Section: Pediatrics

Original Research Article

ASSESSMENT OF INOTROPE SCORE AS A PREDICTOR OF MORTALITY IN PEDIATRIC SEPTIC SHOCK: A SINGLE-CENTER STUDY FROM MYSORE

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ABSTRACT

Background: Septic shock is a leading cause of mortality in children, particularly in resource-limited settings. Early and appropriate management, including fluid resuscitation and vasoactive therapy, is critical. However, predicting outcomes remains challenging. Inotropic scoring systems, such as the Wernovsky Inotrope Score (WIS) and Vasoactive Inotropic Score (VIS), may help assess mortality risk, but their utility in paediatric septic shock has been inadequately explored. **Objective:** To evaluate the predictive value of WIS and VIS for mortality in children with septic shock.

Materials and Methods: This longitudinal study, conducted over 18 months at a tertiary care hospital, included paediatric patients aged 1 month to 18 years who required vasoactive therapy for septic shock. Exclusion criteria included patients with pre-existing organ dysfunction or who received vasoactive therapy for over 6 hours prior to admission.

The WIS and VIS were calculated using the following formulas:

- WIS = Dobutamine + Dopamine + 100 × Epinephrine (μg/kg/min)
- VIS = Adrenaline × 100 + Norepinephrine × 100 + Milrinone × 10 + Vasopressin × 10,000 + Dopamine + Dobutamine (μg/kg/min)

Statistical Analysis: Data were analyzed using the Student's t-test or Mann-Whitney U test for continuous variables and Chi-square or Fisher's exact test for categorical data. ROC curves and AUC were calculated to assess the predictive accuracy of WIS and VIS for mortality.

Results: Both WIS and VIS effectively predicted mortality. VIS (AUC = 0.837) identified a cutoff ≥28.46, with 84.6% sensitivity and 59.6% specificity. WIS (AUC = 0.865) predicted mortality with a cutoff ≥40.90, achieving 76.9% sensitivity and 64.4% specificity.

Conclusion: WIS and VIS are reliable predictors of mortality in paediatric septic shock, with VIS showing higher specificity and WIS better sensitivity. Larger studies are needed to further validate these findings.

Keywords: Septic shock; Vasoactive Inotrope Score.

INTRODUCTION

Sepsis in children is rising alarmingly on a global scale and is now one among the major causes of morbidity as well as mortality encountered in clinical practice. Despite significant advancements in critical care, sepsis fatality rates remain elevated. Global estimates indicate that sepsis affects approximately 1.2 million children annually, with rates of mortality ranging from 1 to 5% for those with sepsis and ranging from 9–20% for those with severe sepsis.[1,2] Factors linked to increased mortality include younger age, incomplete or unknown vaccination status, failure to adhere to treatment protocols, infections acquired in healthcare settings, pre-existing cardiovascular conditions, and multiple organ dysfunction.[3]

A late finding in paediatric sepsis is shock. Lactic acidosis and the existence of multiorgan failure syndrome are linked to increased mortality rates in paediatric septic shock.

Children in septic shock are frequently treated with vasoactive medicines to assist their circulatory systems and ensure tissue perfusion and oxygen supply. The inotrope score is an objective clinical assessment that is used as a predictor of morbidity and death in children and to measure the requirement for cardiovascular assistance.

The Wernovsky inotrope score (WIS), developed in 1995 by Wernovsky et al,[4] is a simple-to-use instrument for determining the need for inotropic support following cardiac surgery. WIS is calculated as [WIS = Dobutamine dose (mcg/kg/min) + Dopamine dose (mcg/kg/min) + Epinephrine dose (mcg/kg/min) x 100]

The vasoactive inotropic score (VIS), which incorporates extra inotropes, was introduced in 2010 by Gaies et al.[5] The VIS is a tool that is simple to calculate and displays the entire amount of cardiovascular support. It has been proven to be an effective tool for predicting newborn death rates following cardiovascular surgery. According to recent research, the VIS can be used to predict the fatality rates of infants in paediatric critical care, including those with septic shock.[6-8]

Post 2010, several studies were undertaken to assess the therapeutic use of the VIS in adults and adolescents after cardiovascular surgery as well as after cardiac surgeries in newborns.[9-11]

Fifteen research publications were published between 2010 and 2019 in order to validate the VIS. Children were included in nine of them, and individuals with cardiovascular problems were involved in ten. Previous studies have proven the VIS to be a helpful tool to anticipate an unfavorable outcome, despite disparities in the cut-off values and timing of the VIS calculations. Regardless of the etiology, recent research revealed that the VIS was useful in anticipating poor outcomes in patients with paediatric sepsis and in the PICU.[6-8]

The VIS values are estimated by:

VIS = Epinephrine(mcg/kg/min) ×100 + Norepinephrine(mcg/kg/min) × 100 + Milrinone (mcg/kg/min) × 10 + Vasopressin(U/kg/min) × 10 000 +Dopamine(mcg/kg/min) + Dobutamine (mcg/kg/min).

During the first 48 hours of septic shock, four VIS values are computed. The term VISmax is the top VIS value estimated at any time following the initiation of inotropes. VIS0 is the value measured when the therapy with minimum one inotrope began. VIS24 and VIS48 are the values 24 and 48 hours after inotrope therapy began respectively.

Due to the increasing rates of morbidity and death associated with paediatric sepsis, researchers have been searching for indicators and methods that could identify the illness and forecast its course. There have been a number of published studies regarding the effectiveness of the VIS in neonates following heart surgery, but not many regarding its usage in paediatric septic shock.

Hence, this study was conducted to assess the efficacy of inotropic scores both WIS and VIS in prediction of mortality in septic shock in paediatric patients.

Objective

To predict the usefulness of the Inotropic Score as a tool to assess mortality in Paediatric Septic Shock.

MATERIALS AND METHODS

Study Design: Longitudinal study

Study Duration: 18 months

Sampling Technique: Convenience sampling

All participants matching the inclusion criteria during the duration of study shall be included.

Study setting and Method of collection of data:

Patients admitted in PICU of a teaching institution providing tertiary care (JSS)

Inclusion Criteria

We will enrol patients presenting with shock who need vasoactive therapy and are between the ages of one month and eighteen years.

Exclusion Criteria

Children with at least two organ dysfunctions at admission and those who had received vasoactive agent therapy for longer than six hours before admission would be excluded.

The unit protocol will be followed in managing shock. In cold and warm shock, epinephrine and norepinephrine should be administered first, respectively. The treating team will determine the necessity for further fluid boluses, vasoactive agents, and blood products based on the patient's hemodynamic condition, fluid balance, and kind of septic shock.

Age and gender demographics, as well as clinical factors, such as the length of inotrope therapy, the highest value of lactate, the necessity for a blood product transfusion, the use of a steroid, the central line, and any adverse effects, ventilation, and PICU outcome whether patients survived or expired, would be collected.

The following formulas are used to determine the Inotrope Score:

[WIS= 100 x Epinephrine dose (mcg/kg/min) + Dopamine dose (mcg/kg/min) + Dobutamine dose (mcg/kg/min)]

[VIS = Adrenaline x100 mcg/kg/min + Norepinephrine x 100 (mcg/kg/min) +Milrinone x 10 (mcg/kg/min) + Vasopressin x 10000 (U/kg/min) + Dopamine (mcg/kg/min) + Dobutamine (mcg/kg/min)]

Every 24 and 48 hours, or as and when a change in dosage occurs or the inclusion of new medications from the documents, the scores will be computed. We'll compute the mean score value for analytical purposes.

Data from survivors and nonsurvivors will be compared. When comparing continuous data, the Mann-Whitney U test is used if the data are not regularly distributed, or the Student t-test if they are. The Chi-square test (or Fisher exact test if cell

frequencies were less than 5) is used to compare qualitative data. Results with P-value < 0.05 were deemed statistically significant.

Area under the curve (AUC) and receiver operating characteristic (ROC) curves with 95% confidence shall be computed for the WIS and VIS cut-off points.

We'll be using IBM SPSS version 20.0 for data analysis.

Patient Population

Patients aged between 1 month to 18 years requiring inotropic support.

Ethics Committee Clearance

Approval for conducting the study was taken from JSS University Ethics committee obtained.

RESULTS

Analysis: The current study encompassed qualitative and quantitative variables. Qualitative variables were expressed as number (%) while quantitative variables were represented by Mean (Standard Deviation). The Kolmogorov-Smirnov test was used to determine whether the data was normal. Parametric Independent t- tests were employed to compare the two quantitative variables. The Fisher's exact test and Mid P Exact test utilized to determine the association between two independent qualitative variables. ROC analysis was employed to determine the cut-off value and assess the accuracy of predicting mortality based on average WIS and VIS Score among the patients.

A confidence interval of 95% was considered for all statistical tests. Analysis of data was done using SPSS20 and R Studio statistical software.

Table 1: Details of gender and Outcome of patients

	Outcome				Total
Gender	Death		Discharge		
	N	%	N	%	
Female	6	46.2%	2	25.0%	8
Male	7	53.8%	6	75.0%	13
	13	100.0%	8	100.0%	21
Fisher Exact test applied (*P* - Value 0.6198)					

The table shows outcomes by gender for 21 individuals, with death or discharge recorded. Among females, 6 (46.2%) died, and 2 (25.0%) were discharged. Among males, 7 (53.8%) died, and 6 (75.0%) were discharged. The Fisher Exact test, with a P-value of 0.6198, indicates no statistically significant association between gender and outcome.

Table 2: Details of age group and Outcome of patients

Age group	Death		Discharge		Total
	N	%	N	%	
<1 year	3	23.1%	3	37.5%	6
1-6	4	30.8%	0	0.0%	4
6-11	4	30.8%	2	25.0%	6
11-16	2	15.4%	3	37.5%	5
Total	13	100.0%	8	100.0%	21
Fisher Exact test applied (*P-value* >0.05)					

The table presents outcomes by age group for 21 individuals, with death or discharge recorded. Death rates are 23.1% (<1 year), 30.8% (1-6 years), 30.8% (6-11 years), and 15.4% (11-16 years). Discharge rates are 37.5% (<1 year), 0.0% (1-6 years), 25.0% (6-11 years), and 37.5% (11-16 years). The Fisher Exact test, with a P-value greater than 0.05, indicates no statistically significant association between age group and outcome.

Table 3: Comparison of mean duration of Vasoactive therapy among death and survival

	Outcome	N	Mean	Std. Deviation	*P*-value
Duration of Vasoactive Therapy	Death	13	46.08	34.29	.066
	Discharge	8	76.13	34.43	

The table shows the mean duration of vasoactive therapy for 13 dead patients, with a mean of 46.08 hours and a standard deviation of 34.29. The P-value of 0.066 suggests a trend towards significance but does not indicate a statistically significant difference in therapy duration affecting the outcome.

Table 4: Comparison of mean Worst Lactate among death and survival

	Outcome	N	Mean	Std. Deviation	P-value
Worst Lactate	Death	13	8.19	6.92	.260
	Discharge	8	5.15	3.16	

The table presents the worst lactate levels by outcome for 21 patients. Among those who died,[13] the mean worst lactate level was 8.19 ± 6.92. Among those discharged,[8] the mean worst lactate level was 5.15± 3.16. The lack of a statistically significant difference in the worst lactate levels between the death and discharge groups, as indicated by the P-value of 0.260, suggests that the worst lactate levels in this sample do not significantly affect the result.

Table 5: Comparison of mean duration of PICU among death and survival

	Outcome	N	Mean	Std. Deviation	P-value
PICU stay	Death	13	68.31	87.41	.012
	Discharge	8	159.00	61.44	

The table compares the mean and standard deviation of Paediatric Intensive Care Unit (PICU) stay duration between 13 patients who died and 8 who were discharged. Patients who died had a mean PICU stay of 68.31 hours ± 87.41 hours, while those discharged had a longer mean of 159.00 hours ±61.44 hours. The P-value of 0.012 indicates a statistically significant difference, suggesting that shorter PICU stays are associated with higher mortality rates than longer stays among discharged patients.

Table 6: Comparison of Mean of WIS score among the death and survival patients

	Outcome	N	Mean	Std. Deviation	P-value
WIS Score	Death	13	39.80	14.78	.006
	Discharge	8	20.72	12.57	

The table compares the mean and standard deviation of Wernovsky Inotrope Score (WIS) scores between 13 patients who died and 8 who were discharged. Patients who died had a higher mean WIS score of 39.80 ± 14.78, while those discharged had a lower mean of 20.72 ± 12.57. The P-value of 0.006 indicates a statistically significant difference, suggesting WIS scores influence patient outcomes.

Table 7: Comparison of Mean of VIS score among the death and survival patients

	Outcome	N	Mean	Std. Deviation	P-value
Mean VIS	Death	13	53.55	16.71	.002
	Discharge	8	29.04	13.11	

The table compares the mean and standard deviation of Mean Vasoactive Inotropic Scores (VIS) between 13 patients who died and 8 who were discharged. Patients who died had a higher mean VIS of 53.55 ± 16.71, while those discharged had a lower mean of 29.04 ± 13.11. The P-value of 0.002 indicates a statistically significant difference, suggesting VIS influences patient outcomes.

Table 8: Diagnostic accuracy of VIS Score and WIS Score to predict the Mortality

Test Result Variable(s)	AUC	P- value	Asymptotic 95% Confidence Interval		Cut-off Value	Sensitivity	Specificity
			Lower Bound	Upper Bound			
VIS Score	0.837	0.01	.659	1.000	28.46	84.6%	59.60%
WIS Score	0.865	0.006	o.710	1.00	40.90	76.9%	64.4%

VIS and WIS scores demonstrate significant predictive ability with respect to mortality outcomes, based on specified cut-off values. VIS Score, with an AUC of 0.837 and a P-value of 0.01, identifies a mortality cut-off ≥28.46, achieving 84.6% sensitivity and 59.6% specificity. Similarly, WIS Score, with an AUC of 0.865 and a P-value of 0.006, predicts mortality with a cut-off ≥40.90, showing 76.9% sensitivity and 64.4% specificity. These results highlight their robustness in clinical prognostication, crucial for effective patient assessment and management decisions.

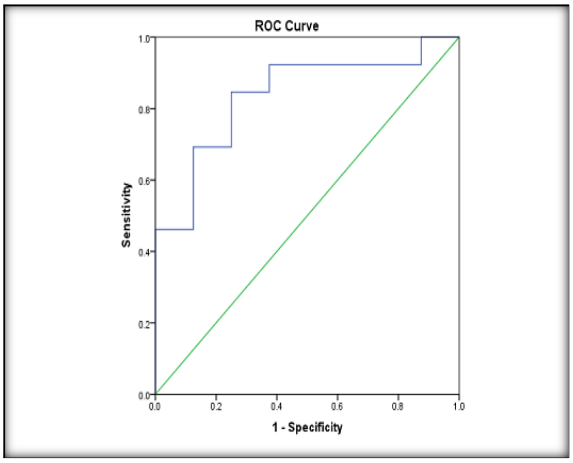

Figure 1: ROC of diagnostic accuracy of prediction of mortality by VIS score

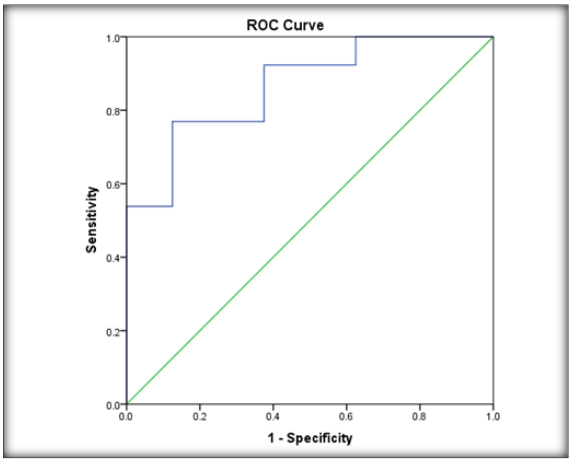

Figure 2: ROC of diagnostic accuracy of prediction of mortality by WIS score

DISCUSSION

This study aimed to evaluate the WIS and VIS as tools for predicting outcomes in pediatric septic shock. No significant differences were found between gender or age groups and mortality outcomes. Lactate levels, though previously studied as predictive markers, did not show a significant association with mortality in this cohort. Mechanical ventilation (MV) was strongly associated with higher mortality, as 72.2% of mechanically ventilated patients died, while all non-ventilated patients survived. Additionally, shorter PICU stays were linked to higher mortality rates, suggesting that prolonged ICU stays may reflect better recovery outcomes.

The VIS and WIS were significant predictors of mortality. VIS ≥28.46 demonstrated 84.6% sensitivity for predicting death, while WIS ≥40.90 had 76.9% sensitivity.

Both scores showed robust predictive ability for patient outcomes. Inotrope use, particularly the need for four inotropes, was associated with higher mortality and a greater likelihood of requiring mechanical ventilation. This supports the role of inotropic support as a marker of severity and poor prognosis.

The findings align with other studies that emphasize the value of VIS and WIS in pediatric sepsis management. These scoring systems can help clinicians assess the severity of illness and make informed decisions regarding treatment and prognosis, ultimately improving patient care in septic shock.

CONCLUSION

Both the VIS and WIS can be used as predictors of mortality in septic shock among paediatric patients. While the VIS showed a better specificity, the WIS demonstrated a better sensitivity in our study. The study helps us be more vigilant as higher scores predict poor prognosis and higher mortality. Hence strict monitoring can be done, and complications can be anticipated. This knowledge can also improve the communication and counselling given to parents. To accurately evaluate the roles of these scoring systems as mortality predictors in paediatric septic shock, prospective trials with a larger patient population are required.

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AUTHORS' CONTRIBUTIONS

Anitha C conceptualized the study and critically revised the manuscript for important intellectual content.

Shreya Nair (corresponding author) designed the study, collected and analyzed the data, performed the statistical analysis, conducted the literature review, and drafted the manuscript.

Both authors read and approved the final version of the manuscript.

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