

Diagnostic Performance of Graded Compression Ultrasonography in Acute Right Iliac Fossa Pain

Ramila Devkota,¹ Laxman Kunwar,¹ Rameshwor Devkota,¹ Sujan Shrestha,¹ Bikash Bikram Adhikari¹

¹National Academy of Medical Sciences, Bir Hospital, Kathmandu, Nepal

Correspondence:

Dr Ramila Devkota
National Academy of Medical Sciences, Bir Hospital,
Kathmandu, Nepal
Email: ramila777@hotmail.com
Phone: +9779841399007



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ABSTRACT

Introduction: Acute right iliac fossa (RIF) pain is a common reason for emergency visits, and acute appendicitis remains the leading surgical cause. Clinical overlaps with other abdominal conditions and relying on clinical assessment alone can lead to diagnostic delays, complications and negative appendectomy. Although computed tomography (CT) offers high diagnostic accuracy, ultrasonography (USG) using a graded compression technique offers a safe, radiation-free, and widely available imaging option, particularly relevant for resource-limited settings such as Nepal. This study aimed to evaluate the diagnostic performance of graded compression ultrasonography in patients presenting with acute RIF pain and to correlate its findings with CT and surgical/histopathological outcomes.

Methods: A descriptive cross-sectional study was conducted in the Department of Radiodiagnosis at a tertiary care center from January to June 2025. Patients of all ages presenting with acute RIF pain and referred for USG were included using convenience sampling. USG findings were compared with CT, intraoperative, and histopathological outcomes. Statistical analysis was performed with SPSS and diagnostic accuracy metrics including sensitivity, specificity, predictive values, and Cohen's Kappa were calculated.

Results: Among 68 patients evaluated, 51 patients (75.00%) were diagnosed with acute appendicitis. Of these, 42 patients (61.76%) had uncomplicated appendicitis, while 9 patients (13.24%) had complicated appendicitis. Other diagnoses included ileitis/colitis (n=5, 7.35%), renal or ureteric calculus (n=3, 4.41%), ileocecal malignancy (n=3, 4.41%), ileocecal tuberculosis (n=1, 1.47%), diverticulitis (n=1, 1.47%), lymphadenopathy (n=2, 2.94%), and normal findings (n=2, 2.94%). USG demonstrated high diagnostic accuracy with a sensitivity of 96.08%, specificity of 94.12%, and positive predictive value of 98.00%. The most common sonographic findings were the target sign in 48 patients (94.12%), appendicolith in 28 patients (54.90%), and free fluid in 9 patients (17.65%). Cohen's kappa coefficient was 0.885, indicating near-perfect agreement between USG and CT or intraoperative findings.

Conclusion: Graded compression ultrasonography provided excellent diagnostic performance for acute right iliac fossa pain, reliably identifying acute appendicitis while also detecting important alternative causes. Given its safety, accessibility, and diagnostic reliability, USG should be considered a primary imaging tool, particularly in resource-limited healthcare settings.

Keywords: Abdominal Pain; Appendicitis; Computed Tomography; Diagnostic Imaging; Ultrasonography.

INTRODUCTION

Acute right iliac fossa (RIF) pain is a common reason for emergency visits and presents a diagnostic challenge because of its varied causes and overlapping presentations.¹⁻⁴ Among these, acute appendicitis remains the most frequent surgical emergency, with a lifetime risk of about one in seven individuals.¹ In the past, surgery was frequently performed based solely on clinical

suspicion, resulting in negative appendectomy rates as high as 30%.² With advances in imaging, this approach is being re-evaluated. Computed tomography (CT) provides high diagnostic accuracy but is often limited in resource-constrained settings like Nepal due to cost, availability, and radiation exposure.⁵ In contrast, ultrasonography (USG), particularly the graded compression technique described by Puylaert, is affordable, safe, and effective for diagnosing appendicitis and alternative RIF pathologies.⁶⁻⁸

Despite its clinical value, there remains a significant lack of robust local data in Nepal evaluating the diagnostic performance of USG in acute RIF pain. Most available evidence is derived from Western populations, limiting its applicability to Nepal's healthcare settings, where variability in operator expertise, patient body habitus, and access to advanced imaging affects diagnostic accuracy and decision-making.

This study aims to evaluate the diagnostic performance of graded compression USG in acute RIF pain and correlate its findings with CT and histopathological outcomes to better guide surgical decision-making.

METHODS

This was a descriptive cross-sectional study conducted in the Department of Radio-diagnosis, Bir Hospital, Kathmandu, Nepal, from January to June 2025 after obtaining the ethical approval from the Institutional Review Board (IRB) of NAMS (Reference number: 1287/2081-2082). Patients of all ages and both sex presenting to the emergency ward with acute right iliac fossa (RIF) pain and referred for ultrasonography with clinical suspicion of acute appendicitis or related pathologies were consecutively enrolled after obtaining informed consent. Those with recurrent appendicitis or other RIF pathologies without acute symptoms, medically unfit for surgery, unwilling for further management, or scheduled for interval appendectomy were excluded.

A convenience sampling method was used. The sample size was calculated based on the expected sensitivity and specificity of ultrasonography for diagnosing acute appendicitis using the formula; $N = (Z^2 \times P \times (1 - P)) / E^2$ where, N= minimum required sample size, Z = 1.96 for 95% confidence interval, P=expected sensitivity or specificity, E = margin of error (0.05). Using the specificity of 0.96,⁹ the calculated sample size was 59.01. Adjusting for a 10% dropout rate, the final target sample size was set at 65 patients.

Data regarding patient demographics, clinical history, examination findings, laboratory investigations, and ultrasonography results were recorded on a standardized proforma. A comprehensive abdominal ultrasonographic evaluation was performed using a 4–5 MHz curved sector transducer to assess for alternative causes of RLQ pain, followed by a graded compression examination of the RLQ using a high-resolution linear array transducer (≥ 7.5 MHz). The examiner oriented the probe using vascular landmarks and applied graded compression to identify the appendix. Patient positioning was adjusted (such as hip and knee flexion) to reduce tenderness and improve visualization. Operative findings and histopathology reports were used as the reference standard to confirm diagnoses. When available, preoperative CT abdomen findings were recorded for correlation with ultrasonography.

Patient confidentiality was strictly maintained throughout the study. Data were entered into password-protected Microsoft Excel sheets and analyzed using SPSS software. Quantitative variables were summarized with means and standard deviations, while categorical variables were presented as frequencies and percentages. Cohen's Kappa test was used to assess agreement between ultrasonography and the reference standard. Diagnostic accuracy metrics of ultrasonography, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were calculated using CT and/or histopathological findings as reference standards.

RESULTS

A total of 68 patients from January to June 2025 met the inclusion criteria and all of them were enrolled in the study. Characteristics of the patients involved in this study are shown in Table 1.

Table 1. Participant Demographics (n=68)

Variables	n (%)
Female	36 (52.90)
Male	32 (47.10)
Age (years)	16-74 (Median=33.00)

Table 2. Spectrum of diseases presenting with RIF pain.

Final Diagnosis	n (%)
Acute appendicitis (Total)	51 (75.00)
Uncomplicated acute appendicitis	42 (61.70)
Complicated appendicitis	9 (13.20)
• Appendicular lump	5 (7.30)
• Appendicular abscess	3 (4.41)
• Appendicular perforation	1 (1.47)
Ileitis / Colitis / Ileocecal valve colitis	5 (7.35)
Renal / Ureteric calculus	3 (4.41)
Ileocecal tuberculosis	1 (1.47)
Ileocecal malignancy	3 (4.41)
Lymphadenopathy	2 (2.94)
Diverticulitis	1 (1.47)
Normal findings	2 (2.94)
Total	68(100)

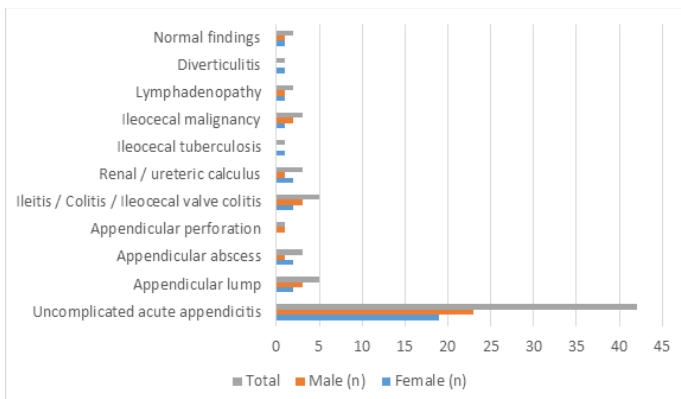


Figure 1. Gender-wise distribution of the causes of RIF pain

Spectrum of various pathologies were diagnosed in 68 (100%) cases presenting with RIF pain (Figure 1). USG diagnosis of renal/ureteric calculus was made in total 3 (4.41%) cases which was supported by the consecutive CT Intravenous Urography findings. Two cases (2.94%) had no significant findings in USG except probe tenderness at RIF, which were later confirmed to be inflammatory focal ileitis/colitis. Among the four cases (5.80%) where ileocecal thickening was reported on USG, three cases (4.41%) (two males and one female with age >50 years) were diagnosed as ileocecal malignancy and a male patient (1.47%) of 33 years was diagnosed as ileocecal tuberculosis. One case (1.47%) which was given differential of diverticulitis on USG was diagnosed as diverticulitis on CT as well.

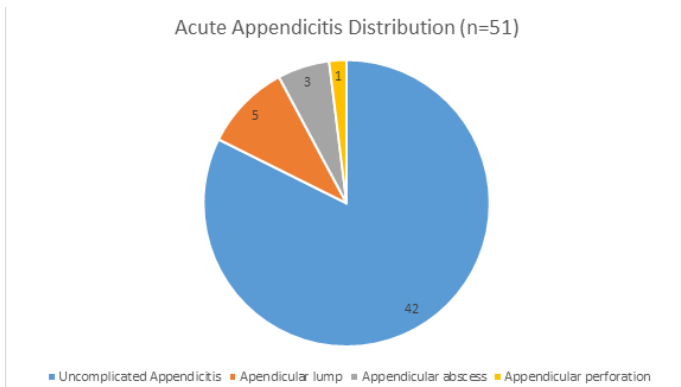


Figure 2. Spectrum of findings in cases of appendicitis

Among the 51(75.00%) patients with confirmed appendicitis, 22(32.35%) were female and 29(42.64%) were male (Table 3). The mean age was similar across both sex, 35.00 years for females and 34.80 years for males. Fecolith was more frequently observed in males (62.10%) compared to females (45.50%), with an overall occurrence of 54.90%. Free fluid in the right iliac fossa (RIF) was more common in females (27.30%) than in males (10.30%), accounting for 17.6% of the total cases. The classic "target sign" was visualized in all females (100.00%) and in 89.70%

of males, with an overall detection rate of 94.10%. The mean appendix diameter was slightly larger in males (8.89 mm) than in females (8.56 mm), while wall thickness was also marginally higher in males (3.31 mm vs. 3.22 mm) (Table 3).

Table 3. Sonographic findings in Cases of acute appendicitis and their demographic distribution.

Variable	Female (n = 22)	Male (n = 29)	Total (n=51)
Mean Age (years)	35.0	34.8	34.9
Fecolith Present (n)	10 (45.50%)	18 (62.10%)	28/51 (54.90%)
Free Fluid in RIF (n)	6 (27.30%)	3 (10.30%)	9/51 (17.60%)
Target Sign Present (n)	22 (100.00%)	26 (89.70%)	48/51 (94.10%)
Appendix Diameter (mm)	Mean: 8.56	Mean: 8.89	Mean: 8.75
Wall Thickness (mm)	Mean: 3.22	Mean: 3.31	Mean: 3.27

Table 4. Sensitivity and Specificity of USG as compared to CT/Intra-op Diagnosis of appendicitis.

	Positive on CT/Intra-op	Negative on CT/HPE	Total
Positive on USG	TP=49	FP=1	50
Negative on USG	FN=2	TN=16	18
Total	51	17	68

TP: True positive, TN: True Negative, FP: False Positive, FN: False Negative

Out of total 68 patients, 29 patients had undergone CECT Abdomen Pelvis, and 55 patients had HPE diagnosis. As seen in table 4, Out of a total of 68 patients, 49 were correctly identified as true positives by USG, while 16 were correctly identified as true negatives. Two cases were false negatives, where USG failed to detect appendicitis that was confirmed on CT or surgery. Only one case was a false positive, where USG suggested appendicitis, but CT/intra-op findings were negative. The sensitivity of ultrasonography was 96.08%, calculated as 49 true positives out of 51 total confirmed positive cases (Sensitivity = $49 / [49 + 2] = 49 / 51 \approx 96.08\%$). The specificity was also high at 94.12%, with 16 true negatives

out of 17 negative cases (Specificity = $16 / [16 + 1] = 16 / 17 \approx 94.12\%$).

Table 5. Diagnostic performance of ultrasonography for acute appendicitis

Parameter	Formula	Value
Sensitivity	$TP / (TP + FN)$	96.08%
Specificity	$TN / (TN + FP)$	94.12%
Positive Predictive Value	$TP / (TP + FP)$	98.0%
Negative Predictive Value	$TN / (TN + FN)$	88.9%
Positive Likelihood Ratio (LR ⁺)	$Sensitivity / (1 - Specificity)$	16.34
Negative Likelihood Ratio (LR ⁻)	$(1 - Sensitivity) / Specificity$	0.0416
Cohen's Kappa (κ)	$(Po - Pe) / (1 - Pe)$	0.885

The positive predictive value (PPV), indicating the probability that patients with a positive USG truly had appendicitis, was 98% ($PPV = 49 / [49 + 1] = 49 / 50$). The negative predictive value (NPV), reflecting the probability that patients with a negative USG truly did not have appendicitis, was 88.9% ($NPV = 16 / [16 + 2] = 16 / 18 \approx 88.9\%$).

Likelihood ratios further supported the diagnostic strength of ultrasonography (Table 5). The positive likelihood ratio was 16.34, indicating strong rule-in capability, while the negative likelihood ratio was 0.0416, demonstrating excellent rule-out performance. Agreement analysis showed an observed agreement of 95.6% with a Cohen's Kappa value of 0.885, indicating almost perfect agreement between ultrasonography and the reference standard.

These results affirm the high diagnostic accuracy and reliability of graded compression ultrasonography in evaluating patients with acute right iliac fossa pain, particularly for diagnosing acute appendicitis.

DISCUSSION

This study shows that graded compression ultrasonography is a highly accurate first-line imaging modality for patients with acute right iliac fossa pain, particularly for diagnosing acute appendicitis, in a tertiary hospital setting in Nepal. The sensitivity of 96.08% and specificity of 94.12%, along with a positive predictive value of 98.00% and negative predictive value of 88.90%, indicate that ultrasonography can both confidently confirm and substantially exclude appendicitis in most clinically suspected cases.

The sensitivity and specificity observed in this study are at the upper range of previously reported values

for ultrasonography in suspected appendicitis, which generally show sensitivities between 85–98% and specificities between 80–95%, reflecting variability in operator expertise, equipment, and patient habitus.^{10–13} In particular, the pooled sensitivity of 88.00% and specificity of 94.00% reported by Doria et al. are comparable to, but slightly lower than, the present study, suggesting that with standardized technique and experienced operators, ultrasonography can perform at least as well as, and sometimes better than, the averages reported in larger meta-analyses.¹⁰

The positive likelihood ratio of 16.34 and negative likelihood ratio of 0.0416 in this study exceed commonly accepted thresholds for strong rule-in and rule-out tests ($LR^+ > 10$ and $LR^- < 0.1$), reinforcing the clinical impact of ultrasonography on post-test probability in suspected appendicitis. These values support the use of ultrasonography not merely as an adjunct to clinical assessment, but as a decisive tool that can guide the need for further imaging or surgery, especially when CT availability is limited.

The Cohen's kappa value of 0.885 indicates almost perfect agreement between ultrasonography and the reference standard of CT and/or intraoperative or histopathological findings, which is consistent with high-quality studies demonstrating strong concordance between ultrasonography and operative diagnoses when performed under optimal conditions. This level of agreement is particularly relevant in resource-constrained environments, where relying on ultrasonography can safely reduce CT utilization without compromising diagnostic confidence.

Regarding specific sonographic signs, the target sign was present in 94.10% of confirmed appendicitis cases, underscoring its role as a key diagnostic feature in routine practice. The prevalence of fecoliths (54.90%) in our study is notably higher than that reported by Singh and Mariadason, where rates around 13.70% have been described,^{14,15} suggesting either a true higher local burden of fecolith-associated appendicitis or possible referral and selection patterns in our center.

The finding that 75% of acute right iliac fossa pain cases were due to appendicitis, while 25% were attributable to other conditions such as ileitis or colitis, renal or ureteric calculi, ileocecal malignancy, tuberculosis, diverticulitis, and lymphadenopathy, highlights the importance of a comprehensive ultrasonographic assessment beyond the appendix alone. This broader diagnostic spectrum supports the role of ultrasonography not only in confirming appendicitis, but also in identifying alternative pathologies that may completely change management, thereby reducing diagnostic anchoring in emergency settings.

Sex-related differences in ancillary findings, such as

more frequent free fluid in females and slightly greater appendix diameter and wall thickness in males, may reflect underlying anatomical or physiological factors or differences in timing of presentation, though these differences were not assessed for statistical significance. Such observations may inform future hypothesis-driven studies on how sex and presentation patterns influence USG appearance and diagnostic thresholds in appendicitis.

A major strength of this study is its prospective design, use of a standardized graded-compression ultrasonography protocol, and correlation with both CT and intraoperative or histopathological findings as reference standards, which enhances internal validity. The exclusive use of experienced radiologists likely contributed to the high diagnostic performance metrics, illustrating what can be achieved with focused training and systematic scanning even in a resource-limited environment.

However, several limitations should be acknowledged. First, ultrasonography remains inherently operator-dependent, and the high accuracy reported here may not be fully replicable in centers with less experienced sonologists, which could limit external validity. Second, CT was not performed in all patients, raising the possibility of verification bias, although the use of intraoperative and histopathological confirmation in the majority of cases partially mitigates this concern. Third, the relatively small, single-center sample size, although statistically adequate, restricts subgroup analyses (for example by

age, body habitus, or degree of inflammation) and may limit generalizability to other populations or healthcare settings. Finally, the convenience sampling and emergency-department-based recruitment may have introduced selection bias potentially inflating performance estimates compared to a broader population.

Despite these limitations, the study supports the use of graded compression ultrasonography as a frontline imaging modality for suspected appendicitis in resource-constrained settings, with the potential to safely decrease unnecessary CT scans and negative appendectomies when integrated with clinical assessment and, where needed, selective cross-sectional imaging.

CONCLUSIONS

In conclusion, given its non-invasive nature, widespread availability, graded compression ultrasonography can be used as the primary imaging modality for acute right iliac fossa pain as it reliably guides the diagnosis and management of suspected appendicitis while also identifying key alternative causes. Strengthening operator training and standardizing graded-compression protocols can further enhance its utility, can be useful in low resource settings and also reduce unnecessary delays and reliance on advanced imaging.

Conflict of Interest: None

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