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Research Article

THE CARDIAC BIOMARKER, NT-PRO BNP, AND HEMODYNAMIC PARAMETER, PCWP IN PATIENTS UNDERGOING ON-PUMP CABG SURGERY

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ABSTRACT

Objective: This study aimed to investigate the correlation between preoperative N-terminal pro-brain natriuretic peptide (NT-proBNP) levels and intraoperative pulmonary capillary wedge pressure (PCWP) in patients undergoing on-pump coronary artery bypass grafting (CABG).

Methods: Pre-operative blood samples were collected to assess NT-proBNP levels. During surgery, PCWP and other hemodynamic parameters were measured using a Swan-Ganz catheter. Plasma dobutamine levels were evaluated 4 h post-incision. Statistical analysis was performed to identify correlations between biomarkers and hemodynamic data.

Results: Pre-operative NT-proBNP levels demonstrated a strong correlation with intraoperative PCWP ($r=-0.84$, $p<0.05$), suggesting its potential as a predictor for low cardiac output syndrome.

Conclusion: NT-proBNP emerges as a valuable biomarker for identifying patients at risk of hemodynamic instability during on-pump CABG procedures. Continuous monitoring of NT-proBNP and PCWP could facilitate risk assessment and improve intraoperative care.

Keywords: Coronary artery bypass grafting procedures, N-terminal pro-brain natriuretic peptide biomarker, Pulmonary capillary wedge pressure, Cardiovascular diseases, Coronary artery disease

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INTRODUCTION

Cardiovascular diseases (CVD) are one of the most significant causes of death and illness globally, with coronary artery disease (CAD) being a factor. According to the World Health Organization, globally, CVDs represent the leading cause of death, responsible for an estimated 17.9 million fatalities each year. After the incidence of COVID-19, the occurrence of heart diseases has increased [1]. Deficiency of micronutrients can also increase the frequency of heart conditions [2]. These conditions, encompassing disorders of the heart and blood vessels, such as coronary heart disease and stroke, disproportionately affect younger populations, with one-third of CVD deaths occurring prematurely in individuals under the age of 70. Coronary artery bypass grafting (CABG) represents a well-recognized surgical intervention for patients with severe CAD, particularly when medical and non-invasive management strategies prove ineffective. Among the various CABG techniques, on-pump CABG, which necessitates the utilization of cardiopulmonary bypass to sustain blood flow during the procedure, is widely employed. CABG is a major surgical procedure that addresses atheromatous blockages within the coronary arteries by creating bypasses using harvested venous or arterial conduits. This intervention restores blood flow to the ischemic myocardium, thereby improving cardiac function, relieving anginal symptoms, and enhancing overall cardiac viability. With an estimated 400,000 procedures performed annually, CABG maintains its position as a leading surgical intervention for CAD [3]. However, it is important to acknowledge that on-pump CABG carries inherent risks, including the potential for low cardiac output syndrome (LCOS), a serious complication that can elevate the risk of morbidity and mortality within the perioperative period.

This study aimed to investigate the relationship between pre-operative N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels and intraoperative pulmonary capillary wedge pressure (PCWP) in patients undergoing on-pump CABG

Rationale:

- NT-proBNP: As a cardiac biomarker, NT-proBNP reflects ventricular stress and can predict left ventricular dysfunction and poor outcomes in cardiac surgery.
- PCWP: An indirect measure of left ventricular end-diastolic pressure, PCWP is essential for guiding fluid management and inotropic support during CABG. However, the relationship between pre-operative NT-proBNP and intraoperative PCWP in CABG patients has not been extensively studied.

Understanding the interplay between NT-proBNP, PCWP, and inflammatory markers will facilitate early risk identification, enable customized intraoperative strategies, and ultimately improve patient outcomes following on-pump CABG.

METHODS

This prospective observational research was conducted at the Department of Cardiothoracic and Vascular Surgery at Fortis Hospital, Mohali, spanning from May 2019 to April 2020. A total of 50 adult patients scheduled for elective on-pump CABG surgery were enrolled after obtaining informed consent (Fig. 1).

Inclusion criteria

Participants aged between 40 and 69 years with preexisting conditions such as hypertension, diabetes, or thyroid dysfunction, along with mild-to-moderate left ventricular dysfunction, were included.

Exclusion criteria

Patients requiring emergency or off-pump CABG and those with severe left ventricular dysfunction were excluded from the study.

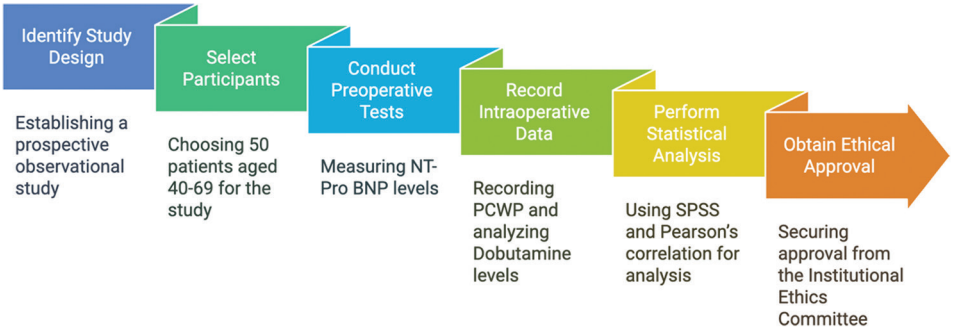

Fig. 1: Study design for the present investigation

Data collection

- Pre-operative: Blood samples were collected to assess NT-proBNP levels.
- Intraoperative: PCWP was monitored using a Swan-Ganz catheter inserted through the right internal jugular vein. Other hemodynamic parameters, including mean arterial pressure (MAP), central venous pressure, cardiac output (CO), and cardiac index, were also documented.
- Post-operative: Blood samples were taken 4 h after the incision to determine plasma dobutamine concentrations through high-performance liquid chromatography.

Data analysis

The data were analyzed using Statistical Package for the Social Sciences software version 29. Pearson's correlation coefficient was used to analyze the correlation between NT-proBNP and PCWP.

RESULTS

Demographic and baseline characteristics

The study included 50 patients, with a mean age of 57.4±8.3 years. Comorbidities such as hypertension (65%) and diabetes mellitus (58%) were common. The pre-operative left ventricular ejection fraction (LVEF) was 42.5±5.8% (Table 1).

NT-proBNP levels and PCWP

The mean pre-operative NT-proBNP level was 1,215±320 pg/mL. Patients with higher NT-proBNP levels were more likely to exhibit elevated PCWP during surgery (Fig. 2).

Intraoperative hemodynamic parameters

The mean PCWP was 14.1±3.2 mmHg during surgery, while CO and MAP were maintained at 4.3±0.8 L/min and 80.3±7.5 mmHg, respectively (Fig. 3).

Correlation between NT-proBNP and PCWP

A strong positive correlation was observed between NT-proBNP levels and PCWP ($r=0.84$, $p<0.001$). LVEF showed a negative correlation with PCWP ($r=-0.67$, $p<0.05$) (Table 2).

Post-operative outcomes

Patients with elevated NT-proBNP levels (>1,500 pg/mL) had longer intensive care unit stays and required more inotropic support compared to those with lower levels (Fig. 4).

To evaluate the role played by NT-proBNP in the pre-existing comorbidities, pre-operative levels of NT-ProBNP among those with and without the comorbidities were compared. By performing an independent t-test, it was concluded that there was no difference in the level of NT-proBNP ($p>0.05$) among participants with and without the comorbidities (Table 3).

Among individuals with increased levels of NT-proBNP, it was observed that 12% were hypertensives, 32% were diabetics, 25% of individuals had dyslipidemia, and 17% of individuals had thyroid dysfunction (Fig. 5).

Using an independent sample t-test, for the level of significance set at 5%, it is inferred that male and female patients had no statistically

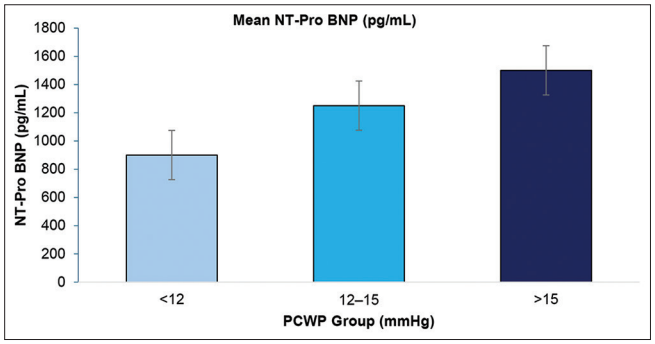

Fig. 2: Bar graphs representing N-terminal pro-brain natriuretic peptide levels across pulmonary capillary wedge pressure groups. Number of patients=50, Bars represent mean while error bars represent standard error of the mean

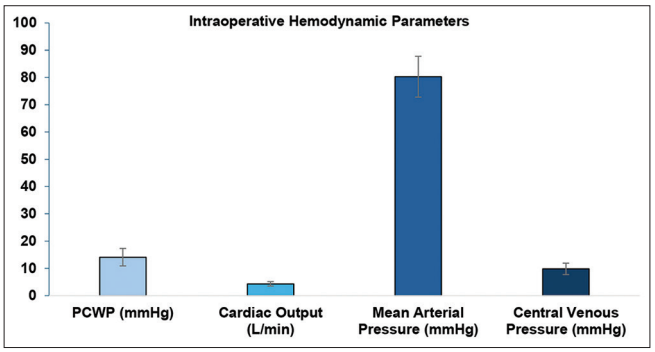

Fig. 3: Intraoperative hemodynamic parameters. Number of patients=50, Bars represent mean while error bars represent standard error of the mean

Table 1: Baseline demographics and clinical characteristics

Parameter	Value
Number of patients	50
Age (years)	57.4±8.3
Male/female ratio	3:1
Hypertension (%)	65
Diabetes mellitus (%)	58
Pre-operative LVEF (%)	42.5±5.8

Number of patients=50, Data given in mean±SD. LVEF: Left ventricular ejection fraction, SD: Standard deviation

significant differences (p>0.05) among them with respect to preoperative values of NT-proBNP (Table 4).

The linear relationship of pre-operative NT-proBNP with PCWP was analyzed using Pearson's correlation analysis. It was inferred that a strong positive linear relationship existed between NT-proBNP level and PCWP level with an r=0.821** and a p<0.01 (Table 5). This indicates that when preoperative NT-proBNP levels increase, intraoperative PCWP levels also increase (Fig. 6).

The normality verification test clearly indicated that NT-proBNP of all age group patients followed normal distribution (p>0.05). Hence, parametric statistical test analysis of variance (ANOVA) was used to compare the NT-proBNP levels among various age group patients (Table 6). The box–whisker plot (Fig. 7) graphically represents the normality assumptions.

It was inferred from Pearson correlation analysis that CPB pump duration and aortic cross-clamp duration were positively correlated with one another (p<0.01). This is graphically represented in the below scatter plot. Whereas pre-operative NT-proBNP levels did not show any correlation with CPB pump duration and aortic cross clamp duration (Table 7).

Table 2: Correlation analysis between NT-proBNP, PCWP, and LVEF

Variable	Correlation with PCWP
NT-proBNP (pg/mL)	r=0.84, p<0.001
LVEF (%)	r=−0.67, p<0.05

Number of patients=50, r=correlation coefficient. NT-ProBNP: N-terminal pro-brain natriuretic peptide, PCWP: Pulmonary capillary wedge pressure, LVEF: Left ventricular ejection fraction

Table 3: Comparison of the level of NT-proBNP levels among individuals with and without various comorbidities

Co-morbidities	NT-proBNP (pg/mL)		t-value	p-value
	Yes	No		
Hypertension	676.41±271.93	725.68±171.61	0.489	0.628
Diabetes mellitus	678.04±255.84	707.36±266.18	0.326	0.746
Hypothyroid	754.26±187.63	667.65±269.79	−0.905	0.371
Dyslipidemia	694.62±251.98	613.17±303.34	−0.666	0.509
H/o previous MI	602.23±311.00	696.03±250.49	0.769	0.446
H/o stroke	743.36±137.65	679.57±264.99	−0.472	0.64

Number of patients=50, Data given in mean±SD. NT-proBNP: N-terminal pro-brain natriuretic peptide, SD: Standard deviation

Table 4: Tests of normality for gender-wise NT-proBNP

Sex	Shapiro–Wilk Statistic	Df	p-value
Pre-operative NT-proBNP (pg/mL)			
Male	0.936	28	0.089
Female	0.936	16	0.301

NT-proBNP: N-terminal pro-brain natriuretic peptide

Table 5: Linear relationship of pre-operative NT-proBNP with intraoperative PCWP

NT-proBNP (pg/mL)	PCWP (mm Hg)
r-value	0.821**
p-value	<0.001

NT-proBNP: N-terminal pro-brain natriuretic peptide, PCWP: Pulmonary capillary wedge pressure

DISCUSSION

Biomarkers have proven valuable in assessing risk and predicting outcomes in patients with CAD. However, their clinical utility in the context of on-pump CABG surgery, the gold-standard surgical revascularization procedure, requires further investigation. The identification of clinically relevant biomarkers has the potential to

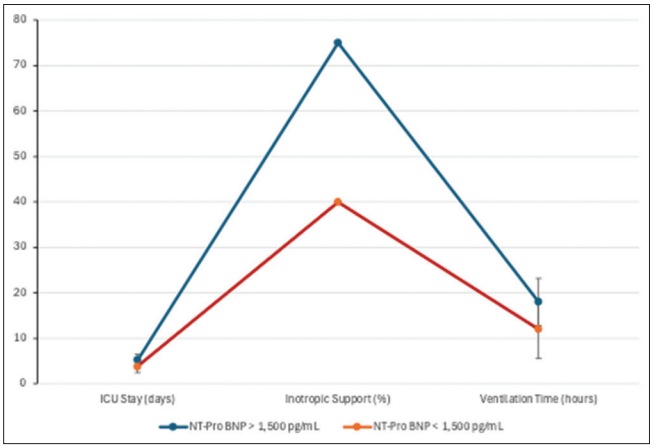

Fig. 4: Postoperative outcomes based on N-terminal pro-brain natriuretic peptide levels. Number of patients=50, line graphs represent mean while error bars represent standard error of the mean

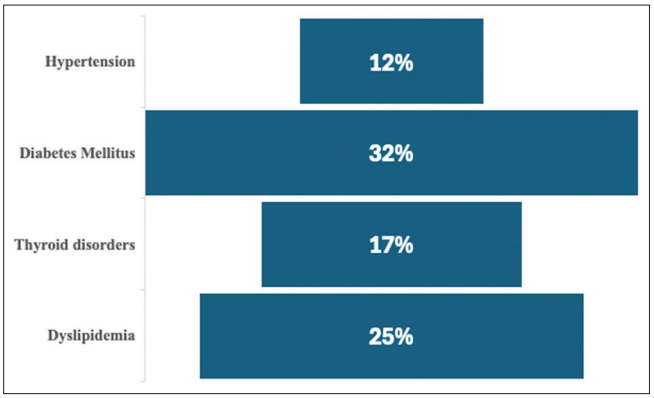

Fig. 5: Pre-existing comorbidities among patients with high N-terminal pro-brain natriuretic peptide

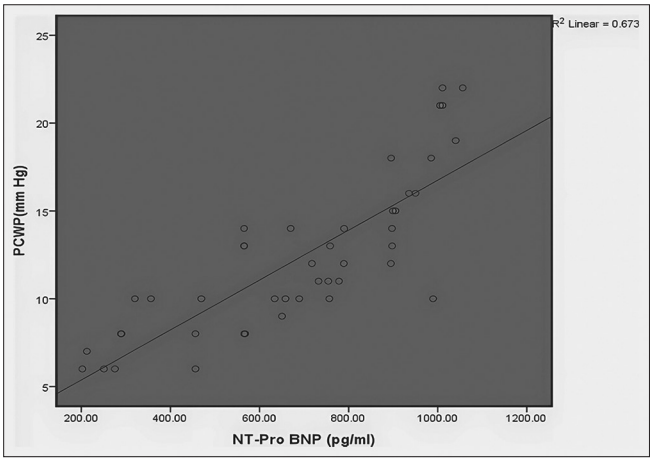

Fig. 6: Scatter plot for correlation of preoperative N-terminal pro-brain natriuretic peptide with intraoperative pulmonary capillary wedge pressure

Table 6: Tests of normality for age group-wise pre-operative NT-proBNP

Age group	Shapiro–Wilk statistic	Df	p-value
NT-proBNP (pg/mL)			
41–50	0.904	11	0.207
51–60	0.929	13	0.331
61–70	0.939	20	0.231

NT-proBNP: N-terminal pro-brain natriuretic peptide

Table 7: Relationship between NT-proBNP, aortic cross-clamp duration, and CPB pump duration

Parameters	NT-proBNP (pg/mL)	Aortic cross-clamp duration (mins)	CPB pump duration (mins)
NT-proBNP (pg/mL)			
r-value	1	0.045	−0.069
p-value		0.769	0.654
Aortic cross-clamp duration (mins)			
r-value		1	0.401**
p-value			0.007
CPB pump duration (mins)			
r-value			1
p-value			-

**p<0.01; *p<0.05. NT-proBNP: N-terminal pro-brain natriuretic peptide

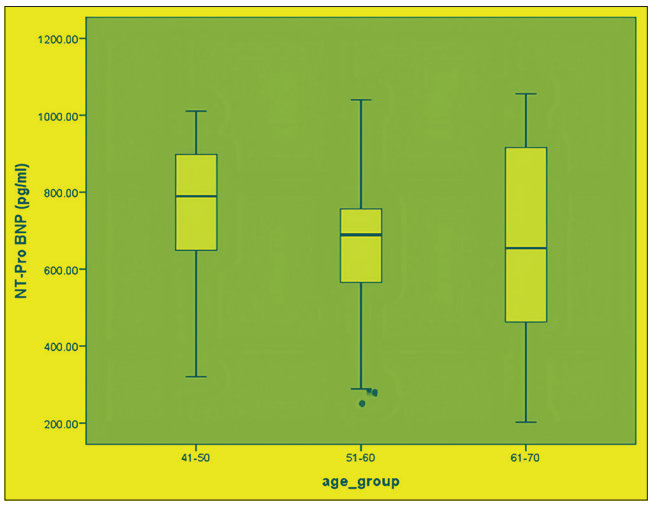

Fig. 7: Age group-wise pre-operative N-terminal pro-brain natriuretic peptide distribution

significantly influence clinical decision-making and ultimately improve patient outcomes.

The European Society of Cardiology (ESC) guidelines for the diagnosis and management of both acute and chronic heart failure establish different cutoff values for NT-proBNP. In non-acute settings, the upper limit of normal for NT-proBNP is set at 125 pg/mL. However, in acute heart failure scenarios, the cutoff value for NT-proBNP is raised to 300 pg/mL [4]. The present study, referencing the 2016 ESC Guidelines, revealed elevated preoperative levels of NT-proBNP among participants undergoing CABG. This elevation in NT-proBNP likely reflects a decline in left ventricular function, a common finding in patients with CAD who require revascularization procedures. Previous research has consistently shown that NT-proBNP serves as an independent predictor of adverse cardiovascular events in patients with stable CAD [5-7].

Using age-dependent cutoffs for NT-proBNP in the ICON study, elevated levels were observed, with a higher prevalence in the 41–50 age group. However, this difference did not reach statistical significance [8]. The present investigation revealed no statistically significant difference in mean NT-proBNP levels when comparing males and females. This discrepancy from prior research findings could be attributed to the unequal distribution of males and females within the study population [9].

Several studies have highlighted the utility of plasma NT-proBNP as a marker of recovery following high-risk CABG surgery. Importantly, NT-proBNP levels demonstrate a strong inverse correlation with LVEF, increasing as LVEF decreases. In the context of LCOS, LV systolic dysfunction results in reduced LVEF and increased LV filling pressure, which is closely associated with elevated NT-proBNP levels. Furthermore, studies have shown that a decline in LVEF due to LCOS is accompanied by an increase in PCWP [9-11].

In the current study, the average PCWP of all 50 participants was observed to be on the higher side of normal. When patients are monitored using a pulmonary artery catheter, elevated PCWP, generally considered to be >16 mm Hg, is a clinical indicator of congestion. Importantly, studies have demonstrated that even levels of PCWP that do not immediately produce noticeable symptoms can still be associated with a poorer prognosis in patients with heart failure [12].

The primary outcome analysis of this study revealed a significant positive correlation between pre-operative NT-proBNP levels and intraoperative PCWP. This finding suggests that elevated pre-operative NT-proBNP levels (>300 pg/mL) may necessitate closer monitoring and potential adjustments, such as utilizing a cardiopulmonary bypass pump with frequent dobutamine administration, during CABG surgery to mitigate the risk of developing LCOS [13]. Similar findings were also reported by Harrison *et al*. and Kazanegra *et al*. and demonstrated a strong positive correlation between NT-proBNP and PCWP [14,15].

This prospective observational study revealed a strong positive correlation between pre-operative NT-proBNP levels and intraoperative PCWP in patients undergoing on-pump coronary artery bypass graft (CABG) surgery. This finding highlights the intricate relationship between cardiac biomarkers and hemodynamic factors during the perioperative period. The observed correlation suggests that higher NT-proBNP levels are associated with increased left ventricular filling pressures, indicating diminished cardiac function and potentially a lower cardiac reserve.

Furthermore, the identification of independent clinical factors, such as advanced age, the existence of diabetes, and extended cardiopulmonary bypass duration, as determinants of the NT-proBNP-PCWP connection emphasizes the complex interplay between patient characteristics, surgical variables, and cardiac hemodynamics. These results underscore the potential benefit of integrating cardiac biomarkers with hemodynamic measures to refine risk assessment and inform targeted strategies in the perioperative management of CABG patients.

These findings have significant clinical implications. By clarifying the association between NT-proBNP and PCWP, healthcare providers can better understand these indicators and utilize them to optimize fluid management, support cardiovascular performance, and potentially improve patient outcomes. Further research is warranted to explore the underlying mechanisms of this observed connection and to assess the clinical advantages of this integrated methodology in the perioperative treatment of CABG patients.

CONCLUSION

This prospective observational study sheds light on the significant correlation between pre-operative NT-proBNP levels and intraoperative

PCWP in patients undergoing on-pump coronary artery bypass graft (CABG) surgery. The findings underscore the intricate interplay between cardiac biomarkers and hemodynamic measures during the perioperative period.

Recognizing the potential clinical benefits of combining these indicators, this study highlights the possibility of improving risk assessment and guiding targeted interventions. Furthermore, identifying the clinical factors that influence this relationship provides valuable insights into the complex pathophysiological mechanisms underlying these observations. These findings have significant implications for the perioperative management of CABG patients and warrant further research to elucidate the exact mechanisms and optimize clinical outcomes.

ETHICS APPROVAL

Approval from ethical committee was obtained for the study.

CONSENT FOR PUBLICATION

For the publication of this case report, written and informed consent was obtained from the patient.

AUTHOR'S CONTRIBUTIONS

Gurpreet Singh-Formulation, conduction of procedure, data collection and anaylsis, manuscript writing and reviewing, Rajwinder Kaur – Manuscript writing, reviewing and data analysis.

CONFLICT OF INTEREST

All the authors state that they do not have any conflict of interest.

AUTHOR FUNDING

The authors did not receive any funding for the study

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