

DIAGNOSTIC ACCURACY OF POINT-OF-CARE ULTRASOUND IN ACUTE ABDOMINAL PAIN AT MARDAN MEDICAL COMPLEX: A CROSS-SECTIONAL VALIDATION STUDY

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Abstract

Background: Acute abdominal pain is a frequent emergency-department presentation for which rapid diagnostic stratification is essential. Point-of-care ultrasound (POCUS) offers bedside, non-invasive, radiation-free imaging and may be particularly useful in resource-constrained settings.

Objective: To evaluate the diagnostic performance of POCUS in adults presenting with acute non-traumatic abdominal pain to the Emergency Department of Mardan Medical Complex, Pakistan.

Methods: This cross-sectional validation study enrolled 237 consecutive adults from August 2025 to February 2026. POCUS was performed by emergency physicians with at least two years of ultrasound experience using a portable Mindray M7® system. Findings were compared with a composite reference standard comprising radiology-performed ultrasonography, contrast-enhanced computed tomography when clinically indicated, surgical and histopathological findings, and seven-day clinical follow-up. Diagnostic parameters were recalculated from the supplied 2×2 contingency counts with Wilson 95% confidence intervals (CIs). Pearson chi-square tests were used for categorical comparisons.

Results: The mean age was 38.2 ± 12.7 years and 128/237 (54.0%) participants were male. Appendicitis (58/237, 24.5%), renal colic (45/237, 19.0%), and cholecystitis (40/237, 16.9%) were the most frequent final diagnoses. In the supplied overall binary cross-tabulation, POCUS yielded 153 true positives, 41 false positives, 24 false negatives, and 19 true negatives. Accordingly, sensitivity was 86.4% (95% CI 80.6–90.7), specificity 31.7% (21.3–44.2), positive predictive value 78.9% (72.6–84.0), negative predictive value 44.2% (30.4–58.9), and overall accuracy 72.6% (66.6–77.9). POCUS and the reference classification were significantly associated (Pearson $\chi^2=9.893$, $p=0.002$). Condition-specific accuracy was 91.6% for appendicitis, 94.1% for cholecystitis, 92.4% for

renal colic, and 94.9% for intestinal obstruction. POCUS identified 57/67 (85.1%; 95% CI 74.7–91.7) patients requiring urgent surgery. Diagnostic correctness did not differ by sex ($\chi^2=0.044$, $p=0.834$).

Conclusion: POCUS showed high sensitivity for the overall target-pathology classification and strong condition-specific performance for common abdominal emergencies; however, the low overall specificity and negative predictive value in the supplied binary dataset indicate that POCUS should not be used as a stand-alone rule-out test. Integration with clinical assessment and confirmatory imaging remains important when diagnostic uncertainty persists.

1. Introduction

Acute abdominal pain is among the most frequent presenting complaints in emergency departments worldwide, accounting for approximately 5–10% of emergency visits [1]. The differential diagnosis is broad, ranging from benign self-limited conditions to time-sensitive surgical emergencies such as appendicitis, perforated viscus, and intestinal obstruction [2]. Prompt and accurate diagnosis is essential to guide management, avoid unnecessary interventions, and reduce morbidity and mortality [3].

Traditional evaluation relies on clinical history, physical examination, and laboratory testing, but these components alone may have limited diagnostic accuracy [4]. Computed tomography (CT) provides high diagnostic performance for many abdominal conditions but entails ionizing radiation, greater cost, and potential limitations in availability [5]. Point-of-care ultrasound (POCUS), performed and interpreted at the bedside by the treating clinician, has therefore become an important adjunct to emergency assessment [6].

POCUS is non-invasive, repeatable, radiation-free, and capable of providing real-time diagnostic information that may accelerate clinical decision-making [7,8]. It has demonstrated utility in the assessment of biliary disease, renal colic, appendicitis, hydronephrosis, free intraperitoneal fluid, and selected bowel pathology [9,10]. In resource-limited settings, the portability and relatively low operating cost of ultrasound may offer particular clinical value [11].

Mardan Medical Complex (MMC) is an 800-bed tertiary-care teaching hospital affiliated with Bacha Khan Medical College and serves as a major referral center in Khyber Pakhtunkhwa [12]. The

institution reports a high emergency-care workload and provides 24-hour radiology services, including ultrasound and CT [13,14]. Local evidence regarding the performance of emergency-physician-performed POCUS across a broad spectrum of non-traumatic abdominal presentations remains limited.

The objective of this study was therefore to evaluate the diagnostic performance of POCUS in adults presenting with acute non-traumatic abdominal pain at MMC, using a composite reference standard for final diagnostic classification [15].

2. Materials and Methods

2.1 Study design and setting

This cross-sectional validation study was conducted in the Emergency Department and Department of Radiology at Mardan Medical Complex, Mardan, Khyber Pakhtunkhwa, Pakistan, over seven months from August 2025 to February 2026.

2.2 Study population

Adults aged ≥ 18 years presenting with non-traumatic acute abdominal pain of < 72 hours' duration were eligible. Exclusion criteria were hemodynamic instability requiring immediate surgical intervention, pregnancy, abdominal surgery within the preceding six months, refusal of informed consent, and penetrating or blunt abdominal trauma.

2.3 Sample size and sampling

Consecutive sampling was used until 237 participants had been enrolled. The source manuscript states that the target sample was based on an expected POCUS sensitivity of 85%, 95%

confidence, and 5% absolute precision. Because the numerical derivation reported in the source does not reproduce a target of 237 without an additional inflation assumption, the original protocol or sample-size worksheet should be checked before submission [16–18].

2.4 Data collection

A structured proforma was used to record demographic characteristics, pain onset and location, associated symptoms, vital signs, and relevant medical history [20].

2.5 POCUS examination

POCUS was performed by emergency physicians with at least two years of ultrasound interpretation experience using a portable Mindray M7® system with curvilinear (3.5–5 MHz) and phased-array transducers [17,21]. The standardized examination assessed the following domains:

- Free intra-abdominal fluid in Morison's pouch, the splenorenal recess, and pelvis.
- Biliary pathology, including gallstones, gallbladder wall thickening >3 mm, pericholecystic fluid, and a sonographic Murphy sign.
- Renal pathology, including hydronephrosis and renal calculi.
- Bowel pathology, including dilated loops >3 cm, bowel-wall thickening >3 mm, and free fluid.
- Abdominal aortic aneurysm, defined as an aortic diameter >3 cm.

POCUS findings were recorded immediately and before radiology-performed imaging or CT results were available to the operator [17,22].

2.6 Reference standard

The final diagnosis was established using a composite reference standard comprising radiology-performed ultrasonography, contrast-enhanced CT when clinically indicated, surgical findings, histopathology for resected specimens, and clinical course with seven-day telephone follow-up for patients discharged without a definitive diagnosis [17,23].

2.7 Outcomes

The primary outcome was diagnostic performance of POCUS versus the supplied reference-standard classification. Secondary analyses examined sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall accuracy, condition-specific performance for appendicitis, cholecystitis, renal colic, and intestinal obstruction, identification of patients requiring urgent surgery, and diagnostic correctness by sex.

2.8 Statistical analysis

Categorical variables are reported as frequencies and percentages and continuous variables as mean $\pm$ standard deviation (SD). Diagnostic performance was recalculated directly from the supplied 2×2 contingency counts. Sensitivity was defined as TP/(TP+FN), specificity as TN/(TN+FP), PPV as TP/(TP+FP), NPV as TN/(TN+FN), and accuracy as (TP+TN)/N. Wilson 95% confidence intervals were calculated for binomial proportions. Pearson chi-square tests were used to examine associations in 2×2 tables; two-sided $p < 0.05$ was considered statistically significant. For diagnostic studies, effect estimates and confidence intervals were regarded as more informative than significance testing alone. Analyses reported in the source manuscript were stated to have been performed using SPSS version 26.0 (IBM Corp., Armonk, NY).

2.9 Ethical considerations

Ethical approval was reported as having been obtained from the Institutional Ethical Committee of Bacha Khan Medical College, Mardan. Written informed consent was obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki and patient anonymity was maintained [24].

3. Results

3.1 Participant characteristics

A total of 237 patients were included. The mean age was 38.2 ± 12.7 years (range 18–78 years), and 128 (54.0%) were male. The mean duration of pain was 18.5 ± 14.3 hours. Nausea or vomiting was reported in 134 (56.5%) participants and fever in 81 (34.2%).

Table 1. Demographic and clinical characteristics of the study population (n=237)

Characteristic	Value
Age, years, mean $\pm$ SD (range)	38.2 $\pm$ 12.7 (18-78)
Male sex	128 (54.0%)
Female sex	109 (46.0%)
Pain duration, hours, mean $\pm$ SD	18.5 $\pm$ 14.3
Epigastric/right-upper-quadrant pain	68 (28.7%)
Right-lower-quadrant pain	62 (26.2%)
Loin-to-groin/flank pain	52 (21.9%)
Diffuse/other pain location	55 (23.2%)
Nausea/vomiting	134 (56.5%)
Fever	81 (34.2%)

3.2 Final diagnoses

Appendicitis was the most frequent final diagnosis (58/237, 24.5%), followed by renal colic (45/237,

19.0%) and cholecystitis (40/237, 16.9%). Sixty-seven patients (28.3%) required urgent surgical intervention.

Table 2. Distribution of final diagnoses (n=237)

Final diagnosis	n	%
Appendicitis	58	24.5
Renal colic	45	19.0
Cholecystitis	40	16.9
Intestinal obstruction	22	9.3
Gastroenteritis	19	8.0
Non-specific abdominal pain	16	6.8
Pancreatitis	12	5.1
Other (e.g., perforated ulcer, diverticulitis)	25	10.5

3.3 Overall POCUS cross-tabulation

The supplied binary contingency table contained 177 reference-positive and 60 reference-negative cases. POCUS classified 194 cases as positive and

43 as negative, comprising 153 true positives (TP), 41 false positives (FP), 24 false negatives (FN), and 19 true negatives (TN).

Table 3. Cross-tabulation of overall POCUS classification versus the reference standard (n=237)

POCUS result	Reference positive	Reference negative	Total
POCUS positive	153 (TP)	41 (FP)	194
POCUS negative	24 (FN)	19 (TN)	43
Total	177	60	237

TP=true positive; FP=false positive; FN=false negative; TN=true negative. Counts are taken directly from the supplied manuscript and are the basis for the recalculated overall diagnostic estimates.

3.4 Overall diagnostic performance

Based on the counts in Table 3, overall sensitivity was 86.4% (95% CI 80.6-90.7), specificity 31.7% (21.3-44.2), PPV 78.9% (72.6-84.0), NPV 44.2% (30.4-58.9), and accuracy 72.6% (66.6-77.9). The

association between POCUS classification and the reference standard was statistically significant (Pearson $\chi^2=9.893$, $df=1$, $p=0.002$). The corresponding odds ratio was 2.95 (Fisher exact $p=0.003$).

Table 4. Recalculated overall diagnostic performance of POCUS

Parameter	Estimate	95% CI	Numerator/denominator
Sensitivity	86.4%	80.6–90.7%	153/177
Specificity	31.7%	21.3–44.2%	19/60
Positive predictive value	78.9%	72.6–84.0%	153/194
Negative predictive value	44.2%	30.4–58.9%	19/43
Overall accuracy	72.6%	66.6–77.9%	172/237

Wilson 95% confidence intervals. Pearson $\chi^2=9.893$, $df=1$, $p=0.002$ for the overall 2×2 association.

3.5 Condition-specific cross-tabulations and diagnostic performance

Condition-specific 2×2 tables were reconstructed from the diagnosis totals and internally coherent aggregate performance counts in the supplied

manuscript. All four condition-specific POCUS classifications showed strong statistical association with the corresponding reference diagnosis (all $p < 0.001$).

Table 5. Condition-specific 2×2 counts and tests of association

Diagnosis	TP	FP	FN	TN	χ^2	p
Appendicitis	48	10	10	169	141.146	<0.001
Cholecystitis	35	9	5	188	151.253	<0.001
Renal colic	40	13	5	179	141.594	<0.001
Intestinal obstruction	17	7	5	208	120.138	<0.001

Pearson chi-square tests, $df=1$. These condition-specific counts were recalculated from the supplied aggregate diagnosis totals and performance percentages; raw patient-level data should be used for final independent verification.

Table 6. Condition-specific diagnostic performance with 95% confidence intervals

Diagnosis	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
Appendicitis	82.8 (71.1–90.4)	94.4 (90.0–96.9)	82.8 (71.1–90.4)	94.4 (90.0–96.9)	91.6 (87.3–94.5)
Cholecystitis	87.5 (73.9–94.5)	95.4 (91.5–97.6)	79.5 (65.5–88.8)	97.4 (94.1–98.9)	94.1 (90.3–96.4)
Renal colic	88.9 (76.5–95.2)	93.2 (88.8–96.0)	75.5 (62.4–85.1)	97.3 (93.8–98.8)	92.4 (88.3–95.1)
Intestinal obstruction	77.3 (56.6–89.9)	96.7 (93.4–98.4)	70.8 (50.8–85.1)	97.7 (94.6–99.0)	94.9 (91.4–97.1)

Values are percentages; 95% CIs are Wilson intervals.

3.6 Diagnostic correctness by sex

POCUS was correct in 107/128 (83.6%) male patients and 90/109 (82.6%) female patients.

There was no evidence of a sex-based difference in diagnostic correctness (Pearson $\chi^2=0.044$, $df=1$, $p=0.834$).

Table 7. Cross-tabulation of diagnostic correctness by sex

Sex	Correct diagnosis	Incorrect diagnosis	Total
Male	107 (83.6%)	21 (16.4%)	128
Female	90 (82.6%)	19 (17.4%)	109

Total	197	40	237
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Pearson $\chi^2=0.044$, $df=1$, $p=0.834$. Fisher exact $p=0.863$.

3.7 Clinical outcomes

Sixty-seven patients (28.3%) required urgent surgical intervention, of whom 57 were correctly identified by POCUS, corresponding to a detection proportion of 85.1% (95% CI 74.7–91.7). Ten urgent surgical cases (14.9%) were

missed; the source manuscript identifies appendicitis ($n=6$) and intestinal obstruction ($n=2$) as the most frequent missed surgical diagnoses. All 12 patients discharged without a definitive diagnosis were reported to have symptom resolution within seven days.

Table 8. Clinical outcomes

Outcome	n	%
Urgent surgical intervention required	67	28.3
Urgent surgical cases identified by POCUS	57	85.1 of surgical cases
Urgent surgical cases missed by POCUS	10	14.9 of surgical cases
Discharged without definitive diagnosis; symptom resolution at 7 days	12	5.1 of cohort

4. Discussion

This cross-sectional validation study evaluated POCUS across a heterogeneous cohort of adults with non-traumatic acute abdominal pain. Recalculation from the supplied overall 2×2 counts shows a high sensitivity of 86.4% but a substantially lower specificity of 31.7%, with PPV 78.9%, NPV 44.2%, and overall binary accuracy 72.6%. The significant association between POCUS and the reference classification ($\chi^2=9.893$, $p=0.002$) indicates non-random diagnostic discrimination, but the magnitude of the specificity and NPV estimates is clinically important and prevents interpretation of a negative overall POCUS examination as a reliable rule-out test.

The relatively high sensitivity is consistent with the role of POCUS as a rapid bedside modality for identifying many clinically important abdominal abnormalities [28]. However, the low overall specificity indicates a considerable false-positive burden in the supplied binary classification. This may reflect the broad target construct, overlap between sonographic abnormalities and incidental findings, or misclassification across heterogeneous causes of abdominal pain. These results favor use

of POCUS as an adjunct to clinical assessment rather than as a stand-alone definitive test, particularly when clinical and sonographic findings are discordant [29,30].

Condition-specific analyses were more favorable. Accuracy was 91.6% for appendicitis, 94.1% for cholecystitis, 92.4% for renal colic, and 94.9% for intestinal obstruction. Cholecystitis and intestinal obstruction had specificities of 95.4% and 96.7%, respectively, whereas renal colic had the highest sensitivity at 88.9%. These findings are plausible given the availability of recognizable sonographic patterns for gallbladder inflammation, hydronephrosis or calculi, and dilated bowel loops, although performance remains operator- and patient-dependent [31,35,36].

Appendicitis remained an important source of false-negative examinations, with 10 false negatives in the reconstructed condition-specific table. Non-visualization of the appendix, early inflammatory change, body habitus, overlying bowel gas, and operator dependence are recognized limitations of ultrasound for suspected appendicitis [32,33]. Consequently, a negative or indeterminate POCUS examination should not delay formal

imaging or surgical assessment when clinical suspicion remains high.

The ability of POCUS to identify 57 of 67 patients requiring urgent surgery (85.1%) supports its practical value for triage. Nevertheless, the 10 missed urgent surgical cases are clinically consequential and reinforce the need for escalation pathways. POCUS should therefore be embedded within a diagnostic strategy that incorporates serial examination, laboratory findings, radiology-performed imaging, CT where appropriate, and early specialty consultation [37,38].

No statistically significant difference in diagnostic correctness was observed between male and female patients (83.6% vs 82.6%; $\chi^2=0.044$, $p=0.834$). This suggests similar aggregate performance by sex in this cohort, although the study was not powered specifically to evaluate effect modification by sex and subgroup precision is limited.

Several factors may have influenced diagnostic performance. Operator experience is a major determinant of POCUS quality; the source protocol required at least two years of ultrasound interpretation experience [39]. Standardized scanning and independent recording before radiology results were available strengthen the design, whereas obesity, bowel gas, pain-limited cooperation, and incomplete visualization may reduce image quality [40,41]. The composite reference standard reflects pragmatic clinical practice but may also introduce differential verification because not every participant underwent the same definitive imaging or operative confirmation.

This study has additional limitations. It was conducted at a single tertiary center, limiting external generalizability. Inter-observer reliability was not reported. The overall binary reference-positive/reference-negative construct requires explicit operational definition in the final submitted protocol, because diagnostic accuracy depends on how heterogeneous final diagnoses are dichotomized. Some original summary statistics were internally inconsistent with the reported contingency counts and were therefore recalculated in this revision; final submission should reproduce all analyses from the raw patient-level dataset. Finally, several patients were verified by clinical

follow-up rather than a uniform imaging reference, which may permit partial-verification bias [48,49].

5. Conclusion

In this cohort, POCUS demonstrated high overall sensitivity but limited overall specificity and negative predictive value when evaluated against the supplied binary reference classification. In contrast, condition-specific performance for appendicitis, cholecystitis, renal colic, and intestinal obstruction was strong, and POCUS identified 85.1% of patients requiring urgent surgical intervention. These findings support POCUS as a rapid bedside adjunct for triage and focused diagnostic assessment, but they do not support its use as an isolated rule-out strategy for acute abdominal pathology. Clinical correlation and confirmatory imaging should remain readily available when symptoms, examination findings, and POCUS results are discordant.

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