The Nuts and Bolts of Acute Appendicitis

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Objectives

• Overview of the anatomy and pathophysiology of acute appendicitis
• Discussion of clinical signs and symptoms of acute appendicitis
• Discussion of diagnostic studies (imaging and laboratory) useful in suspected appendicitis
• Review uncommon presentations of appendicitis
• Review populations at-risk for complicated appendicitis and/or mis-diagnosis

Anatomy

• The Appendix
  – Blind pouch originating from the cecum
  – Function not understood; Most likely an evolutionary “remnant”
  – High lymphoid tissue content → Peaks in adolescence then atrophies with age
  – Variable anatomic location
    • Most in right lower quadrant (RLQ)
    • Retro-cecal (~50%); Pelvic (~33%); RUQ (~5%); LUQ (<1%); LLQ (<1%)

Acute Appendicitis: Factoid

• Basic facts
  – One of the most common surgical emergencies
  – Lifetime incidence between 5-10%
  – Most cases (~70%) between ages 10 to 30 years
  – About one-third mis-diagnosed on initial work-up
  – Between 1/4 and 1/3 ruptured at surgery
  – Mortality (<0.2% unruptured; 3-5% ruptured)
Pathophysiology

- Modern thoughts on acute appendicitis
  - Luminal obstruction secondary to various factors
    - Some association with viral illness possible
    - Lymphoid hyperplasia
    - Fecalith
    - Parasites
    - Foreign bodies
    - Inflammatory bowel disease
    - Neoplasm (i.e., carcinoid)

The Kolesnikov Classification

- Appendiceal colic
  - Simple “superficial” appendicitis
  - Destructive appendicitis
    - Phlegmon; Gangrene; Perforation
  - Complicated appendicitis
    - Infiltrate; Abscess; Diffuse purulent peritonitis
- Other complications
  - Pylephlebitis; Sepsis; Retroperitoneal phlegmon; Local abdominal abscess

Pathophysiology

- Modern thoughts on acute appendicitis
  - Trapped mucosal secretions → Appendiceal distention
  - Visceral pain onset within 12-18 hours
  - Increasing pressure within the appendix obstructs (1) lymphatic flow, then (2) venous outflow, leading to gangrene and perforation
  - Pain pattern: Periumbilical → Localized RLQ → Generalized (post-rupture)
  - Most likely “perforation window” between 30-36 hours → Gives you some time between initial presentation and/or clinical suspicion and operative intervention

Microbiology

- Monobacterial 24%; Polymicrobial 76%
- Aerobic bacteria
  - Escherichia coli
  - Staphylococcus aureus
  - Enterococcus organisms
  - Pseudomonas aeruginosa
- Anaerobic bacteria
  - Bacteroides
  - Clostridium
  - Peptostreptococcus
  - Enterobacter (aerobe-anaerobe)
  - Streptococcus milleri (microaerophilic)

Point-of-Care Quick Ref: Appendicitis
(www.pediatriccareonline.org/pco/ub/view/Point-of-Care-Quick-Reference/397133/)
Clinical Presentation

- Classic presentation
  - Loss of appetite (anorexia)
  - Periumbilical pain
  - Nausea and vomiting
  - Progressive development of RLQ pain
  - Diarrhea (usually pelvic location)
  - Tenderness to palpation (rebound)

Signs: Overview

- Abdominal tenderness 95-100%
- RLQ tenderness 90-95%
- Presence of rebound 33-68%
- Rectal tenderness 30-40%
- Cervical motion tenderness (female) ~30%
- Abdominal rigidity 10-15%
- Psoas sign 3-5%
- Obturator sign 5-10%
- Rovsing’s sign 5-10%
- Palpable mass 5-10%
- Temperature 37.9°F

Symptoms: Overview

- Abdominal pain 97-100%
- Anorexia 70-92%
- Nausea 67-78%
- Pain “migration” to RLQ 49-61%
- Vomiting 49-74%
- Fever 10-20%
- Diarrhea 5-15%
- Constipation 5-15%

History & Physical

- Kocher’s sign
  - Tenderness migrates from umbilicus to the McBurney’s point
- Rovsing’s sign
  - Pain in RLQ upon palpation of LLQ
- Psoas sign
  - RLQ pain produced with flexion/extension of right hip
### History & Physical

- **Obturator sign**
  - Periappendiceal pain upon flexion and internal rotation of the hip
- **Dunphy’s sign**
  - Increased pain with coughing
- **Sitkovsky’s sign**
  - Increase of pain in right iliac area when patient on left side

### MANTRELS

<table>
<thead>
<tr>
<th>Score</th>
<th>Probable appx</th>
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<tbody>
<tr>
<td>5-6</td>
<td>Possible appx</td>
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<tr>
<td>7-8</td>
<td>Probable appx</td>
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<tr>
<td>9-10</td>
<td>Very probable appx</td>
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### Differential Diagnosis

<table>
<thead>
<tr>
<th>Gastrointestinal</th>
<th>Gynecologic</th>
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<tbody>
<tr>
<td>Cholecystitis</td>
<td>Ectopic pregnancy</td>
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<tr>
<td>Crohn’s disease</td>
<td>Endometriosis</td>
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<tr>
<td>Diverticulitis</td>
<td>Ovarian torsion</td>
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<tr>
<td>Duodenal/gastric ulcer</td>
<td>Pelvic inflammatory disease</td>
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<tr>
<td>Epiploic appendagitis</td>
<td>Ruptured ovarian cyst</td>
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<tr>
<td>Gastroenteritis</td>
<td>Tubo-ovarian abscess</td>
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<td>Intestinal obstruction</td>
<td>Dysmehorrhea</td>
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<td>Meckel’s diverticulitis</td>
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<td>Mesenteric lymphadenitis</td>
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<td>Necrotizing enterocolitis</td>
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<td>Neoplasm (carcinoid, carcinoma, lymphoma)</td>
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<tr>
<td>Differential Diagnosis</td>
<td>Diagnostic Challenges</td>
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<tr>
<td><strong>Systemic</strong></td>
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<tr>
<td>• Diabetic ketoacidosis</td>
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<td>• Henoch-Schonlein purpura</td>
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<td><strong>Genitourinary</strong></td>
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<td>• Kidney stone</td>
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<td>• Pyelonephritis</td>
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<td>• Wilms’ tumor</td>
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<td><strong>Pulmonary</strong></td>
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<tr>
<td>• Pleuritis</td>
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<tr>
<td>• Pneumonia (basilar)</td>
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<td>• Pulmonary infarct</td>
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<tr>
<td><strong>Miscellaneous</strong></td>
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<tr>
<td>• Parasitic infection</td>
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<tr>
<td>• Psas abscess</td>
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<tr>
<td>• Rectus sheath hematoma</td>
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- **Diagnostic Challenges**
  - **Appendicitis vs Cholecystitis**
    - RLQ versus RUQ; Diaphragm irritation; Murphy’s sign; Elevation of liver function tests incl. bilirubin
  - **Appendicitis vs Obstetric / Gynecologic**
    - Vaginal discharge; Association with menstrual cycle; Variable gastrointestinal complaints
    - Cervical motion tenderness (more common in Gynecologic emergencies)

- **Diagnostic Challenges**
  - **Appendicitis vs Renal colic**
    - Periodic acute pain in lumbar region; Pain radiation to thigh; Hematuria
    - Pasternatsky’s sign → Tapping of lumbar region reproduces the pain
  - **Appendicitis vs Perforated Ulcer**
    - Sharp, diffuse pain; Patient “remembers exact time”; Air on plain films; Rigid anterior abd wall

- **Diagnostic Challenges**
  - **Ovulating women**
    - Pelvic inflammatory disease
    - Tubo-ovarian abscess
    - Cervical motion tenderness
  - **Pregnancy**
    - Missed appendicitis mortality as high as 2% maternal; 30-35% fetal
    - WBC elevated in pregnancy
    - Appendix migrates (may present with RUQ pain)
    - Ultrasound / MRI / CT scan (ionizing radiation) Diagnostic laparoscopy
Laboratory Work-Up

- White blood cell count
- Differential count
  - Bandemia
  - Segmented neutrophils
- Various adjunctive laboratory methods
  - Erythrocyte Sedimentation Rate (ESR) → May be normal with appendicitis
  - Interleukin-6 (IL-6)
  - C-Reactive Protein (CRP)


Appendicitis: Imaging

Computed tomography → Tubular structure with non-filling; Fecalith may be present

Ultrasound → Non-compressible tubular structure; Highest utility in non-obese/pregnant patient

MRI → Dilated tubular structure with surrounding inflammatory changes; Becoming the test of choice in pregnancy

Image source: Wikimedia Commons

### High Risk Populations: Pediatric

- Most common surgical disorder in children
- Approximately 5% of “abdominal pain” visits
- As many as 50% initially misdiagnosed
  - For <2 year olds → Perforation rate near 100%
  - For 3 to 5 year olds → Perforation 70-75%
  - For 6 to 10 year olds → Perforation ~40%
- “Competing dx” → Acute gastroenteritis
  - Pain & vomiting in appendicitis
  - Vomiting & Diarrhea then pain in gastroenteritis
  - Lack of localized tenderness

### High Risk Populations: Geriatric

- Only 20% have “classic presentation”
- Physical exam affected by co-morbidities
  - No RLQ tenderness in about 25% cases
  - Nausea, vomiting, anorexia less reliable
  - WBC may not be as elevated
- Can’t rely on vital signs as much
- Diagnostic delays >85% of the time
- Perforation rate 45-85%
To Operate or Not To Operate

- Increasing evidence for antibiotics ± percutaneous drainage in patients with significant surgical risk factors → Low complications but high recurrence rate
- Significant proportion of surgeons in some countries/regions perform interval appendectomy routinely, guided by patient age, physiology, and symptoms
- Most common reasons to perform interval appendectomy include recurrence and “abnormal findings” (i.e., suspected mass, unexpected symptoms)
- Recurrence rate following non-operative management of appendicitis is up to 25%

Mason RJ. Surgical Infections 2008;9:481-488

Laparoscopic Appendectomy

- Since late 1990s/early 2000s the most commonly utilized modality for appendectomy
- Can be used for simple or complicated appendicitis, including perforation/abscess
- Significantly fewer wound problems compared to open appendectomy
- Quicker recovery and return to work
- Evidence for lower incidence of small bowel obstruction

Image source: Wikimedia Commons

Open Appendectomy

- Performed infrequently in the modern OR
- Reserved for special situations
  - Severe peritonitis due to ruptured appendicitis
  - Inability to safely complete laparoscopic procedure
  - Contraindication to laparoscopic procedure
- Greater incidence of bowel obstruction (1.5% versus 0.2%)

**Open Appendectomy**

![Image of Open Appendectomy](source: Wikimedia Commons)

- Prospective evidence demonstrates potential benefits to this approach; Validated in "resource-restricted" settings
- Patients presenting with an abscess can safely undergo IR percutaneous drainage and IV antibiotics, followed by interval appendectomy
- Risks have been found to be acceptable and should not deter this approach in the appropriate candidate patient
- Recurrence rates following non-operative management of appendicitis: Up to 25% → Routine vs emergent appendectomy

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**Interval Appendectomy**

- Antibiotic Management:
  - Regimens may vary, depending on local patterns
    - Ciprofloxacin / Metronidazole
    - Ampicillin / Sulbactam
    - Ancef / Metronidazole
    - Piperacillin / Tazobactam
    - Amoxicillin / Clavulanic acid
  - When cultures available (i.e., abscess) treatment per C&S preferred
  - Antibiotics have now been validated as first-line therapy for acute appendicitis
    - Fewer complications than primary surgical therapy
    - The only drawback is the possibility of complications related to recurrent episodes

Percutaneous Drainage

- Evidence supports percutaneous drainage of periappendiceal abscess followed by interval appendectomy
- More circumstantial evidence points to benefits of percutaneous drainage in the setting of multiple abscesses as alternative to laparotomy
- Significant body of literature supporting postoperative management of remote abscesses complicating the course of appendicitis


Take-Home Messages

- Despite significant medical progress, appendicitis continues to carry a significant morbidity and mortality
- Prompt diagnosis and early surgical referral may reduce risk of perforation and prevent complications
- Ultrasound and advanced (CT/MRI) imaging reduced rate of perforated appendicitis from ~35% to ~16%
- Nonoperative management becoming more prevalent; interval appendectomy and long-term nonoperative follow-up becoming more accepted

Pediatric Care Online. Point-of-Care Quick Ref: Appendicitis (https://www.pediatriccareonline.org/pcot/ub/view/Point-of-Care-Quick-Reference/397133)