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Original Research Article

Diagnostic accuracy of the RUSH protocol in identifying the cause of shock: a prospective study from an Indian emergency department

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ABSTRACT

Background: Shock is a life-threatening emergency characterized by inadequate tissue perfusion, requiring rapid identification of the underlying etiology to guide targeted management. Early clinical assessment may be unreliable because of overlapping presentations. The Rapid Ultrasound in Shock and Hypotension (RUSH) protocol provides a structured point-of-care ultrasonography (PoCUS) approach to differentiate shock subtypes at the bedside.
To evaluate the diagnostic accuracy of the RUSH protocol in identifying the etiology of non-traumatic undifferentiated shock in an Indian emergency department and to assess its agreement with the final confirmed clinical diagnosis.
Methods: This prospective observational study included 100 adult patients presenting with shock to a tertiary emergency department. All patients underwent a standardized RUSH examination performed by trained emergency physicians. Ultrasound-based provisional diagnoses were compared with final diagnoses established using comprehensive clinical evaluation, imaging and laboratory investigations. Diagnostic performance was assessed using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and Cohen's kappa coefficient.
Results: The mean patient age was 44.97±10.88 years, with a male predominance (69%). Distributive shock was the most common etiology (39%). The RUSH protocol showed the highest diagnostic accuracy for obstructive shock (sensitivity, specificity, PPV and NPV all 100%, κ=1.0). Good agreement was observed for cardiogenic (κ = 0.93), hypovolemic (κ=0.87) and distributive shock (κ=0.87), while overlap was greatest in hypovolemic/distributive shock (κ=0.76).
Conclusions: The RUSH protocol is a rapid, reliable bedside tool for early etiological diagnosis of shock and supports timely, goal-directed resuscitation in emergency settings.

Keywords: Diagnostic accuracy, Emergency medicine, PoCUS, Point-of-care ultrasound, RUSH protocol, Shock

INTRODUCTION

Shock is a critical clinical condition characterized by inadequate tissue perfusion and oxygen delivery, which, if not promptly identified and managed, can result in cellular injury, multi-organ dysfunction and death. Rather than being a disease entity in itself, shock represents a final common pathway for various life-threatening conditions.

Accurate and timely identification of the underlying cause is vital, as the management strategies differ significantly depending on the etiology.[1] Shock is broadly categorized into five types hypovolemic, cardiogenic, distributive, obstructive and mixed each with distinct pathophysiological mechanisms. However, in the emergency department (ED), their clinical presentations often overlap, with nonspecific features such as hypotension, tachycardia, altered mental status and cold extremities. This overlap creates a diagnostic challenge during the critical early phase, often referred to as the "golden hour," when rapid intervention can be life-saving.[2] Traditional diagnostic approaches including physical examination, electrocardiography, chest radiography, laboratory investigations and invasive hemodynamic monitoring may be time-consuming or inconclusive in the early stages.[3] Invasive procedures also carry procedural risks and may not always be feasible in emergency or resource-limited settings. As a result, there is an increasing reliance on rapid, repeatable and non-invasive diagnostic tools to guide early management.

PoCUS has emerged as a valuable diagnostic modality in emergency and critical care settings. It allows bedside assessment of cardiac function, volume status and identification of specific pathologies such as pericardial tamponade, pneumothorax, pulmonary edema and intra-abdominal bleeding. The RUSH protocol is a standardized PoCUS framework designed to evaluate patients in shock systematically.[4] It examines three critical components: “the pump” (cardiac function), “the tank” (volume status via IVC and peritoneal cavity) and “the pipes” (vascular integrity and presence of DVT or aneurysms). This method provides real-time, actionable information that can significantly improve diagnostic accuracy and reduce time to treatment.

Although several international studies have demonstrated the utility of the RUSH protocol in emergency settings, evidence from Indian healthcare systems remains limited. Moreover, few studies have directly compared RUSH-based provisional diagnoses with final diagnoses established through comprehensive clinical evaluation, imaging and laboratory work-up.[5] This study aims to fill that gap by evaluating the diagnostic accuracy of the RUSH protocol in identifying the etiology of non-traumatic undifferentiated shock in a tertiary emergency care setting in India. By comparing the RUSH-based initial diagnosis with the final confirmed diagnosis, the study seeks to validate PoCUS as an effective early diagnostic tool, potentially improving patient outcomes through faster, targeted interventions.[6]

METHODS

Study design and setting

This was a prospective observational study conducted from November 2018 to April 2019 in the Emergency Department of Yashoda Super Specialty Hospital, Hyderabad. Ethical approval was obtained from the institutional review board (Ref. No: YSSH/2018/47) and informed consent was taken from all participants.

Participants

We included 100 adult patients (aged ≥18 years) presenting with signs of shock, defined as systolic blood pressure <90 mmHg or a shock index>1 with evidence of poor perfusion. We excluded patients with trauma, pregnancy-related hypotension, morbid obesity (BMI>40), active external bleeding or chronic effusions.

Ultrasound examination

Each patient underwent a bedside RUSH protocol ultrasound using a Philips Ultrasound machine with a 3.5–5 MHz probe. Scans were performed by trained emergency physicians with over three years of PoCUS experience. They were blinded to the patient’s lab and imaging results to minimize bias. The RUSH exam assessed cardiac function, lung patterns, IVC diameter and collapsibility and abdominal and lower limb veins for free fluid or thrombosis.

Final diagnosis

The final diagnosis was determined after reviewing all clinical, imaging and laboratory data by a senior emergency consultant team. Diagnoses were grouped into five categories hypovolemic, cardiogenic, distributive, obstructive and mixed.

Data analysis

Statistical analysis was performed using SPSS version 26. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated. Agreement between RUSH findings and final diagnosis was measured using Cohen’s kappa coefficient.

RESULTS

Age wise distribution

The patients in young age group<30 years accounted for 15% (15) cases. Patients in age group 31-40 years accounted for 25% (25) cases. Patients in middle age group 41-50 years accounted for 30% (30) cases. Patients in age group 51-60 years accounted for 15% (15) cases. Patients in age group 61-70 years accounted for 10% (10) cases. Patients in age group >70 years accounted for 5% (5) cases. The average age in present study was 44.975+/-10.88(19-85 years).

Sex wise distribution

The Male patients accounted 69% (69) cases and Females were 31% (31) cases. It clearly shows male preponderance in incidence. Among the 100 patients studied, the mean age was 44.97±10.88 years. Distributive shock was most common (39%), followed by hypovolemic/distributive (24%), cardiogenic (22%), hypovolemic (10%) and obstructive shock (5%). In hypovolemic shock, most patients had increased ejection fraction (>70%), an 'A' lung profile, IVC diameter <1.5 cm and >50% collapsibility. In distributive shock, ejection fraction was mostly normal, with predominant 'A' and 'C' lung profiles and >50% IVC collapsibility. In cardiogenic shock, reduced ejection fraction (<55%) and a 'B' profile were seen in 90.9% of cases, with <50% IVC collapsibility. Hypovolemic/distributive shock showed free fluid in 70.5%, normal ejection fraction, 'A' profile in most cases and >50% IVC collapsibility in all patients.

These findings support the RUSH protocol's effectiveness in differentiating shock types using key sonographic markers. In cases of obstructive shock (n=5), ultrasonographic findings included reduced ejection fraction (<55%) in 100%, cardiac tamponade in 40% and right heart strain in 60% of patients. All patients exhibited an 'A' profile on lung ultrasound and a distended IVC with <50% collapsibility. The sensitivity, specificity and positive predictive value of ultrasound in diagnosing various shock types are presented in Table 2. Table 3 shows the correlation between clinical and ultrasound diagnoses, along with the Cohen's kappa coefficient, indicating the level of agreement. The sensitivity, specificity and positive predictive value of ultrasound in diagnosing various types of shock were statistically analyzed and are presented in table 2. The results indicate that ultrasound demonstrated the highest sensitivity, specificity and positive predictive value in diagnosing obstructive shock. In contrast, hypovolemic/distributive shock showed the lowest specificity and positive predictive value, while distributive shock had the lowest sensitivity. Table 3 illustrates the correlation between clinical and ultrasound-based diagnoses, along with the Cohen's kappa coefficient, reflecting the degree of diagnostic agreement.

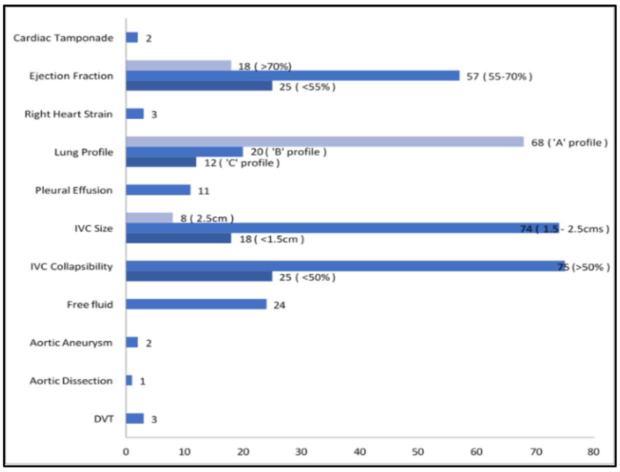

Figure 1: Graphical representation of collective parameters that predict the diagnosis of each type of shock on ultrasound.

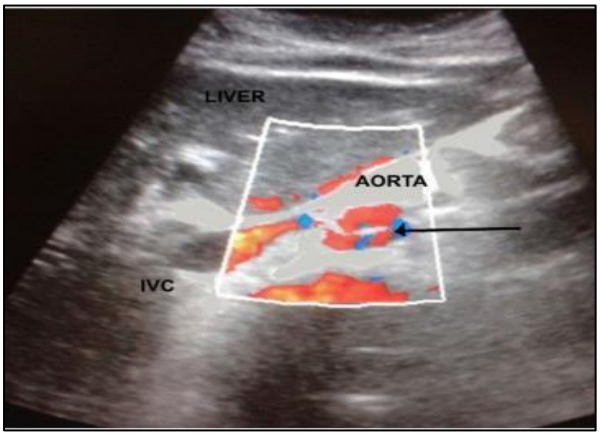

Figure 2: Colour Doppler image (axial section) showing aortic dissection in a case of hypovolemic shock in our study. The arrow shows the dissected intimal flap.

Figure 3: 'C' profile in a case of distributive shock in my study.

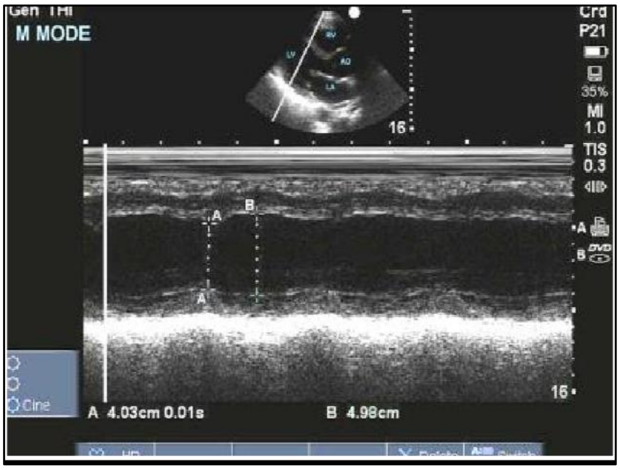

Figure 4: Evaluation of ejection fraction using M mode echocardiography. Distance A represents the end systolic diameter and distance B represents the end diastolic diameter. Ejection fraction by Teicholz method was 39.1% in this case (hypodynamic), seen in a case of cardiogenic shock in study.

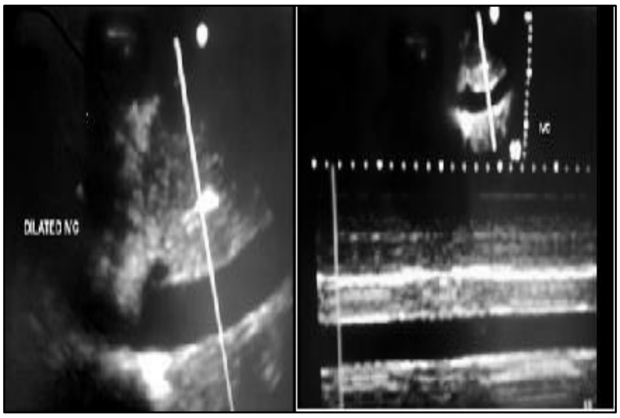

Figure 5: Absent collapsibility of the IVC on M Mode in a case of obstructive shock in my study.

Table 3 demonstrates that ultrasound had an overall good correlation with the final clinical diagnosis in evaluating shock. The strongest agreement was observed in cases of obstructive shock, while the lowest agreement was noted in hypovolemic/distributive shock. Additionally, this study uniquely conducted a statistical evaluation of individual ultrasound parameters to identify the most reliable predictors for each type of shock, as presented in table 4. This level of parameter-specific analysis has not been previously reported in similar studies, making this research distinct. Table 4 outlines key ultrasonographic parameters predictive of each type of shock. Hypovolemic shock was most associated with high ejection fraction (>70%), small IVC size with >50% collapsibility and an 'A' lung profile. Distributive shock typically showed normal ejection fraction (55–70%), an 'A' or 'C' lung profile and >50% IVC collapsibility.

Cardiogenic shock was characterized by reduced ejection fraction (<55%), 'B' profile and <50% IVC collapsibility. Hypovolemic/distributive shock commonly presented with normal to high ejection fraction, free fluid and pleural effusion. Obstructive shock showed reduced ejection fraction, right heart strain, cardiac tamponade, distended IVC with <50% collapsibility and deep vein thrombosis. These findings highlight the role of specific ultrasound features in distinguishing shock types.

Figure 5 provides a visual representation of the collective ultrasonographic parameters associated with each type of shock. It highlights key predictors such as ejection fraction, lung profile, IVC size and collapsibility, presence of free fluid, pleural effusion, cardiac tamponade and right heart strain. The graph clearly illustrates how specific combinations of these parameters help differentiate between hypovolemic, distributive, cardiogenic, hypovolemic/distributive and obstructive shock, supporting the diagnostic utility of the RUSH protocol in emergency settings.

Table 1: Baseline demographics.

Variable	Category/Value	N (%)
Age (in years)	Mean±SD	44.91±14.8
Sex	Male	69 (69.0)
	Female	31 (31.0)
Type of shock	Distributive shock	39 (39.0)
	Hypovolemic/distributive	24 (24.0)
	Cardiogenic shock	22 (22.0)
	Hypovolemic shock	10 (10.0)
	Obstructive shock	5 (5.0)

Table 2: Sensitivity, specificity and positive predictive value of ultrasound in diagnosing different types of shock.

Shock type	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Hypovolemic shock	80	100	100	97.83
Distributive shock	79.49	96.72	93.94	88.06
Cardiogenic shock	81.82	97.44	90	95
Hypovolemic/distributive	100	86.84	70.59	100
Obstructive shock	100	100	100	100

Table 3: Correlation between final diagnosis and ultrasound diagnosis for shock and the Cohen's kappa inter-rater coefficient of agreement between them.

Types of shock	Final diagnosis (clinical and biochemical)	Ultrasound diagnosis (RUSH)	Cohen's kappa coefficient	Strength of agreement
Hypovolemic (n=10)	10	8	0.87	Good
Distributive (n=39)	39	33	0.87	Good
Cardiogenic (n=22)	22	20	0.93	Good

Continued.

Types of shock	Final diagnosis (clinical and biochemical)	Ultrasound diagnosis (RUSH)	Cohen's kappa coefficient	Strength of agreement
Hypovolemic/Distributive (n=24)	24	34	0.76	Good
Obstructive (n=5)	5	5	1	Very good

Table 4: Collective parameters which predict the diagnosis of each type of shock.

Parameters	Hypovolemic (n=10)	Distributive (n=39)	Cardiogenic (n=22)	Hypovolemic/ Distributive (n=24)	Obstructive (n=5)
Ejection fraction	>70% (n=8)	55-70% (n=33)	<55%, (n=20)	55-70% (n=24) and >70% (n=10)	<55%, (n=5)
Right heart strain	-	-	-	-	Present (n=3)
Cardiac tamponade	-	-	-	-	Present (n=2)
Lung Profile	'A' profile(n=8)	'A' profile (n=23), 'C' profile (n=10)	'B' profile (n=20)	'A' Profile (n=32), 'C' profile (n=2)	'A' profile (n=5)
Pleural effusion	-	-	-	Present (n=11)	-
IVC size	<1.5 cm (n=8), 1.5 to 2.5 cm (n=2)	1.5 to 2.5 cm (n=31), >2.5 cm (n=2)	1.5 to 2.5 cm (n=17), >2.5 cm (n=3)	<1.5 cm (n=10), 1.5 to 2.5 cm (n=24)	>2.5 cm (n=5)
IVC collapsibility	>50%, (n=8)	>50%, (n=31) <50%, (n=2)	<50%, (n=20)	>50%, (n=31) <50%, (n=3)	<50%, (n=5)
Free fluid	-	-	-	Present (n=24)	-
Aortic aneurysm	Present (n=2)	-	-	-	-
Aortic Dissection	Present (n=1)	-	-	-	-
Deep vein thrombosis	-	-	-	-	Present (n=3)

Table 5: Correlation of RUSH protocol in diagnosing different types of shock in present study with different studies.

S. no.	According to rush protocol different categeories of shock	Present study (n=100)	Kumar et al, (n=130)[11]	El Syed et al, (n=168)[12]	Bagheri et al, (n=25)[11]	Ghane et al, (n=77)[12]
1.	Hypovolemic Shock	8/10 (80%)	94.4%	2	17/17 (100%)	16/16 (100%)
2.	Distributive Shock	33/39 (79.48%)	75%	95	3/4 (75%)	8/11 (72.7%)
3.	Cardiogenic Shock	20/22 (81.81%)	96.3%	36	3/5 (60%)	18/20 (90%)
4.	Hypovolemic /Distributive Shock (Mixed)	34/24 (100%)	80.9%	16	2/2 (100%)	7/11 (63.6%)
5.	Obstructive Shock	5/5 (100%)	100%	5	-	10/11 (90.9%)

DISCUSSION

This prospective study was carried out in the Emergency Department of Yashoda Hospital, Hyderabad, from June 2020. Detailed clinical, radiological, sonographic and biochemical data were systematically collected and evaluated. Point-of-care ultrasonography, employing the RUSH protocol, proved to be highly effective in the early identification of the underlying causes of undifferentiated hypotension. When conducted within the first hour of patient arrival, the RUSH examination showed strong diagnostic agreement with the final clinical diagnosis, demonstrated by a Cohen's kappa coefficient of ≥0.6. These results highlight the accuracy and promptness of bedside ultrasound as a valuable diagnostic tool in emergency settings. A total of 100 patients presenting with shock were evaluated using the RUSH protocol alongside standard diagnostic modalities. The following section provides a comparative analysis of these findings in relation to existing literature.[10]

Age

The patients were in the age group of >18 years Mean age 44.975+/-10.88. The youngest was 19 years and oldest was 85 years. Majority of cases were in the age group of 41-50 years(30%) followed by 31-40 years (25%).[11]

Sex

There is a male preponderance in present study with 69% patients being males. This is similar to study conducted by Ghane et al which showed male preponderance of 62% compared to present study.[12]

RUSH protocol positive for different categeories of shock

RUSH protocol is positive in diagnosing hypovolemic shock in 80.0% cases, in distributive shock 79.48% cases, cardiogenic shock 81.81% cases, hypovolemic / distributive shock 100% cases, obstructive shock 100% cases. this is correlating with studies kumar et al, Sayed et al, Harir et al, Ghane et al.[12] In this study, bedside ultrasound was most accurate in diagnosing obstructive shock, showing perfect agreement with the final clinical diagnosis (Cohen's kappa=1), with the highest sensitivity, specificity and positive predictive value. The lowest sensitivity was seen in distributive shock, while the combination of hypovolemic and distributive shock showed the lowest specificity, PPV and agreement (Cohen's kappa=0.76), due to similar ultrasound features that made them harder to tell apart. The study also demonstrated that using a combination of specific ultrasound findings can aid in accurately identifying the type of shock, which supports faster emergency treatment and better clinical decisions.

In this study, hypovolemic shock demonstrated good sensitivity (80%), excellent specificity (100%) and good agreement with the final diagnosis. Of the 10 patients ultimately diagnosed with hypovolemic shock, the RUSH protocol correctly identified 8 cases. Key ultrasonographic findings included increased ejection fraction (>70%), 'A' lung profile, IVC diameter <1.5 cm and IVC collapsibility >50%, each observed in 80% of cases (8/10). Etiologies included gastroenteritis (n=5), aortic aneurysm (n=2), GI bleeding (n=2) and aortic dissection (n=1).[13] In this study, distributive shock demonstrated good sensitivity, specificity and overall agreement with the final clinical diagnosis. The RUSH protocol correctly identified 33 out of 39 cases. Key ultrasonographic findings in these patients included a normal ejection fraction in 84.6% (33/39), an 'A' profile on lung ultrasound in 58.9% (23/39), a 'C' profile (consolidation) in 25.6% (10/39),and a normal-caliber inferior vena cava (IVC) with >50% collapsibility in 84.6% (33/39).[14] Among the confirmed cases, 36 were diagnosed with septic shock and 3 with anaphylactic shock. However, two cases initially labelled as distributive shock were later reclassified as cardiogenic shock and the RUSH protocol failed to identify six true cases of distributive shock.[15]

Cardiogenic shock demonstrated good sensitivity (81%), excellent specificity and good agreement with the final diagnosis.[16] The RUSH protocol correctly identified 18 out of 22 cases. Key ultrasonographic findings included reduced ejection fraction (<55%), 'B' profile on lung ultrasound and IVC collapsibility <50%, each seen in 90.9% of cases (20/22). Among the final diagnoses, 19 patients had decompensated heart failure and 3 had myocardial infarction. Two cases were misdiagnosed as cardiogenic but were later confirmed as distributive shock, while two cases were missed by the RUSH protocol.[17] Obstructive shock showed excellent sensitivity, specificity and very good agreement with the final diagnosis. All five patients were correctly identified using the RUSH protocol. Key ultrasonographic findings included reduced ejection fraction (<55%), 'A' profile on lung ultrasound and distended IVC with <50% collapsibility in 100% of cases.[18,19] Cardiac tamponade was detected in 40% (2/5) and right heart strain in 60% (3/5). Final diagnoses included two cases of cardiac tamponade and three of pulmonary thromboembolism.[20]

One significant limitation identified in this study was the difficulty in clearly differentiating hypovolemic shock from distributive shock using the RUSH protocol. These two categories often share similar sonographic features, making real-time distinction challenging in the emergency setting. An unexpected observation was that a patient with clinically confirmed hypovolemic shock demonstrated a 'C' lung profile (consolidation), a finding typically associated with infection or sepsis. This highlights that ultrasound patterns may not always conform to expected diagnostic classifications. In this study, the final diagnosis was established using a clearly defined clinical and laboratory gold standard, which strengthened the accuracy and reliability of the diagnostic comparisons. This approach differs from other studies that did not use a uniform gold standard for confirmation.

CONCLUSION

The RUSH protocol, when performed within 25 minutes of patient arrival, demonstrated high diagnostic accuracy and strong agreement with final clinical diagnoses across all major shock types. Its bedside applicability, rapid execution and non-invasive nature make it an invaluable tool for early shock evaluation, particularly in resource-limited Indian emergency settings. Incorporating structured PoCUS training and routine RUSH implementation into emergency medicine practice and curricula can significantly enhance early resuscitative decision-making and improve patient outcomes.

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