TEXAS CHILDREN'S HOSPITAL
EVIDENCE-BASED OUTCOMES CENTER
Acute Appendicitis/Appendectomy
Evidence-Based Guideline

Definition: Acute appendicitis is the inflammation of the veriform 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. [1,2]

Incidence: 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%. [1-5]

Diagnosis: 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. [4,5]

Inclusion Criteria [1-6]
- 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]
Children with appendicitis have a risk of progressing to septic shock. Clinicians should immediately refer to the Septic Shock guideline and intervene rapidly if patient has toxic-appearance, ill-appearance, altered mental status, and/or compromised perfusion with abnormal vital signs.

Vital Sign Changes of Sepsis [8]

Age	Heart Rate	Resp Rate	Systolic BP	Temp (°C)
0d - 1m	>205	>60	<60	<36 or >38
>1m - 3m	>205	>60	<70	<36 or >38
>3m - 1y	>190	>60	<70	<36 or >38.5
>1y - 2y	>190	>40	<70 + (age in yr x 2)	<36 or >38.5
>2y - 4y	>140	>40	<70 + (age in yr x 2)	<36 or >38.5
>4y - 6y	>140	>34	<70 + (age in yr x 2)	<36 or >38.5
>6y - 10y	>140	>30	<70 + (age in yr x 2)	<36 or >38.5
>10y - 13y	>100	>30	<90	<36 or >38.5
>13y	>100	>20	<90	<36 or >38.5

Signs and Symptoms of Shock [8]

Exam Abnormalities			
	Cold Shock	**Warm Shock**	**Non-Specific**
Peripheral Pulses	Decreased or weak	Bounding	
Capillary Refill (central vs. peripheral)	≥3 sec	Flash (<1 sec)	
Skin	Mottled, cool	Flushed, ruddy, erythroderma (other than face)	Petechiae below the nipple, any purpura
Mental Status			Decreased, irritability, confusion, inappropriate crying or drowsiness, poor interaction with parents, lethargy, diminished arousability, obtunded

Clinical history and physical (H&P) alone is sufficient for diagnosis when the index of suspicion for appendicitis is high or low. [5,9]

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] [10-13]

- 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 ≤4: Low suspicion for appendicitis
PAS 5-7: Equivocal for appendicitis
PAS ≥8: High suspicion for appendicitis

Laboratory Assessment [5,14]

Diagnostic:

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

Radiologic Evaluation [5,10-13,15,16]

- US is the initial imaging modality for children with appendicitis.
- CT should be obtained only when US is equivocal or further investigation is needed

Critical Points of Evidence*

Evidence Supports

- Use the PAS to predict the presence of appendicitis in children ≥4 years. [10-13] – Strong recommendation, moderate quality evidence
- Utilize ultrasound (US) as the initial imaging modality in children with appendicitis. CT should be obtained only when US is equivocal or further investigation is needed in diagnosing appendicitis in children. [15, 17-21] – Strong recommendation, moderate quality evidence.
  Remarks: 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. [22]
- A timely diagnosis of appendicitis should be made by physicians in the ED. [23] – Strong recommendation, low quality evidence
- Laparoscopic appendectomy is the preferred surgical approach (vs. open surgery) for children with appendicitis. [24-28] – Strong recommendation, moderate quality evidence
- Postoperative pain medications should be scheduled. [29,30] – 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. [31-34] – Strong recommendation, moderate quality evidence
- An ultrasound should be used postoperatively to determine whether or not an abscess is present in patients with complicated appendicitis. [35] – Strong recommendation, very low quality evidence
- A localized fluid collection should be drained if the collection has an estimated size of >4cm. [36-38] – Strong recommendation, very low quality evidence
- Discontinue antibiotic therapy at discharge once clinical discharge criteria are met (afebrile, tolerating regular diet, pain controlled with oral pain medications, ambulating, and benign abdominal physical exam with no tenderness or mass). [39-44] – Strong recommendation, low quality evidence

Evidence Against

- Do not withhold analgesia. Withholding analgesia does not aid in the diagnosis of appendicitis. [45-50] – Strong recommendation, high quality evidence
- Do not routinely obtain perioperative cultures. [51-56] – Strong recommendation, low quality evidence
  Remarks: All children with drained abscesses should have anaerobic and aerobic cultures obtained from abscess fluid.
- Do not routinely administer postoperative antibiotics to children with *simple* appendicitis. [57,58] – Strong recommendation, moderate quality evidence
- Do not use biomarker testing to predict further antibiotic therapy in pediatric patients with complicated appendicitis with ongoing signs and symptoms post-appendectomy. [40,44,59-63] – Strong recommendation, low 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 only 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 - 20 mL/day and the patient is clinically improving. Routinely flush the drain with 10mL of saline per day. Consider TPA in complex collections with minimal output from a correctly placed drainage catheter after discussion between clinical teams, including surgery and IR. The amount of TPA should be determined based on size and location of collection. – Consensus recommendation
- There is insufficient evidence for the following topics: non-operative management of appendicitis, [16,64-68] interval appendectomies for abscesses or phlegmons. [69-71]

*NOTE: The references cited represent the entire body of evidence reviewed to make each recommendation.

Condition-Specific Elements of Clinical Management

Classification of Appendicitis

- Appendicitis is classified based upon intraoperative findings
- Complicated appendicitis includes the presence of an ileus, diffuse peritonitis, fibrino-purulent fluid in location other than RLQ, and/or a visible hole in appendix.
- Gangrenous appendicitis is treated as simple appendicitis.

Surgical Approach [24,25]

- 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 [45-48]

- Intraoperative cultures should not be routinely be obtained.
- All children with drained abscesses should have anaerobic and aerobic cultures obtained from abscess fluid.

Pain Management [29,30,39-44,73-75]

- Administer analgesia to promote comfort.
- Withholding analgesia does not improve diagnostic accuracy.
- Schedule postoperative pain medication.

Antibiotics [31-34,40,44,59-63,76,77]

- 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.
- If the patient has a penicillin allergy or the intraoperative culture shows *Pseudomonas*, use/change to PO ciprofloxacin and metronidazole.
- Discontinue antibiotic therapy at discharge once clinical discharge criteria are met (afebrile, tolerating regular diet, pain controlled with oral pain medications, ambulating, and benign abdominal physical exam with no tenderness and mass).
- Postoperative antibiotics are unnecessary in children with simple appendicitis.

Postoperative Imaging and Procedures – Complicated Appendicitis [35]

- Perform US at 6-7-days postoperatively to rule out abscess in patients with complicated appendicitis, if clinical suspicion for abscess.
- Drain localized fluid collection if estimated size ≥4 cm.

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.
- Consult Infectious Disease if complicated intra-abdominal abscess(es), recurrent abscess or multiple drains, prolonged length of stay.
- 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

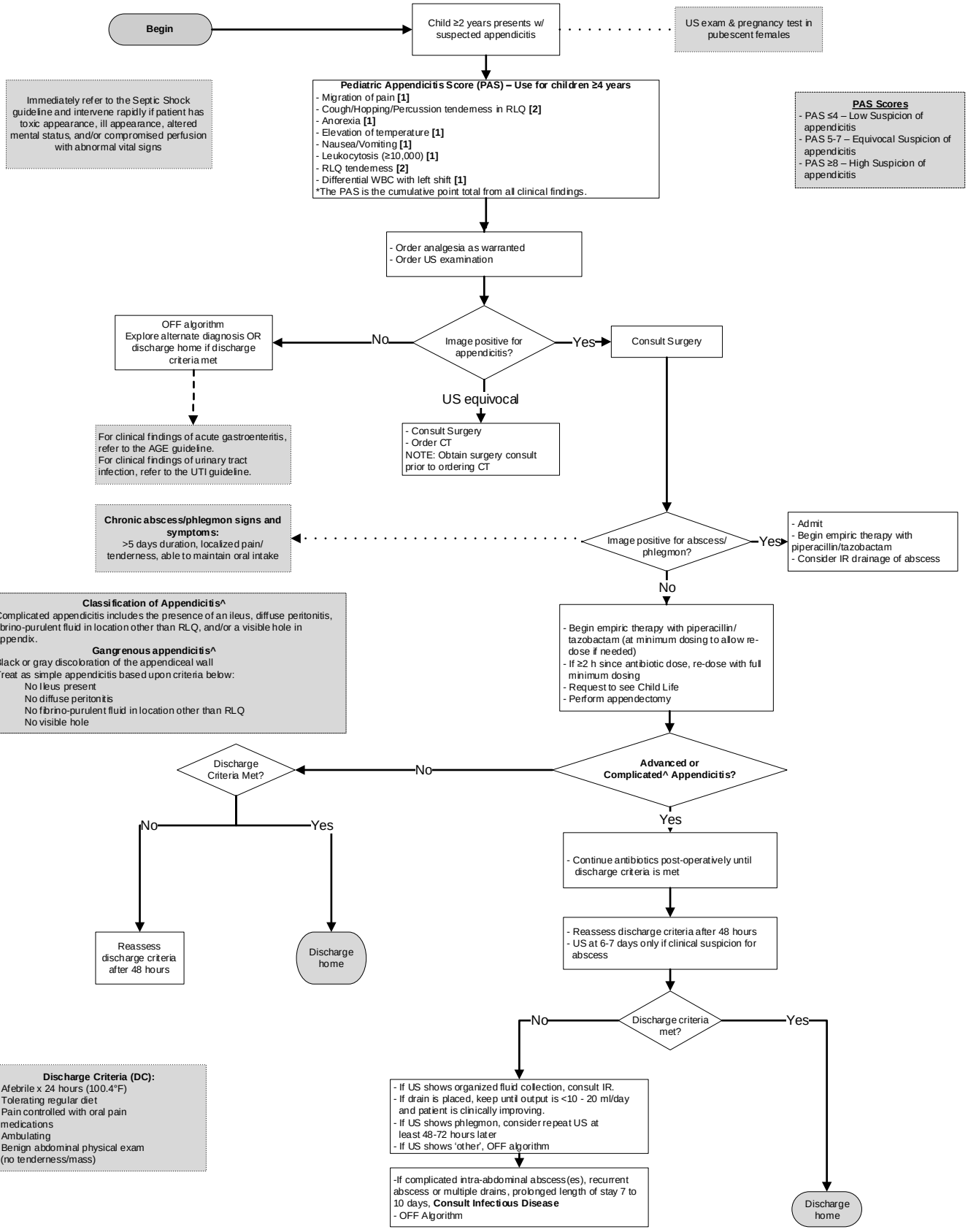
Process

- 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

TCH Evidence-Based Outcomes Center
Acute Appendicitis/Appendectomy Management Algorithm



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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 Emergency Physicians Clinical Policy: Critical Issues in the Evaluation and Management of Emergency Department Patients with Suspected Appendicitis, Surgical Infection Society and Infectious Disease Society of America Diagnosis and Management of Complicated Intra-abdominal Infection in Adults and Children, Therapeutic Agents Committee of the Surgical Infection Society Guidelines on Antimicrobial Therapy for Children with Appendicitis, International Pediatric Endosurgery Group Guidelines for Appendectomy

3. Literature Review of Relevant Evidence
   - Searched: 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 evaluate 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.

Recommendation	
STRONG	Desirable effects clearly outweigh undesirable effects or vice versa
WEAK	Desirable effects closely balanced with undesirable effects
Quality	**Type of Evidence**
High	Consistent evidence from well-performed RCTs or exceptionally strong evidence from unbiased observational studies
Moderate	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
Low	Evidence for at least 1 critical outcome from observational studies, RCTs with serious flaws or indirect evidence
Very Low	Evidence for at least 1 critical outcome from unsystematic clinical observations or very indirect evidence

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.

Version History

Date	Comments
Jan 2012	Originally completed
Apr 2015	Addendum for postoperative management of complicated appendicitis; remainder of guideline reaffirmed
Mar 2018	Removed TPN recommendation and clarified algorithm wording for complicated appendicitis
July 2018	Added two PICO questions, updated algorithm, archived original question
Jan 2019	Revised the 'Vital Sign Changes of Sepsis' table
Feb 2023	Guideline Update