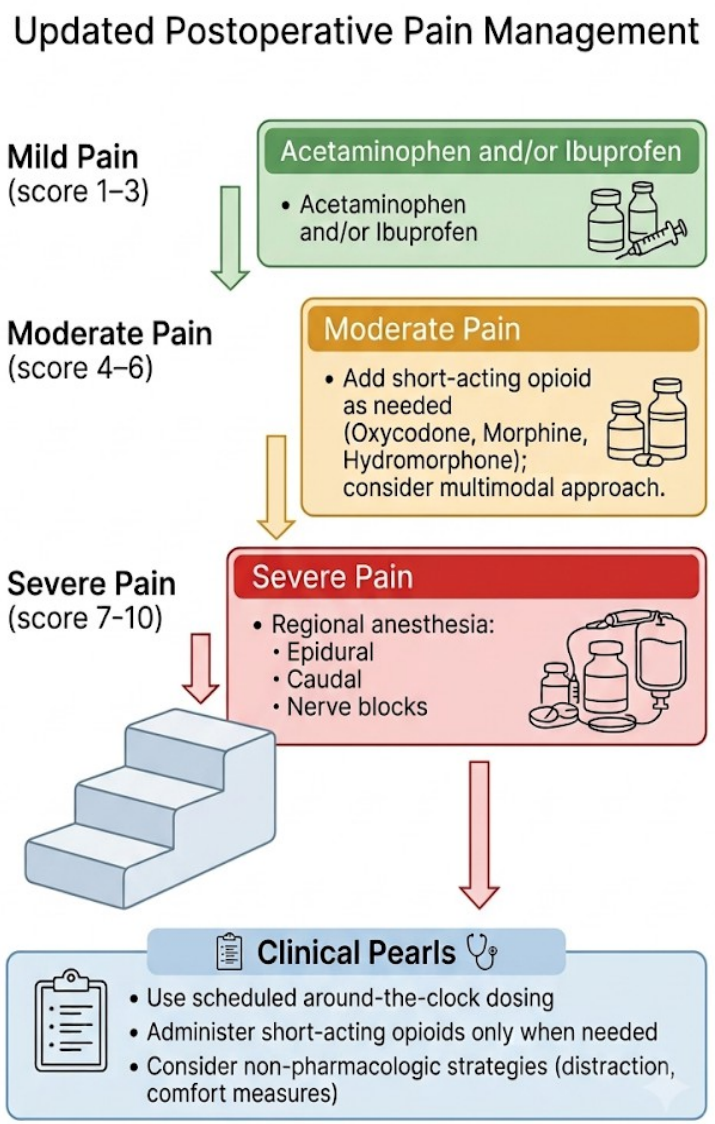


Neonatal Surgical Conditions

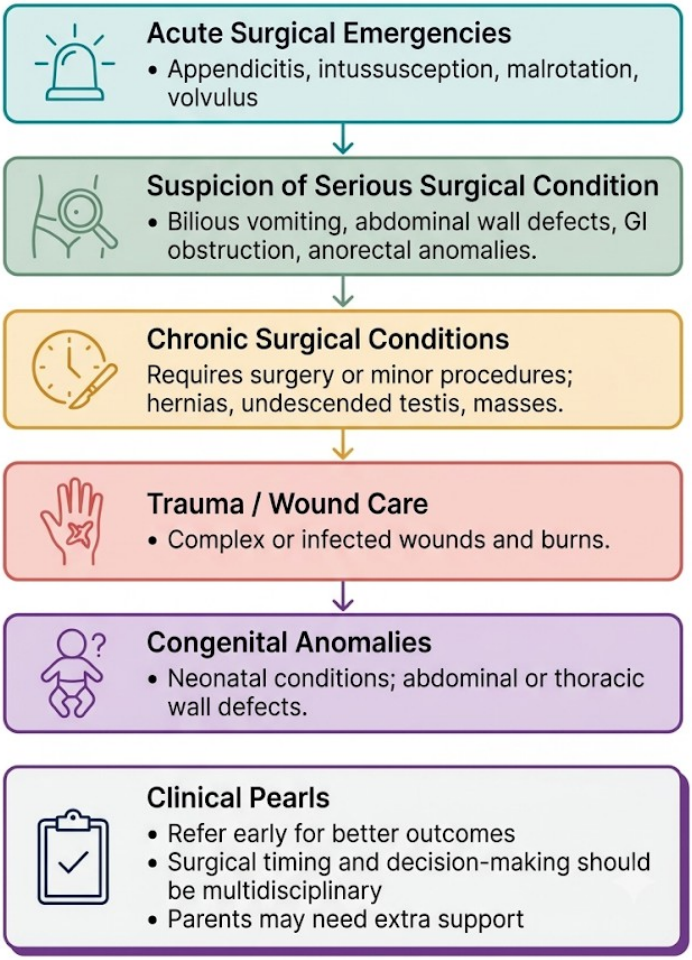
Algorithm: Neonatal Resuscitation and Stabilization



Pain Management in Children



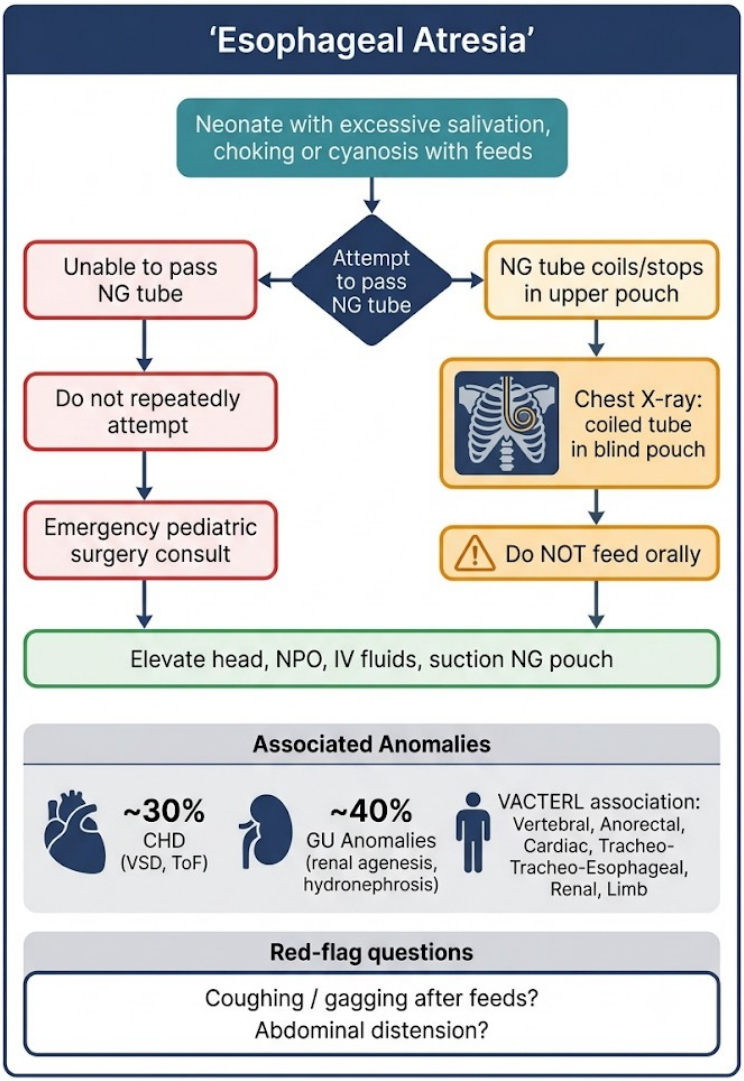
Referral Criteria to Pediatric Surgery



Empiric Antibiotics in Pediatric Surgical Conditions

Condition	Initial Antibiotic Therapy
Acute Appendicitis	Ceftriaxone + Metronidazole
Necrotizing Enterocolitis (NEC)	Ampicillin + Gentamicin ± Metronidazole
Necrotizing Fasciitis	Piperacillin-Tazobactam + Clindamycin ± Vancomycin
Open Fracture / Contaminated Trauma (Prophylaxis)	Cefazolin

Algorithm: Esophageal Atresia



Clinical Overview

Esophageal atresia

is a congenital anomaly characterized by interruption of esophageal continuity, often associated with a tracheoesophageal fistula. It commonly presents in the neonatal period with feeding difficulties and respiratory compromise due to aspiration. Early recognition is critical to prevent complications such as aspiration pneumonia and respiratory distress.

- **Incidence:** Occurs in approximately 1 in 3,000 to 4,500 live births.
- **Most Common Type:** Type C (Proximal atresia with distal fistula) accounts for about 85% of all cases.
- **Associated Anomalies:** Up to 50% of infants have associated malformations. The most common is the VACTERL association (Vertebral, Anal, Cardiac, TEF, Renal, Limb).
- **Cardiac Links:** Cardiovascular anomalies (specifically ASD, VSD, and Tetralogy of Fallot) are present in 35% of these patients.
- **Survival Rate:** In modern centers, the survival rate is over 90%, but it decreases in the presence of low birth weight (<1500g) or major cardiac defects.
- **Clinical Signs:** Excessive salivation (drooling), choking, and cyanosis during the first feeding.

- **Pathophysiology:** Failure of the foregut to lengthen and separate into the esophagus and trachea during the 4th to 6th week of gestation.

Diagnostic Approach

Clinical suspicion arises in neonates with excessive salivation, choking, or cyanosis during feeding.

Initial evaluation includes:

- Attempted passage of a nasogastric tube (typically unsuccessful)
- Chest and abdominal radiography, which may show:
- A coiled nasogastric tube in the proximal esophageal pouch
- Presence of air in the stomach (suggesting distal fistula).

Management

Initial management focuses on stabilization and prevention of aspiration:

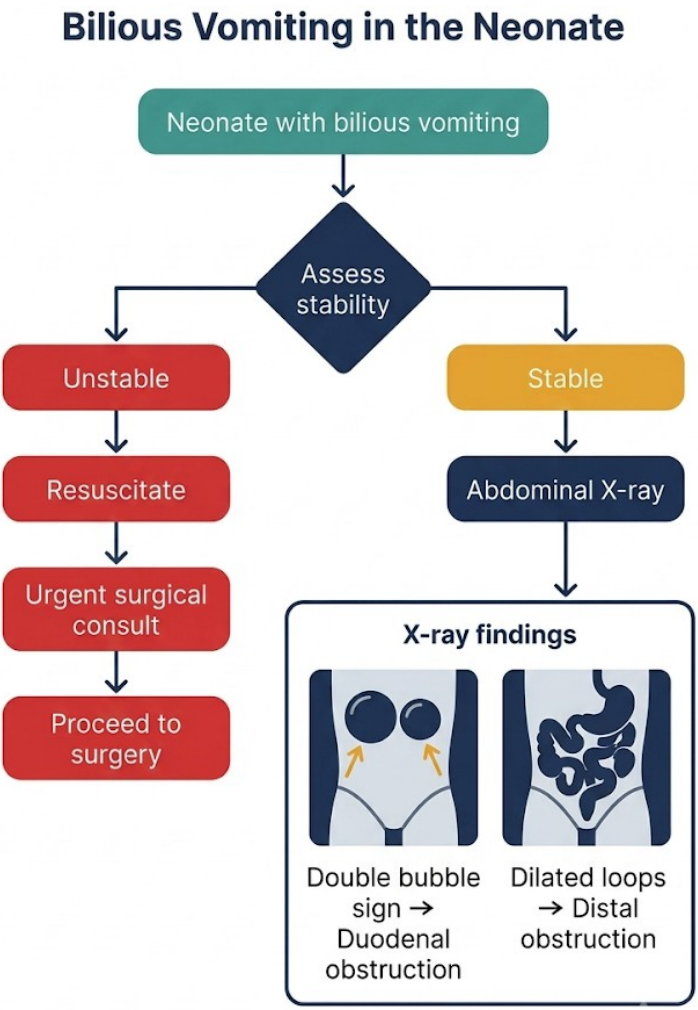
- NPO (nothing by mouth)
- Continuous suction of the proximal esophageal pouch
- Elevation of the head of the bed
- Intravenous fluids

Definitive treatment consists of surgical repair, including ligation of the fistula and primary esophageal anastomosis.

Clinical Pearls

- "The 10-French Rule": If a 10Fr or 12Fr stiff catheter meets resistance at 10-12 cm from the gums, the diagnosis is virtually certain.
- Aspiration Risk: The greatest danger is not the inability to swallow, but the reflux of gastric acid through the distal fistula into the lungs.
- Pre-op Check: Always perform an Echocardiogram before surgery to identify the side of the aortic arch (in 5% of cases, it is right-sided, which changes the surgical approach).
- The most common variant is esophageal atresia with distal tracheoesophageal fistula
- Always evaluate for associated anomalies (VACTERL association)

Algorithm: Bilious Vomiting in the Neonate



Clinical Overview

Bilious vomiting in the newborn:

is a surgical emergency until proven otherwise. It often indicates intestinal obstruction distal to the ampulla of Vater and requires prompt evaluation. Early recognition is essential to prevent bowel ischemia and other serious complications.

The "Surgical Rule": Bilious vomiting in a neonate is a **surgical emergency** until proven otherwise.

Incidence: Approximately **30% to 50%** of neonates presenting with bile-stained emesis will have a condition requiring surgical intervention.

Risk of Delay: In cases of Midgut Volvulus (the most feared cause), a delay in diagnosis of more than **6 to 12 hours** significantly increases the risk of massive bowel necrosis, leading to Short Bowel Syndrome or death.

Differential Diagnosis by Frequency:

- **Malrotation with Midgut Volvulus** (Most critical).
- **Intestinal atresia** (Duodenal, jejunal-ileal).
- **Meconium Ileus** (Often the first sign of Cystic Fibrosis).

- **Hirschsprung Disease** (Presenting with delayed meconium passage).

Diagnostic Approach

Initial evaluation should include clinical assessment, nasogastric decompression, and abdominal radiography. In stable neonates, an upper gastrointestinal contrast study is the preferred imaging modality for evaluating malrotation with midgut volvulus.

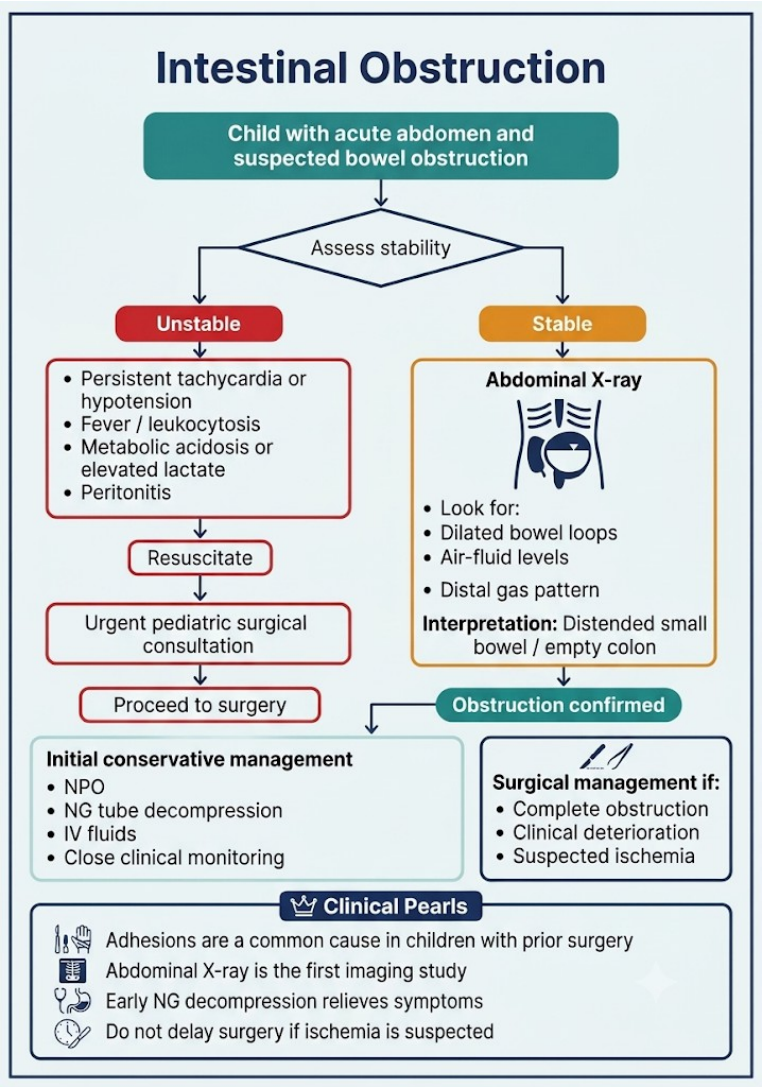
Management

Management depends on the underlying cause. Conditions such as malrotation with volvulus require urgent surgical intervention, while other causes of obstruction may require stabilization followed by definitive surgical treatment.

Clinical Pearls

- Bilious vomiting = surgical emergency until proven otherwise.
- The most critical diagnosis to exclude is malrotation with midgut volvulus.
- Do NOT delay imagining stable patients.
- Early intervention is lifesaving and prevents extensive bowel necrosis.

Algorithm: Intestinal Obstruction



Clinical Overview

Intestinal obstruction is an occlusion of the intestinal lumen. It is one of the most common causes of neonatal bowel obstruction.

Pathophysiology by Location:

- **Duodenal Atresia:** Result of a **failure of recanalization** of the duodenum during the 8th–10th week of gestation.
- Association: 30% of cases occur in infants with **Trisomy 21 (Down Syndrome)**.
- **Jejunoileal Atresia:** Typically caused by an **intrauterine vascular accident** (ischemic event) leading to necrosis and resorption of a segment of already formed bowel.

Classification (Grosfeld):

- Type I: Mucosal web (intact wall).
- Type II: Fibrous cord connecting two ends.
- Type IIIa: Complete separation with a V-shaped mesenteric defect.
- Type IIIb: **"Apple-peel" atresia** (jejunum coils around a single artery).
- Type IV: Multiple "string of sausages" atresias.

Diagnostic Approach

Suspicion (The Neonatal Obstruction Profile)

- **Prenatal:** Maternal polyhydramnios and dilated bowel loops on fetal ultrasound.
- **Postnatal:** Bilious vomiting within the first 24–48 hours of life.
- Abdominal distension (more prominent in distal atresia; absent in duodenal atresia).
- Failure to pass meconium.

"Bubble" Rule

Step 1: Plain Abdominal X-ray (Upright/Lateral Decubitus).

Step 2: Interpret the Bubbles:

- "Double Bubble" Sign: Pathognomonic for Duodenal Atresia. (One bubble is the stomach, the other is the proximal duodenum).
- "Triple Bubble" Sign: Suggests Jejunal Atresia.
- Multiple Dilated Loops + Air-Fluid Levels: Suggests Distal Ileal Atresia.

Management Strategy

- Decompression**:** Immediate placement of an Orogastric (OG) tube (Replogle preferred).

Clinical Pearls

- The "Gas" Warning: If you see a "double bubble" but there is gas distally in the rest of the abdomen, it is NOT complete atresia. It is Duodenal Stenosis or Malrotation/Volvulus. This is an emergency!
- Down Syndrome Screening: Every patient with Duodenal Atresia must be screened for cardiac defects (VSD/AVSD) before going to the OR.
- Biliary Anatomy: In duodenal atresia, the Ampulla of Vater often opens very close to the atretic segment. Extreme care is needed during repair to avoid biliary injury.

Surgical pre-operative

1. **Hydration:** Correction of electrolytes (hypokalemic, hypochloremic metabolic alkalosis if vomiting has been prolonged).

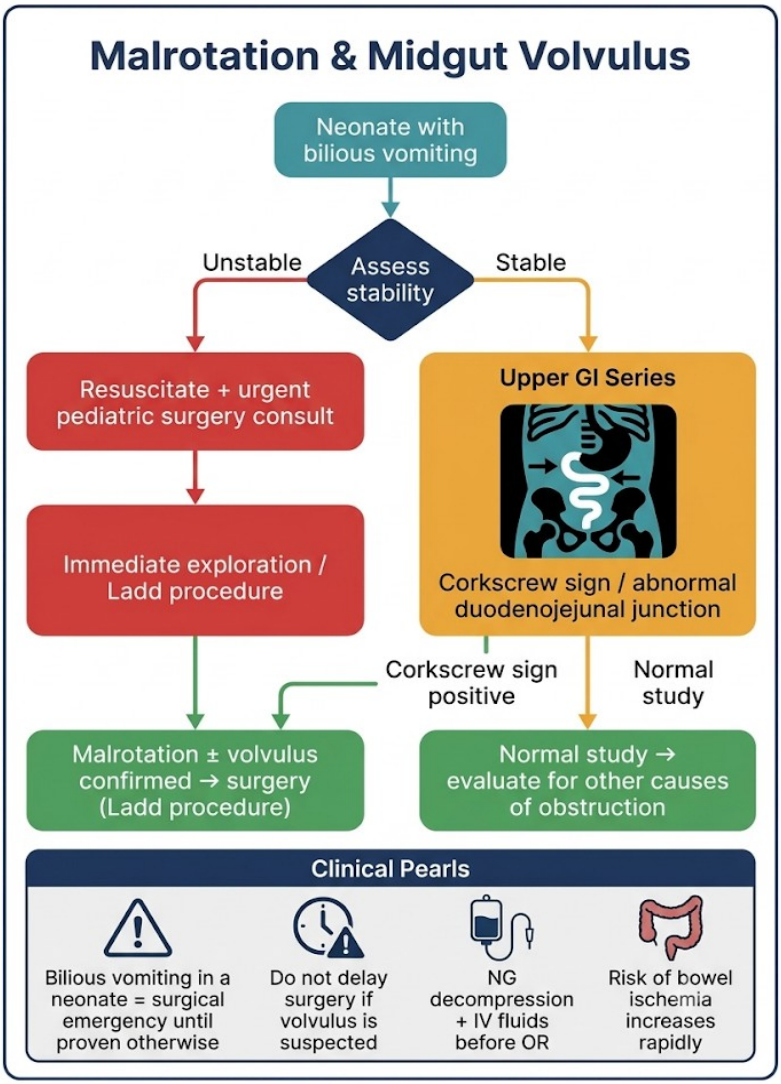
2. **Surgical Procedures:**

- **Duodenal:** Diamond-shaped Duodenoduodenostomy.

- **Jejunoileal:** Resection of the dilated proximal "bulb" and end-to-back anastomosis.

3. **Post-operative:** Expect a long period of "functional ileus." TPN (Total Parenteral Nutrition) is often required as the dilated proximal bowel takes time to develop effective peristalsis.

Algorithm: Malrotation and Midgut Volvulus



Clinical Overview

Intestinal malrotation is a congenital anomaly resulting from abnormal rotation and fixation of the midgut during embryologic development. This condition predisposes to midgut volvulus, a life-threatening complication characterized by twisting of the bowel around the superior mesenteric artery, leading to intestinal ischemia.

It most commonly presents in the neonatal period with bilious vomiting, although it can occur at any age.

Incidence: Occurs in approximately **1 in 500** live births.

Timing: Although it can be present at any age, **75%** of symptomatic cases occur in the **first month of life**, and 90% within the first year.

The Danger (Volvulus): Midgut volvulus (torsion of the entire small bowel around the SMA) occurs in approximately **40%** of patients with malrotation.

Associated Anomalies: Frequently associated with other lateralization defects, Gastroschisis, Omphalocele, and Congenital Diaphragmatic Hernia (CDH).

Mortality: Low if diagnosed early but rises to **65-90%** if massive bowel necrosis occurs.

Pathophysiology: Failure of the normal 270° counterclockwise rotation of the midgut around the Superior Mesenteric Artery (SMA) during embryonic development.

- **Ladd's Bands:** Peritoneal bands that fix the cecum to the RUQ, crossing over and obstructing the duodenum.
- **Midgut Volvulus:** The narrow mesenteric base allows the bowel to twist, leading to arterial occlusion and total midgut ischemia.

Diagnostic Approach

Clinical suspicion should be high in any neonate with bilious vomiting.

Initial steps include:

- Stabilization (NPO, nasogastric decompression, IV fluids)
- Abdominal radiography (may be nonspecific)

- In stable patients, the upper gastrointestinal contrast study is the diagnostic modality of choice and may show:
- Abnormal position of the duodenojejunal junction
- Corkscrew appearance (suggestive of volvulus)

Management

Malrotation with suspected volvulus is a surgical emergency.

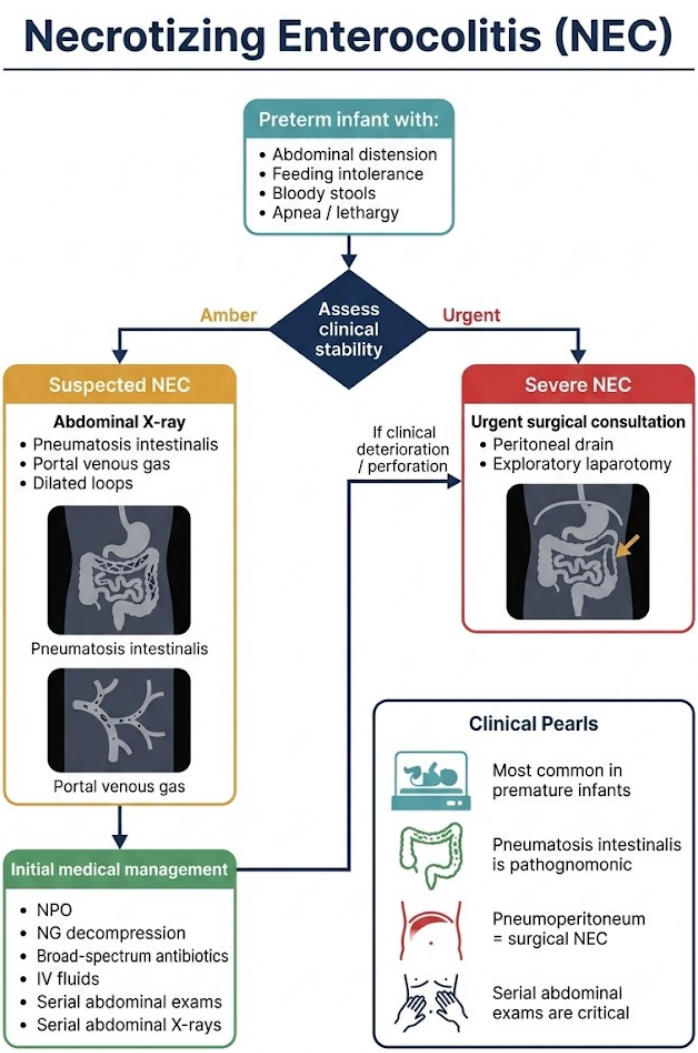
- Immediate surgical intervention (Ladd procedure)
- Assessment of bowel viability
- Resection of necrotic bowel if present

Delay in treatment may result in extensive bowel necrosis and short bowel syndrome.

Clinical Pearls

- Bilious vomiting in neonates must always raise suspicion for volvulus
- Upper GI series is the gold standard diagnostic test
- Volvulus can rapidly lead to bowel ischemia
- Early surgical intervention is critical

Algorithm: Necrotizing



Clinical Overview

Necrotizing enterocolitis (NEC) is a severe gastrointestinal emergency that primarily affects premature neonates. It is characterized by intestinal inflammation, ischemia, and potential necrosis. Early recognition is essential, as the disease can rapidly progress to perforation and systemic instability.

Incidence: Affects **1 to 3 per 1,000** live births.

The Prematurity Factor: Over **90%** of cases occur in preterm infants weighing less than 1,500g (VLBW). In this group, the incidence can rise up to **7-10%**.

Mortality: Remains high, ranging from **20% to 30%**, increasing significantly if surgical intervention is required.

Timing: Onset is inversely proportional to gestational age (extremely preterm infants may present later, around 3-4 weeks of life).

It is the most common gastrointestinal emergency in the NICU. **Pathophysiology:** Multifactorial (The "Perfect Storm"):

1. **Intestinal Immaturity:** Fragile mucosal barrier.

2. **Enteral Feeding:** Substrate for bacterial proliferation.
3. **Circulatory Instability:** Ischemia-reperfusion injury.
4. **Dysbiosis:** Abnormal bacterial colonization (often after antibiotic use).

Diagnostic Approach

Clinical suspicion arises in neonates with feeding intolerance, abdominal distension, and systemic signs such as lethargy or temperature instability.

Abdominal radiography is essential and may reveal:

- Pneumatosis intestinalis
- Portal venous gas
- Free air (in advanced stages)

Laboratory findings may include metabolic acidosis, thrombocytopenia, and leukocytosis or leukopenia.

Management

Management depends on disease severity.

- **Medical Management (Stage I & II):**
- **NPO + Gastric Decompression** (Replogle tube).
- **Triple Antibiotics** (Ampicillin + Gentamicin + Metronidazole).

- **Total Parenteral Nutrition (TPN).**
- **Surgical Management (Stage III):**
- **Indication: Perforation** (Pneumoperitoneum) or "Clinical Deterioration" despite maximal medical therapy.
- **Procedures:** 1. Primary Peritoneal Drainage (for very unstable/small ELBW infants) or 2. Exploratory Laparotomy with resection of necrotic bowel and ostomy.

Clinical Pearls

- The "Fixed Loop" Sign: A bowel loop that remains in the same position on serial X-rays suggests localized necrosis and may be an early indication for surgery even without free air.
- The Hyponatremia Warning: A sudden drop in serum sodium often indicates "third spacing" of fluids due to worsening capillary leak and bowel gangrene.
- Abdominal Wall Erythema: This is a late sign. If the skin is red or purple, the underlying bowel is already necrotic.
- Serial abdominal radiographs (every 6–8 hours) are vital during the acute phase to monitor for progression or perforation.

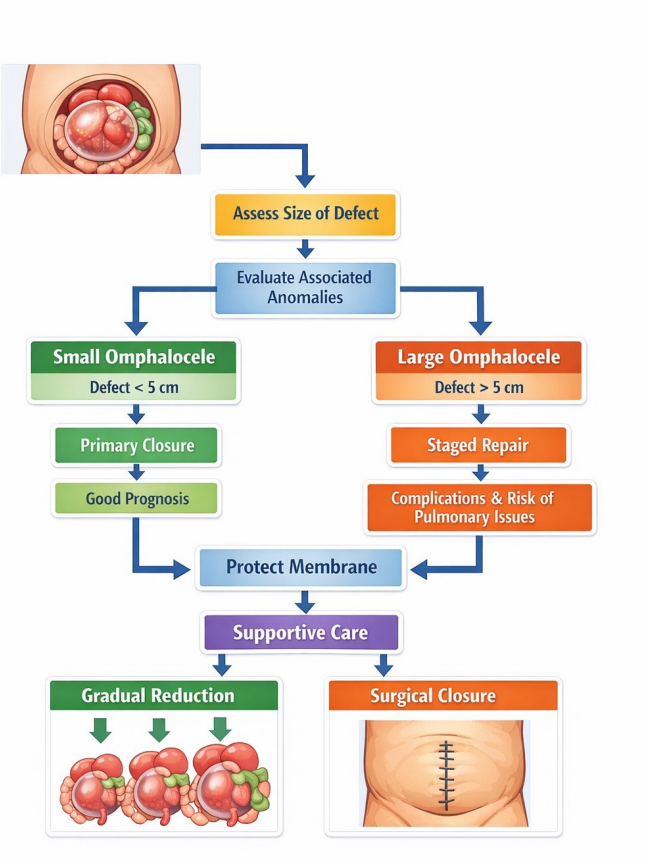
- Initial management is medical for the majority of cases in the absence of intestinal perforation.

Surgical pre-operative bundle

1. **Resuscitation:** Aggressive fluid management (babies can lose massive amounts of fluid into the bowel wall).
2. **Blood Products:** Correct coagulopathy and maintain Platelets >50,000 before surgery.
3. **Post-op:** High risk of "Short Bowel Syndrome" if large segments are resected. Always aim for "Bowel-Sparing" surgery.

Abdominal Wall Defects

Congenital defects in the anterior abdominal wall that allow herniation of intra-abdominal viscera. is the most important risk factor



Omphalocele

A midline abdominal wall defect at the base of the umbilical cord, with the herniated viscera covered by a peritoneal sac.

Incidence: Approximately **1 in 4,000** live births.

Associated Anomalies: High frequency (50-70%). The most common are cardiac defects (up to 30%), chromosomal abnormalities (Trisomy 13, 18, 21), and Beckwith-Wiedemann Syndrome (macroglossia, organomegaly, hypoglycemia).

Maternal Age: Unlike gastroschisis, omphalocele is more common in mothers at **advanced maternal age**.

Prognosis: Primarily determined by the associated anomalies (especially cardiac) and the degree of pulmonary hypoplasia in "Giant Omphaloceles."

Pathogenesis: Failure of the midgut to return to the abdominal cavity during the 10th to 12th week of gestation.

Delivery Room**:** Immediate assessment of the sac (intact vs. ruptured).

Protection**:** Cover the sac with **sterile saline-soaked gauze** and a plastic wrap (bowel bag) to prevent heat and fluid loss.

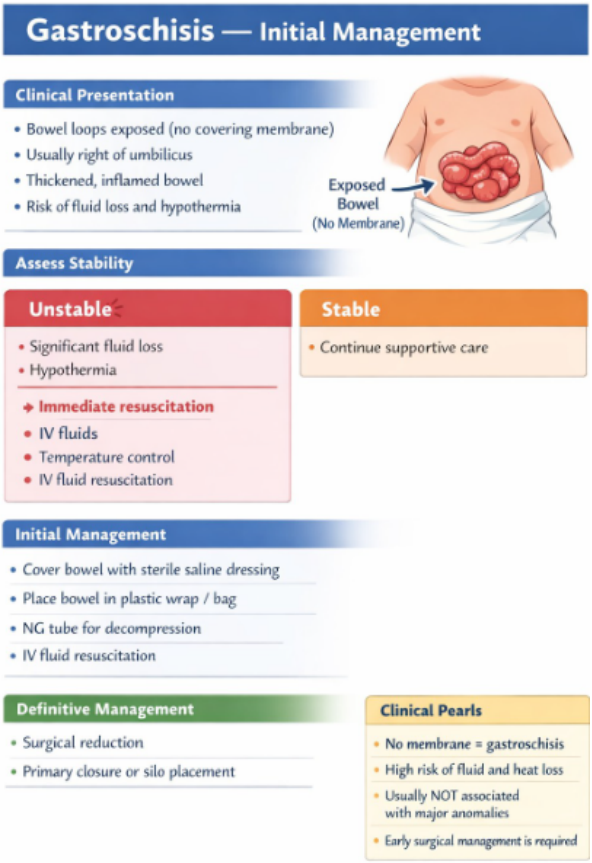
Stabilization**:** * Decompress the stomach with an **OG tube**.

- Maintain thermoregulation.
- **Echocardiogram** and Renal Ultrasound are mandatory before surgery.

Surgical Strategy:

- **Small/Medium (<5 cm):** Primary closure.
- **Giant (>5 cm or liver-containing):** Staged closure (Silo) or "Paint and Wait" strategy (using topical escharotic agents to allow epithelialization).

Algorithm: Gastroschisis



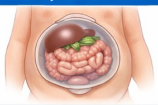
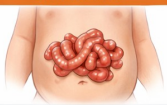
Gastroschisis (Comparison)

- **Incidence: 1 in 2,000 to 3,000** live births (becoming more common than omphalocele).
- **Maternal Age:** Strongly associated with **young maternal age** (<20 years).
- **Associated Anomalies: Rare (<10%)**, except for intestinal atresia (10-15%) due to vascular accidents.
- **Location:** Almost always to the **right of a normal umbilical cord**. No covering sac.

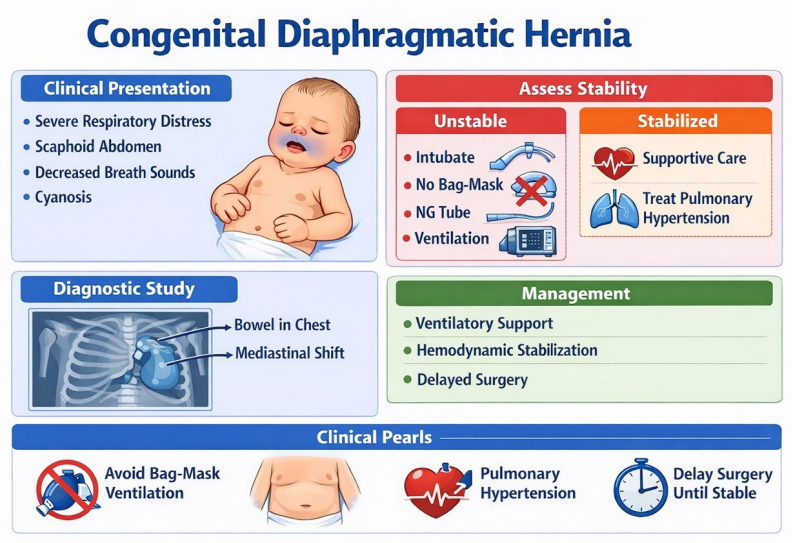
Clinical Pearls

- **"The Sac is the Key":** If there is a sac, it's an Omphalocele. If the bowel is "naked" and to the right of the cord, it's Gastroschisis.
- **Hypoglycemia:** In Omphalocele, always check blood glucose to rule out Beckwith-Wiedemann Syndrome.
- **Bowel Condition:** In Gastroschisis, the bowel often appears thickened and covered by a "peel" (fibrinous matrix) due to exposure to amniotic fluid.

Omphalocele vs Gastroschisis

Omphalocele		Gastroschisis
		
Defect location:	Midline (umbilical ring)	Right of umbilicus
Covering membrane:	Present (sac with peritoneum)	Absent
Exposed organs:	Covered bowel ± liver	Exposed bowel only
Associated anomalies:	Common (cardiac, chromosomal)	Rare
Genetic association:	High (e.g., trisomies)	Low
Bowel condition:	Usually normal	Inflamed, thickened
Prenatal diagnosis:	Yes (US + AFP)	Yes (US + AFP)
Delivery considerations:	Planned, tertiary center	Planned, tertiary center
Initial management:	Protect sac, avoid rupture	Cover bowel immediately
Surgical approach:	Staged or primary closure	Gradual reduction (silo)
Prognosis:	Depends on anomalies	Generally good

Algorithm: Congenital Diaphragmatic Hernia (CDH)



Clinical Overview

CDH is a developmental defect in the diaphragm that allows abdominal viscera to herniate into the thoracic cavity during fetal life.

Incidence: Approximately 1 in 2,500 to 3,500 live births.

Laterality: 85% occurs on the left side (Bochdalek hernia). Right-sided and bilateral cases are much rarer and often carry a worse prognosis.

Mortality: Overall survival is 70-80% in centers with ECMO capability, but it is entirely dependent on the degree of Pulmonary Hypoplasia and Pulmonary Hypertension.

Associated Anomalies: Present in 40% of cases, with congenital heart disease being the most frequent.

Embryology: Failure of the pleuroperitoneal membranes to fuse with the septum transversum and esophageal mesentery around the 8th–10th week of gestation.

The Pathophysiology Triad:

- Pulmonary Hypoplasia: Reduced number of bronchial generations and alveoli.
- Pulmonary Hypertension: Hypertrophy of the pulmonary arterial muscle layer leading to right-to-left shunting.
- Cardiac Dysfunction: Compression and displacement of the heart by herniated organs.

The Emergency (Immediate Care)

Delivery Room (The "Golden Rules")

- Immediate Intubation: If prenatally diagnosed or suspected at birth, intubate immediately.
- DO NOT Use Bag-Mask Ventilation: This distends the intrathoracic stomach and intestines, further compressing the hypoplastic lungs.
- Gastric Decompression: Place a large-bore Orogastric (OG) tube (10Fr+) to continuous suction to keep the bowel deflated.

Stabilization Strategy (The "Gentle" Approach)

- Lung-Protective Ventilation: Aim for "Permissive Hypercapnia."
- Low peak inspiratory pressures (PIP <25 cmH2O).
- Target Pre-ductal SpO_2 (right hand): 85–95%.
- Accept PaCO_2 between 45–60 mmHg.
- Inhaled Nitric Oxide (iNO): If pulmonary hypertension is severe and shunting is present.

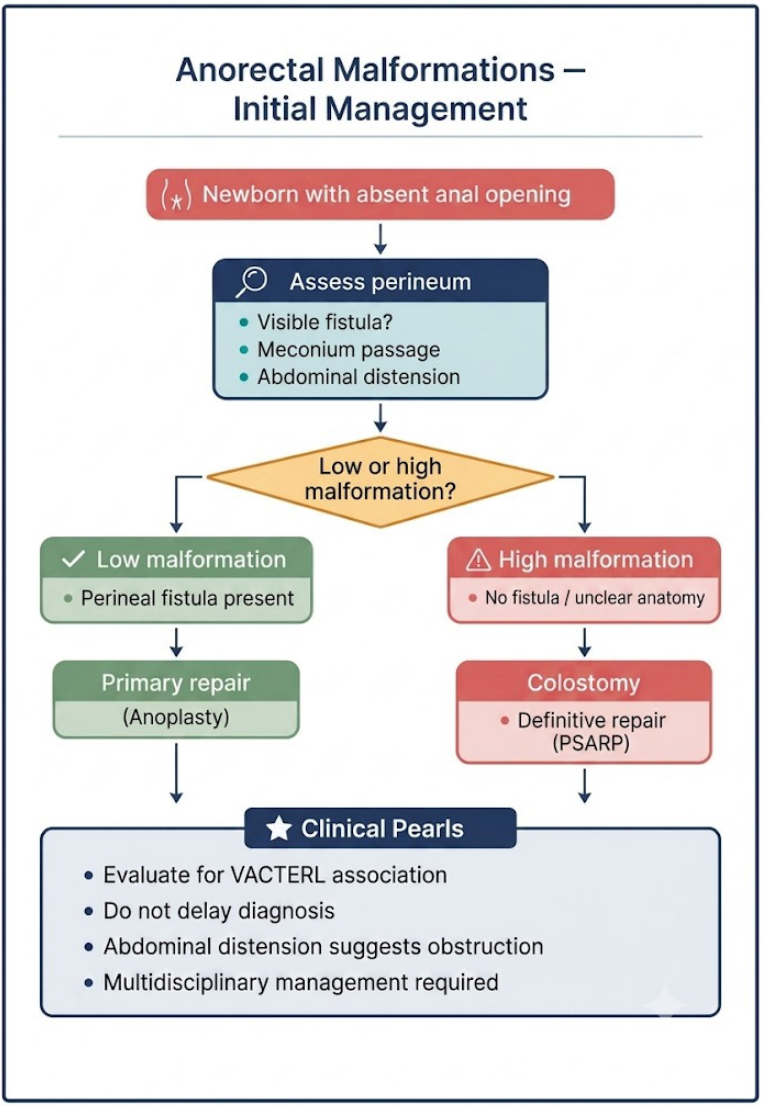
Clinical Pearls

- The "Scaphoid" Abdomen: A newborn with respiratory distress and a "sunken" or scaphoid abdomen is a classic sign of CDH (the organs are in the chest, not the belly).
- Pre-ductal vs. Post-ductal: Always place pulse oximeters on the Right Hand (pre-ductal) and any Foot (post-ductal). A significant difference indicates severe pulmonary hypertension and right-to-left shunting.
- Honeymoon Period: Some babies look stable for the first few hours, then crash as pulmonary vascular resistance rises. Stay vigilant.

Pre-operative Bundle.

- Echocardiogram: Essential to assess the degree of pulmonary hypertension and rule out associated cardiac defects (found in 30%).
- Access: Pre-ductal arterial line (Right Radial) for frequent ABGs.
- Surgical Consent: "Diaphragmatic repair, possible use of prosthetic mesh (Gore-Tex), and potential ECMO (Extracorporeal Membrane Oxygenation) backup."

Algorithm: Anorectal Malformation



Clinical Overview

Anorectal malformations encompass a wide spectrum of congenital defects involving the terminal anus and rectum. They range from simple imperforate anus to complex cloacal malformations.

- Incidence: 1 in 5,000 live births.
- Gender: Slightly more common in males.
- **VACTERL** Association: Up to 60% of patients have associated anomalies. A renal ultrasound and spinal ultrasound/MRI are mandatory in the initial workup.
- Classification: Divided into "High", "Intermediate", or "Low" lesions based on the relationship of the rectum to the levator ani muscle complex.

Diagnostic Approach

Perineal Inspection: Perform a meticulous physical exam within the first 24 hours. Look for a visible fistula on the perineum (rectoperineal fistula), a "flat bottom" (suggesting poor musculature/sacral agenesis), or a single opening (suggesting a cloaca in females).

Invertogram: In cases without a visible fistula, a cross-table lateral radiograph in the prone position (after 16–24

hours of life to allow bowel gas to reach the distal rectum) helps determine the distance between the distal rectal pouch and the perineal skin.

Associated Anomalies: Perform a spinal and renal ultrasound, echocardiogram, and sacral X-rays to screen for VACTERL components.

Management:

Initial Management:

NPO and start IV fluids. Nasogastric decompression is essential.

Surgical Strategy:

Low defects (with perineal fistula): May undergo primary anoplasty without a colostomy.

High or Complex defects: Require a divided sigmoid colostomy in the newborn period to allow for growth before definitive repair (Posterior Sagittal Anorectoplasty - PSARP or "Peña procedure").

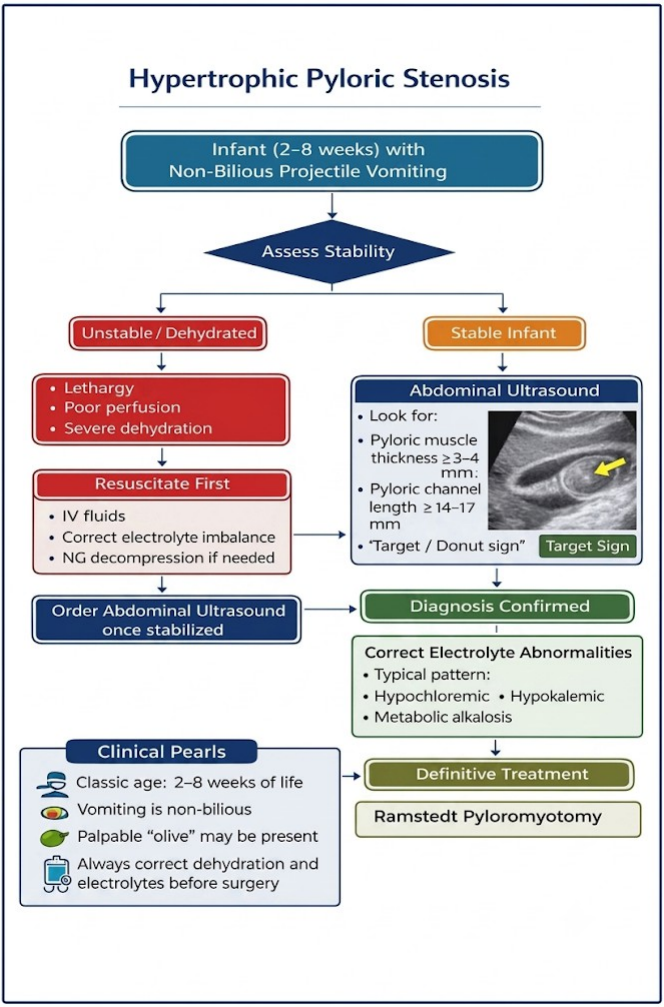
Cloaca: Represents a surgical emergency requiring specialized multidisciplinary care and immediate decompression of the urinary tract and vagina if distended (hydrocolpos).

Clinical Pearls:

- Wait 16–24 hours before performing an invertogram or deciding on a colostomy to allow distal bowel gas to equilibrate.
- In females, a single perineal opening is a Cloacal Malformation until proven otherwise, check for hydrocolpos.
- The "flat bottom" sign is a poor prognostic indicator for future fecal continence due to underdeveloped levator muscles.
- Always check for a patent esophagus (VACTERL association) before the first feed.

Algorithm: Hypertrophic Pyloric Stenosis (HPS)

Hypertrophic Pyloric Stenosis



Clinical Overview

Hypertrophic pyloric stenosis is a condition characterized by hypertrophy of pyloric muscle, leading to gastric outlet obstruction. It typically presents in infants between 2 and 8 weeks of age with progressive, non-bilious projectile vomiting. Affected infants may develop dehydration and significant electrolyte imbalances.

Incidence: Approximately 2 to 4 per 1,000 live births.

Risk Factors: First-born males ("The First-born Son disease"), maternal smoking, and early postnatal exposure to Erythromycin or Azithromycin.

Gender Ratio: Significant male predominance of 4:1.

Genetic/Environmental Link: Increased risk with maternal smoking and use of erythromycin in the first weeks of life.

Pathophysiology: Continuous vomiting of gastric juice (rich in HCl) leads to a unique metabolic state: Hypochloremic, Hypokalemic, Metabolic Alkalosis.

The Renal Paradox: As the body tries to conserve sodium and volume, it eventually excretes H+ ions in the urine, leading to paradoxical aciduria.

Diagnostic Approach

- Clinical Presentation: Non-bilious projectile vomiting and persistent hunger ("hungry vomiter"). On physical examination, a palpable “olive-shaped” mass may be felt in the right upper quadrant.
- Laboratory Findings: Classic hypochloremic, hypokalemic metabolic alkalosis.
- Imaging: Ultrasound is the diagnostic modality of choice, showing a thickened pyloric muscle (>3-4 mm) and an elongated pyloric channel (>14-16 mm.

Management:

Medical Stabilization (Priority)

HPS is a medical emergency, not a surgical one. Initial management focuses on intravenous fluid resuscitation and correction of electrolyte and acid-base abnormalities.

Surgical Treatment

Once the infant is metabolically stable, a Ramstedt pyloromyotomy (laparoscopic or open) is performed to divide the hypertrophied muscle.

Surgical and pre-operative

1. **Resuscitation Fluid:** Initial bolus of Normal Saline (NS), followed by D5 0.45% NS + Potassium (once urine output is confirmed).

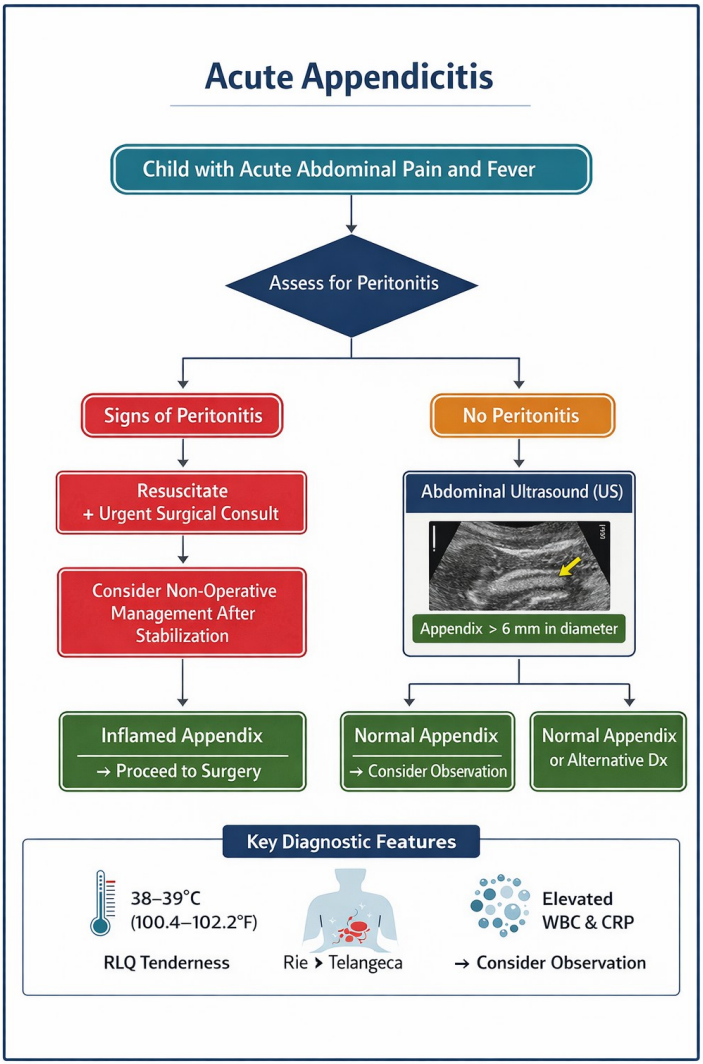
2. **Surgical Procedure:** Ramstedt Pyloromyotomy (can be performed via umbilical incision or laparoscopically). The muscle is split, but the mucosa is left intact.

3. **Feeding Protocol:** Start small volume feeds (Pedialyte or breast milk) 4–6 hours post-op, advancing to full feeds within 24 hours (Ad Libitum feeding is increasingly common).

Clinical Pearls:

- Vomiting is strictly non-bilious; if bile is present, look for other causes of obstruction.
- Never rush to the operating room; surgery should only be performed after electrolytes (especially chloride and CO2) are normalized.
- The "olive" mass is most easily felt after the infant has vomited and the stomach is decompressed.
- Postoperative emesis is common and usually resolves within 24-48 hours.

Algorithm: Acute Abdomen in children



Acute Appendicitis

Clinical Overview

Acute appendicitis results from the obstruction of the appendiceal lumen, leading to inflammation, ischemia, and potential perforation. While it can occur at any age, it is most common in adolescents. In younger children, clinical presentation is often atypical, frequently leading to a higher rate of perforation at the time of diagnosis.

Incidence: The most frequent condition requiring emergency abdominal surgery in children worldwide.

Lifetime Risk: Approximately 9% for males and 7% for females.

Peak Age: Most common between 10 and 18 years. It is rare in children under 2 years (<2% of cases).

Perforation Rate: Closely linked to age. In children <5 years old, the perforation rate at diagnosis is 60-90%, compared with 10-20% in adolescents.

Gender: Slight male predominance (1.2:1).

Pathophysiology: Obstruction (usually by a **fecalith**, lymphoid hyperplasia, or parasites) → Bacterial overgrowth (E. coli, B. fragilis) → Increased

intraluminal pressure → Venous congestion → Arterial compromise → Gangrene/Perforation.

Classification:

- **Simple (Non-perforated):** Inflammation limited to the appendix.
- **Complex (Perforated):** Presence of a fecalith in the peritoneum, abscess, or phlegmon.

Diagnostic Approach

Clinical Presentation:

The classic triad includes periumbilical pain migrating to the right lower quadrant (RLQ), anorexia, and nausea/ vomiting.

Physical exam may reveal tenderness at McBurney's point, rebound tenderness, or guarding.

Clinical Scoring

Instead of just "pain," use the **Pediatric Appendicitis Score (PAS)**:

- **Symptoms:** Migration of pain to RLQ (1 pt), Anorexia (1 pt), Nausea/Vomiting (1 pt).

- **Signs:** Fever >38°C (1 pt), RLQ Tenderness (2 pts), Pain with coughing/hopping (2 pts).
- **Labs:** Leukocytosis >10,000 (1 pt), Neutrophilia/Left shift (1 pt).

Interpretation and Scoring

- **Score 0–3:** Low risk. Consider discharge with "return-to-ER" instructions or 12h re-evaluation.
- **Score 4–6:** Intermediate risk. **Mandatory Imaging** (Ultrasound first).
- **Score 7–10:** High risk. Surgical consultation. Imaging may be skipped in classic cases to avoid delay.

Imagining

- **1st Line: Ultrasound (US).** Look for: Non-compressible appendix > 6 mm, target sign, appendicolith, or peri appendiceal fluid.
- **2nd Line (If US is equivocal): CT scan** (with IV contrast) or **MRI** (to avoid radiation).

Management:

- **Initial Management:**

NPO, provide intravenous fluid resuscitation, and administer analgesia. Start broad-spectrum intravenous

antibiotics once the diagnosis is confirmed or highly suspected.

• **Surgical Treatment:**

- Laparoscopic appendectomy is the gold standard for definitive treatment.
- **Non-operative Management:** In select cases of uncomplicated appendicitis or contained perforated phlegmon/ abscess, initial management with antibiotics and interval appendectomy may be considered.

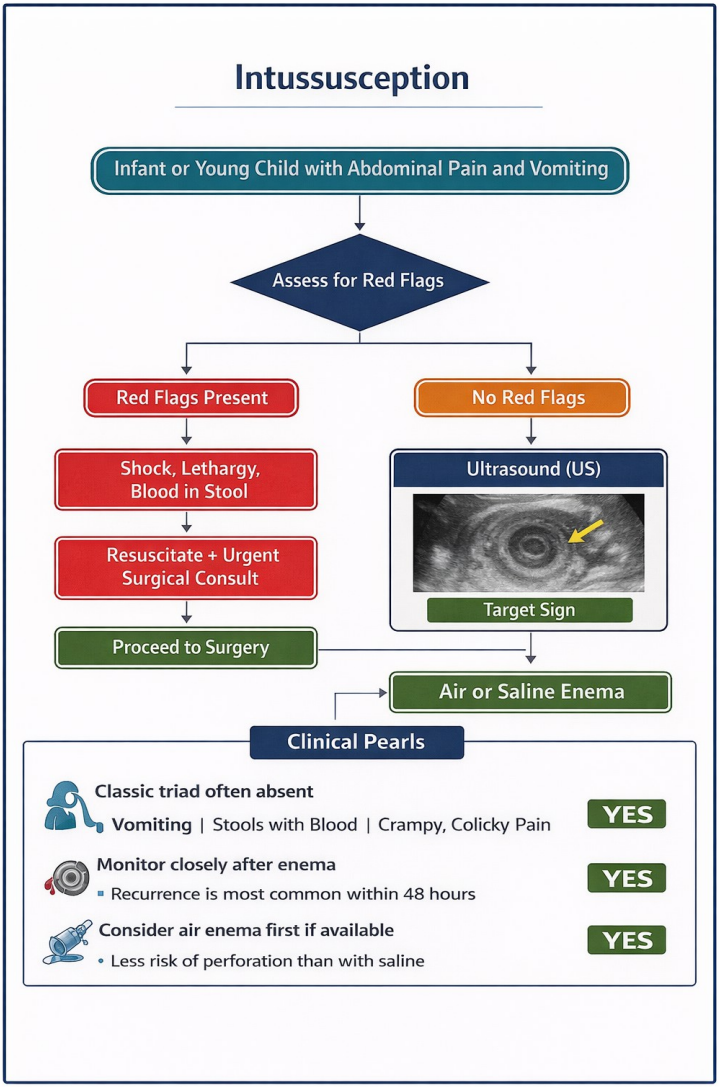
Surgical and pre-operative bundle.

1. **Hydration:** Isotonic fluids (NS or LR) to correct deficits from vomiting.
2. **Antibiotics:** CefoxitinorCeftriaxone+Metronidazole.
3. **Approach: Laparoscopic Appendectomy** is the gold standard (less pain, faster recovery, lower wound infection rate).
4. **The Phlegmon Exception:** If the patient has a palpable mass and symptoms for >5 days but is stable, consider **Interval Appendectomy** (Non-operative management with antibiotics + surgery in 6–8 weeks).

Clinical Pearls

- Migration of pain from the umbilicus to the RLQ is the most reliable clinical predictor.
- A normal White Blood Cell (WBC) count does not rule out appendicitis, especially early in the disease.
- Younger children (under 5 years) have a significantly higher risk of perforation due to non-specific symptoms.
- If the appendix cannot be visualized on ultrasound but there is secondary fat stranding or fluid, clinical suspicion should remain high.

Algorithm:Intussusception



Intussusception

Clinical Overview

Intussusception occurs when a proximal segment of the bowel telescopes into an adjacent distal segment (usually the ileum into the colon). This leads to venous obstruction, bowel wall edema, and, if untreated, arterial compromise and bowel necrosis. Most cases in toddlers are idiopathic (secondary to lymphoid hyperplasia), while in older children, a "lead point" such as a Meckel's diverticulum or polyp should be suspected.

Incidence: The most common cause of intestinal obstruction in infants between **6 and 36 months** of age.

Peak Age: 60% of cases occur in children **under 1 year**; 80% occur before age 2.

Gender: More common in males (**3:2 ratio**).

Seasonal Variation: Often correlates with peak times for **viral gastroenteritis** and upper respiratory infections (leading to lymphoid hyperplasia of Peyer's patches).

• In **90%** of pediatric cases, it is **idiopathic** (no lead point). In older children (>2-3 years), suspicion of a pathological lead point (Meckel's diverticulum, polyp, lymphoma) must increase.

Pathophysiology: The invagination causes venous and lymphatic obstruction, leading to bowel wall edema. Ifuntreated, it progresses to arterial compromise, mucosal sloughing (**"Currant Jelly" stool**), and necrosis.

Lead Points: * Idiopathic (90%): Often follows a viral infection (hypertrophied Peyer's patches).

- Pathological (10%): Meckel's diverticulum, polyps, duplication cysts, or Henoch-Schönlein Purpura (HSP).

Location: Most commonly **Ileocolic**.

Diagnostic Approach and Management

In stable patients, non-operative reduction with air or contrast enema is the first-line treatment.

Surgical intervention is indicated if:

- Enema reduction fails
- There are signs of perforation
- The patient is hemodynamically unstable
- Clinical presentation is often variable but may include:
- Intermittent, severe abdominal pain
- Vomiting
- Lethargy
- "Currant jelly" stools (late finding)

Ultrasound is the diagnostic modality of choice and typically demonstrates the “target sign.”

Post- reduction and Surgical Bundle.

1. **Observation:** Admit for 12–24 hours if reduced by enema to monitor for recurrence.

2. **Surgical Indications:**

- Failed non-surgical reduction (usually after 3 attempts).
- Evidence of bowel necrosis or perforation.
- Identifying a pathologic lead point (especially in children >5 years old).

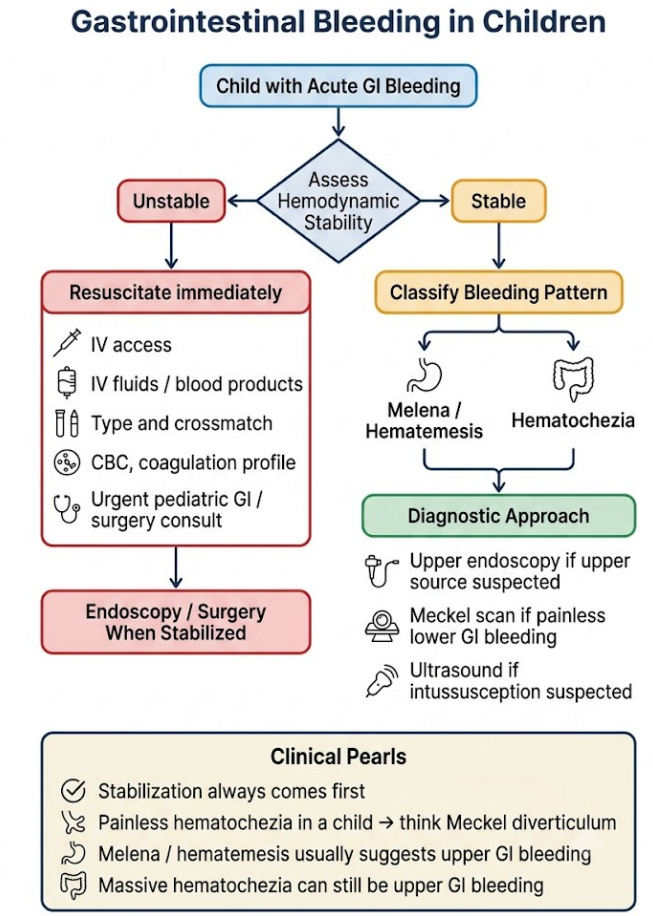
Procedure: Hutchinson Maneuver (manual reduction by " milking" the bowel). Do NOT pull the intussusceptum out.

Clinical Pearls:

- The "currant jelly" stool is a late finding indicating bowel ischemia; do not wait for its appearance to suspect the diagnosis.
- Ultrasound is nearly 100% accurate in experienced hands and avoids ionizing radiation.
- Up to 10% of cases may recur, usually within the first 24–48 hours after successful reduction.

- In children older than 5 years, they always look for a pathologic lead point (e.g., Meckel's diverticulum, lymphoma, or duplication cyst).

Algorithm: Gastrointestinal Bleeding in Children.



Gastrointestinal Bleeding

Clinical Overview

Gastrointestinal (GI) bleeding in children ranges from mild to life-threatening and can originate from the upper or lower gastrointestinal tract. The clinical presentation varies depending on the location and severity of the bleeding.

Upper GI bleeding typically presents with hematemesis or melena, while lower GI bleeding may present with hematochezia.

Age-Related Incidence:

- **Neonates:** Most common cause is **swallowed maternal blood** or Vitamin K deficiency.
- **Infants: Anal fissures** (most common overall) and Milk Protein Allergy.
- **Children (2-5 years): Meckel's Diverticulum** and Juvenile Polyps.
- **Adolescents:** Inflammatory Bowel Disease (IBD) and Peptic Ulcer Disease.

Meckel's Diverticulum "Rule of 2s":

- Affects **2%** of the population.
- Located **2 feet** (60 cm) from the ileocecal valve.
- **2 inches** long.
- Symptoms often present before age **2**
- **Upper vs. Lower:** Upper GI bleeding (proximal to the Ligament of Treitz) represents about **20%** of cases in children, whereas Lower GI bleeding represents **80%**.

Diagnostic Approach:

- **Initial Assessment:** Evaluate hemodynamic stability first. Tachycardia and delayed capillary refill are early signs of significant blood loss in children.

Characterizing the Bleed:

- **Hematemesis/Melena:** Suggests an Upper GI source (e.g., esophageal varices, peptic ulcer).
- **Hematochezia (Bright red blood):** Suggests a Lower GI source or a very brisk UGIB.
- **"Currant Jelly" Stool:** Highly suggestive of Intussusception.

- **Work-up:** Nasogastric (NG) tube lavage can help confirm an active UGIB. For suspected Meckel's diverticulum, a **Technetium-99m pertechnetate scan** (Meckel's scan) is the study of choice. Colonoscopy or endoscopy is used for definitive localization.

Management:

- **Resuscitation:** Establish large-bore IV access and initiate fluid resuscitation with isotonic crystalloids. Provide blood products (Packed Red Blood Cells) if the patient remains unstable or has significant hemoglobin drop.
- **Medical Therapy:** Proton Pump Inhibitors (PPIs) for suspected peptic disease; Octreotide for suspected variceal bleeding.
- **Surgical Intervention:** Reserved for hemodynamically unstable patients despite resuscitation, or specific surgical lesions such as **Meckel's diverticulum**, intestinal duplication cysts, or malrotation.

Clinical Pearls:

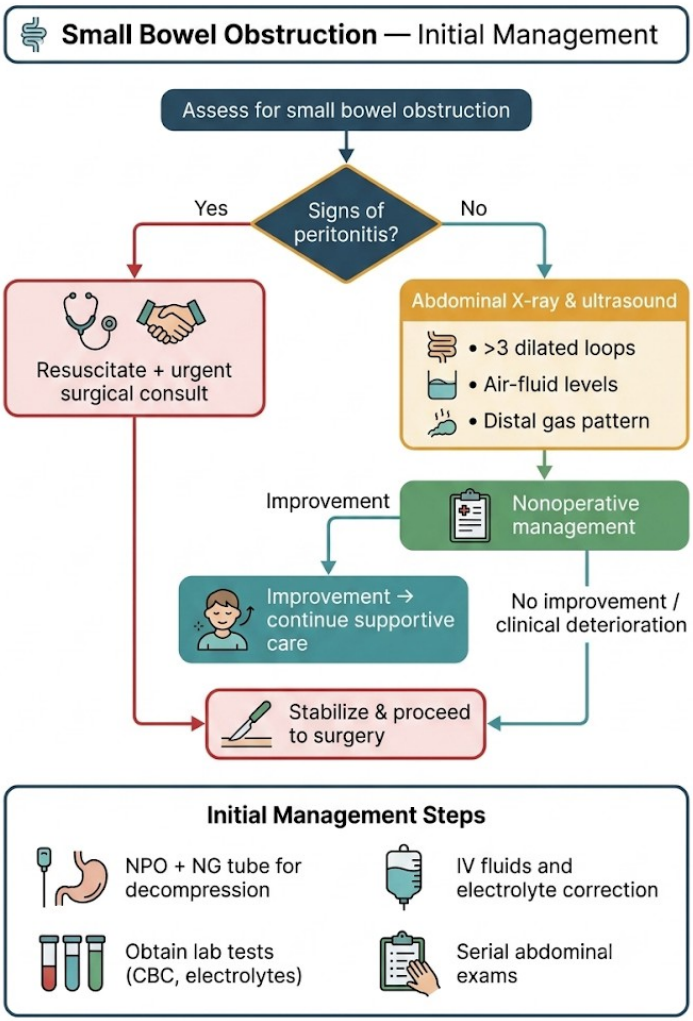
- Always rule out "fake" bleeding (ingestion of red food dye, beets, or maternal blood in neonates via the Apt test).

- Painless, massive common hematochezia in a toddler is a **Meckel's diverticulum** until proven otherwise.
- Significant GI bleeding in a neonate with abdominal pain must be treated as **malrotation with midgut volvulus** until excluded.
- A negative NG aspirate does not 100% rule out an Upper GI source if the bleeding is intermittent or distal to the pylorus.

UPPER GI BLEEDING vs. LOWER GI BLEEDING

	Upper Gi Bleeding	Lower Gi Bleeding
Origin	Above ligament of Treitz	Below ligament of Treitz
Presentation	Hematemesis, melena	Hematochezia
Color	Dark / coffee-ground	Bright red
Severity	Can be massive	Variable
Common causes	Ulcers, Gastritis	Polyps, colitis
Diagnostic test	Endoscopy	Colonoscopy
NG tube	Stabilization + endoscopy	Depends on cause

Algorithm: Small Bowel Obstruction (SBO)



Small Bowel Obstruction

Clinical Overview

Small bowel obstruction in children can be congenital or acquired. In the pediatric population, the most common cause of acquired SBO is postoperative adhesions. Regardless of the cause, the pathophysiology involves proximal bowel dilation, decreased mucosal absorption, and potential progression to bowel ischemia or perforation.

- **Post-Surgical Cause:** Adhesions are the most common cause of SBO in children who have undergone prior abdominal surgery (up to 5-10% of patients post-laparotomy).
- **Congenital Causes:** In children without prior surgery, look for incarcerated hernias (most common non-surgical cause) or congenital bands (Ladd bands).
- **Frequency:** Represents about 10% of all pediatric emergency abdominal admissions.
- **Complications:** The risk of bowel strangulation is approximately 10-15% in cases of complete obstruction.

Diagnostic Approach:

- Clinical Presentation: Bilious vomiting, abdominal distension, and colicky abdominal pain. High-pitched "tinkling" bowel sounds may be heard early, while a silent abdomen suggests late-stage obstruction or ileus.
- Imaging: Abdominal X-rays (supine and upright) are the first step. Look for dilated loops of small bowel with air-fluid levels and a lack of gas in the distal colon/rectum.
- Contrast Studies: An upper GI series or a contrast enema may be necessary if the diagnosis is unclear or to rule out malrotation.

Management:

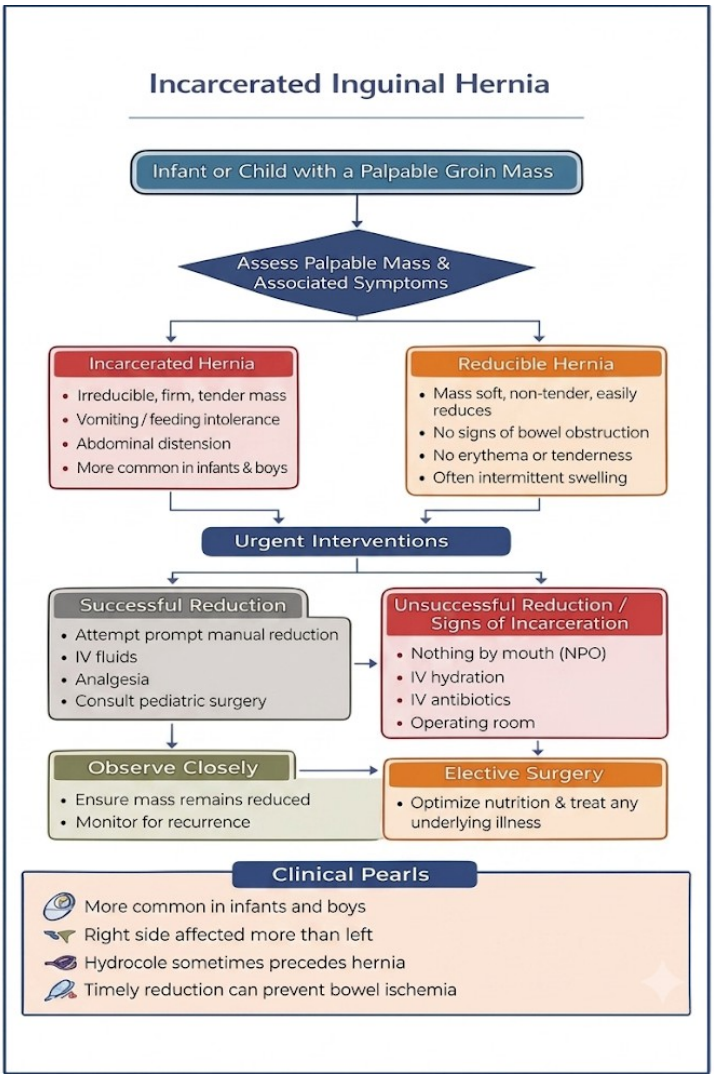
- **Initial Management:** "Drip and Suck" Intravenous fluid resuscitation to correct dehydration and nasogastric (NG) tube decompression to prevent aspiration and reduce distension.
- **Observation:** Many cases of adhesive SBO resolve with non- operative management (NPO and decompression) within 24–48 hours.
- **Surgical Intervention:** Indicated if there are signs of strangulation (fever, tachycardia, localized tenderness,

leukocytosis) or if the obstruction fails to resolve with conservative management.

Clinical Pearls:

- The most common cause of SBO in a child with a previous laparotomy is adhesions.
- In a child without previous surgery, an SBO should prompt a search for a hernia, intussusception, or a congenital band.
- Bilious vomiting in a neonate is an absolute indication to rule out SBO/Malrotation.
- "Never let the sun rise or set on a complete bowel obstruction”a classic surgical maxim emphasizing the need for timely decision-making.

Algorithm: Incarcerated Inguinal Hernia



Incarcerated Inguinal Hernia

Clinical Overview

An inguinal hernia occurs when abdominal contents (usually bowel or omentum, or ovaries in females) protrude through a patent processus vaginalis. An incarcerated hernia is one that cannot be reduced back into the abdominal cavity by manual manipulation. If left untreated, it can progress to strangulation, where the blood supply to the herniated organ is compromised, leading to ischemia and necrosis.

- **Incidence:** Inguinal hernias occur in **1-5%** of all children, but the incidence rises to **30%** in preterm infants.
- **Risk of Incarceration:** Highest in the first 6 months of life (up to 30% of all pediatric hernias will incarcerate at this age).
- **Gender:** Much more common in males (**8:1 ratio**) due to the descent of the testes.
- **Side:** More frequent on the **right side (60%)** than the left (30%), with 10% being bilateral.

Diagnostic Approach

- **Clinical Presentation:** A firm, often painful, non-reducible lump in the inguinal canal or scrotum. The child may be irritable, vomiting, and show signs of intestinal obstruction. In cases of strangulation, the overlying skin may be erythematous, edematous, or discolored.
- **Physical Examination:** Attempt a gentle reduction (unless signs of peritonitis or systemic toxicity are present). In females, always consider the possibility of an incarcerated ovary, which is often less painful than incarcerated bowel.
- **Imaging:** Diagnosis is primarily clinical. **Ultrasound** can be used if the diagnosis is in doubt, helping to differentiate a hernia from a hydrocele, testicular torsion, or lymphadenopathy.

Management:

- **Manual Reduction:** If there are no signs of strangulation (fever, leukocytosis, or skin changes), initial management involves sedation and a "Trendelenburg" position to attempt manual reduction.
- **Surgical Treatment: * Emergency Surgery:** Indicated if the hernia is non-reducible after several attempts or if there are signs of strangulation.

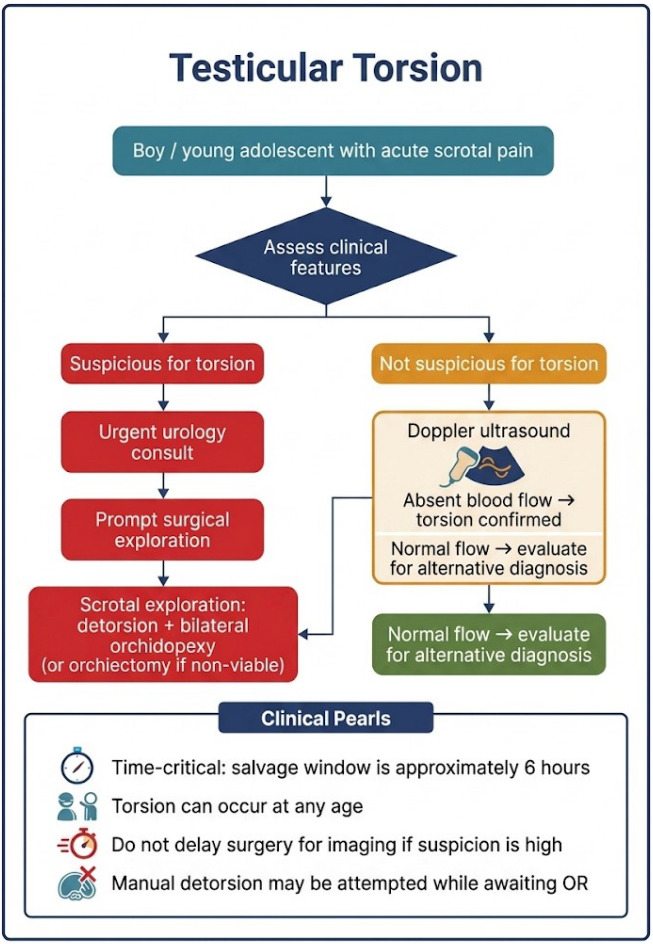
- **Urgent Surgery:** If successfully reduced, the patient should be admitted and undergo surgical repair (high ligation of the sac) within 24–48 hours to prevent re-incarceration.
- **Warning:** Never attempt to reduce a hernia if there is evidence of bowel gangrene or peritonitis, as this could return necrotic bowel into the abdomen.

Clinical Pearls:

- The younger the child, the higher the risk of incarceration (highest in the first year of life).
- In premature infants, incarcerated hernias are a common cause of bowel obstruction.
- For males, always check both testes after reduction to ensure the testis was not inadvertently pushed into the abdomen (iatrogenic undescended testis).
- A "silk glove sign" (feeling the layers of the hernia sac sliding over each other) is a classic finding of a patent processus vaginalis on physical exam.

Urologic and Genital Emergencias

Algorithm: Testicular Torsion



Testicular Torsion

Clinical Overview

Testicular torsion occurs when the spermatic cord twists, obstructing the venous return and eventually the arterial supply to the testis. This leads to acute ischemia and irreversible hemorrhagic infarction if not corrected within 4–6 hours. It is most common during puberty (due to the "bell-clapper" deformity) but can occur at any age, including the neonatal period.

Incidence: Affects approximately 1 in 4,000 males under age 25.
Bimodal Peak: * Perinatal period (extravaginal torsion).
Puberty (intravaginal torsion), between 12 and 18 years (most common).
The "Golden 6 Hours": Salvage rates are nearly 100% if detorsion occurs within 6 hours. This drops to 20% at 12 hours and 0-10% after 24 hours.
Anatomical Predisposition: The "Bell-clapper" deformity (failure of normal posterior anchoring of the gubernaculum) is present in 12% of the male population and is often bilateral.
Side: Slight predilection for the left side (due to a longer spermatic cord).

Diagnostic Approach

- **Clinical Presentation:** Sudden onset of severe, unilateral scrotal pain, often accompanied by nausea and vomiting. On exam, the testis may be high-riding with a horizontal lie. The **cremasteric reflex is typically absent**.
- **Physical Exam:** Look for "Prehn's sign" (elevation of the scrotum does not relieve pain in torsion, unlike epididymitis), though this is not always reliable in children.
- **Imaging: Color Doppler Ultrasound** is the study of choice, showing decreased or absent blood flow to the affected testis. However, imaging should never delay surgical intervention if the clinical suspicion is high.

Management:

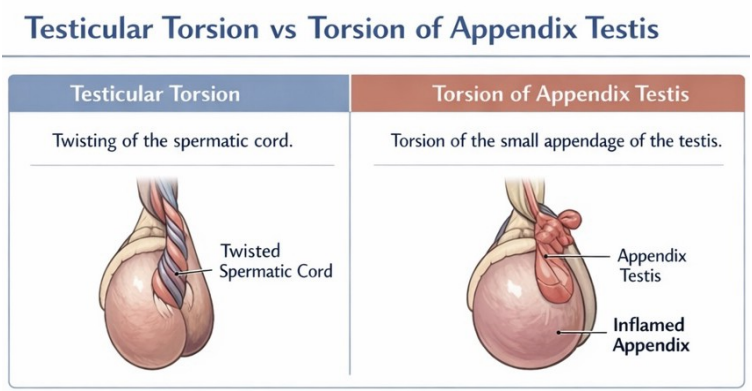
- **Manual Detorsion:** Can be attempted "opening a book" (medial to lateral rotation), but it is a temporary measure and does not replace the need for surgery.
- **Surgical Emergency:** Immediate scrotal exploration and detorsion.
- **Orchiopexy:** If the testis is viable, it is fixed to the scrotal wall. The **contralateral** testis must also be

fixed (bilateral orchiopexy) because the anatomic predisposition is usually bilateral.

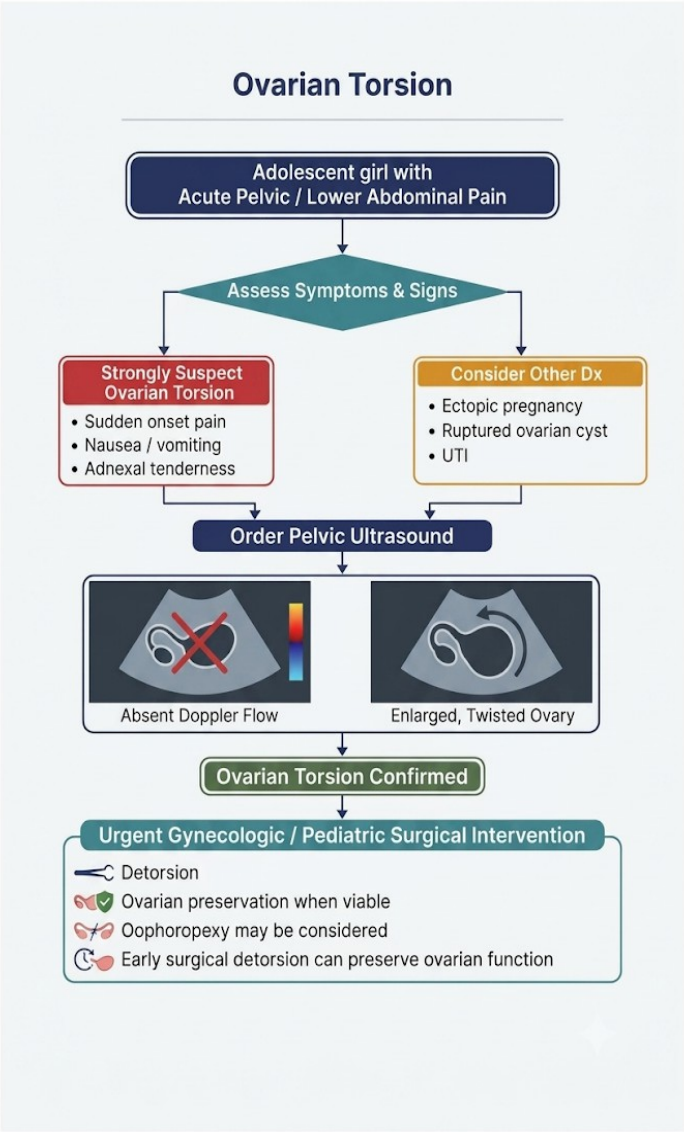
- **Orchiectomy:** If the testis is clearly necrotic, it is removed to prevent auto-antigen sensitization.

Clinical Pearls:

- The "Golden Period" for testicular salvage is less than 6 hours from the onset of pain.
- An absent cremasteric reflex is the most sensitive physical exam finding for torsion.
- A "Blue Dot Sign" on the upper pole of the testis suggests **torsion of the appendix testis**, which is managed conservatively, but torsion of the main testis must be ruled out first.
- Normal blood flow on ultrasound does not 100% rule out intermittent or early torsion; clinical judgment is paramount.



Algorithm: Ovarian Torsion



Ovarian Torsion

Clinical Overview

Ovarian torsion involves the partial or complete rotation of the ovary on its ligamentous supports, often involving the fallopian tube (adnexal torsion). This rotation compromises venous and lymphatic drainage, leading to massive stromal edema, and eventually arterial occlusion and hemorrhagic infarction. It occurs most frequently in post-menarchal females and is often associated with an ovarian cyst or mass (the "lead point").

Incidence: Represents **3%** of pediatric surgical emergencies.

Age Groups: Can occur at any age, but **50%** of cases occur in pre-menarchal girls.

Predisposing Factors: * An ovarian mass (cyst or tumor) is present in **90%** of cases in adults, but in children, **up to 50%** of torsions occur in **normal ovaries** due to an elongated mesosalpinx.

Mass Size: The "threshold of risk" is usually a mass **>5 cm**.

Side: More frequent on the **right side (60%)**, likely because the sigmoid colon on the left limits ovarian mobility.

Diagnostic Approach:

- **Clinical Presentation:** Sudden onset of severe, sharp, and often colicky lower abdominal or pelvic pain. Nausea and vomiting are very common and help differentiate it from other causes of pelvic pain.
- **Physical Exam:** Lower abdominal tenderness and occasionally a palpable adnexal mass. However, the exam can be non-specific, especially in younger children.
- **Imaging: Pelvic Ultrasound with Color Doppler** is the primary imaging modality. Key findings include an enlarged, edematous ovary with peripheral follicles (the "string of pearls" sign) and a "whirlpool sign" of the twisted vascular pedicle.
- **Note:** The presence of arterial flow on Doppler **does not** rule out torsion, as the blood supply is dual and the torsion may be intermittent.

Management:

- **Initial Management:** Fluid resuscitation, analgesia, and keeping the patient NPO for potential surgery.
- **Surgical Intervention: Laparoscopy** is the gold standard for both diagnosis and treatment.

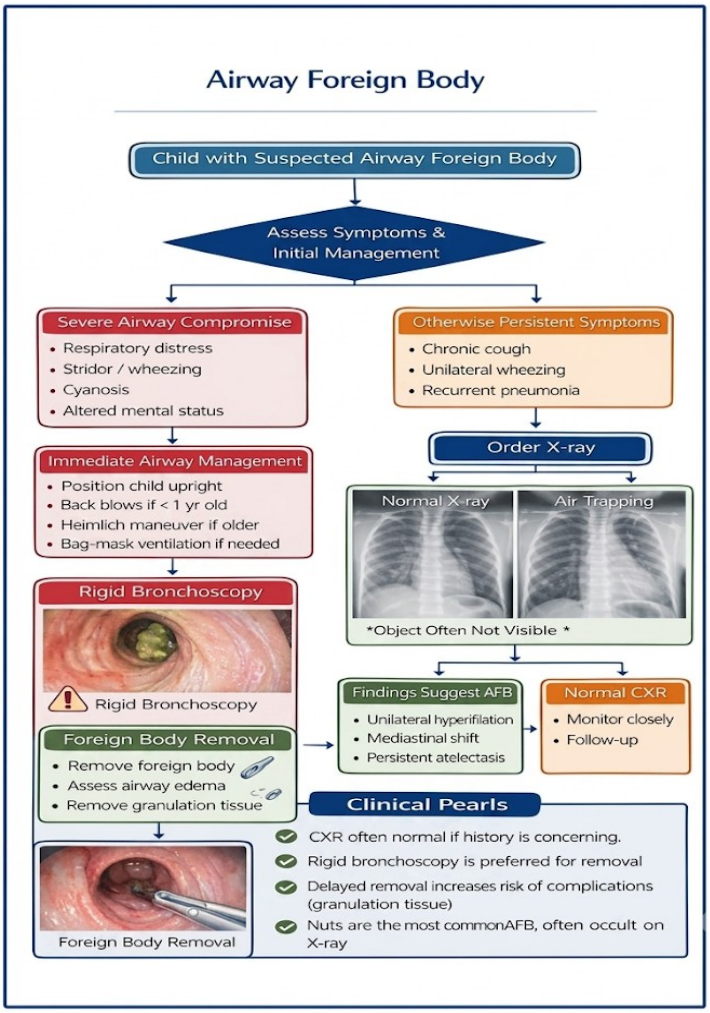
- **Detorsion:** The modern approach is to untwist the ovary (detorsion) regardless of its initial appearance (even if it looks black/dusky), as many ovaries recover function.
- **Cystectomy:** If a benign-appearing cyst is the lead point, it may be drained or removed, though this is sometimes delayed to a second procedure to allow the edema to subside.

Clinical Pearls:

- Intermittent pain that suddenly resolves may indicate "detorsion-retorsion" episodes.
- Nausea and vomiting occur in approximately 70% of cases; their presence in a girl with pelvic pain should strongly raise suspicion of torsion.
- Do not rely solely on the presence of Doppler flow to exclude the diagnosis; clinical history is more reliable.
- Oophorectomy (removal of the ovary) is rarely indicated in children unless the tissue is clearly friable and disintegrating.

Foreing Bodies

Algorithm: Airway Foreign Body



Airway Foreign Body
Clinical Overview

Foreign body ingestion is common in children, particularly between 6 months and 3 years of age. Most objects that reach the stomach pass spontaneously; however, objects lodged in the esophagus represent a risk of mucosal injury, perforation, or airway compromise. The most dangerous items are button batteries (due to electrochemical burns) and multiple magnets (due to pressure necrosis between bowel loops).

- **Mortality:** Leading cause of accidental death at home in children **<3 years**.
- **Gender:** More common in males (**2:1 ratio**).
- **Organic Objects:** Peanuts and other nuts account for **70-80%** of organic aspirations.
- **Location:** * Right main bronchus: **55-60%** (due to more vertical anatomy).
- Left main bronchus: **30-35%**.
- Larynx/Trachea: **5-10%** (Highest risk of sudden asphyxia).
- **Radiographic False Negatives:** Up to **20%** of children with a confirmed airway foreign body have a **normal initial chest X-ray**.

Diagnostic Approach

- **Clinical Presentation:** Dysphagia, drooling, gagging, or chest pain. Some children may be asymptomatic. If the object is large or high up, it may cause respiratory symptoms like stridor or wheezing due to tracheal compression.
- **Imaging: Plain radiographs (AP and Lateral)** of the neck, chest, and abdomen are mandatory.
- **Coins:** Appear as a circular "face" on AP view if in the esophagus (coronal plane).
- **Button Batteries:** Show a characteristic **"double-contour"** or "halo" sign on AP view and a step-off on the lateral view.
- **Note:** Radiolucent objects (plastic, wood, some fish bones) may not appear on X-ray; in these cases, a contrast study or direct endoscopy may be required if suspicion is high.

Management:

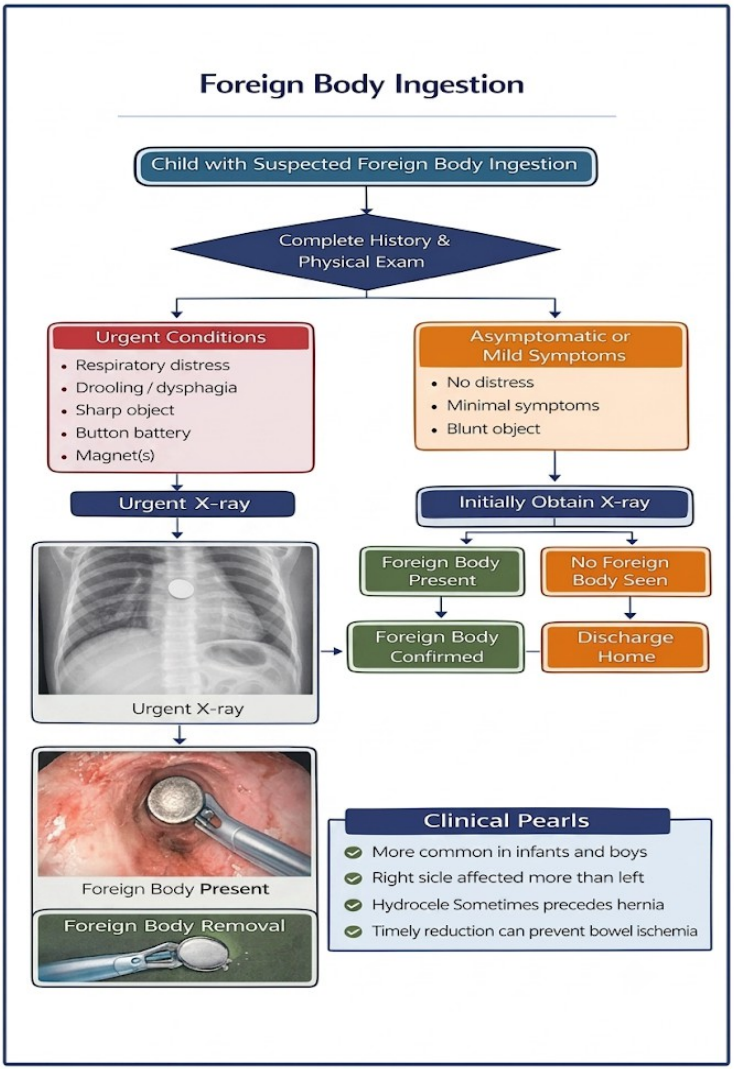
- **Urgent Endoscopy:** Indicated for:
- **Button batteries** lodged in the esophagus (absolute emergency).
- Sharp objects.

- Multiple magnets.
- Objects causing complete obstruction (drooling/ inability to swallow).
- **Observation:** Smooth, blunt objects (like coins) in an asymptomatic child may be observed for up to 24 hours to see if they pass into the stomach spontaneously. Once in the stomach, most blunt objects can be followed at home.

Clinical Pearls:

- A "coin" on X-ray must be carefully inspected for the "halo sign" to rule out a button battery; a battery can cause perforation in as little as 2 hours.
- The three most common sites of entrapment are the upper esophageal sphincter (cricopharyngeus), the mid-esophagus (aortic arch), and the lower esophageal sphincter.
- Respiratory symptoms in a child with a known ingestion suggest either tracheal compression or a shared foreign body in the airway.
- If a child has swallowed multiple magnets, they must be removed or monitored extremely closely, as they can trap segments of bowel between them, leading to fistulas.

Algorithm: Foreign Body Ingestion



Foreign Body Ingestion

Clinical Overview

Airway foreign body aspiration is a leading cause of accidental death in children under the age of 3. Most aspirated objects are organic (e.g., nuts, seeds, popcorn), but small toy parts are also common. The object most frequently lodges in the right mainstem bronchus due to its more vertical orientation, but it can also become trapped in the larynx or trachea, causing complete airway obstruction.

- **Peak Age:** 80% of cases occur in children, with a peak incidence between **6 months and 3 years**.
- **Common Objects: Coins** are the most frequently ingested object (70%).
- **Anatomic Impaction:** 75% of objects lodge at the **cricopharyngeus muscle** (the upper esophageal sphincter).
- **The Critical Danger (Button Batteries):** Can cause liquefactive necrosis and perforation within **2 hours**. Aorto-esophageal fistula is the most feared fatal complication.
- **Magnets:** Ingestion of multiple magnets carries a **100% risk** of pressure-induced bowel perforation or fistula if not removed.

Diagnostic Approach:

- **Clinical Presentation:** The classic "penetration syndrome" involves sudden choking, gagging, and coughing while eating or playing. This may be followed by a "quiescent period" where symptoms subside, leading to a dangerous delay in diagnosis. On exam, look for unilateral wheezing or decreased breath sounds.
- **Imaging: Inspiratory and Expiratory Chest X-rays** (o decubitus films in younger children) are the standard.
- **Indirect Signs:** Since most objects are radiolucent, look for **air trapping** (hyperinflation on the affected side), mediastinal shift away from the affected side, or atelectasis.
- **Note:** A "normal" chest X-ray does **not** rule out an airway foreign body if the clinical history is suspicious.

Management:

- **Initial Management:** If the child is coughing and breathing, do not interfere. If there is complete obstruction (unable to speak or cough), perform age-

appropriate back blows/chest thrusts (infants) or the Heimlich maneuver (children).

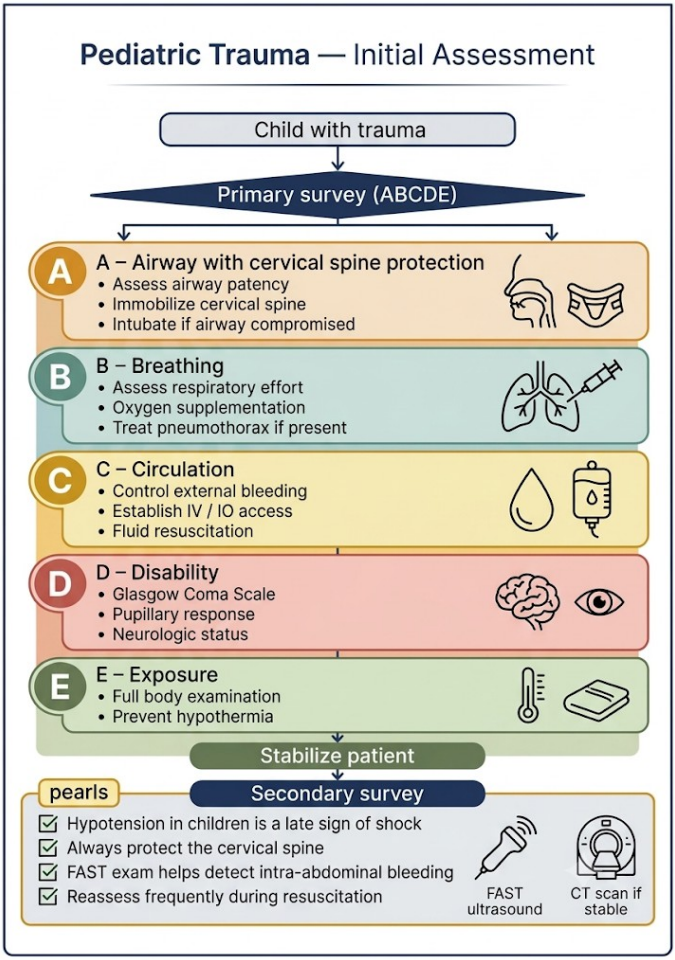
- **Definitive Treatment: Rigid Bronchoscopy** is the gold standard for both diagnosis and removal. It must be performed in a controlled operating room environment with experienced anesthesia and surgical teams.
- **Post-operative Care:** Chest physiotherapy and occasionally steroids or antibiotics if there are signs of secondary infection or significant mucosal edema.

Clinical Pearls:

- A history of sudden choking followed by a "silent" period is highly suspicious; never ignore a parent's report of a choking episode.
- Unilateral wheezing that does not respond to bronchodilators (like Albuterol) is a foreign body until proven otherwise.
- Rigid bronchoscopy is preferred over flexible bronchoscopy for object retrieval as it provides a stable airway and better instrumentation.
- Organic foreign bodies (like peanuts) are particularly dangerous because they swell and release oils that cause severe

Trauma

Algorithm: Pediatric Trauma



Initial Assessment of Pediatric Trauma (ABCDE)

The management of the injured child follows the Advanced Trauma Life Support (ATLS) principles, adapted for pediatric anatomy and physiology. Children have a higher surface-area-to-body-mass ratio, less protective fat, and more compliant bones, making them more susceptible to multisystem injury and hypothermia. The "Pediatric Trauma Triangle" (Appearance, Work of Breathing, and Circulation to Skin) is a rapid way to assess the child's status.

- Global Impact: Trauma is the leading cause of death in children over 1 year of age.
- Mechanism of Injury: Blunt trauma accounts for 80-90% of pediatric cases (falls, motor vehicle accidents, and bicycle crashes).
- Anatomic Risk: Children have a higher head-to-body ratio, making Head Injury the most common cause of traumatic death (up to 80% of fatal cases).
- Organ Vulnerability: Due to less subcutaneous fat and a more compliant rib cage, internal organs (liver, spleen) are less protected than in adults.

Abdominal Trauma

Blunt Abdominal Trauma (Splenic & Liver Injury)

- Most Affected Organs: The Spleen is the most commonly injured organ in blunt pediatric trauma, followed closely by the Liver.
- Non-OperativeManagement(NOM):Inhemodynamically stable children, NOM is successful in over 90-95% of splenic and liver injuries, regardless of the CT grade.
- Mortality: Isolated solid organ injury has a low mortality (<5%); however, mortality rises significantly when associated with hollow viscus injury or severe head trauma.
- The "Seatbelt Sign": The presence of a transverse abdominal bruise from a seatbelt is associated with a 25% risk of intra-abdominal injury (specifically hollow viscus or Chance fracture of the spine).

Airway (with cervical spine protection)

- Assess airway patients
- Look for obstruction (blood, secretions, foreign body)
- Provide airway support as needed
- Maintain cervical spine immobilization

Breathing

- Assess respiratory effort and symmetry
- Check oxygen saturation
- Provide supplemental oxygen
- Identify life-threatening conditions (e.g., tension pneumothorax)

Circulation

- Assess heart rate, pulses, and capillary refill
- Control external bleeding
- Establish IV/IO access
- Fluid resuscitation: 20 mL/kg isotonic bolus (repeat as needed)

Disability (neurologic status)

- Assess level of consciousness (AVPU or GCS)
- Check pupil size and reactivity

Exposure

- Fully exposed the patient
- Look for hidden injuries
- Preventing hypothermia

Unstable patient:

- Continue resuscitation
- Immediate surgical consultation
- Prepare for urgent intervention (OR if indicated)

Stable patient:

- Proceed to Secondary Survey

APROACH

- Full head-to-toe examination
- Detailed history (AMPLE):
    - Allergies
    - Medications
    - Past medical history
    - Last meal
    - Events surrounding the injury
    - Order imaging and labs as indicated

Management:

- **Resuscitation:** Initial fluid bolus of **20 mL/kg** of isotonic crystalloid (Normal Saline or Lactated Ringer's). If the child remains hemodynamically

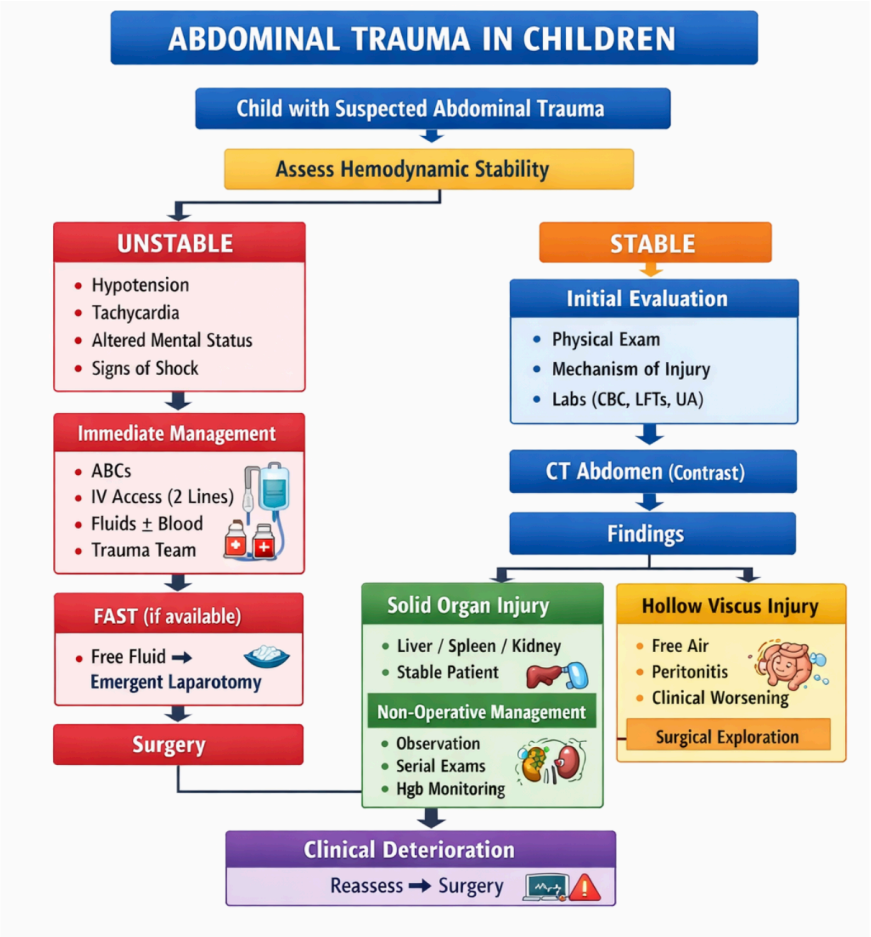
unstable after two boluses, initiate blood products (10 mL/kg).

- **Secondary Survey:** A head-to-toe examination and detailed history (AMPLED: Allergies, Medications, Past medical history, Last meal, Events/Environment, Drugs/Immunization).
- **Definitive Care:** Transfer to a pediatric trauma center if specialized surgical or intensive care is required.

Clinical Pearls:

- Hypotension in a child is a **late sign** of shock; treat based on tachycardia and perfusion.
- The large head of a young child causes neck flexion when supine; use a shoulder roll to maintain a neutral airway position.
- Gastric decompression with a nasogastric tube is essential in pediatric trauma to improve respiratory effort and facilitate the abdominal exam.
- "Children are not small adults"their ribs are more elastic, so significant internal organ injury can occur without overlying rib fractures.

Algorithm: Abdominal Trauma



Clinical Overview

The abdomen is the third most commonly injured area in pediatric trauma. Because children have less abdominal wall musculature and a more flexible rib cage, their solid organs (liver, spleen, and kidneys) are less protected and more prone to injury from blunt forces, such as motor vehicle accidents, falls, or handlebar injuries. The primary goal is to identify intra-abdominal hemorrhage or hollow viscus injury while avoiding unnecessary surgery.

Diagnostic Approach:

- Clinical Presentation: Abdominal pain, tenderness, distension, or seatbelt signs (ecchymosis across the abdominal wall). Referred pain to the left shoulder (Kehr's sign) may indicate splenic injury.

Initial Screening:

- FAST Exam: Useful for detecting free intraperitoneal fluid, though a negative FAST does not rule out solid organ injury in children.
- Laboratory Tests: Elevated liver transaminases (AST/ALT) or amylase/lipase can suggest specific organ injury

- Gold Standard Imaging: CT scan of the Abdomen and Pelvis with IV contrast is the definitive study for stable patients to grade solid organ injuries and look for "blush" (active extravasation) or free air.

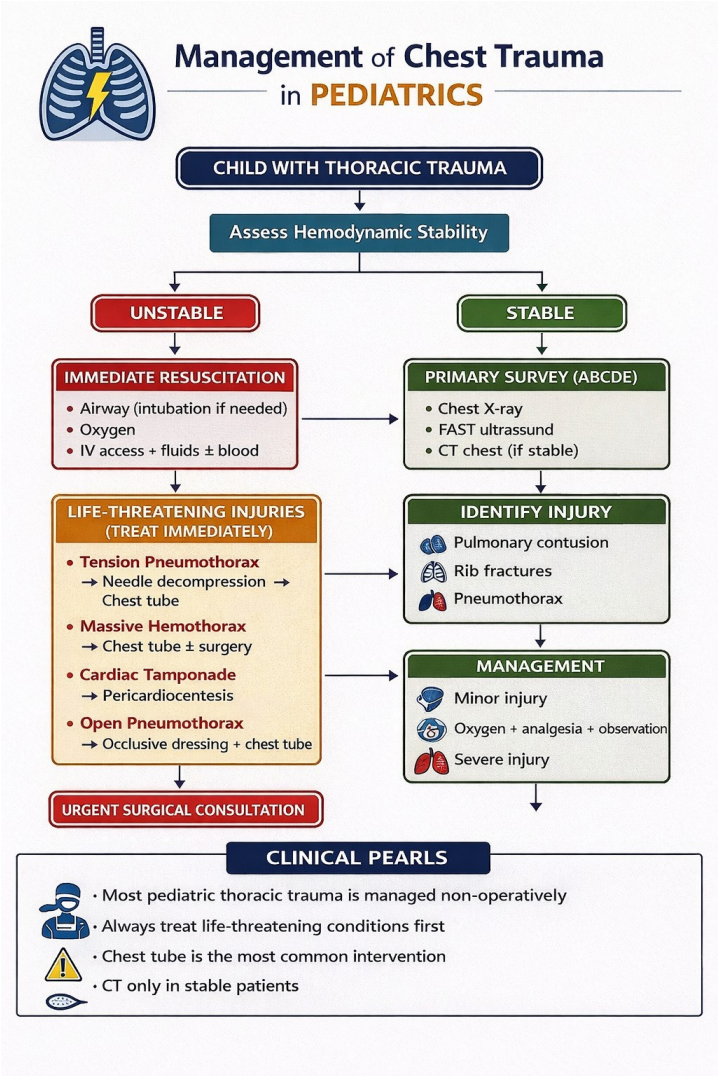
Management:

- Hemodynamically Unstable: If the patient remains unstable despite adequate fluid and blood resuscitation (transfusion of >40 mL/kg), immediate Laparotomy is indicated.
- Hemodynamically Stable: The vast majority of pediatric solid organ injuries (Spleen, Liver, Kidney) are managed non-operatively, regardless of the injury grade. This involves:
- Admission for serial abdominal exams and hemoglobin monitoring.
- Strict bed rest (duration typically depends on the grade of injury).
- Activity restrictions upon discharge.
- Hollow Viscus Injury: If free air or signs of peritonitis are present, surgical exploration is required to repair bowel perforations.

Clinical Pearls:

- "The Pediatric Rule": Hemodynamic stability, not the CT grade of the injury, determines the need for surgery.
- A "Seatbelt Sign" is highly associated with hollow viscus (bowel) injury and lumbar spine fractures (Chance fractures).
- Handlebar injuries are classic triggers for isolated pancreatic or duodenal injuries due to compression against the spine.
- Delayed presentation of abdominal pain and bilious vomiting after trauma should raise suspicion for a duodenal hematoma.

Algorithm: Thoracic Trauma



Thoracic Trauma

Clinical Overview

Thoracic injuries are the second leading cause of trauma-related death in children. Due to a highly compliant chest wall, children rarely sustain rib fractures; however, the kinetic energy is transmitted directly to the underlying parenchyma, leading to pulmonary contusions. The most life-threatening conditions—tension pneumothorax, massive hemothorax, and cardiac tamponade—must be identified during the Primary Survey.

- Frequency: Occurs in only 5-10% of pediatric trauma cases but carries a high mortality rate (up to 25%).
- Compliance: The pediatric chest wall is highly compliant. Therefore, severe internal injuries (Pulmonary Contusion) can occur without overlying rib fractures.
- Rib Fractures: Presence of rib fractures in a young child is a marker of high-energy impact and should increase suspicion for underlying lung or solid organ injury.
- Tension Pneumothorax: A life-threatening emergency that must be diagnosed clinically (respiratory distress, tracheal deviation, absent breath sounds) before X-ray.

Diagnostic Approach:

- **Clinical Presentation:** Respiratory distress, tachypnea, hypoxia, or pleuritic chest pain. Physical exam may show a deviated trachea, absent breath sounds, or crepitus (subcutaneous emphysema).

Initial Screening:

- **Chest X-ray (AP):** The initial study of choice to identify pneumothorax, hemothorax, or widened mediastinum.
- **eFAST Exam:** Highly sensitive for detecting pneumothorax and pericardial effusion at the bedside.
- **Advanced Imaging: CT scan of the Chest** with IV contrast is the gold standard for stable patients to evaluate for pulmonary contusions, aortic injury, or tracheobronchial tears.

Management:

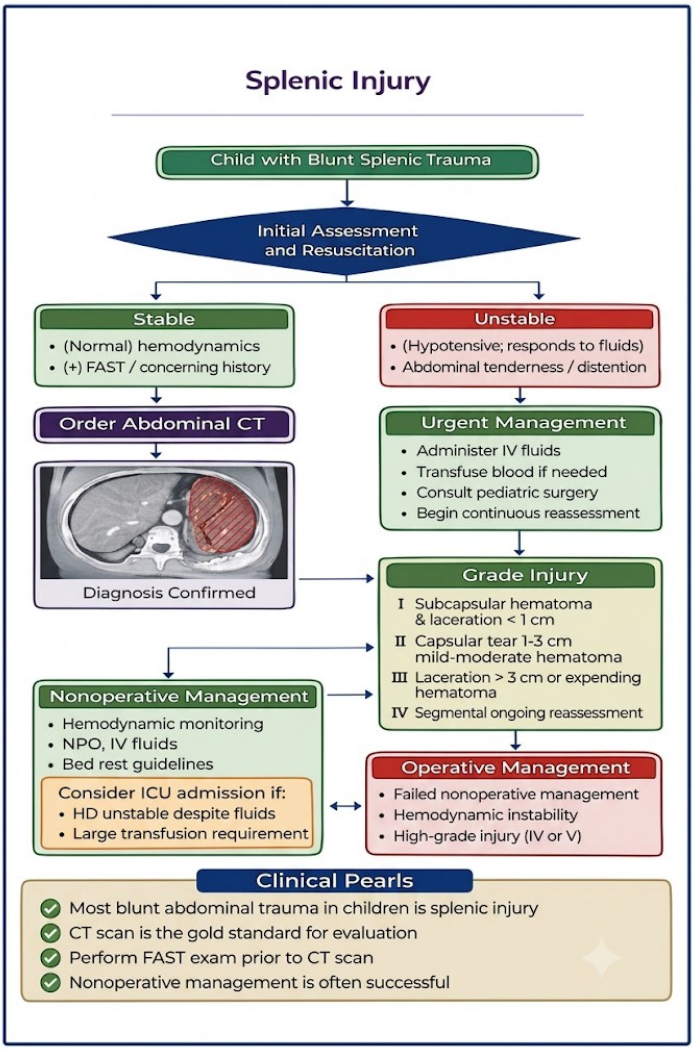
- **Life-Threatening Injuries: *Tension Pneumothorax:** Immediate needle decompression followed by tube thoracostomy (chest tube).
- **Massive Hemothorax:** Tube thoracostomy and volume resuscitation.

- **Pulmonary Contusion:** Primarily supportive care with supplemental oxygen, aggressive pulmonary toilet, and pain management. Avoid over-resuscitation with IV fluids, as it can worsen the contusion.
- **Rib Fractures:** Require excellent pain control (often regional anesthesia) to prevent splinting and secondary pneumonia.

Clinical Pearls:

- "The Pliable Chest": A child can have a severe **pulmonary contusion** or even a transected bronchus without a single broken rib.
- If a chest tube is placed for a pneumothorax and a massive, continuous air leak persists, suspect a **tracheobronchial tree injury**.
- The presence of rib fractures in a young child should raise a high index of suspicion for **Non-Accidental Trauma (NAT)**.
- Commotio cordis (sudden cardiac arrest from a blunt blow to the chest) is a rare but critical consideration in pediatric sports-related trauma.

Algorithm: Splenic Trauma



Splenic Injury

Clinical Overview

The spleen is highly susceptible to injury in children due to its relatively large size, thin capsule, and less protected position beneath a compliant rib cage. Most injuries result from motor vehicle accidents, falls, or direct blows (e.g., handlebar or sports injuries). The modern management of pediatric splenic trauma is overwhelmingly non-operative, as the spleen plays a vital role in immune function, particularly in filtering encapsulated bacteria.

- Mechanism: Usually, a direct blow to the left upper quadrant (falls, motor vehicle accidents, or sports).
- Anatomy: The pediatric spleen is more protected by the rib cage than in adults, but its capsule is thinner.
- Non-Operative Management (NOM): Over 90% of pediatric splenic injuries are managed without surgery, regardless of the grade, provided the patient is hemodynamically stable. This preserves splenic immune function, preventing OPSI (Overwhelming Post-Splenectomy Infection).

Diagnostic Approach:

- **Clinical Presentation:** Left upper quadrant (LUQ) pain and tenderness. **Kehr's sign** (referred pain to the left shoulder) is a classic finding due to diaphragmatic irritation.

Imaging:

- **FAST Exam:** Used in the trauma bay to identify free fluid (hemoperitoneum).
- **CT scan with IV Contrast:** The gold standard for stable patients. It allows for **AAST (American Association for the Surgery of Trauma) Grading** (I to V) based on the depth of laceration or the extent of subcapsular hematoma.
- **Laboratory Findings:** Serial hemoglobin/hematocrit monitoring is essential to assess for ongoing blood loss.

Management:

- **Non-Operative Management (NOM):** The standard of care for hemodynamically stable children, regardless of the CT grade. This includes:
- Intensive care or close ward observation.
- Serial abdominal exams and hemoglobin checks.

- Strict bed rest for a period determined by the grade of injury.
- **Angioembolization:** May be considered in stable patients with a "contrast blush" (active extravasation) on CT.
- **Surgical Intervention (Splenectomy/ Splenorrhaphy):** Reserved only for patients with **hemodynamic instability** refractory to aggressive fluid and blood resuscitation (>40 mL/kg of blood products).

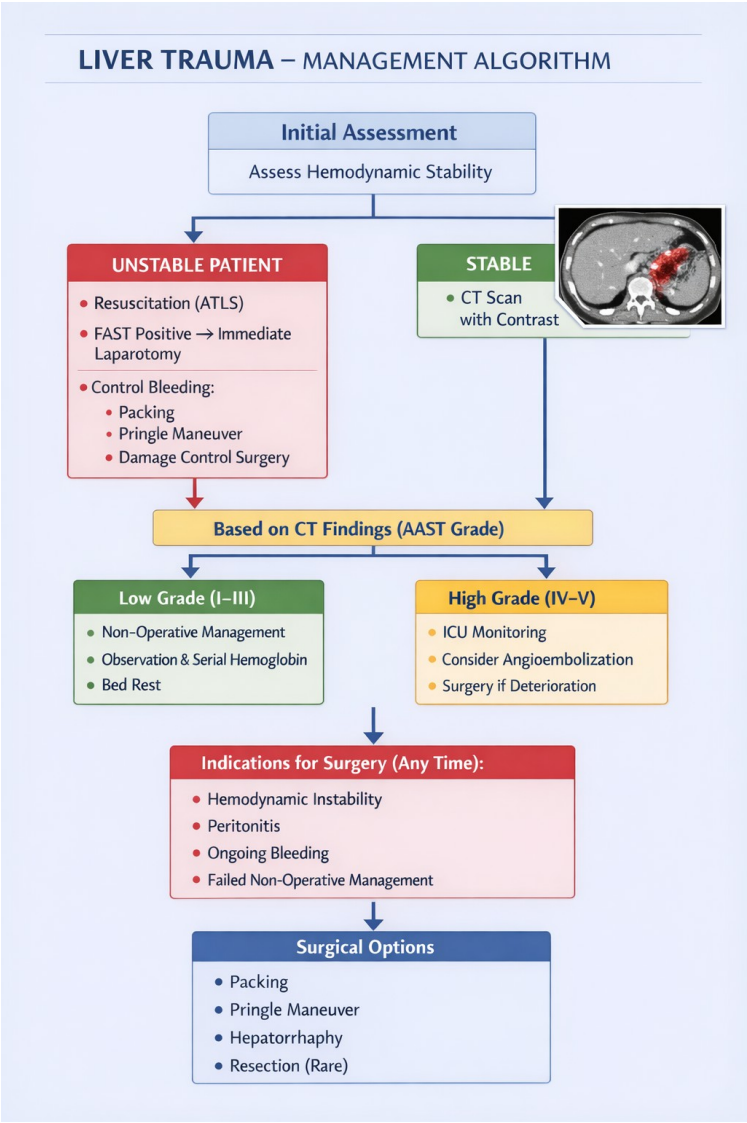
Clinical Pearls:

- "Grade does not dictate surgery": A stable Grade IV injury is managed non-operatively, while an unstable Grade II injury may require a laparotomy.
- Over 90% of pediatric splenic injuries can be successfully managed without surgery.

Overwhelming Post-Splenectomy Sepsis (OPSS): If a splenectomy is performed, the child requires lifelong vaccinations (Pneumococcus, Meningococcus, H. influenzae) and prophylactic antibiotics.

- Delayed splenic rupture is rare in children but should be considered if there is a sudden drop in hemoglobin days after the initial injury.

Algorithm: Liver Trauma



Liver Trauma

Clinical Overview:

Hepatic injuries in children usually result from blunt force to the right upper quadrant (RUQ). Because the pediatric liver is relatively large and less protected by the ribs, it is prone to subcapsular hematomas and parenchymal lacerations. The majority of these injuries can be managed non-operatively, but high-grade injuries (Grade IV-V) or those involving the retrohepatic veins can be life-threatening.

Diagnostic Approach:

- Clinical Presentation: RUQ pain, tenderness, and occasionally right shoulder pain. Watch for signs of hemorrhagic shock (tachycardia, delayed capillary refill).
- Laboratory Findings: Significant elevation of AST/ALT (>200 U/L) is a highly sensitive marker for hepatic injury in the setting of trauma.

Imaging:

- FAST Exam: To identify free fluid (hemoperitoneum) in the perihepatic space (Morison's pouch).

- CT Scan with IV Contrast: The gold standard to grade the injury (AAST Grade I-VI). Look specifically for a "contrast blush" indicating active arterial bleeding.

Management:

- Non-Operative Management (NOM): The standard of care for hemodynamically stable patients. Includes ICU/ward observation, serial abdominal exams, and hemoglobin monitoring.
- Angioembolization: A valuable tool for stable patients with active arterial extravasation (blush) on CT, avoiding the need for laparotomy.
- Surgical Intervention: Indicated only for hemodynamic instability despite aggressive resuscitation. Surgical options include packing the liver, Pringle maneuver (clamping the hepatoduodenal ligament), or primary repair.
- ERCP: May be required late in the course (5–7 days) if there is evidence of a bile leak or persistent biloma.

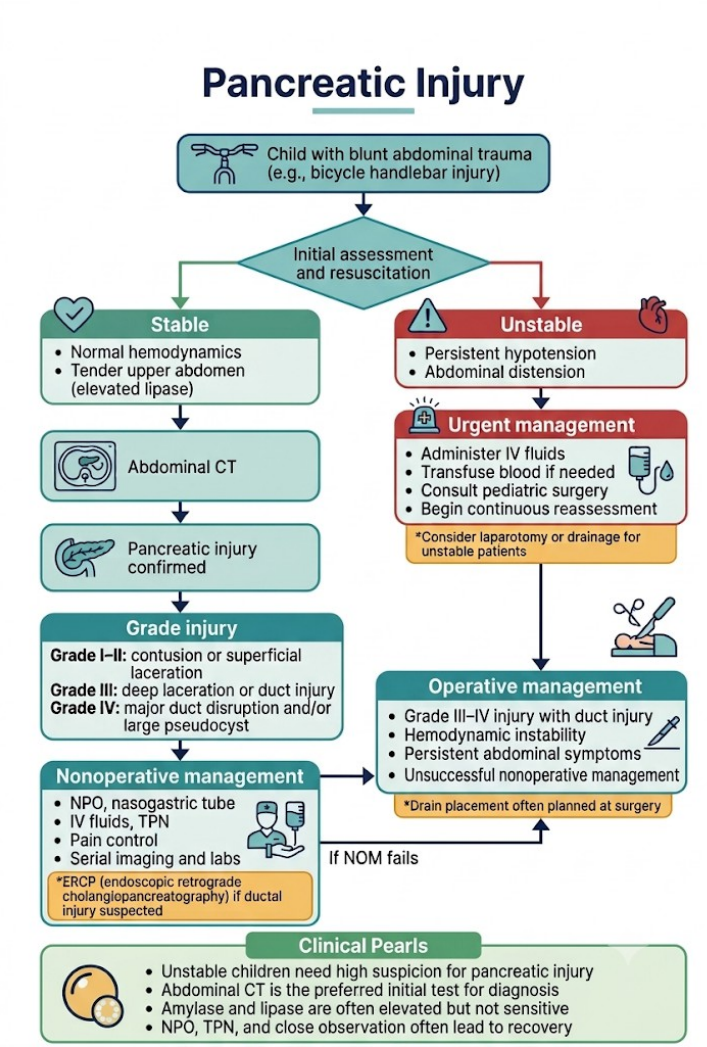
Clinical Pearls:

- "Stability over Grade": Like the spleen, a Grade V liver laceration in a stable child is managed without surgery.

- Liver injuries have a higher association with bile leaks and bilomas than splenic injuries; monitor for delayed fever or increasing abdominal distension.
- The Pringle Maneuver is a life-saving surgical technique to control bleeding by compressing the portal vein and hepatic artery.
- If AST/ALT are normal after blunt trauma, a significant liver injury is extremely unlikely.

Pancreatic Injury

Algorithm: Pancreatic Trauma



Pancreatic Injury

Clinical Overview

Pancreatic injuries in children are relatively rare but classic in specific mechanisms of injury, such as a direct blow to the epigastrium (e.g., bicycle handlebar injury, a fall onto a blunt object, or a seatbelt injury). The pancreas is compressed against the rigid vertebral column, leading to contusion, laceration, or complete transection. The most critical factor in management is whether the main pancreatic duct is intact.

Diagnostic Approach:

- **Clinical Presentation**: Initial symptoms may be mild. Patients often present with epigastric pain, nausea, and vomiting that worsen over 24–48 hours as "traumatic pancreatitis" develops.
- **Laboratory Findings:** Serum Amylase and Lipase levels are usually elevated, though they may be normal in the first few hours after injury. Serial monitoring is more useful than a single value.

Imaging:

- CT Scan with IV Contrast: The initial study of choice. Look for pancreatic edema, peripancreatic fluid, or a visible fracture line.

- MRCP (Magnetic Resonance Cholangiopancreatography): The gold standard for evaluating the integrity of the pancreatic duct if CT findings are equivocal.
- ERCP: Reserved for therapeutic intervention (e.g., stenting a ductal leak).

Management:

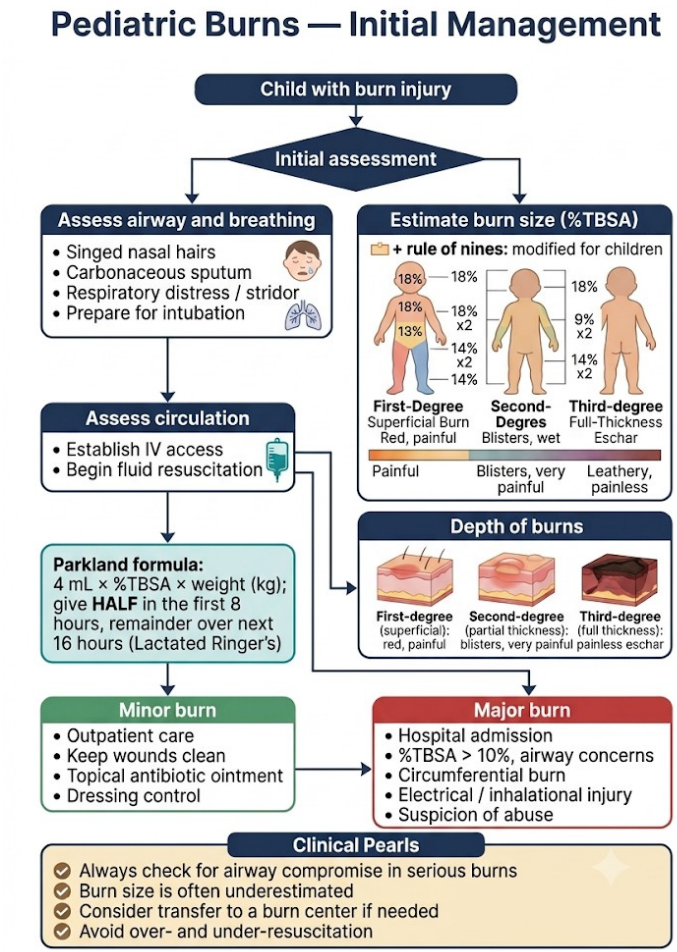
- Grade I-II (Contusion/Minor Laceration): Managed non-operatively with bowel rest (NPO), intravenous fluids, and gradual advancement of diet.
- Grade III-V (Ductal Injury/Transection): * Distal Transection: Usually managed with a distal pancreatectomy (often spleen-preserving).
- Proximal/Head Injury: Managed more conservatively with external drainage to allow a controlled fistula to form, as resection of the head (Whipple) is rarely indicated in trauma.
- Complications: Pancreatic Pseudocysts are common post-trauma. Many resolve spontaneously; others may require percutaneous or internal drainage if they become large or symptomatic.

Clinical Pearls:

- A "Handlebar Injury" to the upper abdomen is a pancreatic or duodenal injury until proven otherwise.
- Initial CT scans can miss up to 40% of pancreatic injuries in the first few hours; if symptoms persist, repeat imaging is mandatory.
- The management of pancreatic trauma is increasingly shifting toward non-operative drainage of ducts, even in some high-grade injuries, to preserve endocrine and exocrine function.
- Persistent vomiting after abdominal trauma should raise suspicion for either a pancreatic injury or a duodenal hematoma.

Burns

Algorithm: Burns



Clinical Overview

Burns in children are most commonly scalds (hot liquids) in toddlers and flame burns in older children. The severity of a burn is determined by the depth (Superficial, Partial-thickness, or Full-thickness) and the Total Body Surface Area (TBSA) affected. Inhalation injury must always be suspected in closed-space fires.

- **Mechanism:** Scalds (hot liquids) are the leading cause of burns in children under 5 years (60-70%). Flame burns become more common in older children and adolescents.
- **Location:** Most pediatric burns occur in the kitchen or bathroom.
- **Total Body Surface Area (TBSA):** Children have a larger head-to-body ratio. Using the "Rule of Nines" without modification leads to errors; the Lund-Browder Chart is the gold standard for pediatric assessment.
- **Inhalation Injury:** Present in 10-20% of patients admitted to burn units and is the strongest predictor of mortality.

Diagnostic and Management Approach

Initial management follows the ABCDE approach, with special attention to airway compromise.

Assess burn severity:

- TBSA (use age-appropriate charts)
- Depth of burn
- Location (face, hands, genitalia)

Airway:

- Consider inhalation injury in facial burns or smoke exposure
- Early intubation if suspected

Fluid resuscitation:

- Indicated for burns ≥10–15% TBSA
- Use Parkland formula: 4 mL × kg × %TBSA (Lactated Ringer)
- Give 50% in the first 8 hours, 50% in the next 16 hours
- Target urine output ≥1 mL/kg/hr

Additional management:

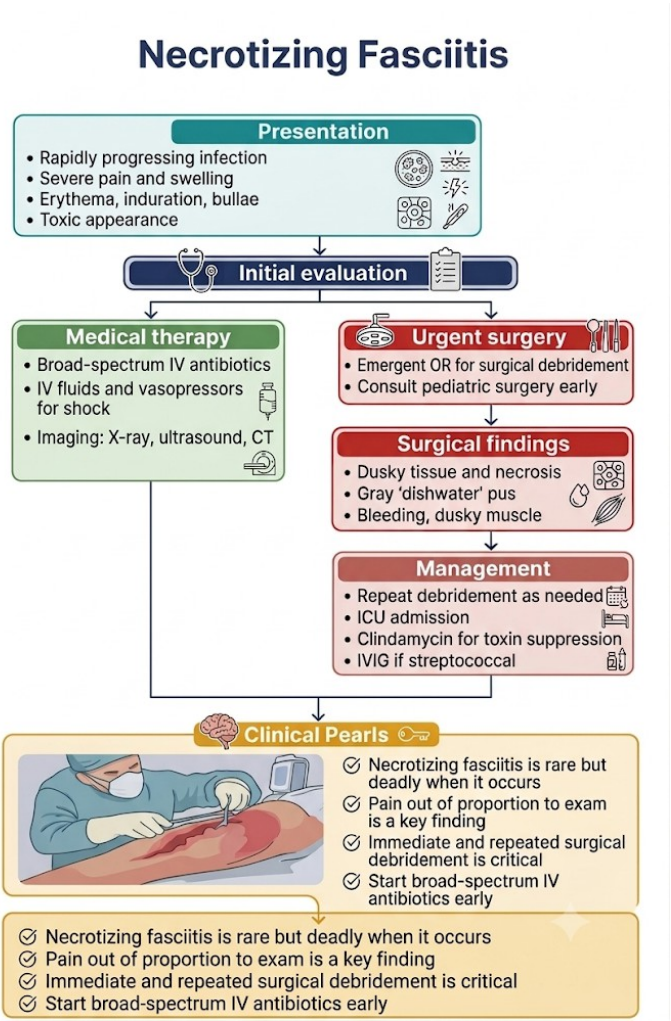
- Adequate analgesia
- Wound care and sterile dressings
- Tetanus prophylaxis if indicated

Consider transfer to a burn center for severe injuries.

Clinical Pearls

- "The head is big": In an infant, the head accounts for nearly 18% of TBSA, whereas in an adult it is only 9%.
- **Hypothermia** is a major risk during the initial assessment; keep the room warm and use warm blankets.
- Urine output is the best indicator of adequate resuscitation (Goal: **1 mL/kg/hr** for children <30 kg).
- Always consider **Non-Accidental Trauma (NAT)** if the burn pattern is symmetric (e.g., "stocking/glove" immersion) or lacks splash marks.

Necrotizing Fasciitis & Soft Tissue Infections



Soft Tissue Infections

Clinical Overview:

Necrotizing fasciitis is a life-threatening, rapidly progressive "flesh-eating" bacterial infection of the deep fascia and subcutaneous tissues. It leads to vascular thrombosis and widespread tissue necrosis. In children, it is often polymicrobial (Type I) or caused by Group A Streptococcus (Type II). Mortality is high, and survival depends entirely on early clinical suspicion and immediate surgical intervention.

- Incidence: Rare in children but carries a high mortality rate (10-25%).
- Risk Factors: In neonates, it often starts from omphalitis (umbilical cord infection) or post-circumcision. In older children, it follows varicella (chickenpox) lesions or trauma.
- Microbiology: * Type I: Polymicrobial (aerobes + anaerobes).
- Type II: Monomicrobial (most commonly Group A Streptococcus).
- Site: The trunk and extremities are most affected. In the perineal area, it is known as Fournier’s Gangrene.
- Diagnostic Approach:

- Clinical Presentation: The hallmark is "pain out of proportion" to the physical exam findings. Early signs include erythema, warmth, and edema.
- Red Flags: Rapidly spreading borders, crepitus (gas in tissues), skin bullae (fluid-filled blisters), and skin anesthesia (due to nerve destruction).
- Systemic Signs: High fever, tachycardia, and "toxic" appearance. Late-stage signs include "dishwater" drainage and septic shock.
- Imaging: While diagnosis is primarily clinical, Plain X-ray may show subcutaneous gas. CT Scan is more sensitive, showing fascial thickening and gas along tissue planes. Never delay surgery for imaging if suspicion is high.

Management:

- Surgical Emergency: Immediate and aggressive surgical debridement of all necrotic tissue until healthy, bleeding tissue is reached. Multiple return trips to the operating room (serial debridement) are almost always required.
- Antibiotics: Start broad-spectrum IV antibiotics immediately (e.g., Vancomycin, Piperacillin/Tazobactam, and Clindamycin—which is critical for its

antitoxin effect against Group A Strep).

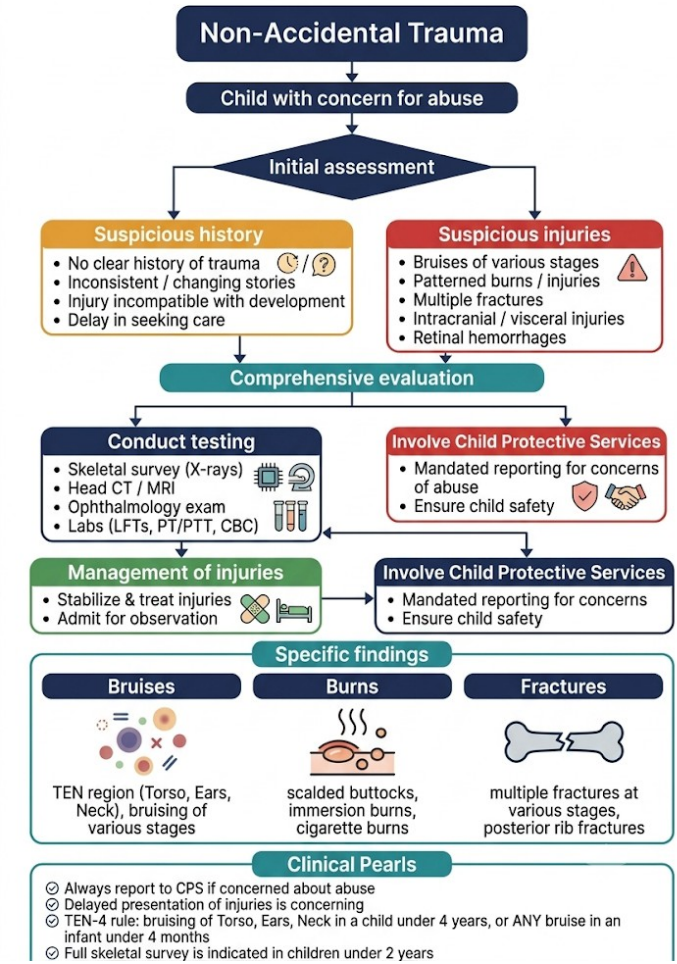
- Supportive Care: Aggressive fluid resuscitation in the ICU, nutritional support, and potentially hyperbaric oxygen therapy if available.

Clinical Pearls:

- "The Finger Test": During surgery, if the fascia separates easily from the muscle with a finger and there is a lack of bleeding, the diagnosis is confirmed.
- In neonates, necrotizing fasciitis often starts at the umbilicus (omphalitis) or after a circumcision.
- Hardness or "woody" induration of the skin is a classic late sign of deep tissue destruction.
- If you see gas on an X-ray in a child with a skin infection, they are in the operating room until proven otherwise.

Child Protection

Algorithm; Non-Accidental Trauma (NAT) / Child



Non-Accidental Trauma

Abuse

Clinical Overview

- Incidence: Approximately 1 in 10 children experience some form of maltreatment.
- Age Group: The highest risk of fatality is in children under 1 year of age.
- Skeletal Markers: "Classic Metaphyseal Lesions" (CML) and posterior rib fractures have a high specificity for abuse.
- Head Trauma: Abusive Head Trauma (AHT) is the leading cause of death from NAT.
- Legal Duty: In most jurisdictions, physicians have a mandatory reporting obligation upon "reasonable suspicion."

Definition: Physical injury inflicted upon a child by a caregiver (Child Abuse). As a surgeon, you are often the first line of detection for these patients.

- **Legal Responsibility:** In almost all jurisdictions, medical professionals are **mandated reporters**. You do not need proof, only "reasonable suspicion."

- **High-Risk Groups:** Infants <1 year old and children with developmental disabilities.

Diagnostic Approach

1. THE HISTORY (The "Inconsistency" Rule)

- The mechanism of injury does not match the child's developmental age (e.g., a 2-month-old "falling" off a couch).
- Delay in seeking medical attention.
- Story changes between different caregivers.

2. PHYSICAL EXAM SIGNS

- **Bruising:** "If they don't cruise, they shouldn't bruise." Look for bruises on the ears, neck, or torso (TEN-4-FACESp rule).
- **Patterned Injuries:** Cigarette burns, belt marks, or bite marks.
- **Fractures:** Femur fractures in non-ambulatory infants or posterior rib fractures (highly specific for shaking/ squeezing).

3. THE WORKUP

- **Skeletal Survey:** X-rays of every bone in the body (mandatory in children <2 years with suspected NAT).

- **Head CT/MRI:** To look for Subdural Hematoma (SDH) or Retinal Hemorrhages.

CLINICAL PEARLS & SURGICAL INSIGHTS

- **Rib Fractures in Infants:** Are nearly pathognomonic for NAT. It takes a massive force to break an infant's pliable ribs.
- **The "Wait" Period in Trauma:** If a child has a pulmonary contusion, the X-ray might look normal initially. The "white-out" often develops **6–12 hours** after the initial event.
- **Documenting Injuries:** Use neutral, objective language. Instead of "The father burned the child," write "There is a 2cm circular partial-thickness burn on the left palm; history provided by father is inconsistent with clinical findings."

TRAUMA MONITORING BUNDLE

1. **Analgesia:** Adequate pain control is vital to prevent splinting and atelectasis in chest trauma.
2. **Multidisciplinary Team:** For NAT, involve Social Work, Child Protection Services (CPS), and specialized pediatrics immediately.

3. **The "Safety" Admission:** If you suspect NAT, the child should be admitted for "social protection" regardless of the severity of the surgical injury.

References & Suggested Reading

1. Ashcraft's Pediatric Surgery, 7th Edition.
2. Holcomb, Murphy, & St. Peter. Elsevier (2019).
3. Pediatric Surgery, 7th Edition. Coran, Adzick, Krummel, et al. Elsevier Saunders (2012).
4. Advanced Trauma Life Support (ATLS), 10th
5. Edition. American College of Surgeons (2018).
6. The Mont Reid Surgical Handbook, 7th
7. Edition. Elsevier (2018).
8. APSA (American Pediatric Surgical
9. Association). Clinical Practice Guidelines and Outcomes Resources.
10. WHO Guidelines on Hygiene in Health Care. World Health Organization (2009).

Medical Disclaimer

Important Notice:

The information provided in Pediatric Surgery in Algorithms is intended for educational and informational purposes only. It is designed to assist medical students, residents, and healthcare professionals in clinical decision-making and is not a substitute for formal medical training, professional judgment, or institutional protocols.

No Physician-Patient Relationship:

The use of this manual does not establish a physician-patient relationship. While every effort has been made to ensure the accuracy of the dosages, algorithms, and clinical data at the time of publication, medical knowledge is constantly evolving.

Clinical Responsibility:

Practitionersmustalwaysverifydosages,contraindications, and procedures with the latest official drug inserts and hospital guidelines. The author and publisher shall not be held responsible for any clinical outcomes, errors, or omissions resulting from the application of the information contained in this book.

Emergency Situations:

In any clinical emergency, follow your local Advanced Life Support (ALS) or Pediatric Advanced Life Support (PALS) protocols and consult with a senior board-certified pediatric surgeon.