Common Pediatric Surgical Emergencies

Objectives:
- Appendicitis, Pyloric Stenosis, Intussusception
  1. Describe the clinical presentation of these common pediatric surgical conditions
  2. Review the pathophysiology of these common pediatric surgical conditions
  3. Discuss operative approaches and surgical care of infants and children with these conditions (some new stuff too)

Assessing Abdominal Pain in Children: A Humbling Experience

Abdominal Pain – very common complaint in kids
- History difficult to pinpoint specifics, kids don’t pay attention/easily distracted/stoic, symptoms ignored/not appreciated by parents.
- Physical Exam – age difficulties (infant, teenager), size considerations, intimidation by MD or system
- Supplemental Diagnostic Procedures: no one perfect test, more time/resources, can still be inconclusive.

EVALUATION: “Abdominal Pain” - History of Present Illness -
- Location, movement of pain
- Quality, duration, severity of pain
- Triggers / Relief Factors
- Associated Symptoms - Anorexia, Nausea/Emesis, bowel habits, fevers/chills, etc

EVALUATION: Additional History
- Age of patient
- Pre-existing medical conditions
- Family History
- Trauma
- Exposures, food consumption
- Last menstrual period
EVALUATION: “Abdominal Pain” - Physical Exam -

Overall appearance: resting vs. agitated, acute distress

Vital Signs - fevers, tachycardia

Hydration status: mucous membranes, cap refill, urine output/wet diapers

Lung Exam: attention to RLL, recent coughing spells

Musculoskeletal: ability/posture with walking, lower extremity movement.

EVALUATION: “Abdominal Pain” - Abdominal Exam -

Abdomen-masses, presence of hernias

Tenderness: location, severity

Peritoneal Signs: percussion, shake, rebound, heel tap, guarding, hyperesthesia

Referred Signs: Rovsing’s, obturator, psoas

Appendicitis

Inflammation of the appendix

Most common abdominal surgical problem in children, occurs in approx. 7% of all people

Classic history: early periumbilical visceral pain, then nausea/fever, then RLQ focal pain

Sine qua non: focal RLQ pain with peritoneal signs

Peak Incidence at 10-12 yrs.

Increased complication rate in very young (<5 yrs)

Huge variation in presentation

5-10% negative rate for appendicitis balanced against risks of perforation.

Appendicitis

Pathophysiology: Luminal Obstruction

• Fecalith (30-40% of specimens)
• Lymphoid hyperplasia
• Food / foreign body
• Parasites
• Cancer

The Appendix

What does the appendix “do”?!

• Nothing
• Immune / neuroendocrine function
• Bacterial storage

Obstruction

Inflammation

Ischemia

Perforation

Distention

Increased Pressures

Bacterial overgrowth

Translocation
Pathophysiology: **Luminal Obstruction**

**Too Simple?**

- Several studies have shown appendicitis without obstruction
  - Ones study measuring intraluminal pressures
  - Gangrenous – have increased pressures
  - Phlegmonous – normal pressures

- Acute appendicitis vs. perforated appendicitis: separate entities?

- Neuroimmune appendicitis
  - Serotonin (increase mucosal secretions, Nausea / emesis)
  - VIP (neural proliferation = increased pain without inflammation?)
  - Morphologically normal appendix with appendicitis symptoms

**Physiology of Pain**

**“Visceral” pain**

- Foregut – Celiac – epigastric
- Midgut – SMA – periumbilical
- Hindgut – IMA – suprapubic

- Autonomic mediated, bilaterally innervated
- Associated autonomic symptoms: sweating, nausea, tachycardia; poorly localized

**Appendix innervation**

- T8 – T10 = referred pain to epigastric / periumbilical area

**“Somatic” pain**

- Parietal peritoneum, mesentery
- Unilateral innervation from spinal nerves
- Sharp, precisely localized
- Exacerbated with movement, palpation

**Variable locations for appendix**

- Retrocecal
- Pelvic
- Midline
- Malrotation

**Appendicitis:**

- School aged child (age 5-12 years)
  - Based upon observational studies, the relative frequency and variability of clinical findings in infants and children younger than five years is as follows:
    - Abdominal pain – 72 to 94 percent
    - Fever – 62 to 90 percent
    - Vomiting – 80 to 83 percent
    - Rebound tenderness – 81 percent
    - Guarding – 62 to 72 percent
    - Anorexia – 42 to 74 percent
    - Abdominal distension – 56 percent
    - Diarrhea (frequent, low volume, with or without mucus) – 32 to 46 percent

- Adolescents
  - Clinical presentation:
    - Classic Pain Pattern: diffuse periumbilical abdominal pain, localizing to RLO, intensification;
    - Anorexia (95%), Nausea and Vomiting (85%), fevers (60-80%), diarrhea (10-30%)
    - Indigestion, flatulence, bowel irregularity, generalized malaise
    - Females – also consider ovarian pathology
Appendicitis Diagnostics:

**Laboratory**
- CBC w/ diff
- BMP
- CRP
- Pregnancy test
- Other considerations: CMP, amylase, lipase

**Imaging**
- Abdominal Xray
- Ultrasound
- CT Scan
- MRI

**Abdominal Xray**
- **Pro**
  - Low cost
  - No radiation
  - Quick
  - Easily available
  - May help with other causes of Abd pain (constipation, SBO, etc.)
- **Con**
  - Not that helpful for appendicitis

**Ultrasound**
- **Pro**
  - Low cost
  - No radiation
- **Con**
  - May have limited availability
  - Very Tech dependent
  - May be nondiagnostic (nonvisualization)
  - Body habitus dependent
  - “Invasive”

**CT Scan**
- **Pro**
  - High sensitivity and specificity
  - Rarely nondiagnostic
  - Not body habitus or Tech dependent
  - Quick
  - May reveal other pathology
- **Con**
  - Higher cost
  - High(er) radiation
  - Usually need IV contrast
CT of Appendicitis with fecolith

Appendicitis Diagnostics:

MRI

<table>
<thead>
<tr>
<th>Pro</th>
<th>Con</th>
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<tbody>
<tr>
<td>High sensitivity and specificity</td>
<td>Highest cost</td>
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<tr>
<td>Not body/habitus or Tech dependent</td>
<td>Longer exam</td>
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<tr>
<td>No radiation</td>
<td>Limited availability</td>
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CT vs. Ultrasound

Very Hospital Dependent
- Hospital resources
  - US Tech quality / availability
  - Community hospitals utilize CT scans 4-5x more for pediatric appendicitis
- Hospital Culture / Protocols
- American College of Radiology
- American College of Surgeons

Is low-dose radiation really harmful?

- Multiple studies linking CT scan radiation to rise in cancer rates
- Small group emerging stating radiation may not be harmful and may actually be beneficial
  - Increase in free radicals occurs but activates DNA repair system and immune system
  - Links radiation to decreased cancer rates
- Mohan Doss – Fox Chase Cancer Center - PA
**PAS- Pediatric Appendicitis Score**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Point Value</th>
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<tbody>
<tr>
<td>Migration of Pain</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1</td>
</tr>
<tr>
<td>Nausea/vomiting</td>
<td>1</td>
</tr>
<tr>
<td>RLQ tenderness</td>
<td>2</td>
</tr>
<tr>
<td>Coughing/hooping/percussion</td>
<td>2</td>
</tr>
<tr>
<td>Pain</td>
<td>1</td>
</tr>
<tr>
<td>Fever</td>
<td>1</td>
</tr>
<tr>
<td>Leukocytosis</td>
<td>1</td>
</tr>
<tr>
<td>Left shift on WBC differential</td>
<td>1</td>
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≥ 8 = Appendicitis
≤ 5 = Observe

*PAS is a pediatric scoring system for evaluating appendicitis.*

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**Surgical Management of Appendicitis**

- Diagnosis of Appendicitis: Appendectomy (acute, perforated)
  - RLQ: open, 3 port vs. single port Laparoscopic, NOTES
- Diagnosis of Appendicitis: perforated with abscess
  - Initial IR drainage with PICC placement
  - Treatment with IV antibiotics/PO antibiotics
  - Interval laparoscopic appendectomy at 2-4 months
- Diagnosis equivocal: admit for 23 hour observation, follow up studies.
- Non-operative therapy: N/A

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**Laparoscopic Appendectomy**

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**Appendicitis with Fecalith**
Appendectomy-perforated

Non-operative Management of Appendicitis (NOT)

Antibiotic protocols vary widely but typically include 1 to 2 days of inpatient broad spectrum intravenous therapy (eg, piperacillin-tazobactam, imipenem and metronidazole, or ceftriaxone and metronidazole) until resolution of symptoms and normalization of white blood cell count occur followed by oral antibiotics (eg, amoxicillin-clavulanic acid or ciprofloxacin and metronidazole) as an outpatient.

Non-operative treatment (NOT) of early appendicitis has been proposed and may be an option in selected children with early, uncomplicated appendicitis depending on surgeon preference.

May be safe and effective for older children who can better describe their symptoms (over six years of age) with features of early appendicitis:

- Worsened pain for 24 hours
- White blood cell count (15,000)
- Increased CRP
- Nucial or reactant protein
- Nucial appendicitis on imaging
- Nucial perforation not for ruptured based upon clinical finding

NOT may be especially appropriate in children who meet the above criteria and who have co-morbidities that raise the risk of appendectomy.

NOT should only be performed by a surgeon with pediatric expertise.

Non-operative Management of Appendicitis

Initial findings from small prospective observational studies, nonrandomized trials, and one randomized trial indicate potential benefits for selected children who undergo NOT of acute, uncomplicated appendicitis. However, more evidence, preferably from large randomized trials, is needed to provide guidance as to which patients should undergo NOT or appendectomy.

Highly variable recovery
- Based partially on severity
  - Acute, perforated, abscess with interval approach
- Length of hospitalization: recovery room to weeks
- Antibiotic type and duration
- Pain control needs: NSAIDs to narcotics
- Nutrition: Regular diet to TPN
- Activities: school, sports, bathing

Difficulties in comparison of treatments:
- Treatment of non-appendicitis
- Recurrence
  - 15-30% at 2 years after NOT
- Rare lesions — cancers, parasites, etc.
- Cost Analysis

Postoperative

Appendicitis: Complications

- Intra-abdominal Abscess
  - 5-10 days post-op
  - Abdominal pain, fever, anorexia, emesis

Acute-appendicitis (>2%)
- Gangrenous
- Perforated (20-30%)
  - Decreased with continued antibiotics
Appendicitis:
Complications

- Superficial Wound Infection: 1-5%
- Intra-abdominal Abscess: 2.5%
- Bowel Obstruction: 1%
- Mortality < 1%
- Perforation before puberty - normal fertility
- Hernias

Intussusception

- Defined as telescoping of proximal bowel (intussusceptum) into distal bowel (intussuscipiens)
- Most common cause of bowel obstruction in children
- Occurs frequently following recent viral illness

Intussusception

- Most common age: 5-9 months; 50% within 1st year of life, 90% within 2 years
- 80% are ileocolic
- Incidence of anatomic lead point increases with age - Meckel's polyp, carcinoid, HSP, foreign body
- Most are idiopathic, with Peyer's patches as lead point
- Small bowel-small bowel intussusception normal, spontaneously resolve. (seen with higher resolution of newer CT scans)

Intussusception - Presentation

- Intermittent Severe Crampy Abdominal Pain - child stiffens, pulls up legs, writhing
- Ceases as suddenly as it started, in between attacks with normal exam/activity
- Nausea and/or vomiting, lethargy
- With progression, bloody or "currant jelly" stools
- Exam - benign
- May have empty RLQ or palpable mass

Intussusception - "Currant Jelly" stools

- Defined as telescoping of proximal bowel (intussusceptum) into distal bowel (intussuscipiens)
- Most common cause of bowel obstruction in children
- Occurs frequently following recent viral illness
Intussusception - Pathology

- Venous insufficiency, edema, arterial insufficiency, then necrosis with perforation/peritonitis.
- As obstruction worsens, clinical dehydration, bacteremia, then hypovolemic and septic shock.

Intussusception - Evaluation

Ultrasound with target or donut sign

- If intussusception suspected, NGT for decompression and IVF with bolus
- When clinically stable, no peritonitis, proceed with diagnostics
- Diagnostics: ultrasound for diagnosis, arrange fluoroscopy (or ultrasound) for hydrostatic reduction (barium 1 liter or air 120+ mm Hg); continue until reflux into distal ileum. Trials of 5 minutes each for 3 attempts.
- If partially reduced, e reduction, consider delayed reduction enema.
- Varying rates of success 85-90%
- If peritonitis, or if not reduced, to OR for manual reduction.

Intussusception - Contrast enema reduction
Intussusception-Air contrast enema

Emergence of Ultrasound Guided Reduction

Hydrostatic reduction performed under US rather than Fluoroscopy
  • Avoids radiation. Otherwise similar risks as fluoroscopic reduction
  • Similar success rates (70’s – 90’s %)
  • First studies from mid-1990’s, now some out reporting 20-year experiences
  • Doppler Evaluation may be helpful
    • May bowel ischemia / risk for perforation
  • Most studies performed using saline for reduction but can be done with contrast agent as well
    • Allows easy confirmation with KUB after exam – contrast seen in small bowel
  • Cost difference? - No data

Intussusception-Operation

• R/LQ transverse incision vs laparoscopy.
• Slow manual reduction of intussusception: push/milk, don’t pull
• If unable to reduce, may need resection.
• If reduced, observe for viability. Appendectomy.
• Deal with pathologic lead point if present.

Intussusception
Ileocolic intussusception

Intussusception - Treatment and Management

If reduced by contrast enema
- PO feeds started; no medications; observed overnight, 10-25% chance of recurrence in the first 24hrs

If has open reduction or resection
- IV fluid, pain medication, NPO, +/- NGT
- Await return of bowel function
- Encourage activity
- Start with clears and advance as tolerated
- Discharge when tolerating diet and pain controlled with PO medication
- Repeat enema for recurrent symptoms

Hypertrophic Pyloric Stenosis

- Incidence 2.5/1000 births, M:F 4:1, common in Caucasians, rare in Asians
- Associated factors:
  - 19% of offspring if mother was affected
  - 7% if father was affected
- Etiology unknown. Theories include:
  - Gastric acidity leading to muscle spasm/hypertrophy
  - Abnormal innervation, NO synthase response
  - Diminished pacemaker cells, abnormal motility

Hypertrophic Pyloric Stenosis - Anatomy and Physiology
- The pylorus is a band of smooth muscles located between the stomach and duodenum
- Hypertrophy of pylorus leads to gastric outlet obstruction

Hypertrophic Pyloric Stenosis
- Age 3wks to 3 months, seen with prematurity, <10% above 3 months of age
- Presentation: non-bilious emesis shortly after feeding. Progress to projectile. Remains hungry, continues despite formula changes.
- Weight loss
- Dx: overfeeding, GERD, salt wasting adrenogenital syndrome, elevated ICP, gastric duplication, antral web, extrinsic compression
- If BILIOUS, possible surgical emergency

Pyloric Stenosis
- Normal values

Hypertrophic Pyloric Stenosis
- Examination: sunken fontanelle, irritable, hungry
- May appear dehydrated or malnourished
- Mid-epigastrium with palpable olive shaped mass (with relaxation of abdominal muscle)
- May see visible gastric peristaltic waves
**Pyloric Stenosis**

**Diagnostic work-up**

- Laboratory studies
  - Serum Electrolytes must be corrected prior to surgery
    - Hypokalemia
    - Hypochloremia
    - Hypercapnea (metabolic alkalosis)
- Diagnostic studies
  - Ultrasound
    - Pyloric wall thickness over 3.5 mm
    - Pylorus channel length over 14 mm
    - Failure of pyloric channel to open or stomach to empty
  - Upper GI series - String sign

**Pyloric Stenosis - Ultrasound**

- Ultrasound - most sensitive, easily performed
- Findings diagnostic of
  - Pyloric stenosis
  - Muscle thickness > 4 mm length > 15 mm

**Hypertrophic Pyloric Stenosis**

- Pyloric stenosis can be a medical emergency but not a surgical emergency!! (Anesthesia)
- Gastric decompression with NGT
- Preoperative correction of dehydration and electrolyte abnormalities (hypokalemia, hypochloremia, metabolic alkalosis):
  - Normal saline bolus 20 cc/kg
  - IV maintenance at 3.5x, D5 ½ NS, add K with voiding
  - Electrolytes corrected to Cl > 100, CO2 < 30
- Could take days
**Hypertrophic Pyloric Stenosis**

- Operative Repair: Pyloromyotomy
  - RUQ incision
  - Supraumbilical incision
  - Laparoscopic pyloromyotomy
  - Assess for mucosal integrity at completion, 2 halves move

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**Pyloromyotomy**

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**Pyloric Stenosis - Post operative Management**

- Feeds begun at 3 hours, advance to 120 cc/kg/d by 24 hours.
- Apnea/Brady cardia monitoring for 24 hours, related to general anesthesia
- Little pain management needed; avoid opioids due to risk of apnea
- Acetaminophen PRN; antacids in cases of gastritis
- Complications: unrecognized perforation, incomplete myotomy (rare, difficult to diagnose), wound infection rates to 10%; antibiotic administration for 24hrs postop

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**Question**

- True statements concerning appendicitis include:
  - Appendicitis is most common in children under 5 years of age
  - The pain of appendicitis typically develops in the midgut referral region and migrates to the hindgut referral region
  - The diagnosis of appendicitis should usually be based on history and physical exam
  - A normal CT scan excludes the diagnosis of appendicitis
  - A “negative” appendectomy represents the failure of the surgeon to make an appropriate diagnosis

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**Pyloric Stenosis - Same Operation?**
**Question**

Pyloric stenosis:
Is best handled with extended observation
Requires immediate surgery
Is treated with surgical resection of the pylorus
Is associated with a hypochloremic hypokalemic metabolic alkalosis
Can be treated as an outpatient, with discharge home postop

**Question**

True statements concerning intussusception include:

- There is no underlying intestinal abnormality acting as a lead point in the majority of children with intussusception.
- A nonspecific abdominal x-ray finding is an adequate screening test to exclude the diagnosis of intussusception.
- Most cases are treated successfully with operative reduction.
- Diagnosis and treatment may be achieved using an air enema.

#1 and #4

Thank you
Questions?