Diagnostic Accuracy of Gray Scale Ultrasonography versus Color Doppler in Suspected Cases of Acute Appendicitis

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Significance:
A common surgical emergency is acute appendicitis. Various diagnostic tools are available to diagnosis acute appendicitis. Radiological investigations play an important role in making accurate and early diagnosis and thus preventing morbidity associated with the disease.

Abstract

Background: A common surgical emergency is acute appendicitis. Various diagnostic tools are available to diagnosis acute appendicitis. Radiological investigations play an important role in making accurate and early diagnosis and thus preventing morbidity associated with the disease. To determine the diagnostic accuracy of gray scale ultrasonography versus color Doppler in suspected cases of acute appendicitis.

Materials and Methods: The study was carried in the department of Radiology of Mayo Hospital, Lahore. A total of 75 patients were enrolled of age 18-40 years, both genders who were suspected cases of acute appendicitis. All patients underwent baseline investigations along with gray scale ultrasonography and color Doppler. All patients were subjected to surgery to confirm the diagnosis and findings were subjected to statistical analysis.

Results: The mean age of the patients was 23.25 ±10.55 and mean transverse diameter of appendix was 8.37 ±3.39. There were 62.7% males and 37.3%females. Findings of gray scale ultrasonography and color Doppler were then correlated with surgical findings to calculate the diagnostic accuracy of these modalities. The results revealed that gray scale ultrasonography sensitivity, specificity, positive predictive value, negative predictive value and accuracy was 92.7%, 94.32%, 95%, 91.4% and 93.3% respectively, whereas color Doppler had sensitivity, specificity, positive predictive value, negative predictive value and accuracy of 97.7%, 93.9%, 95.3%, 97% and 96% respectively. Diagnostic accuracy of both modalities together was 98.6%.

Conclusion: Color Doppler has better diagnostic accuracy than gray scale ultrasonography for diagnosis of acute appendicitis and the combination of both modalities yields diagnostic accuracy that is similar to gold standard.

Introduction

Among surgical problems that are of acute nature, the commonest one is acute appendicitis (1). Despite the fact that a lot of advancements have been made in the modalities that can be used for diagnosis, yet it poses great clinical challenge to the surgeons while deciding clinically about its presence in around 30-40% cases (1). This uncertainty in diagnosis leads to negative appendectomy in 15-30% cases and raises the chances of morbidity and mortality (2). It is still not possible to make the diagnosis of acute appendicitis accurately owing to different atypical presentations clinically, which are frequently encountered as multiple inflammatory as well as non-inflammatory conditions mimic the scenario of this pathology clinically (3). Common mistakes in diagnosing such patients are made in females who are of reproductive age and in patients who are at extremes of ages (4).

Severe outcomes can be anticipated in scenarios where the diagnosis of acute appendicitis is missed, these included perforation of appendix, peritonitis, and abscess formation leading to increased rate of mortality by up to 10% (5). There are 12% chances of missing an acute appendicitis (6).

Despite the fact that a lot of improvements have been made in establishing diagnosis and making decision regarding treatment of acute appendicitis with the help of clinical and laboratory techniques as well as by utilizing different scoring methods, still the decision to operate a patient for acute appendicitis still puzzles the surgeons a lot (7).

Imaging plays an important part making diagnosis of acute appendicitis as well as complications arising from it and also helps in providing alternate diagnosis where necessary (8). The main radiological modality used for establishing diagnosis of acute appendicitis is ultrasonography. Graded compression ultrasonography (USG) is an inexpensive, fast and noninvasive method with an accuracy rate of 71%–90% for the diagnosis of acute appendicitis (9). Still few cases are missed due to various reasons like obesity, severe guarding and excessive bowel gases (10). Moreover, lack of proper infrastructure (poor quality ultrasound machine) and sufficient time to patient care can lead to less detection of appendicitis by ultrasound (11).

Another imaging modality that has gained attention in recent years is the Color Doppler which can detect

appendiceal wall hyperemia, thus helping in differentiating an enlarged appendix from acute appendicitis and gangrenous appendicitis. It has been shown to have a higher diagnostic accuracy compared to conventional gray scale ultrasound. In a study by Joseph, H.T. et al, it was found that the diagnostic accuracy of color Doppler was 97.08% compared to ultrasound that was 95.09% in detecting acute appendicitis (12).

A lot of international research has been carried out on the diagnostic accuracy of ultrasonography and Color Doppler. However, no such study has been carried out in Pakistan. So the purpose of current study was to assess the diagnostic accuracy of graded compression ultrasonography and color Doppler in suspected patients of acute appendicitis keeping surgical notes (operative findings) as gold standard. This study will help in yielding more accurate diagnosis and thereby benefiting the affected patients as well as reducing workload of hospitals by reducing the number of negative appendectomies, and to recommend imaging modality that can be used as first-line for diagnosing acute appendicitis. Accurate early diagnosis of appendicitis can decrease its complications and minimize the mortality, morbidity and costs.

Materials and Methods

Participants: The study was carried out in the Radiology Department of Mayo Hospital, Lahore from 1stJanuary 2020 till 30th September, 2020. A total of 75patients, aged 18 to 40 years of both genders were included in the study who were diagnosed as having suspected acute appendicitis were included i.e. who presented with right lower abdominal pain along with any one or more of these symptoms i.e. nausea/vomiting, decreased appetite, guarding and tenderness of the right iliac fossa. Patients who were non-cooperative, pregnant females, or patients who presented with adnexal mass or a history of renal stones were excluded from the study.

Study Design: It was a cross sectional comparative study. After taking informed consent and approval from the ethical review board of the hospital, all eligible participants were enquired about their symptoms and were examined thoroughly. Baseline investigations such as CBC, serum electrolytes, RFTs, LFTs, CRP was carried out. Findings were noted down on a predesigned performa. IV line was secured in all patients. Patients were then subjected to gray scale ultrasonography followed by Color Doppler to look for acute appendicitis and findings of both modalities were noted down. On gray scale ultrasonography, appendicitis was labeled if the transverse diameter was >6mm of an incompressible, tubular structure which was filled with fluid and was blind ended. Those with a diameter between 4-6mm were labeled as suspected acute appendicitis. On color Doppler, if the surrounding walls of appendix were hyperemic, it was labeled as appendicitis.

After radiological evaluation, all patients were evaluated for anesthesia fitness that was carried out by the anesthesia team and was followed by surgical intervention for suspected acute appendicitis. Findings of the surgical intervention were noted down and were compared with those of ultrasonography and color Doppler and were subjected to statistical analysis.

Statistical Analysis: The data was analyzed through SPSS version 24.0. Quantitative measures such as age, transverse diameter were presented as mean and standard deviation. Qualitative variables such as gender, presenting symptoms (nausea, vomiting, rebound tenderness, anorexia, fever), visualization of appendix, transverse diameter, compressibility, abnormal appendiceal wall signature, appendicolith, echogenic surrounding mesentery, free fluid presence, mesenteric lymph nodes involvement, hyperemia and its type, ultrasound findings, color Doppler findings and findings of surgical intervention were presented as frequency and percentages. 2*2 table was made to determine the diagnostic accuracy of gray scale ultrasonography and color Doppler in diagnosing acute appendicitis keeping surgical intervention findings as gold standard. Sensitivity, specificity, positive predictive value and negative predictive value were calculated.

Results:

75 patients were enrolled in the study. The mean age of the patients was 23.25 years with a standard deviation of 10.55 and the mean transverse diameter of appendix on ultrasonography was 8.37 with a standard deviation of 3.39 (table 1). There were 47 (62.7%) males and 28 (37.3%) females. Among males, 36% had appendicitis and in females 21.3% had appendicitis.21.3% patients were of lower class, 34.7% belonged to lower middle class and 44% were of middle class. The frequency of presenting symptoms and other qualitative variables is mentioned in table 2.

Findings of gray scale ultrasonography and color Doppler were then correlated with surgical findings to calculate the diagnostic accuracy of these modalities. The results revealed that gray scale ultrasonography had a sensitivity of 92.7%, specificity of 94.32%, positive predictive value of 95%, negative predictive value of 91.4% and accuracy of 93.3%, whereas color Doppler had a sensitivity 97.7%, specificity94%, positive predictive value 95.3%, negative predictive value 97% and accuracy of 96%. The results also revealed that the sensitivity, specificity, positive predictive value, negative predictive value and accuracy of gray scale

ultrasonography combined with color Doppler was 97.7%, 96.9%, 98%, 97% and 98.6% respectively.

Table 1: Showing Mean and Standard Deviation of Quantitative Variables

QUANTITATIVE VARIABLES	N=75, MEAN±SD
Age	23.25±10.55
Transverse diameter of Appendix	8.37±3.39

Table 2: Showing Frequency and Percentages of Qualitative Variables

QUALITATIVE VARIABLES	N=75 (100%)
GENDER:	
Male	47 (62.7%)
Female	28 (37.3%)
SOCIOECONOMIC STATUS:	
Lower Class	16 (21.3%)
Lower Middle Class	26 (34.7%)
Middle Class	33 (44%)
PRESENTING COMPLAINTS:	
Nausea	69 (92%)
Vomiting	69 (92%)
Rebound Tenderness	58 (77.3%)
Anorexia	45 (60%)
Fever	74 (98.7%)
GRAY SCALE ULTRASONOGRAPHIC FINDINGS:	
Visualization Of Appendix	74 (98.7%)
Transverse Diameter >6mm	37 (49.3%)
Non-compressible Appendix	37 (49.3%)
Abnormal Appendicular Wall Signature	40 (53.3%)
Appendicolith	4 (5.3%)
Free Fluid	11 (14.7%)
Mesenteric Lymph Nodes	10 (13.3%)
Probe Tenderness	29 (38.7%)
COLOR DOPPLER FINDINGS:	
Hyperemia	41 (54.7%)
Type of hyperemia:	
Curvilinear/diffuse	34 (45.3%)
punctate	9 (9.4%)
APPENDICITIS DIAGNOSIS:	
On Gray Scale Ultrasound	37 (49.3%)
Color Doppler	43 (57.3%)

Discussion

A major bulk of emergencies related to abdominal surgeries are formed by cases of acute appendicitis (1). Despite higher prevalence, acute appendicitis always puts the judgment made by surgeon on clinical grounds to an actual test at an early stage different modalities are used for making early diagnosis of this condition (2). The most effective methods of diagnosing are total leucocyte count, C-reactive protein, ultrasound and CT abdomen (4). However, none has proven to be perfect and all these modalities have certain pros and cons. Suggestions have been given that utilizing different diagnostic tools in combination can help in getting better results diagnostically (7).

The current study revealed that color Doppler has a higher sensitivity and diagnostic accuracy compared to gray scale ultrasonography when used alone for the diagnosis of acute appendicitis. However, when both of these imaging modalities were combined, the overall sensitivity, specificity, PPV, NPV and diagnostic accuracy was increased more that was almost like the gold standard. Transverse diameter > 6mm and non-compressible appendix were significant findings associated with acute appendicitis on gray scale ultrasonography and hyperemia was significantly correlated with acute appendicitis on color Doppler.

In view of diagnostic accuracy, a study was conducted by Gaitini, D. et al in 2018 (25), who conducted a study to evaluate the diagnostic accuracy of color Doppler and contrast enhanced CT scan for diagnosing acute appendicitis. The results revealed that color Doppler Sonography and CT correctly diagnosed acute appendicitis in 66 of 75 patients and in 38 of 39 patients, respectively, and correctly denied acute appendicitis in 312 of 326 and in 92 of 92 patients. Sonography was inconclusive in 17 of 418 cases and CT, in one of 132 cases. Sonography and CT allowed alternative diagnoses in 82 and 42 patients, respectively. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for color Doppler sonography were 74.2%, 97%, 88%, 93%, and 92%, respectively, and for CT, 100%, 98.9%, 97.4%, 100%, and 99% (25). The authors concluded that color Doppler ultrasonography had a good diagnostic yield for diagnosing acute appendicitis. Transverse diameter of appendix of >6 mm and non-compressibility was significantly associated with positive diagnosis (25). Similar results have been shown by current study with diagnostic accuracy of gray scale ultrasonography as 93.3%. Current study also revealed that transverse diameter >6mm and non-compressibility were associated significantly with the diagnosis of acute appendicitis on gray scale ultrasonography.

In another study by Joseph, H.T., 2020, 102 patients with acute appendicitis were evaluated by ultrasound and color Doppler, keeping histo-pathological findings as gold standard. The sensitivity was high of color

Doppler than that of ultrasound, where as they were equal in terms of specificity. Color Doppler had an accuracy of 97.08% and ultrasound had an accuracy of 95.09% (12). Similar results were shown by current study. The current study also revealed that color Doppler had superior sensitivity and accuracy than ultrasound, however, specificity of both was equal.

Thus, addition of color Doppler to routine ultrasound can enhance the diagnostic yield in acute appendicitis. Our study had certain limitations. Firstly, it was conducted in a single center so the results cannot be generalized. Secondly, the sample size was sample, so the results cannot be taken as representation of whole population. Thirdly, there was selection bias, as color Doppler could only be used when appendix was visualized by gray scale ultrasound. Lastly, healthy individuals were not assessed, as only those who were suspected to have acute appendicitis were enrolled.

Conclusion

The study concluded that color Doppler have a better overall sensitivity and diagnostic accuracy compared to gray scale ultrasound alone. However, when both were combined the diagnostic yield was near accurate to the findings of gold standard and thus can help in identification of complicated cases of acute appendicitis by providing early, accurate diagnosis and enabling in making better decisions about further management of such cases.

Conflict of interest: Authors do not have any conflict of interest to declare.

Disclosure: None

Human/Animal Rights: No human or animal rights are violated during this study.

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