

Appendicitis

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The Operative Review of Surgery. 2023; 1:77-92.

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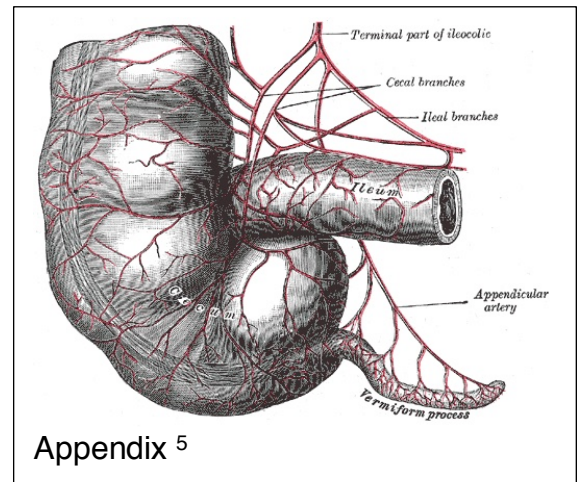
Mnemonics

References

Pathophysiology

Normal Appendix Anatomy

- Maximal Outer Diameter: 6-mm¹
 - Considered the Most Important Diagnostic Criteria to Exclude Appendicitis¹
- Maximal Mural Thickness: 3-mm^{2,3}
- Length: 8-10-cm¹
- Luminal Capacity: **0.1 cc**⁴
 - Fluid > 0.5 cc Raises Intraluminal Pressure⁴
- “Vermiform Appendix” Simply References the “Worm-Like” Appearance
- Blood Supply:
 - Appendicular Artery within the Mesoappendix (Off the Ileocolic Artery)
 - Venous Drainage Goes to the Portal System



Function of the Appendix

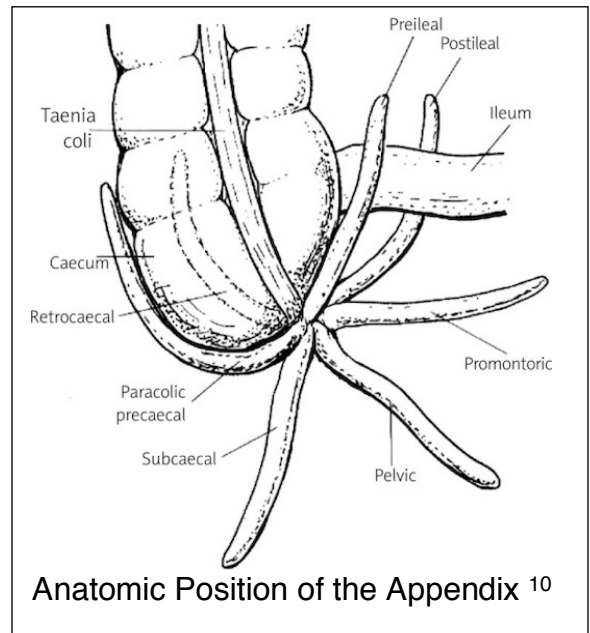
- Reservoir for Good Bacteria After Diarrheal Infection Cleans Out the Colon⁶
 - *Historically Thought to Be a Vestigial Structure without Function
- Secretes IgA and Mucin to Assist in this Biofilm Creation⁷

Anatomical Positioning ^{8,9}

- Retrocecal (32-62%) – Behind the Cecum (Most Common)
- Pelvic (10-37%) – Within Pelvis
- Subcaecal (2-24%) – Inferior to & Extending from the Cecum
- Preileal (1-19%) – Anterior to Ileum
- Postileal (0.4-16%) – Posterior to Ileum

Appendicitis Pathology

- Primarily Caused by Luminal Obstruction and Stasis
 - *Exact Cause is Poorly Understood ¹¹
- Causes of Luminal Obstruction: ¹¹
 - Appendicolith (Fecalith at the Appendiceal Orifice)
 - Impacted Stool
 - Appendiceal/Cecal Tumor
- Effects of Luminal Obstruction: ¹²
 - Swelling and Mucous Secretion
 - Increased Luminal and Intramural Pressures
 - Small Vessel Thrombosis and Lymphatic Stasis
 - Impaired Blood Flow and Venous Congestion
 - Bacterial Infection
 - Can Progress to Ischemia and Necrosis
- Lymphoid Hyperplasia was Previously Believed to Be a Primary Cause of Appendicitis but Now Disproven – *See Below



Presentation

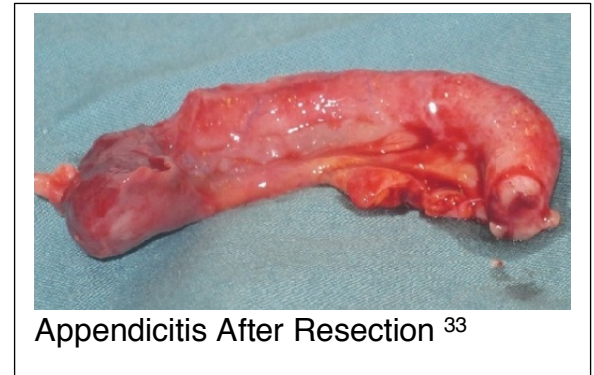
Epidemiology ¹³

- Most Common in Age 20-30's
- More Common in Men
- More Common in Patients with Low Socioeconomic Status

Perforation

- 13-20% Present with Perforation ¹⁴
- Can Present with a Contained Walled-Off Abscess or Free Perforation

- Most Common Site of Perforation: Antimesenteric Border Just Beyond the Point of Obstruction¹⁵
 - Typically in the Middle Third of the Appendix
 - This Area Has the Poorest Blood Supply
- Risk Factors for Perforation:
 - Pediatrics^{16,17}
 - Can Be Significantly Higher for Younger Children < 3-5 Years^{17,18}
 - Possibly Due to Delayed Diagnosis
 - Due Underdeveloped Omentum it is More Difficult to Wall Off an Abscess After Perforation¹⁹
 - Age > 50 Years²⁰
 - Symptom Duration > 24 Hours²¹
 - Presence of a Fecalith^{22,23}
 - WBC > 15,000²⁴
 - CRP > 30,000²⁵
 - HIV²⁶
 - In-Hospital Delay to Surgery May Be Associated with Increased Risk of In-Hospital Perforation – Studies Contradictory²⁷⁻²⁹
- Increased Mortality Rate: 5%³⁰
 - Compared to 0.1% for Non-Gangrenous Appendicitis and 0.6% for Gangrenous Appendicitis³⁰



Presentation

- Lifetime Risk of Developing: 7-8%³¹
- Initial Periumbilical Pain that Migrates to the Right Lower Quadrant
 - 50-60% Demonstrate Migration¹³
 - Initial Periumbilical Pain Caused **Appendix Stretching** Leading to Stimulation of T8-10 **Visceral** Nerve Fibers³²
 - Migrating Right Lower Quadrant Pain Caused by **Inflammation of the Surrounding Parietal Peritoneum** Leading to Stimulation of the **Somatic** Nerve Fibers¹³
- Pain Worse with Walking, Jumping or Coughing
- Anorexia (80-85%)¹³
- Nausea and Vomiting (40-60%)¹³
 - Nausea and Anorexia **Occur After** Pain Once Secondary Visceral Afferent Fibers Stimulate the Medullary Vomiting Center (Occurs Before Pain in Gastroenteritis)
- Fever

Diagnosis

Physical Exam Signs

MN

- *McBurney Sign*
 - Right Lower Quadrant Tenderness at McBurney's Point
 - McBurney's Point: 1/3 the Distance from the Anterior-Superior Iliac Spine (ASIS) to the Umbilicus
 - Sensitivity: 50-94%; Specificity: 75-86% ¹³
 - **Most Reliable Finding**
- *Rovsing Sign*
 - Right Lower Quadrant Pain with Left Lower Quadrant Palpation
 - Sensitivity: 22-68%; Specificity: 58-96% ¹³
- *Iliopsoas/Psoas Sign*
 - Right Lower Quadrant Pain on Extension of the Right Thigh
 - Indicates: **Retrocecal** Appendix
 - Sensitivity: 13-42%; Specificity: 79-97% ¹³
- *Obturator Sign*
 - Right Lower Quadrant Pain on **Internal Rotation** of Right Thigh
 - Indicates: **Pelvic** Appendix
 - Likely to Associated with Dysuria & Diarrhea
 - Sensitivity: 8%; Specificity: 94% ¹³



Appendicitis with Fecalith ³⁹

Diagnosis

- Labs: WBC and CRP
- First-Line Imaging: Computed Tomography (CT)
 - Study of Choice by the American College of Radiology ^{34,35}
 - IV Contrast Preferred, Oral Contrast Not Necessary ³⁶
 - Sensitivity: 91%; Specificity 90% ¹³
- Alternative Imaging Modalities:
 - *Ultrasound (US)*
 - Some Consider as an Initial Imaging Test Although Negative US Does Not Rule Out Appendicitis and Should Be Followed by CT if US Equivocal ³⁷
 - Preferred for Pediatrics or Pregnant Women to Limit Radiation Exposure ¹³
 - Sensitivity: 78%; Specificity: 83% ¹³
 - *Magnetic Resonance Imaging (MRI)*
 - Most Commonly Used in Pediatrics or Pregnant Women if US Equivocal ¹³
 - More Expensive and Less Familiarity



Perforated Appendicitis ³⁹

- Radiographic Findings:
 - Appendix Noncompressible
 - Appendix Distended \geq 6-7 mm
 - Appendix Wall Thickening \geq 3 mm
 - Appendicolith (40%)³⁸
 - Associated with More Severe Inflammation and Increases Risk for Perforation
 - Periappendiceal Fluid and Fat Stranding

Complicated Appendicitis Definitions⁴⁰

- Gangrenous Appendicitis with or without Perforation
- Appendicitis with an Intraabdominal Abscess
- Appendicitis with Periappendicular Contained Phlegmon
- Appendicitis with Periappendicular Purulent/Free Fluid

Diagnostic Scoring Systems Prior to Imaging

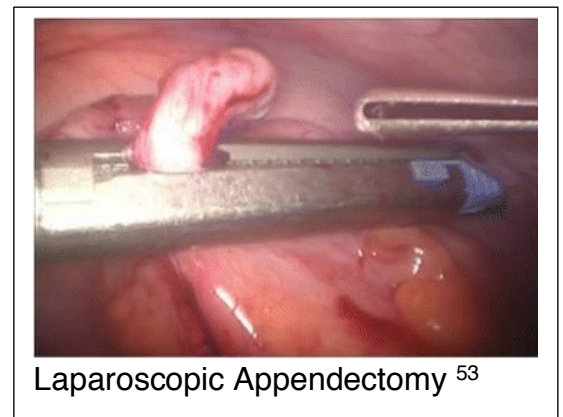
- *Alvarado Scoring System*⁴¹ **MN**
 - The Most Commonly Used System in Adults
 - Points:
 - Tenderness in RLQ (2)
 - Migration to RLQ (1)
 - Rebound Tenderness (1)
 - Anorexia (1)
 - Nausea/Vomiting (1)
 - Elevated Temperature (1)
 - Leukocytosis; WBC > 10,000 (2)
 - Shift of Neutrophils (1)
 - Interpretation:⁴²
 - Low Scores (0-3): Evaluate Other Etiologies (No CT Indicated)
 - Intermediate Scores (4-6): CT Scan
 - High Scores (7-10): Surgical Consultation
 - Low Scores Are Better to “Rule-Out” Appendicitis than High Scores Are to “Rule-In”
 - Score < 3-4 to “Rule-Out” Appendicitis Has 96% Sensitivity
 - Score > 6-7 to “Rule-In” Appendicitis Has 58-88% Sensitivity
- *Pediatric Appendicitis Score (PAS)*⁴³
 - Most Commonly Used in Pediatrics
 - Points:
 - RLQ Tenderness (2)
 - Pain with Cough, Percussion or Hopping (2)
 - Anorexia (1)
 - Nausea/Emesis (1)
 - Migration of Pain (1)
 - Fever (1)
 - Leukocytosis; WBC > 10,000 (1)
 - Neutrophilia; ANC > 7,500 (1)

- Interpretation: ⁴⁴
 - Low Scores (0-3): Evaluate Other Etiologies
 - Intermediate Scores (4-6): Imaging
 - High Scores (7-10): Imaging vs Surgery
- Additional Scoring Systems:
 - *Appendicitis Inflammatory Response (AIR) Score* ⁴⁵
 - *RIPASA (Raja Isteri Pengiran Anak Saleha Appendicitis) Score* ⁴⁶
 - *Eskelinen Score* ⁴⁷
 - *Ohmann Score* ⁴⁸
 - *Tzanakis Score* ⁴⁹
 - *Lintula Score* ⁵⁰
 - *Fenyo-Lindberg Score* ⁵¹
 - *Karaman Score* ⁵²

Treatment

Definitive Management

- Uncomplicated Appendicitis: Laparoscopic Appendectomy
 - *See Appendectomy
 - May Consider Nonoperative Management with Antibiotics Alone for Select Patients – *See Below
- Complicated Appendicitis (Phlegmon/Abscess): Antibiotics & Interval Appendectomy at 6-8 Weeks
 - Percutaneous Drainage if Abscess > 3-4 cm
 - Antibiotic Course:
 - After Percutaneous Drainage: 4 Days ⁵⁴
 - If Unable to Perform Percutaneous Drainage: 7 Days
 - 80% Successful in Avoiding Appendectomy on Initial Admission ⁵⁵
- Free Perforation: Appendectomy



Intraoperative Findings

- Normal Appendix: Historically Recommended That the Appendix was **Always Resected** Even if Normal at Diagnostic Laparoscopy for Acute Right Iliac Fossa Pain
 - Goal: Prevent Risk of Diagnostic Confusion in the Future
 - Debated in Modern Practice ⁵⁶
- Friable Base: **Partial Cecectomy**
 - Take Care to Preserve the Ileocecal Valve
- Suspect Chron's Disease & Cecum Inflamed: **No Intervention**

Nonoperative Management

- Some Promote Antibiotic Treatment Alone for Uncomplicated Acute Appendicitis ⁵⁷
 - Not Recommended for Complicated Appendicitis
- ***In General, Surgical Management is Preferred but May Consider Nonoperative Management if Unfit for Surgery or the Patient Refuses Surgery**
- Benefits:
 - Most Respond Clinically
 - Faster Return to Work (Not for Complicated/Perforated Cases)
 - No Increased Perforation Rate
 - 89-91% Are Able to Avoid Surgery at Initial Admission
- Negatives:
 - **High Recurrence Rates**
 - 29% Require Appendectomy by 90 Days ⁵⁷
 - 25% Without Appendicolith ⁵⁷
 - 41% With Appendicolith ⁵⁷
 - 14-40% Require Appendectomy within the First Year ⁵⁷⁻⁶⁰
 - 40-50% Require Appendectomy within the First 5-Years ^{57,61}
 - 2.28x Higher Rates of Complications ⁵⁷
 - Treatment Efficacy at 1-Year: ⁶²
 - Nonoperative Management: 63.8%
 - Surgical Management: 93%
 - **Contraindicated if Fecalith Present** – High Rate of Complicated Appendicitis that May be Underestimated on Imaging
- Immunocompromised & Significant Comorbidity Patients Have Mostly Been Excluded from Prior Studies with Uncertain Efficacy

Interval Appendectomy

- Definition: Appendectomy Done After a Trial of Nonoperative Management with Antibiotics
 - Generally Done After 6-8 Weeks
- Comparison to an Immediate Appendectomy for Complicated Appendicitis:
 - Decreased Risk of Complications (SBO, Prolonged Ileus, Surgical Site Infection & Reoperation) ⁶³
 - May Have Longer Return to Activity (Debated) ^{63,64}
- Some Recommend Against Interval Appendectomy Due to Low Recurrence Rate, Although One of the Most Compelling Reason for Interval Appendectomy is the Increased **Risk of Neoplasm** After Perforation
 - Risk of Recurrence: 5-38%
 - Risk of Neoplasm After Interval Appendectomy for Complicated Appendicitis: 11% ⁶⁵
 - If Interval Appendectomy is Forgone, Patients Over 40 Years Old Should Have an Interval Colonoscopy and CT ³⁰

Incidental (Prophylactic) Appendectomy

- Definition: Appendectomy During Another Separate Procedure without Evidence of Appendicitis
- Goal: Eliminate Future Risk of Appendicitis
- Indications Not Defined
- Associated with Complications and Generally Avoided ⁶⁶
- Contraindications: ⁶⁷
 - Unstable Hemodynamics
 - Established Crohn's Disease
 - Inaccessible Appendix
 - Predetermined Plan for Radiation Treatment
 - Pathologically or Iatrogenically Immunosuppressed
- Most Often Done for Patients Under Age 30-35 Years (Highest Incidence) During Hysterectomy, Cholecystectomy, Sigmoidectomy, or Trauma Laparotomy

Appendicitis in Pregnancy

General Information

- Overall Pregnant Women are Less Likely than Nonpregnant Women to Have Appendicitis ⁶⁸
- The Most Common Non-Obstetric Indication for Surgery During Pregnancy
- Appendix Perforation is More Common – Possibly Due to Diagnostic Challenges and Hesitancy to Operate on Pregnant Women ^{69,70}

Considerations by Trimester

- First Trimester:
 - Appendicitis is the Most Common Cause of Acute Abdominal Pain
- Second Trimester:
 - Most Frequent Trimester ⁶⁸
- Third Trimester:
 - Lowest Overall Rate of Appendicitis ⁷¹
 - Most Likely to Perforate ^{69,70}

Risks/Outcomes

- Maternal Morbidity and Mortality are Similar to Nonpregnant Women ⁷²
- Uncomplicated Appendicitis: ^{73,74}
 - Fetal Loss: 1.5-2.0%
 - Preterm Labor: 6%
- Complicated Appendicitis: ^{73,74}
 - Fetal Loss: 8-36%
 - Preterm Labor: 11%

- Highest Risk for Fetal Mortality: Appendix Rupture
- In General, Appendectomy During Pregnancy Does Not Negatively the Child ⁷⁵

Presentation

- Only 50-60% Have a Classical Clinical Presentation
- May Instead Present with Heartburn, Flatulence, or Diarrhea
- Location of Pain:
 - Most Commonly at McBurney's Point Regardless of Trimester ^{76,77}
 - May Migrate to the Right Mid-Upper Quadrant in the Third Trimester Due to a Gravid Uterus ^{78,79}
- Leukocytosis May Be Normal in Pregnancy ⁸⁰

Treatment

- Uncomplicated Appendicitis: Appendectomy
 - Optimal Approach Remains Inconclusive ⁸¹
 - Laparoscopic vs Open Appendectomy
 - Laparoscopic Associated with Lower Overall Complications and Shorter Length of Stay ⁸¹
 - Laparoscopic Associated with Higher Rate of Fetal Loss (Odds Ratio 1.82) ^{81,82}
 - Similar Rates of Preterm Labor ⁸²
 - Laparoscopic Trocar Placement: ***See Appendectomy**
 - Open Incision: Generally Recommended to Make at McBurney's Point or the Site of Maximal Pain (Possibly More Cephalad)
- Complicated Appendicitis:
 - Phlegmon/Abscess: Debated
 - Poor Evidence to Guide Decision Making
 - Consider Antibiotics with Percutaneous Drainage and Interval Appendectomy (Similar to Nonpregnant Patients) vs Immediate Appendectomy
 - Free Perforation: Open Appendectomy

Similar Pathology

Appendiceal Lymphoid Hyperplasia

- Definition: Increased Size of Lymphoid Tissue within the Appendix
- A Physiologic Response to Inflammation ⁸³
- Often Associated with Inflammatory Conditions Such as Viral Gastroenteritis or Mesenteric Adenitis ⁸³
- **Previously Believed to Be a Primary Cause of Appendicitis** but Now Disproven ⁸³
- Can Mimic Appendicitis with a Noncompressible and Dilated Appendix ⁸⁴
- Most Successful Parameters to Distinguish Appendicitis from Lymphoid Hyperplasia: ⁸⁴
 - Periappendiceal Fluid Collection
 - Lamina Propria Thickness ≤ 1 mm

Mesenteric Lymphadenitis (Mesenteric Adenitis)

- Also Known as “Pseudoappendicitis”
- Definition: Mesenteric Lymph Node Inflammation
 - A Self-Limiting Inflammatory Condition that Resolves Over 1-10 Weeks
 - Can Be a Primary/Nonspecific Etiology or Secondary
- Often Presents Similar to Appendicitis
- Most Common in Pediatrics
 - More Common than Appendicitis in the First Decade of Life ⁸⁵
- Secondary Causes: ⁸⁶
 - Viral Infection – Most Common Cause
 - Gastroenteritis
 - Upper Respiratory Infection (URI)
 - Bacterial Infection
 - Inflammatory Bowel Disease
 - Lymphoma
- Diagnosis: Generally Made by Imaging (US or CT) ⁸⁵
 - Must First Rule Out Other Diagnoses
- Treatment: Supportive Care (Fluid Resuscitation and NSAID’s) ^{85,86}
 - No Biopsy or Surgery Necessary

Periappendicitis

- Definition: Appendiceal Serosal Inflammation without Mucosal Inflammation
 - Caused by Non-Appendiceal Inflammation
- Often Presents Similar to Appendicitis
- 1-5% of Appendices Resected for Clinical Acute Appendicitis are Found to Have Periappendicitis Alone ⁸⁷
- Causes: ⁸⁷
 - Salpingitis (Gonococcal or Chlamydial) – Most Common Cause ⁸⁷
 - Pelvic Inflammatory Disease (PID)
 - Peritoneal Tuberculosis
 - Inflammatory Bowel Disease (IBD)
 - Infectious Colitis
 - Diverticulitis
 - Urologic Disease
 - Distant Perforation Elsewhere
 - Colonic Neoplasia
 - *Valentino’s Syndrome*: Periappendicitis Caused by a **Perforated Gastric/Duodenal Ulcer** ⁸⁸
- Diagnosis May Be Difficult to Make Preoperatively
- Treatment: Based on Underlying Cause

Appendiceal Mucocele (Non-Neoplastic Mucinous Lesion/Retention Cyst)

- ***See Appendiceal Mucocele**

Appendix Cancer

- *See Colon Cancer

Mnemonics

Signs of Appendicitis

- McBurney Sign – “Burns” Right Over the Appendix
- Rovsing Sign – Think “Roving” Pain Elicited from a Distant Site
- Psoas Sign (Pso-Po) – Posterior (Retrocecal Position)
- Obturator Sign (Ob-Ob) – Obstetrics (Pelvic Location & Internal Rotation to Pelvis)

Alvarado Score

- Often Referred to as “MANTRELS” Score
- M: Migration to RLQ (1)
- A: Anorexia (1)
- N: Nausea/Vomiting (1)
- T: Tenderness in RLQ (2)
- R: Rebound Tenderness (1)
- E: Elevated Temperature (1)
- L: Leukocytosis; WBC > 10,000 (2)
- S: Shift of Neutrophils (1)

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