

Imaging Examination for Diagnosing Acute and Chronic Appendicitis in Children

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Abstract

Appendicitis is the most common cause of acute abdominal pain in children requiring immediate surgical intervention. Diagnosis is often challenging due to nonspecific clinical symptoms, particularly in younger children. Diagnostic imaging plays a crucial role in establishing a rapid and accurate diagnosis. Ultrasonography (US) is the preferred initial modality because it is safe, non-invasive, and radiation-free. Computed Tomography (CT) offers higher sensitivity and specificity and can detect complications; however, its use is limited by radiation exposure. Magnetic Resonance Imaging (MRI) serves as a radiation-free alternative with high diagnostic accuracy, though its use remains limited by cost and availability. A stepwise approach using US as the first-line test followed by CT or MRI when results are inconclusive is considered effective in reducing negative appendectomy rates and complications. Selecting the appropriate imaging modality according to the child's clinical condition and available resources is essential for optimal diagnosis.

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INTRODUCTION

Appendicitis is an inflammation of the inner lining of the appendix that can spread to surrounding tissue. In children, approximately 1–8% of cases of abdominal pain are caused by acute appendicitis, although the incidence in preschool-aged

children is relatively rare, accounting for only about 2–9% of all cases.¹

Acute appendicitis is the most common abdominal surgical emergency in the pediatric population. Despite its high incidence, the diagnosis of acute appendicitis is often challenging because the classic

symptoms such as periumbilical pain, nausea, vomiting, and pain shifting to the lower right quadrant do not always appear and are less reliable, especially in children under five years of age. In this condition, imaging plays an important role in ensuring accurate and rapid diagnosis. Ultrasonography (US) is the initial modality widely used because it has high accuracy and can reduce or even replace the need for further examinations such as Computed Tomography (CT) scan or Magnetic Resonance Imaging (MRI) in cases of acute appendicitis.²

In addition to the acute form, appendicitis can also occur in a chronic form characterized by persistent abdominal pain. In Indonesia, appendicitis was recorded as the second most common non-communicable disease causing hospitalization in 2009 and 2010. Compared to acute appendicitis, chronic appendicitis is less common, with non-specific symptoms and a slow disease progression.³ Therefore, imaging tests are also necessary to confirm the diagnosis of chronic appendicitis. US can help rule out other possible diagnoses, such as acute appendicitis, urogenital abnormalities, or inflammation of the intestine and mesentery. However, if the US results are inconclusive or show normal tissue, the diagnosis must still be based on the clinical picture and may be followed up with a CT scan or MRI if necessary.⁴ Based on the above, the author is interested in explaining the role of imaging examinations in establishing the diagnosis of acute and chronic appendicitis in children.

DEFINITION OF ACUTE AND CHRONIC APPENDICITIS

Appendicitis is defined as inflammation of the inner lining of the appendix that then spreads to other parts.³ Acute appendicitis is the condition that most often requires emergency abdominal surgery in the pediatric population.⁵ Meanwhile, chronic appendicitis is one of the causes of chronic abdominal pain that can occur in children.³

EPIDEMIOLOGY

Acute appendicitis is one of the most common surgical emergencies in children. Its incidence is estimated to be around 1–2% of all pediatric

surgical admissions. In general, 1–8% of children who present with abdominal pain are found to have acute appendicitis. However, in the preschool age group, this condition is relatively rare, accounting for only about 2–9% of all cases of acute appendicitis. The rate of misdiagnosis is also quite high, ranging from 28–57% in children aged 2–12 years, and can even approach nearly 100% in children under 2 years of age. This indicates a significant diagnostic challenge in pediatric clinical practice.¹ Meanwhile, chronic appendicitis is reported much less frequently than its acute form. The incidence of chronic appendicitis is estimated to be around 1.5% in patients with clinical symptoms resembling acute appendicitis.⁶

CLINICAL MANIFESTATION

The clinical manifestations of acute appendicitis in children vary greatly depending on age group, making diagnosis often challenging. In neonates, acute appendicitis is very rare and is usually not caused by lumen obstruction, but rather by ischemia or other congenital abnormalities. Typical symptoms include abdominal distension (60–90%), vomiting (59%), palpable mass (20–40%), and irritability or lethargy. In some cases, it may be accompanied by hypothermia, hypotension, or respiratory distress. In infants and toddlers (<3 years), the dominant symptoms are vomiting (85–90%), abdominal pain (35–81%), fever (40–60%), and diarrhea (18–46%). Other symptoms that may appear are irritability, cough or rhinitis, and limited pelvic movement due to pain. Physical examination generally shows fever and diffuse abdominal tenderness (55–92%), while local tenderness in the lower right quadrant is found in less than 50% of cases. Because the symptoms are nonspecific, diagnosis is often delayed (approximately 3–4 days after onset), resulting in a very high risk of complications such as perforation (82–92%) or intestinal obstruction. In preschool children (aged 3–5 years), clinical manifestations are usually more obvious because children are able to communicate their complaints. Almost all cases report abdominal pain (89–100%), which is often accompanied by vomiting (66–100%), fever (80–87%), and anorexia (53–

60%). Physical examination shows local tenderness in the right lower quadrant (58–85%) more often than diffuse pain. In addition, involuntary guarding (85%), rebound tenderness (50%), and an elevated body temperature $>37.5^{\circ}\text{C}$ (82%) may be found. In general, the clinical presentation of acute appendicitis in young children is often non-specific, making it easy to misinterpret as gastroenteritis, respiratory tract infection, or other infectious diseases. This contributes to a high rate of misdiagnosis, reported to be 70–100% in children <3 years of age, and increases the risk of complications such as perforation and peritonitis.¹

Unlike its acute form, chronic appendicitis presents with more subtle and long-term symptoms. Patients generally complain of abdominal pain that lasts more than 48 hours or episodic pain that recurs. The pain is usually described as mild to moderate, located in the lower right quadrant, and can last for months or even years. These symptoms may appear with or without fever or other systemic symptoms that are usually seen in acute appendicitis. Laboratory test results generally show no abnormalities, such as a white blood cell count that remains within normal limits. Several studies support the existence of chronic appendicitis. A study in Wisconsin reported 44 patients with lower right quadrant abdominal pain lasting more than one month who underwent laparoscopic exploration and appendectomy. Of these, 28 patients (63.6%) showed histological abnormalities in the appendix, while 14 patients (31.8%) had other abnormalities. Interestingly, 31 patients (70.5%) experienced partial or total improvement of symptoms within 2 years after appendectomy. Another study in Munich, Germany, of 112 patients with clinical signs of chronic appendicitis showed that 42% had chronic inflammation of the appendix and 51% showed fibrosis.⁴

STRATEGIES FOR COMPARING DIAGNOSES AND THEIR CHALLENGES

The diagnosis of appendicitis in children, both acute and chronic forms, is challenging in clinical practice due to the highly variable presentation of symptoms, limited laboratory tests, and imaging

accuracy that is not always conclusive. Diagnosis requires integration of clinical presentation, laboratory tests, and imaging modalities.⁷

Clinical Overview

In acute appendicitis, classical symptoms include periumbilical pain that migrates to the lower right quadrant, accompanied by nausea, vomiting, and fever, which are frequently atypical in children. In neonates and infants, symptoms may include abdominal distension, vomiting, diarrhea, or lethargy, which are easily misinterpreted as gastrointestinal or respiratory infections. In preschool children, right lower quadrant pain is more prominent, but it can still resemble other conditions. This explains the high rate of misdiagnosis in children <3 years of age, which has been reported to reach 70–100%.^{7,8} On the other hand, chronic appendicitis has more subtle clinical manifestations. Patients usually complain of recurrent or persistent abdominal pain lasting more than 48 hours, often located in the right lower quadrant, with mild to moderate intensity. The pain can last for weeks to years, with or without fever or systemic symptoms. Not infrequently, patients remain in relatively good general condition, so the diagnosis is often missed or only considered after recurrent episodes.³

Laboratory Examination

In acute appendicitis, laboratory tests commonly show leukocytosis with a predominance of neutrophils and elevated C-reactive protein. However, these findings are not specific because they can be present in various intra-abdominal inflammatory processes.^{7,8} In contrast, in chronic appendicitis, laboratory results are frequently within normal limits, for example, leukocyte counts are not elevated, so they cannot be the basis for diagnosis. This is consistent with reports that in chronic appendicitis, it is not uncommon for laboratory tests to show neither leukocytosis nor an increase in other inflammatory markers. Urinalysis is also generally within normal limits and is more often performed to rule out a differential diagnosis of urinary tract infection, given that approximately 10% of patients with abdominal pain have urinary tract

abnormalities. In acute appendicitis, the inflammatory process can cause pyuria, hematuria, or bacteriuria in up to 40% of patients, but these findings are not characteristic of the chronic form.³

Imaging Diagnostic

Imaging modalities play an important role in confirming the diagnosis of appendicitis in children. US is the first-line examination because it is safe, non-invasive, radiation-free, and relatively easy to perform. US can show thickening of the appendix wall, lumen dilation >6 mm, the presence of stercolite, and periappendicular fat stranding. However, its accuracy is highly dependent on the operator's skill and the patient's condition, such as obesity or atypical appendix location.^{7,8}

CT of the abdomen with contrast provides higher sensitivity and specificity than US, and is capable of detecting complications such as abscesses,

perforations, or phlegmons. In recent studies, CT findings of an enlarged appendix diameter >8 mm and periappendicular fat infiltration (fat stranding) are the strongest indicators of acute appendicitis compared to negative appendectomy cases. However, CT still raises concerns regarding radiation exposure in children. MRI is an alternative, especially in children, because it is radiation-free and has high diagnostic accuracy. However, limitations in examination time, cost, and equipment availability mean that its use is not yet routine in all health facilities.^{7,8}

In chronic appendicitis, imaging often shows signs of chronic inflammation such as thickening of the appendix wall or fibrosis, but the results are not always conclusive. Several studies report that although imaging can reveal abnormalities, a definitive diagnosis can often only be confirmed after appendectomy with histopathological examination. On X-ray examination, a single air-fluid level may

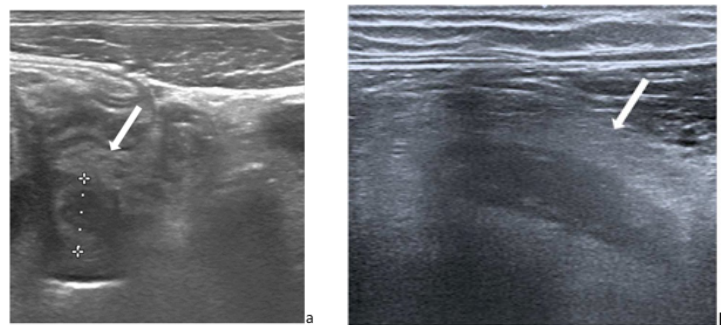


Figure 1. Acute appendicitis on axial (a) and longitudinal (b) US images, with a diameter of 12 mm (marker) and fat stranding (arrow).⁷

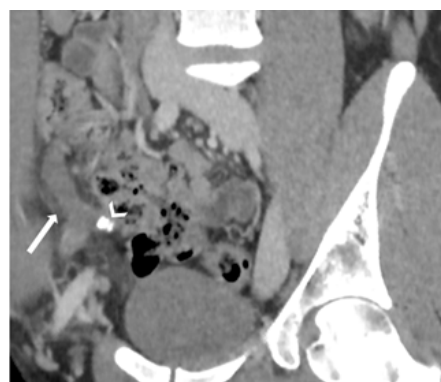


Figure 2. Portal phase CT coronal reconstruction with contrast shows acute appendicitis: enlarged appendix (12 mm) and fat stranding (arrow). A stark contrast appears at the base of the appendix (arrowhead).⁷

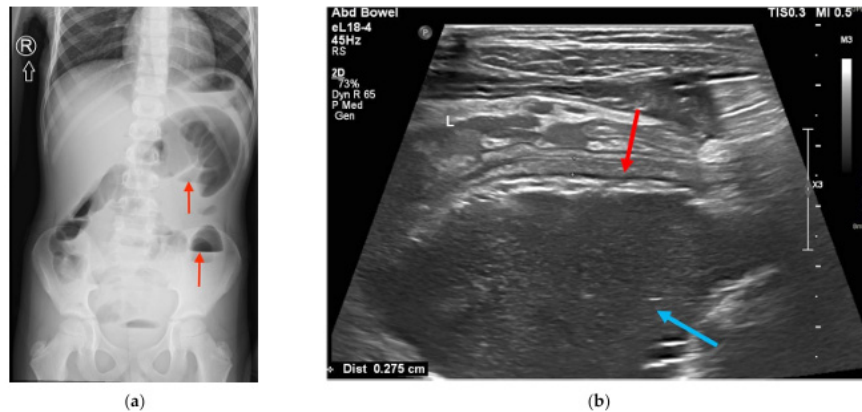


Figure 3. Imaging examination of a 6-year-old child diagnosed with chronic appendicitis (a) Single air-fluid level on plain abdominal radiograph (red arrow); (b) US examination showing intestinal wall edema (red arrow) and dilated intestinal lumen filled with fluid (blue arrow).⁶

be visible, indicating intestinal obstruction. US may show dilation of the intestinal lumen containing fluid, decreased motility, and intestinal wall edema. CT with contrast often shows significant intestinal dilation, loss of the typical intestinal pattern, and mesenteric and omental fat stranding as signs of inflammatory infiltration. However, these findings are not specific, so imaging plays a greater role in excluding differential diagnoses and detecting complications, while definitive diagnosis remains determined intraoperatively or through histopathological analysis.⁶

Based on the literature, the main challenges in diagnosing acute appendicitis in children are non-specific clinical symptoms at an early age, a high rate of misdiagnosis, and delayed diagnosis, which can lead to serious complications. Although modern imaging has improved diagnostic accuracy, negative appendectomy is still reported, even in patients who have undergone preoperative CT.^{7,8} In chronic appendicitis, the challenges are even greater because the symptoms are vague, laboratory tests are often normal, and imaging is non-specific. The diagnosis is usually made by exclusion and is only confirmed after surgery.⁶

TYPES OF IMAGING EXAMINATIONS

Imaging plays an important role in confirming

the diagnosis of acute appendicitis in children, given that clinical examination alone often has limitations in terms of accuracy and a high rate of misdiagnosis. The three main modalities that are widely used are US, CT, and MRI.⁹

Ultrasonography (US)

US is the first-line imaging modality in children with suspected appendicitis because it is non-invasive, radiation-free, relatively quick, and more economical. The graded compression technique allows visualization of the appendix with a sensitivity of approximately 69% and a specificity of 81%. However, its limitation is high inter-examiner variability, so accuracy is highly dependent on radiological experience.⁹

Computed Tomography (CT)

CT, especially low-dose CT with intravenous contrast, provides higher sensitivity and specificity than US, reaching 91% and 90%, respectively. CT is considered the gold standard in the diagnosis of appendicitis because it provides detailed images, including signs of complications such as periappendicular abscess, perforation, or the presence of appendicolith. However, radiation exposure is a major concern in pediatric populations, so its use is usually considered when US results are inconclusive.⁹

Magnetic Resonance Imaging (MRI)

MRI is increasingly being used as an alternative to CT, especially to avoid radiation exposure in children. MRI has a sensitivity of 97% and specificity of 96%, which is even higher than CT. This examination generally uses T1, T2, and T2 fat suppression sequences, with or without intravenous contrast. Its disadvantages include longer examination times, higher costs, and limited availability of equipment in some healthcare facilities.⁹

Combination Strategy

An increasingly popular approach is a stepwise strategy, which involves performing an US as an initial examination, followed by a CT or MRI scan if the US results are inconclusive. The combination of US and CT has been reported to have a sensitivity of 97% and a specificity of 91%, while the combination of US and MRI can achieve a sensitivity of 98% and a specificity of 88%. This strategy is considered capable of reducing the number of negative appendectomies and minimizing the risk of radiation exposure in children.⁹

THE ROLE OF IMAGING EXAMINATIONS

Acute appendicitis is one of the most common causes of non-traumatic acute abdominal pain requiring emergency surgery. Diagnosis based solely on clinical and laboratory findings is often insufficiently accurate, leading to a high rate of negative appendectomies (normal appendix removal) and delayed diagnosis, which can result in complications. With advances in technology, imaging examinations have become an essential part of diagnosing appendicitis, reducing the rate of negative appendectomies, and lowering healthcare costs. In addition, imaging in acute appendicitis also plays a role in:⁷

1. Identifying the appendix and its variations in position, which often complicate diagnosis.
2. Determining the characteristic signs of appendicitis, such as thickening of the appendix wall, lumen dilation >6–10 mm, the presence of stalkolite, and periappendicular fat stranding.

3. Detecting complications including perforation, abscess, phlegmon, or small bowel obstruction.
4. Excluding differential diagnoses, such as infectious terminal ileitis, diverticulitis of the cecum, pelvic inflammatory disease, Meckel's diverticulitis, or cecal neoplasms that may resemble appendicitis.

In chronic appendicitis, the diagnostic challenge is greater as the symptoms are non-specific and often resemble other conditions, such as gastrointestinal infections, inflammatory bowel disease, or irritable bowel syndrome. Imaging studies are important for excluding these differential diagnoses, although their sensitivity and specificity are not as good as in acute appendicitis. US may show thickened bowel walls, fluid-filled lumen, and decreased bowel motility, but these findings are often nonspecific. Plain abdominal radiographs may show an air-fluid level, but cannot confirm the diagnosis. CT with contrast is more informative because it can detect chronic inflammation, hidden abscesses, or microperforations, although the results may still be inconclusive, requiring definitive diagnosis to be made intraoperatively. Meanwhile, MRI has great potential because it is radiation-free and sensitive to signs of chronic inflammation, but its use is still limited due to availability and cost. Thus, in acute appendicitis, imaging plays a key role as the primary modality for accelerating diagnosis, assessing complications, and reducing unnecessary surgeries. In chronic appendicitis, although imaging results are often inconclusive, its role remains important in ruling out differential diagnoses, monitoring potential complications, and supporting clinical decision-making prior to surgical intervention.⁶

COMPARISON OF IMAGING ACURACY

The accuracy of imaging examinations is crucial to the success of acute appendicitis diagnosis, particularly in reducing the number of negative appendectomies and accelerating appropriate treatment. The three main modalities used are US, CT, and MRI, each with its own advantages and limitations. US is the most commonly used initial modality in children and pregnant women because it does not

involve radiation exposure. According to a meta-analysis, US with graded compression technique has a sensitivity of approximately 86% and a specificity of 81%. Although safe and relatively inexpensive, the main limitations of US are its high dependence on operator experience and the difficulty of identifying the appendix in obese patients or those with atypical appendix locations. CT has superior diagnostic performance compared to US. Its sensitivity reaches 91% with a specificity of 90%, making it the gold standard in the diagnosis of acute appendicitis. The advantage of CT lies in its ability to detect signs of inflammation, complications (such as perforation and abscess), and rule out differential diagnoses. The use of low-dose CT with intravenous contrast has been shown to provide similar accuracy to standard CT, thereby minimizing radiation exposure, although it remains a particular concern in pediatric populations.⁷ In a study by Song et al., abdominal CT was found to have high sensitivity and specificity compared to other modalities, but the rate of negative appendectomies was still 8.5% overall and increased to 12.9% in cases with inconclusive abdominal CT results. The findings most associated with true appendicitis were enlargement of the appendix with a diameter greater than 8 mm and the presence of periappendicular fat infiltration, while other findings such as appendicolith or wall thickening without secondary inflammatory signs were not strong enough to establish a diagnosis.²

MRI also offers very high accuracy, with sensitivity reported to range from 85–100% and specificity from 93–100% in various studies. MRI is very useful for pediatric and pregnant patients because it is radiation-free. In addition, diffusion sequences can help assess acute inflammation in more detail. However, its limitations include high cost, longer examination duration, and limited availability in some healthcare centers.⁷

CLINICAL IMPLICATIONS AND ALGORITHMS

The imaging approach for children with suspected appendicitis should be tailored to the clinical risk level determined by the Pediatric Appendicitis Score (PAS). This score divides patients into three

categories: low risk (PAS 1-3), moderate risk (PAS 4-6), and high risk (PAS 7-10). In children with low PAS (1-3), the likelihood of appendicitis is very low (<1%). Therefore, imaging is not recommended, and patients are better managed with clinical observation accompanied by education about warning signs. In children with moderate PAS (4-6), the risk of appendicitis increases to about 15%. This group is challenging because US examinations are often nondiagnostic, especially in patients who are obese, female, or have a retrocecal appendix. Therefore, MRI is recommended as the primary modality of choice because it has high accuracy equivalent to CT but without radiation exposure. If MRI is not available, US can be used as an initial examination, but if the results are inconclusive, it should be followed immediately by MRI or CT. In addition, in patients with symptoms that improve during observation in the emergency department, further imaging can be avoided.¹⁰

In children with high PAS (7-10), the risk of appendicitis reaches $\pm 60\%$, so imaging tests are necessary to confirm the diagnosis before surgical intervention. US is recommended as the initial examination because it is non-invasive and radiation-free. If US confirms appendicitis, the patient can be referred directly for surgery. However, if the US results cannot confirm the diagnosis, MRI is the next option. CT scans are used only when MRI cannot be performed or when there is suspicion of perforated appendicitis, given the significant radiation exposure. In the context of chronic appendicitis, imaging also plays an important role. US is often inadequate due to minimal and intermittent inflammatory findings. Therefore, MRI or CT is more useful for detecting chronic changes in the appendix, such as wall thickening, fibrosis, or residual abscesses. Overall, this algorithm emphasizes reducing unnecessary imaging, especially in low-risk groups, and maximizing the use of MRI in moderate-risk groups and cases where US is non-diagnostic. CT is only used selectively in certain conditions. Thus, the diagnosis of acute and chronic appendicitis in children can be established more accurately while minimizing unnecessary radiation exposure.¹⁰

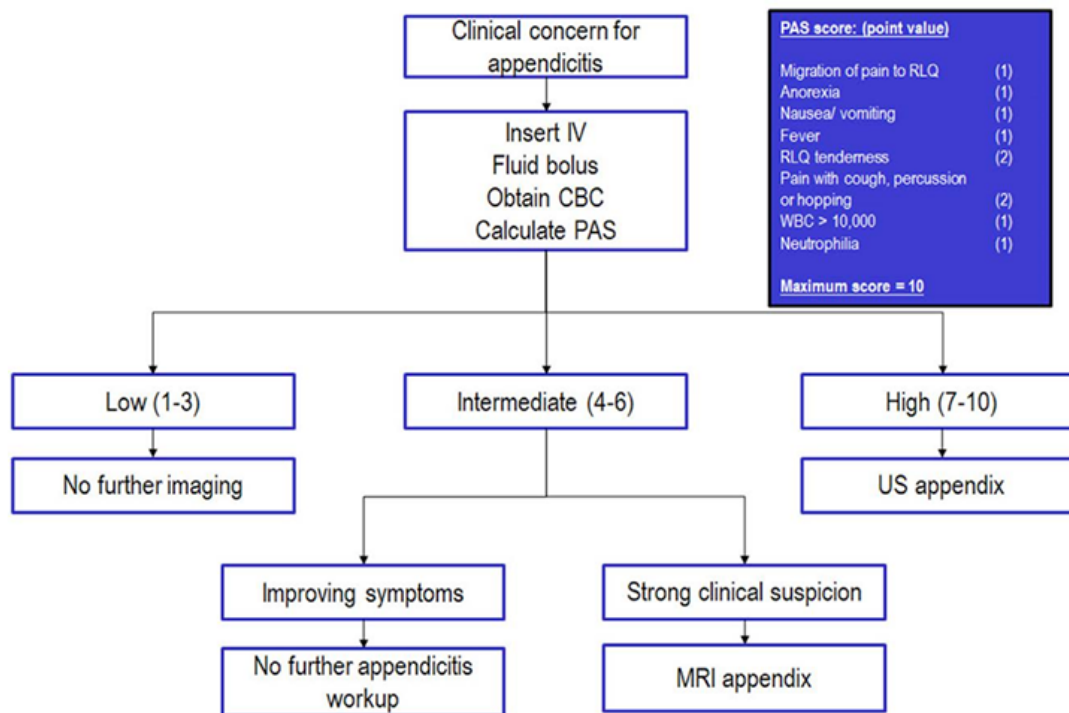


Figure 4. Algorithm for Imaging Examination of Appendicitis in Children.¹⁰

CONCLUSION

Imaging examinations have a crucial role in establishing the diagnosis of acute and chronic appendicitis in children. Although clinical and laboratory examinations remain the initial steps, imaging helps improve diagnostic accuracy, expedite treatment, and reduce the number of negative appendectomies and complications. US is the first-line modality because it is safe and radiation-free, while CT offers high sensitivity and specificity as the gold standard, although radiation risks must be considered. MRI is an excellent alternative without radiation exposure, but it is still limited by cost and availability. Selecting the appropriate imaging modality, tailored to the clinical condition and available facilities, is crucial to ensure accurate diagnosis and optimal management in children with suspected appendicitis.

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