Appendicitis: When Simple Becomes not so Simple

Elizabeth H. Ey  
_Wright State University_, elizabeth.ey@wright.edu

Jeffrey C. Pence  
_Wright State University_, jeffrey.pence@wright.edu

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Appendicitis: When simple becomes not so simple

Elizabeth H. Ey, MD
Associate Clinical Professor of Pediatrics
Department of Medical Imaging
Dayton Children’s Medical Center

Jeffrey C. Pence, MD, FACS, FAAP
Associate Professor of Surgery
Department of Surgery
Dayton Children’s Medical Center

Learning Objectives

- To further understand a contemporary approach in the management of acute appendicitis
- To acknowledge that appendicitis represents a continuum of disease
- To define “simple” versus “complicated” appendicitis
- To understand the importance of diagnostic and therapeutic imaging in appendicitis
- To explore alternative therapeutic strategies in complicated appendicitis based upon outcomes analyses

Appendicitis: When simple becomes not so simple

Historical Perspectives

- Reginald Fitz (Harvard, 1886)
- Presented “Perforative Inflammation of the Vermiform Appendix with Special Reference to Its Early Diagnosis and Treatment” to the Association of American Physicians
- Conclusively demonstrated that “perityphlitis” began with inflammation of the appendix
- Suggested immediate surgical intervention (3 days or less) for, or to prevent, spreading peritonitis

Fitz RH: Perforative inflammation of the vermiform appendix: With special reference to its early diagnosis and treatment. Trans Assoc Am Physicians 1:107, 1886

McBurney C: Experience with early operative interference in cases of disease of the vermiform appendix. N Y State Med J 50:676, 1889


““The seat of greatest pain…has been very exactly between an inch and a half and two inches from the anterior spinous process of the ilium on a straight line drawn from the process to the umbilicus” excess

Historical Perspectives

- Charles McBurney (1889)
- Greatest contributor to the treatment of appendicitis
- Published the landmark treatise on the surgical treatment of appendicitis before rupture
- Subsequently published (1894) the exposure of the appendix through an incision which now bears his name

Historical Perspectives

- “The seat of greatest pain…has been very exactly between an inch and a half and two inches from the anterior spinous process of the ilium on a straight line drawn from the process to the umbilicus” excess

McBurney C: Experience with early operative interference in cases of disease of the vermiform appendix. N Y State Med J 50:676, 1889

Introduction

- Most commonly diagnosed surgical condition of the abdomen
- Approximately 7% of individuals will develop acute appendicitis in their lifetime
- 250,000 cases diagnosed annually in United States
- Accounts for >1 million inpatient hospital days annually
- Cost of >3 billion US dollars per annum

Introduction

- Most commonly *misdiagnosed* surgical condition of the abdomen
- Incidence of perforated appendicitis ranges generally from 30–45 percent in pediatric and elderly populations
- Continues to cause significant morbidity and rare mortality

Anatomical Considerations

**What’s constant…**
- Three taenia coli converge at the junction of the cecum with the appendix
- Relationship of the appendiceal base to the cecum remains constant

**What’s not constant…**
- Length of the appendix may vary from <1 cm to >30 cm (typically 6–9 cm)
- Position of the appendiceal tip is markedly variable

Pathophysiology

**LUMINAL OBSTRUCTION**
- Appendicolith (40%)
- Lymphoid hypertrophy
- Parasites
- Foreign bodies
- Tumors

**INTRALUMINAL HYPERTENSION**
- Ongoing secretion
- Bacterial proliferation
- Appendiceal dilation

→ Sympathetic nervous system
→ Vague abdominal pain

**TRANSMURAL INFLAMMATION**
→ Somatic nervous system
→ Localized abdominal pain
→ Periappendiceal inflammation

**GANGRENE/MICROPERFORATION**

**GROSS PERFORATION**
→ Generalized peritonitis

**PHLEGMON/ABSCESS**

**A Dichotomous Disease**

**Simple appendicitis:**
- “Early” in time course
- Mild periappendiceal inflammation
- Nonperforated

**Complicated appendicitis:**
- “Late” in time course
- Significant periappendiceal inflammation
- Phlegmon
- Mass
- Abscess
The Surgeon’s Dilemma

- Simple appendicitis ———— Simple

- Simple appendicitis ———— Operate

Not every inflamed appendix is ready to burst, study finds

And many of the common surgeries may be unneeded to Helvetica

USA Today
January 19, 2010

The Surgeon’s Dilemma

- Complicated appendicitis ———— Not so simple

- Complicated appendicitis ———— Not so simple

- Complicated appendicitis ———— Not so simple

How do I distinguish complicated appendicitis?
Do I operate immediately in complicated appendicitis?
If so, what technique?
If I don’t operate, what should my expectations be?
If conservative management is successful, is interval appendectomy necessary?
I want to distinguish simple from complicated appendicitis. I believe that complicated appendicitis may harbor increased risks with acute appendectomy:

- Higher risk of intraoperative complications
- Higher risk of conversion
- Prolonged operative time
- Higher risk of postoperative complications (abscess formation)

I acknowledge that the total length of hospitalization, antibiotic administration, and cost of treatment will be unchanged if I employ initial nonoperative management.

Results:

- No intraoperative complications
- 7/34 (20%) required laparoscopic to open conversion
- 15/27 (56%) total complications in laparoscopic group
- 11/27 (41%) formed postoperative intraabdominal abscess in laparoscopic group
- 2/11 required laparotomy for drainage

Conclusions:

- Laparoscopic appendectomy for complicated appendicitis in children is associated with a notable increase in the incidence of postoperative intraabdominal abscess formation
- Early open conversion for complicated appendicitis if identified incidentally (intraoperatively)
Roach JF, et al.

- 360 (32%) radiographic, operative, or pathologic evidence of perforation (complicated appendicitis)
- 92/360 (26%) abscess or phlegmon on preoperative imaging
- 60/92 (65%) immediate appendectomy
- 32/92 (35%) conservative treatment with delayed (interval) appendectomy

Conclusions

- Optimal treatment of children who present with greater than 5 days of symptoms and preoperative imaging suggestive of complicated appendicitis is delayed appendectomy
- Initial nonoperative management is safe and effective with no children failing delayed appendectomy and no complications requiring repeat admission

Simillis C, et al.

A meta-analysis comparing conservative treatment versus acute appendectomy for complicated appendicitis (abscess or phlegmon).

Surgery 147:818-29, 2010

- Database search using Medline, EMBASE, Ovid, and Cochrane through June 2, 2008
- 74 total reports identified
- 17 reports evaluated in final meta-analysis
- 1/17 reports was a non-randomized prospective study
- 7/17 reports were pediatric

Outcomes for analysis

- Duration of hospital stay
  - Mean duration of hospital stay during first hospitalization
  - Overall duration of hospital stay, including IA and complications
- Duration of antibiotic administration
  - Excluded oral course completed subsequent to discharge
- Complications
  - Overall
  - Specific, including wound infection and abscess formation
- Reoperations
  - Postoperative complications after IA or AA

Results

### Table 2

<table>
<thead>
<tr>
<th>Outcome of interest</th>
<th>Studies</th>
<th>Patients</th>
<th>OR*</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of IV antibiotics</td>
<td>4</td>
<td>321</td>
<td>1.02</td>
<td>0.39</td>
</tr>
<tr>
<td>Duration of initial hospitalization</td>
<td>8</td>
<td>825</td>
<td>0.49</td>
<td>0.76</td>
</tr>
<tr>
<td>Overall duration of hospital stay</td>
<td>7</td>
<td>319</td>
<td>0.64</td>
<td>0.98</td>
</tr>
<tr>
<td>Overall complications</td>
<td>16</td>
<td>1,490</td>
<td>0.24</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Wound infection</td>
<td>10</td>
<td>1,024</td>
<td>0.28</td>
<td>0.001</td>
</tr>
<tr>
<td>Abdominal/ pelvic abscess</td>
<td>8</td>
<td>941</td>
<td>0.19</td>
<td>0.003</td>
</tr>
<tr>
<td>Ileus/bowel obstruction</td>
<td>8</td>
<td>941</td>
<td>0.35</td>
<td>0.004</td>
</tr>
<tr>
<td>Reoperation</td>
<td>4</td>
<td>363</td>
<td>0.17</td>
<td>0.02</td>
</tr>
</tbody>
</table>

*OR <1.0 favored CT group
Pediatric Subset Analysis
(n=7)

- No differences in duration of first hospitalization
- CT group had fewer overall complications (OR 0.21; P<0.001)
- CT group had fewer wound infections (OR 0.11; P=0.007)
- CT group had significantly less abdominal/pelvic abscess formation (OR 0.11; P<0.001)

Conclusions

Conservative management of complicated appendicitis is associated with:

- no change in duration of hospital stay
- no change in duration of intravenous antibiotic administration
- decreased overall complication rate
- decreased rate of reoperation

Radiology:
The importance and impact of imaging

Elizabeth H. Ey, M.D.
Associate Clinical Professor of Pediatrics, WSUBSOM
Department of Medical Imaging
Dayton Children’s Medical Center

Appendicitis: Imaging Evaluation

- Conventional radiographs – 2 views
- Ultrasound (US)
- Computerized Tomography (CT)

Abdominal Pain Imaging

- Child presents with abdominal pain
- Initial evaluation
  - History
  - Physical exam
  - Laboratory evaluations
  - Imaging

Conventional Radiographs

- Advantages
  - Readily available
  - Quick
  - No patient preparation
  - Little radiation (2 views – 100 mRad)
  - Low cost
Useful findings on conventional radiographs for abdominal pain

- Pneumoperitoneum
- Pneumonia
- Fecalith
- Small bowel obstruction
- Constipation (?)
Fecalith

Appendicitis: Imaging Evaluation

Ultrasound

Ultrasound Appendicitis

• Advantages
  • No ionizing radiation (0 mRad)
  • No intravenous contrast
  • Utility lies in a subgroup of children
    • Clinical findings are equivocal
    • To establish diagnosis of appendicitis
    • Aid in the diagnosis of other abdominal and pelvic conditions that may mimic appendicitis

• Disadvantages
  • Examination limited by obesity
  • Limited by bowel gas
  • Operator dependent, site dependent
  • Reported accuracy varies widely

• Sensitivity
  • Reports range from 44%-94%

• Specificity
  • Reports range from 47%-95%
**Ultrasound Appendicitis**


- Meta-analysis US based adult and pediatric studies published 1986 and 1994
- Overall **sensitivity** of **85%**
- Overall **specificity** of **92%**

**Graded Compression Technique**


- Using a high resolution, linear array transducer
- Gentle, gradual pressure applied to anterior abdominal wall to displace and compress normal bowel loops
- Creating a window to McBurney’s point

**Graded Compression Technique**

- Longitudinal and horizontal imaging is performed
- Ask the child to point to the site maximal tenderness for reference
- Localize the ascending colon, move inferiorly
- Localize normal compressible terminal ileum
- Cecal tip is 1-2 cm below terminal ileum

**Ultrasound for Appendicitis**

- Criteria
  - Tubular, blind ending structure
  - Non compressible
  - Diameter (outer wall to outer wall) > 6 mm
- May also see
  - Fecalith – shadowing structure in lumen
  - Hyperemia of wall
  - Enlarged mesenteric lymph nodes
  - Periappendiceal fat inflammation
  - Phlegmon or abscess

**Ultrasound for Appendicitis**

- False negative diagnosis
  - Failure to visualize the entire appendix
    - Inability to adequately compress the RLQ
    - Aberrant location of appendix – retrocecal
    - Appendiceal perforation
    - Early inflammation at the distal tip

**Ultrasound for Appendicitis**

- False positive diagnosis
  - Identify a normal appendix as abnormal
    - Should be 6 mm or less diameter, compressible, no adjacent inflammatory changes
  - Other causes of RLQ inflammation
    - Crohn disease
    - Inflamed Meckel diverticulum
    - Pelvic inflammatory disease
**Normal Appendix**

- 4 mm

**Acute Appendicitis: Simple, non perforated**

- Echogenic, shadowing fecalith
- Wall hyperemia

**Acute Appendicitis: Simple, non perforated**

- Target Appearance:
  - Fluid filled lumen
  - Echogenic mucosa and submucosa
  - Hypoechoic muscularis

**Complicated Appendicitis**

*Spectrum of gangrenous to perforated appendicitis*

- Loss of echogenic submucosal layer
- Absent blood flow in thickened wall
- Lumen may no longer be distended with fluid
- Periappendiceal or pelvic fluid collection
  - Simple fluid
  - Echogenic, inflammatory mass (phlegmon)
  - Loculated, complex fluid collection (abscess)
    - +/- air bubbles or swirling complex fluid

**Complicated Appendicitis**

- Inflamed periappendiceal fat
Complicated Appendicitis

Appendicitis: Imaging Evaluation

Computerized Tomography

CT Appendicitis

Advantages
- Highly sensitive and specific modality for diagnosis of acute appendicitis
- Reported sensitivity 87%-100%
- Reported specificity 89%-98%
- Reduced operator dependence
- Superior contrast sensitivity (air, fat, fluid, bone)
- High anatomic detail
- More useful than US for complicated appendicitis

Disadvantages
- Relatively high radiation dose (1000 mRad)
- Do it well the first time!
- Younger, thinner patients have less intrabdominal fat to separate the appendix from adjacent bowel
- Highest diagnostic efficacy found using rectal contrast and IV contrast

CT Appendicitis

- Normal appendix on CT
  - Can be identified in over 75% of children
  - Usually less than 7 mm in diameter
  - Lumen may contain contrast or air

CT features of appendicitis
- Distended appendix >7 mm diameter*
- Appendiceal wall thickening and enhancement
- Fecalith
- Circumferential or focal cecal wall thickening*
- Pericecal fat stranding
- Adjacent bowel wall thickening
- Free peritoneal fluid
- Mesenteric lymphadenopathy
- Intraperitoneal phlegmon or abscess

CT Normal Appendix

CT Normal Retrocecal Appendix

CT Simple Appendicitis

CT Simple Appendicitis
CT Complicated Appendicitis
6 days later
Phlegmon now Abscesses

CT Complicated Appendicitis
Abscesses

CT Complicated Appendicitis
Percutaneous Abscess Drains

Clinical Scenario

Patient 1
- 2 day history of abdominal pain
- Reported fever
- Nausea and emesis with anorexia
- Temperature 38.7°C
- Right lower quadrant tenderness
- WBC 16,700
- Segmented neutrophils 83%
- C-reactive protein 21.4

Patient 2
- 2 day history of abdominal pain
- Reported fever
- Nausea and emesis with anorexia
- Temperature 39.0°C
- Suprapubic tenderness
- WBC 24,300
- Segmented neutrophils 90%
- C-reactive protein 24.3
**Clinical Scenario**

**Patient 1**
- Conservative management
- PICC
- Dual antibiotic therapy
- Oral diet by HD 2
- Afebrile by HD 3
- WBC 7,500
- Segmented neutrophils 60%
- C-reactive protein 8.2
- Total LOS 5 days
- Interval appendectomy 6-8 weeks

**Patient 2**
- Operative management
- PICC
- Dual antibiotic therapy
- Oral diet by HD 4
- Afebrile by HD 4
- WBC 7,000
- Segmented neutrophils 69%
- C-reactive protein 1.6
- Total LOS 7 days

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**Treatment**

Now I’ve decided *not* to operate initially…

How successful is delayed appendectomy?

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**Bufo AJ, et al.**


- Retrospective review
- 87 patients with perforated appendicitis
- 1995-1997
- 46 patients underwent immediate appendectomy
- 41 patients placed on interval appendectomy pathway
- 34/41 successfully bridged to interval appendectomy

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**Results**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Immediate Appendectomy</th>
<th>Interval Appendectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>46</td>
<td>34*</td>
</tr>
<tr>
<td>Hospital days</td>
<td>6.2 +/- 3.1</td>
<td>4.2 +/- 3.0</td>
</tr>
<tr>
<td>Hospital charges (USD)</td>
<td>11,044 +/- 11,321</td>
<td>6,435 +/- 4,447</td>
</tr>
<tr>
<td>Total charges (USD)</td>
<td>12,426 +/- 12,002</td>
<td>7,525 +/- 3,250</td>
</tr>
<tr>
<td>Percent complications</td>
<td>21</td>
<td>6</td>
</tr>
</tbody>
</table>

*Excludes “failures” of intent to treat (7 patients = 17%)

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**Conclusions**

- Antibiotic therapy, followed by interval appendectomy, decreases postoperative morbidity in the treatment approach to perforated appendicitis
- Cost savings are realized in the delayed operative management of perforated appendicitis in children
Treatment

I can successfully perform an interval appendectomy consistently and safely…

But should I?

Recurrent/Interval Appendicitis

- Hoffmann J, et al. (1984) 20%
- Eriksson S and Granstrom L (1995) 37%
- Friedell M and Perez-Izquierdo (2000) 8%
- Oliak D, et al. (2001) 8%
- Brown CV, et al. (2003) 6%
- Ella SH, et al. (2005) 43%
  + appendicolith 72%
  - appendicolith 26%

Puapong D, et al.
Routine interval appendectomy in children is not indicated.

- Retrospective study
- 12 year period (1992-2004)
- 6,439 children
- 72 (1.1%) initially treated nonoperatively
- 11/72 (15%) underwent interval appendectomy
- 61/72 (85%) underwent observation

Results

- Mean observation period of 7.5 years (range 2 months to 12 years)
- 5/61 (8%) developed recurrent appendicitis
- All recurrences within 3 years
- 80% of recurrences within 6 months
- Cumulative mean LOS without IA 6.6 days
- Cumulative mean LOS for recurrent appendicitis 9.6 days
- Cumulative mean LOS for IA 8.5 days

Conclusions

- Recurrent appendicitis is rare in pediatric patients following successful nonoperative management
- Low recurrence rate of 8% fails to justify routine interval appendectomy
Appendicitis: When simple is not so simple

**Summation**

- Appendicitis happens (relatively frequently)
- Beat the perforation
- When in doubt, seek help (*adjunct imaging*)
- Distinguish simple from complicated appendicitis

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**Appendicitis:**

**When simple is not so simple**

**Summation**

- Complicated appendicitis can (*and probably should*) be treated conservatively
- Interval (laparoscopic) appendectomy remains appropriate in the pediatric population (particularly in the presence of a retained appendicolith)
- Prospective randomized trial