Quality Improvement in Appendectomy

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Disclosures

• None
Objectives

• Gain perspective on historical context and more recent trends in relation to outcomes and quality improvement
• Identify opportunities for improving outcomes along the continuum of the clinical course of acute appendicitis
• Appreciate how existing literature applies to these quality improvement opportunities
Outline

• Perspective
  – History/Background
  – Current statistics

• Opportunities for Improvement of Outcomes
  – Delay in presentation/treatment
  – Diagnosis
  – Decision to operate
  – Operative approach
  – Perioperative care
Pathogenesis

• Luminal Obstruction
  • Fecaliths
  • Parasites
  • Lymphoid Hyperplasia
  • Foreign Bodies
  • Primary Tumor
  • Metastatic Tumor

• Distension $\rightarrow$ ↑Intramural pressure
• Stasis and thrombosis
• Ischemia
• Necrosis
• Perforation
History

• “Appendicitis” coined by Reginald Heber Fitz (pathologist at Mass General) in 1886
• 1889: Recognizing that appendicitis ranges unpredictably between spontaneous resolution to perforation and potential death, McBurney advocates early appendectomy
• 1981: first Lap appy by Semm, German Gynecologist
Epidemiology

- 6-7% will develop appendicitis during lifetime
- Most common emergency operative procedure worldwide
- 2006: 341,000 appys in non-federal U.S. hospitals
- Accounts for ~1,000,000 hospital days annually
Historical Statistics

- Complication rate range 9-15%
- Mortality has decreased over the past century from 26% to <1%
- Complicated Appendicitis
  - Perforation rate 20%
  - Abscess rate 12%
  - Complication rate increases with greater delay between onset and surgery
- Rate of negative appendectomies is inversely proportional to rate of perforation
  - Negative appy is the price to be paid for minimizing perforation
  - Acceptable negative appendectomy rate up to 20%
    - As high as 40% in women of childbearing age
  - Mortality of 0.14% in negative appendectomy
Advances in Diagnosis and Treatment

- Evolving CT technology
  - Popularized by Rao in 1998
  - Usage has increased from 18.5% (1998) to 94.2% (2007)
  - Sensitivity of 94%
  - Specificity of 95%

- Increasing prevalence of Laparoscopy
  - 2008: 76.4% done laparoscopically

- Advancement of antibiotic treatment as alternative in uncomplicated appendicitis
Current Statistics

- **NIS 2006-2008**
  - Overall morbidity 8.27%
    - Lap 7.1% vs. Open 10.5%
  - In-Hospital mortality 0.06%
    - Lap 0.04% vs. Open 0.1%

- **NSQIP 2005-2008**
  - Overall morbidity 5.5%
    - Lap 4.5% vs. open 8.8%
    - Organ space infection
      - All 4.8%
      - Complicated 6.3%
  - Mortality 0.09%

- **Postop organ space infection** (Moore 2011)
  - Laparoscopic = 3.3%
  - Open = 2.6%

- **Complicated appendicitis (2005 to 2007 NSQIP)**
  - LOS: lap 3.98 days vs. open 5.14 days
  - Superficial SSI: lap 1.68% vs. open 5.95%
  - Wound dehiscence: lap 0.24% vs. open 1.39%
  - Organ space infection: lap 6.74% vs. open 3.69%

- **Negative Appendectomy**
  - Ranges from 1.7% to 12.5%
Opportunities for Improvement

• Interval between onset and OR
• Diagnosis
• Decision to operate
• Operative approach
• Perioperative care
ONSET to OR
Onset to OR

- Increased delay from onset of symptoms to operative intervention is associated with more advanced disease (Temple, Maroju, Eldar, Ditillo, Hale)
  - Ditillo demonstrated increasing proportion of complicated appendicitis with greater delay between onset and OR
    - <12 hours = 94% uncomplicated
    - >72 hours = 54% uncomplicated

- More advanced/complicated disease associated with higher morbidity and mortality
  - NIS data
    - Uncomplicated: morbidity 4.92%, mortality 0.04%
    - Complicated: morbidity 21.5%, mortality 0.15%
Onset to OR

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- More advanced/complicated disease associated with higher morbidity and mortality
  - NIS data
    - Uncomplicated: morbidity 4.92%, mortality 0.04%
    - Complicated: morbidity 21.5%, mortality 0.15%
• Single institution, 6 month prospective study
• 95 consecutive adults undergoing appy
  – Determined time of:
    • Onset
    • ED presentation
    • Surgical Consult
    • OR
• Results
  – Perforated significantly correlated to delay in presentation (57 vs. 22 hours, p<0.007)
  – Significantly shorter ED to OR time for perforated appendicitis (6.53 vs. 8.79 hours, p<0.02)
    • Accounted for by more rapid surgical evaluation
  – No comment regarding significance of in-hospital delays
• Conclusion:
  – “Delay in presentation accounts for the majority of perforated appendices. Clinical evaluation is effective for identifying patients with more advanced disease.”
In-hospital Delay Increases the Risk of Perforation in Adults with Appendicitis

Mirjam Busch - Florian S. Gutzwiller - Sonja Dellig - Rolf Kueettel - Urs Mettler - Urs Zwegg

- Multi-institutional, 11 Swiss hospitals 2003-2006
- Prospectively followed 1,827 adult patients
- Grouped by in-hospital delay (admission to ED to OR)

Results:
- Higher perforation rate for in-hospital delay >12 hours (29.7% vs. 22.7%, p=0.01)
- No significant increase at 6 or 9 hours
- Delay correlates with institution size, time of admission and technique (open vs. lap)

Conclusions:
- “In-hospital delay negatively influences outcome after appendectomy. In-hospital delay of more than 12 h, age over 65 years, time of admission during regular hours, and the presence of co-morbidity are all independent risk factors for perforation. “
Delay in Decision to OR

- Data inconclusive regarding impact of in-hospital delay
- Ditillo, 2006: "Is it safe to delay appendectomy in adults with acute appendicitis"
  - Retrospective Review
  - OR = 13 (4.7-37.1) for progressive pathology for >72 hours vs. <12 hours
  - Progression more profoundly associated with pre-hospital vs. in-hospital delay
  - Conclusion: “risk of developing advanced pathology and postoperative complications increases with time; therefore, delayed appendectomy is unsafe.”
- Ingraham, 2010: “Effect of delay to operation on outcomes in adults with acute appendicitis”
  - Retrospective cohort study
  - Statistically significant increased (but clinically insignificant:
    - Operative time, postoperative LOS and total LOS
  - No difference in 30-day morbidity and mortality
  - Conclusion: “delay of appendectomy for acute appendicitis in adults does not appear to adversely affect 30-day outcomes.”
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Delay in Decision to OR

- Udgiri, 2011: “Appendicitis, is it an emergency?”
  - Retrospective review
  - Defined delayed as >10 hours ED to incision
  - Female more likely to be delayed
  - Increased LOS, intra-abdominal abscess, readmission rates
  - No difference in rate of conversion to open
  - Conclusions: “early surgical intervention is beneficial in acute appendicitis”
- Qureshi, 2011: “The impact of an Acute Care Emergency Surgical Service on timely surgical decision-making and emergency department overcrowding.”
  - Significant reduction in surgical decision time 12.6 vs. 10.8 hours
  - Significant decrease in ED LOS for appendicitis 17.0 vs. 11.8 hours
  - No difference in hospital LOS, perforation rate
  - Conclusion: “ACS service reduced surgical decision time and improved overall ED overcrowding.”
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- Retrospective series in VA system
- 4950 appendectomies
- Statistics similar to general literature
  - Negative appy = 12.8%, uncomplicated 66.4%, perforated 20.9%
- Results
  - Perforated appendicitis (not specified how time of perforation determined)
    - 52% occurred before first medical contact
    - 68% occurred before surgical evaluation
  - Outpatient delay significantly predicts perforation (p<0.001)
  - Inpatient delay non-significant increase in perforation
  - Negative appy rate had no association with any interval of delay
- Conclusions:
  - “Perforation rates are determined predominantly by patient- and primary care-related factors over which surgeons have little control. Negative appendectomies are predominantly related to the wide overlap in presenting signs and symptoms between appendicitis and the diseases that most often mimic it but do not require operative intervention (due to lack of sensitive, specific, and accurate diagnostic tools). “
  - “Ascertaining and correcting the reasons that so many patients have perforation at the outset represents the single greatest potential avenue for decreasing morbidity in patients with appendicitis.”
DIAGNOSIS
Impact of CT on Outcomes

- General trends in the literature
  - Highly accurate: sensitivity 94%, specificity 95%
    - Resulting in lower negative appendectomy rate
  - Dramatically increased utilization of CT in past decade
  - CT increases ED LOS (OR delay) by 2-5 hours
  - Increasing concern for CT-related cancer risk
    - Extrapolated from atomic bomb survivors
    - Estimate lifetime risk of death from cancer due to abdominal CT
      - <0.06% in 25 year old
      - <0.02% in age > 40
Impact of CT

- Pritchett, 2010: “Management of acute appendicitis: the impact of CT scanning on the bottom line”
  - Retrospective review
  - CT added 3.5 hours in delay
  - Increased cost contributed to decrease in contribution to margin: $6,347 to $4,295
  - Conclusion: “Increasing use of CT scanning in acute appendicitis increases cost of care, decreases contribution to margin, prolongs patient’s stay in the emergency department, and delays time to operation.”
- Coursey, 2010: “Diagnosing appendicitis: do more preoperative CT scans mean fewer negative appendectomies?”
  - Retrospective analysis
  - CT usage increased from 18.5% to 94.2% from 1998 to 2007
  - Negative appy rate significantly declined, 16.7% to 8.7%
    - Negative rate in women <45 declined from 42.9% to 7.1%
    - No reduction in other women or in men of any age
  - Retrospective analysis
  - Pre-op CT vs. no CT had reduced negative appy rate, 4.7% vs. 12.7% (p=0.03)
  - Among men, rate fell from 11.9% to 2.5% (p=0.01) with pre-op CT
  - Conclusion: “Negative appendectomy rate was decreased for adult patients who underwent preoperative CT compared with patients who did not undergo preoperative imaging. Although most prior studies suggested that CT is efficacious only in decreasing the negative appy rate among women, we found that men benefit from CT as well.”
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Impact of CT

- Raja, 2010: “Negative appendectomy rate in the era of CT: an 18-year perspective”
  - Retrospective review
  - Negative appendectomy rate decreased significantly from 23.0% to 1.7% (p<0.0001) comparing current to pre-CT eras
  - Significant decrease in annual number of appendectomies 217 to 119 (p=0.0003)
  - Usage of CT increased from 1% to 97.5%
  - Conclusion: “There was a significant reduction in both the NAR and the number of appendectomies in patients who presented to the emergency department during an 18-year period, which was associated with a significant increase in the use of preoperative abdominal CT.”

- Markar, 2011: “Increased use of preoperative imaging and laparoscopy has no impact on clinical outcomes in patients undergoing appendicectomy”
  - Single institution, retrospective cohort study comparing 1999 to 2009
  - CT usage increased from 0% to 26%
  - Non-significant decrease in negative appendectomy rate from 25.7% to 12.8%
  - No difference in perforation or complication rate
  - Conclusions: “This study shows that significant increase in the use of pre-operative imaging and laparoscopy in the management of patients with acute appendicitis failed to reduce negative appendicectomy, perforation and complications rates. The patient's age was the only predictor of negative appendicectomy and perforation.”
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Meta-analysis of 28 studies (2 RCT, 26 cohort)

Objective: To evaluate the impact of abdominal CT on the clinical outcomes of patients presenting with suspected appendicitis

Findings:
- Negative appendectomy rate of 8.7% compared with 16.7% using clinical evaluation alone (p<0.001)
- Significantly lower negative appendectomy rate of CT era compared to pre-CT era 10.0% vs. 21.5%
- Significant increase in time to surgery with CT, mean of 5 hours
- Perforation trended toward increased with CT but was not significant 23.4% vs. 16.7% (p=0.15)
- Perforation rate during CT era not significantly different 20.0% vs. 19.6% (p=0.74)

Conclusions: This meta-analysis supports the hypothesis that the use of preoperative abdominal CT is associated with lower negative appendectomy rates. The use of CT in the absence of an expedited imaging protocol may delay surgery, but this delay is not associated with increased appendiceal perforation rates. Routine CT in all patients presenting with suspected appendicitis could reduce the rate of unnecessary surgery without increasing morbidity.
DECISION to OPERATE
To Operate or Not?

• Candidate selection
  – Risks for morbidity
  – Natural course/resolution

• Alternatives to surgery
  – Are antibiotics a reasonable alternative to surgery?
Predictors of Morbidity/Mortality

- Risk factors for perforation
  - Age
  - Comorbidities
  - Gender
  - Socioeconomic status

- Margenthaler, 2003
  - Review of VA NSQIP data
  - Significant preoperative predictors of morbidity
    - ASA V, >10% weight loss in prior 6 months
  - Significant predictors of 30-day mortality
    - Completely dependent functional status, steroid usage, current pneumonia, bleeding disorders

- Mortality strongly related to age
  - Blomquist, 2001
    - Lowest risk age 20-29 = 0.07 per 1000
    - Highest risk age >90 = 164 per 1000
Alternative to Surgery?

- Spontaneous resolution estimates range from 3.6% to 20.0% (Liu, 2011)
  - Repostulates possibility of multiple etiologies of appendicitis including strictly infectious

- Role of antibiotics in uncomplicated acute appendicitis
  - Many retrospective studies, few well done RCT
  - 5 meta-analyses
    - Best and most representative of quality evidence is Cochrane Review
Meta-analysis of 5 RCTs

Objective: Is antibiotic treatment as effective as surgical appendectomy (laparoscopic or open) in patients with acute appendicitis on recovery within two weeks, without major complications (including recurrence) within one year?

Findings:
- 73.4% of patients treated with antibiotics and 97.4% with appendectomy were cured in two weeks without major complication within one year

Conclusions:
- The upper bound of the 95% CI of ABT for cure within two weeks without major complications crosses the 20% margin of appendectomy, so the outcome is inconclusive. Also the quality of the studies was low to moderate, for that reason the results should be interpret with caution and definite conclusions cannot be made. Therefore we conclude that appendectomy remains the standard treatment for acute appendicitis. Antibiotic treatment might be used as an alternative treatment in a good quality RCT or in specific patients or conditions where surgery is contraindicated.
Alternative to Surgery

• Trends in Literature
  – Lower complication rate with antibiotics (apples to oranges?)
  – Failure of antibiotic management up to 42% at one year

• Despite analysis of the same data, conclusions vary widely
  – Selection bias and crossover to surgery in the RCTs suggest that appendectomy is still the gold standard therapy for acute appendicitis. (Varadhan, 2010)
  – Antibiotics are both effective and safe as primary treatment for patients with uncomplicated acute appendicitis. Initial antibiotic treatment merits consideration as a primary treatment option for early uncomplicated appendicitis. (Varadhan, 2012)
OPERATIVE APPROACH
Surgery! Now what?

- Open appendectomy as Gold Standard for one century
- Lap appy introduced in 1981
- Usage of laparoscopic technique has skyrocketed with improved training/technique
  - 2008 NSQIP data = 82.4% laparoscopic
- Lap vs. open evaluated
  - Various methods
    - Retrospective studies
    - RCTs
    - Comparative Effectiveness
  - Looking at:
    - In-hospital results
    - 30-day results
    - 1-year results
  - Based on various national databases:
    - University Healthcare Consortium
    - NSQIP (several times)
    - Nationwide Inpatient Sample
Lap vs. Open

• Highly discussed/disputed
  – “Less filling, tastes great”
• Almost uniformly come to same results/different conclusions
  – Laparoscopic
    • Lower LOS, overall complication rate, SSI rate,
    • Higher organ space infection, postop hemorrhage, OR cost, overall cost
    • Variable regarding operative time, recovery time, readmission rate
• Pendulum is swinging increasingly toward laparoscopic appendectomy with increasing usage and improving skills
Laparoscopic Versus Open Appendectomy: 
An Analysis of Outcomes in 17,199 Patients Using ACS/NSQIP 
Page AJ, Pollock JD, Perez S, Davis S, Lin E and Sweeney JF  
J Gastrointest Surg 2010

- 3,025 open (17.6%) vs. 14,174 lap (82.4%) 
  - Significantly shorter OR time, hospital LOS 
  - Significantly lower: 
    - Superficial SSI 
    - Deep SSI 
    - Wound disruption 
    - Complications 
    - Perioperative mortality 

- Conclusions: Using the ACS/NSQIP PUF file, we demonstrate that laparoscopic appendectomy has better outcomes than open appendectomy for the treatment of appendicitis. While the operative treatment of appendicitis is surgeon specific, this study lends support to the laparoscopic approach for patients requiring appendectomy.
Objective: To demonstrate the use of propensity scores to evaluate the comparative effectiveness of laparoscopic and open appendectomy using Public Use File of ACS NSQIP.

- 21,475 patients, 72% had LA, 28% had OA.
- No difference in
  - mortality (0.3% vs. 0.2%)
  - reoperation (1.8% vs. 1.5%)
  - incidence of major complications (5.9% vs. 5.4%)
- LA had significantly fewer
  - wound infections (OR = 0.4, [0.3-0.5])
  - episodes of sepsis (OR=0.8, [0.6-1.0])
- LA had a greater risk
  - intra-abdominal abscess (OR=1.7, [1.3-2.2])
- Conclusions: After accounting for patient severity, open and laparoscopic appendectomy had similar clinical outcomes. In this case study, propensity score methods and multivariate adjustment yielded nearly identical results.
Perioperative Care

- **Bickel, 2011**
  - RCT to assess the influence of hyperoxygenation on surgical site infection in open appendectomy
  - Significantly lower SSI 5.6% vs. 13.6% (p=0.04)
  - Shorter mean LOS, 2.51 vs. 2.92 days (p=0.01)

- **Moore, 2011**
  - Single institution, retrospective review to determine if intraoperative irrigation decreases postoperative intra-abdominal abscess
  - 176 patients: 39% OA, 61% LA
  - 28% perforation rate
    - 43 of 50 (86%) of perforated patients underwent irrigation
    - No significant difference in postoperative abscess rate with irrigation

- **Coakley, 2011**
  - Retrospective review to determine impact of postoperative antibiotics on outcome of non-perforated appendicitis
    - No difference in superficial or deep SSI, or organ space infection
    - Significant correlation with increased C. diff infection, postoperative diarrhea and LOS
    - Trend toward higher readmission rate, reoperative rate and UTI
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Summary

- Reduction of complicated appendicitis by impacting delays between onset and OR
- Prudent utilization of diagnostic modalities to optimize diagnostic accuracy while minimizing impact on operative delay
- Judicious patient selection, recognizing viable alternatives to surgery may be best option for this patient
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