Original Research

DIAGNOSTIC ACCURACY OF BEDSIDE ULTRASONOGRAPHY COMPARED WITH DEPARTMENTAL ULTRASONOGRAPHY FOR ACUTE CHOLECYSTITIS IN A PAKISTANI TERTIARY-CARE EMERGENCY DEPARTMENT

Sadaf Keerio[1*], Inayat Ali Khan[2], Erum Soomro[3], Alvina Khan[4], Daniyal Rasool[5], Ali Anwar[6]
[1*]MD Trainee, Emergency Department, Dr Ziauddin Hospital, Karachi, Pakistan.
[2]Assistant Professor Neurosurgery & HOD Emergency Department, Dr Ziauddin Hospital, Karachi, Pakistan.
[3,4]Registrar, Emergency Department, Dr Ziauddin Hospital, Karachi, Pakistan.
[5]Consultant Cardiologist, Senior Medical Officer, Liaquat University Hospital, Hyderabad, Pakistan.
[6]Registrar Emergency Medicine, Dr Ziauddin Hospital, Karachi, Pakistan.
Corresponding Author: Sadaf Keerio,
MD Trainee, Emergency Department, Dr Ziauddin Hospital, Karachi, Pakistan
Email: SadafKeerio94@gmail.com

ABSTRACT
Background. Acute cholecystitis is a common surgical emergency requiring rapid imaging confirmation. Departmental ultrasonography is the reference standard but is frequently delayed in busy or resource-constrained emergency departments (EDs). Point-of-care ultrasound (POCUS) performed by emergency physician's offers a faster alternative, but local validation in Pakistan is sparse.

Objective. To evaluate the diagnostic accuracy of bedside ultrasonography for acute cholecystitis against departmental ultrasonography as the gold standard.

Methods. A cross-sectional analytical study enrolled 138 adults presenting with right upper quadrant or epigastric pain to the ED of Dr. Ziauddin Hospital, Karachi. Bedside ultrasonography was performed by emergency physicians/residents using a standardized RUQ protocol; departmental ultrasonography was performed independently by radiologists, blinded to bedside findings. Sensitivity, specificity, predictive values, accuracy, Cohen's κ, and 95% Wilson confidence intervals were computed. Subgroup analyses examined gender, age, and diabetes status.

Results. Mean age was 44.2 ± 13.6 years; 62.3% were female and 30.4% had diabetes. Departmental ultrasonography confirmed acute cholecystitis in 110/138 patients (79.7%). Bedside ultrasonography yielded a sensitivity of 89.1% (95% CI 81.9–93.6), specificity of 78.6% (60.5–89.8), PPV 94.2%, NPV 64.7%, and overall accuracy 87.0%. Cohen's κ was 0.627 (substantial agreement). Performance was comparable across gender ($p = 0.91$) and age ($p = 0.62$) and modestly lower in diabetics (83.3% vs 88.5%; $p = 0.40$). Mean time-to-scan was 12 ± 6 minutes for POCUS versus 85 ± 40 minutes for departmental imaging.

Conclusion. Bedside ultrasonography performed by emergency physicians is a sensitive, accurate, and substantially faster diagnostic tool for acute cholecystitis in a Pakistani tertiary ED. POCUS does not replace departmental imaging particularly for advanced complications but its operational advantages support wider integration into emergency medicine training and practice in resource-limited settings.

Keywords: Acute Cholecystitis, Gallstones, Point-Of-Care Ultrasound, Emergency Medicine, Diagnostic Accuracy, Pakistan.

INTRODUCTION
Gallstone disease is one of the most common gastrointestinal disorders worldwide, affecting an estimated 10–20% of adults[1] and accounting for a substantial share of acute abdominal presentations to emergency departments (EDs)[2]. Acute cholecystitis most often arising from cystic-duct obstruction by gallstones, is a leading surgical emergency, with delayed diagnosis associated with progression to gangrenous cholecystitis, perforation, and biliary sepsis[3]. Modern understanding of stone formation centres on the imbalance between cholesterol, bile salts, and phospholipids in bile, modulated by gallbladder hypomotility and a range of metabolic determinants[4]. In Pakistan,

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population-based data from Karachi report a gallstone prevalence of approximately 10%, with strong female predominance (≈3:1)[5], and the regional burden continues to rise alongside obesity and type-2 diabetes.

Departmental ultrasonography performed by radiologists is the established first-line imaging modality and reference standard for acute cholecystitis, with reported sensitivity and specificity exceeding 85–90% in experienced hands[6]. The Tokyo Guidelines (TG13/TG18) operationalize this dependence on imaging by requiring concordant local signs, systemic inflammatory markers, and characteristic ultrasonographic findings to establish a definite diagnosis[7]. In real-world Pakistani EDs, however, access to formal radiology is frequently constrained by after-hours staffing, fasting requirements, and the logistics of transferring unstable patients to the imaging suite[8]. These delays can postpone definitive treatment in a time-sensitive condition.

Point-of-care ultrasound (POCUS), performed at the bedside by emergency clinicians, has emerged internationally as a rapid, radiation-free adjunct to clinical assessment[9], and has been described as the "visual stethoscope" of contemporary emergency medicine[10]. International meta-analytic data place its pooled sensitivity at roughly 87% and specificity at 82% for acute cholecystitis when performed by trained emergency physicians[11]. POCUS has also been shown to be deployable in low- and middle-income settings, where access to formal radiology is constrained[12]. Despite this evidence base, locally validated accuracy data from Pakistani EDs remain scarce, and skepticism about operator-level reliability persists. The present study addresses this gap by directly comparing bedside ultrasonography performed by emergency physicians and residents against departmental ultrasonography in a tertiary-care Pakistani ED.

METHODS

Study Design and Setting

This cross-sectional analytical diagnostic-accuracy study was conducted in the Emergency Department of Dr. Ziauddin Hospital, North Nazimabad Campus, Karachi, a tertiary-care facility staffed continuously by emergency physicians and accredited residents and equipped with portable ultrasound. Each enrolled patient underwent both an index test (bedside ultrasonography) and the reference standard (departmental ultrasonography) in sequence at a single visit.

Participants

Consecutive adults (≥ 18 years) presenting with right upper quadrant or epigastric pain clinically suspicious for biliary disease were screened. Patients were included if they could provide informed consent. Exclusion criteria were prior cholecystectomy, alternative confirmed diagnoses (acute viral hepatitis, dengue fever, or pancreatitis), and conditions precluding adequate scanning (severe obesity, subcutaneous emphysema, excessive bowel gas, or hemodynamic instability).

Sample Size

The required sample size was calculated using the standard formula for a single proportion ($n = Z^2 \cdot P(1-P)/d^2$), assuming an expected gallstone prevalence of 10% in the local population[5], a 95% confidence level ($Z = 1.96$), and a 5% margin of error ($d = 0.05$). This yielded a target sample of 138 patients.

Index Test: Bedside Ultrasonography

Bedside scans were performed at the patient's stretcher by emergency physicians or residents using a portable curvilinear-probe ultrasound machine and a standardized right-upper-quadrant protocol. Examiners assessed for gallstones (hyperechoic foci with posterior acoustic shadowing), gallbladder wall thickness > 3 mm, wall edema, pericholecystic fluid, and a sonographic Murphy's sign. Findings were recorded on a structured proforma immediately after the scan, prior to and blinded from the radiologist's report.

Reference Standard: Departmental Ultrasonography

Comprehensive hepatobiliary ultrasonography was subsequently performed by radiologists in the radiology department using high-resolution equipment, with interpretation blinded to bedside findings. The radiologist report was treated as the gold standard.

Statistical Analysis

Continuous variables are summarized as mean ± standard deviation and categorical variables as frequencies and percentages. Sensitivity, specificity, positive and negative predictive values, and overall accuracy were calculated against the radiologist reference, with 95% confidence intervals derived using the Wilson score method. Inter-method agreement was quantified with Cohen's κ; a paired McNemar test was performed for discordant pairs. Subgroup performance by sex, age (< 40 vs ≥ 40 years), and diabetes status was compared using χ^2 tests; $p < 0.05$ was considered significant. Analyses were performed in SPSS version 21.

Ethics

The protocol was approved by the Institutional Review Board of Dr. Ziauddin University Hospital. Written informed consent was obtained from every participant. Bedside ultrasonography was performed at no cost to patients and did not delay routine clinical care; participation was voluntary and did not affect management.

RESULTS

Cohort characteristics

All 138 enrolled patients completed both index and reference imaging; none were lost to follow-up. The cohort was predominantly female (62.3%) with a mean age of 44.2 ± 13.6 years (range 19–78). Diabetes was present in 30.4% and hypertension in 26.1%. Right upper quadrant pain was the dominant complaint (95.7%), and a clinical Murphy's sign was elicited in 81.2% (Table 1).

Table 1. Demographic and Clinical Characteristics of the Study Cohort (N = 138).

Variable	Value, n (%) or mean ± SD
Total patients	138 (100%)
Female	86 (62.3%)
Male	52 (37.7%)
Age (years)	44.2 ± 13.6
Diabetes mellitus	42 (30.4%)
Hypertension	36 (26.1%)
Obesity (BMI ≥ 30)	34 (24.6%)
Right upper quadrant pain	132 (95.7%)
Nausea / vomiting	94 (68.1%)
Fever	78 (56.5%)
Clinical Murphy's sign positive	112 (81.2%)

Imaging Findings

Departmental ultrasonography confirmed acute cholecystitis in 110 patients (79.7%); gallstones were detected in 116 (84.1%), wall thickening in 88 (63.8%), and pericholecystic fluid in 30 (21.7%). Bedside ultrasonography classified 104 patients (75.4%) as positive for acute cholecystitis, with gallstones identified in 112 (81.2%), wall thickening in 84 (60.9%), pericholecystic fluid in 28 (20.3%), and a sonographic Murphy's sign in 96 (69.6%). The 2 × 2 contingency of paired findings is presented in Table 2.

Table 2. Bedside vs. Departmental Ultrasonography for Acute Cholecystitis

	Departmental US +	**Departmental US −**	**Total**
Bedside US positive	98 (TP)	6 (FP)	104
Bedside US negative	12 (FN)	22 (TN)	34
Total	**110**	**28**	**138**

Diagnostic Performance

Against the radiologist reference, bedside ultrasonography demonstrated a sensitivity of 89.1% (95% CI 81.9–93.6) and a specificity of 78.6% (60.5–89.8), with PPV 94.2%, NPV 64.7%, and overall accuracy 87.0% (Table 3). Cohen's κ was 0.627, indicating substantial inter-method agreement, and the McNemar test on discordant pairs (12 false negatives vs 6 false positives) was non-significant ($\chi^2 = 1.39$; $p = 0.24$), consistent with no systematic directional disagreement between modalities.

Table 3. Diagnostic Performance of Bedside Ultrasonography (Reference: Departmental Ultrasonography)

Metric	Estimate	95% CI (Wilson)
Sensitivity	89.1%	81.9 – 93.6
Specificity	78.6%	60.5 – 89.8
Positive predictive value	94.2%	88.0 – 97.3
Negative predictive value	64.7%	47.9 – 78.5
Overall accuracy	87.0%	—
Cohen's κ (agreement)	0.627	Substantial

Subgroup Analyses

Diagnostic performance was comparable across sex and age strata, with no significant subgroup differences (Table 4). Accuracy was modestly lower in patients with diabetes (83.3%) than in non-diabetics (88.5%), although this difference did not reach statistical significance ($p = 0.40$)—a pattern consistent with the well-documented atypical presentations and subtler ultrasonographic findings in diabetic cholecystitis.

Table 4. Diagnostic Performance of Bedside Ultrasonography by Subgroup

Subgroup (n)	Sens.	Spec.	Acc.	p
Female (86)	90.2%	76.9%	87.2%	0.91

Male (52)	87.5%	80.0%	86.5%	
< 40 y (54)	88.0%	77.8%	85.2%	0.62
≥ 40 y (84)	90.0%	79.2%	88.1%	
Diabetic (42)	85.7%	75.0%	83.3%	0.40
Non-diabetic (96)	91.2%	80.0%	88.5%	

Time-To-Diagnosis and Complications

Bedside ultrasonography was completed substantially faster than departmental imaging (mean 12 ± 6 minutes vs 85 ± 40 minutes from ED arrival), translating to an approximately seven-fold reduction in time-to-scan. Advanced complications were uncommon overall: empyema in 6 patients (4.3%), gangrenous cholecystitis in 4 (2.9%), and gallbladder perforation in 2 (1.4%). Departmental ultrasonography identified all of these; only about half were prospectively suspected on bedside scanning, indicating reduced sensitivity of POCUS for advanced disease.

DISCUSSION

In this prospective single-centre Pakistani cohort, bedside ultrasonography performed by emergency physicians and residents demonstrated 89.1% sensitivity, 78.6% specificity, 87.0% overall accuracy, and substantial agreement with departmental ultrasonography (κ = 0.627). Time-to-scan was reduced approximately seven-fold. To our knowledge, this is among the first locally validated diagnostic-accuracy studies of POCUS for acute cholecystitis in a Pakistani tertiary ED.

Our sensitivity is concordant with published international meta-analytic estimates of 80–90% for emergency-physician-performed gallbladder POCUS[11] and aligns with single-centre prospective and retrospective accuracy reports from North America[13][14]. The high PPV (94.2%) suggests that a positive bedside scan in this clinical population reliably identifies true disease. Specificity (78.6%) and NPV (64.7%) were lower than some Western reports, however, reflecting both the high pre-test probability of disease in our cohort (79.7% prevalence) and the inherent operator-dependence of POCUS for subtle findings such as mild wall thickening and small pericholecystic collections[15]. Comparable patterns have been described in synthesised reviews of right-upper-quadrant imaging accuracy, where ultrasound consistently outperforms computed tomography for biliary calculi but shows greater operator-related variance for inflammatory features[16]. The clinical implication is that a negative bedside scan in a high-risk patient should not be used to definitively exclude acute cholecystitis; integration with clinical and laboratory criteria, as proposed by structured bedside scores[17], and confirmatory departmental imaging remain warranted.

The modest reduction in accuracy among patients with diabetes (83.3% vs 88.5%) mirrors prior observations that autonomic neuropathy and a blunted inflammatory response can produce atypical or muted sonographic features in this group[18]. Similar challenges have been reported when applying severity-grading systems—such as the AAST EGS grade and the Tokyo Guidelines—to elderly and metabolically complex cohorts[19]. Although the subgroup difference was not statistically significant in our data, it is clinically relevant and underscores the need for a low threshold for departmental imaging in diabetic patients with persistent suspicion. In contrast, diagnostic performance was stable across sex and age strata, supporting the broader applicability of POCUS in routine ED workflow[20].

The roughly seven-fold reduction in time-to-diagnosis (12 vs 85 minutes) is the most operationally consequential finding. In a high-volume Pakistani ED where after-hours radiologist availability, fasting requirements, and patient-transfer logistics commonly delay departmental imaging[8] immediate bedside imaging can shorten the interval to surgical consultation, antibiotic initiation, and disposition. Combining bedside ultrasound with structured inflammatory marker assessment further increases diagnostic yield against the Tokyo Guidelines reference[21]. POCUS was, however, less reliable for detecting advanced complications (empyema, gangrene, perforation), where comprehensive radiology examination retained its diagnostic edge. Integrating prospectively validated bedside scoring tools[22] with POCUS may help formalize this triage role, with departmental ultrasonography reserved for inconclusive cases, suspected complications, and clinically equivocal presentations.

Strengths and limitations

Strengths of this study include a prospective design with paired imaging in every patient, blinded interpretation of the reference standard, an a priori sample-size calculation, and reporting of confidence intervals and inter-rater agreement. Limitations are the single-centre tertiary-care setting (which may overstate POCUS performance relative to community EDs); the absence of formal stratification by operator experience, which is known to influence accuracy; the lack of cross-validation against HIDA scintigraphy or surgical/histopathological outcomes; and the under-representation of advanced complications, which precluded formal accuracy analysis for that subgroup. The relatively low NPV must also be interpreted in the context of high disease prevalence in the enrolled population.

Implications and future directions
These data support the integration of structured POCUS training into emergency-medicine curricula in Pakistan[23] and the formal incorporation of bedside ultrasound into ED triage pathways for suspected biliary disease. Given the regional epidemiology of gallstone disease including distinct compositional and demographic patterns documented in Pakistani cohorts[24] multi-centre validation across community and tertiary settings, formal stratification by operator competency, integration with the Tokyo Guidelines (TG18) clinical-laboratory framework, and cost-effectiveness analyses would strengthen the local evidence base. Emerging artificial-intelligence-assisted ultrasound interpretation may further mitigate operator dependence and merits prospective evaluation in this setting.

CONCLUSION

Bedside ultrasonography performed by emergency physicians and residents in a Pakistani tertiary-care ED is a sensitive, accurate, and substantially faster diagnostic tool for acute cholecystitis, with substantial agreement against departmental ultrasonography. It does not replace radiologist-performed imaging—particularly for advanced complications and in cases where a negative bedside study would otherwise drive disposition—but its operational advantages strongly support broader adoption of POCUS in Pakistani emergency medicine.

Declarations

Ethics Approval: Approved by the Institutional Review Board of Dr. Ziauddin University Hospital. Written informed consent was obtained from all participants.

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Conflicts of interest. The authors declare no competing interests.

Data Availability: De-identified data are available from the corresponding author on reasonable request.

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