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POINT-OF-CARE ULTRASOUND (POCUS) IN THE INITIAL MANAGEMENT OF REFRACTORY SEPTIC SHOCK: AN INTEGRATIVE REVIEW

ULTRASSONOGRAFIA POINT-OF-CARE (POCUS) NO MANEJO INICIAL DO CHOQUE SÉPTICO REFRATÁRIO: UMA REVISÃO INTEGRATIVA

ULTRASONIDO EN EL PUNTO DE ATENCIÓN (POCUS) EN EL MANEJO INICIAL DEL SHOCK SÉPTICO REFRACTARIO: UNA REVISIÓN INTEGRADORA

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ABSTRACT

Point-of-care ultrasonography (POCUS) has become an essential tool in the care of critically ill patients, enabling rapid, dynamic, and repeatable hemodynamic assessment. In refractory septic shock, where persistent hypotension and hypoperfusion impose therapeutic challenges, POCUS has proven particularly useful to integrate parameters of

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responsiveness, tolerance, and congestion, supporting individualized decisions on fluids and vasopressors. This study is an integrative review of the literature, exploratory and descriptive in nature, developed through searches in the PubMed, Scopus, Web of Science, SciELO, and Cochrane Library databases, covering the period from 2010 to 2025. A total of 47 articles were included, comprising systematic reviews, clinical trials, cohort studies, and international guidelines, selected according to relevance and methodological quality. The results demonstrated that passive leg raising (PLR) combined with LVOT-VTI is the most robust strategy for predicting fluid responsiveness. Lung ultrasound (LUS) stood out in the identification of hemodynamic intolerance, while the venous excess ultrasound (VExUS) score emerged as a promising tool to estimate the risk of fluid overload and acute kidney injury. Structured protocols such as RUSH and SIMPLE showed increased diagnostic accuracy of shock phenotypes and favored the multimodal application of POCUS. It is concluded that POCUS represents a transformative milestone in the management of refractory septic shock, as it enables personalized, safe, and real-time approaches. However, gaps remain regarding its impact on hard clinical outcomes, highlighting the need for multicenter trials and methodological standardization to consolidate its incorporation as a standard of care.

Keywords: Point-of-Care Ultrasonography. Septic Shock. Fluid Resuscitation. Echocardiography. Venous Congestion.

RESUMO

A ultrassonografia point-of-care (POCUS) consolidou-se como ferramenta essencial no atendimento de pacientes críticos, permitindo avaliação hemodinâmica rápida, dinâmica e repetitiva. No choque séptico refratário, em que a persistência da hipotensão e da hipoperfusão impõe desafios terapêuticos, a POCUS tem se mostrado particularmente útil para integrar parâmetros de responsividade, tolerância e congestão, oferecendo suporte para decisões individualizadas de fluidos e vasopressores. O presente estudo configura-se como uma revisão integrativa da literatura, de caráter exploratório e descritivo, desenvolvida a partir de busca nas bases PubMed, Scopus, Web of Science, SciELO e Cochrane Library, no período de 2010 a 2025. Foram incluídos 47 artigos, entre revisões sistemáticas, ensaios clínicos, coortes e diretrizes internacionais, selecionados conforme critérios de relevância e qualidade metodológica. Os resultados demonstraram que a elevação passiva dos membros inferiores (PLR) associada ao LVOT-VTI apresenta maior robustez na predição de responsividade a fluidos. A ultrassonografia pulmonar (LUS) destacou-se na identificação de intolerância hemodinâmica, enquanto o escore de congestão venosa sistêmica (VExUS) emergiu como instrumento promissor para estimar risco de sobrecarga e lesão renal aguda. Protocolos estruturados, como RUSH e SIMPLE, mostraram incremento na acurácia diagnóstica do fenótipo de choque e favoreceram a aplicação multimodal da POCUS. Conclui-se que a POCUS representa um marco transformador no manejo do choque séptico refratário, pois possibilita abordagem personalizada, segura e em tempo real. Entretanto, lacunas permanecem quanto ao impacto em desfechos clínicos duros, exigindo ensaios multicêntricos e padronização metodológica para consolidar sua incorporação como padrão de cuidado.

Palavras-chave: Ultrassonografia à Beira do Leito. Choque Séptico. Ressuscitação Volêmica. Ecocardiografia. Congestão Venosa.

RESUMEN
La ecografía en el punto de atención (POCUS) se ha consolidado como una herramienta esencial en la atención de pacientes críticos, permitiendo una evaluación hemodinámica rápida, dinámica y repetitiva. En el shock séptico refractario, donde la hipotensión persistente y la hipoperfusión plantean desafíos terapéuticos, la POCUS ha demostrado ser particularmente útil para integrar parámetros de respuesta, tolerancia y congestión, apoyando la toma de decisiones individualizada sobre fluidos y vasopresores. Este estudio es una revisión bibliográfica integrativa, exploratoria y descriptiva, desarrollada con base en búsquedas en las bases de datos PubMed, Scopus, Web of Science, SciELO y la Biblioteca Cochrane de 2010 a 2025. Se incluyeron cuarenta y siete artículos, incluyendo revisiones sistemáticas, ensayos clínicos, cohortes y guías internacionales, seleccionados con base en criterios de relevancia y calidad metodológica. Los resultados demostraron que la elevación pasiva de miembros inferiores (PLR) combinada con LVOT-VTI es más robusta en la predicción de la respuesta a fluidos. La ecografía pulmonar (LUS) se ha destacado en la identificación de la intolerancia hemodinámica, mientras que la escala de congestión venosa sistémica (VExUS) se ha convertido en una herramienta prometedora para estimar el riesgo de lesión renal aguda y sobrecarga. Protocolos estructurados, como RUSH y SIMPLE, han demostrado una mayor precisión diagnóstica para los fenotipos de choque y han favorecido la aplicación multimodal de la POCUS. Concluimos que la POCUS representa un hito transformador en el manejo del choque séptico refractario, permitiendo un enfoque personalizado, seguro y en tiempo real. Sin embargo, persisten lagunas en cuanto a su impacto en los resultados clínicos, lo que requiere ensayos multicéntricos y estandarización metodológica para consolidar su incorporación como estándar de atención.

Palabras clave: Ecografía a Pie de Cama. Choque Séptico. Reanimación con Volumen. Ecocardiografía. Congestión Venosa.

1 INTRODUCTION

Point-of-care ultrasonography (POCUS) has been consolidated in the last two decades as a central tool in bedside hemodynamic evaluation of sepsis and septic shock, as it integrates cardiac, pulmonary, and venous findings in real time and allows serial reassessments at no additional physiological cost. Contemporary guidelines and recent revisions emphasize that, in the first hours of volume management, the decision about fluids and vasoactives should be based primarily on dynamic (rather than static) metrics, a scenario in which POCUS offers high clinical and operational value (Evans et al., 2021; Verras et al., 2023; Polyzogopoulou et al., 2023; Kaselitz; Seymour, 2025).

Refractory septic shock represents a particularly challenging subgroup, characterized by persistent hypotension and hypoperfusion despite adequate initial measures, often requiring high doses of vasopressors. It is important to note that there is no universal definition : a recent systematic review showed great variability in the thresholds used (e.g., norepinephrine ≥1.0 μg/kg/min), while educational documents cite lower ranges (≥0.25 μg/kg/min per ≥4 h), reinforcing the heterogeneity and urgency of refined and individualized assessment strategies (Hernández et al., 2023; ACEP, 2025; StatPearls, 2024).

The literature associates sustained positive fluid balance with worse outcomes, including higher mortality and ICU time, so that indiscriminate resuscitation with large volumes may be deleterious in some septic patients. Classic studies and subsequent cohorts have demonstrated that both early excess and cumulative fluid accumulation in the first few days correlate with increased mortality, driving the concept of fluid stewardship and the four D's (drug, dose, duration, de-escalation) throughout the four phases (resuscitation, optimization, stabilization and evacuation) of septic shock (Boyd et al., 2011; Acheampong; Vincent, 2015; Malbrain et al., 2018).

In this context, dynamic metrics outperformed static markers (e.g., PVC) in predicting fluid responsiveness. Passive lower extremity elevation (PRL) accompanied by systemic output measurements, ideally via VTI of the LV outflow tract (LVL-VTI) by focal echocardiography, is consistently recommended to guide volume with a lower risk of overload. Reviews and meta-analyses point to the physiological robustness of PLR when well standardized and measured by direct flow method, in line with the recommendations of the Surviving Sepsis Campaign 2021 (Monnet; Teboul, 2016; Monnet; Teboul, 2022; Evans et al., 2021; Hotz et al., 2024).

Ultrasound evaluation of the inferior vena cava (IVC) is widespread, but its performance is context-dependent: meta-analyses and systematic reviews show moderate accuracy and significant heterogeneity, with better utility in controlled ventilation and relevant limitations in spontaneously breathing patients; therefore, it should not be used alone to decide fluids (Kim et al., 2021; Júnior et al., 2023; Chaves et al., 2024).

In the pulmonary domain, lung ultrasonography (LUS) allows the detection and monitoring of extravascular pulmonary water by B-lines, contributing to the balance between fluid responsiveness and tolerance , i.e., it helps to recognize the point at which more volume tends to cause damage (worsening oxygenation, edema) rather than hemodynamic benefit. Narrative reviews and clinical studies support the use of LUS to guide frequent reassessments during volume resuscitation of critically ill patients (Berry et al., 2025; Mohamed et al., 2020).

More recently, the evaluation of systemic venous congestion by the VExUS score has emerged as a complementary tool to estimate fluid tolerance and risk of congestion-related organ dysfunction (e.g., acute kidney injury), being feasible at the bedside and with encouraging reproducibility, especially when using ECG tracingscoupled with venous Doppler acquisition (Longino et al., 2024). In refractory septic shock scenarios, the combination of cardiac output (VTI) and degree of congestion (VExUS) is promising to guide both fluid de-escalation and vasoactive/inotropic adjustments (Longino et al., 2024).

In addition to point measures, structured POCUS protocols for hypotension/shock, such as RUSH ("pump-tank-pipes") and FoCUS approaches such as SIMPLE, increase the diagnostic accuracy of the shock phenotype and anchor hemodynamic decision-making in the physiological picture of the patient, favoring safe and timely choices in the initial period (Perera et al., 2010; Seif et al., 2012; Mok, 2016; ACEP Sonoguide, 2021).

In view of this evidence, it is proposed that, in refractory septic shock, POCUS be applied in a multimodal and iterative manner: (a) PLR + LVOT-VTI to identify fluid responsiveness; (b) LUS (B-lines/aeration score) to estimate tolerance and risk of overload; (c) VExUS to measure systemic congestion and guide de-resuscitation; and (d) RUSH/FoCUS protocols to confirm shock phenotype and concurrent causes. However, while intermediate outcomes (diagnostic accuracy, volumes administered) are favourable, effects on hard outcomes (e.g., mortality) remain inconsistent across real-world emergency department cohorts, a gap that justifies this integrative review, aimed at critically synthesizing

the evidence and proposing a practical framework of application in the first hours of management (Ablordeppey et al., 2024; Verras et al., 2023; Evans et al., 2021).

2 METHODOLOGY

The present study is an integrative literature review, of an exploratory and descriptive nature, focused on the use of point-of-care ultrasonography (POCUS) in the initial management of refractory septic shock. The choice for integrative review is justified by the need to gather, critically analyze, and synthesize different types of evidence, from clinical trials and meta-analyses to international consensus and guidelines, in order to offer a comprehensive view of protocols, dynamic metrics, and imaging tools applicable to clinical practice (Whittemore; Knafl, 2005; Souza; Silva; Carvalho, 2010; Mendes; Scott; Galvão, 2008).

2.1 SOURCES AND SEARCH STRATEGY

The bibliographic search was conducted between March and September 2025 in the PubMed/MEDLINE, Embase, Web of Science, Scopus, SciELO, and Cochrane Library databases. In addition, official documents from medical societies such as the Surviving Sepsis Campaign (SSC), the Society of Critical Care Medicine (SCCM) and the American College of Emergency Physicians (ACEP) were consulted.

The descriptors were selected from DeCS/MeSH, including: *Septic Shock; Sepsis; Point-of-Care Ultrasonography; Echocardiography; Passive Leg Raising; Velocity Time Integral; Lower Vena Cava; Lung Ultrasound; Venous Excess Ultrasound (VExUS).*

2.2 INCLUSION CRITERIA

- Original articles, systematic reviews, meta-analyses, and guidelines published between 2010 and 2025;
- Publications in Portuguese, English or Spanish;
- Studies that specifically addressed the use of POCUS in the hemodynamic or therapeutic evaluation of patients with refractory septic shock;
- Studies that presented evidence related to fluid responsiveness, vasopressor/inotrope adjustment, or prevention of complications resulting from fluid overload.

2.3 EXCLUSION CRITERIA

- Isolated case reports or clinical series with very small samples;
- Opinion articles, editorials or texts without scientific support;
- Duplicate posts;
- Studies that did not clearly specify the context of septic shock or that did not relate POCUS to clinical decision-making.

2.4 ANALYSIS PROCEDURE

The literature analysis was conducted in three stages:

1. Exploratory reading of titles and abstracts, to identify potentially relevant studies;
2. Selective reading of full articles, prioritizing those that directly addressed the use of POCUS in refractory septic shock;
3. Integrative and interpretative reading, organizing the findings into four thematic axes: (a) dynamic metrics for predicting fluid responsiveness (PLR-VTI, VCI variation); (b) fluid tolerance assessment (LUS, B-lines, aeration score); (c) measurement of systemic congestion (VExUS); (d) multimodal protocols with initial approach (RUSH, SIMPLE, FoCUS).

2.5 METHODOLOGICAL LIMITATIONS

As this is an integrative review, this study did not follow formal protocols of systematic reviews, such as PRISMA, which may introduce greater subjectivity in the selection and interpretation of sources. The heterogeneity of the included studies, in terms of methodological design, sample, and POCUS protocols used, represents a potential bias, making it difficult to directly compare the findings. In addition, the time constraint (2010–2025) may have excluded classical studies that are still relevant. Attempts were made to mitigate these limitations through the inclusion of clinical trials, cohorts, meta-analyses, systematic reviews, and international guidelines, ensuring diversity and robustness of the analysis (Whittemore; Knafl, 2005; Souza; Silva; Carvalho, 2010; Mendes; Scott; Galvão, 2008).

3 RESULTS

The search resulted in the selection of 47 articles that met the established criteria, including clinical trials, prospective and retrospective cohorts, systematic reviews, meta-analyses, and international guidelines. The analysis made it possible to organize the findings

into four main axes: prediction of fluid responsiveness, fluid tolerance, evaluation of systemic venous congestion, and multimodal protocols for initial approach in refractory septic shock.

3.1 PREDICTION OF FLUID RESPONSIVENESS

Several studies have confirmed that dynamic metrics, such as passive lower limb elevation (PRL) associated with LVOT-VTI analysis by focal echocardiography, are robust methods to identify patients with potential for a favorable response to volume expansion. Meta-analyses indicate high accuracy and better clinical applicability when compared to static parameters, such as central venous pressure (CVP) (Monnet; Teboul, 2016; Monnet; Vieillard-Baron; Teboul, 2024). These findings corroborate the recommendations of the Surviving Sepsis Campaign 2021, which emphasizes the superiority of dynamic variables (Evans et al., 2021).

On the other hand, the evaluation of the inferior vena cava (IVC) was less consistent. Recent systematic reviews and meta-analyses highlight significant heterogeneity in diagnostic performance, especially in non-mechanically ventilated patients, in whom the IVC variation has low sensitivity and specificity (Kim et al., 2021). Still, in populations under controlled ventilation, the IVC can provide complementary clues when interpreted in conjunction with other parameters.

3.2 FLUID TOLERANCE

The use of lung ultrasonography (LUS) has emerged as a relevant tool for assessing fluid tolerance and monitoring the risk of fluid overload. The presence of diffuse B-lines is associated with pulmonary congestion and worsening oxygenation, which may signal the need to interrupt fluid resuscitation. Recent narrative reviews point to LUS as a useful and practical method to integrate responsiveness and tolerance, allowing a more balanced view of the amount of volume (Berry et al., 2025; Mohamed et al., 2020).

3.3 EVALUATION OF SYSTEMIC VENOUS CONGESTION

In recent years, the systemic venous congestion score (VExUS) has established itself as a promising instrument for estimating fluid tolerance and the risk of acute kidney injury (AKI). Prospective studies have demonstrated good interobserver reproducibility, especially when associated with electrocardiographic tracing, increasing the accuracy of venous Doppler analysis (Longino et al., 2024). Pilot trials suggest that VExUS-guided strategies

reduce the volume of fluids administered without compromising hemodynamic stability, which represents an advance in the context of refractory septic shock (Innes et al., 2024).

Even more recently, integrative approaches combining VTI (cardiac output) and VExUS (degree of congestion) have been explored, offering a "balance" perspective between responsiveness and fluid tolerance, aligned with the concept of personalized resuscitation (Prager et al., 2025).

3.4 MULTIMODAL PROTOCOLS

Structured POCUS protocols, such as RUSH (*Rapid Ultrasound for Shock and Hypotension*) and SIMPLE, have been shown to be useful in increasing diagnostic accuracy in phenotypic differentiation of shock. Classic studies and educational guidelines from ACEP report that these protocols can increase the initial diagnostic accuracy from approximately 60% to more than 80% when applied systematically (Perera et al., 2010; Seif et al., 2012; ACEP, 2021).

In refractory septic shock, the literature indicates that the integration between different POCUS domains (cardiac, pulmonary, and venous) provides a multimodal approach, allowing for dynamic adjustment of volume replacement, vasopressor titration, and prevention of circulatory overload. However, observational studies suggest a more evident impact on intermediate outcomes (reduced infused volume, greater diagnostic accuracy), while the influence on mortality remains inconsistent, which reinforces the need for larger-scale clinical trials (Ablordeppey et al., 2024; Verras et al., 2023).

4 DISCUSSION

The findings of this review reinforce that point-of-care ultrasonography (POCUS) has been consolidated as an indispensable instrument in the evaluation and hemodynamic management of patients in septic shock, especially in the refractory subgroup, in which the persistence of hypotension and hypoperfusion requires quick and individualized decisions. The main contribution of POCUS in this context is the ability to integrate different dimensions of physiological assessment, cardiac function, pulmonary congestion, and systemic venous congestion, allowing the clinician to guide volume resuscitation and the use of vasopressors more safely.

The literature consistently shows that dynamic metrics outperform static metrics in predicting fluid responsiveness. Passive elevation of the lower limbs (PLR), associated with

the measurement of LVOT-VTI, is considered the functional gold standard, with robust performance demonstrated in meta-analyses and systematic reviews (Monnet; Teboul, 2016; Monnet; Vieillard-Baron; Teboul, 2024). The method has sensitivity and specificity superior to those obtained by static variables, such as CVP and atrial filling pressure, which have historically dominated clinical practice. In addition, PLR is reversible, non-invasive and replicable, characteristics that make it suitable for daily practice. However, studies emphasize that the correct execution and interpretation depend on adequate training and access to quality echocardiography, which may limit its applicability in services with less infrastructure (Evans et al., 2021).

In the case of the inferior vena cava (IVC), often used as a simpler alternative, the results remain contradictory. Recent systematic reviews indicate that IVC variability has acceptable accuracy in patients on controlled mechanical ventilation, but loses reliability in individuals on spontaneous ventilation, where multiple confounding factors interfere with measurement (Kim et al., 2021). This limitation reinforces the notion that no isolated parameter should guide the therapeutic approach, but rather compose a set of data interpreted in a contextualized way.

The analysis of fluid tolerance is another essential dimension in the management of refractory shock. Lung ultrasonography (LUS) allows early identification of the presence of pulmonary congestion by detecting B-lines, signaling the risk of volume overload and worsening oxygenation. Studies suggest that LUS can complement the assessment of responsiveness, offering a clinical balance between benefit and risk of volume expansion (Berry et al., 2025). This perspective is in line with the concept of fluid stewardship, which proposes the rational administration of fluids in four phases (resuscitation, optimization, stabilization, and evacuation), similar to the reasoning applied to antimicrobials (Malbrain et al., 2018). Thus, pulmonary POCUS increases the safety of resuscitation, avoiding excessive fluid accumulation, a factor associated with higher mortality and duration of mechanical ventilation.

One of the most recent advances is the use of the systemic venous congestion score (VExUS), which combines ultrasound findings of inferior vena cava and Doppler flow patterns in liver, door, and renal veins. Prospective studies have shown that VExUS is able to predict complications associated with fluid excess, especially acute kidney injury (AKI), with greater accuracy than traditional parameters (Longino et al., 2024). Pilot trials suggest that its application can reduce the volume of fluids administered without compromising tissue

perfusion (Innes et al., 2024). This approach shifts the focus from the evaluation of mere responsiveness to the notion of hemodynamic tolerance, introducing a more complete model of clinical decision-making. Although promising, VExUS still lacks validation in multicenter studies and large-scale clinical trials.

The integration between responsiveness (PLR-VTI), tolerance (LUS) and congestion (VExUS) reflects the trend towards a multimodal approach to POCUS. This paradigm is supported by structured protocols, such as RUSH and SIMPLE, which organize the evaluation into logical steps, covering pump (heart), reservoir (volume) and piping (vasculature) (Perera et al., 2010; Seif et al., 2012). These protocols have shown an increase in diagnostic accuracy from about 60% to up to 85% in the diagnosis of the type of shock (ACEP, 2021). In refractory septic patients, its systematic application helps to rule out alternative causes of hypotension, such as cardiac tamponade or pulmonary embolism, allowing volume resuscitation to be adjusted to the patient's actual phenotype.

Despite the advances, the literature still has significant gaps. First, most studies focus on intermediate outcomes (infused volume, diagnostic accuracy, modification of therapeutic management), while few have evaluated mortality, length of hospital stay, or quality of life. Second, the methodological heterogeneity is striking: the POCUS protocols used, the cutoff points adopted, and the experience of the operators vary, making it difficult to compare studies directly. Another limiting factor is the absence of a universal definition for refractory septic shock, with different criteria employed in research, which can bias the results and restrict clinical applicability (Hernández et al., 2023).

In addition, operational and educational aspects also pose challenges. Although POCUS is considered a fast-performing technique, its proper application requires structured training, a learning curve, and maintenance of competence. In overloaded emergency services, the availability of time and equipment can limit their systematic use. This reinforces the importance of implementing formal training programs in clinical ultrasonography, as well as the inclusion of POCUS as an essential competence in medical residency curricula in emergency and intensive care.

Finally, it is relevant to highlight that the transition from a practice guided only by fluid responsiveness to a model that also incorporates tolerance and congestion represents a paradigm shift in septic patient care. This change requires not only robust clinical evidence, but also a process of standardization of protocols, integration with advanced monitoring systems, and acceptance by the multiprofessional team. Multicenter clinical trials, evaluating

harsh outcomes and cost-effectiveness, are key to consolidating POCUS as the standard of care in the management of refractory septic shock.

5 CONCLUSION

This integrative review reinforces that point-of-care ultrasonography (POCUS) plays a central role in the initial management of refractory septic shock, standing out as a versatile tool, with rapid execution, and capable of integrating multiple dimensions of hemodynamic assessment. A critical analysis of the literature demonstrates that the systematic application of POCUS not only improves diagnostic accuracy, but also enables a more individualized therapeutic approach, in line with the pathophysiological complexity of septic shock.

Among the metrics studied, passive elevation of the lower limbs (PLR) associated with the LVOT-VTI assessment emerged as the most consistent strategy to identify patients with potential fluid responsiveness. This method overlaps with static measures and is in line with international guidelines, such as the Surviving Sepsis Campaign 2021, which emphasize the use of dynamic variables as a standard of care (Evans et al., 2021). Despite its robustness, the dependence on adequate training and quality equipment limits its dissemination in environments of less complexity, configuring a challenge to be overcome through educational and infrastructure policies.

The analysis of fluid tolerance, performed mainly by lung ultrasonography (LUS), represents another relevant conceptual advance. The ability to detect early pulmonary congestion and quantify B-lines increases the safety of resuscitation, preventing progression to pulmonary edema and organ dysfunctions resulting from excess fluid. This approach strengthens the concept of fluid stewardship, which proposes rational and phased administration of fluids, balancing immediate benefits and cumulative risks (Malbrain et al., 2018).

In the emerging field of systemic venous congestion assessment, the VExUS score has shown promise in offering an objective marker of circulatory overload, correlating with the occurrence of acute kidney injury and other complications. Pilot trials suggest that VExUS-guided protocols reduce the total volume of fluids administered without compromising hemodynamic stability (Innes et al., 2024; Longino et al., 2024). However, it is a metric in the consolidation stage, which still needs methodological standardization and validation in multicenter clinical trials so that it can be incorporated as a universal recommendation.

The multimodal integration of the different POCUS domains, responsiveness (PLR-VTI), tolerance (LUS) and congestion (VExUS), demonstrates greater potential than the isolated application of parameters, promoting a holistic view of the patient's hemodynamic status. Structured protocols, such as RUSH and SIMPLE, organize this integration in a systematic way, allowing decision-making to be more agile and accurate, especially in emergency and intensive care scenarios. These protocols also favor the standardization of teaching and practice, reducing variability between operators and institutions.

Despite the favorable evidence, critical gaps remain. Most studies focus on intermediate outcomes, such as diagnostic accuracy, infused volume, or management modification, while few have evaluated robust clinical outcomes, such as mortality, length of hospital stay, or incidence of organ failure. In addition, the heterogeneity of the methodological designs, the absence of uniform criteria for defining refractory septic shock, and the variability in the experience of the operators limit the comparability and generalization of the results.

The clinical implications are clear: POCUS should be incorporated routinely and multimodally into the initial approach to refractory septic shock, helping to balance the need to expand circulating volume and the risk of inducing or aggravating congestion. From an educational point of view, it is essential to implement structured training and certification programs in clinical ultrasound for emergency and intensivists, ensuring that the technique is applied in a standardized and reproducible way.

In the field of research, multicenter investigations, preferably randomized controlled trials, are needed to evaluate the impact of POCUS on mortality, duration of mechanical ventilation, acute kidney injury, and hospital costs. Cost-effectiveness studies are also a priority, especially in middle- and low-income countries, where the availability of resources is limited and the adoption of technologies depends on the demonstration of economic benefit beyond the clinical.

In summary, POCUS should be understood as a transformative tool in the care of refractory septic shock, with the potential to become a standard of care in the coming years. Its consolidation will depend on three pillars: (1) generation of evidence of a high methodological level; (2) standardization of diagnostic and therapeutic protocols; and (3) wide dissemination of training among health professionals. By integrating responsiveness, tolerance, and congestion, POCUS not only refines decision-making, but also ushers in a new paradigm of personalized, safer, and more effective resuscitation for critically ill patients.

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