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

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

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

Appendicitis: When simple becomes not so simple

“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”

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 50:676, 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

- 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**

<table>
<thead>
<tr>
<th>LUMINAL OBSTRUCTION</th>
<th>Transmural inflammation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendicolith (40%)</td>
<td>Somatic nervous system</td>
</tr>
<tr>
<td>Lymphoid hypertrophy</td>
<td>Localized abdominal pain</td>
</tr>
<tr>
<td>Parasites</td>
<td>Periappendiceal inflammation</td>
</tr>
<tr>
<td>Foreign bodies</td>
<td></td>
</tr>
<tr>
<td>Tumors</td>
<td></td>
</tr>
</tbody>
</table>

**INTRALUMINAL HYPERTENSION**

- Ongoing secretion
- Bacterial proliferation
- Appendiceal dilation

Sympathetic nervous system

Vague abdominal pain

**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

USA Today
January 19, 2010

The Surgeon’s Dilemma

• Simple appendicitis ——— Operate

The Surgeon’s Dilemma

• Complicated appendicitis ——— Not so simple

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

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**Horwitz, JR, et al.**

*Should Laparoscopic Appendectomy Be Avoided for Complicated Appendicitis in Children?*


- 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)

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**Roach JP, et al.**

*Complicated appendicitis in children: a clear role for drainage and delayed appendectomy.*


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

**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

<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>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>981</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>0.82</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

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**Radiology: The importance and impact of imaging**

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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 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

Ultrasound for Appendicitis

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
- 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

- 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 Appendicitis

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

**Image Guided Pigtail Drain Placement**

**CT Complicated Appendicitis**

**CT Complicated Appendicitis**

Phlegmon
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

Patient 1
Patient 2
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 60%
- 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 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%
- Ela 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

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