RESEARCH PAPER

Point-of-Care Ultrasound in Emergency Shock Assessment: Diagnostic Yield, Training Barriers and Patient Outcomes

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ABSTRACT

Shock is a diagnosis, unstable and time-critical. In 2017, sepsis was estimated to cause 48.9 million cases and 11 million deaths worldwide (sepsis alone), and emergency hypotension is linked to significantly higher mortality. While point-of-care ultrasound (POCUS) is encouraged as a complement to the traditional physical exam at the bedside, this does not mean that a diagnostic advantage translates into improved outcomes. This flash review critically synthesised primary evidence related to POCUS for emergency shock assessment, and a secondary literature review was performed for theory only, and not to generate findings. A secondary review design was used. The literature review and the RUSH pump, tank and pipes model were based on reviews, guidelines and conceptual papers. Twenty primary studies were located and analysed thematically. Results: Four themes emerged: diagnostic yield, shock subtype discrimination, management and patient outcomes, and training barriers. POCUS frequently minimized diagnostic uncertainty and enhanced diagnostic concordance, particularly in the studies conducted. A multicentre randomised trial, however, did not reveal any survival benefit; therefore, better information does not always lead to better hard outcomes. In general, obstructive and cardiogenic shock responded better to ultrasound than did distributive and mixed shock. Again and again, implementation was limited by training, credentialing, time, supervision and documentation. POCUS should be viewed as an outcome intervention that can be used as an adjunct to diagnosis, not as a diagnostic intervention.

Keywords: point-of-care ultrasound; emergency shock; RUSH protocol; diagnostic accuracy; thematic analysis; training barriers; patient outcomes
How to cite this article: Zheng L, Rusip G, Girsang E. Point-of-Care Ultrasound in Emergency Shock Assessment: Diagnostic Yield, Training Barriers and Patient Outcomes. Int J Drug Deliv Technol. 2026;16(47s): 520-529. DOI: 10.25258/ijddt.16.47s.60

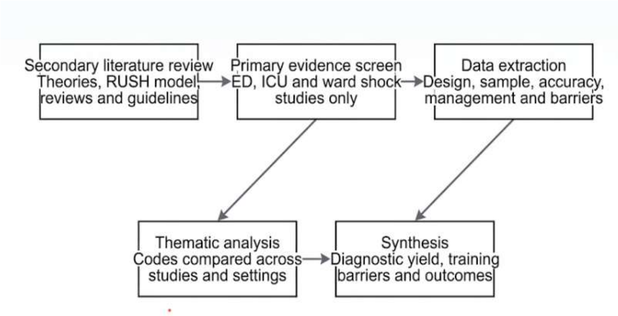
INTRODUCTION

In the field of emergency medicine, shock assessment is a race between physiologic and uncertainty. Hypotension, altered perfusion/tachycardia may be present, and the treatable cause may be haemorrhage, sepsis, pulmonary embolism, tamponade, severe left ventricular failure, or a combination of these. The rewards are great. The Global Burden of Disease analysis estimated 48.9 million incident sepsis cases and 11 million sepsis-related deaths in 2017, accounting for almost one-fifth of all global deaths (Rudd et al., 2020). Other than the emergency cohorts, hypotension and shock also correlate with high mortality and resource utilization (Holler et al., 2015; Jones et al., 2006). Guidelines regarding sepsis and circulatory failure, therefore, focus on the need to recognise it, treat it with a target approach, and undertake a dynamic reassessment rather than relying on a single, static sign (Evans et al., 2021; Vincent & De Backer, 2013).

The advantages of POCUS are related to time compression: cardiac contractility, right ventricular strain, inferior vena cava behaviour, lung artefacts, pericardial fluid, free intraperitoneal fluid and aortic pathology can all be evaluated during resuscitation. It is not just about visualisation, it is about decision support. The bedside scan should give the clinician better clues to choose among vasopressors, fluids, blood, pericardiocentesis, thrombolysis, surgery, and antibiotics more safely. The technology can also foster false confidence if operators are not well trained, if image quality is not good enough, or if ultrasound signs are extended to complex mixed shock.

Figure 1 summarises the review design. The conceptual lens was coded in secondary literature, and findings were coded in primary papers. This separation is important, as reviews may include the same original studies and might mask any limitations in blinding, reference standards and operator training.

Figure 1: *Secondary review design separates the literature review theory from the primary study findings.*



Literature Review and Theoretical Lens

The literature review was deliberately limited to secondary and conceptual literature. The RUSH is still the most popular model, as it converts shock questions into pump, tank and pipe questions (Perera et al., 2010, 2012). The pump component deals with contractility, tamponade and RVP. The tank component deals with volume, VC and free fluid. The pipes component deals with the aorta, deep veins and obstructive vascular disease. The model is useful but can be misleading for distributive and mixed shock, and septic vasodilation can occur with myocardial dysfunction, hypovolaemia or pulmonary embolism.

Systematic reviews offer a prudent theoretical starting point. Stickles et al. (2019) determined that RUSH was better at ruling in some shock categories than at ruling them out. Pooled specificity was high across all subgroups, especially in obstructive and cardiogenic shock, as reported by Yoshida et al. (2023); however, heterogeneity and differences in blinding and reference standards were also noted. A similar conclusion was reached by Berg et al. (2022), who also reported that POCUS would enhance diagnostic accuracy, but without clear evidence of effects on outcomes. In critical care settings, the same trend was observed: a robust signal for obstructive and cardiogenic shock, but less certainty for the other shock subtypes, as reported by Karigowda et al. (2024).

The theoretical lesson is then not a sales pitch, but comparative. POCUS should be evaluated using actual thinking and common sense, not no thinking and common sense. It can overcome anchoring bias when identifying tamponade or severe ventricular failure, but it can also lead to premature closure if a single sign is used as a diagnostic criterion. That lens was used in this review to interpret primary studies critically.

METHODS

The secondary review was conducted as a rapid review design and resulted in a short, concise flash article. Secondary sources, consensus papers and guidelines were used for the literature review. The findings section did not include these papers and only included primary studies reporting original data on POCUS, ultrasound protocols, focused Ultrasound or training in shock/emergency haemodynamic assessment.

Randomised trials, prospective or retrospective diagnostic studies, observational cohorts, surveys and educational implementation studies were eligible for the primary studies. Relevance to emergency shock, undifferentiated hypotension, circulatory failure, suspected obstructive shock, sepsis-related resuscitation or POCUS training barriers were required for inclusion. The studies were pulled for design, setting, sample, protocol, comparator, outcomes and limitations. Since the designs and endpoints were not homogeneous, no attempt was made to pool the statistics. Instead, the thematic analysis was conducted, following Braun and Clarke's (2006) stages of familiarisation, coding, theme construction, review of disconfirming evidence and interpretive synthesis.

Headline accuracy was not the focus of critical appraisal; instead, internal validity was prioritised. Special effort was made to review the blindness, reference standard quality, sample size, spectrum bias, confounding, generalisability, operator training and associations between diagnostic gains and management or patient outcomes. This is also in line with the guidance for diagnostic studies (e.g., QUADAS-2, STARD) (Bossuyt et al., 2015; Whiting et al., 2011).

Primary Evidence Coded for Findings

Table 1: *Primary studies were used to synthesize the findings. Secondary reviews were not coded as findings.*

Study	Design and sample	Main primary finding	Method critique
Jones et al. (2004)	RCT, ED hypotension, n=184	Immediate ultrasound improved the accuracy of the most likely diagnosis at 15 minutes: 80% vs 50%.	Strong comparator, but an older single protocol and a short diagnostic endpoint.
Haydar et	Prospective	POCUS	Measures

al. (2012).	septic shock utility study	changed planned treatment in 53% of cases and increased clinician certainty in many others.	clinician utility, but is not powered for mortality.
Volpicelli et al. (2013)	Prospective multiorgan POCUS, n=108	Showed feasibility and diagnostic value in nontraumatic symptomatic hypotension.	Reference standard and operator dependence limit certainty.
Bagheri-Hariri et al. (2015).	ED RUSH cohort, n=25	RUSH influenced the classification of unknown shock.	Very small sample, high risk of unstable estimates.
Ghane et al. (2015).	Prospective ED diagnostic study, n=52	High agreement with final diagnosis; better performance in obstructive and hypovolemic shock than mixed states.	Small subtype cells and clinical reference standard.
Shokoohi et al. (2015).	Prospective observational hypotension study, n=118	Diagnostic uncertainty fell by 27.7%; POCUS changed fluids, vasoactive treatment, imaging and consultations.	Important process outcomes, but no randomised outcome comparison.
Sasmaz et	Prospective	Diagnostic	Before-and-

al. (2017).	nontraumatic shock study, n=180	consistency increased from 60.6% before POCUS to 85.0% after POCUS.	after design is vulnerable to incorporation bias.
Atkinson et al. (2018).	International multicentre RCT, n=273	No 30-day or discharge survival benefit: 76.5% vs 76.1%.	Robust design, but stopped early, and mortality may be insensitive to diagnostic gains.
Nazerian et al. (2018).	Primary diagnostic study, shock with suspected PE	Focused cardiac and venous ultrasound supported PE-related obstructive shock assessment.	Applies to suspected PE subgroup, not all shock.
Rahulkumar et al. (2019).	Resource-limited prospective study, n=130	Mean exam 12 minutes; accuracy was highest for obstructive and cardiogenic categories, lower for distributive and mixed shock.	Single setting, operator and case-mix effects likely.
Daley et al. (2019).	ED suspected PE diagnostic study	Focused cardiac ultrasound increased sensitivity for PE in patients with abnormal vital signs.	Disease-specific study with spectrum effects.
Javali et al. (2020).	Prospective undifferentiated	Clinical accuracy was 45%,	Shows integration matters;

	hypotension, n=100	POCUS alone 47%, and combined clinical plus POCUS 89%.	POCUS alone was not sufficient.
Schnittke & Damewood (2019).	Resident implementation study	Documentation protocol increased POCUS use in decision-making and improved exam capture.	Implementation outcome, not clinical accuracy.
Zieleskiewicz et al. (2021).	Prospective ward emergency cohort, n=165	Adequate diagnosis 94% vs 80%; time to treatment shorter with POCUS.	Observational and ward-based, with residual confounding.
Keefer et al. (2021).	SHoC-ED secondary primary-data analysis, n=135	FOCUS detection of LV dysfunction had 62.5% sensitivity and 94.1% specificity for cardiogenic shock.	Low sensitivity means negative scans cannot exclude cardiogenic shock.
Ramadan et al. (2022).	Prospective echo-US protocol, n=140 analysed	Protocol often diagnosed shock earlier; management was altered in 39.3%.	Lower positive predictive value for hypovolemic shock.
Elsayed et al. (2022).	EM trainee survey, n=52	Only 15% were credentialed; time constraints and credentialing processes were major	Survey self-report and local training culture.
		barriers.	
Peach et al. (2023).	SHoC-ED diagnostic accuracy analysis, n=270	Overall diagnostic accuracy was similar: 93.7% POCUS vs 93.6% usual care.	Challenges the assumption that POCUS always adds value in expert systems.
Lin et al. (2024)	Prospective ED shock classification, n=270	Misclassification was 14.4%, often initial hypovolemic, later distributive shock.	Highlights subtype ambiguity despite modern protocols.
Jarvinen et al. (2025).	Nationwide Finnish EM survey, n=134	Barriers included inadequate training, supervision, time and device availability; 96.5% of open comments requested structured training.	Perceptions may not equal observed practice.

Findings: Thematic Analysis of Primary Studies

The twenty main studies were coded into five overlapping themes. Selected studies that had sufficient data to perform a pre- vs. post- comparison of diagnostic performance are shown in Figure 2. The coding density is shown by theme in Figure 3.

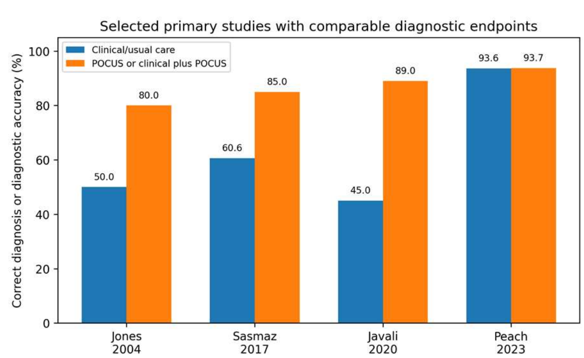


Figure 2: *Diagnostic accuracy or diagnostic concordance in selected primary studies with comparable endpoints.*

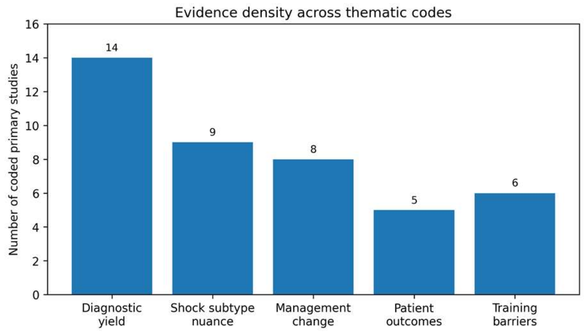


Figure 3: *Thematic evidence density across the twenty primary studies.*

Theme 1: POCUS improves diagnostic yield, but the gain depends on baseline uncertainty

Clinicians with high uncertainty at the outset achieved the most significant diagnostic improvements. Immediate ultrasound was shown to increase the likelihood of the correct diagnosis from 50% to 80% within 15 minutes (Jones et al., 2004). Similarly, Sasmaz et al. (2017) reported an increase in diagnostic consistency from 60.6% to 85.0%, and Javali et al. (2020) showed that diagnostic accuracy was only 45% with clinical assessment alone. In contrast, it was 89% when POCUS and clinical data were combined. The results of these studies support the use of POCUS as an uncertainty-reduction tool. In contrast, Peach et al. (2023) observed nearly the same accuracy in both the POCUS and usual-care arms of the SHoC-ED, suggesting that the benefit is smaller when expert clinical systems perform well.

Theme 2: Obstructive and cardiogenic shock are more ultrasound-responsive than distributive and mixed shock

The coded studies all identified a continuum of subtypes. The following studies demonstrated that POCUS is particularly convincing when anatomy and physiology are congruous with a visual sign: poor left ventricular function, free fluid or aortic pathology, pericardial fluid, right ventricular strain and anatomy and physiology matching a visual sign (Ghane et al., 2015; Javali et al., 2020; Keefer et al., 2021; Daley et al., 2019; Nazerian et al., 2018). Mixed, distributive and hypovolemic shock were more unstable categories, however. The positive predictive value for hypovolemic shock was lower, as reported by Ramadan et al. (2022), and many patients with hypovolemic shock were later categorized as distributive, as reported by Lin et al. (2024). This is important because a small or collapsed inferior vena cava can be indicative of hypovolaemia, vasodilation or ventilatory conditions, not just one diagnosis.

Theme 3: POCUS changes management more consistently than it changes mortality

There are widespread management effects. Changes to fluids, vasoactive agents, blood products, imaging, consultations and disposition were reported by Shokoohi et al. (2015). Haydar et al. (2012) reported that POCUS changed the management of septic patients in 53% of cases. Earlier protocol-based diagnosis and management changes were reported by Ramadan et al. (2022) in 39.3%, and shorter time to treatment was reported by Zieleskiewicz et al. (2021). However, the evidence of the outcome was more conservative. No survival advantage was found in the Atkinson et al. (2018) cohort, and the mortality advantage in the uncontrolled Zieleskiewicz cohort was reduced after propensity adjustment. The contrast suggests a lack of proof of process improvement and patient-centered outcomes.

Theme 4: Training barriers are not peripheral; they determine whether diagnostic promise is safe

There was consistency in training evidence throughout all systems. Elsayed et al. (2022) reported that credentialing levels were low among trainees in emergency settings, while beliefs in the importance of ultrasound were firm. The following were persistent barriers identified by Jarvinen et al. (2025): inadequate training, supervision, and time and access to devices. Schnittke and Damewood (2019) demonstrated that documentation procedures can increase the use of medical decision-making; thus, implementation is not necessarily education-centred. These studies view training as a patient-safety concern. A protocol that works well in trained hands may be an impediment to diagnostic accuracy if users are not skilled in image acquisition and have limited support and feedback for the images they interpret.

Table 2; *Thematic synthesis and implications.*

Theme	Convergent primary evidence	Contrasting evidence or limitation	Practice implication
Diagnostic yield	Jones, Sasmaz and Javali show improved concordance after or with	Peach found little added accuracy over usual care.	Use POCUS where uncertainty is high, not as a ritual

	POCUS.		scan.
Subtype discrimination	Obstructive and cardiogenic shock show clearer sonographic signatures.	Distributive, hypovolemic and mixed shock remain difficult to distinguish.	Integrate ultrasound with history, lactate, treatment response and serial reassessment.
Management change	Shokoohi, Haydar and Ramadan show changes in treatment or investigation.	Atkinson found no survival benefit.	Measure downstream decisions and patient outcomes, not only scan accuracy.
Training barriers	Surveys and implementation studies identify barriers related to time, supervision, credentialing and documentation.	Self-reported competence may not match observed skill.	Structured curricula, supervised scans and image review are essential.

DISCUSSION

The current results lend general support to the RUSH theory, but only if the model is considered a question set rather than diagnostic shorthand. Perera et al. (2010, 2012) suggested that scanning of the pump, tank and pipes can help organise shock physiology at the bedside. This is supported primarily by the visual findings, such as those of tamponade, ventricular failure and pulmonary embolism (Nazerian et al., 2018; Rahulkumar et al., 2019; Daley et al., 2019). This is also consistent with published secondary review results, which show a higher rule-in value than a rule-out value for some shock types (Stickles et al., 2019; Yoshida et al., 2023).

However, the review makes it difficult to draw simple conclusions about improvements in outcomes attributable to improved diagnosis with POCUS. The mixed findings about diagnosis in Jones et al. (2004), Shokoohi et al. (2015), Sasmaz et al. (2017) and Javali et al. (2020), compared with the neutral survival finding in SHoC-ED (Atkinson et al., 2018). This does not contradict. Mortality is related to the severity of the disease, availability of treatment, team response, source control of sepsis and system delays. While POCUS could help expedite the cognitive pathway towards a decision, it does not replace a delayed antibiotic, unavailable intensive care or irreversible physiology. This is in line with sepsis guidance, which integrates imaging as part of a package of swift resuscitation and source control, rather than a standalone intervention (Evans et al, 2021).

The results also contradict another widely held assumption – that diagnostic categories do not change. Lin et al. (2024), Ramadan et al. (2022), and Javali et al. (2020) demonstrate that the shock state can change as information comes in. This renders the final clinical diagnosis an ideal reference standard that is but less accurate. It also clarifies why the clinical plus POCUS strategy is a good approach, whereas POCUS alone is a poor approach (as shown in Javali et al., 2020). The safest reading: ultrasound is not an alternative to clinical judgement, but it is an update to it.

Training evidence takes the conversation from diagnostic science to implementation science. The accuracy of the reviews by Berg et al. (2022) and Yoshida et al. (2023) is still promising, but the main studies on training indicate that accuracy depends on credentialing, supervision, documentation and access (Elsayed et al., 2022; Jarvinen et al., 2025; Schnittke & Damewood, 2019). The many staff turnovers, lack of image archiving and feedback at a department with the same outcomes as a research site are not likely. The operator experience, scan quality, changes in decisions and adverse effects of misinterpretation would therefore be considered standard outcomes and should be reported in future studies.

CONCLUSION

POCUS is an effective and reliable test for shock assessment in the emergency department, particularly when shock is obstructive or cardiogenic and baseline diagnostic uncertainty is high. The main evidence is that uncertainty has been repeatedly reduced, management changes are often made, and there is limited and inconsistent evidence for mortality benefit. Technology is not the major constraint, but translation: mixed shock, weak reference standards, operator variation and training barriers all lead to reduced reliability. Implementation of POCUS in EDs should be carried out with a structured protocol, supervised training, image review, documentation and outcome audit. A pragmatic multicentre trial in the future would focus on the links between diagnostic accuracy, treatment timeliness, adverse decision-making, access-to-treatment inequities, and patient-centred outcomes.

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