Appendicitis: When Simple Becomes not so Simple

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Appendicitis: When simple becomes not so simple

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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

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

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

McBurney C: Experience with early operative interference in cases of disease of the vermiform appendix. N Y State Med J 50(6/76), 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”
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

***TRANSMURAL INFLAMMATION***

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

**SOMATIC NERVOUS SYSTEM**

**Sympathetic nervous system**
- Vague abdominal pain

**LOCALIZED ABDOMINAL PAIN**

**PERITONEAL INFLAMMATION**
- Generalized peritonitis

**PHLEGMON/ABSCESSES**

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

**The Surgeon’s Dilemma**

- Simple appendicitis —— Operate

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**Not every inflamed appendix is ready to burst, study finds**

USA Today
January 19, 2010

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**The Surgeon’s Dilemma**

- Complicated appendicitis —— Not so simple

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**The Surgeon’s Dilemma**

- 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 open 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

**Horwitz, JR, et al.**

- Retrospective review
- 2 year period (1994-1996)
- 56 children with complicated appendicitis
- 34 children underwent initial laparoscopic appendectomy
- 22 children underwent open appendectomy

**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 JP, et al.**

- Retrospective review
- 1106 children undergoing either open or laparoscopic appendectomy
- 5 year study period (2000-2006)
Rouch 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

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</th>
<th>Immediate appendectomy (n = 60)</th>
<th>Drainage and delayed appendectomy (n = 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak duration of symptoms (days)</td>
<td>4.6 ± 5.3</td>
<td>6.0 ± 3.8</td>
</tr>
<tr>
<td>Admission temperature</td>
<td>38.3 ± 0.9</td>
<td>38.3 ± 1.4</td>
</tr>
<tr>
<td>Admission WBC</td>
<td>166 ± 9</td>
<td>193 ± 12</td>
</tr>
<tr>
<td>Hospital LOS (interval appendectomy)</td>
<td>9.1 ± 3</td>
<td>8.3 ± 7</td>
</tr>
<tr>
<td>Well-defined mass on preoperative imaging</td>
<td>31 (52%)</td>
<td>31 (97%)</td>
</tr>
<tr>
<td>Clasification requiring admission</td>
<td>6 (10%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

* p < 0.05

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

<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>961</td>
<td>0.19</td>
<td>0.003</td>
</tr>
<tr>
<td>Ileus/bowel obstruction</td>
<td>8</td>
<td>946</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**

- 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

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**Radiology:**

*The importance and impact of imaging*

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Dayton Children’s Medical Center

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**Appendicitis: Imaging Evaluation**

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

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**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 (?)
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 for 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

- 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

- 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

- Inability to adequately compress the RLQ
- Aberrant location of appendix – retrocecal
- Appendiceal perforation
- Early inflammation at the distal tip
**Normal Appendix**

- 4 mm
- Compression

**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

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

**Outside CT No Contrast**
Simple or Complicated?

**RLQ Ultrasound – Same Day**

**CT Complicated Appendicitis**
After 5 days antibiotics

**CT Complicated Appendicitis**

**Image Guided Pigtail Drain Placement**

**CT Complicated Appendicitis**
Phlegmon
**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 7,000
- 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

Treatment

Now I’ve decided not to operate initially…

How successful is delayed appendectomy?


- 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

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%)

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 and Granstram L (1995) 37%
- Friedell M and Perez-Izquierdo (2000) 8%
- Oliak D, et al. (2001) 8%
- Brown CV, et al. (2003) 6%
- Elia SH, et al. (2005) 43%
  + appendicolith 72%
  - appendicolith 26%

Puapong D, et al.

- 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