

Acute Appendicitis in Children: The Diagnostic Challenges

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Acute appendicitis (AA) remains the most common atraumatic acute surgical condition of the abdomen. About one third of patients with AA are younger than 18 years of age; the peak incidence occurring between ages 11 and 12 years.¹ AA is ultimately diagnosed in 1% to 8% of children who present to pediatric emergency departments (EDs) with acute abdominal pain. Males and females have a lifetime appendicitis risk of 8.6% and 6.7%, respectively. Although AA is uncommon in infants and younger children, neonatal and even prenatal cases have been described.

Causes of misdiagnosis: Nonspecific signs and symptoms together with the rarity of this disorder in infancy account for overall misdiagnosis rates of 70% to 100% in those 3 years or younger. In fact, up to 28% of children at this age with AA are admitted to the hospital with an incorrect diagnosis. In preschool-aged children, misdiagnosis rates range from 19% to 57% with perforation in 43% to 72% because of the inability of such children to give accurate history and physician's low index of suspicion.¹ The misdiagnosis rate falls to 12% to 28% for school-aged children and less than 15% for adolescents.² Chang found that 15% of patients (the misdiagnosed group) were seen twice or more in the ED before AA was diagnosed.³ Misdiagnosed patients had a relatively shorter duration of symptoms at their initial visit, most presented late at night, had shorter stay in the ED, fewer laboratory tests, less diagnostic imaging, and fewer physical findings. AA can mimic virtually any intra-abdominal pathology; but the most common differential diagnoses are acute gastroenteritis, constipation, acute pyelonephritis, mesenteric adenitis, Meckel's diverticulitis, cholecystitis, pancreatitis, pleuritis and pneumonia. In teenage girls, ectopic pregnancy, rupture of ovarian cysts, ovarian torsion and pelvic inflammatory disease should be excluded.

Effects of misdiagnosis: False-negative diagnoses are associated with higher rates of perforation, postoperative complications, and need for postoperative interventions, as well as longer hospitalizations.⁴ Appendiceal perforation is nearly universal in children of 3 years or younger, compared with less than 15% in adolescents.² Although the diagnosis and treatment have improved, AA continues to cause significant morbidity and rarely, a cause of death. Many symptoms of AA are nonspecific. The variability of clinical presentation of AA leads to laparotomies that do not reveal an inflamed appendix. Recent literature report negative appendectomy rates to be less than 10%. Clinical experience and advances in imaging methods have improved the diagnostic accuracy but are not foolproof.

Clinical and laboratory parameters: Anorexia, non-specific periumbilical pain which migrate to right lower quadrant of abdomen, nausea and vomiting and fever are early symptoms of AA. Localised pain is typically in McBurney point, in the flank or back. Diarrhoea occurs more frequently in children (from irritation of terminal ileum or cecum, or from pelvic abscess) than in adults and can result in misdiagnosis of gastroenteritis. Tachycardia, Rovsing sign of referred pain, localised tenderness in McBurney point or midway between twelfth rib and the posterior superior iliac spine or rectal tenderness (pelvic appendicitis) are early signs. Local muscular rigidity over appendix, rigidity of psoas muscle (psoas test) or obturator muscle (obturator test) due to retrocecal appendicitis is definite signs. Generalised tenderness and rigidity indicate generalised peritonitis. A boggy tender mass may indicate abscess or appendicular mass. A critical aspect of evaluation when the diagnosis is unclear, is serial examinations after admission in a hospital, by the same physician.

Total leucocyte and neutrophil counts, a neutrophil-lymphocyte ratio greater than 3.5 and sequential C-reactive protein levels are helpful in the diagnosis.

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tive protein (CRP) measurements are helpful.² The only mandatory test in patients with suspected appendicitis is a pregnancy test in female patients of child-bearing age.² In majority of children with suspected AA, the combination of clinical history, physical findings and laboratory studies provide sufficient data for making the diagnosis; but misdiagnosis leading to negative appendectomy ranging from 10% to 30% has been reported.¹ The MANTRELS score, based on weighing eight clinical factors (Migration of pain from central area to right lower quadrant 1, Anorexia or acetoneuria 1, Nausea with vomiting 1, Tenderness in the right lower quadrant 2, Rebound tenderness 1, Elevated temperature $\geq 38^{\circ}\text{C}$ (100.4°F) 1, Leukocytosis ($>10,400$ cells/mm³) 2, Shifted WBC count ($>75\%$ neutrophils) 1, Total possible points 10) was proposed to improve the diagnostic accuracy. Patients with score ≤ 5 are unlikely to need an emergency operation and can be observed as outpatient with little risk. 50% of the patients with score 6 were operated. All the patients operated were with the score ≥ 7 . It has sensitivity 100%, specificity 85.1%, positive predictive value 91.7% and negative predictive value 100%.^{5,6} Pediatric appendicitis score (PAS) was suggested in 2002;⁷ but in a retrospective study, Goulder found that the PAS cannot be recommended as it would lead to an unacceptable risk of wrongly discharging or delaying necessary surgery in 13% of patients with appendicitis.⁸

Imaging studies: In cases where the diagnosis is equivocal, observation with serial examinations and imaging studies may be useful. Imaging may also be needed for patients who have received antibiotics prior to evaluation. Ultrasonography (US) and computed tomography (CT), separately or in combination, are the modalities used most frequently although magnetic resonance imaging (MRI) has similar diagnostic accuracy as CT. American College of Radiology recommend that imaging in children with atypical or equivocal clinical findings for appendicitis begin with US. If the appendix is not visualized or the findings on US are otherwise not diagnostic, the patient may either be observed with serial physical examinations and repeated imaging (US, CT or MRI) performed at a later time. If a clinical diagnosis of appendicitis cannot be made or, if more prompt diagnosis is desired, the patient may directly proceed to contrast-enhanced CT or MRI.⁹ Use of MRI instead of CT is limited to pediatric specialty centers because of issues related to cost, availability, limited experience with interpretation, and the potential need for sedation in younger children. Given the technical limitations of US in diagnosing appendicitis in very obese children, some clinicians may choose to perform contrast CT or MRI as the initial

imaging strategy in these patients. In compliance with this protocol, the following findings were reported.⁹

- Sensitivity and specificity for identifying appendicitis were 99 and 91 percent, respectively.
- Rates of negative appendectomies and missed appendicitis were 8 and 0.5 percent, respectively.
- CT was avoided in 53 percent of patients.

Imaging studies have variable success. Plain radiographs of the abdomen are primarily indicated in children with suspected appendicitis to confirm a clinical suspicion of bowel obstruction or perforation. Plain abdominal radiography may show fecoliths in 10% to 20% cases and may be an indication for surgery when symptoms are present.

Ultrasonography (US): The diagnosis of appendicitis cannot be reliably excluded by US unless a normal appendix is seen. Reported visualization rates vary from 22 percent to 98 percent depending upon the experience and technique of the sonographer, as well as the child's body habitus.⁹ Overall sensitivities of US performed by pediatric ultrasound technicians and/or pediatric radiologists for appendicitis, varied from 74% -100% and specificities from 88%-99%.⁹ The addition of posterior manual compression and scanning in the flank and pelvis, in addition to the right lower quadrant, may improve visualization of the appendix and permit more accurate diagnosis of appendicitis. With focused ultrasonographic training, pediatric emergency physicians can diagnose AA with substantial accuracy. Such bedside sonography had a sensitivity of 85%, specificity of 93%, positive likelihood ratio of 11.7, and negative likelihood ratio of 0.17.¹⁰ Ultrasound findings that support the diagnosis of AA include the following:

- Noncompressible tubular structure in right lower quadrant
- Wall thickness of the appendix greater than 2 mm
- Overall diameter greater than 6 mm
- Free fluid in the right lower quadrant
- Thickening of the mesentery
- Localized tenderness with graded compression
- Presence of a calcified appendicolith (fecolith).

Ultrasonography is particularly useful in peri and post-pubertal females to identify alternative gynecologic diagnoses, such as ovarian cyst or ovarian torsion. A small number of children with a normal appendix visualized on US may have early, or tip, appendicitis. Consequently, clinical correlation and imaging with enhanced CT or MRI may be required to exclude appendicitis.

Computed Tomography (CT): CT is typically more available and less operator dependent than ultrasonography. CT is also useful in establishing alternative diagnoses for abdominal pain (9). In children, sensitivity for the diagnosis of AA by CT is 94%-100% and specificity is 93%-100%. CT has the disadvantage of exposure to ionizing radiation, health care costs, and delay in surgical treatment. CT was associated with the greatest reduction in the negative appendectomy rate among young children (<5 years of age). Techniques to improve the accuracy and safety of CT include the use of intravenous contrast and limiting the examination to a focused CT of the pelvic contents.⁹

Findings on CT that support the diagnosis of appendicitis include:

- Wall thickness greater than 2 mm
- Appendicolith (fecalith)
- Enlargement of the appendix
- Concentric thickening of the appendiceal wall (target sign)
- Phlegmon, Abscess and Free fluid
- Thickening of the mesentery and fat stranding

CT use has increased for patients with appendicitis over time.¹¹ Combination of pelvic USS followed by limited CT with rectal contrast if needed gives better results. Evaluation at a community compared with a children's hospital is associated with higher CT and lower US use before appendectomy. US and CT sensitivities for appendicitis were diminished for studies performed at community hospitals compared with the children's hospital.¹²

Recent Advances: Sign of dry lips in 88% patients found to have AA at surgery and histopathology compared with other signs and symptoms is important.¹³ Calprotectin (a biomarker associated with intestinal mucosa inflammation) in combination with traditional inflammatory biomarkers WBC and CRP offers some benefit in the reduction of false positive test results in children with abdominal pain at sufficient low risk for appendicitis; further diagnostic radiological testing may be avoided.¹⁴ Groselji found that IL-6 serum concentration, the laboratory marker with the highest diagnostic accuracy in their study, should be a part of the diagnostic procedure for AA in children.¹⁵ A study indicated that mean platelet volume was significantly decreased along with the White Blood Cell Count elevation in pediatric AA patients.¹⁶ In conjunction with the clinical symptoms, a procalcitonin level > 0.39 and WBC count could be a strong predictor of AA in children.¹⁷

END NOTE

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