**Definition:** (1,2) Acute appendicitis is the inflammation of the vermiform appendix; a blind ended tube connected to the cecum of the bowel. Although the cause is unknown, most theories relate to an obstruction of the appendiceal lumen which prevents the escape of secretions and eventually leads to a rise in intra-luminal pressure with the appendix. The increased pressure can lead to mucosal ischemia with stasis, providing an environment for bacterial overgrowth. The obstruction may be caused by: fecolith, parasites, calculi, foreign body, neoplasm, stricture of worms, lymphoid hyperplasia secondary to Crohn’s disease, carcinoid syndrome or viral illnesses including upper respiratory infection, mononucleosis, and gastroenteritis.

**Incidence:** (1-5) Acute appendicitis is the most common abdominal condition requiring surgery in children, accounting for more than 320,000 operations in the United States annually. Appendicitis accounts for 1/3 of all childhood admissions for abdominal pain. The incidence of perforated appendix is highest in infants. 70-95% of children <1 year, 70-90% of children 1-4 years, and 10-20% of adolescents with acute appendicitis have a perforated appendix. The reported median perforation rate in children is 38.7%.

**Diagnosis:** (4,5) The diagnosis of acute appendicitis must be considered in children who present with abdominal pain. It is most common in 4- to 15-year-olds.

**Inclusion Criteria** (1-4)
- Children ≥2 years presenting with abdominal pain and signs/symptoms highly suspicious of acute appendicitis

**Exclusion Criteria**
- Children <2 years
- Previous appendectomy
- History of bloody stools
- Crohn’s disease
- History of cystic fibrosis, transplant or malignancy

**Diagnostic Evaluation** (3,5-7)
Clinical history and physical (H&P) alone is sufficient for diagnosis when the index of suspicion for appendicitis is high or low. (3,6)

**History: Assess for**
- Pain in the abdomen that is continuous even when lying down, first around the umbilicus, then moving to the lower right abdomen (McBurney’s Point)
- Pain may also be in the right upper quadrant (RUQ) under the gallbladder, in the pelvis, across the top of the bladder, and behind the large intestine, depending on the position of the appendix
- Pain intensifies with activity, deep breathing, coughing, and sneezing
- Nausea, loss of appetite, lack of interest in favorite food, vomiting
- Frequent, small volume stool or mucous (tenesmus)
- Fever, essentially always following onset of other symptoms
- Abdominal swelling
- Menstrual and sexual history

**Physical Examination: Assess for** (6,7)
- A quiet child reluctant to move, sometimes with hips flexed
- Child reluctant to stand erect, walk, or make sudden movements
- Tenderness in the right lower quadrant (RLQ) of the abdomen (examine last)
- Peritoneal signs

**Classic Signs and Symptoms for High Index of Suspicion Cases:** (5)
- Nausea, anorexia (less reliable in young children)
- Point of maximal tenderness in RLQ
- Vomiting after onset of pain
- Progressive increase in pain
- Migration of pain to RLQ after onset in mid abdomen (usually periumbilical)

**Classic Signs and Symptoms for Low Index of Suspicion Cases:** (5)
- Absence of nausea, emesis or anorexia
- Minimal or absent abdominal tenderness without localization in RLQ
- Normal WBC and differential
- Pain that is intermittent or cramping in nature

**Pediatric Appendicitis Score (PAS) [point value]** (9-12)
- Migration of pain [1]
- Anorexia [1]
- Nausea/Vomiting [1]
- RLQ tenderness [2]
- Cough/Hopping/Percussion tenderness in RLQ [2]
- Elevation of temperature [1]
- Leukocytosis (≥10,000) [1]
- Differential WBC with left shift [1]
- *The PAS is the cumulative point total from all clinical findings

**PAS ≤5: Low suspicion for appendicitis**
NOTE: Sensitivity of 97.6%, with a negative predictive value of 97.7%

**PAS 1-7: Equivocal for appendicitis**

**PAS 8+: High suspicion for appendicitis**
NOTE: Specificity of 95.1%, with a positive predictive value of 85.2%
Evidence Supports

- Use the PAS to predict the presence of appendicitis in children ≥4 years. (9-12) – Strong recommendation, moderate quality evidence
- Obtain a WBC and CRP to assist in the diagnosis of appendicitis in equivocal cases only. (5,13) – Strong recommendation, moderate quality evidence.
- Obtain a US in equivocal cases only. CT should be obtained only when US is equivocal in diagnosing appendicitis in children. (14-19) – Strong recommendation, moderate quality evidence.

NOTE: CT is more accurate than US in diagnosing appendicitis in children. However, the risk of radiation exposure needs to be considered. Texas Children’s Hospital data supports US as equivalent to CT in diagnosing appendicitis in the majority of children, excluding some obese patients. (20)

- A timely diagnosis of appendicitis should be made by physicians in the ED. (21) – Strong recommendation, low quality evidence
- Laparoscopic appendectomy is the preferred surgical approach (vs. open surgery) for children with appendicitis. (22-26) – Strong recommendation, moderate quality evidence
- Postoperative pain medications should be scheduled. (27,28) – Strong recommendation, low quality evidence
- In complicated/advanced appendicitis, monotherapy should be administered for a minimum of 3 days to reduce postoperative infectious complications in children undergoing an appendectomy. (29-32) – Strong recommendation, moderate quality evidence
- Children with complicated appendicitis who meet clinical but not laboratory discharge criteria should be transitioned to PO ciprofloxacin and metronidazole; if present: fever >99.9°F, WBC >14,000, ileus, pain. (43-45) – Weak recommendation, very low quality evidence

Evidence Against

- Do not withhold analgesia. Withholding analgesia does not aid in the diagnosis of appendicitis. (47-52) – Strong recommendation, high quality evidence
- Do not routinely obtain laboratory studies for diagnostic purposes in cases where the index of suspicion for appendicitis is either high or low. (5,13) – Strong recommendation, moderate quality evidence
- Do not routinely obtain imaging if there is a high or low suspicion for appendicitis. (14-19) – Strong recommendation, moderate quality evidence
- Do not routinely obtain perioperative cultures, except for cases of perforated appendicitis with abscess. (53-56) – Strong recommendation, low quality evidence
- Do not routinely administer postoperative antibiotics to children with simple appendicitis. (57-58) – Strong recommendation, moderate quality evidence

Evidence Lacking/Inconclusive

- Children with complicated appendicitis and a penicillin allergy should be treated with IV ciprofloxacin and metronidazole; if they meet clinical but not laboratory discharge criteria, transition to PO ciprofloxacin and metronidazole for discharge to home. – Consensus recommendation
- Patients with complicated appendicitis who do not achieve discharge criteria should be imaged at 6-7 days if clinical suspicion for abscess. – Consensus recommendation
- In patients with complicated appendicitis who require percutaneous drainage, keep the drain in place until output is <10 mL/day. – Consensus recommendation
- There is insufficient evidence for the following topics: non-operative management of appendicitis (59-64), interval appendectomies for abscesses or phlegmons. (65-67)

*NOTE: The references cited represent the entire body of evidence reviewed to make each recommendation.
Condition-Specific Elements of Clinical Management

**Laboratory Assessment:** (5,13)

**Diagnostic:**
- Utilize only in cases where H&P is not definitive for acute appendicitis (exception: urine pregnancy test in post-pubescent females).

**Postoperative:**
- Use WBC trending for determination of length of antibiotic treatment and presence of postoperative infection/abscess.

**Radiologic Evaluation:** (5.9-12.14.68)
- Use US imaging in cases where H&P is equivocal for acute appendicitis (PAS 5-7) or differential diagnosis is gynecologic.
- If diagnosis remains equivocal, consult with radiologist and surgeon regarding further imaging.

**Surgical Approach:** (22.23)
- Laparoscopic approach is preferred; perform open appendectomies only for: (1) very small children in whom insufflation is not technically feasible, (2) cases of neglected perforated appendicitis with large abscesses, or (3) as a conversion from laparoscopy due to inappropriate visualization, extreme inflammation.

**Perioperative Cultures:** (33-56)
- Obtain intraoperative cultures only for patients with perforated appendicitis with abscess.

**Pain Management:** (27-28,47-52,69-71)
- Administer analgesia to promote comfort.
- Withholding analgesia does not improve diagnostic accuracy.
- Schedule postoperative pain medication.

**Antibiotics:** (29-41,72,73)
- Administer piperacillin/tazobactam (Zosyn®) monotherapy as soon as possible once the diagnosis is confirmed.
- Administer a second dose of monotherapy prior to making the surgical incision if it has been ≥2 hours since the last dose.
- Continue monotherapy for a minimum of 3 days in children with complicated appendicitis.
- Transition children with complicated appendicitis who meet clinical but not laboratory discharge criteria to PO amoxicillin/clavulanate for discharge at home. If the patient has a penicillin allergy or the intraoperative culture shows *Pseudomonas*, use/change to PO ciprofloxacin and metronidazole.
- Postoperative antibiotics are unnecessary in children with simple appendicitis.

**Postoperative Imaging and Procedures – Complicated Appendicitis:** (42-46)
- Perform US at 6-days postoperatively to rule out abscess in patients with complicated appendicitis, if clinical suspicion for abscess.
- Drain abscess if estimated volume of ≥15 mL and Interventional Radiology has confirmed the abscess.
- Consider draining a hematoma if ≥2 of the following are present: fever >99.9°F, WBC >14,000, ileus, pain.
- Consider initiating TPN in patients with complicated appendicitis if NPO >7 days anticipated.

**Discharge Criteria**
- Afebrile
- Tolerating regular diet
- Pain controlled with oral pain medications
- Benign abdominal physical exam (no tenderness/mass)
- Ambulating

**Consults/Referrals:**
- Consult surgery for a PAS ≥8 or proven appendicitis.
- Consult IR for abscess confirmation.
- Request to see Child Life for coping techniques, procedural teaching, and psychosocial support.
- Request to see Nutritional Support for dietary modifications related to surgery and healing.

**Measures**

**Process**
- Perforation rates noting ED admit time, time at which diagnosis was made, and time of surgery
- Appropriateness of antibiotic therapy
- Diagnostic accuracy (sensitivity, specificity) of US and CT
- BMI of children who received CT
- Indication for ordering CT
- Frequency of lab orders for diagnostic purposes where the PAS is 5-7
- Frequency of radiologic studies in patients where the PAS is 1-4 or ≥8
- Percentage of CT scans to rule out abscess in patients with complicated appendicitis
- Percentage of undrainable collections found when imaging to rule out abscess at 6 days or 7 days

**Outcome**
- Return visit within 24 hours of previous ED visit
- Length of stay (ED, Inpatient and Special Care)
- Readmission rate for postoperative complications within 30 days
- Complications (negative appendectomy, abscess, and wound infection)
- Percentage of patients experiencing any moderate or severe pain in the first 3 postoperative days
- Percentage of patients experiencing >1 episode of moderate or severe pain on any of the first 3 postoperative days
For clinical findings of acute gastroenteritis, refer to the AEG guideline.
For clinical findings of urinary tract infection, refer to the UTI guideline.

**Pediatric Appendicitis Score (PAS)** – use for children ≥ 4 years
- Migration of pain [1]
- Cough/Hopping/Percussion tenderness in RLQ [2]
- Anorexia [1]
- Elevation of temperature [1]
- Nausea/Vomiting [1]
- Leukocytosis (≥10,000) [1]
- RLQ tenderness [2]
- Differential WBC w/ left shift [1]

'The PAS is the cumulative point total from all clinical findings.

**Discharge Criteria (DC):**
- afebrile
- tolerating regular diet
- pain controlled with oral pain medications
- ambulating
- benign abdominal physical exam (no tenderness/mass)

**Chronic abscess/phlegmon signs and symptoms:**
- >5 days duration, localized pain/tenderness, able to maintain oral intake

**If US shows abscess** with estimated volume ≥15 mL and the abscess is confirmed by IR, drain; keep drain in place until output is <10 mL/day
- If US shows hematoma, consider drain in IR if ≥2 of the following are present: fever >99.9°F, WBC >14,000, ileus, pain
- If US shows phlegmon, consider repeat US at least 48-72 h later
- If US shows ‘other’, off algorithm

**Acute Appendicitis/Appendectomy Management**

Begin

Child ≥2 years presents w/ suspected appendicitis

Pt 2-3 years: low suspicion for appendicitis
Pt ≥4 years and PAS ≤4

- Order analgesia as warranted
- Consider initiating PCA
- Order US examination

OFF algorithm
Explore alternate diagnosis OR DC home if DC criteria met

Image positive for appendicitis

- Us equivocal

Consult Surgery

- Consult Surgery
- Order CT
NOTE: Obtain surgery consult prior to ordering CT

Image positive for chronic abscess/phlegmon

- Admit
- Provide analgesia
- Begin empiric therapy w/ piperacillin/tazobactam
- Consider IR drainage of abscess

- Perform appendectomy

Reassess DC criteria after 48 h

DC criteria met

- Obtain culture of abscess if present
- Consider central access for nutritional therapy if anticipate NPO >7 days duration
- Continue antibiotics post-operatively for a minimum of 72 h

DC home

- Reassess DC criteria after 48 h
- US at 6-7 days if no improvement and clinical suspicion for abscess

- Transition to PO amoxicillin/clavulanate for discharge to home if elevated WBC (>12K); if intraoperative culture shows Pseudomonas, change to PO ciprofloxacin and metronidazole DC home

- If US shows abscess with estimated volume ≥15 mL and the abscess is confirmed by IR, drain; keep drain in place until output is <10 mL/day
- If US shows hematoma, consider drain in IR if ≥2 of the following are present: fever >99.9°F, WBC >14,000, ileus, pain
- If US shows phlegmon, consider repeat US at least 48-72 h later
- If US shows ‘other’, off algorithm

-Transition to PO amoxicillin/clavulanate for discharge to home if elevated WBC (>12K); if intraoperative culture shows Pseudomonas, change to PO ciprofloxacin and metronidazole DC home

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References


Solomkin, J. S., Mazuski, J. E., Bradley, J. 


Clinical Standards Preparation
This clinical standard was prepared by the Evidence-Based Outcomes Center (EBOC) team in collaboration with content experts at Texas Children’s Hospital. Development of this clinical standard supports the TCH Quality and Patient Safety Program initiative to promote clinical standards and outcomes that build a culture of quality and safety within the organization.

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Development Process
This clinical standard was developed using the process outlined in the EBOC Manual. The literature appraisal documents the following steps:

1. Review Preparation
   - PICO questions established
   - Evidence search confirmed with content experts

2. Review of Existing External Guidelines
   - Cincinnati Children’s Hospital Emergency Appendectomy, BMJ
   - Clinical Evidence on Appendicitis, American College of


3. Literature Review of Relevant Evidence
   - Searched: Cochrane, PubMed, CINHAL, Google Scholar, ProQuest, and SumSearch

4. Critically Analyze the Evidence
   - 9 systematic reviews, 21 randomized controlled trials, and 39 nonrandomized studies

5. Summarize the Evidence
   - Materials used in the development of the clinical standard, literature appraisal, and any order sets are maintained in an appendicitis/appendectomy evidence-based review manual within EBOC.

Evaluating the Quality of the Evidence
Published clinical guidelines were evaluated for this review using the AGREE II criteria. The summary of these guidelines are included in the literature appraisal. AGREE II criteria evaluates Guideline Scope and Purpose, Stakeholder Involvement, Rigor of Development, Clarity and Presentation, Applicability, and Editorial Independence using a 4-point Likert scale. The higher the score, the more comprehensive the guideline.

This clinical standard specifically summarizes the evidence in support of or against specific interventions and identifies where evidence is lacking/inconclusive. The following categories describe how research findings provide support for treatment interventions.

"Evidence Supports" provides evidence to support an intervention. "Evidence Against" provides evidence against an intervention. "Evidence Lacking/Inconclusive" indicates there is insufficient evidence to support or refute an intervention and no conclusion can be drawn from the evidence.

The GRADE criteria were utilized to evaluate the body of evidence used to make practice recommendations. The table below defines how the quality of the evidence is rated and how a strong versus weak recommendation is established. The literature appraisal reflects the critical points of evidence.

<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Type of Evidence</th>
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<tr>
<td>STRONG</td>
<td>Desirable effects clearly outweigh undesirable effects or vice versa</td>
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<tr>
<td>WEAK</td>
<td>Desirable effects closely balanced with undesirable effects</td>
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<tr>
<th>Quality</th>
<th>Type of Evidence</th>
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<tr>
<td>High</td>
<td>Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies</td>
</tr>
<tr>
<td>Moderate</td>
<td>Evidence from RCTs with important limitations (e.g., inconsistent results, methodological flaws, indirect evidence, or imprecise results) or unusually strong evidence from unbiased observational studies</td>
</tr>
<tr>
<td>Low</td>
<td>Evidence for at least 1 critical outcome from observational studies, RCTs with serious flaws or indirect evidence</td>
</tr>
<tr>
<td>Very Low</td>
<td>Evidence for at least 1 critical outcome from unsystematic clinical observations or very indirect evidence</td>
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Recommendations
Practice recommendations were directed by the existing evidence and consensus amongst the content experts. Patient and family preferences were included when possible. The Content Expert Team and EBOC team remain aware of the controversies regarding appendicitis/appendectomies in children. When evidence is lacking, options in care are provided in the clinical standard and the accompanying order sets (if applicable).

Approval Process
Clinical standards are reviewed and approved by hospital committees as deemed appropriate for its intended use. Clinical standards are reviewed as necessary within EBOC at Texas Children’s Hospital. Content Expert Teams are involved with every review and update.

Disclaimer
Practice recommendations are based upon the evidence available at the time the clinical standard was developed. Clinical standards (guidelines, summaries, or pathways) do not set out the standard of care and are not intended to be used to dictate a course of care. Each physician/practitioner must use his or her independent judgment in the management of any specific patient and is responsible, in consultation with the patient and/or the patient’s family, to make the ultimate judgment regarding care.

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