Acute Appendicitis: What’s New with an Old Foe?

UCSF Postgraduate Course in General Surgery
Maui, HI
March 21, 2011

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- Introduction
- Nonoperative Management
- Timing of Surgery
- Interval Appendectomy
- Summary
Appendectomy is one of the most common surgical procedures performed worldwide; More than 300,000 appendectomies are performed annually in the United States, accounting for ~1 million hospital days; Individual lifetime risk of appendicitis is 7% for women and 9% for men; Understanding the history of appendicitis and surgery of the appendix helps underscore some of the current management controversies.

Acute Appendicitis

- First unequivocal report of acute appendicitis was by the German anatomist, surgeon and botanist Lorenz Heister in 1711;
- Heister described a perforation of the appendix with a small adjacent abscess during the autopsy of a criminal;
- He is credited for coining the word tracheotomy and his name is lent to the plant genus Heisteria and to the anatomical folds of the cystic duct, i.e. the spiral valves of Heister.

Lorenz Heister (1683-1758)
• First appendectomy was performed by Claudius Amyand, the Sargent Surgeon to George II, in 1735;
• He operated on a 11-year old boy with a right scrotal hernia and fistula and discovered a perforated appendix within the scrotum.
• His name is lent to the eponym for the presence of an incarcerated appendix within an inguinal hernia sac, i.e. an *Amyand’s hernia*.

Claudius Amyand (1680-1740)

• However, it was Reginald Heber Fitz, a pathologist at Harvard, who first proposed the appendix as the cause of much right lower quadrant inflammation or typhlitis in 1886, some 150 years after the appendix was first described;
• Importantly, Fitz recommended the early surgical removal of the appendix.
• He was the first to coin the term *appendicitis*.

REGINALD HEBER FITZ (1845-1913)
• In 1889, Charles McBurney published the first of several important papers supporting early surgical removal of the appendix;
• He went on to develop a muscle-splitting incision for the operation.
• His name is assigned to the point of maximal abdominal tenderness with appendicitis (*McBurney’s point*) and the classic appendectomy incision (*McBurney’s incision*).

Charles Heber McBurney (1845-1913)

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**Acute Appendicitis**

• For 125 years, since the pioneering work of Fitz and McBurney in the late 1880’s, open appendectomy has been the standard of care and gone virtually unchallenged;

• Similarly, most surgeons consider acute appendicitis an progressive inflammatory condition that inexorably leads to perforation if not surgically removed in a timely manner, reinforcing the century-old recommendations of a pathologist.

• However, appendectomy is not harmless and non-operative management with antibiotics has been established for uncomplicated diverticulitis, salpingitis and neonatal enterocolitis.
What is the evidence that acute appendicitis, if given enough time, leads to perforation?

- Considerable information can be derived from studying the treatment of suspected acute appendicitis in remote medical care environments, e.g., submarines, Antarctic expeditions and space stations;

- There are 10 published studies of nonoperative treatment of appendicitis between 1959-2001 involving over 1,200 patients;

- Estimated cumulative outcome rates are:
  - 65-80% successful resolution of symptoms
  - ~25% recurrence at 1 year
  - <1% mortality

What is the evidence that acute appendicitis, if given enough time, leads to perforation?

- A meta-analysis of 3 RCTs (World J Surg 2010;34:199-209)
  - 350 pts randomized to antibiotics for uncomplicated appendicitis with 65% success (n=238) and 15% recurrence (n=38, 9 perforations, 1 gangrenous) rates.

- Antibiotic treatment yielded a RR=0.43 (0.16,1.18) p=0.10 with 200 patients (57%) remaining asymptomatic at 1 year.

- The authors concluded that, "although antibiotics may be used as primary treatment for selected patients with suspected uncomplicated appendicitis, this is unlikely to supersede appendectomy at present. Selection bias and crossover to surgery in the RCTs suggest that appendectomy is still the gold standard therapy for acute appendicitis."

- Interestingly, <7% of patients developed perforated or gangrenous appendicitis when randomized to treatment with antibiotics.
What is the evidence that acute appendicitis, if given enough time, leads to perforation?

- There is strong epidemiological evidence that uncomplicated versus perforated appendicitis are two different pathologic conditions;

- A Swedish study of 56,172 patients (BMJ 1994;308:107-110) operated on for suspected appendicitis over 2 decades demonstrated that the incidence of perforated appendicitis was 16% and independent of age, time, or appendectomy rate, while the incidence of uncomplicated appendicitis was dependent on age, decreased over time and directly related to the appendectomy;

![Graph showing incidence of perforating versus non-perforating appendicitis in relation to removal of normal appendix in 23 sets of data obtained from previous and present studies. Regression lines exclude two outliers.](BMJ 1994;308:107-110)
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- The authors concluded that,
  - perforating and non-perforating appendicitis are different clinical entities,
  - appendicitis that resolves spontaneously is common, and
  - perforation rate is useless as a measure of quality in managing suspected appendicitis.

Acute Appendicitis: surgical management

- Appendectomy remains the therapeutic gold standard.

- Is suspected acute appendicitis a surgical emergency? What is the urgency of the surgical procedure?
A recent retrospective cohort study of ACS-NSQIP data (2005-2008) examined the effect of delay from admission to surgery on 30-day outcomes after appendectomy in adults;

The 32,782 patients under study were stratified into three groups as a function of time to surgery:

- ≤ 6 hours (24,647 patients; 75%)
- 6-12 hours (4,934 patients; 15%)
- >12 hours (3,201 patients; 10%)

These data were risk-adjusted and compared severity of disease, surgical approach, wound classification, length of stay, and overall morbidity and mortality rates.

Table 2. Disease and Treatment Characteristics of Patients Undergoing Appendectomy for Acute Appendicitis Stratified by Time Interval From Surgical Admission to Operation at ACS NSQIP Hospitals

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>≤8 (n=24,647 (75.2%))</th>
<th>&gt;8 and ≤12 (n=4934 (15.1%))</th>
<th>&gt;12 (n=3201 (9.9%))</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease severity^a</td>
<td>21,345 (87.3%)</td>
<td>4223 (85.3%)</td>
<td>2992 (93.7%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Surgical approach</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laparoscopic</td>
<td>18,793 (76.2%)</td>
<td>3819 (77.4%)</td>
<td>2450 (75.9%)</td>
<td>.07</td>
</tr>
<tr>
<td>Open</td>
<td>5854 (23.8%)</td>
<td>1115 (22.6%)</td>
<td>792 (24.1%)</td>
<td></td>
</tr>
<tr>
<td>Operation time, mean (SD), min</td>
<td>50.38 (27.29)</td>
<td>49.94 (23.31)</td>
<td>54.85 (26.62)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Wound class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean or clean-contaminated</td>
<td>8460 (54.2%)</td>
<td>1717 (54.8%)</td>
<td>1304 (40.7%)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Contaminated or dirty/infected</td>
<td>16182 (45.8%)</td>
<td>3217 (45.2%)</td>
<td>1899 (59.3%)</td>
<td></td>
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Table 3. Postoperative Length of Stay and 30-Day Outcomes of Patients Undergoing Appendectomy for Acute Appendicitis Stratified by Time Interval From Surgical Admission to Operation at ACS NSQIP Hospitals

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<td>Postoperative length of stay, mean (SD), days</td>
<td>1.86 (2.70)</td>
<td>1.75 (2.18)</td>
<td>2.19 (3.34)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Overall mortality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cause of death, No. (%)</td>
<td>1291 (5.3%)</td>
<td>234 (4.7%)</td>
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<td>.008^a</td>
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<td>5.4</td>
<td>6.1</td>
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<tr>
<td>Other (55.0%)</td>
<td>1 (proven)</td>
<td>0.9 (0.8-1.0)</td>
<td>1.0 (0.8-1.25)</td>
<td>...</td>
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<tr>
<td>Bacterial/mortality</td>
<td></td>
<td></td>
<td></td>
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Acute Appendicitis: interval appendectomy

- An appendiceal mass complicates 2-10% of cases of appendicitis;

- The mass results from pathology ranging from an inflammatory phlegmon to a walled off abscess;

- Fever and leukocytosis are common and CT has >95% diagnostic accuracy;

- Despite this relatively common condition, several management controversies persist, including:
  - conservative treatment versus emergency resection
  - need for interval appendectomy
  - open versus laparoscopic surgical technique

- The standard treatment was introduced by Ochsner in 1901.

• Ochsner claimed to be related to Vesalius. He graduated from Rush Medical College, Chicago in 1886. In 1900 he was appointed the chair of surgery at the University of Illinois College of Medicine, holding this tenure until his death 25 years later.

• A major figure in American surgical politics, serving as president of the American College of Surgeons (1923) and the American Surgical Association (1924).

• His most important article concerned peritonitis as a complication of appendicitis (1901). In that paper he proposed a treatment of appendicitis with which his name remain linked: Ochsner-Sherren treatment. when operation is not advisable, treatment should consist of bowel rest (no cathartics or oral intake) combined with gastric lavage and rectal “feeding”.

Albert John Ochsner
(1858 -1925)
He reported on 565 cases of appendicitis wherein patients with diffuse peritonitis had an operative mortality of 55%, while those with gangrenous or perforated appendicitis who were treated conservatively had a 5% mortality. Thus, delaying surgery was strongly advised largely to avoid diffuse peritonitis.

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- In 1897 he published a paper entitled “Surgical Treatment of Habitual Criminals” that would have widespread impact. He described performing vasectomies and wrote that with the physical elimination of “all habitual criminals from the possibility of having children,” crime would decrease significantly. A similar treatment “could reasonably be suggested for chronic inebriates, imbeciles, perverts and paupers.”

Albert John Ochsner (1858 -1925)
Acute Appendicitis: interval appendectomy

<table>
<thead>
<tr>
<th>advantages</th>
<th>disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservative approach</td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>Failure rate and recurrent symptoms in up to 46%</td>
</tr>
<tr>
<td>Allows acute episode to settle</td>
<td>Delayed emergency surgery in non-responders is hazardous</td>
</tr>
<tr>
<td>Good response in &gt;90%</td>
<td>More costly (antibiotics, longer hospital stay, time out of work)</td>
</tr>
<tr>
<td>Interval appendectomy may be needed with 2nd hospital admission</td>
<td></td>
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<tr>
<td>Has a complication rate of 12-23%</td>
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</tbody>
</table>

| Emergency surgery | |
| Safe, feasible and cost-effective | May be difficult, especially if delayed |
| Acceptable operative time | Differentiation between inflammatory and malignant masses may be difficult |
| No need for interval appendectomy or 2nd admission | Unnecessary ileo-cecal resection may be performed |
| Deals with pathology right away, including the unexpected | May have higher complication rate than interval appendectomy |
| No need for extended follow-up and further investigations | |

• Review of 9 articles examining early surgery for appendiceal mass with a total of 340 patients (36% children) published between 1976 - 2005 employing both open and laparoscopic approaches.

• Seven of the articles concluded that emergency surgery was feasible, safe, associated with minimal morbidity and cost-effective.

• A recent trial randomized 131 children diagnosed with perforated appendicitis to early (<24 h) versus interval appendectomy (6-8 weeks) and concluded that early surgery significantly reduced time away from normal activities (14 v. 19 days) and had a lower adverse event rate (30% v. 55%) compared to interval surgery (Arch Surg published online Feb. 21, 2011);

• Strikingly reminiscent of the debate between early versus delayed surgery for acute cholecystitis.
Acute Appendicitis: is interval appendectomy necessary?

- A survey of 663 surgeons in North America noted that 86% routinely performed interval appendectomy, most commonly out of concern for recurrent appendicitis (J Am Coll Surg 2003;196:212-221);

- Importantly, a large retrospective cohort study of 1,012 patients treated initially conservatively revealed a 5% risk of recurrent appendicitis after a median follow-up of 4 years (Arch Surg 2005;140:897-901);

- Pathologic examination of interval appendectomy specimens frequently reveals a patent lumen and/or no evidence of previous inflammation;

- Given the available data, treatment recommendations vary based on the surgeon’s decision regarding the advisability of early surgery and the age, gender and clinical course of the patient.

Appendiceal Mass: Treatment Algorithm

J Gastrointest Surg 2008;12:767-775
Acute Appendicitis: Summary

- Despite the frequency of the condition, "modern" surgical practice is largely governed by level 4 and 5 evidence that is 100-150 years old;

- Nonoperative management of uncomplicated acute appendicitis with antibiotics is a reasonable alternative to immediate surgery, with estimated 65-80% success and 25% recurrence rates;

- Suspected uncomplicated appendicitis requires timely, but not urgent surgery;

- Early surgery is a feasible, safe and cost-effective alternative to the conservative management of appendiceal mass;

- Interval appendectomy should be selectively performed based on the patient’s age, gender and clinical condition;