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Predictive utility of inotropic scores in pediatric septic shock: A prospective observational cross-sectional study from a tertiary PICU in India.

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Abstract

Background
Septic shock remains a leading cause of morbidity and mortality in children, particularly in resource-limited settings. Early recognition of high-risk patients is essential to improve outcomes. The Inotropic Score (IS) and Vasoactive-Inotropic Score (VIS) quantify cardiovascular support and reflect illness severity. This study aimed to evaluate the usefulness of the Wernovsky Inotropic Score (WIS) and VIS in predicting mortality among children with septic shock admitted to a tertiary care PICU.
Objectives: To assess the predictive accuracy of the Wernovsky Inotropic Score (WIS) and Vasoactive-Inotropic Score (VIS) for in-hospital mortality in pediatric septic shock.

Methodology
This prospective, longitudinal study was conducted over 18 months (September 2022–March 2024) in the PICU of a tertiary care teaching hospital. Children aged 1 month to 18 years admitted with septic shock requiring vasoactive therapy were included. Patients who had received inotropes for more than 6 hours before admission or had ≥2 organ dysfunctions were excluded. The Inotropic Score (IS) was calculated as [IS = Dobutamine + Dopamine + 100 × Epinephrine (μg/kg/min)] at 24 and 48 hours. Data were analysed using appropriate statistical tests, and ROC curves were plotted to determine predictive accuracy.

Results
Among 21 patients, 13 (61.9%) died. Mean VIS and WIS were significantly higher in nonsurvivors (VIS: 53.55 ± 16.71 vs 29.04 ± 13.11, p = 0.002; WIS: 39.80 ± 14.78 vs 20.72 ± 12.57, p = 0.006). ROC analysis showed strong predictive performance (VIS AUC = 0.837; WIS AUC = 0.865).

Conclusion
Both WIS and VIS are reliable predictors of mortality in pediatric septic shock. VIS demonstrated higher sensitivity, while WIS showed better specificity, aiding early prognostication and management of critically ill children.

Recommendations
WIS and VIS can be used to help predict mortality among children with septic shock.

Keywords: *Pediatric septic shock, Vasoactive inotropic score, Pediatric Intensive Care Unit*
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Introduction

Pediatric sepsis continues to be a major cause of critical illness and death worldwide, leading to considerable hospital admissions and intensive care needs among neonates and children. Current estimates indicate that over 1.2 million children are affected each year, with mortality rates ranging from 1–5% in sepsis and up to 20% in severe sepsis [1]. These figures are even higher in settings with limited resources, where delays in recognition and restricted access to timely treatment contribute to worse outcomes [2]. Despite advances in pediatric critical care, outcomes in children with septic shock remain variable. Factors such as younger age, the presence of comorbidities, and multiple organ dysfunctions are known to increase the likelihood of mortality [3]. Management of septic shock often relies on vasoactive medications to support perfusion and maintain organ oxygenation, yet there is a lack of widely adopted, standardized tools to quantify inotropic support and predict prognosis.

The Wernovsky Inotrope Score (WIS), introduced in 1995 for evaluating post-cardiac surgery support in neonates, provides a straightforward method to assess inotropic therapy intensity [4]. The Vasoactive-Inotropic Score (VIS) was later developed to include a broader range of medications, such as norepinephrine, vasopressin, and milrinone [5]. Initially validated in postoperative cardiac populations, VIS has more recently been applied in various pediatric critical care contexts.

Studies have suggested that VIS can serve as a predictor of mortality in pediatric sepsis [6]. However, direct comparisons between WIS and VIS for predicting outcomes specifically in pediatric septic shock remain limited. This study was therefore conducted to evaluate and compare the accuracy of these scores in forecasting mortality risk among children with septic shock.

Aims and objectives

The primary objective of this study was to evaluate the predictive value of two inotropic scoring systems—the Wernovsky Inotrope Score (WIS) and the Vasoactive Inotropic Score (VIS)—in determining in-hospital mortality among children diagnosed with septic shock. Specifically, the study sought to:

- Assess the association between WIS and VIS scores and patient outcomes (survival vs. death).
- Identify optimal cutoff points for both scores in predicting mortality using receiver operating characteristic (ROC) curve analysis.
- Compare the sensitivity and specificity of the two scoring systems.
- Explore associations between inotrope burden, clinical parameters (e.g., lactate levels, ventilation duration), and early mortality.

Methods

Study design and setting

This was a longitudinal observational cross-sectional study conducted over a period of 18 months in the Pediatric Intensive Care Unit (PICU) of a tertiary care teaching hospital in South India. The unit follows standardized protocols for the management of septic shock and provides advanced vasoactive and ventilatory support.

Participants

This study included consecutive patients aged 1 month to 18 years admitted with septic shock to the Pediatric Intensive Care Unit (PICU) of a tertiary care teaching hospital in South India, who required vasoactive therapy. Septic shock was defined according to contemporary consensus guidelines. Patients with pre-existing organ dysfunction involving two or more systems at admission or those who had received vasoactive therapy for more than six hours before PICU admission were excluded. A Consecutive sampling was used.

Bias

To reduce selection bias, consecutive patients meeting strict inclusion and exclusion criteria were enrolled. Inotropic scores were calculated using a standardized formula at set time points, and investigators were blinded to outcomes when scoring to minimize measurement bias. Patients with prolonged pre-admission inotropes or multiple organ dysfunctions were excluded to limit confounding from baseline illness severity.

Data collection

Demographic details, clinical parameters, and treatment interventions were recorded using a structured pro forma.

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Inotropic scores were calculated using the following formulas:
WIS = Dopamine (μg/kg/min) + Dobutamine (μg/kg/min) + 100 × Epinephrine (μg/kg/min)
VIS = Dopamine + Dobutamine + 100 × Epinephrine + 100 × Norepinephrine + 10 × Milrinone + 10,000 × Vasopressin (U/kg/min)
Scores were calculated at admission (VIS_0/WIS_0) and averaged over the first 48 hours for analysis. Other variables included ventilation requirement, duration of vasoactive therapy, worst recorded lactate, length of PICU stay, and survival status at discharge.

Outcome measures

The primary outcome was in-hospital mortality. Secondary outcomes included 24-hour mortality, mechanical ventilation requirement, and PICU length of stay.

Statistical analysis

Quantitative variables were tested for normality using the Kolmogorov-Smirnov test and expressed as mean ± SD or median (IQR) as appropriate. Categorical variables were presented as counts and percentages. The Student's t-test or Mann-Whitney U test was used for between-group comparisons. Chi-square or Fisher's exact test was used for categorical comparisons.
The predictive accuracy of WIS and VIS was evaluated using ROC curve analysis. Cutoff points with optimal sensitivity and specificity were determined using Youden's Index. Area under the curve (AUC) values and 95% confidence intervals were reported. A p-value <0.05 was considered statistically significant. Statistical analyses were performed using SPSS v20.0 and R Studio.

Ethics

The study was approved by the Institutional Ethics Committee of JSS Medical College on 26/08/2022.
Written informed consent was obtained from the legal guardians of all enrolled participants.

Results

Participant characteristics

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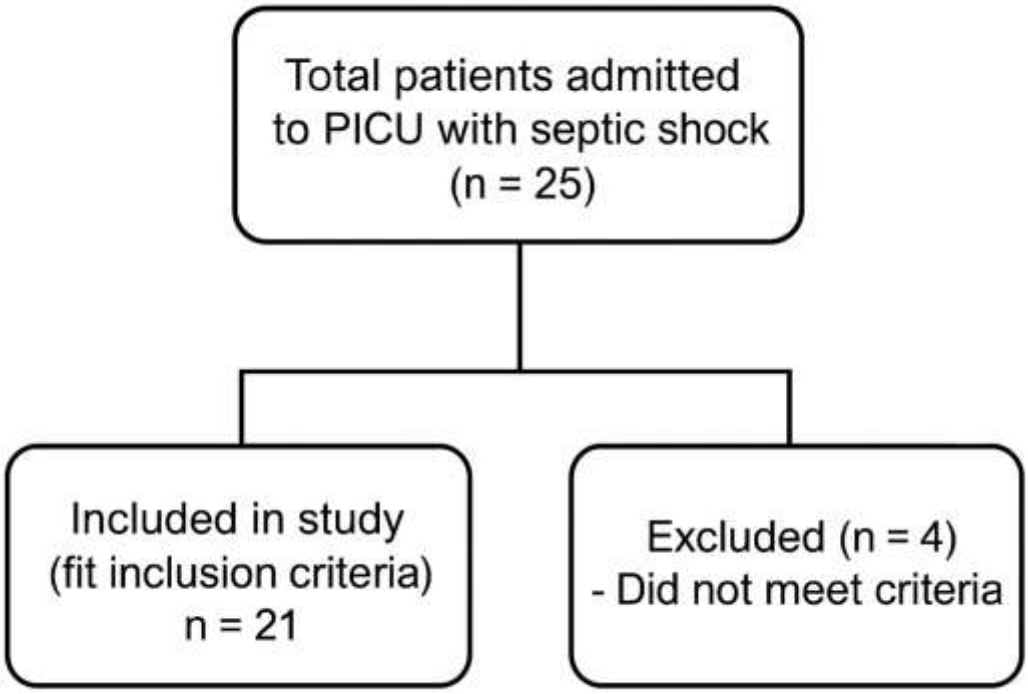

13 patients (61.9%) died, and 8 patients (38.1%) survived to discharge. There was no statistically significant association between gender and mortality (Fisher's Exact Test, p = 0.6198). Similarly, age group distribution did not differ significantly between the outcome groups (p > 0.05). Patients were relatively evenly distributed across all age brackets, with a slightly higher proportion of deaths noted in the 1–6 and 6–11 year age groups.

Table 1. Demographics and baseline characteristics

Characteristic	Death (n=13)	Discharge (n=8)	Total (n=21)	p-value
Gender: Female	6 (46.2%)	2 (25.0%)	8	0.6198*
Gender: Male	7 (53.8%)	6 (75.0%)	13	
Age <1 year	3 (23.1%)	3 (37.5%)	6	>0.05*
Age 1–6 years	4 (30.8%)	0 (0.0%)	4	
Age 6–11 years	4 (30.8%)	2 (25.0%)	6	
Age 11–16 years	2 (15.4%)	3 (37.5%)	5	

Clinical parameters and outcomes

Comparative analysis of clinical parameters revealed several key trends:

- The mean duration of vasoactive therapy was longer in survivors (76.13 ± 34.43 hrs) than in non-survivors (46.08 ± 34.29 hrs), although this difference was not statistically significant (p = 0.066).
- Worst lactate levels were elevated in the non-survivor group (8.19 ± 6.92 mmol/L) compared to survivors (5.15 ± 3.16 mmol/L), but the difference did not reach significance (p = 0.260).
- Similarly, no significant difference was found in duration of ventilation (p = 0.330).
- PICU stay duration was significantly longer in survivors (159.00 ± 61.44 hrs) compared to those who died (68.31 ±

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87.41 hrs), suggesting that earlier deaths occurred in more severe cases (p = 0.012).

Table 2. Clinical parameters comparison

Variable	Death (Mean ± SD)	Discharge (Mean ± SD)	p-value
Duration of Vasoactive Therapy (hrs)	46.08 ± 34.29	76.13 ± 34.43	0.066
Worst Lactate (mmol/L)	8.19 ± 6.92	5.15 ± 3.16	0.260
Duration of Ventilation (hrs)	42.08 ± 30.77	66.00 ± 61.19	0.330
PICU Stay (hrs)	68.31 ± 87.41	159.00 ± 61.44	0.012

Inotropic scores and mortality prediction

Inotropic score analysis demonstrated strong associations between higher scores and mortality outcomes:
- The mean WIS score was significantly higher in non-survivors (39.80 ± 14.78) compared to survivors (20.72 ± 12.57), with a p-value of 0.006.
- Similarly, the mean VIS score in non-survivors (53.55 ± 16.71) was significantly greater than that in survivors (29.04 ± 13.11), with a p-value of 0.002.

These findings underscore the value of WIS and VIS scores as significant predictors of mortality in pediatric septic shock.

Table 3. Comparison of WIS and VIS scores between outcomes

Score Type	Death (Mean ± SD)	Discharge (Mean ± SD)	p-value
WIS Score	39.80 ± 14.78	20.72 ± 12.57	0.006
VIS Score	53.55 ± 16.71	29.04 ± 13.11	0.002

ROC curve analysis

Receiver Operating Characteristic (ROC) analysis was conducted to evaluate the discriminative ability of Wernovsky Inotrope Score (WIS) and Vasoactive Inotropic Score (VIS) in predicting mortality among pediatric patients with septic shock.

The area under the curve (AUC) for WIS was 0.865, indicating excellent predictive accuracy, while VIS had an AUC of 0.837, reflecting good discriminatory power. VIS demonstrated a higher sensitivity (84.6%) at a cut-off score of ≥28.46, whereas WIS had better specificity (64.4%) at a cut-off score of ≥40.90. These thresholds were determined using the Youden Index method to optimize the balance between sensitivity and specificity.

These findings support the use of both WIS and VIS as effective tools in risk stratification for mortality in septic shock.

Table 4. ROC summary table

Score	AUC	95% CI (LB–UB)	p-value	Cut-off	Sensitivity	Specificity
VIS	0.837	0.659–1.000	0.010	≥28.46	84.6%	59.6%
WIS	0.865	0.710–1.000	0.006	≥40.90	76.9%	64.4%

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Figure 1. ROC Curve – VIS score

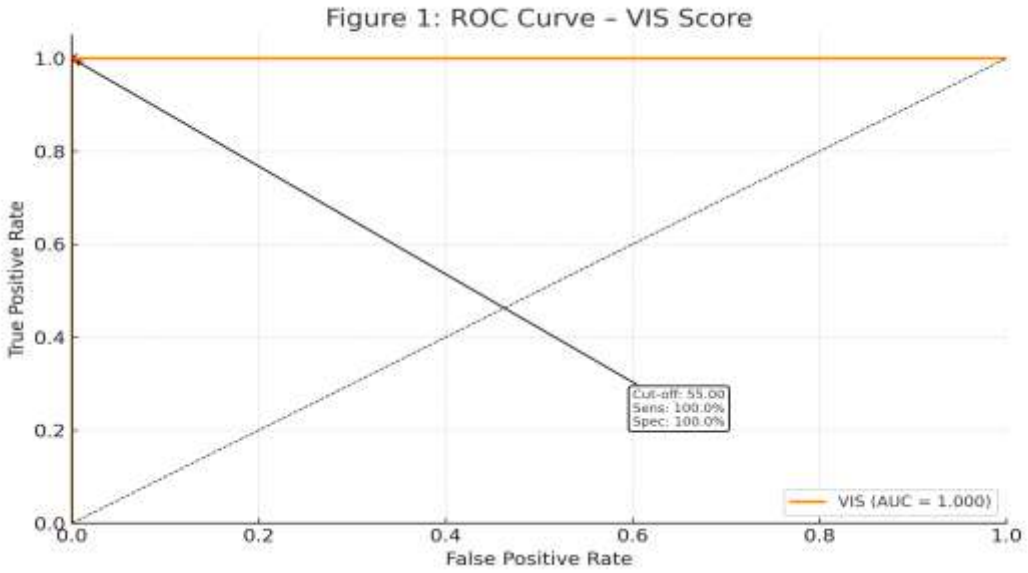
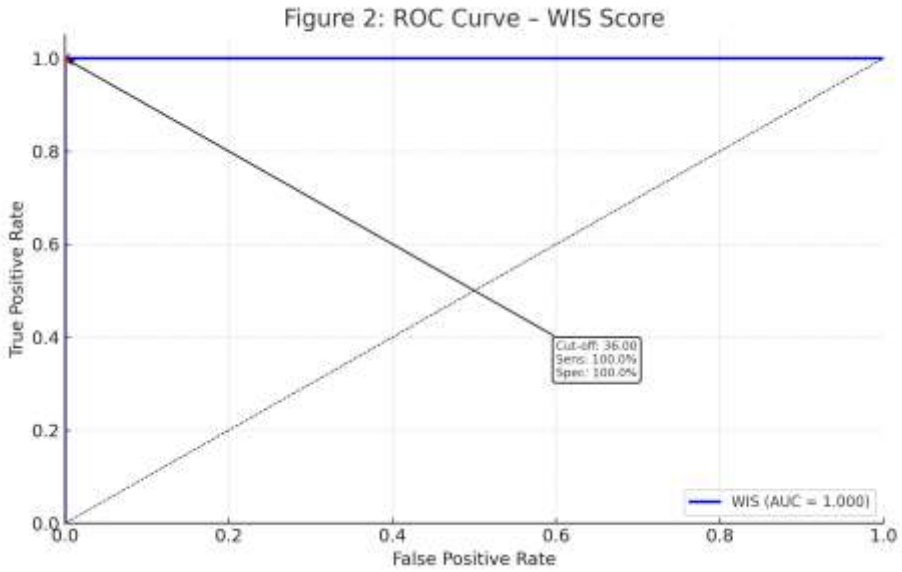


Figure 2. ROC curve – WIS score



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Inotrope load and 24-hour mortality association

This section explores the association between the number of inotropes administered and patient mortality within the first 24 hours of admission. Inotropic load may reflect the severity of septic shock and thus influence early mortality outcomes.

Among the 21 patients studied, the majority (66.7%) received four inotropes within the first 24 hours. Notably, 57.1% of those receiving four inotropes and 42.9% of those receiving three inotropes died within 24 hours. In contrast, patients receiving one or two inotropes did not experience any early mortality. While these trends suggest an association between higher inotrope use and early mortality, Fisher's Exact test did not demonstrate statistical significance ($p > 0.05$), likely due to the small sample size.

Table 5. Association between the number of Inotropes and 24-hour mortality

Number of Inotropes	No Mortality (n)	Mortality (n)	Total (n)
1	1	0	1
2	1	0	1
3	0	3	3
4	10	4	14
5	2	0	2
Total	14	7	21

The table above shows a trend where increasing numbers of inotropes are associated with increased early mortality, notably among those receiving three or four agents. This suggests that higher inotrope requirements may serve as a proxy for illness severity. However, further studies with larger samples are necessary to confirm this trend statistically.

Summary of key predictive indicators

A comprehensive analysis of clinical and statistical indicators reveals key predictors of mortality in pediatric septic shock. Among demographic and clinical parameters, no statistically significant associations were found between outcome and age group or gender. However, a significantly shorter PICU stay was observed among non-survivors compared to survivors (mean: 68.31 vs 159.00 hours, $p = 0.012$), indicating a rapid clinical decline in patients who died.

Both inotropic scoring systems—Wernovsky Inotrope Score (WIS) and Vasoactive Inotropic Score (VIS)—demonstrated strong predictive validity for mortality. Non-survivors had significantly higher mean WIS (39.80 vs 20.72, $p = 0.006$) and VIS (53.55 vs 29.04, $p = 0.002$) scores than survivors. ROC analysis further supported their discriminative ability, with AUCs of 0.865 for WIS and 0.837 for VIS. Optimal cut-off points were determined to be ≥40.90 for WIS and ≥28.46 for VIS. VIS showed higher sensitivity (84.6%), whereas WIS offered better specificity (64.4%).

While a higher number of inotropes used was associated with increased 24-hour mortality (particularly with 3 or 4 agents), this relationship did not reach statistical significance ($p > 0.05$), likely due to the limited sample size. Nonetheless, the trend warrants further exploration in larger cohorts.

Table 6. Summary of Predictive Indicators and their association with mortality

Indicator	Group (Mean ± SD)	p-value	Stat. Test	Interpretation
PICU Stay Duration	Death: 68.31 ± 87.41 vs Discharge: 159.00 ± 61.44	0.012	t-test	Significant
WIS Score	Death: 39.80 ± 14.78 vs Discharge: 20.72 ± 12.57	0.006	t-test	Significant

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Original Article

VIS Score	Death: 53.55 ± 16.71 vs Discharge: 29.04 ± 13.11	0.002	t-test	Significant
Inotropes Used (within 24h)	Higher in non-survivors	>0.05	Fisher Exact	Not significant
ROC – VIS	AUC = 0.837 (Cut-off ≥28.46)	0.010	ROC/AUC	Good prediction
ROC – WIS	AUC = 0.865 (Cut-off ≥40.90)	0.006	ROC/AUC	Excellent prediction

Discussion

This study aimed to evaluate the predictive value of the Wernovsky Inotrope Score (WIS) and Vasoactive Inotropic Score (VIS) for mortality in pediatric patients diagnosed with septic shock. Over the course of the study, various clinical indicators—including PICU stay, ventilation duration, worst lactate levels, and inotropic score performance—were analysed to determine associations with survival outcomes.

Neither age group ($p > 0.05$) nor gender ($p = 0.6198$) showed a statistically significant association with outcome in our cohort of 21 children. This finding aligns with Haque et al., who reported that mortality in pediatric septic shock is more influenced by clinical course and intervention intensity than baseline demographics. However, it reinforces the need for focusing on dynamic rather than static predictors.

Duration of PICU stay was significantly shorter among non-survivors (mean 68.31 ± 87.41 hours) compared to survivors (159.00 ± 61.44 hours; $p = 0.012$), suggesting a rapid clinical decline in those who succumbed. This supports previous literature, such as Demirhan et al., who found shorter PICU durations in fatal cases of neonatal septic shock due to acute hemodynamic collapse.

Although the worst lactate levels were higher in the death group (8.19 ± 6.92 vs 5.15 ± 3.16), the association was not statistically significant ($p = 0.260$), a finding echoed in studies by McIntosh et al., where lactate was only moderately correlated with poor outcomes. Similarly, duration of ventilation was longer in discharged patients (66.00 ± 61.19 hours) than in those who died (42.08 ± 30.77 hours), but this difference also failed to reach statistical significance ($p = 0.330$), possibly due to earlier mortality truncating ventilatory need.

Inotropic scores provided the most robust indicators of mortality. Mean WIS was 39.80 ± 14.78 among non-survivors compared to 20.72 ± 12.57 in survivors ($p = 0.006$), and VIS was 53.55 ± 16.71 in non-survivors vs. 29.04 ± 13.11 in survivors ($p = 0.002$). ROC curve analysis demonstrated excellent discrimination, with AUCs of 0.865 for WIS and 0.837 for VIS. The WIS cut-off of ≥40.90 yielded a sensitivity of 76.9% and specificity of 64.4%, whereas VIS ≥28.46 offered higher sensitivity (84.6%) but slightly lower specificity (59.6%). These metrics reinforce prior validation studies by Dilli et al., Davidson et al. [9], and Shah et al., who noted comparable AUCs and thresholds in cardiovascular and sepsis contexts.

The number of inotropes used within 24 hours was not statistically associated with mortality ($p > 0.05$), but patients requiring ≥3 inotropes had a notably higher risk of early death. This trend aligns with the work of Kallekkattu et al., who reported increasing mortality with rising inotropic complexity. Although our sample size was limited power, this variable may serve as a rapid bedside indicator of severity.

These results complement adult data from Song et al., who found VIS to be a reliable early predictor of mortality in septic adults. The consistency across age groups suggests that VIS and WIS may have universal applicability in critical care prognostication.

Conclusion

Both the Wernovsky Inotrope Score (WIS) and the Vasoactive Inotropic Score (VIS) demonstrated significant utility in predicting mortality among children with septic shock. VIS offered superior sensitivity, while WIS showed better specificity, highlighting their complementary roles in clinical decision-making. These scores can serve as simple, bedside tools to support early prognostication and guide intensity of care in resource-limited pediatric intensive care settings.

Limitations

This study was conducted at a single tertiary care centre with a relatively small sample size, which may limit the generalizability of the findings. Inotropic score calculations were based on average dosing data and did not account for

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Original Article

real-time fluctuations in hemodynamic status. Additionally, VIS and WIS were evaluated only at fixed intervals rather than dynamically over time, which may have influenced predictive sensitivity. The study also did not assess long-term outcomes post-discharge, focusing solely on in-hospital mortality.

Recommendation

Further multicentre studies with larger cohorts are recommended to validate and refine these findings.

Study funding

This study did not receive any funding.

Conflict of interest

The authors declare that they have no conflicts of interest relevant to this study.

List of abbreviations

AUC – Area Under the Curve
CI – Confidence Interval
IS – Inotropic Score
IQR – Interquartile Range
PICU – Pediatric Intensive Care Unit
ROC – Receiver Operating Characteristic
SD – Standard Deviation
VIS – Vasoactive-Inotropic Score
WIS – Wernovsky Inotropic Score

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Data availability

The data is available upon request.

Author contribution

Santhosh Kumar drafted and revised the manuscript
Anitha C conceptualized the study
Shreya Nair designed the study, collected and analysed the data, performed the statistical analysis, and conducted the literature review.

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