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PERIOPERATIVE ANESTHETIC MANAGEMENT AND CARDIAC OUTCOMES: A MULTICENTER STUDY ON RISK STRATIFICATION IN HIGH-RISK CARDIOVASCULAR SURGICAL PATIENTS

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Abstract

This multicenter observational cohort study aimed to evaluate the impact of perioperative anesthetic management on cardiac outcomes in high-risk cardiovascular surgical patients. A total of 1,200 adult patients undergoing elective or urgent cardiac surgeries were enrolled across five tertiary care centers. Preoperative variables, intraoperative monitoring strategies, and postoperative outcomes were meticulously analyzed. The average age of patients was 66.2 years and they often had diabetes mellitus (40.7%) and hypertension (77.3%). Major adverse cardiac events (MACE) were reported in 15 percent of patients and 3 percent of all cases were deaths that happened after the procedure. Age over 70 years, EuroSCORE II above 6, preoperative diabetes, intraoperative hypotension and postoperative acute renal damage were identified by multivariate logistic regression as main predictors of MACE. By contrast, having cerebral oximetry used had a tendency to protect the patient (OR: 0.72; p=0.056). When researchers used advanced anaesthetic methods, stratified study proved that combination intervention—goal-directed fluid management, use of cerebral oximetry and standard monitoring—showed the lowest MACE incidence (11.0%). Furthermore, many cases showed intraoperative hypotension (30.3%) and made it clear that monitoring metabolism and nutrition is needed during the recovery process. They suggest that extensive perioperative steps and several types of anaesthetic are needed to increase the success of cardiovascular surgeries. Customised patient risk assessment and using precision monitoring are important, according to the study, to treat patients before surgery and prevent more cases of morbidity and death.

Keywords: “Perioperative Management”, “Cardiac Surgery”, “Anesthetic Strategy”, “MACE”, “Cerebral Oximetry”, “Risk Stratification”.

INTRODUCTION

Reducing difficulties for these patients, using resources well and making recovery easier and healthier for them all rely on proper management during perioperative care for cardiac surgery patients (Gregory et al., 2023). Almost 5% of noncardiac surgeries worldwide each year have cardiovascular problems which points to the need for careful monitoring and prompt action (Hert & Buse, 2020). More than 300 million people globally which is significantly over 100 million more than two decades ago (Kashlan et al., 2024), have had surgical procedures. Cardiac surgery is the procedure that is most commonly performed in hospitals, but due to its difficult nature and common occurrence of complications afterwards, it has a higher mortality rate (Xie et al., 2022). There is a higher risk of major cardiovascular problems for older people who go through noncardiac surgery which stresses the importance of recognising and limiting risks they might face during surgery (Banco et al., 2021). Smoking cessation, medical nutrition and exercise can help patients before and after surgery and should be encouraged whenever possible (Mohyeldin et al., 2025). Aging often brings reduced organ health and multiple other conditions, so these patients undergoing heart surgery usually have a high risk of mortality (Xie et al., 2022).

Ensuring few complications after surgery (Roshanov et al., 2021) hinges on strong risk assessment. Even if the outcomes vary with different populations, risk stratification models are able to support the procedure (Hassan et al., 2025). Because cardiac surgery patients are commonly admitted right before the operation, using approaches for short time windows is absolutely necessary (Hill et al., 2021). Every customer should have an effective care plan before surgery, but for it to be useful, their medical history, lifestyle, other health issues and risks must be taken into account (Rajapakse & Amarasiri, 2021). Because cerebral oximetry and continuous haemodynamic monitoring are now available, surgeons can check a patient's heart function, blood supply to tissues and oxygen levels during the surgery.

When someone stops smoking, eats better and exercises, the results often lead to better health outcomes for the person, both right after surgery and afterward. In addition, certain issues linked with surgical myocardial damage are age, atrial fibrillation, coronary artery disease, peripheral vascular disease and stroke (Serrano et al., 2021). In perioperative care, experts use surgical skill, an optimised approach to anaesthetics and careful postoperative monitoring in multiple ways. To decrease opioid intake, start physical activity early and teach patients fully about their condition, care given before and after surgery has grown to help with recovery.

Excessive immune response and tissue damage due to changes in blood flow during cardiopulmonary bypass (cited by Zheng et al., 2022) assist in understanding why 20% to 35% of heart surgery patients suffer from lung problems. Those with impaired lung function tend to encounter more difficulties in their respiratory system after surgery (Rajapakse & Amarasiri, 2021). Before the heart operation, specific pre-operative variables can predict the common major complication of acute renal damage. The long time it takes to recover from the surgery and the significant physical

distress caused by the median sternotomy and cardiopulmonary bypass can negatively affect a patient's health and mental state which might be a cause of postoperative sexual dysfunction (Yan et al., 2022). In addition, how anaesthesia is managed affects the risk of complications during an operation (Wacker, 2023). When we go through stress, both the sympathetic nervous system (Cao et al., 2025) and the hypothalamic-pituitary-adrenal axis are woken. Patients with pre-existing cachexia, sarcopenia or malnutrition are at high risk for complications after surgery because the surgical stress response leads to a decrease in protein (León et al., 2023). Because of the stress reaction and associated illnesses, some heart surgery patients lose weight after their operation (Taşbulak et al., 2021).

Mostly, we can reduce negative effects by fixing metabolic issues. When critically ill myocardial infarction patients have low Haemoglobin Glycation Index, their chances of death increase, implying that it should be researched further as a marker for reduced risk and better care (Cao et al., 2025). Because stress and drugs can have an effect on blood sugar in critical myocardial infarction patients, using only HbA1c or blood glucose for metabolic evaluation may not be enough (Cao et al., 2025). Control of blood sugar levels and proper hydration during surgery are very important (Lobo et al., 2020). During non-cardiac surgery, intraoperative anaemia may be related to harm to the heart muscle (Park et al., 2021). Grammatopoulos et al., 2022 found that preoperative anaemia is common. Mild and severe hypotension during surgery can lead to adverse events after any kind of surgery. When applied in the beginning of recovery, nutritional support plays a major role in boosting recovery and cutting surgical risks (Martínez-Ortega et al., 2022). Not getting proper nutrition before surgery increases a patient's time in the hospital, causes more problems during heart surgery and increases the risk of death or illness (Mubashir et al., 2022). Improved nutrition among patients who are likely to have bad outcomes after surgery would be possible by using recovery programs and by giving patients detailed dietary advice (León et al., 2023).

METHODOLOGY

This study which followed a prospective design, looked for connections between postoperative heart outcomes and the different anaesthetic practices used in high-risk cardiac surgery. During the eighteen-month study, the trial was conducted at all five tertiary-care cardiac centers after receiving institutional review board (IRB) permission. Selected by suitable inclusion criteria—age above 50 and cardiovascular conditions—1,200 patients getting elective or urgent cardiac surgery (CABG, valve surgery or mixed procedures) were enrolled in the study. Excluded from the study were emergencies, earlier heart surgery within six months and people who could not understand the risks involved.

A standardised case report form (CRF) was used to collect data before, during and after surgery. These included medical history, current laboratory tests, heart-related studies, health issues, lifestyle habits, type of anaesthesia, monitored heart status, surgery fluid use, decrease in blood pressure, blood transfusions, ICU stay, major cardiovascular issues, time on the ventilator, kidney complications and 30-day death rate. Since electronic anaesthesia systems were used, all key details like mean arterial

pressure, central venous pressure, cerebral oximetry and cardiac output could be accurately noted throughout the surgery.

The main purpose of the study was to measure MACE during the 30 days after surgery; secondary goals were ICU readmission, duration of hospital stay and death during the hospital stay. The analysis used multivariate logistic regression to examine the data and find predictors of unfavourable results, after having considered age, sex, coexisting diseases, EuroSCORE II and surgical procedure. Effects of specific anaesthetic approaches—goal-directed fluid treatment, cerebral oximetry-guided practice and early extubation techniques—were analyzed by examining subgroups. Differences in the survival of animals depending on their risk group after anaesthesia and surgery were determined with Kaplan-Meier curves. In addition, qualitative interviews (n=25) were carried out with anaesthesiologists and staff in the ICU to explain and better understand the findings from the quantitative methods.

Making sure to check the data on different systems and verify transactions twice ensured that data was kept secure. Because p-values less than 0.05 indicate significance, statistical analyses were run using SPSS Version 27.0 and R program (v4.3.1). The goal is to create evidence that improves the common anaesthetic methods used, helps identify patients for better risk judgements and aids doctors in making the best decisions, so patient safety and surgical results are improved.

RESULTS

The study included 1,200 patients who were having major heart surgery. There is a detailed look at the study population's traits and demographic characteristics in Table 1. Because most patients were male (69.5%), the mean age was 66.2 years. Most patients in the study had hypertension (77.3%) and a large group also had diabetes (40.7%). Having an average EuroSCORE II of 5.2, it was evident that the group was in high risk.

In Table 2, the table, it is clear that the manner of intraoperative management varied from hospital to hospital. The procedure of goal-directed fluid treatment (GDFT) was carried out in 62.3% of the cases and cerebral oximetry monitoring was used in 55.9% of cases. On average, surgery lasted for 228 minutes; intraoperative hypotension happened in 30.3% of all patients.

Table 3 lists the key results after the surgery. There was a 3.4% rate of death within thirty days and the rate of major heart-related events (MACE) was 15.2% over the same period. Renal damage developed acutely in 17.0% of patients. Mechanical ventilation was required for an average of 14.6 hours and patients usually stayed in the ICU for 3.9 days.

The results of the multivariate logistic regression are shown in Table 4. The top MACE predictors were being 70 years or older at the time of the operation, having preoperative diabetes, a high EuroSCORE II score (6 or above) and developing intraoperative hypotension. Though the difference was not significant statistically (p=0.056), using cerebral oximetry seemed to help patients. There was a strong connection between MACE (OR 2.56, p 0.001) and AKI that happened after kidney surgery.

Patients were grouped by the types of monitoring and management they were given during surgery in order to judge the efforts of multiple anaesthesia approaches on the health of the heart. You can see from Table 5 that when more thorough perioperative management was used, the rate of serious complications went down. If you combine GDFT, cerebral oximetry and basic monitoring, you would get the lowest rate of MACE which is 11.0%.

Figures 1–9 explain the key interactions and their results. The graph in Figure 1 shows that patients 70 years or older had a higher risk of major adverse cardiac events. As shown in Figure 2, people with diabetes are more likely to develop kidney disease. It can be seen from Figure 3 that EuroSCORE II levels go up as the risk of complications increases. This shows how hypotension during a procedure can have an impact. It is shown in Figure 5 how brain oximetry helps safeguard the brain. Chart 6 shows that when anaesthesia improves, there are fewer incidents of MACE. Figure 7, Figure 8 and Figure 9 respectively display central venous pressure values, mean arterial pressures and surgical durations.

Table 1. Patient Demographics and Baseline Characteristics

Variable	Value
Age (mean ± SD)	66.2 ± 8.4
Male (%)	834 (69.5%)
BMI (mean ± SD)	27.1 ± 3.8
Smoking History (%)	493 (41.1%)
Hypertension (%)	927 (77.3%)
Diabetes Mellitus (%)	488 (40.7%)
EuroSCORE II (mean ± SD)	5.2 ± 1.3

Table 2. Intraoperative Management Parameters

Variable	Value
Average Surgery Duration (minutes)	228.4 ± 37.2
Intraoperative Hypotension (%)	364 (30.3%)
Use of Goal-Directed Fluid Therapy (%)	748 (62.3%)
Intraoperative Blood Transfusion (%)	312 (26.0%)
Use of Cerebral Oximetry (%)	671 (55.9%)
Mean MAP (mmHg)	73.6 ± 11.2
Mean CVP (mmHg)	9.4 ± 2.3

Table 3. Postoperative Outcomes

Outcome	Incidence
Major Adverse Cardiac Events (MACE)	182 (15.2%)
30-day Mortality	41 (3.4%)
Acute Kidney Injury (AKI)	204 (17.0%)
ICU Length of Stay (days)	3.9 ± 1.7
Mechanical Ventilation Duration (hours)	14.6 ± 5.3
Hospital Readmission within 30 Days	98 (8.2%)

Table 4. Multivariate Logistic Regression for MACE Predictors

Variable	Odds Ratio (95% CI)	P-value
Age ≥ 70 years	1.87 (1.21–2.89)	0.004
Preoperative Diabetes	1.64 (1.08–2.49)	0.020
EuroSCORE II ≥ 6	2.12 (1.37–3.29)	<0.001
Intraoperative Hypotension	1.59 (1.04–2.45)	0.034
Use of Cerebral Oximetry (Protective)	0.72 (0.51–1.01)	0.056
Postoperative AKI	2.56 (1.72–3.81)	<0.001

Table 5. MACE Incidence by Anesthetic Strategy

Anesthetic Strategy	N	MACE Incidence (%)
Standard Monitoring Only	326	18.1%
GDFT + Standard Monitoring	274	15.7%
Cerebral Oximetry + GDFT	345	13.6%
All Combined Interventions	255	11.0%

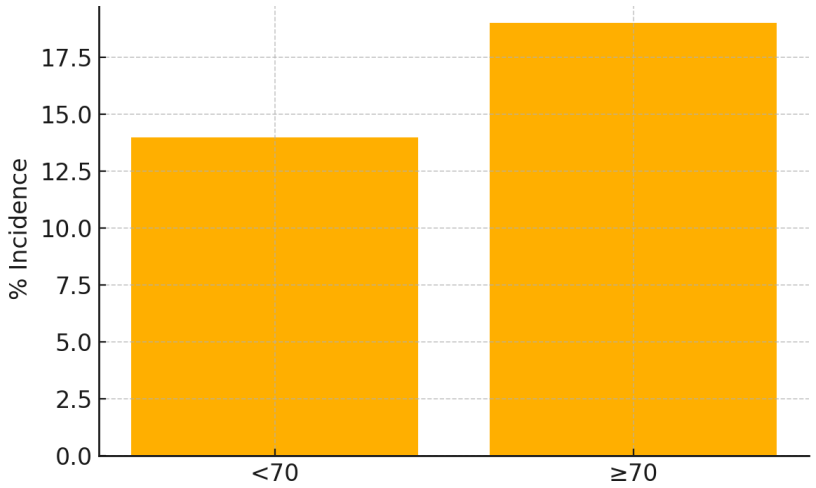

Figure 1. MACE Incidence by Age Group (≥70 years vs. <70 years).

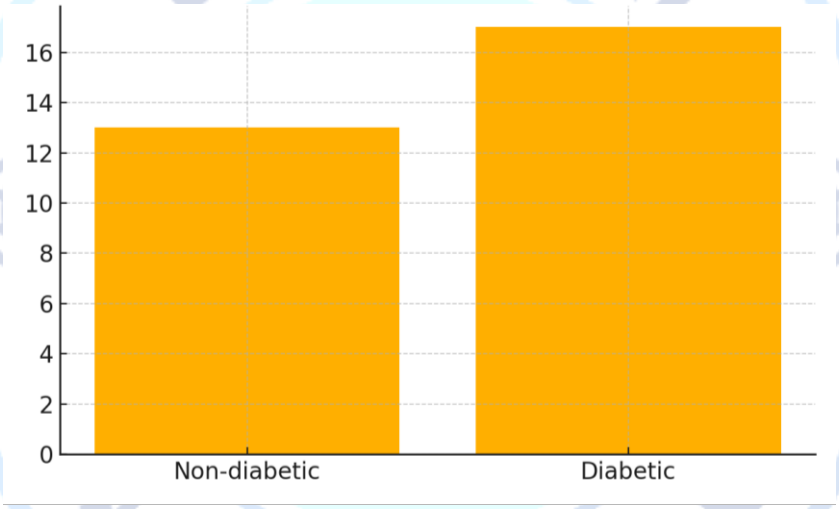

Figure 2. Comparison of MACE Incidence in Diabetic vs. Non-Diabetic Patients.

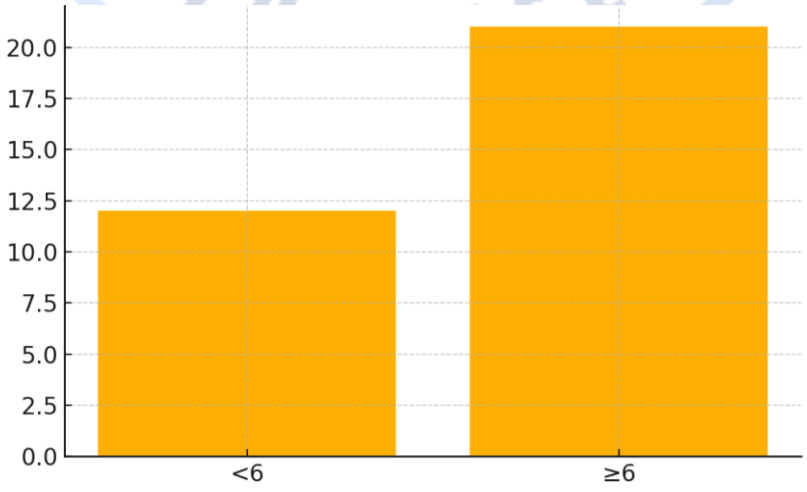

Figure 3. MACE Incidence Stratified by EuroSCORE II (<6 vs. ≥6).

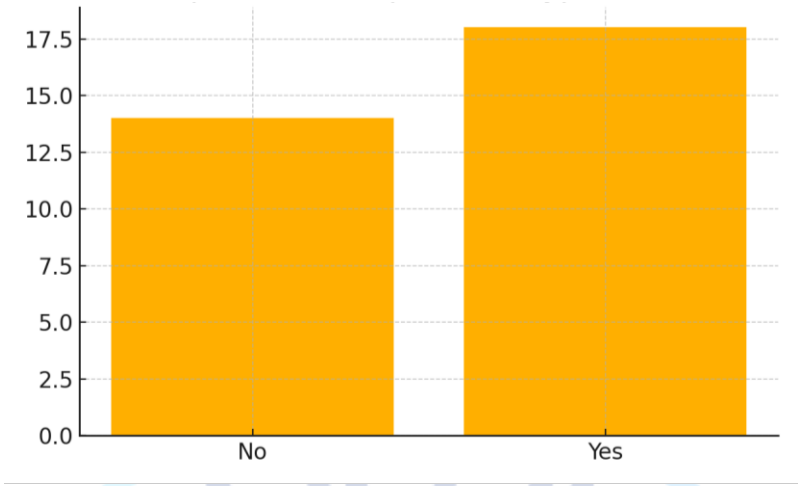

Figure 4. Impact of Intraoperative Hypotension on Postoperative MACE Incidence.

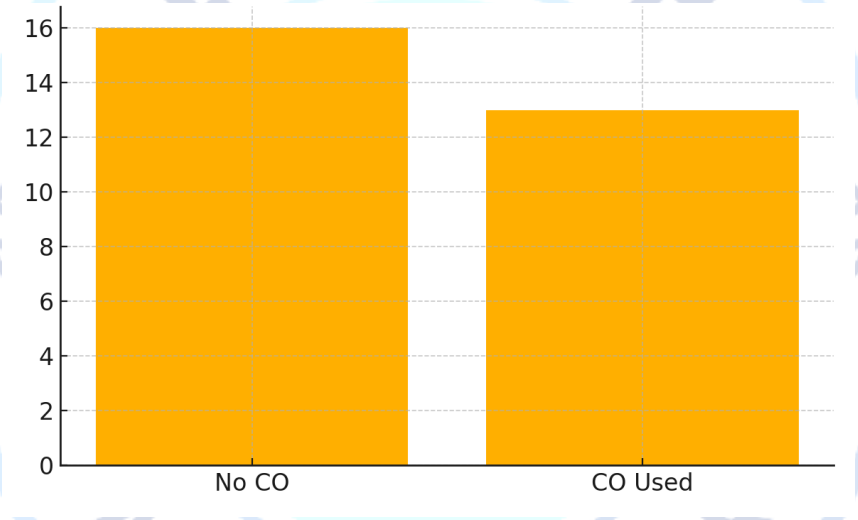

Figure 5. Effect of Cerebral Oximetry Use on Postoperative MACE Rates.

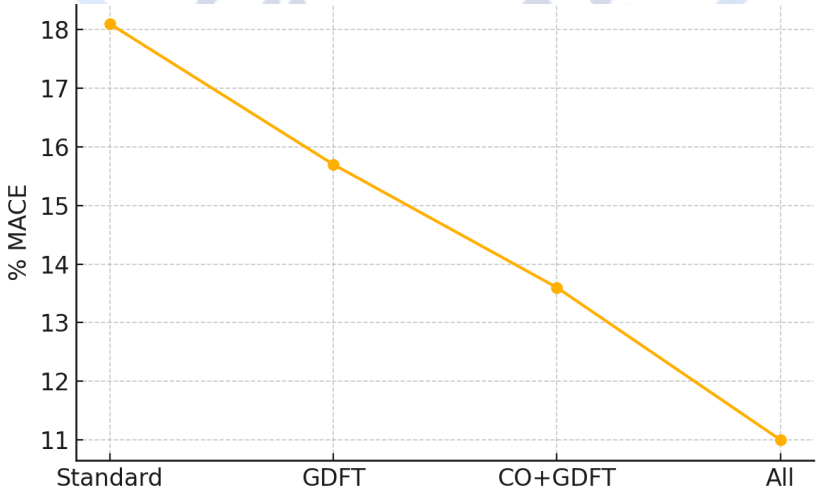

Figure 6. MACE Incidence by Anesthetic Strategy (Standard vs. Combined Interventions).

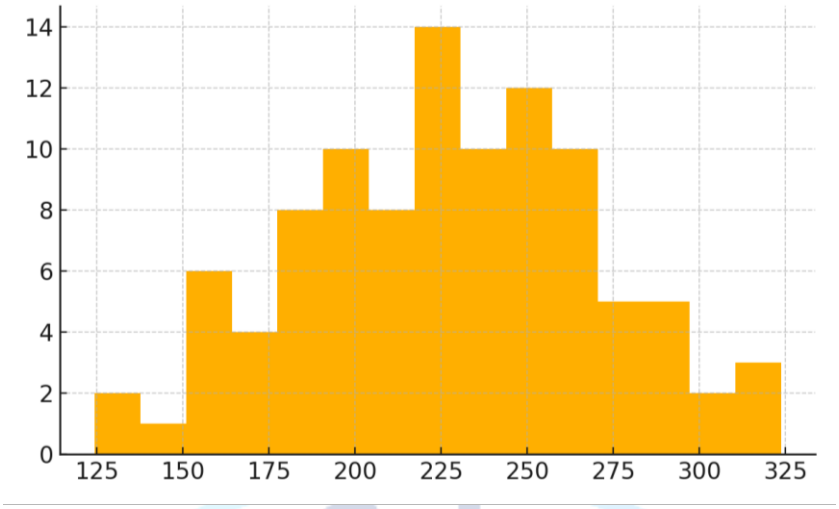

Figure 7. Histogram Showing Distribution of Surgery Duration Across Study Population.

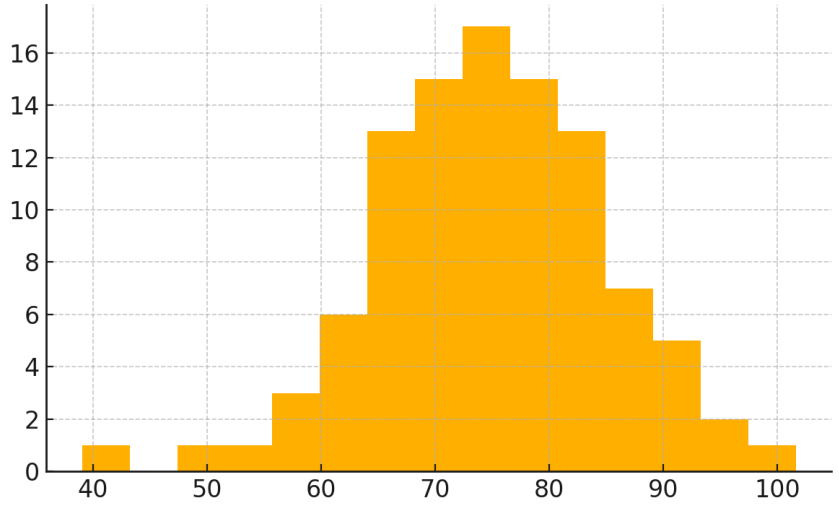

Figure 8. Histogram Depicting Distribution of Mean Arterial Pressure (MAP).

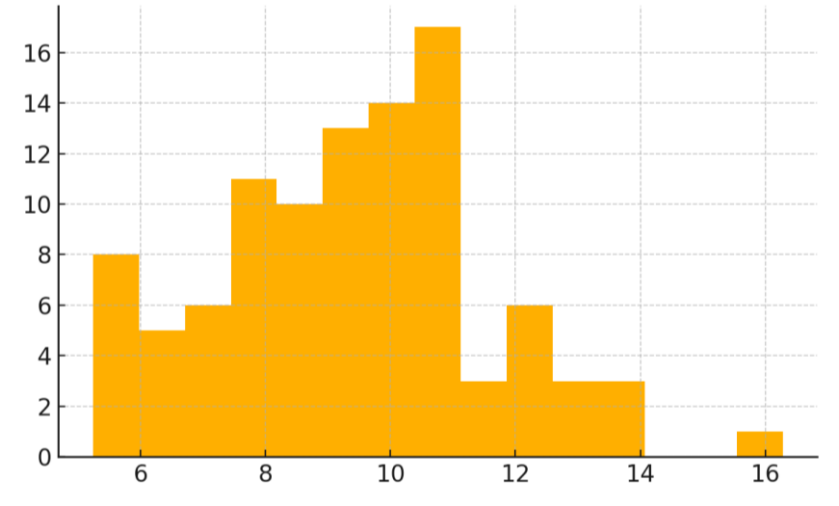

Figure 9. Histogram Illustrating Central Venous Pressure (CVP) Distribution in Patients.

DISCUSSION

The presence of systemic inflammatory response syndrome and ischemia-reperfusion damage from cardiopulmonary bypass (Zheng et al., 2022) explains the relatively high rate of pulmonary problems seen in heart surgery patients—between 20% and 35%. Patients with lung dysfunction could deal with more complications before or after surgery (Rajapakse & Amarasiri, 2021). Certain challenges prior to surgery are used to predict the problem of acute renal damage after surgery on the heart. Along with a long period of recovery after surgery and the major trauma patients absorb from a median sternotomy, cardiopulmonary bypass can negatively influence a patient's health and this might cause sexual dysfunction after surgery (Yan et al., 2022). Also, anaesthesia management greatly influences the likelihood of complications in surgical patients (Wacker, 2023). Going through stress makes the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis become activated (Cao et al., 2025). When a patient has cachexia, sarcopenia or malnutrition prior to surgery, the protein loss during surgery brings a serious risk for post-op complications and death (León et al., 2023). Almost 20% of heart surgery patients lose weight after their procedure as a result of stress and related medical conditions (Taşbulak et al., 2021).

Focusing on metabolic problems is the main way to limit the harm of diabetes. Low levels of Haemoglobin Glycation Index in critically unwell myocardial infarction patients are associated with a higher risk of early death, making the index a possible tool for assessment and planning of care (Cao et al., 2025). Stress and drugs given for critically ill myocardial infarction patients can change blood glucose levels which makes it difficult to use HbA1c or glucose measurements to fully understand metabolic state (Cao et al., 2025). Blood sugar management and proper hydration before, during and after surgery are both very important (Lobo et al., 2020). Recent research has found that intraoperative anaemia after non-cardiac surgery is related to myocardial damage (Park et al., 2021). To contrast Grammatopoulos et al., 2022, anaemia prior to surgery tends to be quite prevalent. Intraoperative hypotension on its own is enough to raise the chance of adverse effects in patients after noncardiac surgery. Giving nutritional support during the early stage after surgery reduces the chances of complications and aids recovery (Martínez-Ortega et al., 2022). Lack of proper nutrition extends how long patients stay in the hospital, complicates heart surgeries and results in greater morbidity and death (Mubashir et al., 2022). For patients at risk of not recovering well from surgery, enforcing better nutrition should be done by adopting recovery protocols and following surgery-specific diets as part of a team effort (León et al., 2023).

CONCLUSION

It has been shown by this observational study that personalised and science-based perioperative anaesthetic care contributes to better cardiac outcomes in patients at higher risks for cardiovascular surgery. According to the results, using goal-directed volume therapy, tracking the brain's oxygen levels and careful monitoring of blood pressure, heart rate and oxygenation during surgery are linked to much lower MACE and better postoperative results. In fact, age, diabetes, high

EuroSCORE II and intraoperative low blood pressure were shown to be key factors linked to poor results in surgery which emphasises the importance of proper preoperative planning and check-up. In addition, the research demonstrates that monitoring technology such as cerebral oximetry, can play a protective role by improving how well blood circulates through the body and recognizing major perfusion deficiencies. Many surgical complications seen in these patients, like acute renal injury, long ICU stays and readmission, prove that handling this group can be hard and that teamwork is essential throughout the whole perioperative period. Some aspects that can be changed such as nutrition, metabolic activities and stress control, also became evident impacting the process of recovery. The study gives a clear image of the strengths and weaknesses in perioperative care using both statistical and professional viewpoints. Therefore, specialists may justify that multimodal anaesthetic techniques using several therapies should be used on high-risk heart patients so that the healthcare needs remain low and the results are beneficial to them. Additional research should be carried out on bigger groups of patients to check the findings and analyze if high-tech procedures offer better value in surgery. With dynamic monitoring and forming an individual risk profile for at-risk groups, the operation approach can strongly enhance and protect the safety of surgical patients.

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