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Research Article

Ultrasonography as a Diagnostic Tool for Appendicitis in Paediatric Patients

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Abstract: ***Introduction:*** Ultrasound is commonly used as a tool for investigation of acute appendicitis in children. The accuracy of ultrasound in appendicitis depends on the ability to visualize the appendix and the potential contribution from secondary signs. The study was a retrospective analysis of children referred for sonographic investigation of possible acute appendicitis at an Australian tertiary pediatric hospital between January 2008 and December 2010. ***Material and Method:*** The present study was conducted on 100 pediatric patients with possible diagnosis of appendicitis at Department of Radiology, Shadan Institute of Medical Sciences, Teaching Hospital & Research Centre, Hyderabad. Over a period of one year. All of the patients underwent initial clinical evaluation followed by ultrasonography (USG), which was used to assess the existence of signs associated with appendicitis or its complications. USG Imaging findings were then compared in patients with and without complications. False positive, false negative, true positive and true negative values were calculated. Sensitivity and specificity of ultrasonography in determining appendicitis was evaluated. ***Results:*** Of the 100 pediatric patients, 65 (65%) were male and 35 (35%) were female. There were also 65 (65%) true positive and 35 (35%) true negative cases based on ultrasonography findings. In our study, USG sensitivity was 83.6%, specificity was 80.6%, positive predictive value was 94.4%, and negative predictive value was 80.6%. ***Conclusion:*** Ultrasonography is indicated in the diagnosis of appendicitis in pediatric patients and has optimal sensitivity and specificity in the diagnosis. Furthermore, it is a suitable diagnostic method for evaluating complications of appendicitis.

Keywords: Appendicitis, Ultrasound, Pediatrics, Ultrasonography, Children, Appendicitis, Pediatrics, Abdomen, Ultrasonography, Diagnostic tool.

INTRODUCTION

Acute appendicitis is the most common surgical emergency in Australia, accounting for almost 10% of emergent surgeries. [1] Ultrasound is an important first-line imaging tool in children with suspected appendicitis due to the lack of potentially harmful ionizing radiation compared with that generated by computed tomography. [2] Whilst magnetic resonance imaging has been demonstrated to be a potential first-line modality in children with appendicitis, [3] it is not yet widely available in Australia. The sensitivity and specificity of pediatric appendiceal sonography diagnosing appendicitis are reported to be approximately 90%. [4] These figures can be misleading, with varied interpretation of equivocal ultrasound results. Equivocal results are particularly common when the appendix is not identified. [5] Visualization of the appendix has been documented in as few as 29% of ultrasound examinations, [6] and as many as 99%. [7] These cases with insufficient sonographic evidence to warrant appendectomy are often deemed to be negative and are sometimes excluded from statistical analysis altogether.

In cases where the appendix is not seen, and a radiological diagnosis remains equivocal, secondary sonographic signs of appendicitis may support a positive finding or, in their absence, a negative result. [8] These secondary sonographic signs may include: the presence of free fluid; inflammation of the periappendiceal mesentery that demonstrates a more echogenic appearance in comparison with the contra lateral iliac fossa the presence of an appendicolith, dilated bowel loops and echogenic debris in the urinary bladder. This study aims to determine the accuracy of appendiceal sonography diagnosing appendicitis in children at an Australian tertiary children's hospital in order to compare with published standards and identify potential areas of improvement for a future prospective study.

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Material and Methods

The present study is a prospective, observational and descriptive study which was performed in the at Department of Radiology, Shadan Institute of Medical Sciences, Teaching Hospital & Research Centre, Hyderabad. Over a period of one year of all the patients being referred to the medical college and hospital with the possible diagnosis of appendicitis, 100 pediatric patients were included.

Inclusion criteria: Patients between the age of 2 to 15 years, presenting with abdominal pain, pain in the right iliac fossa (RIF) or right lower quadrant and being in a stable hemodynamic condition.

Exclusion criteria: Patients with chronic infectious diseases like ileocecal tuberculosis were not included in this study.
Patients with characinoid tumors and other neo-plastic lesions of the appendix were not included in the study.

Ultrasonographic evaluation

All the pediatric patients were first clinically evaluated by a surgeon. Those with suspected appendicitis were then referred to the radiology department to undergo ultrasonographic evaluation, which was done by GE VOLUSON E8 AND LOGIQ P9, using a linear high frequency probe (3–11 mHz), and a convex low frequency probe (1–5 mHz). These patients were evaluated for right lower quadrant pain, and also underwent further ultrasonographic evaluation for existence of complications of appendicitis, such as abscess formation, free fluid in the abdomen, hyper-echoic line under the mucosa, increased echogenicity of fatty tissue surrounding the appendix and serosal irregularity to look for area of perforation or impending perforation. The accuracy of USG in diagnosing appendicitis was then compared with clinical diagnosis, laparotomy findings and resulting histopathological examination (HPE).

Statistical analysis

Wherever applicable, descriptive statistical analysis was done.

Result

In the present study, a total of 100 subjects were included out of which 65 (65%) were males and 35 (35%) were females (table-1).

Table 1: Distribution of gender

Gender	No. of patients	Percentage %
Male	65	65
Female	35	35
Total	100	100

Table 2: Distribution of different age groups of patients

Age	No. of patients	Percentage %
2-5 years	2	2
6-10 years	47	47
11-15 years	51	51
Total	100	100

In our study, most of the subjects were 11-15 years i.e., 51 out of 100 (51%), followed by 6-10 years, i.e., 47 out of 100 (47%).

Table 3: USG diagnosis of right iliac fossa (RIF) pain

Symptoms	No. of cases	Percentage %
Acute Appendicitis	59	59
Right Ureteic Colic	10	10
Pelvic inflammatory Disease	7	7
Ovarian Cyst	1	1
Appendicular Mass	2	2
Intestinal Ascariasis	1	1
Inconclusive	20	20
Total	100	100

In table 3, above observation shows that all the cases presented with pain in the right iliac fossa and clinical suspicion of acute appendicitis which were the selection criteria for the present study. Acute appendicitis symptoms were (59%), right ureteric colic (10%), pelvic inflammatory disease (7%), ovarian cyst (1%) and intestinal ascariasis (1%). 20% of cases were inconclusive.

Table 4: Clinical Symptoms

Symptoms	No. of cases	Percentage %
Pain Abdomen	100	100
Vomiting	76	76
Fever	18	18
Dysuria	5	5
Diarrhoea	1	1

In table 4, irrespective of the pathology, vomiting was found to be present in 76% of the cases. Murphy's triad of symptoms i.e. pain in abdomen, vomiting and fever held well in the diagnosis of acute appendicitis in our study.

Table 5: Clinical Signs

Signs	No. of cases	Percentage %
RIF tenderness	100	100
Rebound tenderness	93	93
Neutrophilia	65	65
Leucocytosis	51	51
Rovsing sign	45	45
Guarding	12	12
Urine Microscopy – Pus cells and RBCs	6	6

In table 5, Tenderness in right iliac fossa was the most common sign elicited in all the cases (100%).

Table 6: Correlation of USG Diagnosis with histopathological examination (HPE)

Total No. of cases	No. of cases
USG Positive	65
USG Negative	35
HPE positive	57
HPE negative	3
USG negative cases operated	6
HPE positive	3
HPE negative	3
Result	
Total cases of USG	120
USG Positive	60
HPE positive	57
True positive	57
True negative	37
False positive	3
False negative	3

In table 6, Out of the 65 operated cases, 57 were HPE positive and 3 were found to be negative on HPE. The sonologically negative cases were managed conservatively. In the conservative group of 35 cases, appendectomy was done for 6 cases due to the persistence of symptoms and due to the surgeon's suspicion. Out of these 6 operated cases, 3 were reported to be acute appendicitis on HPE and 3 cases of appendicle masses were treated conservatively and were subjected to interval appendectomy after a 3-month duration.

Table 7: Evaluation of USG

Evaluation of USG	Values (%)
Sensitivity	83.6%
Specificity	80.6%
Positive predictive Value	85.2%
Negative predictive value	82.4%
Diagnostic accuracy	84.6%
False positive error rate	6.1%
False negative error rate	3.9%
Likelihood ratio positive	9.7%
Likelihood ratio negative	0.04%

In table 7, the overall specificity (80.6%) and sensitivity (85.2%) of USG in diagnosis of appendicular pathology were high, indicating accurate diagnosis by USG in almost all pediatric patients with pain in RIF.

Discussion

Although appendicitis is common at all ages, it is one of the most common causes of acute abdominal pain in children and adolescents. [9] Various factors such as age, sex, race, geographical location, diet, and appendix position can affect appendicitis-related mortality. [10] The most important symptoms of appendicitis are abdominal pain, nausea, vomiting, and fever. Pain is the most common symptom and occurs in 50 to 100% of cases. Nausea and vomiting are usually followed by pain. [11]

The pain is usually somatic and is felt around the umbilical region. In abdominal examination, in addition to tenderness and guarding, rebound tenderness is of great importance in diagnosis. [12]

Proper and early diagnosis of appendicitis is important to reduce the complications of perforation. However, negative appendectomy often results in surgical and anesthetic complications such as positive appendectomy. Therefore, many methods have been suggested to improve diagnostic accuracy in suspicious cases, such as laboratory tests, ultrasound, CT, and laparoscopy. Among imaging modalities, ultrasound is a non-invasive, safe, inexpensive, and affordable method [13], more so, theoretically, Ultrasound has a higher diagnostic value, especially in children, because of their lower body thickness and less fat than adults. [14]

Sonographic findings in the diagnosis of acute appendicitis are divided into three groups: negative, positive, and suspicious. By evaluating secondary signs of acute appendicitis in the absence of normal or inflamed appendicitis, it is possible to divide the suspicious group into positive and negative groups in terms of the probability of acute appendicitis. [15]

In this regard, the use of ultrasound with a specially designed protocol for the diagnosis of acute and complicated appendicitis in children is necessary to increase the diagnostic accuracy. As mentioned previously, ultrasound as a diagnostic modality in acute appendicitis depends on the operator and protocol, and because of this, it is necessary to determine sensitivity and specificity in each center. [16]

Jones MW et al., [17] investigated the accuracy of sonography in the diagnosis of acute appendicitis in children. In this study, 317 children were referred to a tertiary pediatric hospital with acute abdominal pain. The results of this study showed that the positive predictive value of ultrasound was 92% and negative predictive value was 88%. Sensitivity and specificity were not calculated because there were 43 patients with equivocal ultra sound results. [18] The results of our study are consistent with this study, with the difference that our study had a higher predictive value. The result could be because of the imaging protocol used in our study, where suspicious patients were further evaluated for signs of appendicitis.

In a retrospective study by Ross et al. on 968 children, the efficacy of ultrasonography in determining acute appendicitis in patients with non-visible appendix was studied. In 526 cases, the appendix was not found in sonography, of which 15.6% had a positive pathology for acute appendicitis. The sensitivity and specificity of ultrasound in the group where the appendix was fully visible were reported 99.5% and 81.3%, respectively. The study eventually found that children with no reassuring clinical examinations following incompletely visualized appendices on US may benefit from further imaging modalities, to reduce the rate of negative appendectomy. [19]

We also noticed an increase insensitivity and specificity following secondary evaluation. We utilized ultrasonographic evaluation, but CT scan can also be utilized, as mentioned previously. Interestingly Reddan et al claimed that up to 46% of ultrasound studies do not visualize the appendix and getting help with secondary signs in ultrasound can help make diagnosis more accurate. [20]

Secondary evaluation could also assist in the early diagnosis of appendix perforation and secondary complications, such as abscess formation. Giljaca et al. [21] concluded that ultrasonography could be effective in the diagnosis of perforated appendicitis and the best predictor for perforation was the absence of the echogenic sub-mucosal layer and presence of loculated fluid collection in the pelvis. [22]

In the present study, fluid collection and sub-mucosal disruption were the most common findings of US in patients with perforated appendicitis. Importantly, in our study, perforation rate in the second group was 32.6%, and in the third group with secondary signs was 62.5%. This may indicate that perforation of the appendix is probably one of the causes of non-visualized appendix in sonography. It could also indicate that non-visualized appendix may be under diagnosed, leading to perforation.

Regarding negative appendectomy, a study by Bossuyt PM et al [23] showed that 79.5% of appendectomies had some degree of inflammation in the pathology report. Also, the rate of negative appendectomy was 20.5%. [24]

However, in the present study, the rate of negative appendectomy was 1.7%, which may be due to differences in the criteria for selection of patients, as

well as the main purpose of the study and how to evaluate patients.

In a study by Kaewlai R et al., [25] of the 75 children who underwent appendectomy, 5% had a negative appendectomy. This difference in comparison with the present study may be due to a pathologist error or a reduction in the rate of negative appendectomy based on this protocol. [26]

Conclusion

In conclusion, it is necessary to reduce the complications of appendicitis perforation and minimize the number of negative appendectomies. This can be done by getting a detailed history, a thorough examination as well as diagnostic aids such as ultrasound. Based on the present study, ultrasound with the above mentioned protocol is an appropriate diagnostic method in the evaluation of appendicitis in children. In cases of non-visualized appendices, acute appendicitis can be ruled out with high confidence in the absence of secondary signs.

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