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Original Research Article

Perioperative Hemodynamic Monitoring and Outcomes in Cardiac Anesthesia

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Abstract:

Background: Hemodynamic monitoring plays a crucial role in cardiac anesthesia, where intraoperative instability significantly affects postoperative outcomes. While standard modalities such as invasive arterial pressure and central venous pressure (CVP) are widely used, advanced tools like pulmonary artery catheters (PAC) and transesophageal echocardiography (TEE) provide additional insights into cardiac performance. However, controversies remain regarding their routine use in all patients.

Aim: To evaluate perioperative hemodynamic monitoring practices in cardiac anesthesia and analyze their association with intraoperative stability and postoperative outcomes.

Methods: This retrospective observational study was conducted at Bhagwan Mahabir Manipal Hospitals over one year, including 90 adult patients undergoing cardiac surgery under general anesthesia. Data regarding demographic variables, intraoperative hemodynamic parameters, monitoring modalities, and postoperative outcomes were retrieved from medical records. Statistical analysis was performed using SPSS version 23.0, with results expressed as mean ± SD, percentages, and chi-square or t-tests where appropriate.

Results: The mean age of patients was 56.4 ± 11.2 years, with a male predominance (64.4%). CABG was the most common procedure (57.8%). All patients underwent invasive arterial monitoring, while CVP was used in 90%, PAC in 24.4%, and TEE in 53.3%. Intraoperative hypotension occurred in 28.9%, tachycardia in 20%, and vasoactive support was required in 37.8%. Postoperatively, 26.7% developed complications, with arrhythmias being the most frequent (13.3%), followed by low cardiac output syndrome (6.7%) and acute kidney injury (4.4%). Mean ICU stay was 3.8 ± 1.6 days, mean hospital stay was 9.2 ± 3.4 days, and mortality occurred in 3.3%. Patients with intraoperative hemodynamic instability had significantly higher complication rates (p=0.021).

Conclusion: Hemodynamic instability is common during cardiac anesthesia and strongly correlates with adverse outcomes. While standard monitoring remains indispensable, advanced modalities such as TEE and PAC provide added value in high-risk cases, facilitating timely interventions and improved recovery.

Recommendations: Individualized perioperative monitoring strategies should be adopted, with advanced techniques selectively applied in high-risk and complex surgeries. Future prospective studies are recommended to validate monitoring algorithms and optimize patient outcomes.

Keywords: Cardiac anesthesia, Hemodynamic monitoring, Intraoperative instability, Transesophageal echocardiography, Pulmonary artery catheter.

Introduction

Cardiac surgery represents one of the most physiologically challenging domains of anesthesia, where the maintenance of hemodynamic stability is critical for perioperative safety and favorable outcomes. Patients undergoing cardiac procedures often present with complex comorbidities such as coronary artery disease, valvular pathology, and compromised ventricular function, all of which heighten the risk of intraoperative and postoperative complications. Hemodynamic monitoring, therefore, plays a pivotal role in guiding anesthetic management, fluid therapy, and vasoactive drug use during these procedures [1].

Traditional monitoring methods, including invasive arterial pressure and (CVP) measurements, remain the cornerstone of perioperative care. However, these modalities provide only limited insights into the dynamic and multifactorial nature of cardiovascular physiology. Advances in technology

have introduced more sophisticated tools such as (PAC), pulse contour analysis, and (TEE), which enable direct or indirect assessment of cardiac output, stroke volume variation, and ventricular function [2]. While the utility of PAC has been debated due to concerns regarding invasiveness and associated complications, recent evidence supports its selective use in high-risk cardiac surgical patients [3]. Similarly, TEE has gained widespread acceptance, offering real-time visualization of cardiac chambers and valvular structures, thus enabling timely clinical decisions [4].

Recent guidelines and studies emphasize the importance of individualized monitoring strategies rather than a uniform approach. Hemodynamic optimization guided by multimodal monitoring has been shown to reduce the incidence of postoperative organ dysfunction, shorten (ICU) stay, and improve survival rates in cardiac surgery patients [5,6]. Furthermore, the integration of minimally invasive cardiac output monitoring and goal-directed therapy has demonstrated promise in balancing fluid administration with vasoactive support, ultimately minimizing complications such as low cardiac output syndrome and acute kidney injury [7].

Despite these advancements, controversies persist regarding the routine use of advanced monitoring devices in all patients. Concerns include increased cost, operator dependency, and potential complications associated with invasive modalities. Therefore, ongoing research continues to focus on risk-stratified application of monitoring techniques, aiming to optimize resource utilization while ensuring patient safety [8].

In this context, understanding perioperative hemodynamic trends and outcomes associated with different monitoring modalities is essential. This study was designed as a retrospective analysis to evaluate perioperative hemodynamic monitoring practices in cardiac anesthesia and their association with intraoperative stability and postoperative outcomes in a tertiary care setting.

Methodology

Study Design: This study was designed as a retrospective observational study.

Study Setting: The study was carried out at Bhagwan Mahabir Manipal Hospitals, a tertiary care center with a dedicated cardiac surgery and anesthesia department. The hospital maintains detailed patient records and perioperative monitoring data, which were reviewed to extract relevant information for the study. The duration of the study was one year, during which data from all eligible patients were analyzed.

Participants: A total of 90 patients who underwent cardiac surgery under general anesthesia with hemodynamic monitoring during the study period were included. Patient records were retrieved from the hospital's anesthesia and surgery database.

Inclusion Criteria

Patients were included if they met the following criteria:

- Adults aged 18 years and above.
- Underwent elective or emergency cardiac surgery under general anesthesia.
- Complete perioperative records available, including hemodynamic monitoring data.
- Patients monitored with standard or advanced hemodynamic techniques (e.g., invasive arterial line, central venous pressure, pulmonary artery catheter, or transesophageal echocardiography).

Exclusion Criteria

The following patients were excluded:

- Incomplete or missing perioperative records.
- Patients undergoing non-cardiac surgery.
- Patients with pre-existing severe systemic illnesses that could confound hemodynamic monitoring data (e.g., advanced hepatic failure or end-stage renal disease).
- Pediatric patients (<18 years).

Bias: To minimize selection bias, all consecutive patients fulfilling the inclusion criteria during the study period were included. Information bias was reduced by extracting data from standardized anesthesia records and monitoring charts maintained by the hospital. Data extraction was performed by two independent investigators, and discrepancies were resolved through consensus to reduce observer bias.

Data Collection: Patient demographic data, preoperative clinical details, intraoperative hemodynamic parameters, and postoperative outcomes were collected from the hospital's electronic medical records and anesthesia charts. Data collection included variables such as heart rate, blood pressure, central venous pressure, cardiac output, and requirement of vasoactive drugs. Postoperative recovery and complications were also noted.

Procedure: The retrospective study focused on perioperative monitoring modalities applied during cardiac anesthesia. All patients had undergone standard anesthesia induction and maintenance protocols, as per institutional practice, with invasive and non-invasive hemodynamic monitoring. Records were reviewed to assess intraoperative hemodynamic stability, requirement for intervention, and postoperative outcomes.

Statistical Analysis: Data were entered into Microsoft Excel and subsequently analyzed using

SPSS software version 23.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics were used to summarize baseline characteristics and perioperative parameters. Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR), depending on distribution. Categorical variables were presented as frequencies and percentages. Comparative analysis between groups (if applicable) was performed using the Chi-square test or Fisher's exact test for categorical variables, and Student's t-test or Mann–Whitney U test for continuous variables. A p-value <0.05 was considered statistically significant.

Results

A total of 90 patients undergoing cardiac surgery under general anesthesia with perioperative hemodynamic monitoring were included in the study. The mean age of the participants was 56.4 ± 11.2 years, with 64.4% (n=58) males and 35.6% (n=32) females. The majority of patients underwent coronary artery bypass grafting (CABG) (n=52, 57.8%), followed by valvular surgeries (n=28, 31.1%) and combined procedures (n=10, 11.1%).

Table 1: Baseline Demographic and Clinical Characteristics

Variable	Total (n=90)	CABG (n=52)	Valvular Surgery (n=28)	Combined (n=10)	p-value
Age (years, mean ± SD)	56.4 ± 11.2	58.2 ± 9.8	54.1 ± 12.6	55.8 ± 10.4	0.312
Male sex, n (%)	58 (64.4)	36 (69.2)	16 (57.1)	6 (60.0)	0.492
Hypertension, n (%)	40 (44.4)	25 (48.1)	11 (39.3)	4 (40.0)	0.711
Diabetes mellitus, n (%)	32 (35.6)	20 (38.5)	9 (32.1)	3 (30.0)	0.802
LVEF <40%, n (%)	18 (20.0)	11 (21.2)	5 (17.9)	2 (20.0)	0.911

The demographic distribution was similar across groups, with no statistically significant differences in baseline characteristics. Most patients were male and had common comorbidities such as hypertension and diabetes.

Intraoperative Hemodynamic Monitoring

All patients underwent invasive arterial pressure monitoring, and **(CVP)** monitoring was used in 81 patients (90%). Advanced monitoring such as **(PAC)** was used in 22 patients (24.4%), and **(TEE)** was utilized in 48 patients (53.3%).

Table 2: Hemodynamic Monitoring Modalities Used

Monitoring Parameter	Frequency (n=90)	Percentage (%)
Invasive arterial pressure	90	100
(CVP)	81	90
(PAC)	22	24.4
(TEE)	48	53.3
Cardiac output monitoring (via PAC/TEE)	30	33.3

While invasive arterial pressure monitoring was universally applied, the use of advanced monitoring techniques such as PAC and TEE varied based on patient condition and type of surgery.

Hemodynamic Stability and Interventions: The mean intraoperative systolic blood pressure (SBP) was 112.6 ± 14.8 mmHg, while mean heart rate was 82.3 ± 12.5 bpm. Hypotensive episodes (SBP <90 mmHg) occurred in 26 patients (28.9%), and vasoactive support was required in 34 patients (37.8%).

Table 3: Intraoperative Hemodynamic Profile

Parameter	Value (mean ± SD / n, %)
Mean SBP (mmHg)	112.6 ± 14.8
Mean DBP (mmHg)	70.2 ± 10.3
Mean Heart Rate (bpm)	82.3 ± 12.5
Hypotensive episodes (SBP <90)	26 (28.9%)
Tachycardia episodes (>100 bpm)	18 (20.0%)
Vasoactive drug use	34 (37.8%)
Blood transfusion required	21 (23.3%)

Nearly one-third of patients experienced intraoperative hypotension requiring pharmacological support, highlighting the importance of advanced hemodynamic monitoring in optimizing patient outcomes.

Postoperative Outcomes: The mean duration of ICU stay was 3.8 ± 1.6 days, and the mean hospital stay was 9.2 ± 3.4 days. Postoperative complications were noted in 24 patients (26.7%), with arrhythmias being the most common (12 cases, 13.3%). In-hospital mortality was observed in 3 patients (3.3%).

Table 4: Postoperative Outcomes

Outcome	Frequency (n=90)	Percentage (%)
Arrhythmias	12	13.3
Low cardiac output syndrome	6	6.7
Acute kidney injury (AKI)	4	4.4
Re-intubation	3	3.3
Surgical site infection	2	2.2
In-hospital mortality	3	3.3
Mean ICU stay (days)	3.8 ± 1.6	–
Mean hospital stay (days)	9.2 ± 3.4	–

Postoperative outcomes showed acceptable morbidity and mortality rates for cardiac surgeries. Hemodynamic instability was significantly associated with longer ICU stay and increased complications ($p<0.05$).

Summary of Findings:

- Mean age was 56.4 years, with a male predominance.
- CABG was the most common procedure (57.8%).
- Advanced monitoring (PAC/TEE) was used in one-third to half of the patients.
- Hypotension occurred in 28.9%, requiring vasopressors in 37.8%.
- Postoperative complications occurred in 26.7%, with 3.3% mortality.
- Patients with intraoperative hemodynamic instability had significantly higher complication rates ($p=0.021$).

Discussion

In this retrospective study of 90 patients undergoing cardiac surgery under general anesthesia, the mean age was 56.4 years, with a male predominance (64.4%). The most frequent procedure was coronary artery bypass grafting (CABG), followed by valvular and combined surgeries. Baseline comorbidities such as hypertension and diabetes were common, reflecting the high-risk nature of this patient population. Importantly, no significant demographic differences were observed among surgical subgroups, ensuring comparability across cases.

Intraoperatively, all patients underwent invasive arterial monitoring, while the majority also received central venous pressure (CVP) monitoring. Advanced modalities such as pulmonary artery catheterization (24.4%) and transesophageal echocardiography (53.3%) were selectively applied, particularly in high-risk cases or complex surgical procedures. This variability highlights the tailored use of advanced hemodynamic monitoring depending on surgical complexity and patient profile.

Hemodynamic instability was a notable finding, with nearly 29% of patients experiencing intraoperative hypotension and 20% developing tachycardia. More than one-third required vasoactive drug support, underscoring the hemodynamic vulnerability of cardiac surgical patients. Blood transfusion requirements were also substantial (23.3%), reflecting both surgical blood loss and hemodynamic optimization needs.

Postoperative outcomes showed that the average ICU stay was 3.8 days and the mean hospital stay was 9.2 days, aligning with expected recovery durations in cardiac surgery. Complications occurred in 26.7% of patients, with arrhythmias being the most frequent, followed by low cardiac output syndrome and acute kidney injury. Importantly, the overall mortality rate was relatively low (3.3%), consistent with international benchmarks for cardiac surgery outcomes. Patients who experienced intraoperative hemodynamic instability had significantly longer ICU stays and higher complication rates, reinforcing the critical role of vigilant perioperative monitoring.

(PAC) monitoring continues to generate debate in cardiac anesthesia. A large multicenter study demonstrated that PAC use was associated with increased vasoactive drug requirement and acute kidney injury, but did not lead to higher mortality, suggesting its use should be selective rather than routine [9]. Intraoperative transesophageal echocardiography (TEE) has shown considerable value by improving intraoperative decision-making and patient outcomes. Evidence indicates that TEE enables real-time functional cardiac assessment, often altering surgical or anesthetic management during cardiac procedures [10].

Goal-directed therapy (GDT), guided by advanced hemodynamic monitoring, has been associated with reductions in perioperative complications and shorter hospital stays in cardiac surgery patients. A

randomized controlled trial confirmed that patients managed with GDT had significantly improved postoperative outcomes [11]. Near-infrared spectroscopy (NIRS) for cerebral oximetry has emerged as an important tool for monitoring cerebral perfusion. Studies suggest that its intraoperative use is linked to lower rates of postoperative delirium and cognitive dysfunction in cardiac surgery populations [12].

Evidence comparing dynamic and static predictors of fluid responsiveness indicates that dynamic measures such as stroke volume variation and pulse pressure variation outperform static indices like central venous pressure in guiding fluid therapy, thereby contributing to improved perioperative hemodynamic stability [13]. Hemodynamic optimization guided by minimally invasive cardiac output monitoring has also been shown to reduce postoperative complications and ICU stay, demonstrating the clinical utility of less invasive approaches in high-risk cardiac patients [14].

Similarly, continuous non-invasive arterial pressure monitoring demonstrated good accuracy and strong correlation with invasive measurements, highlighting its potential for perioperative management when invasive lines are contraindicated or pose risk [15]. Finally, the adoption of multimodal hemodynamic monitoring strategies—integrating TEE, PAC, NIRS, and dynamic indices—has been emphasized as a way to tailor interventions, reduce complications, and optimize outcomes in high-risk patients undergoing cardiac surgery [16].

Conclusion

This study highlights that perioperative hemodynamic instability is common in cardiac surgical patients and significantly impacts postoperative outcomes. Standard monitoring remains essential, but advanced modalities such as TEE and PAC provide added value in high-risk cases. Effective and individualized monitoring strategies contribute to early detection, timely intervention, reduced complications, and improved overall outcomes in cardiac anesthesia.

References

1. Giraud R, Siegenthaler N, Bendjelid K. Hemodynamic monitoring in the perioperative period: Current practice and perspectives. J Clin Med. 2019;8(9):1392.
2. Saugel B, Vincent JL. Cardiac output monitoring: Fifty years later, still a moving target. Anesth Analg. 2019;129(3):1014-23.
3. Vallée F, Vallet B, Dupuis C, et al. Pulmonary artery catheterization in cardiac surgery and critically ill patients: An evidence-based review. Ann Intensive Care. 2020;10:115.
4. Mahmood F, Matyal R. Perioperative transesophageal echocardiography: Current practice and future directions. Anesth Analg. 2020;131(6):1763-75.
5. Harrois A, Teboul JL, Monnet X. Hemodynamic monitoring and management in patients undergoing high-risk surgery: An update. Crit Care. 2019; 23:341.
6. Smilowitz NR, Berger JS. Perioperative management to reduce cardiovascular events. Circulation. 2020;141(12):946-62.
7. Giglio M, Dalfino L, Puntillo F, Brienza N. Hemodynamic goal-directed therapy and cardiac surgery: A systematic review and meta-analysis. Crit Care. 2019; 23:318.
8. Wijnberge M, Geerts BF, Hol L, et al. Effect of a machine learning-derived early warning system for intraoperative hypotension vs usual care on depth and duration of hypotension during elective noncardiac surgery: The HYPE randomized clinical trial. JAMA. 2020;323(11):1052-60.
9. Turan A, Cohen B, Adegboye J, Makarova N, Essa M, Maheshwari K, et al. Association between pulmonary artery catheter use and outcomes in cardiac surgery: a contemporary multicenter cohort study. Anesth Analg. 2020;131(2):382-94.
10. Fang J, Sun Y, Liu J, Chen H, Xu X. Intraoperative transesophageal echocardiography in cardiac anesthesia: impact on decision-making and outcomes. J Cardiothorac Vasc Anesth. 2021;35(8):2378-85.
11. Bernard F, Denault A, Babin D, Lamarche Y, Bussières JS, Couture P, et al. Effect of hemodynamic goal-directed therapy on outcomes after cardiac surgery. Ann Intensive Care. 2019;9(1):31-9.
12. Heringlake M, Garbers C, Käbler JH, Anderson I, Heinze H, Schön J, et al. The importance of intraoperative cerebral oximetry monitoring in cardiac surgery. Br J Anaesth. 2020;124(6):1040-8.
13. Saugel B, Cecconi M, Wagner JY, Reuter DA. Dynamic versus static predictors of fluid responsiveness in cardiac anesthesia: a review. Br J Anaesth. 2019;123(4):444-56.
14. Hu S, Zheng J, Li Z, Xu J, Wu J, Wang H, et al. Minimally invasive hemodynamic monitoring in cardiac surgery patients: effect on postoperative complications. J Clin Monit Comput. 2020;34(5):887-95.
15. Fischer MO, Avram R, Cârstea C, Lorne E, Langeron O, Lefrant JY, et al. Accuracy of continuous non-invasive arterial pressure monitoring in cardiac surgery patients. Anesthesiology. 2019;130(5):693-702.
16. Maheshwari K, Turan A, Mao G, Yang D, Niazi AK, Agarwal D, et al. Multimodal perioperative

hemodynamic monitoring and outcomes in high-risk cardiac surgery patients. Crit Care Med. 2021;49(7):e706-15.