Original Article

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Time to Calculate the Vasoactive Inotropic Score as a Predictor of Mortality and Morbidity in Cardiac Surgery

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ABSTRACT

Objective: To determine the ideal time for calculating vasoactive inotropic score (VIS) as a reliable predictor of morbidity and mortality in patients undergoing cardiac surgery with cardiopulmonary bypass.

Methodology: This was a cross-sectional study conducted at department of Anesthesia and cardiac surgery of Choudhary Pervez Ellahi Institute cardiology in Multan on 346 patients undergoing cardiac surgery (CABG, Valvular, CABG + Valvular) with cardiopulmonary bypass. The demographic and perioperative information was taken, such as the type of surgery, cardiopulmonary bypass, and cross-clamp time. VIS was also measured at different points of the postoperative period, and the patients were observed on the clinical outcomes such as in-hospital mortality, length of mechanical ventilation, length of stay in the ICU, and renal failure, as well as low cardiac output syndrome.

Results: A total of 346 patients were included. Mean age was 56.91 ± 10.89 years, and 61.8% were male. Hypertension (44.5%) and diabetes (37.0%) were the most common comorbidities, and CABG was the most frequent procedure (57.2%).The composite outcome occurred in 34.1% of patients, and in-hospital mortality was 9.2%. Acute kidney injury (18.5%) and prolonged ventilation >48 hours (16.8%) were the most common complications. Mean VIS increased from 9.98 ± 6.02 at CICU admission to 12.53 ± 8.03 at 24 hours, with a peak of 23.13 ± 6.14. VIS was significantly higher in non-survivors at all time points, including peak VIS (29.25 ± 6.53 vs 22.51 ± 5.75; $p < 0.001$).On multivariable analysis, CKD (AOR = 1.96, $p = 0.176$) and COPD (AOR = 1.85, $p = 0.295$) showed higher odds of the outcome, but none of the variables reached statistical significance.

Conclusion: The vasoactive inotropic score is a useful forecast of postoperative outcome in cardiac surgery and the 24-hour postoperative VIS showed the greatest predictability of mortality or morbidity. Regular VIS evaluation at this time can enhance risk classification and implement interventions on time.

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Introduction

Cardiac surgery continues to carry a considerable risk of morbidity and mortality despite advances in surgical techniques, anesthetic care, and intensive care support. Mortality following elective cardiac surgery has been reported between 2% and 5%, while emergency and redo procedures may exceed 10%[1,2]. Morbidity is more frequent, with complications such as low cardiac output syndrome, arrhythmias, renal dysfunction, prolonged mechanical ventilation, and infections occurring in up to 40% of cases[3]. Early identification of patients at risk for poor outcomes is therefore crucial to guide timely interventions and improve survival.

Hemodynamic stability is also a pivotal factor that defines the survival outcomes of a patient after operation and a considerable percentage of patients need the pharmacological assistance in terms of inotropic and vasoactive agents to sustain the appropriate perfusion[4]. The necessity of increased doses of these agents is likely to indicate a defect in myocardial functioning, systemic inflammatory response, or complications of the perioperative stage, which were proved to be associated with adverse outcomes[5]. Therefore, the assessment of the

severity of illness and prognosis during the postoperative period is indirect but practical by means of quantification of the degree of vasoactive and inotropic therapy.

The Vasoactive Inotropic Score (VIS) was created in order to offer an objective and standardized approach to ascertaining the extent of pharmacological cardiovascular assistance[6]. Through the doses of the most popular agents, such as dopamine, dobutamine, epinephrine, norepinephrine, and milrinone, VIS produces a single numerical value based on the burden of vasoactive therapy. The greater values of VIS have always led to poor clinical outcomes, including long intensive care unit (ICU) stay, serious complications, and high mortality rates following cardiac surgery[7].

Despite widespread use, there remains uncertainty regarding the optimal time to calculate VIS for prognostication. Some studies have assessed VIS immediately after surgery, while others have calculated it at 24 hours or during peak drug usage in the ICU[8]. Early measurement may allow timely recognition of patients at risk, whereas later assessment may better capture the cumulative burden of hemodynamic instability[9]. Identifying the most appropriate time point for VIS calculation could therefore enhance its predictive power and clinical usefulness[10].

Given the ongoing burden of morbidity and mortality after cardiac surgery and the importance of reliable prognostic tools, determining the ideal time to calculate VIS is essential. This study aims to evaluate the most appropriate postoperative time point for VIS calculation as a predictor of morbidity and mortality in cardiac surgery patients. By addressing this gap, the study seeks to refine risk stratification and improve postoperative management strategies, ultimately contributing to better patient outcomes.

Methodology

This prospective cross-sectional study was conducted in the Department of Anesthesia and Cardiac Surgery of Choudhary Pervez Ellahi Institute of Cardiology, Multan, over a period of 12 to 18 months. Consecutive adult patients aged 18 years or older undergoing elective or urgent cardiac surgery with cardiopulmonary bypass were included, while those undergoing transplantation, requiring durable mechanical support, dying before CICU admission, transferred more than 24 hours after surgery, or already on high-dose vasoactive support were excluded. The sample size was calculated using OpenEpi software, assuming an anticipated mortality rate of 34.5% among patients with a high early morbidity and mortality score, with a 95% confidence level and 5% absolute precision (margin of error). The minimum required sample size was estimated to be 346 patients.

Baseline demographic, clinical, and operative data were collected prospectively. The vasoactive inotropic score (VIS) was calculated using a standardized formula at CICU admission, and at 6, 12, and peak VIS at 24 hours postoperatively, as well as at the peak value within the first 24 hours. The primary outcome was in-hospital mortality, while secondary outcomes included acute kidney injury, renal replacement therapy, prolonged ventilation, re-intubation, stroke, reoperation for bleeding, ICU and hospital length of stay, and a composite of mortality and morbidity.

SPSS version 27 was used for data analysis, which included descriptive statistics like age, BMI, CBP time, clamp time and VIS time point. Nominal data like gender, hypertension, diabetes, chronic kidney disease, COPD, procedure type, were represented in frequency and percentages. Logistic regression models adjusted for covariates to assess independent predictive value. P values ≤ 0.05 was considered as significant.

Results

A total of 346 patients were included with a mean age of 56.91 ± 10.89 years;61.8% were male. Mean BMI was 27.49 ± 4.28 kg/m², and 26.6% were obese. Diabetes and hypertension were present in 37.0% and 44.5%, respectively, while 12.1% had chronic kidney disease and 8.1% had COPD. CABG was the most common procedure (57.2%). Mean CPB and cross-clamp times were 112.42 ± 27.51 min and 73.22 ± 18.98 min, respectively. (Table. I).

The mean vasoactive-inotropic score (VIS) was 9.98 ± 6.02 at CICU admission and 12.53 ± 8.03 at 24 hours postoperatively, while the mean peak VIS during the first 24 postoperative hours was 23.13 ± 6.14, (Table II).

The most frequent event occurred was composite outcome in 118 (34.1%) of patients. Acute kidney injury 65 (18.5%) and prolonged ventilation >48 hours 58 (16.8%) were the most common individual complications. In-hospital mortality was 32 (9.2%), while reoperation 24 (6.9%), renal replacement therapy 22 (6.4%), reintubation 18 (5.2%), and stroke 12 (3.5%) were less frequent. (Figure. I).

Table I: Baseline demographic, clinical and operative characteristics. (n = 346)

Variable	Category	n (%) / Mean ± SD
Age (years)	Mean±S.D	56.91±10.89
	≤40 years	20 (5.8)
	>40 years	326 (94.2)
Gender	Male	214 (61.8)
	Female	132 (38.2)
BMI (kg/m²)	Mean±S.D	27.49±4.28
	<30 (kg/m²)	254 (73.4)
	≥30 (kg/m²)	92 (26.6)
Diabetes mellitus	Yes	128 (37.0)
	No	218 (63.0)
Hypertension	Yes	154 (44.5)
	No	192 (55.5)
Chronic kidney disease	Yes	42 (12.1)
	No	304 (87.9)
COPD	Yes	28 (8.1)
	No	318 (91.9)
Procedure type	CABG	198 (57.2)
	Valve surgery	104 (30.1)
	Combined	44 (12.7)
CPB time (minutes)	Mean ± SD	112.42±27.51
	≤100 minutes	114 (32.9)
	>100 minutes	232 (67.1)
Cross-clamp time (minutes)	Mean±S.D	73.22±18.98
	≤50 minutes	34 (9.8)
	>50 minutes	312 (90.2)

Table II: Comparison of Vasoactive-Inotropic Score (VIS) at Different Time Points between Survivors and Non-Survivors.

VIS Time Point & length of stay	Mean±S.D	Median (IQR)
At CICU admission (T0)	9.98±6.02	9.8 (10.3)
6 hours post (T6)	11.35±6.94	11.7 (11.4)
12 hours post (T12)	12.48±7.35	10.8 (13.1)
24 hours post (T24)	12.53±8.03	11.5 (13.7)
Peak VIS (first 24 hours)	23.13±6.14	22.5 (8.6)
Length of ICU stay (days)	4.12±2.21	4.0 (3.0)
Length of hospital stay (days)	10.04±4.38	10.0 (6.0)

At CICU admission, mean VIS was 13.12 ± 6.72 in non-survivors versus 9.65 ± 5.85 in survivors (p = 0.001). This difference remained significant at 6 hours (16.42 ± 7.63 vs 10.84 ± 6.67), 12 hours (17.63 ± 8.28 vs 11.92 ± 7.03), and 24 hours (17.41 ± 8.59 vs 12.03 ± 7.82), all p < 0.001. Peak VIS within the first 24 hours was also markedly higher among non-survivors (29.25 ± 6.53 vs 22.51 ± 5.75; p < 0.001). (Table III).

Table III: Comparison of Vasoactive-Inotropic Score (VIS) at Different Time Points between Survivors and Non-Survivors.

VIS Time Point	Mortality		Test of sig.
	Yes 32 (9.2%)	No 314 (90.8%)	
At CICU admission (T0)	13.12±6.72	9.65±5.85	t= 3.23, p=0.001
6 hours post (T6)	16.42±7.63	10.84±6.67	t=4.45 , p<0.001
12 hours post (T12)	17.63±8.28	11.92±7.03	t=4.55 , p<0.001
24 hours post (T24)	17.41±8.59	12.03±7.82	t=3.67 , p<0.001
Peak VIS (first 24 hours)	29.25±6.53	22.51±5.75	t=6.24 , p<0.001

Patients with CKD had 1.95 times higher odds of the outcome compared with those without CKD (AOR = 1.955; 95% CI: 0.741–5.156; p = 0.176). Similarly, patients with COPD had 1.85 times greater odds of the outcome (AOR = 1.854; 95% CI: 0.583–5.891; p = 0.295), although this association was not statistically significant. Higher age category and BMI were also associated with increased odds of the outcome; however, these findings were not significant after adjustment for confounding variables. Diabetes and hypertension likewise showed no significant independent association with the outcome (p>0.050). (Table. IV).

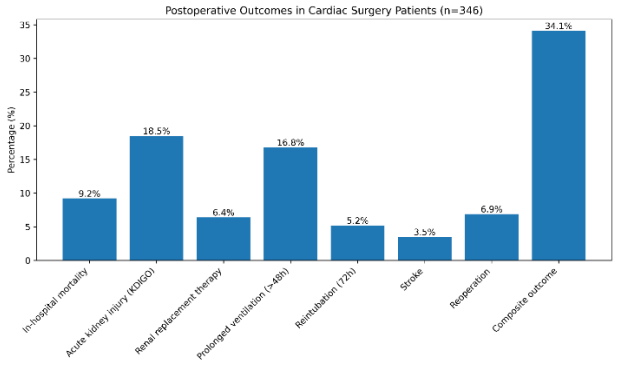

Figure 1. Postoperative outcomes in cardiac surgery patients. (n= 346)

Table IV: Binary Logistic Regression Analysis of Factors Associated with the Mortality.

Variable	B	S.E.	Wald χ^2	p-value	Adjusted OR	95% CI for OR
Age (years)	0.640	1.050	0.371	0.542	1.896	0.242 – 14.850
BMI (kg/m^2)	0.345	0.410	0.707	0.401	1.412	0.632 – 3.154
Diabetes	0.179	0.383	0.219	0.640	1.196	0.565 – 2.534
Hypertension	-0.109	0.385	0.080	0.777	0.897	0.422 – 1.907
CKD	0.670	0.495	1.831	0.176	1.955	0.741 – 5.156
COPD	0.617	0.590	1.095	0.295	1.854	0.583 – 5.891

Abbreviations: OR = Odds Ratio; CI = Confidence Interval; BMI = Body Mass Index; CKD = chronic kidney disease; COPD = Chronic Obstructive Pulmonary Disease; S.E. = Standard Error.

Discussion

In this study, the discriminatory power of the vasoactive-inotropic score (VIS) increased with time, with the highest predictive value observed for the peak VIS within the first 24 hours, which is consistent with previous reports. Koponen et al[11] demonstrated that VISmax was strongly associated with 30-day mortality (AUC 0.76) and composite morbidity (AUC 0.72) after adult cardiac surgery, findings comparable to the AUC of 0.81 observed in this cohort.

Similarly, Mete et al[12] reported that a higher 24-hour VIS was independently associated with poor postoperative outcomes, with an AUC of 0.86, further supporting the utility of later VIS measurements for outcome prediction. Results of this study also align with Keleş et al[13] who found that VIS calculated at later postoperative time points had greater predictive accuracy compared to VIS at ICU admission.

The independent association of elevated 24-hour and peak VIS with in-hospital mortality in this study (adjusted OR 2.74 and 3.12, respectively) is in agreement with prior findings. Koponen et al[11] showed that higher VISmax independently predicted both short- and long-term mortality after cardiac surgery, while Mete et al[12] confirmed a significant association between rising 24-hour VIS values and increased odds of poor outcomes. Furthermore, Hou et al[14] demonstrated that elevated VIS was correlated with acute kidney injury following cardiovascular surgery, and Tohme et al[15] reported that higher 24-hour VIS was associated with adverse outcomes, including mortality, in heart transplant patients.

Kwon et al[16] evaluated the prognostic value of VIS after off-pump coronary artery bypass grafting (OPCAB) in 1,238 patients and found that a higher VISmax was an independent predictor of both early postoperative complications and long-term mortality, with patients in the highest VIS experiencing significantly worse survival over a median follow-up of 5.6 years. This demonstrates that VIS is not only useful in on-pump settings, but also has prognostic significance in off-pump surgery, highlighting its generalizability across different surgical techniques.

A systematic review and meta-analysis of research studies on the use of VIS in the adult patient during cardiac and non-cardiac surgery was undertaken by Sun et al[17]. They have found that high VIS in the initial 24 hours after surgery had a significant relationship with higher mortality, acute renal failure, delayed ventilation, and combined adverse events. Their combined discussion highlighted the fact that VIS is a strong, early, and easily quantifiable predictor of poor outcomes that correlates with the results of this study that showed later and peak values of VIS have stronger predictive ability.

Huang et al[18] furthered the VIS application other than cardiac surgery by investigating 3,064 patients undergoing major abdomen surgery. They showed that large VIS during the initial 24 hours in postoperative period was statistically relevant to in-hospital mortality and reduced ICU stay, and the AUC was 0.77 to predict mortality. This supports the argument that VIS is a simple hemodynamic risk indicator that is not limited to cardiac surgery and the idea that increased vasoactive and inotropic needs are physiological markers of the failure to successfully pump blood and poor outcomes.

In a focused study conducted by Zong et al[19]of 537 adults undergoing isolated CABG, researchers compared VIS, VVR, and a modified VVR (M-VVR). Adjusted analyses showed that for each unit increase in VIS, the odds of poor prognosis increased by about 9% (OR 1.09, 95% CI: 1.05–1.13). The discriminatory ability (AUC) of VIS for poor outcomes was 0.685, while M-VVR performed better (AUC 0.720), indicating that while VIS is a useful predictor, adding ventilation and renal parameters can improve predictive precision

In adults with congenital heart disease (ACHD) undergoing cardiac surgery, a retrospective study of 243 patients demonstrated that VIS_max had excellent discrimination for in-hospital mortality (AUC 0.92, 95% CI: 0.86–0.98) and for composite poor outcome (AUC 0.82, 95% CI: 0.76–0.89). A VIS_max ≥3 was strongly predictive of adverse outcomes, with OR 14.2 for composite poor outcome and OR 19.2 for prolonged ICU LOS[20]. Similar findings were also reported by Levy et al[21] in 2019.

Conclusion

In this prospective cohort, VIS increased during the first 24 hours after cardiac surgery, with the 24-hour and peak VIS showing the strongest predictive ability for mortality and major morbidity. Peak VIS demonstrated good discrimination (AUC 0.81) and was independently associated with adverse outcomes.

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