Original Article

POCUS Findings in Critically Ill Patients in Emergency Department

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Background: Point of care ultrasound (POCUS) has been shown to improve diagnostic accuracy and has been used in a variety of contexts. However, the utility of POCUS as applied to critically ill patients has not been well studied.

Materials and Methods: This was a retrospective descriptive study of critically ill patients who had received POCUS at Srinagarind Hospital's Emergency Medical Department between July 2019 and June 2020. Data was collected from one year of POCUS studies and included ultrasound clips and images, patient age and sex, chief complaint, final diagnosis, and patient disposition. The data was described using descriptive statistics, including medians, counts and percentages.

Results: POCUS data was collected from 2,500 studies performed on 369 patients. Median patient age was 62.7 years; 51.6% of patients were female. Top indications of POCUS scans were of respiratory (34.42%) and cardiovascular system (23.58%) presentations. The most frequent study types performed were cardiac, lung, and inferior vena cava examinations. Abnormal ultrasound findings were found in 258 patients (69.92%). True-positive ultrasound results were found in 162 patients (43.9%). The admission rate of critically ill patients was highest among patients who had true-positive results.

Conclusion: The prevalence of positive POCUS results was quite high in critically ill patients. Moreover, POCUS showed high accuracy. The number of admitted patients was highest among patients who had true-positive ultrasound results.

Keywords: Ultrasonography, Critical illness, Emergency medicine

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Point of care ultrasound (POCUS) is an important aspect of care administered to emergency department patients. It can be used to help to diagnose and perform procedures. POCUS is now widely used in emergency care, especially among emergency medicine physicians, to take care of critically ill patients[1]. It has benefited critically ill patients by shortening ED length-of-stay, reducing laboratory testing wait time, and reducing time normally allotted to completing CT imaging[2]. Moreover, POCUS has been shown to help improve the overall outcomes of patient care in emergency departments[3]. Previous studies have examined selected groups of patients, such as those with trauma, shock, dyspnea, or other already known diagnoses[4-9]. With the introduction of POCUS and training of emergency medicine residents, POCUS has been increasingly used in emergency departments throughout Thailand. However, ultrasound findings in undifferentiated critically ill patients have yet to be documented. The present study aimed to determine prevalence of positive POCUS results among critically ill patients in the Accident and Emergency Department of Srinagarind Hospital, Faculty of Medicine, Khon Kaen University.

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Materials and Methods

Study design

This was a retrospective, single-center, observational study carried out at the Department of Emergency Medicine of a tertiary university hospital in Thailand. Ethics approval was provided by the Khon Kaen University Ethics Committee for Human Research and was registered with the Thai Clinical Trials Registry (HE631355).

Sample size

We included critically ill patients who had undergone ultrasounds with video clips or images recorded in the ultrasound machine of the emergency department from July 2019 to June 2020. Patients without ultrasound

documents were excluded. A sample size for the analysis was determined using a number of prevalence of 0.4[10] and standard normal value of 1.96. The power analysis was determined using an alpha of 0.05 and an absolute precision of 0.05, resulting in an estimated desired effect sample size of 369 subjects.

Study protocol

The study was performed between July 2019 and June 2020. We collected data from critically ill patients (defined as patients admitted to the emergency department who were triaged to Emergency Severity Index levels 1 or 2). Ultrasounds were performed by emergency medicine residents and attending physicians. Data collection forms were completed by emergency medicine residents. Data collected for the present study included ultrasound findings from video clips and images recorded using the ultrasound machine at the emergency department, as well as the patients' age, gender, chief complaint, final diagnosis and patients' disposition status obtained from medical charts and computerized records. All diagnoses were categorized according to organ-systems. A positive ultrasound result was defined as a clear abnormality detected by ultrasound. A negative ultrasound result was defined as unclear findings or a finding of no obvious abnormality. All ultrasound video clips and images were reviewed by one emergency ultrasound specialist and one critical care physician. If ultrasound findings and final diagnosis were the same, the ultrasound finding was considered a true-positive result. If both the ultrasound finding and the final diagnosis were "negative" then this was considered a true-negative result. An inconsistency between an ultrasound finding and final diagnosis was either a false-positive or false-negative ultrasound result.

The present study was primarily aimed at determining the prevalence of positive ultrasound results when POCUS is used to examine critically ill patients admitted to the emergency department and the outcomes of critically ill patients.

Ultrasound equipment

The present study was conducted with a standard Mindray M9 ultrasound machine that was used in the resuscitation room of the emergency department according to protocol. Images can be obtained in B mode, M mode, and color Doppler and power Doppler modes. In terms of transducers, we provided curvilinear, linear, and phased array probes.

Statistical analysis

Continuous-type variables in the data were summarized as mean and standard deviation (SD) or median and range as appropriate. Categorical variables were summarized as counts and percentages. All statistical analyses were performed using the software Stata version 10.1 (Stata Corp, College Drive, TX, USA). Statistical significance was defined as a two-sided *p*-value of 0.05 or less.

Results

From July 2019 to June 2020, this study included 369 patients, on which 2,500 POCUS examinations were carried out at the Department of Emergency Medicine. The median age was 62.7±17.07 years. Male and female patients were equally represented (46.34 % and 51.76%, respectively). Most patients were non-trauma patients (99.73%). The most common anatomical region examined was the cardiac region. However, most patients underwent an ultrasound examination on more than one area. Most ultrasound examinations combined cardiac, lung, and inferior vena cava imaging. POCUS revealed one or more positive findings in 258 (69.92%) of the 369 included patients (Table 1).

Top indications of ultrasound scans were respiratory (34.42%) and cardiovascular system (23.58%) presentations. In terms of chief complaint categories, we found 8 positive scans out of the 10 unique patients with skin, soft tissue, or musculoskeletal system complaints (80%); 11 positive scans out of the 14 unique patients with cardiac arrest (78.57%); and 46 positive scans out of the 59 unique patients with gastrointestinal system complaints (77.97%) (Table 2).

True-positive, true-negative, and false-positive ultrasound results were 162 (43.90%), 111 (30.08%), and 96 (26.02%), respectively. Most patients who had true-positive results (70.99%) had their disposition status reported at admission. The disposition statuses of all patients

Table 1. Patient characteristics of the study

Patient characteristics	
Sex	
Female, n (%)	191 (51.76)
Age, mean ± SD	62.7±17.07
Patient type	
Non-trauma patient, n (%)	368 (99.73)
Area of POCUS examination, n (%)	
Cardiac	297 (80.49)
Lung	147 (39.84)
Inferior vena cava	104 (28.18)
Abdomen (liver, gall bladder, ascites)	42 (11.38)
Abdominal aorta	11 (2.98)
Kidney, urinary bladder	8 (2.17)
Femoral vein	6 (1.63)
Soft tissue & musculoskeletal	5 (1.36)
OB-GYN	4 (1.08)
Appendix	2 (0.54)
EFAST examination	1 (0.27)
Other	2 (0.54)
Patients with abnormal POCUS findings, n (%)	258 (69.92)

Table 2. Abnormal POCUS findings categorized by chief complaint

Chief complaint	n (%)	Abnormal POCUS findings, n (%)
Respiratory system		
Respiratory	127 (34.42)	89 (70.08)
Cardiovascular system	87 (23.58)	61 (70.11)
Chest pain	55 (14.91)	36 (65.45)
Palpitation	14 (3.79)	14 (100)
Hypertension	7 (1.90)	3 (42.86)
Hypotension	4 (1.08)	2 (50)
Bradycardia	2 (0.54)	2 (100)
Syncope	5 (1.36)	4 (0.8)
Gastrointestinal system	59 (15.99)	46 (77.97)
Abdominal pain	47 (12.74)	38 (80.85)
Jaundice	3 (0.81)	2 (66.67)
Diarrhea	6 (1.63)	4 (66.67)
Nausea	3 (0.81)	2 (66.67)
Kidney-ureter-bladder system	4 (1.08)	2 (50)
Flank pain	1 (0.27)	0 (0)
Urinary tract infection	1 (0.27)	1 (100)
Hematuria	2 (0.54)	1 (50)
Fever		
Fever/sepsis	48 (13.01)	31 (64.58)
Neurovascular system	16 (4.34)	11 (68.75)
Alteration of conscious	8 (2.17)	4 (50)
Dizziness	4 (1.08)	4 (100)
Seizure	2 (0.54)	2 (100)
Stroke	1 (0.27)	1 (100)
Headache	1 (0.27)	1 (100)
Skin, Soft tissue and musculoskeletal system	10 (2.71)	8 (80)
Skin and soft tissue infection	6 (1.63)	5 (83.33)
Peripheral edema	3 (0.81)	3 (100)
Muscle pain	1 (0.27)	1 (100)
Other	4 (1.08)	2 (50)
Hyperkalemia	2 (0.54)	2 (100)
Hypermenorrhea	1 (0.27)	0 (0)
Trauma	1 (0.27)	0 (0)
Cardiac arrest	14 (3.79)	11 (78.57)

were shown in Table 3.

Discussion

The present study described 2,500 ultrasound examinations of critically ill patients admitted to the Department of Emergency Medicine. The top indication of ultrasound scans was respiratory presentation, which is consistent with Reynolds[11], who collected data on 784 emergency patients and found the top indications of POCUS were trauma, respiratory presentation, and abdomino-pelvic pain. The present study found a high rate of ultrasound utilization for cardiac, lung, and IVC, which accounted for over half of the scans performed in this study. Prior studies[12,13] have found higher relative rates of ultrasound utilization in FAST or EFAST examinations; however, most patients in our ER were non-trauma patients (80%). A Thai study by Wibulpolprasert[14] found that the anatomical region most commonly examined was the abdomen (80%). However, data for that study was collected from all patients referred to the Department of Radiology for emergency ultrasound rather than from patients visiting the emergency department. Our study found low prevalence of obstetric and gynecologic applications, as in Thailand, most OB-GYN ultrasounds are performed by OB-GYN physicians. In addition, many pregnant patients are evaluated directly by obstetric services rather than undergoing assessment and treatment in the emergency department. These factors likely influenced our results.

Our study found a higher rate of positive POCUS findings (69.92%) than previous research[11]. Most abnormal ultrasound findings in our study were in skin, soft tissue, and musculoskeletal systems (80%), cardiac arrest patients (78.57%) and the gastrointestinal system (77.97%). These findings differed from those of Reynolds[11], which showed that abnormalities most commonly associated with ultrasound findings were thoracic (84.4%), renal (82.1%) and cardiac (80.5%). Our study also found a high rate of true-positive results (43.90%). Moreover, most patients who had true-positive ultrasound results were admitted to the hospital. This implies that POCUS had a substantial impact on patient care, changing diagnostic impression or disposition plans, as has been found in previous studies[11,15,16]. In our study, we also found some false-positive results (26.02%) (meaning the ultrasound findings were inconsistent with the final diagnosis). These may be attributed to imperfect handling of the ultrasound equipment or inappropriate ultrasound interpretation by the clinician who performed the POCUS study.

This was the first study to look at the prevalence of positive POCUS findings in unselected emergency medicine patients who had been triaged to levels 1 or 2 according to the emergency severity index. The strengths of this study were: 1) we identified the area that is most examined using ultrasound equipment; this information can be applied to ultrasound training of emergency medicine residents; and 2) the findings from this study showed the impact of using POCUS in the Emergency Department. A limitation of this research[17-21] was that it could not verify the quality or accuracy of the ultrasound studies and interpretations; we reported only on the relationship between POCUS findings and final diagnosis/dispositions. Ultrasound is a highly operator-dependent imaging modality, and we found some false-positive results in this study. However, ultrasound use

Table 3. Patient disposition status divided by type of diagnostic accuracy by ultrasound

Diagnostic accuracy by ultrasound	n (%)	Patient disposition	n (%)
True-positive results	162 (43.90)	Admission	115 (70.99)
		Discharge	35 (21.60)
		Death	7 (4.32)
True-negative results	111 (30.08)	Admission	70 (63.06)
		Discharge	36 (32.43)
		Death	2 (1.80)
False-positive results	96 (26.02)	Admission	61 (63.54)
		Discharge	23 (23.96)
		Death	1 (1.04)
False-negative results	0 (0)	Admission	0 (0)
		Discharge	0 (0)
		Death	0 (0)

in emergency settings is necessary and impacts clinical practice. Increasing POCUS training for emergency medicine residents, who are responsible for taking care of critically ill patients, may improve clinical skills and could reduce the rate of false-positive results.

Conclusion

The prevalence of positive POCUS findings in this study was quite high. POCUS accuracy (true-positive results) in the emergency setting was good. The number of admitted patients was highest among patients who had true-positive ultrasound results.More studies are needed to evaluate the impact of POCUS on clinical decision making and its role in performing emergency interventions and outcomes in emergency settings.

What is already known on this topic?

Recent studies have investigated prevalence of POCUS use, prevalence of positive POCUS results in resource limited countries, and the impact of POCUS use on certain types of patients, such as those admitted to the ICU. However, such data for emergency patients in Thailand has yet to be gathered. Further exploration of the impact of POCUS in the emergency department appears warranted.

What this study adds?

POCUS has been widely adopted by providers in our academic hospital ED. Positive POCUS results in this setting were found to be quite high and appear to be associated with a higher rate of admission of critically ill patients to the ED.

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Conflicts of interest

The authors declare no conflict of interest.

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