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Validation of the echoSHOCK protocol for diagnosing the cause of shock in patients arriving at the emergency department

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Abstract:

OBJECTIVES: Nontraumatic undifferentiated shock is difficult to manage in the emergency department due to unclear causes, lack of history, and rapid patient deterioration. Timely and appropriate resuscitation is crucial, but both inadequate and excessive resuscitation increase mortality risks. Focused cardiac ultrasound (FoCUS) offers a timely and noninvasive cardiac assessment. The echoSHOCK protocol is derived from FoCUS and improves the ability to identify the etiology of shock in patients at the emergency department. This study's primary objective was to validate the echoSHOCK protocol for diagnosing the cause of shock in patients arriving at the emergency department. This study's secondary objective was to determine the prevalence of different etiologies of shock in patients arriving at the emergency department.

METHODS: Adult patients presenting to the emergency department in shock were included in the study after informed consent was obtained. The shock was defined as a systolic blood pressure of <90 mmHg or a mean arterial pressure of <65 mmHg with signs of poor tissue perfusion. Each patient underwent a detailed history, physical examination, and standard investigations. Clinicians reported a presumed etiology and management plan with a confidence level (0–10). The echoSHOCK protocol was then executed and its results were recorded with the respective confidence levels. The protocol used a phased array probe in B-mode solely and assessed left ventricle function, compressive pericardial effusion, right ventricular dilatation, interventricular septum flattening, and indicators of hypovolemia. The time taken to perform the protocol and the difficulty level were noted. An expert panel followed the patient till hospital discharge and provided the final diagnosis and intervention.

RESULTS: The study enrolled 223 patients with a mean age of 49.12 years. The echoSHOCK protocol showed a 94.2% agreement with expert panel diagnoses on the cause of shock and proposed interventions, with a statistically significant near-perfect agreement (Cohen's Kappa –0.896, $P < 0.001$ and 0.897, $P < 0.001$, respectively). In contrast, the agreement between the clinical assessment, routine workup, and expert panel diagnoses was 46.2% on the cause of shock and 45.7% on the proposed interventions, respectively. The echoSHOCK protocol's median feasibility score was 7 (interquartile range [IQR]: 6–8), and its median performance time was 7 min (IQR: 6–10). Confidence in diagnoses was significantly higher with echoSHOCK (mean: 7.14) than with clinical examination (mean: 4.47) (Wilcoxon Test: $P < 0.001$).

CONCLUSION: The echoSHOCK protocol rapidly identifies shock etiology in patients at the emergency department. This aids in rapid resuscitation.

Keywords:

Emergency, shock, ultrasound

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Box-ED Section

What is already known on the study topic?

- Focused cardiac ultrasound (FoCUS) offers a timely and noninvasive cardiac assessment
- The echoSHOCK protocol is derived from FoCUS and it improves the ability to identify the etiology of shock in patients at the emergency department.

What is the conflict on the issue? Has it importance for readers?

- Nontraumatic undifferentiated shock is a challenging condition to manage for the emergency physician owing to etiological ambiguity, lack of appropriate history, and the fast-deteriorating patient
- While timely diagnosis and appropriate resuscitation is the key to reducing mortality in shock, both inadequate and over-resuscitation are linked with a risk of higher mortality.

How is this study structured?

- In this diagnostic accuracy study, we estimated the validity of the echoSHOCK protocol in diagnosing the etiology of shock among patients presenting to the emergency department with undifferentiated, nontraumatic shock.

What does this study tell us?

- echoSHOCK protocol is a simple, rapid, B-mode ultrasound protocol that can be useful for identifying the cause of shock among patients with undifferentiated shock in the emergency department
- This protocol may be especially useful in rapidly deteriorating patients, where a cause of shock can be quickly estimated, and an initial resuscitation plan finalized. A detailed, extensive evaluation can follow later on.

Introduction

Shock is defined as a clinical syndrome of hypoxia at the cellular and tissue level that can occur through inadequate delivery of oxygen, an elevation in the demand for oxygen, or an amalgamation of these processes. The presentation of the patient in shock is diverse. It can vary from concealed hypoperfusion with preserved blood pressure to circulatory collapse, which is its most severe form.[1,2] The mechanisms of shock can be broadly classified into four categories – hypovolemia, obstructive, cardiogenic, and distributive. There have been considerable improvements in the management of shock over time. However, the short-term mortality still remains high-ranging from 20% to 50%.[3,4] Nontraumatic undifferentiated shock is a challenging condition to manage for the emergency physician owing to etiological ambiguity, lack of appropriate history, and the fast-deteriorating patient.[5,6] While timely diagnosis and appropriate resuscitation is the key to reducing mortality in shock, both inadequate and over-resuscitation are linked with a risk of higher mortality. The concept of optimal resuscitation holds, especially true for fluid resuscitation.[6,7]

Focused cardiac ultrasound (FoCUS) is a time-sensitive and noninvasive cardiac evaluation of the symptomatic patient, executed and construed by the emergency physician within the clinical context.[8,9] A framework of FoCUS for various clinical scenarios was provided by the first International Conference on FoCUS. This formed the basis for the development of a protocol named echoSHOCK by Leroux *et al*.[10,11] The echoSHOCK protocol is a simple, B-mode, goal-directed ultrasound protocol that was found to significantly improve the capability to identify the etiology of shock among patients presenting to the emergency department with undifferentiated, nontraumatic shock.[11]

Precise determination of the etiology of shock among patients presenting to the emergency department can be instrumental in deciding the appropriate resuscitation plan for these patients. Timely and appropriate resuscitation is a critical intervention which can reduce mortality among these patients. Thus, in this diagnostic accuracy study, we estimated the validity of the echoSHOCK protocol in diagnosing the etiology of shock among patients presenting to the emergency department with undifferentiated, nontraumatic shock.

Methods

This diagnostic accuracy study was performed at the department of emergency medicine of a tertiary healthcare center in an urban setting in a predominantly hilly state of India. This emergency department caters to over 75,000 patients annually. All patients aged 18 years and above, who presented to the emergency department in shock were included in the study after taking an informed consent. Shock was defined as a systolic blood pressure of <90 mmHg or a mean arterial pressure of <65 mmHg with signs of inadequate tissue perfusion, for this study. All trauma patients and any patients with clinically diagnosed anaphylactic shock were excluded from this study. Patients were recruited from October 2023 to March 2024.

This study was approved by the ethical committee of All India Institute of Medical Sciences, Rishikesh (Approval Number: AIIMS/IEC/23/395, Dated: October 6, 2023). A written informed consent was obtained from the patients/next of kin.

Initial assessment and treatment

All patients underwent a detailed history and physical examination, and they were investigated and treated according to standard guidelines. For each case, clinicians reported the presumed clinical etiology of shock and its proposed treatment, along with the degree of confidence for this assessment. A list of the possible etiologies of shock and their proposed treatments was made, from which the responses were chosen [Table 1]. The degree of confidence ranged from 0 to 10, with 0 signifying no certainty and 10 signifying complete certainty.

echoSHOCK protocol

The echoSHOCK ultrasound protocol was then carried out. A phased array probe solely in B-mode without Doppler assessment was used for the protocol. The four standard cardiac windows: parasternal long-axis, parasternal short-axis, apical four-chamber, and subcostal, including the inferior vena cava, in sequence, were assessed to determine the existence of a compressive pericardial effusion, dilatation of the right ventricle, interventricular septum flattening, dimensions and systolic function of the left ventricle as well as indicators of hypovolemia. The systolic function of the left ventricle was classified as normal, moderately impaired, or severely impaired. The hypovolemia indices included the presence of a collapsed left ventricle and/or a collapsed inferior vena cava. The findings were entered into the echoSHOCK algorithm [Figure 1] to determine the etiology of the shock and the proposed therapeutic intervention. In addition, the degree of confidence in each ultrasonographic assessment was also noted. The confidence level was measured on a scale from 0 to 10, where 0 indicated no certainty and 10 represented complete certainty. The time taken to perform the echoSHOCK protocol and the level of difficulty were also noted. The level of difficulty was graded on a scale from 1 to 10, where 1 signified impossible, and 10 signified very easy. The clinicians performing the echoSHOCK protocol were trained emergency physicians who underwent accredited training followed by at least 6 months of experience in cardiac examinations.

Final diagnosis

The final diagnosis and intervention were determined by an expert panel who followed each patient till discharge from the hospital. This was used as the reference standard. The expert panel comprised of senior emergency medicine physicians with 4 years or more of experience and accredited training in echocardiography.

Objectives

The primary objective of the study was to validate the echoSHOCK protocol for diagnosing the etiology of shock among patients arriving at the emergency department. The study's secondary objective was to determine the prevalence of different shock etiologies among patients arriving at the emergency department.

This manuscript adheres to the Standards for Reporting of Diagnostic Accuracy guidelines.

Table 1: List of the possible diagnoses and the respective possible treatments of shock for this study

Possible diagnosis	Possible treatment
Cardiac tamponade	Pericardiocentesis
Massive pulmonary embolism	Thrombolysis
Left ventricular failure	Inotropic agents
Hypovolemic/distributive	Fluid challenge
Unknown	Supportive

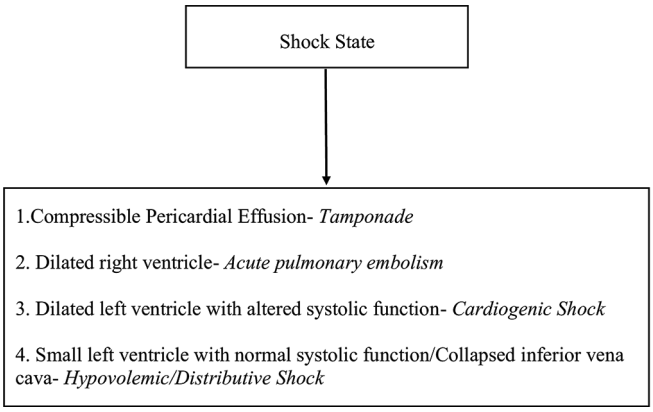

Figure 1: echoSHOCK protocol

Statistical analysis

Microsoft Excel spreadsheet program was used to code and record the data for this study. Data analysis was performed with SPSS version 23 (IBM Corp., NY, USA). Descriptive statistics were presented in various formats based on the type of data. For continuous variables, means with standard deviations (SDs) and medians with interquartile ranges (IQRs) were reported. For categorical variables, frequencies and percentages were reported. The normality of continuous data was evaluated utilizing the Shapiro–Wilk Test. Cohen's kappa coefficient was used to evaluate the degree of agreement. A $P < 0.05$ was considered statistically significant.

Sample size

The sample size for the study was based on a study by Leroux *et al*., who reported the proportion of subjects with updation of diagnosis as 41%.[11] Using the formula provided by Lemeshow *et al*.,[12] where sample size $n = \frac{\left(z_{(\alpha/2)}\right)^2 \times p \times (1-p)}{\delta^2}$ and using a precision value $\delta = 0.10$ (10%); type 1 error $\alpha = 1.96$ and proportion of subjects with an update in diagnosis, $P = 0.41$ (41%),

the calculated sample size for this study was 93, with a confidence interval of 95%.

Results

Two hundred twenty-three patients were enrolled in this study. The mean with SD for age was 49.12 (15.84) years. The baseline characteristics of the study population are summarized in a tabular format in Table 2. Table 3 shows the distribution of the causes of shock according to the clinical examination and routine workup, the echoSHOCK protocol, and the final expert panel diagnosis, along with their respective proposed interventions.

On comparison of the cause of shock according to the clinical examination and routine workup, and the expert panel diagnosis, there was an agreement in 46.2% of the cases. There was a disagreement in the remaining 53.8% of the cases, as presented in a tabular format in Table 4. Thus, a poor agreement was noted among these two methods, which was significant statistically (Cohen's Kappa = 0.115, P = 0.003). Similarly, the proposed interventions according to the two methods agreed in 45.7% of the cases and disagreed in 54.3% of the cases. Here also, a poor agreement was seen, and this was found to be statistically significant (Cohen's Kappa = 0.110, P = 0.005).

A comparison of the cause of shock according to the echoSHOCK protocol with the cause of shock according to the expert panel diagnosis yielded an agreement in 94.2% of cases, with a disagreement in the remaining 5.8%. These findings are presented in a tabular format in Table 5. The two methods showed a near-perfect agreement, with a statistically significant result (Cohen's Kappa = 0.896, $P \leq 0.001$). Similarly, the proposed interventions according to the echoSHOCK protocol and the expert panel diagnosis agreed in 94.2% of the cases and disagreed in the remaining 5.8%. Thus, a near-perfect agreement was noted here as well; with a statistically significant result (Cohen's Kappa = 0.897, $P \leq 0.001$).

The median (IQR) feasibility of the echoSHOCK protocol was 7 (6–8). The median (IQR) of the performance time of the echoSHOCK protocol was 7 (6–10) min. The mean (SD) of the degree of confidence in the cause of shock and the proposed intervention was 7.14 (0.94) through the echoSHOCK protocol, which was considerably higher than the mean (SD) degree of confidence from clinical examination and routine workup - 4.47 (1.37). This observed difference was significant statistically (Wilcoxon Test: v = 127.0, $P \leq 0.001$).

Table 2: Baseline characteristics of the study population

Parameters	Mean±SD/ median (IQR)/*n* (%)
Age (years)	49.12±15.84
18–30	39 (17.5)
31–40	33 (14.8)
41–50	41 (18.4)
51–60	48 (21.5)
61–70	43 (19.3)
71–80	17 (7.6)
81–90	2 (0.9)
Gender	
Male	144 (64.6)
Female	79 (35.4)
Comorbidities	127 (57.0)
Diabetes mellitus	54 (24.2)
Hypertension	54 (24.2)
Chronic liver disease	19 (8.5)
Coronary artery disease	13 (5.8)
Hypothyroidism	10 (4.5)
Pulmonary tuberculosis	5 (2.2)
Chronic kidney disease	4 (1.8)
Stroke	2 (0.9)
Examination	
Pulse rate (beats per min)	116.00 (104.25–127.00)
Systolic blood pressure (mmHg)	72.00 (68.00–80.00)
Diastolic blood pressure (mmHg)	40.00 (39.00–48.00)
Mean arterial pressure (mmHg)	51.30 (47.30–57.00)
SpO_2 (%)	80.00 (68.00–89.00)
Respiratory rate (counts per min)	22.00 (20.00–26.00)
Degree of confidence	
Clinical and routine workup	4.47 (1.37)
echoSHOCK protocol	7.14 (0.94)

SD: Standard deviation, IQR: Interquartile range

Table 3: Distribution of the causes of shock according to the clinical examination and routine workup, echoSHOCK protocol, and the final expert panel diagnosis and the proposed interventions in each

	Clinical and routine workup (%)	echoSHOCK protocol (%)	Expert panel (%)
Cause of Shock			
Hypovolemic/distributive	58.3	61.9	58.7
Left ventricular failure	17.5	25.6	25.6
Cardiac tamponade	3.6	8.5	8.5
Massive pulmonary Embolism	2.7	4.0	7.2
Unknown	17.9	0	0
Intervention			
Fluid challenge	58.3	61.4	58.3
Ionotropic agents	17.5	26.0	26.0
Pericardiocentesis	3.6	8.5	8.5
Thrombolysis	2.7	4.0	7.2
Unknown	17.9	0	0

Table 4: Comparison of the cause of shock according to the clinical examination and routine workup with the cause of shock according to the expert panel

Cause of shock	Cause of shock (expert panel)						Cohen's kappa	
Cause of shock (clinical)	Hypovolemic/ distributive, *n* (%)	Left ventricular failure, *n* (%)	Cardiac tamponade, *n* (%)	Massive pulmonary embolism, *n* (%)	Unknown, *n* (%)	Total, *n* (%)	k	*P*
Hypovolemic/distributive	84 (37.7)	28 (12.6)	10 (4.5)	8 (3.6)	0	130 (58.3)	0.115	0.003
Left ventricular failure	15 (6.7)	16 (7.2)	3 (1.3)	5 (2.2)	0	39 (17.5)		
Cardiac tamponade	4 (1.8)	2 (0.9)	2 (0.9)	0	0	8 (3.6)		
Massive pulmonary embolism	1 (0.4)	1 (0.4)	3 (1.3)	1 (0.4)	0	6 (2.7)		
Unknown	27 (12.1)	10 (4.5)	1 (0.4)	2 (0.9)	0	40 (17.9)		
Total	131 (58.7)	57 (25.6)	19 (8.5)	16 (7.2)	0	223 (100.0)		

The green cells on the diagonal represent cases where both methods agreed. The red-shaded cells represent cases where the two methods disagreed

Table 5: Comparison of the cause of shock according to the echoSHOCK protocol with the cause of shock according to the final expert panel diagnosis

Cause of shock	Cause of shock (expert panel)						Cohen's kappa	
Cause of shock (echoSHOCK)	Hypovolemic/ distributive, *n* (%)	Left ventricular failure, *n* (%)	Cardiac tamponade, *n* (%)	Massive pulmonary embolism, *n* (%)	Unknown, *n* (%)	Total, *n* (%)	k	*P*
Hypovolemic/distributive	129 (57.8)	4 (1.8)	0	5 (2.2)	0	138 (61.9)	0.896	<0.001
Left ventricular failure	2 (0.9)	53 (23.8)	0	2 (0.9)	0	57 (25.6)		
Cardiac tamponade	0	0	19 (8.5)	0	0	19 (8.5)		
Massive pulmonary embolism	0	0	0	9 (4.0)	0	9 (4.0)		
Unknown	0	0	0	0	0	0		
Total	131 (58.7)	57 (25.6)	19 (8.5)	16 (7.2)	0	223 (100.0)		

The green cells on the diagonal represent cases where both methods agreed. The red-shaded cells represent cases where the two methods disagreed

Discussion

This diagnostic accuracy study enrolled 223 patients, where clinical examination and routine workup, alongside echoSHOCK protocol, were used to estimate the etiology of shock and its proposed intervention. This was correlated with the final diagnosis of shock as determined by an expert panel.

The mean (SD) age of our study population was 49.12 (15.84) years, which was quite young as compared to the study population of Leroux *et al*., where the mean (SD) age was 73 (14) years.[11] Distributive and hypovolemic shock is the most common etiology of shock in our study, which is similar to the findings of other studies.[11,13,14]

echoSHOCK protocol successfully identified the cause of shock in 94.2% of cases, which is quite similar to the study by Leroux *et al*., where echoSHOCK protocol successfully identified the cause of shock in 97% of cases.[11] There was a near-perfect agreement in both cases.

The median (IQR) feasibility of echoSHOCK protocol in our study was 7 (6–8) on a scale from 0 to 10, where 0 signified very difficult and 10 signified very easy. In the study by Leroux *et al*., as well the mean (SD) feasibility of echoSHOCK was 7 (2).[11] Adequate transthoracic image acquisition may prove challenging in some emergency department patients owing to obesity, lung hyperinflation, invasive mechanical ventilation or, dressings or drainage tubes. Although some of these impediments may be overcome by maneuvers, such as patient positioning, it is not feasible for all patients in the emergency department.[15,16] Thus, very high levels of feasibility are not possible in the emergency department.

The median (IQR) performance time of the echoSHOCK protocol was 7 (6–10) min in our study, which was considerably less than the mean (SD) duration in the study by Leroux *et al*., which was 13 (5) min.[11] A commonly used protocol for assessing patients with shock in the emergency department is the Rapid Ultrasound for Shock and Hypotension (RUSH) protocol.[17] In a recently conducted study, the mean time taken to perform the RUSH protocol in the emergency department (ED) was 12 min, with a range from 10 to 14 min, which is considerably more than the time taken to perform the echoSHOCK protocol in our study.[18] Although the time taken to perform any ultrasound protocol depends on various factors related to the patient and the performer and may vary with the patient profile, the echoSHOCK protocol utilizes limited views compared to the more detailed RUSH protocol, thus saving time. A particular shortcoming of the echoSHOCK protocol is its omission of the aortic evaluation. Ruptured abdominal aortic aneurysms present a significant mortality risk, especially in older men and current vascular surgery practice

guidelines suggest a goal of 30 min for diagnosis and resuscitation of these patients in the emergency department.[19,20]

Various ultrasound protocols exist for the evaluation of patients with shock. Cardiac and inferior vena cava assessment is the common and integral component of most of these protocols.[21] Thus, these assessments are critical in evaluating a patient with shock, and using a simple, focused protocol directed at these components, like echoSHOCK, can help save valuable minutes for time-sensitive patients with shock in the emergency department.

Limitations

There are various limitations of our study. First, this was a single-center study. Second, there seems to be an over-representation of patients with obstructive shock, namely cardiac tamponade and massive pulmonary embolism, in our study population as compared to the literature.[13,14]

Conclusion

In this study, echoSHOCK protocol was found to accurately identify the cause of shock amongst most patients presenting to the emergency department. This protocol could be quickly performed due to the limited number of views required.

echoSHOCK protocol may be especially useful in rapidly deteriorating patients, where a cause of shock can be quickly estimated, and an initial resuscitation plan finalized. A detailed, extensive evaluation can follow later on. Further multicentric studies comparing its performance with RUSH and other validated protocols can be planned to shed a better light on its diagnostic accuracy.

Author contributions statement

- TS: Conceptualization, Methodology, Investigation, Writing (original draft), Writing (review and editing)
- NK: Conceptualization, Methodology, Formal Analysis, Resources, Software, Supervision, Validation, Visualization
- PS: Investigation, Methodology, Writing (original draft), Writing (review and editing)
- AB: Investigation, Writing (original draft), Writing (review and editing)
- SAMS: Investigation, Writing (original draft)
- SJ: Investigation, Writing (original draft)
- JRJ: Investigation, Writing (original draft)
- JKY: Investigation, Writing (original draft).

Conflicts of interest

None Declared.

Ethical approval

This study was approved by the Institutional Ethics Committee of All India Institute of Medical Sciences, Rishikesh, India, on 06/10/2023, bearing approval number AIIMS/IEC/23/395.

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References

1. Baran DA, Grines CL, Bailey S, Burkhoff D, Hall SA, Henry TD, *et al.* SCAI clinical expert consensus statement on the classification of cardiogenic shock: This document was endorsed by the American College of Cardiology (ACC), the American Heart Association (AHA), the Society of Critical Care Medicine (SCCM), and the Society of Thoracic Surgeons (STS) in April 2019. Catheter Cardiovasc Interv 2019;94:29-37.
2. van Diepen S, Katz JN, Albert NM, Henry TD, Jacobs AK, Kapur NK, *et al.* Contemporary management of cardiogenic shock: A scientific statement from the American Heart Association. Circulation 2017;136:e232-68.
3. Bloom JE, Andrew E, Dawson LP, Nehme Z, Stephenson M, Anderson D, *et al.* Incidence and outcomes of nontraumatic shock in adults using emergency medical services in Victoria, Australia. JAMA Netw Open 2022;5:e2145179.
4. ARISE Investigators, ANZICS Clinical Trials Group, Peake SL, Delaney A, Bailey M, Bellomo R, *et al.* Goal-directed resuscitation for patients with early septic shock. N Engl J Med 2014;371:1496-506.
5. Javali RH, Loganathan A, Srinivasarangan M, Patil A, Siddappa GB, Satyanarayana N, *et al.* Reliability of emergency department diagnosis in identifying the etiology of nontraumatic undifferentiated hypotension. Indian J Crit Care Med 2020;24:313-20.
6. Mosier JM, Stolz U, Milligan R, Roy-Chaudhury A, Lutrick K, Hypes CD, *et al.* Impact of point-of-care ultrasound in the emergency department on care processes and outcomes in critically Ill nontraumatic patients. Crit Care Explor 2019;1:e0019.
7. Carlos Sanchez E, Pinsky MR, Sinha S, Mishra RC, Lopa AJ, Chatterjee R. Fluids and early vasopressors in the management of septic shock: Do we have the right answers yet? J Crit Care Med (Targu Mures) 2023;9:138-47.
8. Arvig MD, Weile JB, Lindberg M, Wamberg J, Posth S. Focused cardiac ultrasound in emergency medicine. Ugeskr Laeger 2023;185:V02230130.
9. Labovitz AJ, Noble VE, Bierig M, Goldstein SA, Jones R, Kort S, *et al.* Focused cardiac ultrasound in the emergent setting: A consensus statement of the American Society of Echocardiography and American College of Emergency Physicians. J Am Soc Echocardiogr 2010;23:1225-30.
10. Via G, Hussain A, Wells M, Reardon R, ElBarbary M, Noble VE, *et al.* International evidence-based recommendations for focused cardiac ultrasound. J Am Soc Echocardiogr 2014;27:683.e1-33.
11. Leroux P, Javaudin F, Le Bastard Q, Lebret Y, Pes P, Arnaudet I, *et al.* Goal-directed ultrasound protocol in patients with nontraumatic undifferentiated shock in the emergency department: prospective dual centre study. Eur J Emerg Med 2021;28:306-11.
12. Lemeshow S, Hosmer DW, Klar J, Lwanga SK. Adequacy of Sample Size in Health Studies. Chicester: Wiley; 1990.
13. Gitz Holler J, Jensen HK, Henriksen DP, Rasmussen LM, Mikkelsen S, Pedersen C, *et al.* Etiology of shock in the emergency department: A 12-year population-based cohort study. Shock 2019;51:60-7.
14. Lafon T, Appert A, Hadj M, Bigrat V, Legarcon V, Claveries P, *et al.* Comparative early hemodynamic profiles in patients presenting to the emergency department with septic and nonseptic acute circulatory failure using focused echocardiography. Shock 2020;53:695-700.
15. Cosyns B, El Haddad P, Lignian H, Daniels C, Weytjens C, Schoors D, *et al.* Contrast harmonic imaging improves the evaluation of left ventricular function in ventilated patients: Comparison with transesophageal echocardiography. Eur J Echocardiogr 2004;5:118-22.

16. Grotberg JC, McDonald RK, Co IN. Point-of-care echocardiography in the difficult-to-image patient in the ICU: A narrative review. Crit Care Explor 2024;6:e1035.
17. Perera P, Mailhot T, Riley D, Mandavia D. The RUSH exam: Rapid ultrasound in shock in the evaluation of the critically lll. Emerg Med Clin North Am 2010;28:29-56, vii.
18. Rahulkumar HH, Bhavin PR, Shreyas KP, Krunalkumar HP, Atulkumar S, Bansari C. Utility of point-of-care ultrasound in differentiating causes of shock in resource-limited setup. J Emerg Trauma Shock 2019;12:10-7.
19. Fleming C, Whitlock EP, Beil TL, Lederle FA. Screening for abdominal aortic aneurysm: A best-evidence systematic review for the U.S. Preventive services task force. Ann Intern Med 2005;142:203-11.
20. Chaikof EL, Dalman RL, Eskandari MK, Jackson BM, Lee WA, Mansour MA, *et al*. The society for vascular surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. J Vasc Surg 2018;67:2-77.e2.
21. Seif D, Perera P, Mailhot T, Riley D, Mandavia D. Bedside ultrasound in resuscitation and the rapid ultrasound in shock protocol. Crit Care Res Pract 2012;2012:503254.