# 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)

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 (1) venous outflow, then (2) arterial inflow, 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
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

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/pcot/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)

### Symptoms: Overview

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal pain</td>
<td>97-100%</td>
</tr>
<tr>
<td>Anorexia</td>
<td>70-92%</td>
</tr>
<tr>
<td>Nausea</td>
<td>67-78%</td>
</tr>
<tr>
<td>Pain “migration” to RLQ</td>
<td>49-61%</td>
</tr>
<tr>
<td>Vomiting</td>
<td>49-74%</td>
</tr>
<tr>
<td>Fever</td>
<td>10-20%</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>5-15%</td>
</tr>
<tr>
<td>Constipation</td>
<td>5-15%</td>
</tr>
</tbody>
</table>
### Signs: Overview

<table>
<thead>
<tr>
<th>Sign</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal tenderness</td>
<td>95-100%</td>
</tr>
<tr>
<td>RLQ tenderness</td>
<td>90-95%</td>
</tr>
<tr>
<td>Presence of rebound</td>
<td>33-68%</td>
</tr>
<tr>
<td>Rectal tenderness</td>
<td>30-40%</td>
</tr>
<tr>
<td>Cervical motion tenderness (female)</td>
<td>~30%</td>
</tr>
<tr>
<td>Rectal tenderness</td>
<td>30-40%</td>
</tr>
<tr>
<td>Cervical motion tenderness (female)</td>
<td>~30%</td>
</tr>
<tr>
<td>Abdominal rigidity</td>
<td>10-15%</td>
</tr>
<tr>
<td>Psoas sign</td>
<td>3-5%</td>
</tr>
<tr>
<td>Obturator sign</td>
<td>5-10%</td>
</tr>
<tr>
<td>Rovsing’s sign</td>
<td>5-10%</td>
</tr>
<tr>
<td>Palpable mass</td>
<td>5-10%</td>
</tr>
<tr>
<td>Temperature</td>
<td>37.9°F</td>
</tr>
</tbody>
</table>

### 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>Item</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration of pain (Umbilical → RLQ)</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1</td>
</tr>
<tr>
<td>Nausea/Vomiting</td>
<td>1</td>
</tr>
<tr>
<td>Tender RLQ</td>
<td>2</td>
</tr>
<tr>
<td>Rebound (tenderenss)</td>
<td>1</td>
</tr>
<tr>
<td>Elevated temperature</td>
<td>1</td>
</tr>
<tr>
<td>Leukocytosis</td>
<td>2</td>
</tr>
<tr>
<td>Shift to left (on differential)</td>
<td>1</td>
</tr>
</tbody>
</table>
## MANTRELS

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

## Differential Diagnosis

<table>
<thead>
<tr>
<th>Gastrointestinal</th>
<th>Gynecologic</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Cholecystitis</td>
<td>• Ectopic pregnancy</td>
</tr>
<tr>
<td>• Crohn's disease</td>
<td>• Endometriosis</td>
</tr>
<tr>
<td>• Diverticulitis</td>
<td>• Ovarian torsion</td>
</tr>
<tr>
<td>• Duodenal/gastric ulcer</td>
<td>• Pelvic inflammatory disease</td>
</tr>
<tr>
<td>• Epiploic appendagitis</td>
<td>• Ruptured ovarian cyst</td>
</tr>
<tr>
<td>• Gastroenteritis</td>
<td>• Tubo-ovarian abscess</td>
</tr>
<tr>
<td>• Intestinal obstruction</td>
<td>• Dysmehorrhea</td>
</tr>
<tr>
<td>• Meckel's diverticulitis</td>
<td></td>
</tr>
<tr>
<td>• Mesenteric lymphadenitis</td>
<td></td>
</tr>
<tr>
<td>• Necrotizing enterocolitis</td>
<td></td>
</tr>
<tr>
<td>• Neoplasm (carcinoid, carcinoma, lymphoma)</td>
<td></td>
</tr>
</tbody>
</table>
## Differential Diagnosis

<table>
<thead>
<tr>
<th>Systemic</th>
<th>Genitourinary</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Diabetic ketoacidosis</td>
<td>• Kidney stone</td>
</tr>
<tr>
<td>• Henoch-Schonlein purpura</td>
<td>• Pyelonephritis</td>
</tr>
<tr>
<td>• Wilms’ tumor</td>
<td>• Wilms’ tumor</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pulmonary</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pleuritis</td>
<td>• Parasitic infection</td>
</tr>
<tr>
<td>• Pneumonia (basilar)</td>
<td>• Psoas abscess</td>
</tr>
<tr>
<td>• Pulmonary infarct</td>
<td>• Rectus sheath hematoma</td>
</tr>
</tbody>
</table>

## 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

### 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

### 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

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

Image source: Wikimedia Commons
Appendicitis: Imaging

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

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

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%

### Highlights

- High Index of Suspicion

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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
Laparoscopic Appendectomy

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

Interval Appendectomy

- 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

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


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5 days – 2 wks
Afebrile; Normal WBC

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/pco/ub/view/Point-of-Care-Quick-Reference/397133/)