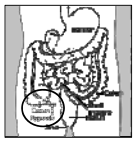
The Nuts and Bolts of Acute Appendicitis

Stanislaw P. Stawicki, M.D., F.A.C.S.
Assistant Professor, Department of Surgery
Director of Research
Division of Trauma, Critical Care, and Burn
The Ohio State University School of Medicine

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

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**

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 (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**

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 Batteriol 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)**

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 <u>right</u> iliac area when patient on <u>left</u> side**

MANTRELS

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

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**

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 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)**

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

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

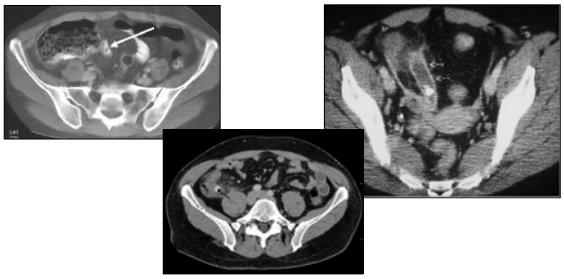
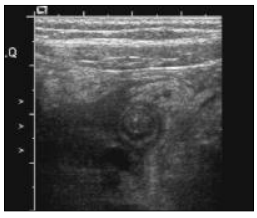


Image source: Wikimedia Commons

Appendicitis: Imaging

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



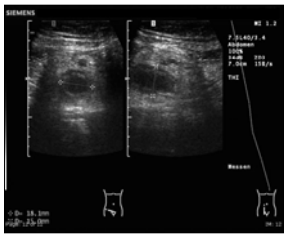
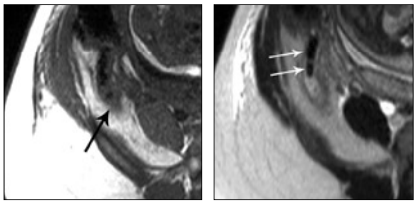


Image source: Wikimedia Commons

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

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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High Index of Suspicion

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High Index of Suspicion

To Operate or Not To Operate

- Increasing evidence for antibiotics ± percutaneous drainge 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 RJ. Surgical Infections 2008;9:481-488
Sakorafas *et al*. World J Gastrointest Surg 2012;4:83-86

Laparoscopic Appendectomy

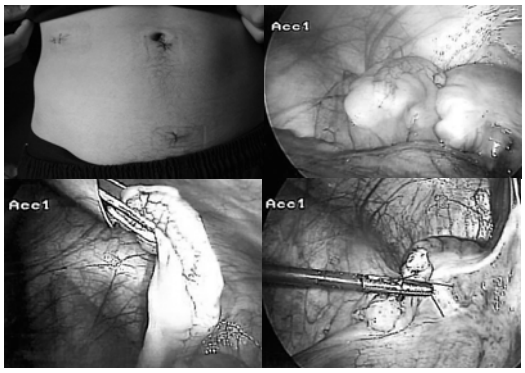

Image source: Wikimedia Commons

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

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

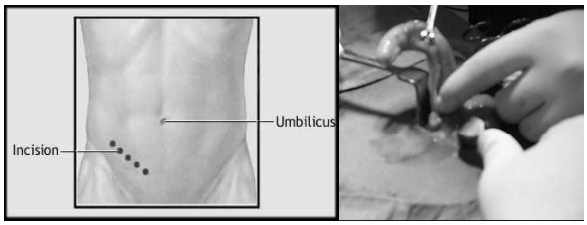

Image source: Wikimedia Commons

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

Corfield L. Surg Today 2007;37:1-4.
Hansson et al. World J Surg 2012;36:2028-2036.

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
  - [illegible]icillin / Sulbactam
  - [illegible]etronidazole
  - [illegible]zobactam
  - [illegible]nic acid
  - When[illegible]i.e., abscess) treatment[illegible]
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5 days – 2 wks
Afebrile; Normal WBC

Corfield L. Surg Today 2007;37:1-4.
Hansson et al. World J Surg 2012;36:2028-2036.

Percutaneous Drainage

- **Evidence supports percutaneous drainge of periappendiceal abscess followed by interval appendectomy**
- **More circumstantial evidence points to benefits of percutaneous drainge 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**

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