

The Cross-Sectional Study of Echocardiographic Evaluation of Sepsis-Induced Myocardial Dysfunction in Sepsis and Its Correlation with Higher Morbidity and Mortality in Sepsis

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Received: 05-08-2026 / Revised: 02-09-2026 / Accepted: 07-10-2026

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Conflict of interest: Nil

Abstract:

Background: Sepsis-induced myocardial dysfunction (SIMD) is an under-recognised cause of morbidity and mortality in sepsis. Data from Indian populations are limited. The current study aimed to evaluate myocardial dysfunction by 2D echocardiography in sepsis and correlate it with NT-proBNP, hospital stay, and mortality.

Methods: This cross-sectional observational study was conducted in the Medicine wards and ICU of a tertiary care centre in South Gujarat from August 2025 to April 2026. We enrolled 100 adults with sepsis (Sepsis-3 criteria) using purposive sampling after written informed consent. Patients with cirrhosis, chronic kidney disease, cardiac disease, non-sinus rhythm, BMI ≥ 30 kg/m², or malignancy were excluded. We analysed data using SPSS 26 with the chi-square test.

Results: Mean age was highest in the 51–60-year group, and 62% were male. Echocardiographic abnormalities were present in 72% of patients, mainly diastolic (52%) and systolic (48%) dysfunction. NT-proBNP was elevated in 74%. Overall mortality was 28%. Mortality was 36.1% with abnormal echocardiography versus 7.1% with normal findings ($p = 0.008$). Elevated NT-proBNP was associated with hospital stay beyond 14 days ($p = 0.001$). Abnormal echocardiography (aOR 4.8), elevated NT-proBNP (aOR 3.9), lactate >2 mmol/L (aOR 5.6), and acute kidney injury (aOR 2.6) independently predicted mortality.

Conclusion: Myocardial dysfunction is common in sepsis and is associated with higher mortality and prolonged stay. Echocardiography combined with NT-proBNP aids early risk stratification.

Keywords: Sepsis, Sepsis-induced myocardial dysfunction, Echocardiography, NT-proBNP, Mortality, Morbidity.

DOI: 10.25258/ijcpr.18.10.28

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Introduction

Sepsis is a life-threatening organ dysfunction caused by a dysregulated host response to infection, and it remains a leading cause of death in intensive care units, particularly in developing countries. The Sepsis-3 definitions identify organ dysfunction,

measured by a rise in the Sequential Organ Failure Assessment (SOFA) score, as the hallmark of the condition. [1] The cardiovascular system is among the most commonly affected, and it strongly influences outcomes. Sepsis-induced myocardial

dysfunction (SIMD) is now recognized as a distinct entity, characterized by reversible systolic and/or diastolic depression of the left ventricle, right ventricle, or both, in the absence of acute coronary syndrome. This has shifted the understanding of septic shock from a purely vasodilatory state to one that also involves intrinsic cardiac dysfunction. [2] Reported incidence ranges from 20% to 65%, depending on the population, severity of illness, timing of assessment, and diagnostic criteria. Since the early work of Parker et al. showed reversible left ventricular systolic dysfunction in septic shock, it has become clear that SIMD is heterogeneous, presenting as reduced ejection fraction, impaired strain with normal ejection fraction, diastolic dysfunction, or right ventricular dysfunction. [3] The pathogenesis is multifactorial. Pro-inflammatory cytokines (TNF- α , IL-1 β , IL-6) and excess nitric oxide depress myocardial contractility through direct negative inotropic effects and impaired calcium handling. [4] Mitochondrial dysfunction, microcirculatory and endothelial derangement, autonomic dysregulation, altered β -adrenergic signaling, and myocardial edema further impair cardiac performance. [5] Unlike ischemic cardiomyopathy, SIMD is often reversible in survivors, so early identification and management may improve outcomes. Echocardiography is an indispensable bedside tool in sepsis, offering non-invasive, real-time assessment of cardiac structure, ventricular function, preload, cardiac output, and pulmonary pressures. Transthoracic echocardiography is especially suited to the ICU because it is safe, accessible, and repeatable. [6] Left ventricular ejection fraction (LVEF) has traditionally been used, but it may miss subtle dysfunction in the hyperdynamic state of early sepsis. Greater emphasis is therefore placed on diastolic parameters (E/A ratio, E/e' ratio, left atrial size), right ventricular function (TAPSE, fractional area change), and advanced techniques such as tissue Doppler imaging and strain analysis. [7] Echocardiographic abnormalities are common in sepsis and are linked to more vasopressor use, prolonged mechanical ventilation, longer ICU stay, and higher mortality. SIMD worsens hemodynamic instability and tissue perfusion, increasing the need for vasopressors and inotropes and the risk of arrhythmias and ischemia. Diastolic dysfunction is associated with fluid intolerance and pulmonary congestion, complicating resuscitation. [8] Right ventricular dysfunction, tied to ARDS, mechanical ventilation, and raised pulmonary vascular resistance, independently predicts adverse outcomes but is often missed without routine echocardiography. [9] Although early reports suggested that reduced LVEF might be associated with better survival, recent evidence shows that both systolic and diastolic dysfunction mark disease severity and poor prognosis. Diastolic dysfunction is

linked to higher mortality independent of systolic function, and right ventricular dysfunction is a powerful predictor, particularly in ventilated patients. These findings favor comprehensive echocardiographic evaluation over reliance on a single parameter. [10] Data from Indian and regional populations remain limited, and differences in patient characteristics, comorbidities, and healthcare resources call for population-specific studies. A cross-sectional evaluation can clarify the prevalence and patterns of myocardial dysfunction and their relationship with morbidity and mortality. [11] Such understanding may support early risk stratification and better hemodynamic management. This study therefore aims to evaluate myocardial dysfunction by echocardiography in patients with sepsis and to correlate the findings with morbidity and mortality outcomes.

Materials and Methods

This was a hospital-based cross-sectional observational study of patients diagnosed with sepsis, assessed at a single point during their hospital admission. Patients were evaluated clinically and with laboratory investigations, biomarkers, and 2D echocardiography, without any intervention by the investigators. This allowed associations between echocardiographic findings, biochemical markers, and clinical outcomes (morbidity and mortality) to be analyzed in a real-world setting.

Study setting and duration: Medicine wards and Medicine Intensive Care Unit (ICU) of a tertiary care center in South Gujarat from August 2025 to April 2026.

Ethical approval: Approved by the Institutional Ethics Committee (Reference No. GMC/STU/RRC-1/Approval/17869, dated 05-08-2025). Written informed consent was obtained from all participants before enrolment.

Sampling technique: Purposive sampling. Eligible patients were enrolled consecutively until the required sample size was reached.

Study tool: Predesigned, semi-structured proforma.

Inclusion criteria

1. Patients aged more than 18 years
2. Diagnosed with sepsis according to the Sepsis-3 criteria
3. Patients who gave written informed consent

Exclusion criteria

1. Cirrhosis of the liver
2. Chronic kidney disease
3. Pre-existing cardiac disease or cardiac rhythm other than sinus rhythm
4. Body mass index ≥ 30 kg/m²
5. History of malignancy

Sample size calculation: The sample size was calculated using $n = 4PQ/L^2$, where P is the

prevalence of sepsis-induced myocardial dysfunction, $Q = 100 - P$, and L is the allowable error. Taking P as approximately 45% from Beesley et al. and L as 10% (absolute): $n = (4 \times 45 \times 55) / 10^2 = 9900 / 100 = 99$. The sample size was rounded off to 100 patients.

Statistical analysis: Data were recorded in the proforma and entered into Microsoft Excel. Data were analyzed using SPSS version 26. Quantitative variables were summarized as mean $\pm$ standard deviation, and categorical variables as frequencies and proportions. For bivariate analysis, the chi-square test was used to assess associations between echocardiographic parameters and outcomes. A p -value < 0.05 was considered statistically significant. Tables, graphs, and charts were used for presentation.

Results

Echocardiographic Evaluation of Sepsis-Induced Myocardial Dysfunction and Its Correlation with Morbidity and Mortality in Sepsis. A total of 100 patients with sepsis were enrolled in the study. The

baseline characteristics of the cohort showed the following features. Nearly two-thirds of patients were above 40 years of age, and the 51–60-year group was the largest (26%). There was a male predominance (62% male, 38% female). Farmers/laborers (28%) and homemakers (22%) were the commonest occupational groups. Fever (92%) was the commonest presenting complaint, followed by breathlessness (68%), altered sensorium (46%), reduced urine output (38%), and chest discomfort (22%). Hypertension (34%) and diabetes mellitus (28%) were the commonest comorbidities, and 30% had no comorbidities. Smoking (32%) and alcohol use (26%) were the commonest addictions. On general examination, pallor (48%) and edema (34%) were the commonest findings. Laboratory values showed anemia, leukocytosis, thrombocytopenia, deranged INR, raised bilirubin, creatinine, and liver enzymes, hyponatremia, and raised lactate (Table 1). NT-proBNP was elevated (≥ 300 pg/mL) in 74% of patients.

Table 1: Laboratory investigations (n = 100)

Parameter	Mean $\pm$ SD	Normal range
Hemoglobin (g/dL)	9.4 $\pm$ 1.8	12-16
TLC (/mm ³)	15,200 $\pm$ 4,600	4,000-11,000
Platelets (lakhs/mm ³)	1.2 $\pm$ 0.5	1.5-4.5
Hematocrit (%)	29 $\pm$ 6	36-46
RBS (mg/dL)	168 $\pm$ 62	70-140
INR	1.6 $\pm$ 0.5	0.9-1.2
Bilirubin (mg/dL)	2.1 $\pm$ 1.4	0.2-1.2
Creatinine (mg/dL)	1.9 $\pm$ 1.2	0.6-1.3
Sodium (mEq/L)	130 $\pm$ 6	135-145
Potassium (mEq/L)	4.9 $\pm$ 0.8	3.5-5.0
SGOT (U/L)	78 $\pm$ 40	<40
SGPT (U/L)	64 $\pm$ 36	<40
ALP (U/L)	162 $\pm$ 62	40-129
Lactate (mmol/L)	3.8 $\pm$ 1.6	<2.0

Echocardiographic evaluation demonstrated abnormalities suggestive of sepsis-induced myocardial dysfunction in 72% of patients, while 28% had a normal echocardiographic examination. Left ventricular diastolic dysfunction was the most frequently observed abnormality, present in 52% of patients, followed by left ventricular systolic

dysfunction in 48%. Global hypokinesia was observed in 36% of patients, while IVC dilatation greater than 2.0 cm was noted in 34%. Tricuspid regurgitation and right ventricular dysfunction were present in 24% and 22% of patients, respectively. Mitral regurgitation was identified in 18% of patients (Table 2).

Table 2: 2D echocardiographic findings (n = 100)

Finding	n	%
LV diastolic dysfunction	52	52.0
LV systolic dysfunction	48	48.0
Global hypokinesia	36	36.0
IVC dilatation (>2.0 cm)	34	34.0
Tricuspid regurgitation	24	24.0
RV dysfunction	22	22.0
Mitral regurgitation	18	18.0
Normal echocardiography	28	28.0

Length of hospital stay and duration of hospitalization: 58% of patients had a hospital stay

of ≤ 14 days, whereas 42% remained hospitalized for more than 14 days (Table 3).

Table 3: Length of hospital stay		
Duration	n	%
≤ 14 days	58	58.0
> 14 days	42	42.0

Clinical outcome of the 100 patients included in the study: 72 patients (72%) were discharged from the hospital, whereas 28 patients (28%) died during

hospitalization (Table 4). Thus, the overall in-hospital mortality in the study population was 28%. Sepsis

Table 4: Outcome		
Outcome	n	%
Discharged	72	72.0
Death	28	28.0

A significant association was observed between abnormal echocardiographic findings and in-hospital mortality. Among patients with abnormal echocardiography suggestive of sepsis-induced myocardial dysfunction, 26 of 72 patients (36.1%) died, compared with only 2 of 28 patients (7.1%)

with normal echocardiography. This difference was statistically significant (Yates-corrected $\chi^2 = 7.02$, $p = 0.008$). Patients with an abnormal echocardiographic examination had higher odds of mortality than those with normal echocardiography (crude OR 7.4, 95% CI: 1.6–33.5) (Table 5).

Table 5: Association between echocardiography and mortality					
Echo finding	Survived (n = 72)	Died (n = 28)	Total	χ^2	p
Abnormal (SIMD)	46	26	72	7.02	0.008
Normal	26	2	28		

The combined assessment of echocardiographic status and NT-proBNP demonstrated a graded increase in adverse outcomes. Mortality was lowest among patients with normal echocardiography and normal NT-proBNP (6.7%), and increased to 18.2% among those with abnormal echocardiography despite normal NT-proBNP. Among patients with elevated NT-proBNP, mortality was 22.2% in those with normal echocardiography and increased markedly to 58.3% in patients who had both abnormal echocardiography and elevated NT-proBNP.

A similar pattern was observed for prolonged hospitalization. The proportion of patients with a hospital stay exceeding 14 days was 13.3% among those with normal echocardiography and normal NT-proBNP, increasing to 36.4% in patients with abnormal echocardiography and normal NT-proBNP. Among patients with elevated NT-proBNP, prolonged hospitalization occurred in 44.4% of those with normal echocardiography and 66.7% of those with abnormal echocardiography. These findings indicate that the coexistence of echocardiographic abnormalities and elevated NT-proBNP was associated with the greatest burden of adverse outcomes (Table 6).

Table 6: Combined impact on outcomes		
Combination	Mortality (%)	Stay > 14 days (%)
Echo normal + NT-proBNP normal	6.7	13.3
Echo abnormal + NT-proBNP normal	18.2	36.4
Echo normal + NT-proBNP elevated	22.2	44.4
Echo abnormal + NT-proBNP elevated	58.3	66.7

Univariate analysis demonstrated that abnormal echocardiography, elevated NT-proBNP, lactate > 2 mmol/L, and acute kidney injury were significantly associated with mortality. Abnormal echocardiography was associated with more than sevenfold higher odds of death (OR 7.4, 95% CI: 1.6–33.5; $p = 0.008$). Elevated NT-proBNP was also significantly associated with mortality (OR 4.6, 95%

CI: 1.8–11.6; $p = 0.001$). Lactate > 2 mmol/L showed a strong association with mortality (OR 6.8, 95% CI: 2.6–17.9; $p < 0.001$), while acute kidney injury was associated with approximately threefold higher odds of death (OR 3.2, 95% CI: 1.3–7.9; $p = 0.01$). Age > 60 years was not significantly associated with mortality in the univariate analysis (OR 2.4, 95% CI: 0.9–6.2; $p = 0.08$) (Table 7). sepsis

On multivariate logistic regression analysis, abnormal echocardiography remained an independent predictor of mortality (adjusted OR [aOR] 4.8, $p = 0.003$). Elevated NT-proBNP (aOR 3.9, $p = 0.008$), lactate >2 mmol/L (aOR 5.6, $p <$

0.001), and acute kidney injury (aOR 2.6, $p = 0.04$) also remained independently associated with mortality after adjustment. The association between age and mortality was no longer statistically significant following adjustment.

Table 7: Univariate analysis for mortality

Variable	OR	95% CI	p
Abnormal 2D echo	7.4	1.6-33.5	0.008
Elevated NT-proBNP	4.6	1.8-11.6	0.001
Lactate >2 mmol/L	6.8	2.6-17.9	<0.001
Acute kidney injury	3.2	1.3-7.9	0.01
Age >60 years	2.4	0.9-6.2	0.08

In multivariate logistic regression, abnormal echo (aOR 4.8, $p = 0.003$), elevated NT-proBNP (aOR 3.9, $p = 0.008$), lactate >2 mmol/L (aOR 5.6, $p < 0.001$), and acute kidney injury (aOR 2.6, $p = 0.04$) remained independent predictors of mortality.

Discussion

In this cross-sectional study of 100 patients with sepsis, 72% had echocardiographic evidence of myocardial dysfunction. Mortality was 36.1% in these patients versus 7.1% in those with a normal echocardiogram. Elevated NT-proBNP was associated with a longer hospital stay, and patients with both abnormal echocardiography and raised NT-proBNP had the worst outcomes. Most patients were older than 40 years, and 62% were male. Male predominance is commonly reported in sepsis cohorts and may reflect sex differences in the inflammatory response and later health-seeking. Farmers, laborers, and homemakers formed the largest groups, which suggests that delayed access to care and socioeconomic factors contribute to sepsis severity. Hypertension and diabetes were the commonest comorbidities, and smoking and alcohol use were frequent. Alcohol dependence is independently associated with sepsis, septic shock, and hospital mortality. [12] The laboratory profile of anemia, leukocytosis, thrombocytopenia, raised lactate, creatinine, bilirubin and INR indicates multi-organ dysfunction, in keeping with the Sepsis-3 definition. [13] Diastolic dysfunction (52%) was the most common echocardiographic abnormality, followed by systolic dysfunction (48%), global hypokinesia (36%), and right ventricular dysfunction (22%). Normal echocardiography in 28% shows that myocardial involvement is heterogeneous. The overall prevalence is consistent with the wide range reported for septic cardiomyopathy [14]. The predominance of global rather than regional abnormalities supports a diffuse, potentially reversible process. [15,16] Diastolic dysfunction has been linked to mortality independent of systolic function [16], which supports assessing several parameters rather than ejection fraction alone. The overall mortality of 28% is similar to that reported in other series of sepsis

with organ dysfunction. Abnormal echocardiography was associated with higher odds of death (OR 7.4, 95% CI 1.6-33.5). It remained an independent predictor after adjustment for lactate, NT-proBNP, and acute kidney injury (aOR 4.8, 95% CI 1.7-13.4). The wide interval reflects the small number of deaths ($n = 2$) in the normal-echo group. Since myocardial depression in septic shock was first described as profound but reversible [17], early detection may help guide haemodynamic management. NT-proBNP was elevated in 74% of patients. Among them, 51.4% stayed more than 14 days, compared with 15.4% of those with normal levels ($\chi^2 = 10.2$, $p = 0.001$). NT-proBNP is raised by myocardial strain, cytokine-mediated injury, and volume overload, so it can complement echocardiography in risk stratification. The combination of both abnormalities carried the highest mortality (58.3%), supporting an integrated approach.

The limitations are the single-centre, cross-sectional design, purposive sampling and a modest sample size. A single echocardiogram could not capture changes over time or recovery. Excluding patients with cardiac disease, chronic kidney disease, cirrhosis, cancer or obesity limits generalisability. Finally, myocardial dysfunction on echocardiography and raised NT-proBNP were common in sepsis and were associated with higher mortality and a longer stay. Routine bedside echocardiography with NT-proBNP measurement is recommended for early risk stratification of septic patients.

Conclusion

Sepsis-induced myocardial dysfunction was common in this study, present in 72% of patients on echocardiography, with diastolic dysfunction the most frequent finding. Abnormal echocardiography and elevated NT-proBNP were each associated with higher mortality, and elevated NT-proBNP was also associated with a longer hospital stay. Patients with both abnormalities had the worst outcomes. Echocardiographic dysfunction, elevated NT-proBNP, raised lactate and acute kidney injury were

independent predictors of death. Routine bedside echocardiography with NT-proBNP measurement should therefore be considered early in sepsis for risk stratification and haemodynamic management. Larger multicentre studies with serial assessment are needed to confirm these findings.

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