



Enhanced Diagnostic Precision in Revisited Emergency Patients via Point-of-Care Ultrasound: A Tool for Emergency Department Quality Management

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Purpose: Unscheduled return visits to the emergency department (ED) were categorized into physician-related, illness-related, and patient-related factors, which are associated with an increased risk of adverse health outcomes, including patient dissatisfaction, infections, hospitalization, transfer to another facility, and mortality. Individuals within 48–72 hours of the initial visit are deemed at elevated risk for diagnostic or management-related errors. The Point-of-care ultrasound (POCUS) may serve as a bedside tool to reduce medical errors by enhancing diagnostic precision. This study aims to determine the diagnostic accuracy of POCUS for detecting various illnesses in revisited patients in the emergency department.

Patients and Methods: A retrospective observational study was conducted on unplanned revisits by patients to the emergency department within 72 hours, spanning the period from January 2023 to September 2024. Sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio were evaluated based on electronic emergency department medical records and ultrasound documentation.

Results: Five hundred seventy patients were included in this study. POCUS demonstrated a diagnostic accuracy of 75.61% (95% CI 71.87, 79.09), a sensitivity of 81.87% (95% CI 77.65, 85.58), a specificity of 62.50% (95% CI 55.08, 69.51), a positive likelihood ratio of 2.18 (95% CI 1.80, 2.65), and a negative likelihood ratio of 0.29 (95% CI 0.23, 0.37).

Conclusion: POCUS demonstrated greater diagnostic accuracy, which may enhance diagnostic precision in revisited patients with various illnesses.

Keywords: precision medicine, ultrasound, revisit, emergency department, quality

Introduction

Unplanned emergency department (ED) visits pose a significant challenge for emergency care facilities and serve as a reflection of their overall quality of care. This is a critical key performance indicator for emergency medical services.^{1–3} An unscheduled revisit is defined as a patient returning to the ED within 72 hours of discharge for the same issue.^{4–6} Unplanned 72-hour ED returns account for approximately 4% of all ED visits.^{7–10} Factors contributing to ED revisits include those related to the patient's illness, ED treatment, and the medical service system. The nature of the disease, medical errors, patient satisfaction, and inadequate assessment or treatment during the initial ED visit may all play a role. Patients who return to the emergency department within 48–72 hours of their initial visit are considered at high risk for diagnostic or management-related errors.^{11,12} Most studies have focused on reducing preventable medical errors to enhance the quality of emergency healthcare.^{1,2,13}

Point-of-care ultrasound (POCUS) has been widely utilized by attending emergency physicians at the bedside as an additional diagnostic tool for various conditions in the emergency department. Most studies have concluded that POCUS can enhance diagnostic accuracy, particularly in life-threatening situations.^{14–17} For revisited patients, improved diagnostic accuracy was crucial in minimizing medical errors and ED treatment. Our hypothesis was that the use of POCUS on revisited patients would improve diagnostic precision and reduce medical errors caused by physicians. The primary objective of this study was to determine the diagnostic precision of POCUS performed on revisited emergency patients.

Materials and Methods

This was a retrospective review of computerized medical records conducted at the Department of Emergency Medicine, Srinagarind Hospital, Khon Kaen University, Thailand, from January 2023 to September 2024. The main objective of this study was to investigate the diagnostic precision of POCUS in revisited emergency patients.

Srinagarind Hospital is a college of medicine hospital affiliated with Khon Kaen University's Faculty of Medicine. Located in Khon Kaen, Thailand, it serves approximately 60,000 to 70,000 emergency patients annually.

Data Collection

Adult patients (age >18 years) admitted to the ED within 72 hours of their first visit with the same issue and who underwent POCUS between January 2023 and September 2024 were included in this study. Patients without ultrasound documentation or those transferred to another institution were excluded.

The principal investigator extracted electronic medical records using the Health Object Program[®], an authorized electronic medical records system, and assigned each patient an anonymous identifier. Extracted data from patients who revisited the ED within 72 hours for the same issue included demographic information from the patient's profile, the final diagnosis recorded and defined by the ICD-10 International Classification of Diseases (used as the reference test), and the POCUS examination results.

POCUS was frequently conducted as a standard assessment on patients in the emergency room, including ultrasound assessments from head to toe. Each patient was evaluated by a designated attending physician, comprising emergency medicine residents who had completed one month of ultrasound residency training and emergency doctors with over five years of expertise in POCUS. The decision about how to conduct POCUS at that moment was dependent upon individuals.

The ultrasound curriculum comprised a one-month rotation for first-year emergency medicine residents, featuring didactic lectures totaling 300 minutes, with each class lasting 30 minutes to 1 hour across ten distinct content areas: (1) cardiac, (2) pulmonary, (3) abdominal, (4) aortic, (5) deep venous thrombosis, (6) soft tissue and musculoskeletal, (7) ocular, (8) renal and urinary system, (9) obstetric and gynecologic system, and (10) procedural guidance and POCUS protocol, supplemented by 18 hours of bedside ultrasound instruction with actual patients.

The final diagnosis in this study served as the reference test and was classified according to the ICD-10 International Classification of Diseases, 10th edition. The attending physician responsible for the case documented the ICD-10, employing (1) clinical evaluation, (2) laboratory tests, and/or (3) formal imaging procedures, including chest radiography or chest computed tomography (CT), for diagnosing thoracic conditions such as pneumothorax, pneumonia, and pulmonary embolism; abdominal ultrasound conducted by the emergency radiology service or abdominal CT for diagnosing abdominal conditions such as appendicitis, diverticulitis, and abdominal aortic aneurysm; and transthoracic echocardiography (TTE) performed by cardiologists for diagnosing cardiac conditions such as myocardial infarction and infective endocarditis.

The accuracy of detecting sonographic pathological findings for each anatomical region was assessed across the entire population with abnormal POCUS results. Discrepancies between POCUS findings and the final diagnosis were analyzed and classified as false positives or false negatives. The Mindray M9 ultrasound machine (Mindray, Shenzhen, China) was used for POCUS examinations, employing either a convex, phased array, or linear probe depending on the anatomical site under examination.

Data was compiled and organized into a research database by two independent investigators, who reviewed and removed any duplicate entries. Our investigators gathered the data following the patients' final diagnosis at the time of

their discharge from our hospital. Our investigators were not affiliated with the clinicians responsible for patient care. The data set contained null values, with columns having more than half of the rows as null being removed. In cases of data inconsistencies, the senior investigator, who has over ten years of experience in this field, was consulted to ensure data accuracy.

Sample Size

The sample size for the diagnostic test was determined based on an estimated prevalence of 0.32 with a standard normal value of 1.96. The power analysis was conducted with an alpha of 0.05. Specificity was set at 1.0, with $1 - \text{specificity}$ at 0.956, and an absolute precision of 0.1 according to previous study.¹⁴ This resulted in an estimated desired sample size of 541 subjects.

Statistical Analysis

Continuous variables in the data were summarized using mean and standard deviation or median and range, as appropriate. Categorical variables were summarized with counts and percentages. Prevalence, accuracy, sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio were calculated.¹⁸ Data were entered into Microsoft Excel and analyzed using IBM SPSS for Windows version 27.0, licensed to Khon Kaen University (SPSS Inc., Chicago, Illinois, USA).

Results

A total of 3200 patients revisited the ED during the study period, with 1650 (51.56%) representing unplanned visits within 72 hours. Of these, 325 patients (10.16%) were excluded due to presenting different complaints compared to their first ED visit. Among the remaining patients, 1025 (32.03%) underwent POCUS in the emergency department. The study ultimately included 570 patients (17.81%) with complete data. Of these, 51.9% were male, with a median age of 65.7 years (IQR 50.12–85.27). The most prevalent chief complaints among revisiting patients were related to the gastrointestinal and hepatobiliary systems. This study identified abnormal ultrasound findings in 385 patients (67.54%), with the most prevalent pathologies being reduced left ventricular systolic function at 10%, local B-lines at 9.59%, and free abdominal fluid at 9.06%, as detailed in Table 1.

POCUS exhibited an overall diagnostic accuracy of 75.61%, with a sensitivity of 81.87% and a specificity of 62.50%. Abnormal POCUS findings were most commonly observed in musculoskeletal (69.70%), cardiac (64.62%), and abdominal (62.75%) assessments. POCUS demonstrated high diagnostic accuracy in cardiac (87.69%), renal (86.96%), and abdominal (83.81%) evaluations. Table 2 provides an overview of the primary outcomes of this study.

Table 1 Baseline Characteristics of Unplanned Revisited Patients Who Underwent POCUS

Variables	Revisited Patients Within 72 hours Who Underwent POCUS (N = 570)
Age (year), median (IQR)	65.70 (50.12, 85.27)
Women, %	296 (51.90)
Triage level, %	
Resuscitation (1)	7 (1.23)
Emergent (2)	121 (21.23)
Urgent (3)	410 (71.90)
Non urgent (4)	32 (5.61)

(Continued)

Table 1 (Continued).

Variables	Revisited Patients Within 72 hours Who Underwent POCUS (N = 570)
Chief complaint divided by organ system, %	
The central nervous system	42 (7.37)
The cardiovascular system	65 (11.40)
The respiratory system	121 (21.23)
The gastrointestinal system	134 (23.52)
The hepatobiliary system	113 (19.82)
The kidney and urinary bladder system	46 (8.07)
The obstetrics and gynecology	15 (2.63)
The musculoskeletal system	34 (5.96)
Abnormal POCUS findings, %	386 (67.72)
Reduced left ventricle systolic contraction	40 (10.00)
Right ventricle strain	4 (1.03)
Pericardial effusion	2 (0.51)
Pleural effusion	10 (2.59)
Diffused B-lines	21 (5.44)
Local B-lines	37 (9.59)
Pneumothorax	4 (1.03)
Free fluid in abdomen	35 (9.06)
Liver mass	22 (5.69)
Intrahepatic duct dilated	16 (4.15)
Abdominal aortic aneurysm	11 (2.84)
Gall bladder wall thickening > 4 mm.	30 (7.77)
Gall stone	12 (3.11)
Enlarged diameter of appendix \geq 6 mm.	24 (6.22)
Diverticulum	4 (1.03)
Pancreatic pseudocyst	1 (0.25)
Hydronephrosis	10 (2.59)
Twinkle artifact in kidney and urinary bladder system	3 (0.78)
Cobblestone appearance in soft tissue	20 (5.18)
Abscess	4 (1.03)
Retain foreign bodies in musculoskeletal system	1 (0.25)
Deep venous thrombosis	2 (0.51)

(Continued)

Table 1 (Continued).

Variables	Revisited Patients Within 72 hours Who Underwent POCUS (N = 570)
Ovarian cyst	4 (1.03)
Free fluid in pelvic area	2 (0.51)
Pelvic mass	1 (0.25)

Abbreviations: IQR, Interquartile range; POCUS, Point of Care Ultrasound; mm, Millimeter.

Table 2 Overview of the Primary Metrics for Assessing the Accuracy of POCUS

Abnormal POCUS Study	Prevalence % (95% CI)	Accuracy % (95% CI)	Sensitivity % (95% CI)	Specificity % (95% CI)	+LR (95% CI)	+LR (95% CI)
Overall	67.72 (63.71, 71.54)	75.61 (71.87, 79.09)	81.87 (77.65, 85.58)	62.50 (55.08, 69.51)	2.18 (1.80, 2.65)	0.29 (0.23, 0.37)
Cardiac	64.62 (51.77, 76.08)	87.69 (77.18, 94.53)	88.10 (74.37, 96.02)	86.96 (66.41, 97.22)	6.75 (2.34, 19.52)	0.14 (0.06, 0.32)
Thoracic	51.24 (41.99, 60.43)	75.21 (66.54, 82.60)	82.26 (70.47, 90.80)	67.80 (54.36, 79.38)	2.55 (1.73, 3.76)	0.26 (0.15, 0.46)
Abdomen	62.75 (56.40, 68.80)	83.81 (78.61, 88.17)	85.16 (78.57, 90.36)	81.52 (72.07, 88.85)	4.61 (2.99, 7.11)	0.18 (0.12, 0.27)
OB-GYN	60.00 (32.29, 83.66)	80.00 (51.91, 95.67)	88.89 (51.75, 99.72)	66.67 (22.28, 95.67)	2.67 (0.84, 8.46)	0.17 (0.02, 1.15)
KUB	28.26 (15.99, 43.46)	86.96 (73.74, 95.06)	76.92 (46.19, 94.96)	90.91 (75.67, 98.08)	8.46 (2.76, 25.91)	0.25 (0.09, 0.69)
MSK	69.70 (51.29, 84.41)	60.61 (42.14, 77.09)	56.52 (34.49, 76.81)	70.00 (34.75, 93.33)	1.88 (0.68, 5.19)	0.62 (0.33, 1.15)

Abbreviations: CI, Confidence interval; LR, Likelihood Ratio; POCUS, Point of Care Ultrasound; OB-GYN, Obstetrics and gynecology; KUB, Kidney and urinary bladder system; MSK, musculoskeletal.

Discussion

Unplanned revisits significantly compromise the quality of care provided by the emergency department. Physician-related factors, such as misdiagnosis, management errors, and disposition decisions, were identified as critical contributors to patient revisits.^{3,4} POCUS, a widely utilized bedside diagnostic tool in the emergency department, could play an important role as part of advanced precision medicine to address these issues and enhance ED management.^{19–21}

This study demonstrated that POCUS has a diagnostic accuracy of 75.61% for prevalent diseases found in revisited ED patients, with a sensitivity of 81.87%, specificity of 62.50%, and a positive likelihood ratio of 2.18 for overall assessments. Most prior studies have reported a range of diagnostic accuracy for POCUS in various conditions within the ED.^{15–17,22–24} However, one study that evaluated overall diagnostic accuracy for POCUS in the emergency department yielded findings inconsistent with ours, reporting a higher diagnostic accuracy—exceeding 95% for common conditions encountered in the ED, with specificity over 90%.¹⁴ This discrepancy may be explained by the fact that the majority of POCUS examinations in our department were performed by emergency medicine residents, who may possess differing levels of proficiency. Our findings indicated a positive likelihood ratio of 2.18, suggesting that abnormal POCUS findings in revisited patients may serve as a useful diagnostic tool, effectively doubling the accuracy of disease identification.

Our study found that cardiac POCUS exhibited the highest performance, achieving an accuracy of 87.69%, sensitivity of 88.10%, specificity of 86.96%, and a high positive likelihood ratio of 6.75. These results are consistent with previous research demonstrating 79.3% sensitivity and 87.3% specificity for detecting acute myocardial ischemia.²⁵ Another study reported a positive likelihood ratio for detecting pulmonary edema with lung POCUS (7.4, 95% CI 4.2, 12.8) and reduced ejection fraction observed via bedside echocardiogram (4.1, 95% CI 2.4, 7.2).²⁶ Thus, cardiac POCUS proved particularly advantageous for identifying acute myocardial ischemia, reduced left ventricular function, and pulmonary edema.

It is also worth noting that abdominal pain was one of the primary complaints among revisited patients. Previous studies have shown that such patients are often elderly and exhibit a high rate of hospital admission.²⁷ These patients typically require extensive resources for illness investigation. Our study demonstrated that abdominal POCUS, including gastrointestinal and hepatobiliary ultrasound, exhibited excellent accuracy (83.81%), sensitivity (85.16%), and specificity (81.52%). This suggests that POCUS may assist in managing patients with abdominal pain who might otherwise require advanced imaging, such as a computed tomography scan, which may be unavailable in some hospitals.

Conversely, musculoskeletal POCUS in our study displayed the lowest diagnostic accuracy, at 60.61%, with a sensitivity of 56.5% and specificity of 70.00%. This finding aligns with prior research indicating a significant prevalence of false positives and false negatives in this domain.¹⁴

Currently, modern technology is widely utilized in medical practice.^{28–31} POCUS represents a novel innovation that may serve as a tool for supporting clinical medicine and healthcare systems. In low to middle-income countries, POCUS emerged as a novice instrument for emergency physicians. In Thailand, POCUS has been recognized by emergency physicians, general practitioners, and interns with fewer than 15 years of experience. Moreover, the POCUS education was constrained by a shortage of specialists. The strength of our study was the application of POCUS in reassessed patients, aimed at reducing medical mistakes in healthcare system according to enhanced precision medicine. However, the limitations of this study include: (1) it was a single-center investigation, potentially introducing bias regarding the study population compared to other institutions; (2) it was a retrospective observational study, with the decision to perform POCUS on revisited patients based on physician preference; (3) the proficiency of POCUS practitioners varied; (4) the knowledge and competence of the ultrasonographic operators including inter- and intra-operator variability were not evaluated in this study; (5) This study reported the overall accuracy of POCUS, which does not concentrate on specific conditions. Future research may need to concentrate on particular conditions or conduct subgroup analyses to enhance applicability.

Conclusion

POCUS is a valuable and widely accessible tool that can enhance and support emergency physicians' decision-making for revisited patients admitted to the emergency department. POCUS demonstrates high diagnostic accuracy and a strong positive likelihood ratio, enabling it to effectively validate suspected conditions. However, additional diagnostic testing may be required for certain specific diseases, particularly in the context of musculoskeletal POCUS. Further investigation is needed to externally validate and better characterize the association between POCUS and specific illnesses identified in revisited emergency patients.

Abbreviations

ED, Emergency Department; POCUS, Point-of-Care Ultrasound; CI, Confidence Interval; LR, Likelihood Ratio; OB-GYN, Obstetrics and Gynecology; KUB, Kidney and Urinary Bladder System; MSK, Musculoskeletal.

Data Sharing Statement

The datasets analyzed during the current study are not publicly available due to the inclusion of information that could compromise patient confidentiality but are available from the corresponding author upon reasonable request.

Ethics Approval and Informed Consent

The Khon Kaen University Ethics Committee for Human Research approved the study, which adhered to the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines (HE671605). The requirement for informed consent was waived. To ensure confidentiality, all identifiers were removed from the collected data.

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Author Contributions

All authors made significant contributions to the reported work, including conception, study design, execution, data acquisition, analysis, and interpretation. They were involved in drafting, revising, or critically reviewing the article; provided final approval of the version to be published; consented to submission to the journal; and accepted responsibility for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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