Appendicitis: Trends in Diagnosis and Treatment

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Objectives

1. Central role of imaging in diagnosis
2. Standard pathways
3. Increasing use of ultrasound
4. Selection of patients for imaging
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Background

Appendicitis in children
• Most common emergency abdominal operation
• 70-80,000 cases per year in United States
• 2nd most expensive surgical procedure

Historically
• Clinical diagnosis
  - History
  - Physical examination
  - Basic lab tests
• Negative appendectomy rate 15-20%
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CT scan revolution

1997 High diagnostic accuracy for appendicitis with CT
   Radiology 1997, 202:139-44

1998 Reduce negative appendectomy, hospital admissions, hospital costs

1999 Effective in children
   Pediatrics 1999, 104:440-6

1999 Use in conjunction with ultrasound
   JAMA 1999, 282:1041-6
Surgical Care & Outcomes Assessment Program (SCOAP)

• Collaborative of 55 hospitals in Washington state

Children having appendectomy 2008-2012

• 2538 children ≤ 18 years
  • mean age 11.3 years (± 4.1)
  • perforation rate: 21.7%
• 99.7% preoperative imaging
• 52.7% CT scan first
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Negative appendectomy

High negative appendectomy rate unacceptable
- Children SCOAP 3%
- Adults SCOAP
  - 19,000 patients > 15 yo
  - Negative appendectomy 5.4%
- Adults National Inpatient Sample
  - Negative appendectomy
  - 1998 15% to 2007 8%

2015 Negative Appendectomy Rate Children 3-5%
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*Imaging in evaluation of abdominal pain*
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Risks of Radiation

Increasing awareness of risks of radiation CT scans

• Future malignancy
  - Arch Int Med 2009, 169: 2071
  - Arch Int Med 2009, 169: 2078
  - Proc Natl Acad Sci USA 2003, 100:13761

American College of Radiology
Society for Pediatric Radiology

• recommends ultrasound first in evaluation of abdominal pain children
  - J Am Coll Radiol 2011, 8:749
Ultrasound accuracy approaches that of CT
Seattle Children’s reviewed 304 patients in 2006
- Highest sensitivity (98.7%) and specificity (95.4%)
  - Maximum outer diameter of appendix ≥ 7 mm
  - Wall thickness > 1.7 mm
- Correctly classified 96.6% cases
  - 1 (0.5%) false negative
  - 6 (2.9%) false positive

Pediatr Radiol 2011, 41:993-999
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Variability between hospitals - Washington state

CT Scan Rates for children by Hospital
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*Imaging safely – a statewide effort*

Collaborative to improve the care of children with appendicitis

- Decrease overall use of advanced imaging
- When indicated use
  - US first
  - CT second
- Maintain low (<5%) negative appendectomy
- Optimize Quality, Safety, and Value
Improving appendicitis diagnosis

*Imaging safely – a statewide effort*

- Pre-Operative Protocol
- Web-access to Tips and Tricks
- Standardized Reporting
- Collaborative Meetings
- Ultrasound Training
- Quarterly Reports
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*Imaging safely – a statewide effort*

**Standardize**
- Imaging capture
- Sonographer worksheet template
- Radiologist reporting template

Am J Surg 2015 Epub
www.becertain.org/hospitals/safe_and_sound
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*Imaging safely – a statewide effort*

Percentage of patients receiving US first
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*Imaging safely – a statewide effort*

![Percentage with Any CT Scan over years](chart.png)
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Statewide projects

Washington State Hospital Association initiative to improve pediatric care

- First project - develop standards for care of children with appendicitis
- Collaborative group
  - Surgeons
  - Emergency Department Physicians
  - Radiologists
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Statewide projects to improve appendicitis care

Pre-operative
1. ED/Surgeons - evaluation of abdominal pain
2. ED/Surgeons/Radiologists - imaging

Operative
3. Surgeons/Infectious Disease - antibiotic stewardship
4. Surgeons - operative approach, indications for operative, non-operative, delayed management

Post-operative
5. Surgeons/Infectious Disease - antibiotic stewardship, duration of treatment, conversion from IV to PO
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Evaluation of abdominal pain

- Patients with Abdominal pain
- Patients for R/O Appendicitis
- Patient needing imaging
- Patients needing surgery
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Evaluation of abdominal pain – scoring systems

2002 Samuel *J Ped Surg*

- 1,170 children age 4-15
- Scoring system for appendectomy

2014 Ebell *Ann Emer Med*

- Systematic review 26 studies
- Scores should be used as indications for imaging

### Table 2. Comparison of the Diagnostic Weight of the Diagnostic Indicants Between Group 1 and Group 2

<table>
<thead>
<tr>
<th>Diagnostic Indicants</th>
<th>Appendicitis (group 1) Diagnostic Weight</th>
<th>Nonappendicitis (group 2) Diagnostic Weight</th>
<th>P Value*</th>
<th>PAS (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cough/percussion tenderness</td>
<td>0.96</td>
<td>0.37</td>
<td>&lt;.001</td>
<td>2</td>
</tr>
<tr>
<td>Hopping tenderness</td>
<td>0.96</td>
<td>0.37</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Anorexia</td>
<td>0.88</td>
<td>0.12</td>
<td>&lt;.001</td>
<td>1</td>
</tr>
<tr>
<td>Pyrexia</td>
<td>0.87</td>
<td>0.12</td>
<td>&lt;.001</td>
<td>1</td>
</tr>
<tr>
<td>Nausea/Emesis</td>
<td>0.86</td>
<td>0.14</td>
<td>&lt;.001</td>
<td>1</td>
</tr>
<tr>
<td>Tenderness in right lower quadrant</td>
<td>0.84</td>
<td>0.37</td>
<td>&lt;.001</td>
<td>2</td>
</tr>
<tr>
<td>Leukocytosis†</td>
<td>0.81</td>
<td>0.2</td>
<td>&lt;.001</td>
<td>1</td>
</tr>
<tr>
<td>Polymorphonuclear neutrophilia</td>
<td>0.80</td>
<td>0.22</td>
<td>&lt;.001</td>
<td>1</td>
</tr>
<tr>
<td>Migration of pain</td>
<td>0.80</td>
<td>0.2</td>
<td>&lt;.001</td>
<td>1</td>
</tr>
</tbody>
</table>

*P < .05 statistically significant.
†Leukocytosis with a white blood count of ≥ 10,000(10⁹/L).
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**Evaluation of abdominal pain – scoring systems**

<table>
<thead>
<tr>
<th>Clinical Variable</th>
<th>Alvarado</th>
<th>PAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration of Pain</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nausea or Vomiting</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Right Lower Quadrant Tenderness</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Rebound Pain</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Elevated Temperature (≥ 37.3, 38)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Leukocytosis (≥ 10,000)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>WBC Left shift (≥ 75% PMN)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cough/percussion/hopping RLQ pain</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
Children ≥ 2 years with suspected appendicitis

- Low clinical suspicion (i.e. PAS 1-3)*
  - Explore alternative diagnosis
  - Supportive observation (home/hospital) and reevaluate as needed

- Moderate clinical suspicion (i.e. PAS 4-7)*
  - Ultrasound
  - Normal appendix
  - Surgery consult

- High clinical suspicion (i.e. PAS 8-10)*
  - Ultrasound
  - Indeterminate
  - Positive/Complicated appendicitis

- Imaging
  - Delayed operation
  - Urgent operation
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Summary

1. Imaging has a central role in the diagnosis of appendicitis in children
2. Standard pathways of diagnosis of management will be increasingly used in diagnosis and management of appendicitis
3. Ultrasound will be the first imaging modality used to diagnose appendicitis
4. Scoring systems will be used to identify patients for advanced imaging modalities