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Original Research Article

ROLE OF ULTRASOUND AS THE PRIMARY IMAGING MODALITY AND COMPUTED TOMOGRAPHY IN SUSPECTED ACUTE APPENDICITIS: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Acute appendicitis is a common surgical emergency in which delayed diagnosis increases the risk of perforation and sepsis, whereas inaccurate diagnosis may lead to negative appendicectomy. Imaging plays an important role when clinical findings are atypical. This study assessed the diagnostic performance of ultrasonography (USG) as the primary imaging modality and the additional value of computed tomography (CT) in selected patients with suspected acute appendicitis.

Materials and Methods: This retrospective record-based study included 60 patients who underwent appendicectomy for suspected acute appendicitis over a 2-year period. Data were obtained from hospital electronic records, radiology archives, operative notes, and histopathology reports. USG was performed in all patients as the initial imaging test and categorized as positive, equivocal/non-diagnostic, or negative. CT was performed only in patients in whom USG was equivocal or in whom there was a persistent clinical suspicion despite negative USG. Final diagnosis was confirmed by operative findings and/or histopathology. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated.

Results: Of the 60 patients, 34 (56.7%) were males and most patients were aged 11-30 years (56.7%). Appendicitis was confirmed in 52 patients (86.7%), while 8 (13.3%) represented negative appendicectomy. USG was positive in 38 (63.3%), equivocal/non-diagnostic in 10 (16.7%), and negative in 12 (20.0%) patients. When equivocal studies were considered non-positive, USG showed sensitivity of 69.2%, specificity of 75.0%, PPV of 94.7%, NPV of 27.3%, and diagnostic accuracy of 70.0%. CT was performed in 22 patients and demonstrated sensitivity of 94.4%, specificity of 75.0%, PPV of 94.4%, NPV of 75.0%, and diagnostic accuracy of 90.9%.

Conclusion: Ultrasonography is a useful first-line investigation in suspected acute appendicitis because of its availability and absence of radiation, but its diagnostic performance is limited by operator dependence, occasional equivocal examinations, and moderate sensitivity. CT provides substantially higher diagnostic accuracy and is an effective problem-solving modality in unresolved cases. A staged USG-first, selective-CT approach appears practical and clinically appropriate.

Keywords: Appendicitis, Ultrasonography, Computed Tomography, Sensitivity and Specificity, Appendectomy.

INTRODUCTION

Acute appendicitis remains one of the most frequent causes of acute abdominal pain requiring emergency surgery and continues to be a major contributor to surgical admissions worldwide.[1] It is encountered across all age groups although it is seen most commonly in adolescents and young adults. Because of its high incidence and the need for timely surgical interventions appendicitis represent an important diagnostic challenge in routine surgical practice.[2] Early diagnosis is essential, as delay in recognition and treatment may result in perforation, abscess formation, peritonitis, sepsis, prolonged hospital stay, and increased postoperative morbidity. On the other hand, An inaccurate diagnosis may lead to unnecessary surgical interventions thereby exposing patients to unnecessary and avoidable operative risks.[3]

The diagnosis of acute appendicitis usually depends upon on a combination of clinical history, physical examination and imaging studies. Classical symptoms in cases of acute appendicitis include periumbilical pain migrating to the right iliac fossa, anorexia, nausea, vomiting, fever and leukocytosis. Clinical scoring systems such as the Alvarado score have also been used to improve diagnostic accuracy and guide management. However, the clinical features in cases of acute appendicitis are not always typical.[4] Children, elderly patients, women of reproductive age and pregnant patients often present with atypical or overlapping symptoms which makes clinical diagnosis difficult. In such situations, dependence on clinical assessment alone may lead either to delay in treatment or to a high rate of negative appendicectomy. This limitation has contributed to the increasing role of imaging in the evaluation of suspected appendicitis.[5]

Ultrasonography is the initial investigation of choice in patients with suspected acute appendicitis. It is widely available, relatively inexpensive, non-invasive and free from ionizing radiation making it particularly useful in children and pregnant women. On ultrasonography, acute appendicitis is usually suggested by the demonstration of a non-compressible blind-ending tubular structure in the right iliac fossa with an outer diameter greater than 6mm. Additional supportive findings may include wall thickening, peri-appendiceal fluid, appendicolith, increased echogenicity of surrounding fat, and localized tenderness elicited during graded compression. Despite these advantages, ultrasonography has recognized limitations. Its diagnostic yield may be affected by operator experience, patient body habitus, overlying bowel gas, and variable appendiceal position. As a result, the appendix may not always be adequately visualized, and the examination may remain equivocal or non-diagnostic in a significant number of patients.[6]

In cases of suspected appendicitis when ultrasound findings remain equivocal computed tomography (CT) can be used as problem-solving modality. CT offers superior anatomic detail as well as allows comprehensive assessment not only of the appendix but also of surrounding bowel loops and mesentery. Typical CT features of acute appendicitis include appendiceal dilatation, mural thickening, mural enhancement, peri-appendiceal fat stranding, appendicolith, peri-appendiceal fluid, phlegmon and abscess formation. Owing to these advantages, CT is generally regarded as a highly accurate technique for diagnosing appendicitis and for identifying complications. At the same time, its use is limited by radiation exposure, greater cost, and reduced desirability in younger patients and pregnant women. Therefore, in many centres, CT is not used routinely as the first-line modality but rather selectively in unresolved cases.[7]

In everyday practice patients with suspected appendicitis are first evaluated with ultrasonography and CT is done in cases in whom ultrasound findings are equivocal. Such an approach may help reduce unnecessary radiation exposure while still improving diagnostic precision and lowering the rate of negative appendicectomy.[8]

Although both ultrasonography and CT are well established in the assessment of suspected appendicitis, there remains a need to evaluate how these modalities perform in actual hospital practice, particularly when CT is used selectively rather than uniformly in all patients. Data derived from routine record-based analysis may provide a more realistic picture of their diagnostic utility within a specific institutional setting. The present study was therefore undertaken to assess the role of ultrasonography as the primary imaging modality and the additional value of computed tomography in selected patients with suspected acute appendicitis. By correlating imaging findings with operative findings and/or histopathological examination, the study aims to determine the diagnostic performance of these modalities and to better define their practical role in the evaluation of acute appendicitis.

MATERIALS AND METHODS

This retrospective study was conducted through analysis of hospital records of patients evaluated for suspected acute appendicitis. A total of 60 cases who were operated for acute appendicitis were identified from hospital electronic records over a duration of two years. All data used in the study were obtained from existing institutional databases, including radiology archives and IPD records. No investigations or interventions were performed specifically for the purpose of this study. The study population consisted of patients who had undergone appendicectomy and in whom relevant imaging, operative, and pathology records were available. Confirmation of the final diagnosis was based on

either operative findings suggestive of appendicitis or histopathological examination of the resected appendix specimen, and these were considered the reference standards for diagnostic correlation.

Radiological information was obtained retrospectively from the Picture Archiving and Communication System (PACS) and ultrasound reports and images. Ultrasonography (USG) was the first imaging modality used for evaluation in patients with suspected acute appendicitis. The ultrasound reports were reviewed for documented findings suggestive of appendicitis. These findings included visualization of a non-compressible blind-ending tubular structure, appendiceal diameter greater than 6 mm, presence of wall thickening, peri-appendiceal inflammatory changes, presence of appendicolith and presence of peri-appendiceal fluid collection. Based on the interpretation recorded in the original radiology reports each case was categorized as positive, equivocal or negative for the diagnosis of acute appendicitis on ultrasonography.

Computed tomography (CT) was performed selectively in patients in whom the ultrasound findings were equivocal, non-diagnostic or when clinical suspicion of appendicitis persisted even after inconclusive sonographic evaluation. CT imaging records available in PACS were reviewed retrospectively for documented features suggestive of appendicitis. Based on the recorded radiology reports, CT findings were then categorized as positive or negative for appendicitis. Diagnostic indices for CT were calculated only in the subset of cases in whom CT imaging records were available.

Operative findings and histopathology data were obtained from medical records. Operative notes were reviewed for documentation of intraoperative findings of acute appendicitis. Histopathology reports were also reviewed from medical records. For the purpose of diagnostic validation, a case was considered confirmed appendicitis when either the operative findings or histopathological examination report demonstrated appendicitis. Imaging findings from USG and CT were then compared against this confirmatory standard derived from record review.

Statistical analysis was performed using SPSS 23.0 software. Descriptive statistics were used to summarize demographic characteristics and imaging findings. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall diagnostic accuracy of ultrasonography were calculated in all patients with available USG records, while similar diagnostic indices for CT were calculated in the subset of patients who underwent CT imaging. Comparative evaluation of imaging findings with the final diagnosis was performed using the Chi-square test or Fisher's exact test, where appropriate.

Inclusion Criteria

- Patients with clinical suspicion of acute appendicitis available in hospital records.
- Patients who underwent ultrasonography of the abdomen for evaluation of suspected appendicitis, and computed tomography (CT) in cases of equivocal or non-diagnostic ultrasonography findings.
- Patients who subsequently underwent appendicectomy.
- Cases in which operative findings confirming appendicitis and/or histopathology reports were available.
- Patients with complete radiological and electronic case record data.

Exclusion Criteria

- Cases with incomplete imaging, operative, or histopathology records.
- Patients with previous appendicectomy.
- Cases in which a definite alternative diagnosis explaining right iliac fossa pain was recorded in the final medical records.
- Pregnant women.

RESULTS

A total of 60 patients were included in the study. The majority of patients belonged to the 21–30 years age group, 19 (31.7%), followed by the 11–20 years group, 15 (25.0%). Together, patients between 11 and 30 years accounted for 34 (56.7%) of the study population, indicating that acute appendicitis was most frequently encountered in younger individuals [Table 1].

Table 1

Age group (years)	Number of cases	Percentage (%)
≤10	4	6.7
11–20	15	25.0
21–30	19	31.7
31–40	11	18.3
41–50	7	11.7
>50	4	6.7
Total	60	100.0

Table 2: Final Diagnosis on the basis of operative findings or histopathology.

Final diagnosis	Number of cases	Percentage (%)
Appendicitis confirmed	52	86.7
Appendicitis not confirmed	8	13.3
Total	60	100.0

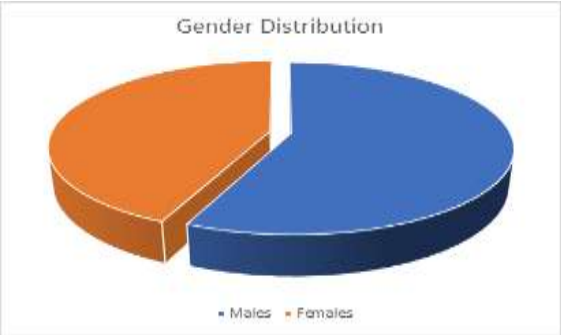

Figure 1: Gender Distribution of the studied cases.

Among the 60 patients, 34 (56.7%) were males and 26 (43.3%) were females, showing a slight male predominance. The male-to-female ratio in the present study was approximately 1.3:1 [Figure 1].

Final confirmation of appendicitis was established on the basis of either operative findings or histopathological examination. Out of the 60 patients who underwent appendicectomy, 52 (86.7%) were confirmed to have appendicitis, while 8 (13.3%) showed no evidence of appendicitis, representing negative appendicectomy cases [Table 2].

Ultrasonography was performed in all 60 (100.0%) patients as the primary imaging modality. USG findings were positive for appendicitis in 38 (63.3%) patients, while 10 (16.7%) had equivocal or non-diagnostic findings. Negative ultrasound findings were recorded in 12 (20.0%) patients. Thus, equivocal and negative USG findings together accounted for 22 (36.7%) patients, who formed the subgroup considered for selective CT evaluation [Table 3].

Table 3: Ultrasonography findings in the study population (n = 60).

USG finding category	Number of cases	Percentage (%)
Positive for appendicitis	38	63.3
Equivocal / non-diagnostic	10	16.7
Negative for appendicitis	12	20.0
Total	60	100.0

Computed tomography was performed in 22 (36.7%) patients following inconclusive or negative ultrasound findings. Among these, 10 (45.5%) underwent CT because of equivocal or non-diagnostic USG findings, whereas 12 (54.5%) underwent CT due to persistent clinical suspicion despite a negative ultrasound examination [Table 4].

Table 4: Indications for CT examination (n = 22).

Indication for CT	Number of cases	Percentage (%)
Equivocal / non-diagnostic USG	10	45.5
Persistent clinical suspicion despite negative USG	12	54.5
Total	22	100.0

For diagnostic accuracy analysis, equivocal USG findings were considered non-positive. Ultrasonography correctly identified appendicitis in 36 (69.2%) of the 52 confirmed cases and showed two false-positive results in 2 (25.0%) of the 8 non-appendicitis cases. A total of 22 (36.7%) cases were categorized as non-positive on USG, including both equivocal and negative examinations. Non-positive USG includes both equivocal and negative ultrasound findings. USG showed a high positive predictive value of 94.7%, but lower sensitivity of 69.2% when equivocal studies were treated as non-positive [Table 5, Table 6].

Table 5: Correlation of USG findings with final diagnosis (n = 60). Non-positive USG includes both equivocal and negative ultrasound findings.

USG result	Appendicitis confirmed	Appendicitis not confirmed	Total
Positive	36	2	38
Non-positive*	16	6	22
Total	52	8	60

Table 6: Sensitive, Specificity, positive predictive value, negative predictive value, Diagnostic Accuracy of USG for diagnosis of appendicitis.

Diagnostic parameter	Value (%)
Sensitivity	69.2
Specificity	75.0
Positive predictive value	94.7
Negative predictive value	27.3
Diagnostic accuracy	70.0

Computed tomography was analyzed in the subset of 22 (36.7%) patients who underwent CT imaging. Among these, appendicitis was ultimately confirmed in 18 (81.8%) patients, while 4 (18.2%) did not have appendicitis. CT correctly detected appendicitis in 17 (94.4%) of the 18 confirmed cases and correctly excluded appendicitis in 3 (75.0%) of the 4 non-appendicitis cases, demonstrating a relatively high diagnostic yield in this selectively imaged subgroup [Table 7, Table 8].

Table 7: Correlation of CT findings with final diagnosis (n = 22).

CT result	Appendicitis confirmed	Appendicitis not confirmed	Total
Positive	17	1	18
Negative	1	3	4
Total	18	4	22

Table 8: Sensitive, Specificity, positive predictive value, negative predictive value, Diagnostic Accuracy of CT for diagnosis of appendicitis.

Diagnostic parameter	Value (%)
Sensitivity	94.4
Specificity	75.0
Positive predictive value	94.4
Negative predictive value	75.0
Diagnostic accuracy	90.9

DISCUSSION

In the present study, acute appendicitis was seen predominantly in younger patients, with 56.7% of cases occurring between 11 and 30 years of age, and there was a slight male predominance (56.7%). Al-Omran M et al reported that appendicitis was more common in males between the age group of 10–19-year.[9] Similarly, Oguntola AS et al found that most cases clustered in the second and third decades of life, with a marginal male predominance.[10] Our findings therefore support the well-recognized age and sex distribution of appendicitis and suggest that the study cohort is representative of the usual clinical population encountered in emergency surgical practice. At the same time, the presence of 13.3% negative appendicectomy in our series reflects the ongoing challenge of distinguishing appendicitis from its many mimics, especially in women and younger patients, among whom alternative gastrointestinal and gynecologic conditions may complicate clinical diagnosis. This emphasizes why imaging has become central to modern appendicitis pathways rather than merely adjunctive.

A major finding of the present study is the limited standalone sensitivity of ultrasonography when equivocal examinations are treated as non-positive. Although USG had a high positive predictive value of 94.7% and a moderate specificity of 75.0%, its sensitivity was 69.2%, largely because 16.7% of examinations were equivocal or non-diagnostic. This pattern is important clinically: a positive ultrasound in our cohort was highly reliable, but a negative or indeterminate ultrasound could not safely exclude disease. This observation is in line with the work of Doria AS et al whose meta-analysis showed that ultrasound has lower pooled sensitivity than CT in both children and adults, even though specificity remains relatively good.[11] Likewise Terasawa T et al concluded in their systematic review that CT is probably more accurate than ultrasonography in adults and adolescents.[12] Our results particularly highlight the methodological importance of how equivocal scans are handled. If indeterminate ultrasonographic studies are counted as failures of diagnostic resolution rather than excluded from analysis, the practical performance of US declines substantially. This is also conceptually consistent with the original work of Puylaert JB who demonstrated the utility of graded-compression sonography but did so in a setting of expert technique and direct visualization.[13]

By contrast, CT in our selectively imaged subgroup showed high sensitivity (94.4%), specificity (75.0%), positive predictive value (94.4%), and overall diagnostic accuracy (90.9%). These results compare favorably with published literature and support the role of CT as a problem-solving modality after inconclusive sonography. Poortman P et al in a blinded prospective comparison, found similar overall diagnostic performance between CT and sonography in a community hospital setting, but their study used focused unenhanced CT and was performed in a highly protocolized environment; importantly, their sonography accuracy was better than that in our series, likely reflecting operator expertise and prospective standardization.[14] In contrast, Gaitini D et al evaluated adult patients using color Doppler sonography and contrast-enhanced multidetector CT and supported CT as a strong triage tool, especially when sonographic findings were inconclusive.[15] Our findings are much closer to that latter real-world model, where CT is deployed after an uncertain initial ultrasound and therefore functions as the decisive test. The high CT positive predictive value in our study suggests that once CT is positive the likelihood of a truly inflamed appendix is high. At the same time, the few false-negative CT cases in our cohort remind clinicians that even high-performing imaging is not infallible, especially in early disease, atypical appendix position, or subtle inflammatory change.

In our series, all patients underwent ultrasound first, while CT was reserved for the 36.7% with equivocal or negative US findings but persistent suspicion. Reich B and colleagues demonstrated that a first-pass strategy using ultrasound followed by confirmatory CT in negative cases could avoid CT in a substantial proportion of patients while preserving diagnostic effectiveness.[16] Similarly, Eng KA et al in a meta-analysis of second-line imaging after initial ultrasound, reported that second-line CT has very high pooled sensitivity and specificity in both children and adults.[17] Our data closely mirror this framework: the proportion of equivocal ultrasound studies created a genuine need for second-line CT,

and once CT was performed, diagnostic accuracy improved markedly. This is especially relevant in resource-variable settings, where universal CT may not be feasible or desirable, but reliance on ultrasound alone may be insufficient. Therefore, the present findings support a selective escalation model rather than a one-test-for-all strategy. Such an approach is also consistent with the principle that imaging should not only diagnose appendicitis but also meaningfully reduce uncertainty after the initial evaluation.

The negative appendicectomy rate in our study was 13.3%, which, although not unexpected in a retrospective surgical cohort, is higher than the rates commonly reported in modern imaging-driven practice. Tseng J et al analyzing ACS-NSQIP data showed that CT use was associated with markedly lower negative appendectomy rates than ultrasound alone or no imaging, and that adding CT after a positive ultrasound reduced the negative appendectomy rate even further.[18] Likewise, Crocker C et al showed that once indeterminate examinations are fully accounted for, CT far outperforms ultrasound in practical diagnostic yield and is associated with a lower negative appendectomy rate.[19] Our findings fit this broader literature well. The single false-positive CT and the two false-positive US findings in our series show that no imaging modality eliminates all diagnostic error; however, the higher CT accuracy suggests that broader or earlier CT use in selected adult patients might have reduced some unnecessary surgeries in our cohort. On the other hand, radiation exposure remains a legitimate concern, particularly in children, adolescents, and pregnant patients, which is why the superiority of CT must be interpreted alongside safety considerations. Rao PM et al concluded that routine appendiceal CT can improve patient management by identifying alternative intra-abdominal pathologies and reducing unnecessary appendectomies.[20] Taken together, our results suggest that ultrasonography remains valuable as an initial, low-risk screening tool, but CT provides the diagnostic confidence needed when sonography is non-diagnostic or discordant with clinical assessment. The overall message of this study is therefore pragmatic: ultrasound is useful to start the evaluation, whereas CT is more reliable for confirming or excluding appendicitis when uncertainty persists.

CONCLUSION

From a radiologic perspective ultrasonography serves as a first-line imaging modality in suspected acute appendicitis because of its wide availability and lack of ionizing radiation. However, its diagnostic performance is limited by occasional equivocal examinations and moderate sensitivity particularly in obese individuals. On the other hand, computed tomography demonstrates substantially higher sensitivity and overall accuracy which makes it an effective problem-solving modality in cases where ultrasound findings remain equivocal. A staged imaging approach using USG first and CT in selective cases appears radiologically sound and clinically practical.

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