1-26-2010

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

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

Appendicitis: When simple becomes not so simple

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

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 50:676, 1889
McBurney C: The incision made in the abdominal wall in cases of appendicitis. Ann Surg 20:38, 1894.

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"

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**

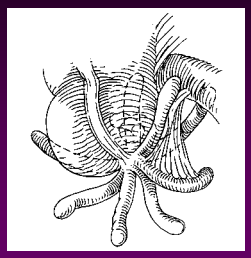
Anatomical Considerations

What's constant…

- **Three taeniae 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

↓

Pathophysiology

↓

TRANSMURAL INLAMMATION → **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**

The Surgeon's Dilemma

- **Simple appendicitis → Operate**

The Surgeon's Dilemma

- **Complicated appendicitis → Not so simple**

Not every inflamed appendix is ready to burst, study finds

And many of the common surgeries may be unneeded

By Rita Rubin
USA TODAY

Appendectomies are the most common emergency general surgical procedure in the USA, but a new study suggests many are unneeded.

According to conventional medical wisdom dating back to the late 19th century, if you don't remove an inflamed appendix, it could burst and lead to potentially life-threatening complications such as an abscess or peritonitis.

The study, out today in the *Archives of Surgery*, implies that perforated, or ruptured, appendicitis is a different disease from non-perforating appendicitis. In other words, some inflamed appendixes won't burst, no matter how long you wait to remove them.

"I don't think the disease is as straightforward as we thought, and I believe it needs to be revisited," says senior author Edward Livingston, chief of gastrointestinal and endocrine surgery at the University of Texas Southwestern Medical Center in Dallas.

Though the cause of appendicitis isn't known, Livingston's study links non-rupturing – but not ruptured – disease to viral infections, an association supported by reports of clusters, or outbreaks, of appendicitis cases.

At a glance

- Number of appendectomies annually in the USA: **250,000-300,000**
- Age group in which appendicitis is most commonly diagnosed: **10-30**
- Overall lifetime risk of developing appendicitis: **about 7%**

Source: USA TODAY reporting

Using U.S. hospital discharge data from 1970 to 2006, the authors found that annual rates of non-rupturing appendicitis fell and rose along with influenza. The researchers are not saying that the flu causes appendicitis, because over the course of a year, seasonal influenza peaks in the winter, while non-rupturing appendicitis is slightly more common in the summer.

But in an accompanying "invited critique" of the study, Rebecca Britt, a surgeon at Eastern Virginia Medical School in Norfolk, speculates that influenza might set up the immune system for infection by another, as-yet-unidentified virus that causes appendicitis.

According to some theories, Livingston and his coauthors write, a viral infection could damage the appendix's mucous membrane, leading to a bacterial infection. Some studies support simply treating appendicitis with antibiotics – which were unavailable when the first appendectomy was performed more than a century ago – could eliminate the need to remove the appendix.

Livingston is planning a trial in which all participants would first be treated with antibiotics for their non-rupturing appendicitis. Only those who don't improve in 12 to 24 hours would have an appendectomy.

He practices what he preaches. Three years ago, Livingston says, his son, then 14, awakened him and his wife, an internist, at 2 a.m. with what appeared to be a classic case of appendicitis. The doctors told their son to go back to bed, and he was fine the next day.

Rodney Mason, an associate professor of surgery at USC, is a believer. At a professional meeting in November, he reported on 70 patients whose "uncomplicated" appendicitis was treated satisfactorily with antibiotics. To answer skeptics who question whether the patients really had appendicitis, he notes that CT scans confirmed that diagnosis.

USA Today
January 19, 2010

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?**

Contemporary
The ^Surgeon's Premise

- 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

Contemporary
The ^Surgeon's Premise

Horwitz, JR, *et al.*
Should Laparoscopic Appendectomy Be Avoided for Complicated Appendicitis in Children?
***J Pediatr Surg* 32:1601-1603, 1997**

- 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.*
Complicated appendicitis in children: a clear role for drainage and delayed appendectomy.
***Am J Surg* 194:769-773, 2007**

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

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**

Results

Table 2
Immediate versus delayed appendectomy

	Immediate appendectomy (n = 60)	Drainage and delayed appendectomy (n = 32)
Prodrome of symptoms (days)	4.6 ± .5	6.9 ± .5*
Admission temperature	38.3 ± .09	38.3 ± .14
Admission WBC	16.6 ± .9	19.3 ± 1.3
Hospital LOS (including interval appendectomy)	7.1 ± .5	8.3 ± .7
Well-defined mass on preoperative imaging	31 (52%)	31 (97%)
Complications requiring readmission	6 (10%)	0 (0%)*

* $P < .05$.

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

Outcome of interest	*Studies*	*Patients*	*OR**	*P-value*
Duration of IV antibiotics	4	321	1.02	0.39
Duration of initial hospitalization	8	825	0.49	0.76
Overall duration of hospital stay	7	319	0.04	0.98
Overall complications	16	1,490	0.24	<0.001
Wound infection	10	1,024	0.28	0.001
Abdominal/pelvic abscess	8	981	0.19	0.003
Ileus/bowel obstruction	8	946	0.35	0.004
Reoperation	4	363	0.17	0.02

***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**

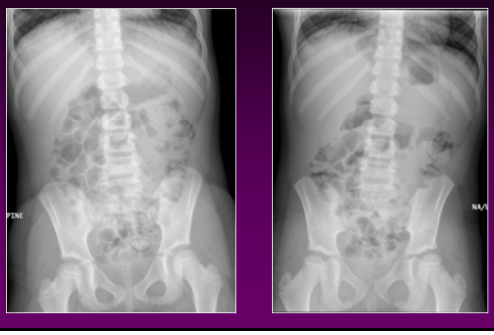
Conventional Radiographs

- **Advantages**
  - **Readily available**
  - **Quick**
  - **No patient preparation**
  - **Little radiation (2 views – 100 mRad)**
  - **Low cost**

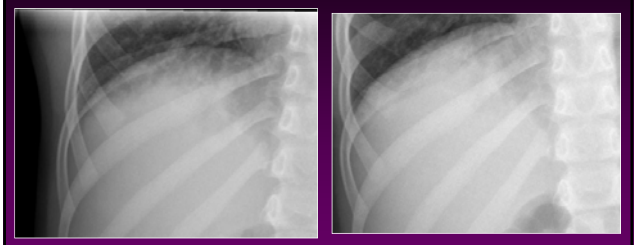
Useful findings on conventional radiographs for abdominal pain

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

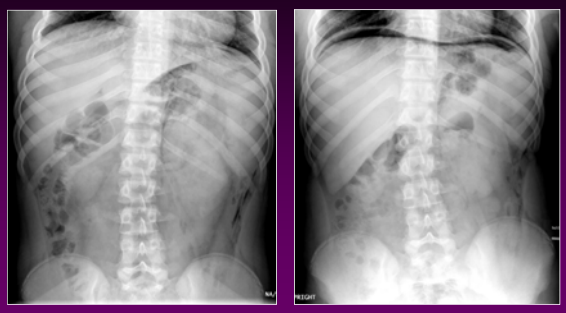
Pneumonia



Pneumonia

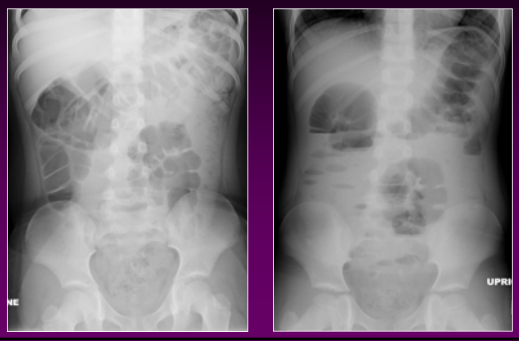


Pneumoperitoneum



Small Bowel Obstruction

Fecalith



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**

Ultrasound Appendicitis

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

Ultrasound Appendicitis

- **Sensitivity**
  - **Reports range from 44%-94%**
- **Specificity**
  - **Reports range from 47%-95%**

Ultrasound Appendicitis

- **Sensitivity**
  - **Reports range from 44%-94%**
- **Specificity**
  - **Reports range from 47%-95%**

Ultrasound Appendicitis

Orr RK, Porter D, Hartman D. Ultrasonography to evaluate adults for appendicitis: Decision making based on meta-analysis and probablistic reasoning. Acad Emerg Med 1995: 2:644-650

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

Graded Compression Technique

Puylaert JB: Acute appendicitis: US evaluation using graded Compression. Radiology 1986; 158:355-360

- 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

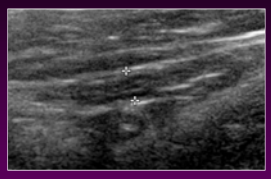
Ultrasound for Appendicitis

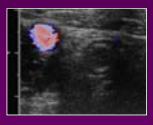
- False negative diagnosis
  - Failure to visualize the entire appendix
    - Inability to adequately compress the RLQ
    - Aberrant location of appendix – retrocecal
    - Appendiceal perforation
    - Early inflammation at the distal tip

Ultrasound for Appendicitis

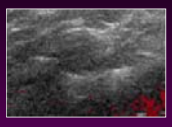
- False positive diagnosis
  - Identify a normal appendix as abnormal
    - Should be 6 mm or less diameter, compressible, no adjacent inflammatory changes
  - Other causes of RLQ inflammation
    - Crohn disease
    - Inflamed Meckel diverticulum
    - Pelvic inflammatory disease

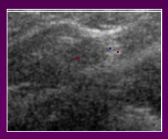
Normal Appendix





4 mm

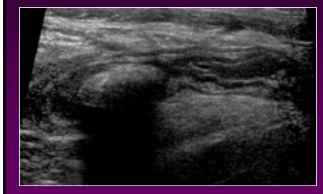




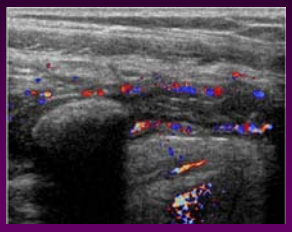
Compression

Acute Appendicitis: Simple, non perforated

Acute Appendicitis: Simple, non perforated

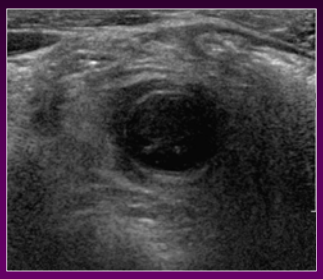


Echogenic, shadowing fecalith



Wall hyperemia

Acute Appendicitis: Simple, non perforated



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

Inflamed periappendiceal fat

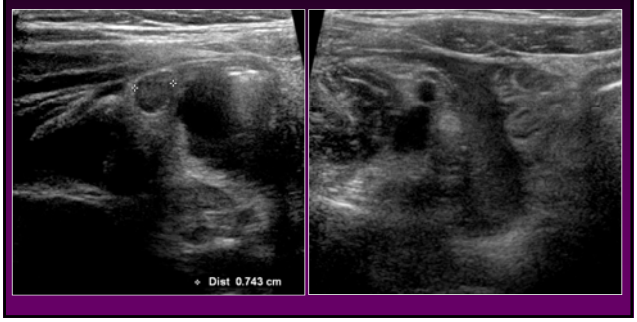
Complicated Appendicitis

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

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

CT 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

Callahan MJ, Rodriquez DP, Taylor GA. CT of Appendicitis in Children; Radiology 2002: 224:325-332.

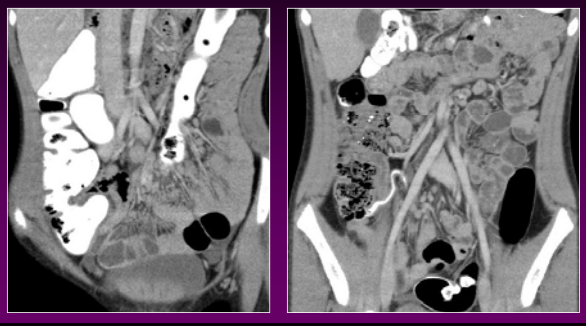
CT Appendicitis

- 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

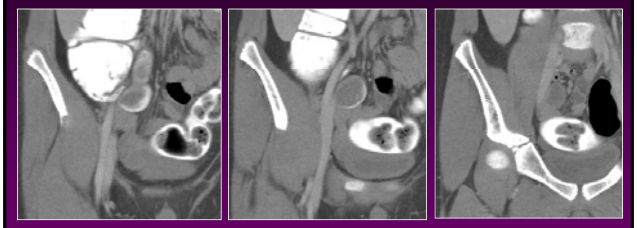
CT Appendicitis

- 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

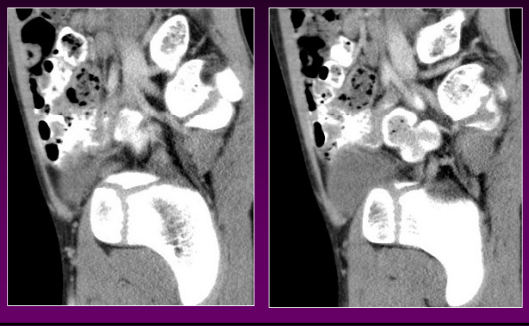
CT Normal Appendix



CT Normal Appendix



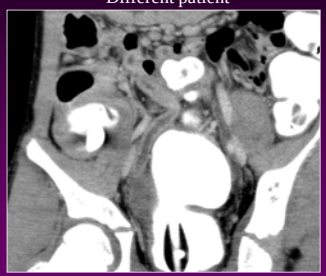
CT Normal Retrocecal Appendix



CT Simple Appendicitis

CT Simple Appendicitis

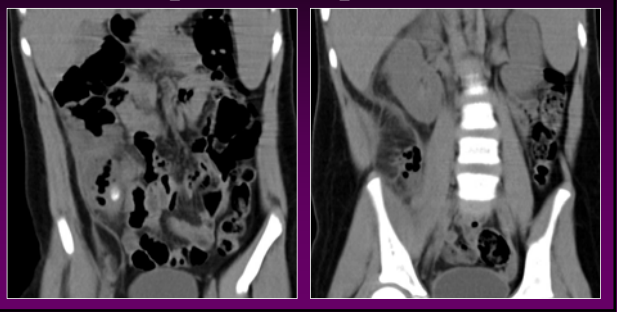
Different patient



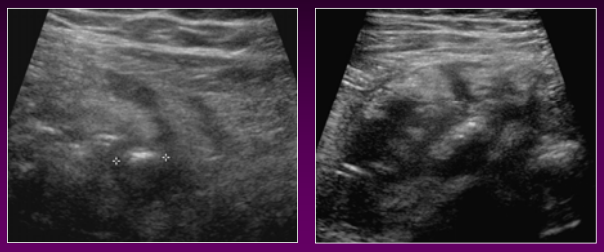
CT Simple Appendicitis

Same patient

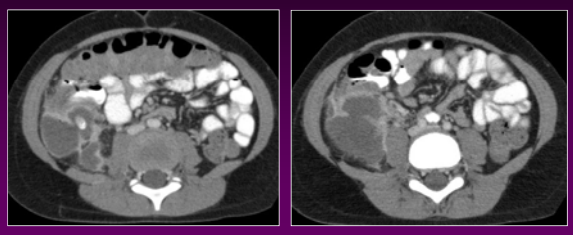
Outside CT No Contrast Simple or Complicated?



RLQ Ultrasound – Same Day



CT Complicated Appendicitis After 5 days antibiotics



CT Complicated Appendicitis

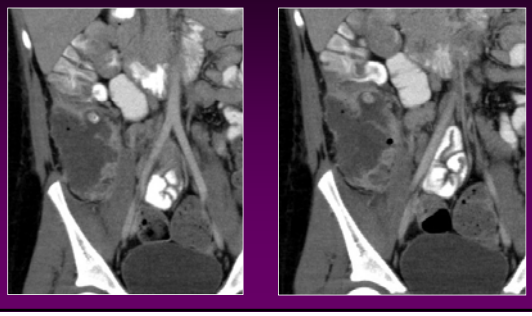
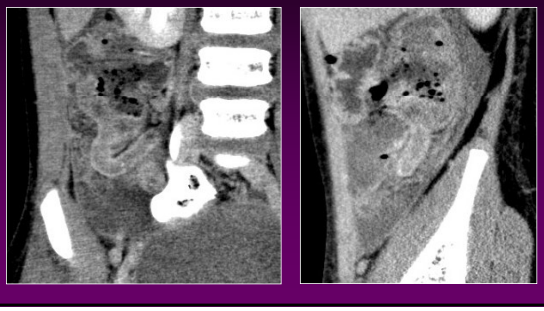
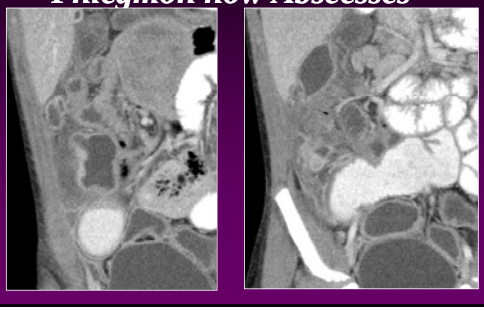


Image Guided Pigtail Drain Placement

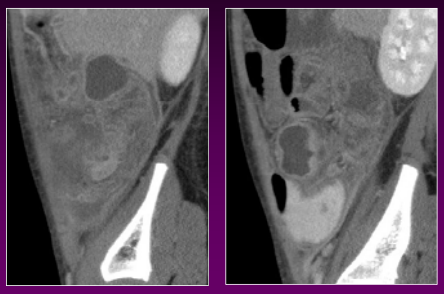
CT Complicated Appendicitis Phlegmon



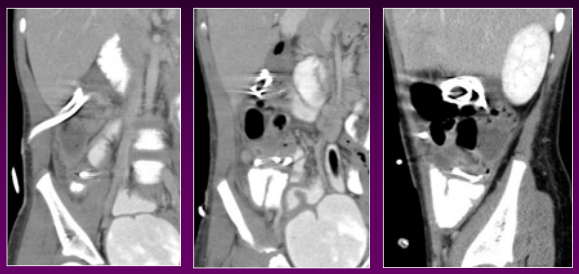
CT Complicated Appendicitis
6 days later
Phlegmon now Abscesses



CT Complicated Appendicitis
Abscesses



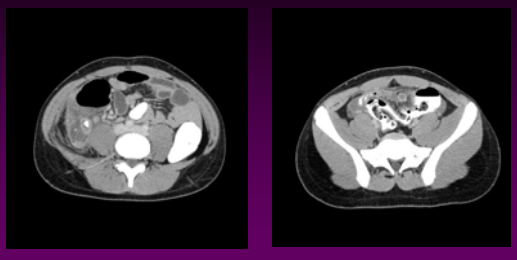
CT Complicated Appendicitis
Percutaneous Abscess Drains

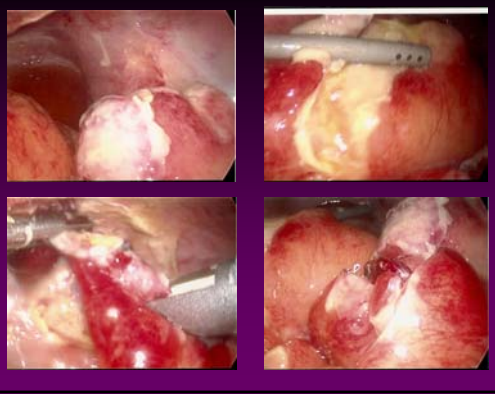


Clinical Scenario

Patient 1	*Patient 2*
• 2 day history of abdominal pain	• 2 day history of abdominal pain
• Reported fever	• Reported fever
• Nausea and emesis with anorexia	• Nausea and emesis with anorexia
• Temperature 38.7 C	• Temperature 39.0 C
• Right lower quadrant tenderness	• Suprapubic tenderness
• WBC 16,700	• WBC 24,300
• Segmented neutrophils 83%	• Segmented neutrophils 90%
• C-reactive protein 21.4	• C-reactive protein 24.3

Patient 1 *Patient 2*





Clinical Scenario

Patient 1	*Patient 2*
• Conservative management	• Operative management
• PICC	• PICC
• Dual antibiotic therapy	• Dual antibiotic therapy
• Oral diet by HD 2	• Oral diet by HD 4
• Afebrile by HD 3	• Afebrile by HD 4
• WBC 7,500	• WBC 7,000
• Segmented neutrophils 60%	• Segmented neutrophils 69%
• C-reactive protein 8.2	• C-reactive protein 1.6
• Total LOS 5 days	• Total LOS 7 days
• Interval appendectomy 6-8 weeks	

Treatment

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

How successful is delayed appendectomy?

Bufo AJ, *et al.*
Interval Appendectomy for Perforated Appendicitis in Children.
***J Laparoendosc Adv Surg Tech A* 8(4):209-214, 1998**

- **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**

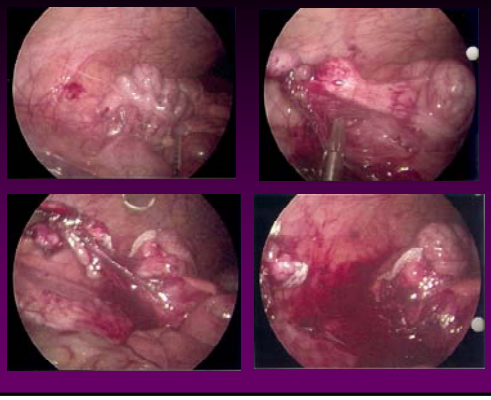
Results

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

*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%
• Ein SH, et al. (2005)	43%
+ appendicolith	72%
- appendicolith	26%

Puapong D, *et al.*
Routine interval appendectomy in children is not indicated.
***J Pediatr Surg* 42:1500-1503, 2007**

- **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**

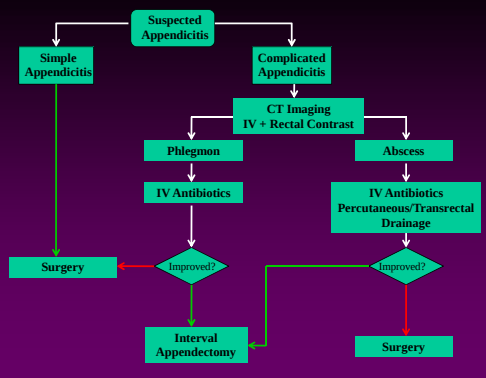
Results

- **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**

TREATMENT ALGORITHM



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**