Journal of Pediatric Surgery 53 (2018) 620–624

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Sonography of suspected acute appendicitis in children: Evaluation of the progress in performance of senior residents

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ARTICLE INFO

Article history:
Received 22 March 2017
Received in revised form 9 May 2017
Accepted 11 May 2017

Key words:
Sonography
Acute appendicitis
Residents
Children
Pediatric radiology

ABSTRACT

Purpose: The objective of this study was to evaluate the progress in performance of senior residents in diagnosing acute appendicitis.
Material and methods: Results were collected and compared of ultrasound examinations performed for suspected acute appendicitis by three senior residents and two faculty members over a six-month period in a university hospital setting. A grid with the sonographic findings was completed separately by the residents and the faculty members immediately after each examination. The duration of each examination was reported. The final ultrasound diagnosis was compared to the surgical and pathological results and to the clinical follow-up.
Results: The residents and faculty members performed 171 consecutive ultrasound examinations including 49 children with acute appendicitis and 122 with normal appendices. The accuracy of the diagnosis by the residents was 96%, and was similar to that of the faculty members (kappa = 0.90) over the six months. The duration of the resident ultrasound examinations was significantly shorter during the second three-month period ($p = 0.01$). No significant differences in diagnostic accuracy were demonstrated by the residents between the first and second three-month periods ($p = 0.06$).
Conclusions: The residents performed well when using sonography to diagnose acute appendicitis in children, and were faster during the second three-month period.
Level of evidence: I.

Acute abdominal pain is a common cause for consultation in pediatric diagnostic imaging [1,2]. Approximately a third of children presenting with acute abdominal pain have appendicitis [3], making this affliction the first cause of abdominal surgery in children [4]. Despite a declining number of appendectomies in our country, decreasing from approximately 300,000 cases during the 1990s to 83,000 in 2011, the number of appendectomies still remains rather high compared to the other Organization for Economic Co-operation and Development (OECD) countries, and is partially explained by the resection of a considerable number of healthy appendices [5]. Indeed, the diagnosis of appendicitis in a child can be difficult, with a considerable proportion of diagnostic errors based on the clinical and laboratory data. The symptoms and clinical signs of acute appendicitis are not specific, which can lead to frequent requests for diagnostic imaging. This constitutes a challenge for pediatric radiologists. Ultrasound is regarded, by the American College of Radiology (ACR), as the method best suited for initially imaging a patient with suspected acute appendicitis [6]. Ultrasound is efficacious, because of its lack of ionizing radiation, high-sensitivity [3,7], and low-cost [8]. The wide range of reported sensitivity and specificity in the ultrasound diagnosis of acute appendicitis in children appears to be because of operator and patient factors [1,3]. Obesity has been cited as a factor responsible for a significant decrease in the effectiveness of ultrasound [9]. Several authors report poor diagnostic results in acute appendicitis when the ultrasound is performed by an operator with little experience in pediatric ultrasound [1,10].

The objective of our study was to prospectively evaluate the progress in performance of senior residents in diagnosing acute appendicitis.

1. Materials and methods

1.1. Patient population

We obtained approval by the local Ethics Committee. All patients gave their informed consent. Between November 2015 and April 2016,

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http://dx.doi.org/10.1016/j.jpedsurg.2017.05.013
0022-3468/

we collected and analyzed prospectively the demographic data and results of ultrasound examinations performed for suspected acute appendicitis by three senior residents in radiology and by two faculty members in a university hospital setting. Senior residents were in their fifth year of training. They had the same general adult radiological training course, including standard radiography, general ultrasound, CT and MRI scans. They did not have experiences in pediatric radiology. Faculty members were exclusively pediatric radiologists, with respectively 4 and more than 30 years of experience. All patients were less than 16 years of age, were examined during regular daytime hours (from 8 a.m. to 7 p.m.), and were referred for suspected acute appendicitis either from the hospital emergency department or from practitioners in the community.

1.2. Sonographic examinations

Ultrasounds were carried out on two ultrasound devices GElogicE9 with a convex probe 2–9 Hz and a high frequency linear probe (9 Hz). An initial ultrasound was performed by one of the three senior residents in diagnostic and interventional imaging. This examination included the entire abdomen and pelvis. Immediately after the senior resident, a second ultrasound was carried out by a faculty member, in the same room with identical equipment, without knowledge of the resident's results. A grid with the sonographic findings was completed separately by the residents and the faculty members immediately after each examination. Then, the senior resident and the faculty member shared their interpretation and a final consensual radiological report was given to the clinician. The duration of each resident and faculty member examinations was tabulated.

An initial ultrasound was performed by one of the three senior residents in diagnostic and interventional imaging. This examination included the entire abdomen and pelvis. Then, a second ultrasound was carried out by a faculty member, without knowledge of the resident's results. A grid with the sonographic findings was completed separately by the residents and the faculty members immediately after each examination. The duration of each resident and faculty member examinations was tabulated.

1.2.1. Grid and diagnostic categorization

The ultrasound elements included the visualization of the appendix (non-visualization, partial or complete visualization), the transverse diameter of the appendix (less than 6 mm, between 6 and 8 mm, greater than 8 mm); the wall's differentiation (preserved or not, Fig. 1), localized tenderness and guarding, infiltration of the periappendiceal fat (Fig. 1), regional lymphadenopathy, and free intraperitoneal fluid. We also recorded complications such as a periappendiceal mass or abscess. At the end of the procedure, depending on the previous ultrasound criteria, four diagnostic conclusions were possible: acute appendicitis, likely appendicitis, appendicitis unlikely, or normal appendix. *Acute appendicitis* was diagnosed when an appendix was enlarged, wall differentiation was not preserved, associated localized tenderness was seen and infiltration of the periappendiceal fat was observed. A *normal* appendix was diagnosed when a normal-sized appendix with preserved wall differentiation, and no infiltration of the periappendiceal fat were observed. In case of non-visualization of the appendix, when all indirect ultrasonographic appendicitis signs were absent, the radiologists have considered that the diagnosis of appendicitis was *unlikely*. In the opposite case, the radiologists concluded *probable* appendicitis.

1.3. Follow-up of the patients

The final ultrasound diagnosis was correlated with the surgical and pathological results and with clinical follow-up. The decision of the surgeons to operate depended mainly on the clinical and ultrasonographical data, and biological data when available. The operative report was available 48 h later, allowing prompt radiological-surgical correlation and feedback to improve resident performance. Once the children were back at home with discharge instructions, the patient's medical record was consulted two weeks after discharge, noting any readmission to the emergency department. In cases where the appendix had not been visualized by ultrasound, the families were contacted by phone three months after their hospitalization to verify that no appendectomy had been performed at another medical center in the interval.

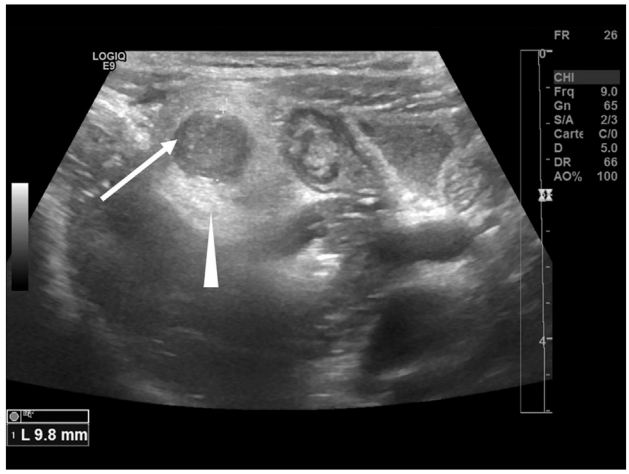

Fig. 1. Transversal slice of an acute appendicitis, showing an increase of size of appendix with a wall's dedifferentiation (white arrow), associated with an infiltration of the periappendiceal fat (white arrowhead).

1.4. Statistical analysis

To evaluate interobserver agreement between residents and faculty members, we assigned a letter to the final ultrasound diagnosis: acute appendicitis = A, probable appendicitis = B, appendicitis unlikely = C and normal appendix = D. A binary classification was used: a positive response (sum of the final ultrasound diagnosis: acute appendicitis, A; and probable appendicitis, B) or a negative response (sum of the final ultrasound diagnosis: appendicitis unlikely, C; and normal appendix, D). Interobserver agreements between resident and faculty members for positive and negative diagnosis were calculated.

1.4.1. Diagnostic errors, false positives, and false negatives

An imaging result was considered false positive when the final ultrasound classification was acute appendicitis (A) or probable appendicitis (B) but the appendix was healthy at surgery, a complementary examination such as computed tomography (CT) was unremarkable, or if the patient had returned home and was symptom-free for fifteen days following the ultrasound. A result was considered false negative when the final sonographic classification was normal appendix or appendicitis unlikely, but a diagnosis of acute appendicitis was established by pathological means.

1.4.2. Descriptive statistics

We calculated the sensitivity, specificity, positive predictive value, negative predictive value, exactitude and confidence intervals for the residents and the faculty members. These calculations were made over the course of the six-month study period and during the first and the second three-month periods by comparing the sonographic results with a gold standard. The gold standard was defined as the pathological diagnosis for the patients treated surgically or the long-term clinical follow-up for the non-operated group. Statistical analyses were performed using the software R version 3.3.1 [11]. A p-value < 0.05 was considered significant. The McNemar test and Kappa coefficient were used to measure interobserver agreement. A Student t test was used to compare duration of examination.