On the Role of Ultrasonography and CT Scan in the Diagnosis of Acute Appendicitis

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Abstract The purposes of this study were to revisit the utility of ultrasonography (USG) as a primary imaging modality in acute appendicitis (AA) and to establish the role of CT scan as a second-line/problem-solving modality. All cases of suspected AA were referred for urgent USG. USG was done with standard protocol for appendicitis. Limited

computed tomographic (CT) scan [NCCT ± CECT (IV contrast only)] was done for the lower abdomen and pelvis where sonographic findings were equivocal. One hundred and twenty-one patients were referred for USG for suspected appendicitis. Eight-four patients underwent surgery for AA based on clinical as well as imaging findings, of whom 76 had appendicitis confirmed at histopathology. Three patients were misdiagnosed (3.6 %) on USG as appendicitis. Of 76 patients of appendicitis confirmed histopathologically, 63 (82.8 %) had features of appendicitis on USG and did not require any additional imaging modality. Of 121 patients, 12 (10 %) needed CT scan because of atypical features on USG. Of these 12 patients, seven had retrocecal appendicitis, and three high-up paracolic appendicitis. USG alone had sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of 81, 88, 92.6, 71.6, and 83 %, respectively. When combined with CT scan in select cases, the sensitivity, specificity, PPV, NPV, and accuracy of combined USG + CT scan were 96 % ($P=0.0014$), 89 %, 93 %, 93.5 % ($P=0.0001$), and 93 % ($P=0.0484$), respectively. Twenty-eight (23 %) patients were given alternative diagnosis on USG. Dedicated appendiceal USG should be used as a primary imaging modality in diagnosing or excluding AA. Appendiceal CT can serve as a problem-solving modality.

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Introduction

Acute appendicitis (AA) is the most common cause for acute abdomen requiring urgent surgical intervention. Despite being a common clinical problem and the recent advances in the diagnostic imaging including high-resolution ultrasonography (USG), computed tomographic (CT) scan, and magnetic

resonance imaging (MRI), diagnosis of AA is not always easy and can be challenging even for the best of clinicians. Misdiagnosis is maximal in women of childbearing age because of frequent overlap with gynecological conditions that may mimic AA clinically. Traditionally, surgeons have accepted a negative appendectomy rate of 20 %, and until recently, the figure has not decreased significantly despite using preoperative diagnostic tests [1]. Laboratory investigations such as total leukocyte count, differential leukocyte count, C-reactive protein (CRP), etc., though sensitive, lack sufficient specificity. USG with graded compression as popularized by Puylaert [2] has long been considered as a very useful modality for diagnosing AA. Although the accuracy of USG for diagnosing appendicitis is considered the same as that of CT scan when done by an experienced radiologist [3], of late, CT scan has been found to be more accurate than USG for this purpose and is being widely advocated and used. The utility of USG vis-à-vis CT scan in diagnosing AA is being increasingly questioned [4–6]. At the same time, there are studies that claim that clinical examination is superior to US/CT examination even today [7, 8]. In the absence of a clear-cut and well-established guideline for the workup of suspected AA, today's clinician is bound to face a dilemma of choosing the most appropriate investigative protocol for successful management of AA. It is in this backdrop that we share our experience of imaging (USG and CT scan) in suspected cases of AA treated in a tertiary care Armed Forces Hospital of India.

Objective

This study aims to revisit and evaluate the accuracy of USG as a primary imaging modality in AA and to establish the role of CT scan as a second-line/problem-solving modality.

Materials and Methods

Settings This study was conducted in a 700-bed tertiary care Armed Forces Hospital of India.

Study Design and Period This was a 2-year prospective study extending from Aug 2009 to July 2011.

Study Population Clinically and/or radiologically suspected AA patients treated in this hospital formed the study group. The study population consisted of armed forces serving personnel and their dependants hailing from various states of India.

Study Protocol As a part of institutional protocol, all clinically suspected cases of AA presenting at the general/

surgical OPD or at the emergency department were immediately admitted in the hospital. An immediate surgical consultation was done in all cases. All cases of suspected AA were referred for urgent USG, mostly by the surgical specialist during or off working hours. The only patients who reported late at night and where immediate surgery was not contemplated underwent USG studies in the first working hour of the morning of the next day. Two radiologists (JD, AM) having 12 (JD) and 7 (AM) years of experience of doing USG carried out the USG studies of all the patients. The patients who were given alternative diagnosis on USG/CT scan were followed up for 6 months for any evidence of recurrence of sign/symptoms suggestive of appendicitis. The gold standard for diagnosis was histopathological examination (HPE) for those operated upon and follow-up for 6 months for those who were given alternative diagnosis. Requirement for informed consent was waived off by the hospital ethics committee.

Study Technique USG was done with standard protocol for appendicitis, including graded compression using a high-frequency (7–10 MHz) linear probe (LOGIQ P5, Wipro GE). Appendicitis was diagnosed by demonstrating a non-compressible appendix having an outer diameter of 07 mm or more. Secondary signs of appendicitis such as localized ileus, periappendiceal fluid, free fluid in the pelvis, echogenic mesenteric/omental fat, and localized lymphadenopathy were also noted. Limited CT scan [NCCT ± CECT (IV contrast only); Sensation 40, Siemens, Germany] was done for the lower abdomen and pelvis where sonographic findings were equivocal or technically suboptimal. Patients whose appendix was not convincingly demonstrated on USG but who showed secondary signs of appendicitis also underwent limited CT scan. The need for surgery in such cases was decided by the treating surgeon on a case-to-case basis. The decision for further imaging with CT scan was always taken by the attending radiologist, taking into consideration USG findings and the overall clinical merit of the case. Statistical analysis was done using chi square test for 2×2 table. A *P* value less than 0.05 was considered statistically significant.

Results

During the study period, nine patients of suspected AA were operated upon who did not undergo USG at our institution, either because they already got USG from outside or because of non-availability of a radiologist at that time or the treating surgeon decided to operate immediately without USG. All these cases were not included in our study. A total of 121 patients were referred for USG with a clinical suspicion of appendicitis. Eighty-four patients underwent surgery for AA

Fig. 1 Thirty-one-year-old man. Longitudinal section of an inflamed appendix demonstrating classic features. Note the enlarged appendix (diameter, 9.2 mm) with periappendiceal inflammatory changes

based on clinical as well as imaging findings (Fig. 1), of whom 76 had appendicitis confirmed at histopathology. Three cases were misdiagnosed (3.6 %) on USG as appendicitis; each had Meckel's diverticulitis, endometriosis with salpingitis, and unruptured tubal ectopic pregnancy (Fig. 2). Two patients, who were reported abnormal on USG, were found to be normal histopathologically. One patient, who got operated upon based on positive clinical findings but negative USG findings for appendicitis, was found to have endometriosis. Two patients, reported normal on USG (one of them a pregnant patient) but operated upon on clinical suspicion, did not reveal any obvious inflammatory pathology per-operative and were reported normal on histopathology. Of 76 patients of appendicitis confirmed histopathologically, 63 (82.8 %) had features of appendicitis on USG and did not require any additional imaging modality. Three patients who were

Fig. 2 Unruptured tubal ectopic pregnancy in a 19-year-old woman was mistaken sonologically as acute appendicitis

reported normal on USG but were operated upon based on clinical suspicion were found to have catarrhal appendicitis. Of these three patients, two were pregnant and one was a child. One patient was diagnosed to have AA on USG, but clinical signs were not very convincing. He was put on conservative treatment. However, he had recurrence of appendicitis after 4 months and was operated upon on the second time with confirmation of the diagnosis. Of 121 patients, 12 (10 %) needed CT scan as an additional tool because of atypical features on USG. Of these 12 cases, seven had retrocecal appendicitis, three high-up paracolic appendicitis (Fig. 3), and one each of typhlitis and diverticulitis confirmed on CT scan. By using CT scan as a second-line imaging modality in those 12 cases, a total of 73 out of 76 (96 %) cases of proven AA could be diagnosed preoperatively. Appendicular lump and appendicular perforation with peritonitis was diagnosed in five and four cases, respectively. USG findings were normal in 13 cases, including three false-negative and three true-negative cases (on HPE). Twenty-eight (23 %) patients were given alternative diagnoses on USG and included mesenteric adenitis (6) and urologic (8), gynecologic (13), and GIT (perforation) causes (1). Most importantly, no fresh appendiceal perforation occurred after hospitalization. USG alone had sensitivity, specificity, PPV, NPV, and accuracy of 81, 88, 92.6, 71.6, and 83 %, respectively. When combined with CT scan in selected cases, the sensitivity, specificity, PPV, NPV, and accuracy of USG + CT scan were 96 % ($P=0.0014$), 89 %, 93 %, 93.5 % ($P=0.0001$), and 93 % ($P=0.0484$), respectively.

Discussion

AA is a common clinical problem. However, despite advances in the field of clinical and imaging sciences, misdiagnosis is not uncommon even today. Successful management of AA depends on prompt and accurate diagnosis followed by early surgery. Although AA has been traditionally considered essentially a clinical diagnosis, a clinician will always face the dilemma of balancing between negative appendectomy and perforation rates if decision is made solely on the basis of clinical findings. This is primarily due to significant overlap of signs and symptoms with various conditions that mimic appendicitis clinically.

High-resolution USG with graded compression has long been considered an important tool in the diagnosis of AA. With the advent of spiral CT and later multi-detector CT, there has been a paradigm shift in the choice of imaging modality for diagnosis of AA. Worldwide, CT scans are being increasingly performed as the primary imaging modality over USG in suspected patients of AA, especially for adults apparently for the sake of higher accuracy but with a relative disregard for the associated radiation burden.

Fig. 3 A 53-year-old woman complained of persistent pain in RIF. USG was equivocal. CT scan was done as a problem-solving tool. Contrast-enhanced CT [axial (a) and coronal (b) plane images] clearly depicts changes of acute appendicitis. Note the relatively high-placed, paracolic position of the appendix. CT scan findings were confirmed at surgery

Literature is abundant with publications documenting higher accuracy of CT scan as compared to USG for diagnosing AA [4, 6, 9]. Clinical policy (2010) from the American College of Emergency Physicians on the evaluation and management of emergency department patients with suspected appendicitis discusses various aspects of CT scan; however, it does not even mention the role of USG in the diagnosis of appendicitis in adults although it does mention about the possible role of both CT and USG in pediatric cases [9]. As far as utility of USG in the diagnosis of AA is concerned, the situation is not completely gloomy either. Till today, there are reports of utility of USG for the diagnosis of AA particularly in pediatric cases [10–13].

We understand that there are at least five different schools of thought as far as the diagnostic algorithm of AA is concerned. First, possibly, majority believe that CT scan should be the primary imaging modality for an accurate and early diagnosis of AA as has been highlighted earlier. Well, the reason for doing CT scan need not always be a scientific one. It could also be because of non-availability of the on-call radiologist/radiology resident in the off working hours [14]. Second, another group believes that USG done by an experienced radiologist is comparable to CT scan. Even we, at our institution, subscribe to this idea. As an institutional protocol, we always perform USG as the primary imaging modality. Whether a patient of suspected AA should undergo CT scan or not is decided by the attending radiologist based on the USG findings and overall merit of the case. Many institutions follow this principle of USG first followed by CT scan if indicated especially in pediatric cases [15, 16]. Third, another school of thought is that WBC count and serum biomarkers such as CRP help in the diagnosis of AA [17, 18]. A single serum biomarker at different time points has been postulated to be equally efficacious as Alvarado score and CT scan and may even be better than USG in predicting pediatric AA [17]. Fourth, another school of thought is that clinical judgment is superior to all laboratory and imaging investigations in the diagnosis of AA [7, 8]. Last but not the least, the fifth school of thought believes in doing diagnostic laparoscopy in

doubtful cases and proceeding with appendectomy if the appendix is found inflamed on laparoscopy.

The today's clinician is at a crossroad and possibly wonders which pathway to follow for timely and successful management of a case of suspected AA. There is no universally accepted guideline in this regard. We are of the opinion, as is also believed earlier, that clinical judgment is of paramount importance in the diagnosis and management of AA, and there can be no substitute to a meticulous clinical examination. By adopting evidence-based clinical protocol, needless investigations (and at times potentially harmful, e.g., CT scan) can be certainly reduced to a minimum without affecting the quality of patient care [19].

Today, there is no debate about the speed and accuracy of CT scan over USG for the diagnosis of AA. However, does this mean that USG has lost its relevance and all patients of suspected AA be subjected to CT scan as the primary modality despite its associated radiation burden? In our opinion, we must exploit the full potential of USG before considering CT scan as another option. If Wiersma et al. [20] could demonstrate a normal appendix in children in 82 % of cases, why can we not identify a pathological appendix? What is really needed today is a dedicated appendiceal USG by an experienced radiologist for suspected cases of AA. CT scan may be best reserved as a second-line or more appropriately problem-solving modality as is being used at our institution. We maintain the policy of “USG first and CT next, if required,” and this has really helped us avoid a large number of potential CT scans. There is a definite role of observation in the ward in case of doubt in the diagnosis. We also follow the principle of active observation in the ward in case the clinical–radiological picture is not clear. As pointed out in the “Results” section, the fact that not a single perforation did take place after hospitalization speaks a lot about the success of our institutional protocol. With this protocol at our institution, only 10 % of cases of suspected AA required CT scan as an additional tool to confirm/exclude the diagnosis as has been brought out in this study. We noted an important fact that we missed nearly all cases of retrocecal and high-up paracolic

appendicitis on USG, and all those cases were picked up correctly on CT scan. Hence, CT scan may be a good option for suspected retrocecal and high-up paracolic appendicitis. As has been brought out in our study, sensitivity, NPV, and overall accuracy of combined USG + CT (in select cases) are significantly more as compared to the USG alone ($P=0.0014$, 0.0001 , and 0.0484 , respectively). However, there was no significant difference between the two protocols in terms of specificity and PPV. The difference between the two protocols in terms of sensitivity and NPV is mainly because of the superiority of CT scan for the diagnosis of retrocecal and high-up paracolic appendicitis as brought out earlier. Another important aspect of the study is the demonstration of a significant number of alternative diagnoses, which itself is also equally important as the diagnosis of AA. This particular role of USG is often forgotten. Of late, even MRI is being considered as a possible alternative to CT scan for the diagnosis of AA [21].

Although USG is known to be highly dependent on the sonologist's skill, CT is not completely operator independent. There are a number of interpretive pitfalls in the CT diagnosis of appendicitis [22, 23]. What are not often discussed are the advantages of USG. Besides the fact that USG has no ionizing radiation and hence can be repeated without any ill effects, which is very important particularly in children and young women, it also provides several clinically relevant and important information that a surgeon would like to know—for example, status of inflamed appendix, location and orientation of appendix, presence or absence of any associated complications, adhesions, free fluid, and so on, besides suggesting alternative diagnoses. All these inputs help tremendously in treatment planning. However, it is important to understand the limitations of USG in providing alternative diagnosis particularly in women of the childbearing age group where misdiagnosis is not uncommon as it happened in some of our cases.

An important limitation of our study is the small sample size particularly for those who underwent CT scan. This limits us to comment much on the utility of CT scan. Another limitation of our study is possibly an inherent bias/preference for USG over CT scan.

Conclusion

In the era of ever-increasing usage of CT scan as a primary imaging modality for diagnosing AA, we still find dedicated appendiceal USG very useful in diagnosing or excluding AA, and hence, USG should be used as the primary and frontline imaging modality for diagnosing AA. Appendiceal CT would be best used as a second-line/problem-solving modality in view of its radiation burden.

Conflict of Interest None

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