

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%)

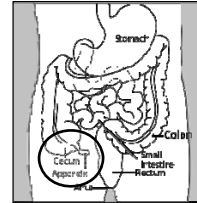


Image source: Wikimedia Commons

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

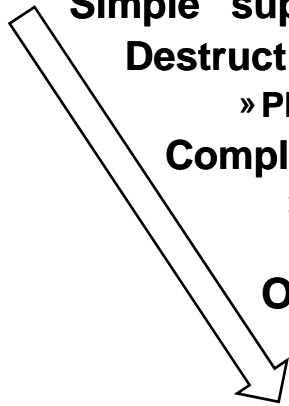
» Phlegmon; Gangrene; Perforation

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

Guasco *et al.* G Bacteriol Virol Immunol 1991;1-12:77-86.

Rautio *et al.* Pediatr Infect Dis J 2000;19(11):1078-1083.

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

- | | |
|----------------------------------|----------------|
| • 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% |

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

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

- **Migration of pain (Umbilical → RLQ)** 1
- **Anorexia** 1
- **Nausea/Vomiting** 1
- **Tender RLQ** 2
- **Rebound (tenderenss)** 1
- **Elevated temperature** 1
- **Leukocytosis** 2
- **Shift to left (on differential)** 1

MANTRELS

- **Score** **5-6** **Possible appx**
- **Score** **7-8** **Probable appx**
- **Score** **9-10** **Very probable appx**

Differential Diagnosis

Gastrointestinal

- Cholecystitis
- Crohn's disease
- Diverticulitis
- Duodenal/gastric ulcer
- Epiploic appendagitis
- Gastroenteritis
- Intestinal obstruction
- Meckel's diverticulitis
- Mesenteric lymphadenitis
- Necrotizing enterocolitis
- Neoplasm (carcinoid, carcinoma, lymphoma)

Gynecologic

- Ectopic pregnancy
- Endometriosis
- Ovarian torsion
- Pelvic inflammatory disease
- Ruptured ovarian cyst
- Tubo-ovarian abscess
- Dysmehorrhea

Differential Diagnosis

Systemic

- Diabetic ketoacidosis
- Henoch-Schonlein purpura

Genitourinary

- Kidney stone
- Pyelonephritis
- Wilms' tumor

Pulmonary

- Pleuritis
- Pneumonia (basilar)
- Pulmonary infarct

Miscellaneous

- Parasitic infection
- Psoas abscess
- Rectus sheath hematoma

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)

Point-of-Care Quick Ref: Appendicitis (www.pediatriccareonline.org/pco/ub/view/Point-of-Care-Quick-Reference/397133/) Sack et al. BMC Surg 2006;6:15.

Appendicitis: Imaging

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

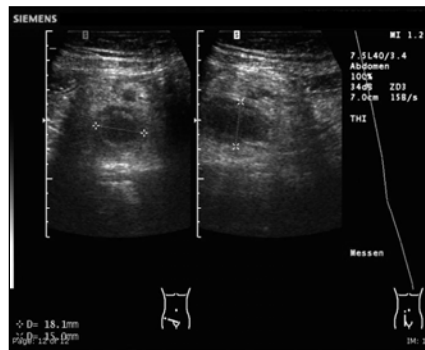


Image source: Wikimedia Commons

Appendicitis: Imaging

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

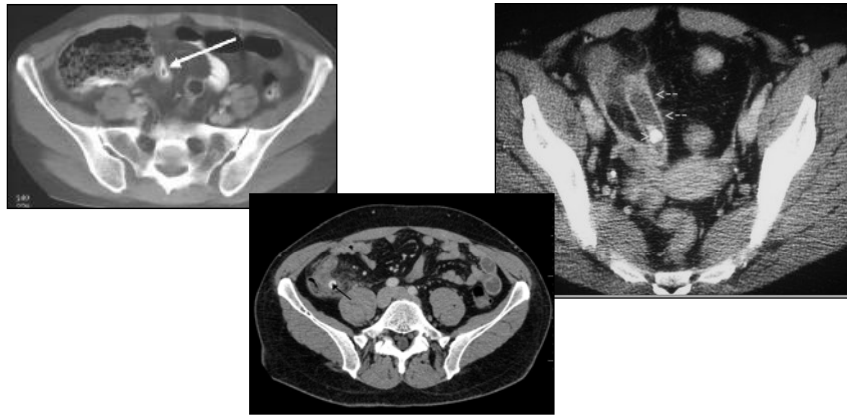
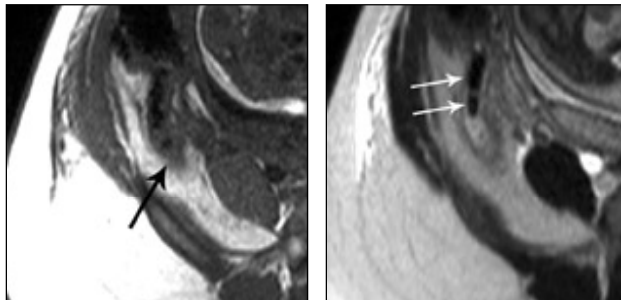


Image source: Wikimedia Commons

Appendicitis: Imaging

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



Modified from McGahan *et al.* Imaging non-obstetrical causes of abdominal pain in the pregnant patient. *Applied Radiology* 2010;39(11):10-25.

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

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High Index of Suspicion

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%

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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%

Corfield L. *Surg Today* 2007;37:1-4.

Oliak *et al.* *Dis Colon Rectum* 2001;44:936-941

Mason R.J. *Surgical Infections* 2008;9:481-488

Sakorafas *et al.* *World J Gastrointest Surg* 2012;4:83-86

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

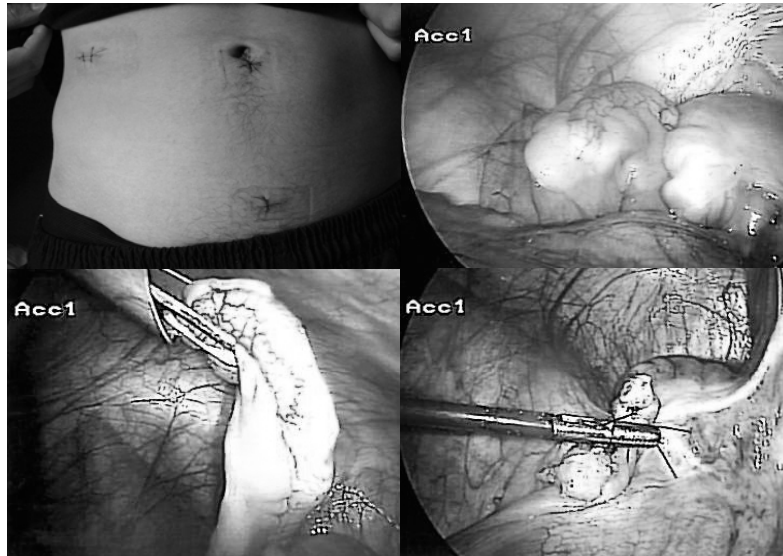


Image source: Wikimedia Commons

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%)

J Pediatr Surg 2007;42:939-942.

Open Appendectomy

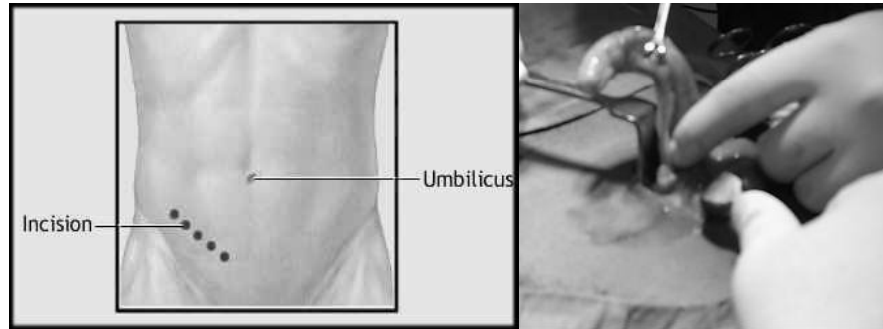


Image source: Wikimedia Commons

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**

Adapted from Corfield L. Surg Today 2007;37:1-4.
Iqbal CW et al. J Surg Res 2012;177(1);127-30.

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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Hansson et al. World J Surg 2012;36:2028-2036.

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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

McCann *et al.* Image-guided drainage of multiple intraabdominal abscesses in children with perforated appendicitis: an alternative to laparotomy. *Pediatric Radiology* 2008;38(6):661-668.

St Peter *et al.* Initial laparoscopic appendectomy versus initial nonoperative management and interval appendectomy for perforated appendicitis with abscess. *J Pediatr Surg* 2010;45:236-240.

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/>)