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An Evidence-Based Review Of Acute Appendicitis In Childhood

March 2012
Volume 9, Number 3

Abstract

The special diagnostic challenges of appendicitis in children, along with the greater dangers of misdiagnosis, delay, and perforation, make swift and accurate diagnosis of appendicitis essential for emergency clinicians. Appendicitis is the most common indication for abdominal surgery in children presenting to the emergency department. Because of the frequently atypical presentation of appendicitis in children, delayed diagnosis is common, affecting as many as 57% of cases of appendicitis in children under 6 years of age. Although the risk decreases with age, perforation has been reported in more than 70% of children in the first 4 years of life at the time of surgery. Because the differential diagnosis for right-lower-quadrant pain in pediatric patients is so extensive, this review notes how signs and symptoms can vary by age group. A discussion of how a detailed, age-appropriate history can help guide the emergency clinician in determining diagnostic strategies is reviewed. Evidence regarding the choices of radiologic studies for children, including ultrasound and computed tomography, is presented, along with prophylactic antibiotics, pain medication, and the benefits of early surgical consult.

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CME Objectives

Upon completion of this article, you should be able to:

1. Identify an appropriate differential diagnosis for pediatric appendicitis the ED.
2. Describe key features of the history and physical examination that may distinguish appendicitis from other conditions.
3. Determine appropriate diagnostic tools for use in pediatric patients in the diagnosis of appendicitis.

For physician information, please see back page.

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Commercial Support: This issue of *Pediatric Emergency Medicine Practice* did not receive any commercial support.

Case Presentation

A 5-year-old boy is brought into the ED by his parents because of worsening abdominal pain, vomiting, and fever over the past 48 hours. They are worried because their son's appetite has dramatically declined in the past 2 days and his fever spiked to 102.3°F (39°C) this evening. There are no known sick contacts. The child is otherwise healthy and up-to-date with all his immunizations. In the ED, the child is febrile to 101°F (38.3°C) and mildly tachycardic. On examination, the child is tired-appearing with a tender abdomen, especially in the right lower quadrant. You note both voluntary and involuntary guarding in this region. The heart and lung portion of the examination is normal except for the previously noted tachycardia. You ask the nurse to place a peripheral IV line in the child, obtain lab work, and start IV fluids. At this point, the parents ask you, "What is your main concern?"

Introduction

Abdominal pain is the most common presenting symptom for children in the emergency department (ED). Acute appendicitis has been diagnosed in 1% to 8% of children evaluated for abdominal pain in urgent care settings, making it the most common surgical etiology found in these patients.[1,2] The diagnosis of appendicitis remains a challenge, especially in younger children, due to a nonspecific presentation and atypical symptoms.[1,3-5] Examples of differences in signs and symptoms of acute appendicitis, by age, are reviewed in **Table 1**.

The diagnosis of appendicitis is usually made using some combination of clinical examination skills, history-taking, laboratory analysis, and imaging studies. A review of pediatric hospital discharges, aged 18 and younger, revealed that there are about 77,000 discharges annually for appendicitis, with a cost of about $680 million.[3] Unfortunately, the misdiagnosis rate for appendicitis remains high, having been noted to occur in 12% of adolescents and up to 67% of children younger than 3 years of age.[6,7] Misdiagnosis results in higher rates of perforation, increased morbidity, and increased cost and length of hospitalization.[8,9] Missed diagnoses of appendicitis can also lead to high malpractice claims.[3,6] Accurate and early diagnosis of acute appendicitis can help decrease rates of perforation and further complications.

This issue of *Pediatric Emergency Medicine Practice* reviews the current literature in the evaluation, diagnosis, and management of children with suspected acute appendicitis. Common clinical presentations of appendicitis will be discussed as well as epidemiology and pathophysiology. Current recommendations for diagnostic workup and management of acute appendicitis in children are covered. For more information on management of appendicitis in adults, see the October 2011 issue of *Emergency Medicine Practice*, "Evidence-Based Management of Suspected Appendicitis In The Emergency Department."

Table 1. Age-Dependent Signs And Symptoms Of Appendicitis

Age Group	Historical Features	Examination Findings
Infancy	Vomiting, diarrhea, irritability, fever, unusual use of right hip	Temperature elevation, diffuse abdominal tenderness
Preschool	Abdominal pain, fever, vomiting, "hamburger sign," vomiting followed by pain	Right-lower-quadrant tenderness more often than diffuse tenderness
School age and adolesence	Periumbilical pain that localizes to right lower quadrant, associated with nausea, vomiting, anorexia	Right-lower-quadrant tenderness, +/- diffuse tenderness, guarding, rebound (more likely following perforation)

Epidemiology

Appendicitis is the most common indication for abdominal surgery in children presenting to the ED. Although children present with abdominal pain year-round, and diagnoses of appendicitis are made throughout the year, it has been noted that rates are higher from May through September.[10,11] Luckmann and Davis reported peak rates in July, August, and September.[11]

Aarabi et al recently reported on the overall rate of appendicitis in New England, which was found to be 9.4 cases per 10,000 person-years.[12] Janik and Firor had previously reported that in the United States, there were approximately 60,000 to 80,000 cases of appendicitis diagnosed annually in the pediatric population.[13] In 1996, Owings and Kozak showed that there were around 67,000 appendectomies performed on children aged 15 years or younger in the United States annually.[14] Appendicitis has been found to be more common in males than females, with incidence rates of 11.1 per 10,000 person-years in males and 7.7 per person-years in females.

A delay in diagnosis is common in young children and has been reported in as many as 57% of cases in children less than 6 years of age.[15] This delay is likely related to the atypical presentation of appendicitis in this age group. Delayed diagnosis, in turn, correlates with perforation.[16] The risk of perforation is highest in the first 4 years of life and has been reported in more than 70% of children in this age group at the time of surgery.[6,7,17] The rate of perforation in adolescents is 10% to 20%. Perforation rates are similar between sexes, and the likelihood of perforation decreases with age.[12]

Pathophysiology

The appendix is a blind, tubular structure that arises from the posteromedial aspect of the cecum, proximal to the ileocecal valve. Appendicitis is a result of obstruction of the appendiceal lumen. The average length of the appendix varies from neonates to adults, ranging from 4.5 cm to 9.5 cm.[18] The orientation of the appendix can be retrocecal, subcecal, preileal, retroileal, or in a pelvic site. This variability in orientation accounts for the range of clinical presentations of appendicitis.[19,20] Fecaliths are considered to be the most common cause of appendiceal obstruction and account for 11% to 52% of cases of appendicitis on pathology.[21,22] Fecaliths are thought to be a result of impacted fecal matter and inorganic salts in the lumen and are noted to occur less frequently in populations with high fiber intake.[21,23] Other etiologies of obstruction include lymphoid tissue hyperplasia, foreign bodies, or parasites. Luminal obstruction leads to colic, which in turn produces the poorly localized abdominal pain typical of early appendicitis. It also causes the appendiceal lumen to dilate and its wall to thicken. Further distention and thickening ultimately lead to vascular congestion and tissue ischemia. This compromises the integrity of the mucosal wall. Intraluminal bacterial overgrowth follows, with breakdown of the mucosal barrier, bacterial invasion of the wall, inflammation, ischemia, and gangrene, eventually leading to perforation. Inflammation of the wall of the appendix causes peritonitis, which produces localized abdominal pain and tenderness as well as typical right-lower-quadrant tenderness, guarding, and rebound. Perforation is rare in the first 12 hours but increasingly common thereafter (especially after 72 hours), and it leads to release of bacteria into the peritoneal cavity. The most commonly recovered species are *Escherichia coli* (71%), *Streptococcus milleri* group (34%), anaerobes (20%), and *Pseudomonas aeruginosa* (19%).[24]

Differential Diagnosis

The differential diagnosis of right-lower-quadrant pain can be extensive. **(See Table 2.)** In young children with right-lower-quadrant pain and fever, the differential will include infectious gastroenteritis and lower lobe pneumonia.[25] However, clinicians must be careful; one retrospective review revealed that among cases of missed appendicitis, 42% were initially diagnosed with gastroenteritis.[16]

If bilious vomiting is present along with abdominal pain in infants and younger children, malrotation with midgut volvulus or intussusception must be considered. In older teenage females, the differential must include gynecologic/obstetrical causes, and an accurate, detailed sexual history should be obtained. Diabetic ketoacidosis should always be considered in a child with abdominal pain, vomiting, and anorexia. In one prospective series, 16 out of 70 children undergoing imaging for appendicitis were diagnosed with mesenteric adenitis, which can often mimic signs and symptoms of acute appendicitis.[26]

Streptococcal pharyngitis can also mimic signs of appendicitis, with fever, headache, nausea, vomiting, and decreased oral intake often accompanying the sore throat.[27]

Table 2. Differential Diagnosis Of Right-Lower-Quadrant Pain

Gastrointestinal
- Appendicitis
- Appendiceal neoplasm
- Gastroenteritis (*Salmonella, Yersinia, Campylobacter*)
- Mesenteric adenitis
- Omental torsion
- Constipation
- Perforated ulcer
- Intussusception
- Small-bowel obstruction
- Crohn disease
- Meckel diverticulitis
- Cecal diverticulitis
- Typhlitis
- Pancreatitis

Gynecological
- Ectopic pregnancy
- Pelvic inflammatory disease
- Ruptured ovarian follicle or cyst (mittelschmerz)
- Ovarian torsion

Obstetrical
- Placental abruption
- Uterine rupture
- Labor
- Severe pre-eclampsia and HELLP syndrome
- Intra-amniotic infection
- Round ligament pain

Genitourinary
- Testicular torsion
- Nephritis
- Urinary tract infection
- Renal colic (stone, ureteropelvic junction obstruction)

Other
- Sickle cell crisis
- Primary peritonitis

Extra-Abdominal Causes
- Pneumonia
- Hemolytic uremic syndromes
- Diabetic ketoacidosis
- Henoch-Schönlein purpura
- Streptococcal pharyngitis

Abbreviation: HELLP, **h**emolysis, **e**levated **l**iver enzymes, low platelet count.

What aspects of the history, physical examination, and workup will help narrow your differential? There are several scoring systems that can be used to help guide management. The Pediatric Appendicitis Score (PAS) is a tool that utilizes history, physical examination, and laboratory results to categorize the risk of appendicitis in children with abdominal pain.[28,29] The PAS is easy to apply, separating patients into low-risk (PAS 1-2), intermediate-risk (PAS 3-6), and high-risk (PAS 7-10) categories. **(See Table 3.)** In a prospective validation study of the PAS that enrolled 849 patients with abdominal pain for up to 7 days, 123 patients with appendicitis (based on pathology) had a mean score of 7 or higher. In patients without appendicitis (confirmed by telephone follow-up at 2 weeks), the mean score was 1.9. (Note: the scorer was an attending pediatric emergency medicine subspecialist.)[29]

The Modified Alvarado Scoring System assigns a point score to diagnostic criteria, with a maximum of 9 points.[30] **(See Table 4.)** A patient with a score < 3 is considered low-risk, while a patient with a score > 7-9 should be strongly considered to have appendicitis. In validation studies, the Alvarado score had a sensitivity of 95% for appendicitis with a score greater than 7 and overall accuracy of 83%.[31]

Several other scoring systems have been described as well. A systematic review of several published scoring systems showed a diagnostic sensitivity of 53% to 99% and specificity of 30% to 99%.[32] As a general rule, the addition of these decision aids to clinical judgment has the potential to improve specificity and lead to lower false-positive rates in diagnosis of acute appendicitis; nonetheless, decision aids cannot definitively determine or exclude the possibility of appendicitis.

Prehospital Care

Children who are suspected to have appendicitis should be kept nothing by mouth (NPO) until a definitive diagnosis is made. Hydration status should be noted, and intravenous (IV) hydration should be initiated, if needed. Transfer to a higher-level facility should be started if a need for a pediatric surgeon and/or pediatric intensive care unit is anticipated.[15]

Emergency Department Evaluation

The clinical presentation of children with appendicitis varies from that of adults. It is important to keep the age of the patient in mind while obtaining history and performing the physical examination. When examining a child with suspected appendicitis, the clinician must keep the child as comfortable as possible. Consider performing an abdominal examination first, in order to obtain the most cooperation. The appendix may be in different locations (eg, retrocecum, pelvis, or extraperitoneum). Patients may present with pain to different sites based upon the location of the appendix. If the appendix is in the retrocecum, the pain may be absent in the abdominal area due to overlap by a distended cecum covering the appendix. Similarly, if the appendix lies in the pelvis, no abdominal pain will be felt in the abdomen; rather, pain will be felt on digital rectal examination. Although physical examinations in younger children can be challenging at best, the physical examination (including repeat examinations, close follow-up, and observation) and history are key to making the diagnosis.

Classic signs of appendicitis on physical examination are:

- Local tenderness with some rigidity of the abdominal wall at or near McBurney point (the point over the right side of the abdomen that is one-third of the distance from the anterior superior iliac spine to the navel. This point roughly corresponds to the most common location of the base of the appendix where it is attached to the cecum.)
- Rovsing sign - pain in the right lower quadrant on palpation of the left side.
- Obturator sign - pain on internal rotation of the right hip.
- Iliopsoas sign - pain on extension of the right hip, which is found in retrocecal appendicitis.

During evaluation of the patient in the ED, pain should be treated appropriately. Randomized tri-

Table 3. Pediatric Appendicitis Score

Item	Score
Anorexia	1
Nausea or vomiting	1
Migration of pain	1
Fever > 100.5°F (38°C)	1
Pain with cough, percussion, or hopping	2
Right-lower-quadrant tenderness	2
White blood cell count > 10,000 cells/mcL	1
Neutrophils plus band forms > 7500 cells/mcL	1
Total	**10 points**

Table 4: Modified Alvarado Scoring System

Item	Score
Migratory right iliac fossa pain	1
Anorexia	1
Nausea/vomiting	1
Fever > 99.5°F (37.5°C)	1
Tenderness in the right iliac fossa	2
Rebound tenderness in the right iliac fossa	1
Leukocytosis	2
Total	**9 points**

als have shown that the use of opioid analgesia in children being evaluated for suspected appendicitis does not mask significant findings on abdominal examination or delay diagnosis.[33,34]

Infants

Infants presenting to the ED can be a challenge. When history is obtained from parents or caregivers, they should be asked about vomiting, diarrhea, irritability, and fever. In some cases, parents may report unusual use of right-side extremities.[17,35] Physical examination may reveal fever, abdominal distention, and diffuse abdominal tenderness. Tenderness is rarely localized to the right lower quadrant.[4,35,36] Some neonates may present with lethargy, abdominal distention, or a palpable abdominal mass. It is important to remember that although the occurrence of appendicitis is much less likely in this age group, it is also more difficult to diagnose. A high index of suspicion is needed, as delayed presentation and diagnosis often results in perforation. The risk of perforation in children younger than 4 years of age has been reported to be more than 70%.[6,17]

Toddlers And Preschoolers

In this age group, children are much better at verbalizing their complaints, but it still very important to obtain a detailed history from the caregiver. Although it is typical for abdominal pain to begin prior to vomiting, in this age group, vomiting may precede the pain.[16] The clinician may need to use some distraction techniques during the physical examination to reduce the anxiety that the child may feel as a stranger examines a tender body part. Remember, children in this age group are likely to give the same answer to most questions: either "yes" or "no." A technique for evaluating rebound tenderness is asking the child to jump up and down. Also, asking the child if he or she is hungry and would he or she eat their favorite food, if offered ("hamburger sign"), can provide a better understanding of whether there is anorexia.

School-Aged Children

In this age group, the history and physical examination become much more clear. Children are able to explain their symptoms better and are able to cooperate with the physical examination. Children often present with the classic symptoms of fever, nausea, vomiting, and anorexia. Periumbilical pain that localizes to the right lower quadrant is a common presenting symptom. Rebound, guarding, and diffuse tenderness are associated with more peritoneal irritation and are concerning for ruptured appendicitis.

Adolescents

Appendicitis is most likely to occur in this age group, with rates reported to be 23.3 per 10,000 per year.[10] The clinical presentation in this age group can be classic in nature, but other factors can complicate the diagnosis. A thorough social and sexual history should be obtained in both female and male patients, as they may not be forthcoming with this information without direct inquiry. Such information can dramatically change the differential diagnosis and workup. The physician must evaluate and consider all the possible diagnoses in a female with right-lower-quadrant pain as well as perform a complete physical examination, including a pelvic examination and bedside pelvic ultrasonography, if available. **(See Table 2, page 3.)** Male patients should also undergo a complete physical examination, including genitourinary examination.

Diagnostic Studies

Laboratory Studies

White Blood Cell Count

An elevated white blood cell (WBC) count and increase in percentage of neutrophils has been noted in 96% of children with appendicitis.[15] This elevation, however, is nonspecific.[37] A WBC count < 8850 cells/mcL and an absolute neutrophil count < 6750 cells/mcL makes appendicitis much less likely (likelihood ratio, 0.06).[38] In a recent study comparing definitive appendicitis with no definitive appendicitis (as seen on pathology), the optimal cutoff value for WBC count was 12,000 cells/mcL, yielding a sensitivity of 71% (95% confidence interval [CI], 61%-80%) and a specificity of 66% (95% CI, 55%-77%).[39] Note that the WBC count should not be relied upon to rule disease in or out. It is important to remember that many other etiologies of abdominal pain—especially infectious causes—will cause an elevation in the WBC count.

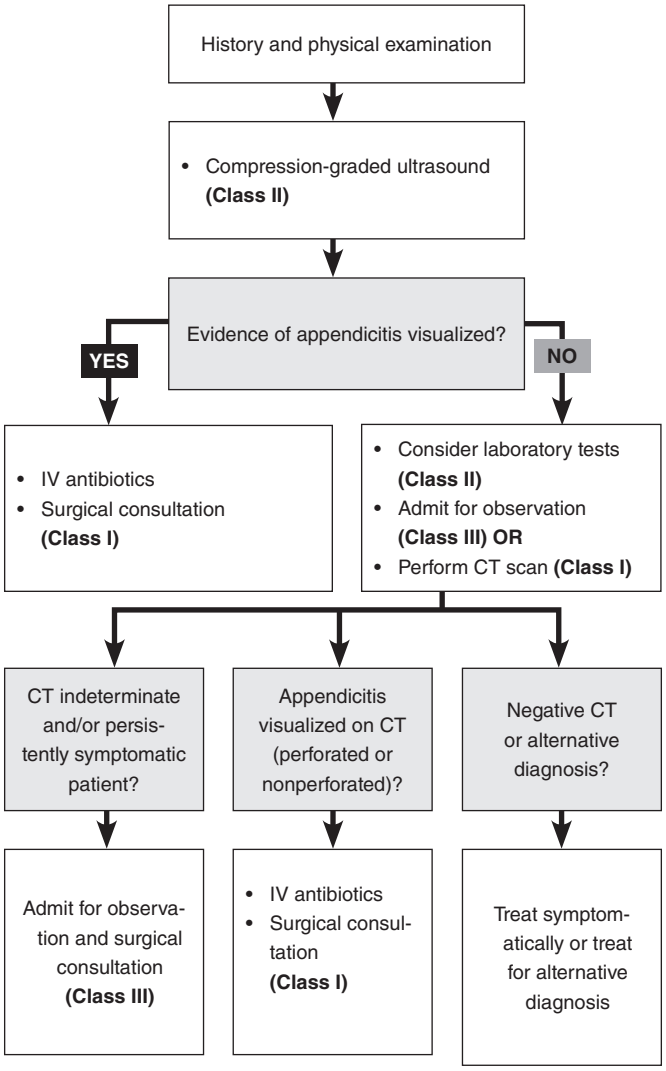
C-Reactive Protein

C-reactive protein (CRP) is a good indicator of acute bacterial infection and rises earlier than WBC count; however, in a recent study, WBC count had a better diagnostic value than the CRP on day 1 of illness in the diagnosis of acute appendicitis but not in the diagnosis of perforated appendicitis.[40] It is thought that bacterial infection is not significantly involved in the early stage of acute appendicitis. An optimal cutoff value of 3 mg/dL (30 mg/L) yielded a sensitivity of 70% (95% CI, 60%-79%) and a specificity of 65% (95% CI, 53%-75%).[39] Note that the WBC count and CRP are nonspecific findings; if suspicion for appendicitis is high, the emergency clinician should still proceed with imaging.

Urinalysis

A urinalysis is routinely performed during the evaluation of suspected appendicitis in children. The main reason is to identify other conditions such as a

Clinical Pathway For Diagnosis Of Appendicitis In Pediatric Patients



Abbreviations: CT, computed tomography; IV, intravenous.

Class Of Evidence Definitions

Each action in the clinical pathways section of *Pediatric Emergency Medicine Practice* receives a score based on the following definitions.

Class I
- Always acceptable, safe
- Definitely useful
- Proven in both efficacy and effectiveness

Level of Evidence:
- One or more large prospective studies are present (with rare exceptions)
- High-quality meta-analyses
- Study results consistently positive and compelling

Class II
- Safe, acceptable
- Probably useful

Level of Evidence:
- Generally higher levels of evidence
- Non-randomized or retrospective studies: historic, cohort, or case control studies
- Less robust RCTs
- Results consistently positive

Class III
- May be acceptable
- Possibly useful
- Considered optional or alternative treatments

Level of Evidence:
- Generally lower or intermediate levels of evidence
- Case series, animal studies, consensus panels
- Occasionally positive results

Indeterminate
- Continuing area of research
- No recommendations until further research

Level of Evidence:
- Evidence not available
- Higher studies in progress
- Results inconsistent, contradictory
- Results not compelling

Significantly modified from: The Emergency Cardiovascular Care Committees of the American Heart Association and representatives from the resuscitation councils of ILCOR: How to Develop Evidence-Based Guidelines for Emergency Cardiac Care: Quality of Evidence and Classes of Recommendations; also: Anonymous. Guidelines for cardiopulmonary resuscitation and emergency cardiac care. Emergency Cardiac Care Committee and Subcommittees, American Heart Association. Part IX. Ensuring effectiveness of community-wide emergency cardiac care. *JAMA*. 1992;268(16):2289-2295.

urinary tract infection or nephrolithiasis as the cause of abdominal pain. It has been shown that some patients with appendicitis have pyuria without bacteriuria. This is thought to be a result of inflammation of surrounding tissues from appendicitis.[15,37] Overall, neither the WBC, the CRP, nor the urinalysis can be used reliably to either rule in or rule out appendicitis. A patient can have appendicitis with a normal laboratory work-up.

Radiologic Studies

Since children often do not have a typical presentation for appendicitis, imaging can be helpful to establish or exclude the diagnosis. Ultrasound and computed tomography (CT), separately or in combination, are the modalities used most frequently.

Ultrasound Versus Computed Tomography

Ultrasound is safe, inexpensive, and available in most institutions. Accuracy of the ultrasound depends on the skill and experience of the sonographer. The distinct advantage of ultrasound over CT is the lack of exposure to ionizing radiation and possible need for sedation. In institutions where pediatric radiologists and properly trained technicians are available, ultrasound imaging can be obtained quickly, which expedites time to diagnosis.

The technique commonly used in ultrasound is graded compression, described by Puylaert.[41] In a meta-analysis of 26 studies that evaluated ultrasound for the diagnosis of appendicitis in 9356 children, pooled sensitivities were 88% (95% CI, 86-90) and specificities were 94% (95% CI, 92-95).[42] In an observational study where ultrasound was inaccurate in 101 examinations, false-positive and false-negative results were thought to be associated with high body mass index (> 85th percentile) or low pretest clinical suspicion for appendicitis.[43] The limitation of ultrasound is not only related to patient's body habitus but also to the difficulty in visualizing a normal appendix in order to definitively rule out the diagnosis of appendicitis. The reported visualization rates of a normal appendix vary greatly, depending on the experience and technique of the sonographer.[44,45]

If ultrasound has proven to be equivocal, the patient should be reassessed to determine the need for further imaging. If there is still a high suspicion for appendicitis and surgical evaluation is available, ultrasound can prove to be accurate as an imaging modality. In a diagnostic strategy based on assessment by a pediatric surgeon, with limited imaging, the sensitivity (99%), specificity (93%), diagnostic accuracy (97%), and negative appendectomy rate (5%) compared favorably with imaging-based strategies.[46] Therefore, a surgeon

Risk Management Pitfalls For Appendicitis In Children

1. **"It's unlikely that this 2-year-old with persistent vomiting has appendicitis. It's a more common diagnosis in a teenager."**
   Although it is more common for teenagers to be diagnosed with appendicitis, it's still a possible diagnosis for a 2-year-old child. Since rates of perforation are much higher in this age group, the possibility of appendicitis should always be considered, especially in a child with persistent symptoms.

2. **"In order to get a more accurate physical examination, the child should not be given any pain medication."**
   Randomized trials have shown that the use of opioid analgesia in children being evaluated for suspected appendicitis does not mask significant findings on abdominal examination or delay diagnosis.[34,35] It may be easier to have the patient cooperate with the examination if their pain is adequately controlled.

3. **"The ultrasound is equivocal and the child's WBC count is normal. Appendicitis can be ruled out even if the patient has persistent pain."**
   A normal WBC count does not rule out appendicitis. An inconclusive ultrasound with persisting symptoms should prompt the emergency clinician to obtain further imaging.

4. **"A 16-year-old female with focal right-lower-quadrant pain and guarding has a high pretest probability of appendicitis, so she doesn't need a pelvic examination."**
   In female patients, it is important to keep pelvic infections, ovarian torsion, and other gynecological pathology on the differential. A proper social/sexual history should be obtained, with a complete physical examination as well as pelvic examination.

5. **"I shouldn't involve the surgeon until I'm absolutely sure the child has appendicitis."**
   The involvement of a surgical team early on for a child with a likely diagnosis of appendicitis can help streamline diagnostic decisions as well as expedite surgical intervention, if necessary.

should be involved early in patient care if the suspicion is high.

CT is generally available and is less operator-dependent than ultrasound. Both ultrasound and CT can be useful in establishing alternative diagnoses. Several studies report sensitivities of 87% to 100% and specificities of 89% to 99% for CT in diagnosis of acute appendicitis.[42,47,48] The examination can be with or without oral/rectal contrast in combination with IV contrast. Imaging can usually be accomplished more rapidly when contrast is given rectally instead of orally,[44,49] but oral contrast can be used in patients who cannot tolerate the rectal route.[50] IV contrast can be used alone or in combination with oral contrast. Some studies have shown that there is no difference when using IV contrast.[51] It is important to remember that CT is associated with ionizing radiation, which has been shown to increase risk of lifetime cancer risk in children.[52-54] Properly performed CT examinations of children should result in much lower exposures that those for the same procedure on an adult. The algorithm in the Clinical Pathway **(see page 6)** summarizes the common proposed approach in helping diagnose a child with suspected appendicitis.[48]

Two additional indications for the use of CT in children that are important when considering imaging modality are: (1) if there is a clinical suspicion of perforation based on history or clinical findings, CT should be performed to properly locate and find a perforation or abscess; and (2) if there is diagnostic uncertainty, multiple diagnoses are being considered, and ultrasound is not a reasonable alternative modality because of fistula formation, malignancy, typhlitis, inflammatory mass, or bowel obstruction.

Treatment

A child who is undergoing a workup for appendicitis should undergo a surgical consultation. The patient should be kept NPO in preparation for the operating room. If noted to be dehydrated, the patient should be started on IV fluids. The patient should be frequently reassessed, and pain should be treated as needed. One systematic review noted a significant reduction in wound infections and intra-abdominal abscesses in patients undergoing appendectomy who received antibiotic prophylaxis.[55] For this reason, antibiotic prophylaxis is recommended for patients with appendicitis to reduce the incidence of wound infection and intra-abdominal abscess formation. Broad-spectrum antibiotics against gram-negative enteric aerobic and anaerobic bacteria (piperacillin and tazobactam, ampicillin and sulbactam with gentamycin, or cefazolin with flagyl) should be instituted.[15] The timing and technique of appendectomy will ultimately be decided by the surgeon.

Misdiagnosis

Due to variation in clinical presentation in younger children, appendicitis continues to be a diagnostic challenge. Children under 5 years of age are especially at risk for misdiagnosis, with rates as high as 57% to 67%, with 7% of children having 2 prior physician evaluations before an established diagnosis.[6,9,17] Any child who has been recently evaluated should raise suspicion for a missed diagnosis (appendicitis or other). The rate of misdiagnosis increases with younger age. Delay in proper diagnosis increases the risk of perforation, rates of abscess formation, length of hospitalizations, and overall morbidity rates.[7] The common misdiagnoses are gastroenteritis, upper respiratory tract infection, urinary tract infection, and constipation.[15,8] Studies have shown that children who are misdiagnosed often have atypical and misdirecting complaints as well as symptoms such as diarrhea with a normal appetite.[56] Other atypical symptoms noted were vomiting prior to pain, dysuria, and respiratory symptoms.[16,17,57,58] Early and accurate diagnosis can ensure prompt treatment and avoidance of associated complications.

Controversies And Cutting Edge

The role of bedside ultrasound in diagnosing pediatric appendicitis is not yet clearly defined. In a study of 132 patients (36% pediatric) by Fox et al, the sensitivity and specificity of bedside ultrasound were found to be 65% and 90%, respectively.[59] Diagnosis of appendicitis was based on finding a nonperistalsing tubular structure in the right lower quadrant that lacked compressibility and measured greater than 6 mm in diameter. Bedside ultrasound may be a skill that can help emergency clinicians expedite care for their patients and should be an area of further research.

Disposition

If the diagnosis of appendicitis has been established, decisions about operating timing and technique will be guided by the surgical team. If the patient is unstable for the operating room, all resuscitative efforts (including IV rehydration, antibiotics, and pain control) should be expedited in the ED, with prompt admission and transfer to the pediatric intensive care unit. On the other hand, if a definitive diagnosis has not been established, the decision to admit for observation versus discharge with close follow-up should also be made in conjunction with the surgical team and parental agreement. The child can also be observed in the ED for a brief period of time, prior to more extensive testing.

Summary

- Appendicitis presents a special diagnostic dilemma in the pediatric patient. The clinical manifestations can vary from nonspecific to the typically expected.
- An age-appropriate, detailed history can help guide the emergency clinician in the right direction.
- Although not specific to appendicitis, laboratory studies such as WBC count and CRP can be elevated in patients with appendicitis.
- A routine urinalysis should be obtained to evaluate for other causes of abdominal pain and may be noted to have sterile pyuria.
- Imaging studies such as ultrasound or CT can help further solidify the diagnosis of appendicitis.
- A surgical consultation should be obtained if the clinical suspicion of appendicitis is high. This can also help redirect additional testing and imaging in a more efficient way.
- If a diagnosis of appendicitis is made, the patient should be kept NPO with appropriate fluid hydration and pain management.
- IV antibiotics should be started preoperatively. Decision on the specific antibiotics and timing of surgery should be made in conjunction with the surgical team.

Case Conclusion

Because of a high suspicion for appendicitis, laboratory work and an abdominal ultrasound were performed. The WBC count came back at 15,000 cells/mcL, and the ultrasound was read as "suspicious for appendicitis" due to noted inflammation and thickening of the appendiceal wall. A pediatric surgical consultation was obtained, and the evaluation confirmed the need for an appendectomy. Antibiotics were started, proper consents were obtained for the OR, and the child was kept NPO with IV fluids and IV pain medication as needed.

Time- And Cost-Effective Strategy For Appendicitis In Children

In a retrospective literature review, it was shown that the most cost-effective method of imaging suspected pediatric appendicitis was to start with ultrasound and follow each negative ultrasound study with a CT study.[60] CT imaging of patients with suspected appendicitis in the ED has been shown to be cost-effective in the prevention of negative appendectomies, prevention of hospitalizations for observation (without ultimate diagnosis of appendicitis), and prevention of an observation period prior to surgery for appendicitis.[61-64]

References

Evidence-based medicine requires a critical appraisal of the literature based upon study methodology and number of subjects. Not all references are equally robust. The findings of a large, prospective, randomized, and blinded trial should carry more weight than a case report.

To help the reader judge the strength of each reference, pertinent information about the study, such as the type of study and the number of patients in the study will be included in bold type following the reference, where available.

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1. Which age range presents with the most typical presentation of appendicitis?
a. Neonates
b. Toddlers
c. School-aged children
d. Adolescents

2. Regarding the epidemiology of appendicitis, which of the following is true?
a. The ratio of perforated cases inversely correlates with age.
b. There is a seasonal variation with a peak of appendicitis in December, January, and February.
c. Preschool children is the most common age group to be diagnosed with appendicitis.
d. 50% of appendectomies are performed in the pediatric population.

3. What is the most common misdiagnosis of appendicitis?
a. Mesenteric adenitis
b. Pneumonia
c. Diabetic ketoacidosis
d. Gastroenteritis

4. Misdiagnosis of appendicitis in a child can result in:
a. Perforation
b. Increased rate of abscess formation
c. Longer hospitalizations
d. All of the above

5. An important consideration in the differential diagnosis of a menstruating female patient is:
a. Pelvic inflammatory disease
b. Ovarian torsion
c. Early pregnancy
d. All of the above

6. What should be the first radiographic test to be performed in a child with suspected appendicitis?
a. Ultrasound
b. CT scan with PO and IV contrast
c. CT scan without contrast
d. If strong suspicion, no need for further testing; call surgery to book an OR

7. The best way to evaluate a preschool child for appendicitis is:
a. Ask the child direct and detailed questions.
b. Send in a third-year medical student to do a full physical examination.
c. Use distraction techniques to evaluate the child for pain, rebound tenderness, and guarding in addition to obtaining a full, detailed history from parents.
d. Rely on surgical evaluation and physical examination.

8. Which of the following laboratory tests can confirm a diagnosis of appendicitis?
a. CBC with differential
b. Basic metabolic panel
c. Liver function tests
d. Blood culture

9. What are the interventions that should be done in a patient with a diagnosis of appendicitis?
a. Pain control
b. IV fluid hydration with NPO status
c. Surgical consultation
d. All of the above

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