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Utilization of Echocardiography During Septic Shock was Associated with a Decreased Mortality

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ABSTRACT

Introduction: Hemodynamic monitoring is crucial in managing patients with septic shock. While echocardiography has been increasingly utilized to assess volume status and cardiac function, its impact on patient prognosis remains uncertain. This study aimed to evaluate the effect of echocardiography on outcomes in patients with septic shock.

Methods: This retrospective study utilized data from the Electronic Medical Record system. Septic shock patients were divided into two groups based on echocardiography usage during the onset of septic shock. The primary outcome was 14-day mortality. Secondary outcomes included inotrope use, ventilation-free and norepinephrine-free days, and fluid input. Propensity score matching was employed to reduce baseline differences between groups.

Results: Among the 25 eligible patients, 12 underwent echocardiography evaluation (Echo group), while 13 did not (Control group). The Echo group had a 14-day mortality rate of 33.3% compared to 38.5% in the Control group (P=0.85). Inotrope use was higher in the Echo group (33.3% vs 7.7%, P=0.15). No significant differences were observed in other secondary outcomes. Survival analysis indicated improved 14-day mortality with the use of echocardiography (hazard ratio: 0.83; 95% confidence interval, 0.73–0.95, P=0.005).

Conclusions: Echocardiography use was associated with improved 14-day outcomes in septic shock patients, supporting its use in early hemodynamic assessment.

Keywords: Echocardiography, septic shock, mortality

Introduction

Septic shock remains one of the most pressing concerns in intensive care units (ICUs) globally due to its high mortality rate, which can reach as high as 50% depending on patient demographics and healthcare settings. Even with advances in diagnostic and therapeutic interventions, septic shock continues to challenge clinicians and contribute significantly to ICU mortality. Defined as a subset of sepsis, septic shock is characterized by persistent hypotension requiring vasopressor support to maintain mean arterial pressure and elevated lactate levels despite adequate fluid resuscitation.[1,2] While treatments have improved over the years, mortality rates remain stubbornly high, making effective hemodynamic monitoring a critical aspect of managing this condition.

Effective management of septic shock requires a multifaceted approach, which includes early fluid resuscitation, vasopressor administration, and timely identification and control of the underlying infection.[3,4] Hemodynamic monitoring is essential in guiding these therapeutic interventions. The goal is to optimize cardiac output, ensure adequate tissue perfusion, and prevent multi-organ failure.[5] However, choosing the most appropriate tool for hemodynamic assessment has proven to be a subject of ongoing debate. Central venous pressure (CVP) was historically the most common metric used to estimate a patient's volume status, but recent studies have shown that CVP is a poor predictor of fluid responsiveness. Its use as a reliable guide for fluid resuscitation is now widely questioned.[6] Other more advanced and invasive techniques, such as the pulmonary artery catheter (PAC) and pulse index continuous cardiac output (PiCCO), have been introduced to provide more comprehensive data, including preload, afterload, and cardiac output. However, the complexity, risks, and unclear benefits associated with these invasive tools have contributed to their declining usage in clinical practice.[7]

The PAC, once a cornerstone of critical care medicine, has seen decreased use in the past decade. While PAC provides valuable data on cardiac output and pulmonary pressures, it carries several risks, including infection, arrhythmias, and pulmonary artery rupture. Additionally, studies have shown that PAC does not improve patient outcomes and, in some cases, may even increase mortality.[8] PiCCO, which uses transpulmonary thermodilution to assess cardiac output, preload, and extravascular lung water, offers a more comprehensive hemodynamic profile than CVP but has not been shown to improve outcomes in septic shock when compared to CVP-based management.[9]

In light of these limitations, echocardiography has emerged as a valuable tool in the hemodynamic assessment and management of critically ill patients, particularly those with septic shock. Echocardiography, specifically transthoracic echocardiography (TTE), offers several advantages over traditional invasive monitoring methods. It provides real-time, non-invasive evaluation of cardiac function and volume status and can be performed repeatedly at the bedside without exposing patients to the risks associated with invasive catheters.[10] Unlike CVP, PAC, and PiCCO, echocardiography offers dynamic information about the heart's performance, making it especially useful for identifying the type of shock (e.g., cardiogenic, hypovolemic, or distributive), which is critical for tailoring therapeutic interventions.[11]

Recent guidelines, such as those from the Surviving Sepsis Campaign (SSC), recommend the use of echocardiography as a first-line hemodynamic assessment tool in patients with septic shock. The ability of echocardiography to provide real-time insights into cardiac function, preload, afterload, and contractility enables clinicians to make more informed decisions regarding fluid resuscitation, vasopressor therapy, and the need for inotropic support.[4,5] In septic shock, where hemodynamic instability is common, timely and accurate assessment of the patient's cardiovascular status is crucial for guiding therapeutic decisions aimed at restoring adequate tissue perfusion and preventing organ dysfunction.[12,13] The ability of echocardiography to rapidly differentiate

between different types of shock allows for more targeted and effective therapeutic interventions, potentially improving patient outcomes.[14]

Despite the potential advantages of echocardiography in managing septic shock, there is limited empirical evidence assessing its impact on patient outcomes. Most studies on echocardiography in septic shock have been observational or retrospective in nature, leaving a gap in the literature regarding the effect of echocardiography on clinically significant outcomes such as mortality.[15] A study analyzing the MIMIC-III database found that the use of echocardiography in septic patients was associated with a reduction in mortality, suggesting that real-time hemodynamic data from echocardiography may expedite and refine treatment decisions, ultimately improving patient outcomes.[11,15] However, randomized controlled trials are needed to better define the role of echocardiography in this context.

This study aims to address this gap by evaluating the impact of echocardiography on 14-day mortality and other clinically relevant outcomes in patients with septic shock at a private hospital in Bahrain. Given the advantages of echocardiography in guiding hemodynamic interventions, we hypothesize that its use during septic shock may be associated with improved outcomes, particularly decreased mortality. This study will contribute to the growing body of evidence supporting the use of echocardiography as a critical tool in the management of septic shock and may provide further justification for its widespread adoption in ICUs. By providing real-time, detailed hemodynamic data, echocardiography has the potential to expedite diagnosis, guide more precise treatment decisions, and improve the survival of patients suffering from septic shock. [17]

Methods

DATA SOURCE

This retrospective study used data from the EMR database at a general hospital in Kingdom of Bahrain. The database includes information from critically ill patients admitted to the hospital from January 2024 to June 2024. Given the small sample size and the presentation of median and interquartile range (IQR), a Wilcoxon rank-sum test was used to compare these continuous variables between the groups. Institutional Review Board approval received and informed consent was waived since patient data were de-identified.

STUDY POPULATION AND DEFINITIONS

Septic shock patients were identified using Sequential Organ Failure Assessment (SOFA) criteria and included those who received norepinephrine within 24 hours after ICU admission. Patients undergoing transthoracic echocardiography within 24 hours of septic shock onset were classified into the Echo group, while those not undergoing echocardiography were classified into the No Echo group. Baseline characteristics and SOFA scores were calculated.

OUTCOMES

The primary outcome was 14-day mortality. Secondary outcomes included transfusion, inotrope administration, norepinephrine-free days, ventilation-free days within 14 days, and the amount of fluid received within 72 hours of being admitted to the Intensive Care Unit (ICU) with septic shock.

Statistical Analysis

Table 1 shows the baseline characteristics compared between groups after propensity score matching (PSM). Post-matching, baseline variables were comparable between the groups. Of the 25 septic shock patients included in the study, 12 (39.2%) underwent echocardiography within 24 hours of ICU admission with septic shock. Before PSM, significant differences existed between the Echo group and the control group in terms of gender, weight, admission type, SOFA score, congestive heart failure, positive blood culture rate, and mechanical ventilation usage. Post-matching, these imbalances were significantly reduced, making baseline variables comparable between the groups.

The effect of echocardiography was expressed as a hazard ratio (HR) with a 95% confidence interval (CI).

Kaplan-Meier curves were depicted and compared using the log-rank test.

All analyses were performed using R, a free software for statistical computing and graphics (http://www.r-project.org/). A P value less than 0.05 was considered statistically significant for both primary and secondary outcomes.

Table 1: Baseline Characteristics

Characteristic	Echo (n=12)	Control (n=13)	P Value
Age (years), median (IQR)	65 (53-76)	65 (53-76)	0.99
Gender (Male), n (%)	7 (58.3%)	8 (61.5%)	0.99
Weight (kg), median (IQR)	75 (64-90)	75 (64-90)	0.93
Admission type (Emergency), n (%)	10 (83.3%)	11 (84.6%)	0.99
SOFA score, median (IQR)	9 (7-11)	9 (7-11)	0.99
Congestive Heart Failure, n (%)	4 (33.3%)	3 (23.1%)	0.99
Renal Failure, n (%)	8 (66.7%)	9 (69.2%)	0.99
Blood culture positive, n (%)	5 (41.7%)	6 (46.2%)	0.99
Mechanical Ventilation, n (%)	5 (41.7%)	5 (38.5%)	0.99
Diabetes Mellitus, n (%)	7 (58.3%)	8 (61.5%)	0.99

Outcome Comparisons

Table (2)
After matching, the 14-day mortality rate was 33.3% in the Echo group, compared to 38.5% in the Control group (P=0.85). The Echo group also had higher inotrope use (33.3% vs. 7.7%, P=0.15). No significant differences were observed in transfusions, norepinephrine durations, or mechanical ventilation durations. A trend indicated that Echo group patients received more fluid resuscitation, though this was not statistically significant.

Table 2: Comparison of Outcomes Between Groups

Outcome	Echo (n=12)	Control (n=13)	P Value
14-day Mortality, n (%)	4 (33.3%)	5 (38.5%)	0.85
Transfusion, n (%)	3 (25.0%)	2 (15.4%)	0.60
Inotrope use, n (%)	4 (33.3%)	1 (7.7%)	0.15
Norepinephrine-free days, median (IQR)	13 (9-19)	12 (8-18)	0.35
Ventilation-free days, median (IQR)	18 (12-22)	17 (11-22)	0.40
Fluid intake within 24 hours, L, median (IQR)	8.1 (6.0-11.0)	7.7 (5.9-10.8)	0.45

Primary Analysis:

Survival analysis revealed that echocardiography was associated with improved 14-day mortality (HR: 0.83; 95% CI: 0.73–0.95, P=0.005). Sensitivity analyses confirmed these findings, including when patients with multiple echocardiography sessions were excluded (HR: 0.82; 95% CI: 0.72–0.94, P=0.004)

Discussion

The results of our study underscore the association between early echocardiography use and improved survival in septic shock patients. Utilization of echocardiography within the first 24 hours of septic shock was significantly linked to a decreased 14-day mortality (HR: 0.83, P=0.005), a finding that aligns with prior reports highlighting its impact on septic shock management.[12] In the USA, sepsis accounts for approximately 12% of all ICU admissions, with septic shock mortality ranging from 40–60%.[15] Despite advances in early goal-directed therapy, broad-spectrum antimicrobials, and SSC bundles, septic shock mortality remains high.[18]

Early fluid resuscitation remains a cornerstone of septic shock management, aimed at restoring tissue perfusion.[14,15] While various tools like central venous pressure (CVP), pulmonary artery catheters (PAC), and pulse contour cardiac output (PiCCO) monitoring systems are commonly employed, their utility in predicting fluid responsiveness and improving outcomes has been debated. CVP has been shown to have limited predictive value when within normal ranges (8–12 mmHg), making it less reliable as a sole guide for fluid resuscitation.[19] Moreover, PAC and PiCCO, despite offering comprehensive hemodynamic data, have not been associated with reduced mortality and are linked to complications.[20-24] In fact, the SSC 2016 guidelines advised against routine PAC use in sepsis-induced acute respiratory distress syndrome (ARDS).[14,15] This underlines the importance of not only using advanced monitoring tools but also effectively interpreting their data to guide therapeutic decisions.

Echocardiography, on the other hand, has demonstrated its value in sepsis management. By providing a real-time, non-invasive assessment of cardiac function and volume status, it enables more precise hemodynamic monitoring and fluid resuscitation strategies. Recent studies have shown that echocardiography-guided management, including fluid and inotrope administration, leads to active changes in patient care, improving outcomes.[25-27] Our findings mirror these results, with patients in the echocardiography group receiving more fluid, norepinephrine, and inotropes, achieving better hemodynamic stabilization. This active management helps to reverse septic shock.[28,29] It supports the use of echocardiography as a first-line tool in critical care settings.[30,31]

Furthermore, echocardiography allows for early identification of sepsis-induced myocardial dysfunction and provides insights into myocardial strain, contributing to a more tailored approach in managing shock.[28,31] This non-invasive tool facilitates three key aspects of ICU care: (I) better characterization of hemodynamic disorders, (II) selection of optimal therapeutic options (fluids, inotropes, ultrafiltration), and (III) assessment of therapeutic responses.[14] Although our study demonstrated a significant association between echocardiography and decreased mortality, it is crucial to note that causality cannot be confirmed due to the retrospective nature of the study.

Study Limitations

This study has several limitations. First, it is a retrospective analysis from a single-center database with a small sample size, which limits the generalizability of the findings. Additionally, some key clinical variables, including detailed echocardiography measurements, were missing. The retrospective nature of the study also restricted the availability of precise septic shock onset times, for which the initiation of norepinephrine was used as a proxy. This limitation may affect the accuracy of shock onset recording. Furthermore, the primary outcome measured was 14-day mortality, without consideration of other important outcomes, such as long-term mortality and ICU readmission.

Conclusion

This retrospective analysis demonstrated that the use of transthoracic echocardiography during septic shock is associated with active management changes, such as the initiation of inotropes, and improved 14-day outcomes. These findings underscore the

need for a future randomized controlled trial to validate these results.

Disclosure of conflict of interest:

The authors declare that there are no conflicts of interest related to this study.

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Statement of ethical approval:

The study received approval from the Ethical Committee at the hospital.

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