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Effects of Perioperative Implanting Intra-Aortic Balloon Pumps on the Prognostic Indicators of Coronary Artery Bypass Grafting Surgery Patients: A Retrospective Study

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KEYWORDS

Coronary Atherosclerotic Heart Disease,
Coronary Artery Bypass Grafting,
Intra-Aortic Balloon Pump

ABSTRACT

This study evaluated the effect of intra-aortic balloon pump (IABP) usage on clinical outcomes in patients undergoing coronary artery bypass grafting (CABG). A total of 258 patients were divided into two groups based on perioperative IABP implementation. The analysis included serum biomarkers, echocardiographic parameters, and hospitalization details before and within 72 hours post-surgery, using t-tests and $\chi 2$ tests as appropriate. The IABP group had higher rates of left main artery stenosis, greater use of bridging vessels, and higher preoperative New York Heart Association (NYHA) grades compared to the control group, while showing lower extracorporeal circulation usage ($p < 0.05$). Postoperatively, the IABP group demonstrated increased levels of myoglobin and pro-brain natriuretic peptide, longer ventilator support duration, extended intensive care unit (ICU) stays, larger left ventricular end-systolic and end-diastolic diameters, reduced left ventricular ejection fraction, and higher hospital mortality and ICU readmission rates ($p < 0.05$). These findings suggest that while IABP may improve certain preoperative parameters, its perioperative use is associated with significant changes in postoperative prognostic indicators.

1. Introduction

Recent research has highlighted coronary atherosclerotic heart disease (CAHD) as one of the most common cardiovascular diseases, contributing to high all-cause mortality rates in developed and developing countries [1]. Coronary artery bypass grafting (CABG) is considered as an effective treatment method for improving cardiac blood supply in CAHD patients, significantly extending their lifespan and enhancing their quality of life [2]. However, patients undergoing CABG often suffer from hypotension, cardiogenic shock, and postoperative low cardiac output syndrome during the perioperative period. In cases where patients face a poor prognosis, intra-aortic balloon pumps (IABP) are often inserted into their descending aorta to improve peripheral organ perfusion and coronary blood supply [3].

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Being the earliest and most widely used mechanical circulation support device, the IABP, with its ease of insertion, offers rapid availability and relative affordability [4]. Nevertheless, despite its historical application in improving cardiac blood supply in various heart diseases, IABP is no longer the primary choice in the majority of cases due to the increasing use of emergency percutaneous coronary intervention and other new mechanical circulation support technologies, challenging its status in treating cardiogenic shock caused by CAHD[5]. Consequently, opinions on its active use remain divided. Apart from its recognized benefits in reducing the use of inotropic agents and the risk of renal replacement therapy, the IABP may also potentially induce or exacerbate adverse cardiovascular and cerebrovascular events [6-9].). Numerous current studies have treated patients who underwent CABG with and without IABP during the perioperative period as a homogeneous group, without considering the unique characteristics and clinical situations of each subgroup during this period. As a result of this approach, significant differences were observed in certain postoperative indicators between the two groups. Therefore, to objectively evaluate the role and significance of IABP in patients undergoing CABG surgery, a comprehensive study encompassing hemodynamics, cardiac ultrasound, and prognostic indicators before, during the perioperative period is needed.

This study collected and analyzed data on hemodynamic, cardiac ultrasound, and prognostic indicators from 258 patients during the perioperative period of CABG to ascertain the impact of IABP usage on these indicators and the patient's prognosis.

2. Methods

2.1. Ethical Statement

The present study had been approved by Ethics Review Committee of the First Affiliated Hospital of Guangxi Medical University (approval number: 2023-E188-01). All patients are aware of the purpose and method of this study and have signed an informed consent form for sample use.

2.2. Sample Source

The current study received approval from the Ethics Review Committee of the First Affiliated Hospital of Guangxi Medical University (approval number: 2023-E188-01). Samples were acquired from the Department of Cardiothoracic Surgery, the First Affiliated Hospital of Guangxi Medical University. Inclusion criteria comprised the following: ① Visits between January 1, 2018, and December 31, 2022; ② Patients diagnosed with CAHD who underwent CABG surgery; ③ Completion of all or part of the required examinations; ④ Admission for treatment based on CAHD as the primary diagnosis, excluding any other secondary diagnoses; ⑤ Age range of patients between 18 and 80 years. Exclusion criteria were as follows: ① Simultaneous performance of CABG surgery with other cardiac surgeries; ② Patients receiving invasive treatments (including mechanical assisted circulation, other cardiac surgeries, etc.) prior to this CABG surgery. All patients were informed about the purpose and method of the study and provided signed informed consent for sample use. According to Chinese guidelines, patient evaluations included dopamine dosage, cardiac output, mean arterial pressure, left atrial pressure, central venous pressure, urine output, and peripheral circulation [10]. IABP-assisted circulation was immediately administered when patients met the indications for using IABP. Senior surgeons discussed treatment options for all cases (including whether to use extracorporeal circulation during surgery, timing of IABP usage, etc.) to ensure maximal benefit for patients during the treatment process. The study collected data encompassing age, height, weight, sex, smoking history, hypertension history, diabetes history, hyperthyroidism history, cerebrovascular accident history, myocardial infarct history, cardiac pathology, New York Heart Association (NYHA) classification, myocardial enzyme index, electrocardiogram results (including arrhythmia and ST-T segment changes), cardiac ultrasound results, CABG operation history, IABP usage, and postoperative hospitalization. CAHD patients were categorized into IABP and control groups based on whether they had an IABP during the perioperative period of CABG.

2.3. Data Analysis

The collected data were organized, and any outliers (such as samples with significant missing values or misclassified data) were excluded. Various methods were used to analyze the included indicators based on whether they represented categorical or quantitative data. Quantitative data encompassed the patient's age, height, weight, percentage of left main

Table 1 | Comparison of preoperative and intraoperative quantitative data between the IABP group and the control group

Variable	Control group			IABP group			t	p-value
	N	M	SD	N	M	SD		
Age	150	60.000	9.991	108	60.917	8.955	-0.759	0.449
BMI	145	24.845	3.482	105	24.064	3.413	1.766	0.079
BSA	145	1.699	0.172	105	1.665	0.187	1.470	0.143
Stenosis degree of left main artery	110	31.773	36.451	78	51.256	39.564	-3.485	0.001
CK before CABG	146	106.178	73.393	106	88.745	71.363	1.883	0.061
CK-MB before CABG	146	15.062	8.981	106	14.446	10.869	0.491	0.624
Number of bypass vessels	149	2.698	0.852	108	2.917	0.799	-2.107	0.036
Left ventricular end systolic diameter	76	35.829	7.915	58	38.328	11.112	-1.454	0.149
Left ventricular end diastolic diameter	76	53.026	6.827	58	54.276	8.577	-0.911	0.364
Interventricular septum thickness	76	11.368	1.495	58	11.224	1.464	0.559	0.577
EF	76	59.658	11.004	58	56.362	15.236	1.393	0.167
CO	75	5.580	1.455	58	5.610	1.645	-0.113	0.910

IABP, intra-aortic balloon pump; N, number; M, mean; SD, standard deviation; BMI, body mass index; BSA, body surface area; CK, creatine kinase; CABG, coronary artery bypass grafting; CK-MB, CK myocardial band; EF, left ventricular ejection fraction; CO, cardiac output.

artery stenosis (obtained from digital subtraction angiography and independently evaluated by two senior radiologists), myocardial enzyme indicators, number of bypass vessels, postoperative hospitalization, and cardiac ultrasound results (including left ventricular ejection fraction and cardiac output). To compare differences in these indicators between the IABP and control groups, independent sample t-tests were used. The patient's gender, smoking history, hypertension history, diabetes history, hyperthyroidism history, cerebrovascular accident history, myocardial infarction history, three-vessel lesions, extracorporeal circulation, and electrocardiogram results constituted categorical data, for which $\chi 2$ tests were employed to compare these indicators between the groups.

Additionally, to investigate the impact of IABP on patients' myocardial enzyme indicators and cardiac ultrasound results, eight metrics were used for follow-up analysis: creatine kinase (CK), CK myocardial band (CK-MB), serum troponin I, left ventricular end-diastolic diameter, left ventricular end-systolic diameter, interventricular septum thickness, ejection fraction, and cardiac output. These indicators were collected pre-operation and after 72 hours. Paired sample t-tests were conducted to examine changes in various indicators before and after surgery within each group of samples. Subsequently, a two-sample mean t-test was used to assess differences in the indicator changes between the two groups. Data analysis was performed using IBM SPSS 23.0, and a significance level of $p < 0.05$ was considered statistically significant.

3. Results

A total of 258 patients underwent CABG surgery from January 1, 2018, to December 31, 2022. Among them, 108 patients used IABP during the perioperative period, while the remaining 150 did not. Analysis of preoperative and intraoperative indicators revealed significantly higher stenosis in the left main artery ($p = 0.001$), increased use of bridging vessels during surgery ($p = 0.007$), and elevated preoperative NYHA classification ($p = 0.006$) in the IABP group compared to the control group. Conversely, the frequency of extracorporeal circulation during surgery was notably lower among IABP patients than in the control group ($p = 0.002$). The remaining preoperative and intraoperative indicators did not display differences between the two groups (Tables 1 and 2).

Table 2 | Comparison of preoperative and intraoperative categorical data between the IABP group and the control group

Term		IABP group	Control group	p-value
NYHA	I	12	23	0.026
	II	46	65	
	III	32	45	
	IV	10	2	
Sex	male	87	21	0.891
	female	119	30	
Smoking	Yes	58	81	0.917
	No	50	68	
Hypertension	Yes	61	95	0.238
	No	47	54	
Diabetic	Yes	34	46	0.917
	No	74	103	
Hyperthyroidism	Yes	1	3	0.487
	No	107	146	
Cerebrovascular accident	Yes	11	18	0.635
	No	97	131	
AMI	Yes	20	27	0.935
	No	88	122	
Triple vessel lesion	Yes	92	115	0.116
	No	15	32	
Unstable angina pectoris	Yes	54	83	0.335
	No	54	65	
Arrhythmias	Yes	14	23	0.622
	No	40	54	
Extracorporeal Circulation	Yes	25	59	0.006
	No	83	90	

IABP, intra-aortic balloon pump; NYHA, New York Heart Association; AMI, acute myocardial infarction

Examination of postoperative indicators indicated that the IABP group exhibited markedly higher myoglobin levels ($p = 0.045$), pro-brain natriuretic peptide (pro-BNP) levels ($p = 0.015$), and longer ventilation duration ($p = 0.006$) and intensive care unit (ICU) stay ($p < 0.001$) compared to the control group. Moreover, the left ventricular end-systolic diameter ($p = 0.039$), left ventricular end-diastolic diameter ($p = 0.023$), hospital mortality rate ($p = 0.027$), and frequency of ICU readmissions ($p = 0.019$) were significantly higher in the IABP group. Conversely, the postoperative left ventricular ejection fraction was notably lower in the IABP group than in the control group ($p = 0.034$). The remaining postoperative indicators did not demonstrate differences between the two groups (Tables 3 and 4).

In addition, independent sample t-tests were conducted to analyze changes in myocardial enzymes and cardiac ultrasound indicators. The improvement rate of left ventricular end-diastolic diameter was found to be significant ($p = 0.041$). However, no differences were observed between the IABP and control groups for CK, CK-MB, serum troponin I, left ventricular end-systolic diameter, interventricular septum thickness, ejection fraction, and cardiac output ($p > 0.05$) (Table 5).

4. Discussion

The current study initially compared the prevalence of preoperative cardiovascular disease between patients in the IABP group and the control group, investigating the potential impact of these differences on surgical outcomes. The results revealed that the average degree of stenosis in the left main artery and the NYHA cardiac function classification of patients in the IABP group were significantly higher compared to those in the control group. This sug-

Table 3 | Comparison of postoperative quantitative data between the IABP group and the control group

Variable	Control group			IABP group			t	p-value
	N	M	SD	N	M	SD		
CK	138	655.935	484.626	105	782.038	778.033	-1.459	0.146
CK-MB	138	26.732	24.450	105	26.152	17.454	0.206	0.837
CK-MB/CK	138	0.046	0.053	105	0.044	0.025	0.319	0.750
Serum troponin I	40	3.290	7.365	39	3.195	12.465	0.041	0.967
Hypersensitive troponin	124	244.712	850.639	97	136.231	313.263	1.194	0.234
Myoglobin	84	332.433	366.263	63	517.372	647.069	-2.037	0.045
Pro-BNP	141	1167.958	1762.393	105	1930.139	2865.560	-2.407	0.017
Duration of ventilator	149	32.106	38.891	108	62.258	93.557	-3.157	0.002
Duration of ICU	150	64.344	58.943	107	111.296	90.777	-4.691	0.000
Left ventricular end systolic diameter	77	33.779	6.882	56	37.304	9.417	-2.377	0.019
Left ventricular end diastolic diameter	77	49.117	6.356	56	52.286	8.051	-2.443	0.016
Interventricular septum thickness	77	11.416	1.321	56	11.250	1.297	0.719	0.473
EF	77	59.533	8.405	56	55.232	13.062	2.160	0.034
CO	75	5.705	1.359	55	5.986	1.622	-1.069	0.287

IABP, intra-aortic balloon pump; N, number; M, mean; SD, standard deviation; CK, creatine kinase; CK-MB, CK myocardial band; Pro-BNP, brain natriuretic peptide precursor; ICU, intensive care unit; EF, left ventricular ejection fraction; CO, cardiac output.

Table 4 | Comparison of postoperative categorical data between the IABP group and the control group

Term		IABP group	Control group	p-value
Death in hospital	Yes	8	2	0.031
	No	100	147	
ST-T segment changes on the ECG	Yes	24	50	0.207
	No	23	30	
Retracheal intubation	Yes	7	2	0.065
	No	101	145	
Re-entering the ICU	Yes	9	3	0.019
	No	99	144	

IABP, intra-aortic balloon pump; ECG, electrocardiogram; ICU, intensive care unit.

gests that patients in the IABP group had diminished exercise tolerance due to reduced cardiac blood supply. To enhance postoperative quality of life, an increased utilization of bypass vessels is recommended for CABG surgery. Thus, it can be inferred that observed patients undergoing IABP application during the perioperative period presented with a relatively suboptimal baseline status characterized by insufficient cardiac perfusion and reduced exercise endurance. According to *2021: The American Association for Thoracic Surgery Expert Consensus Document*, for heart failure and ventricular remodeling patients, IABP use is recommended [11]. Among our included patients, those in the IABP group exhibited lower preoperative cardiac blood supply compared to the control group, reflecting poorer baseline conditions. However, IABP was found to effectively improve postoperative cardiac blood supply in patients with poor baseline conditions. Conversely, our findings suggest that preoperative and intraoperative IABP use can notably reduce the need for extracorporeal circulation among patients. As such, we recommend comprehensive preoperative evaluation and early IABP application in high-risk CAHD patients. Furthermore, our analysis indicates that, compared to the control group, patients receiving IABP therapy

Table 5 | Changes in myocardial enzyme indicators and cardiac ultrasound indicators between IABP group and control group.

Variable	Paired sample t-test Paired t-test										Two sample mean t-test	
	IABP group					Control group						
	N	M	SD	t	p-value	N	M	SD	t	p-value	t	p-value
CK	103	701.107	787.081	9.04	<0.001	136	540.669	483.124	13.051	<0.001	1.943	0.053
CK-MB	100	11.834	21.125	5.685	<0.001	128	10.952	25.349	4.964	<0.001	0.28	0.78
Serum troponin I	39	2.93	12.58	1.455	0.154	39	3.181	7.516	2.643	0.012	-0.107	0.915
Left ventricular end-systolic diameter	51	-1.054	5.125	-1.538	0.13	70	-2.066	5.522	-3.262	0.002	1.038	0.302
Left ventricular end-diastolic diameter	52	-2.018	4.65	-3.248	0.002	73	-3.921	5.611	-6.092	<0.001	1.903	0.041
Interventricular septum thickness	56	0.018	1.228	0.109	0.914	76	0.026	1.222	0.188	0.852	-0.037	0.97
EF	56	-1.304	10.429	-0.935	0.354	76	-0.118	8.806	-0.117	0.907	-0.689	0.492
CO	55	0.336	2.372	0.152	0.298	73	0.129	1.831	0.601	0.55	0.557	0.578

IABP, intra-aortic balloon pump; N, number; M, mean; SD, standard deviation; CK, creatine kinase; CK-MB, CK myocardial band; EF, left ventricular ejection fraction; CO, cardiac output

during the perioperative period had a significantly lower incidence of requiring extracorporeal circulation during CABG surgery. Extracorporeal circulation involves systemic heparinization, potentially leading to severe inflammatory reactions. Additionally, there is a risk of vascular reperfusion injury after cardiac arrest, while intraoperative heart movement may increase the likelihood of ventricular fibrillation [12]. The use of IABP helps prevent cardiac arrest and reduces the need for extracorporeal circulation, thereby minimizing the risk of postoperative complications, including acute respiratory distress syndrome, kidney injury, arrhythmia, and low cardiac output syndrome [14]. This is especially crucial for improving the postoperative survival rate of patients undergoing CABG surgery [14]. Future multi-center research is necessary to determine whether IABP can reduce the use of extracorporeal circulation without worsening patient prognosis after surgery.

Although not statistically significant, we observed a potential trend indicating that CK levels in patients may be higher than those in the control group after receiving IABP treatment. Intriguingly, the changes in CK-MB between the two groups did not exhibit this pattern, suggesting that alterations in CK and CK-MB were not synchronous. As commonly known, CK is a blood marker used to assess muscle tissue damage, originating from myocardial tissue as well as other organ tissues and skeletal muscles. The primary insertion of IABP through femoral artery puncture could potentially reduce blood supply to immobilized lower limbs. Diminished circulation in these muscles can release CK into the bloodstream, causing asynchronous CK and CK-MB levels [15].

Elevated postoperative CK levels may signify a systemic stress response and tissue damage during surgery, while CK-MB is more specific to myocardial tissue damage. Therefore, substantial trauma to the body's tissues during surgery may keep CK-MB levels relatively constant, with CK levels showing a significant increase [16,17].

Moreover, myoglobin serves as a frequently used indicator for myocardial damage, with increased concentrations signifying significant heart muscle injury [18]. However, there is a lack of research on the impact of IABP on postoperative myoglobin levels in patients. Upon analysis, we found that patients' postoperative myoglobin levels were notably higher than those in the control group following IABP application during the perioperative period. This suggests that inevitable cardiac injury during surgery is the primary factor contributing to elevated serum myoglobin. Yet, despite experiencing similar surgical trauma, cardiac injury alone does not seem to fully explain the significant differences in myoglobin levels between the two groups. Upon further investigation, we discovered that the average CK-MB/CK levels were below 5% for both patient groups. According to the 2014 AHA/ACC guideline for managing patients with non-ST-elevation acute coronary syndromes, when CK-MB/CK levels are less than 5%, the increased serum markers of myocardial injury are attributed to skeletal muscle lesions [19]. Consequently, we propose a daring conjecture: the IABP implantation through the femoral artery not only enhances myocardial perfusion but also reduces blood flow to the lower extremities. Ischemic damaged striated muscles release significant amounts of myoglobin and CK, leading to differences in myoglobin levels and CK growth rates between the two groups. Hence, to assess the extent of perioperative myocardial infarction and bridging vascular patency, clinical practitioners should integrate electrocardiograms and other auxiliary examinations with the analysis of myocardial injury indicators. In cases involving IABP use, close attention should focus on blood supply, skin temperature, and limb color to mitigate the risk of lower limb ischemic necrosis.

Our analysis reveals that postoperative pro-BNP levels among patients in the IABP group are significantly higher than those observed in the control group. Pro-BNP serves as a readily accessible blood marker for timely detection of heart failure [20]. However, in this study, a higher level of pro-BNP does not necessarily indicate that patients in the IABP group have a greater risk of heart failure. While the implantation of IABP led to a significant improvement in the patient's cardiac blood supply, it also increased the burden on the heart. In cases where CABG surgery had already caused substantial damage to the myocardium, the additional strain on the heart due to the high load could exacerbate the heart damage, leading to the release of large amounts of pro BNP [21]. Additionally, a substantial amount of myoglobin released by damaged striated muscles can potentially obstruct renal tubules, resulting in reduced renal function and an increase in pro-BNP [22]. Another crucial factor that should not be overlooked is the potential impact of postoperative diuretics or angiotensin-converting enzyme inhibitors on the measurement of pro-BNP levels [23]. Unfortunately, due to the challenge in obtaining medication usage data, this study cannot currently rule out the impact of medication to further explore the mechanisms of IABP's impact on pro-BNP. As a result, caution must be exercised in determining whether patients implanted with IABP are at a higher risk of heart failure based solely on the level of pro-BNP.

Recent research suggests that the prognosis for patients who have undergone cardiac surgery and received IABP treatment is unfavorable. Thiele et al. conducted a randomized controlled study revealing higher mortality rates among patients in the IABP group [24]. Similarly, Ali et al.'s study demonstrated that patients using IABP before cardiac surgery had elevated mortality rates, increased red blood cell input, and longer periods of invasive ventilation compared to the control group [25]. Sayed et al.'s single-center study also reported extended postoperative ICU time, invasive ventilation duration, and higher mortality rates in the IABP group compared to the control group, possibly related to the preoperative ejection fraction of patients [26]. In our study, the IABP-receiving group had significantly prolonged ventilator usage, extended ICU stay, and higher hospital mortality rates, consistent with previous research findings. These results can be attributed to the fact that patients requiring IABP support often present more severe coronary artery disease and poorer health conditions before surgery, leading to a heightened perioperative mortality risk. Our findings indicate that among high-risk patients implanted with IABP during the perioperative period, although they experienced longer mechanical ventilation and extended ICU stays, only 8 out of 110 patients died in the hospital after receiving active treatment. This suggests that IABP was effective in reducing the risk of mortality for most patients during the intraoperative and postoperative periods. Nonetheless, our results solely describe the mortality rate of CABG patients using IABP, necessitating further randomized controlled studies to determine whether IABP can improve the prognosis of such patients. It's important to note that despite IABP support, some patients with severe lesions may still succumb to death. Therefore, it is crucial to utilize various scoring scales such as European system for cardiac operative risk evaluation (EuroSCORE II) and European Society of Thoracic Surgeons Risk Scores (ESTS scores) for early and accurate preoperative evaluations, closely monitor patients during the perioperative period, and make decisive decisions regarding the need for stronger mechanical circulatory devices such as extracorporeal membrane oxygenation [27,28]. Physicians should carefully assess the patient's condition, determine whether to use IABP early or opt for stronger mechanical circulatory support, and provide suitable postoperative monitoring and rehabilitation plans to reduce complications and risks, ultimately ensuring that patients receive optimal treatment outcomes [29].

Our study indicates that patients treated with IABP had a larger post-surgery left ventricular diameter compared to the control group. However, no significant difference in left ventricular diameter was observed between the two groups before surgery. These findings suggest that despite the use of IABP during the perioperative period, left ventricular compliance decreases, and the heart remains in a decompensated state due to factors such as low preoperative cardiac blood supply, poor energy metabolism, and less effective myocardial work in high-risk CAHD patients. These observations are consistent with previous studies. Libera et al. found that IABP utilization can decrease the efferent activity of the sympathetic nerve, leading to a slower heart rate and lower myocardial contractility. Additionally, IABP prolongs the diastole period of the heart, consequently enhancing the degree of heart filling [30]. In high-risk patients with CAHD who underwent IABP therapy during the perioperative period, ongoing left ventricular remodeling increases the risk of heart failure. Therefore, it is recommended to implement more rigorous heart failure treatment plans to improve ventricular remodeling and enhance the patients' quality of life.

In summary, the perioperative implementation of IABP during CABG surgery may moderately improve prognostic outcomes among patients with CAHD. Nevertheless, in cases of severe lesions, caution is crucial when selecting the IABP treatment process. It's important to note that this study is limited as a single-center study, potentially impacting the reliability and generalizability of the results. Moreover, since most patients only receive postoperative follow-up examinations at local hospitals, long-term postoperative information for both patient groups was unattainable. Clinical use of an IABP as a cardiovascular support measure remains effective but requires evaluation and decision-making under medical professional guidance. Furthermore, it's worth noting that certain confounding factors may have influenced the study results, necessitating systematic randomized controlled studies to eliminate these confounding factors.

The present study analyzed 258 samples that underwent CABG surgery, revealing that the use of IABP can enhance heart blood supply, improve energy metabolism, and contribute to ventricular remodeling to some extent. However, for those with severe cardiovascular disease, early implementation of IABP or selection of more effective extracorporeal circulation regimens may offer greater benefits.

Declarations

Abbreviations

IABP: Intra-aortic balloon pump

CABG: Coronary artery bypass grafting

NYHA: New York Heart Association

ICU: Intensive care unit

CAHD: Coronary atherosclerotic heart disease

CK: Creatine kinase

CK-MB: Creatine kinase myocardial band

Ethics approval and consent to participate

The present study had been approved by Ethics Review Committee of the First Affiliated Hospital of Guangxi Medical University (approval number: 2023-E188-01). All patients are aware of the purpose and method of this study and have signed an informed consent form for sample use.

Consent to Publish declaration

Written informed consent was obtained from the participant for publication of identifying information/images in an online open-access publication.

Availability of Data and Materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Clinical trial number

Not applicable.

Competing interests

The authors declare no competing interests.

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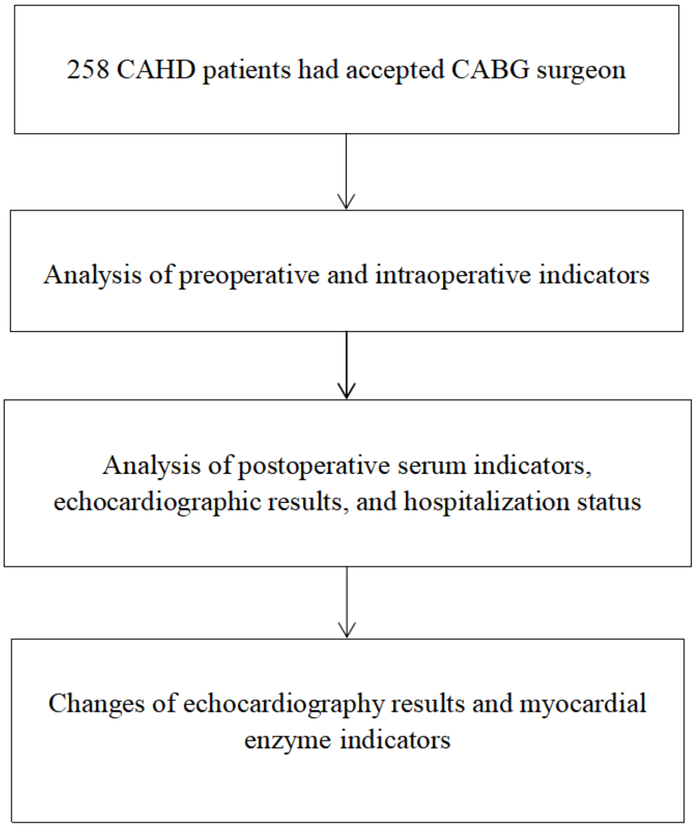

Figure 1 I The flow charts of this study

CAHD, coronary atherosclerotic heart disease;CABG, coronary artery bypass grafting