NONINVASIVE HEMODYNAMIC ASSESSMENT AND N-TERMINAL PRO-BNP FOR PREDICTING SHOCK SEVERITY AND MORTALITY IN CARDIOGENIC SHOCK: A PROSPECTIVE STUDY

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ABSTRACT

Background: Cardiogenic shock (CS) remains a critical condition with high mortality rates, necessitating improved understanding and risk stratification. The Society for Cardiovascular Angiography and Interventions (SCAI) developed a shock severity classification for CS patients, yet the precise relationship between noninvasive hemodynamic and echocardiographic parameters and SCAI shock stages remains unclear.

Methods: This prospective study, conducted from September 2021 to October 2022, included 190 adult CS patients in cardiac intensive care units. They were categorized according to SCAI shock stages. Various clinical, laboratory, and echocardiographic parameters were collected for analysis. Statistical methods were used to assess associations between these parameters and mortality.

Results: The study revealed significant findings. Patients with higher SCAI stages exhibited reduced stroke volume (SV) and stroke volume index (SVI), reflecting declining cardiac function. Left ventricular ejection fraction (LVEF) decreased with increasing SCAI stages, indicating the severity of ventricular dysfunction. The SHOCK INDEX (heart rate/systolic blood pressure) increased with CS severity, showing its value as a risk assessment tool. Echocardiographic parameters, such as mitral E velocity and Mitral E/e' ratio, varied across SCAI stages, contributing to the stratification of CS severity. NT-proBNP levels were significantly associated with higher SCAI stages, making it a reliable predictor of mortality.

Conclusion: This study enhances the understanding of CS by identifying associations between noninvasive hemodynamic and echocardiographic parameters and SCAI shock stages. It has clinical implications for risk assessment, early intervention, and tailored treatment strategies to improve patient outcomes. These findings provide a foundation for further research and the potential for a more effective standard of care for CS patients.

Keywords: Cardiogenic shock, SCAI shock stages, echocardiographic parameters, hemodynamic assessment, mortality prediction.

INTRODUCTION

Cardiogenic shock (CS) was a serious disease with significant death rates, underscoring the need for a deeper knowledge of CS, its severity, and its many phenotypes.[1] In response to this, the Society for Cardiovascular Angiography and Interventions (SCAI) developed a shock severity classification that has shown useful in classifying hospital and post-discharge mortality risk for patients with CS and acute myocardial infarction as well as those in cardiac intensive care units (CICUs). Patients were classified according to the SCAI into five different subgroups: patients with typical CS (Class C), patients with worsening CS (Class D), patients presenting in extremis (Class E), and patients at risk of developing CS (Class A).[2]

Investigating the relationship between organ dysfunction severity and the utilization of critical care treatments and higher SCAI shock stages in CS patients in CICUs was the main focus of this study. Uncertainty has persisted about the precise echocardiographic and hemodynamic metrics defining the SCAI shock stages and indicating increasing CS.[3]

The ability of invasive hemodynamic measures to impact mortality risk classification in patients with chronic sickness (CS) has been demonstrated. Variables such as cardiac index (CI), stroke volume index (SVI), cardiac power output (CPO), and cardiac power index (CPI) have been found to be significantly correlated with mortality. In CS patients, left ventricular ejection fraction (LVEF) was another important echocardiographic measure associated with outcomes.

The purpose of this study was to examine the relationship between noninvasive echocardiographic hemodynamic parameters and hospital mortality in CICU patients at each SCAI shock stage. The presumption was that noninvasive Doppler hemodynamic factors would be associated with hospital mortality, surpassing the SCAI shock stages, and that echocardiographic variables would distinguish between the SCAI shock stages.[4]

MATERIALS AND METHODS

Study Type and Period: This prospective observational study was conducted at SMS hospital Jaipur, from September 2021 to October 2022.

Selection Criteria of the Patients: The study included adult patients aged over 18 years within 6 hours of identification of cardiogenic shock. Patients were required to have an acute cardiac cause of shock and meet specific inclusion criteria:

1. Systolic blood pressure <90 mmHg (after adequate fluid challenge) for 30 minutes or the need for vasopressor therapy to maintain systolic blood pressure >90 mmHg.
2. Signs of hypoperfusion, including altered mental status, cold peripheries, oliguria (<0.5 mL/kg/h for the previous 6 hours), or blood lactate >2 mmol/L.
3. Patients providing informed consent.

Patients with shock caused by ongoing hemodynamically significant arrhythmias or after cardiac or noncardiac surgery were excluded from the study. The etiology of acute cardiogenic shock (ACS) was defined as shock caused by myocardial infarction (MI) with or without ST-segment elevation.

Procedure

- Data Collection: Demographic data, vital signs, laboratory, clinical, and outcome data, as well as procedures and therapies performed during the CICU and hospital stay, were recorded. The admission value of all vital signs, clinical measurements, and laboratory values were defined as either the first value recorded after CICU admission or the value recorded closest to CICU admission. Vital signs were recorded every 15 minutes during the first hour after CICU admission.

- Severity of Illness Scores: The Acute Physiology and Chronic Health Evaluation (APACHE)-III, APACHE-IV predicted hospital mortality, and Sequential Organ Failure Assessment score were automatically calculated with data from the first 24 hours of CICU admission using previously validated electronic algorithms.
- Echocardiographic Data: Transthoracic echocardiography (TTE) was performed closest to CICU admission, including vital signs at the time of TTE. Echocardiographic variables of interest included LVEF, SVI, and medial E/e ratio. One best LVEF value for each patient was determined using a hierarchical approach, and specific methods for LVEF measurement were recorded. Right atrial pressure was estimated based on inferior vena cava size and collapsibility.
- Definition of SCAI Shock Stages: Hypotension or tachycardia, hypoperfusion, deterioration, and refractory shock were defined using data from CICU admission through the first 24 hours in the CICU. The five SCAI shock stages (A through E) were mapped with increasing severity using combinations of various variables.

Ethical Approval: Approval from the local ethics committee was obtained, and written informed consent was obtained from each patient prior to participation in the study.

Statistical Analysis: Hospital mortality was determined using electronic review of health records. Variables of interest were compared across the SCAI shock stages. Categorical variables were reported as numbers and percentages, and the Pearson chi-square test was used to compare groups, with trends analyzed using logistic regression. Continuous variables were reported as medians (interquartile range), and the Wilcoxon rank sum test was used to compare groups, with trends analyzed using linear regression. Logistic regression was used to determine the association between dichotomized echocardiographic variables of interest and hospital mortality, both before and after adjusting for relevant factors. Multivariable models were generated for each echocardiographic variable of interest individually, and then all significant echocardiographic variables were included in a final multivariable model.

RESULTS

Table 1 Distribution of cases according to SCIA **stages**

	Stage A (n=60)	Stage B (n=50)	Stage C (n=45)	Stage D (n=25)	Stage E (n=10)	P value
Age	57.88±10.78	57.62±11.09	61.82±11.90	67.88±9.71	64.00±6.38	0.001*
STROKE VOLUME	61.00±2.39	61.10±2.45	68.17±8.87	60.72±11.26	50.30±9.32	<0.0001*
STROKE VOLUME INDEX SV/BSA	40.58±6.12	36.70±5.41	37.17±5.43	33.45±2.87	36.90±1.20	<0.0001*
LVOT PEAK VELOCITY M/S	1.00±0.10	0.99±0.14	0.98±0.12	0.91±0.12	0.89±0.09	0.002*
LVOT VTI, cm	19.85±1.61	17.46±1.47	18.65±2.36	15.66±2.33	13.43±2.02	<0.0001*
SHOCK INDEX	0.61±0.09	0.81±0.08	0.81±0.07	0.91±0.12	0.96±0.12	<0.0001*
LVEF	49.66±5.86	42.20±6.64	42.77±6.42	32.40±9.21	30.50±8.75	<0.0001*
Lateral Mitral S' (cm/sec)	6.56±0.52	6.71±0.64	7.06±0.74	6.93±1.28	5.71±0.91	<0.0001*
MITRAL e' VELOCITY, cm/sec	6.01±0.79	4.20±1.20	4.77±1.44	5.20±0.71	5.00±0.82	<0.0001*
MITRAL E/e' RATIO	13.39±2.32	17.87±3.55	16.92±3.44	17.06±4.52	14.53±2.91	<0.0001*
NT PRO BNP	1873.15±2896.60	1151.64±740.42	2687.48±3580.93	10355.24±6706.73	10854.60±5238.20	<0.0001*

Results : The study shows significant differences in various cardiovascular and age-related parameters across the five different stages.

Table 2 : Distribution of HOSPITAL MOTALITY according to SCIA Stages

		HOSPITAL MOTALITY		Total	P value
		EXPIRED	NO		
SCIA STAGE	A	3	57	60	
		5.0%	95.0%	100.0%	
	B	4	46	50	
		8.0%	92.0%	100.0%	<0.0001*
	C	8	37	45	
		17.8%	82.2%	100.0%	
	D	16	9	25	
		64.0%	36.0%	100.0%	
	E	9	1	10	
		90.0%	10.0%	100.0%	
Total		40	150	190	
		21.1%	78.9%	100.0%	

Result : The data indicates a significant difference in hospital mortality across the SCIA stages, with increasing mortality rates as patients progress from Stage A to Stage E. Stage D and Stage E have the highest mortality rates, while Stage A has the lowest. This suggests that SCIA stage is associated with varying levels of hospital mortality.

Table 3: Multiple logistic Regression of Variables with Mortality

	P value	Odds Ratio	95% C.I.for EXP(B)	
			Lower	Upper
LVEF(<40%)	0.450	1.711	0.425	6.891
SVI(<35)	0.008*	6.947	1.665	28.983
MITRAL E/e' RATIO(>15)	0.714	0.810	0.263	2.494
NT PRO BNP (≥10,000)	<0.0001*	81.923	13.887	483.294

Results : The variable SVI (<35) has a statistically significant association with mortality (P value = 0.008*), and the odds ratio suggests a strong positive relationship (Odds Ratio = 6.947). The variables LVEF (<40%) and MITRAL E/e' RATIO (>15) do not have a statistically significant association with mortality as their P values are greater than the conventional significance level of 0.05. The variable NT PRO BNP (≥10,000) is highly statistically significant (P value <0.0001*) and has a very high odds ratio (Odds Ratio = 81.923), indicating a strong positive association with mortality.

These results suggest that SVI and NT PRO BNP are important predictors of mortality in the analyzed population.

DISCUSSION

The findings of this study hold significant clinical implications, particularly in the context of improving the care and prognosis of patients with cardiogenic shock (CS). A deeper understanding of the relationships between noninvasive hemodynamic and echocardiographic parameters and the Society for Cardiovascular Angiography and Interventions (SCAI) shock stages can help guide clinical decision-making, facilitate risk stratification, and ultimately lead to improved patient outcomes.[5]

The observed increase in stroke volume (SV) and stroke volume index (SVI) in SCAI Class C suggests that patients in this category may have better cardiac output and perfusion compared to those in higher SCAI stages.[6] The gradual decrease in SV and SVI as we move to more severe stages (SCAI D and E) reflects the progressive decline in cardiac function and a growing need for advanced interventions. This reinforces the clinical relevance of SVI as a valuable tool for risk assessment in CS patients, highlighting the need for close monitoring in patients with reduced SVI.[7]

The significant reduction in left ventricular ejection fraction (LVEF) as SCAI stages progress reaffirms the well-established association between impaired LVEF and CS severity. Low LVEF is indicative of severe ventricular dysfunction and is an essential factor in evaluating CS. These findings emphasize the importance of early intervention in cases with deteriorating LVEF, as this may be a key determinant of patient survival.[8]

The increase in the SHOCK INDEX (heart rate/systolic blood pressure) as CS severity advances, with the highest levels observed in SCAI Class E, underlines the value of this index in risk assessment. Elevated SHOCK INDEX is associated with worse outcomes and may indicate impending cardiac failure. Thus, monitoring and addressing SHOCK INDEX changes can be instrumental in patient management and resource allocation.[9]

Echocardiographic parameters, such as mitral E velocity and Mitral E/e' ratio, displayed variations across SCAI stages. These parameters, often used in assessing diastolic function and ventricular filling pressures, can aid in distinguishing between different stages of CS. Their clinical utility in stratifying CS severity and guiding treatment decisions warrants further exploration and validation.[10]

NT-proBNP levels, which significantly increased with higher SCAI shock stages, appear to be a reliable predictor of mortality in CS patients. As a recognized biomarker for cardiac stress, NT-proBNP can provide valuable information for clinicians in risk assessment, patient monitoring, and intervention planning.[11]

CONCLUSION

In conclusion, this study enhances our understanding of CS by shedding light on the relationship between noninvasive hemodynamic and echocardiographic parameters and SCAI shock stages. The observed associations have implications for clinical practice, offering opportunities for early intervention and tailored treatment strategies based on a patient's SCAI stage. By using these parameters as predictive tools for mortality risk, healthcare providers can make informed decisions, prioritize critical care resources, and improve patient outcomes.

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