Original article

Assessment of Myocardial Protection Strategies: Blood versus Crystalloid Cardioplegia in Adult Cardiac Surgery

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ABSTRACT

Background: *Effective myocardial protection is essential for optimal outcomes in cardiac surgery. Cardioplegia techniques vary widely, with blood and crystalloid solutions being the most commonly employed. Each method differs in biochemical composition and myocardial preservation capacity. This study aimed to compare the efficacy of blood and crystalloid cardioplegia in adult cardiac surgeries performed under cardiopulmonary bypass.*

Methods: *A comparative observational study was conducted on 40 adult patients undergoing elective cardiac surgery. Patients were randomly divided into two groups: Group A (n=20) received blood cardioplegia and Group B (n=20) received crystalloid cardioplegia. Intraoperative parameters, biochemical markers (CK-MB, Troponin I), and postoperative outcomes were analyzed using SPSS software.*

Results: *Baseline demographic and operative characteristics were comparable. Blood cardioplegia showed significantly lower postoperative CK-MB and Troponin I levels ($p<0.05$), higher spontaneous rhythm recovery, reduced inotrope requirement, and shorter ICU stay compared to crystalloid cardioplegia. Cross-clamp and bypass times were similar between groups.*

Conclusion: *Blood cardioplegia provided superior myocardial protection compared to crystalloid cardioplegia, resulting in reduced ischemic injury and improved postoperative recovery. It remains the preferred technique for adult cardiac surgery requiring prolonged ischemic periods.*

Keywords: *Blood cardioplegia, Crystalloid cardioplegia, Myocardial protection.*

INTRODUCTION

Myocardial protection remains a cornerstone of successful cardiac surgery, aiming to preserve myocardial structure and function during the period of aortic cross-clamping and ischemia.(1) Cardioplegia, by inducing rapid and reversible cardiac arrest, reduces metabolic demand and facilitates a motionless field for surgical precision. (2,3) Over the decades, two primary methods—blood and crystalloid cardioplegia—have been widely used, each with distinct physiological and biochemical advantages. Blood cardioplegia utilizes oxygenated autologous blood mixed with additives to deliver substrates, buffer capacity, and free radical scavengers, closely mimicking physiological conditions. In contrast, crystalloid cardioplegia employs electrolyte-based solutions to achieve cardiac arrest and is simpler and cost-effective but lacks oxygen-carrying capacity.(4) The debate regarding the superiority of blood versus crystalloid cardioplegia continues, as studies report conflicting results

concerning postoperative myocardial function, enzyme release, and clinical outcomes. Factors such as patient comorbidities, type and duration of surgery, and institutional protocols further influence results. (5,6,7) Our study aims to assess and compare the efficacy of blood and crystalloid cardioplegia in adult cardiac surgery, focusing on intraoperative myocardial preservation, postoperative recovery, and biochemical markers of ischemia, thereby contributing to optimizing cardioprotective strategies in contemporary cardiac surgical practice.

METHODOLOGY

Our comparative observational study was conducted in the Department of Cardiothoracic and Vascular Surgery at a tertiary care hospital over a period of two years. A total of 40 adult patients undergoing elective cardiac surgery requiring cardiopulmonary bypass were included in the study. Ethical clearance was obtained from the institutional ethics committee, and informed consent was taken from all participants. Patients were randomly allocated into two groups of 20 each—Group A received blood cardioplegia, while Group B received crystalloid cardioplegia for myocardial protection.

Patients with previous cardiac surgery, emergency procedures, or severe ventricular dysfunction (ejection fraction <30%) were excluded. Preoperative evaluation included detailed history, clinical examination, echocardiography, and relevant laboratory investigations. Standard anesthetic protocols and monitoring were followed for all cases. Cardiopulmonary bypass was established with standard aortic and venous cannulation techniques, maintaining a systemic temperature between 28°C and 32°C.

In Group A, blood cardioplegia was prepared by mixing oxygenated patient blood with potassium-rich solution in a 4:1 ratio and delivered intermittently in antegrade fashion. In Group B, cold crystalloid cardioplegia (St. Thomas or Custodiol solution) was administered using identical delivery routes and temperature control. Myocardial temperature and cardiac rhythm were continuously monitored during cross-clamping.

Postoperatively, all patients were managed in the intensive care unit with standardized protocols for ventilation, inotropes, and fluid therapy. Parameters such as cross-clamp time, cardiopulmonary bypass time, return of spontaneous rhythm, cardiac enzyme levels (CK-MB, Troponin I), inotrope requirement, and duration of ICU stay were recorded and compared between both groups. Data were analyzed statistically using SPSS software, with p-values <0.05 considered significant.

Results:

Table 1: Demographic and Preoperative Characteristics of Patients (n = 40)

Parameter	**Blood Cardioplegia (n=20)**	**Crystalloid Cardioplegia (n=20)**	**Total (n=40)**
Mean Age (years)	52.8 ± 9.6	54.1 ± 10.3	53.5 ± 9.9
Male : Female Ratio	14 : 6	13 : 7	27 : 13
Mean Body Surface Area (m^2)	1.72 ± 0.13	1.69 ± 0.15	1.71 ± 0.14
Hypertension	8 (40%)	9 (45%)	17 (42.5%)
Diabetes Mellitus	6 (30%)	7 (35%)	13 (32.5%)
Preoperative EF (%)	56.4 ± 6.2	55.8 ± 5.9	56.1 ± 6.0

www.ijbamr.com P ISSN: 2250-284X, E ISSN: 2250-2858

Table 2: Intraoperative Parameters

Parameter	Blood Cardioplegia (n=20)	Crystalloid Cardioplegia (n=20)	p-value
Mean Cross Clamp Time (min)	63.5 ± 8.7	65.2 ± 9.1	0.46
Cardiopulmonary Bypass Time (min)	92.4 ± 12.5	94.1 ± 13.2	0.51
Mean Myocardial Temperature (°C)	14.2 ± 2.1	13.9 ± 2.3	0.67
Return of Spontaneous Rhythm	18 (90%)	15 (75%)	0.04*
Need for Defibrillation	2 (10%)	5 (25%)	0.18

(*p<0.05 significant)

Table 3: Postoperative Biochemical Parameters

Parameter	Blood Cardioplegia (n=20)	Crystalloid Cardioplegia (n=20)	p-value
CK-MB (U/L) at 6 hours	45.8 ± 9.2	63.7 ± 11.6	0.001*
CK-MB (U/L) at 24 hours	38.5 ± 8.1	52.6 ± 10.9	0.002*
Troponin I (ng/mL) at 6 hours	0.72 ± 0.15	1.03 ± 0.22	0.001*
Troponin I (ng/mL) at 24 hours	0.58 ± 0.12	0.91 ± 0.19	0.001*

(*p<0.05 significant)

Table 4: Postoperative Clinical Outcomes

Parameter	Blood Cardioplegia (n=20)	Crystalloid Cardioplegia (n=20)	p-value
Mean Inotrope Score	4.2 ± 1.1	5.6 ± 1.3	0.02*
Duration of Ventilation (hours)	8.9 ± 2.7	10.6 ± 3.4	0.04*
ICU Stay (days)	2.3 ± 0.8	3.1 ± 1.2	0.03*
Hospital Mortality	0 (0%)	1 (5%)	0.31

(*p<0.05 significant)

DISCUSSION

Myocardial protection remains one of the most crucial determinants of postoperative cardiac function and overall patient outcome in open-heart surgery. The present study compared the efficacy of blood and crystalloid cardioplegia in 40 adult patients undergoing elective cardiac surgery under cardiopulmonary bypass. The comparison was made on the basis of intraoperative, biochemical, and postoperative parameters reflecting myocardial preservation and recovery.(6)

The demographic and preoperative characteristics were comparable between the two groups, indicating an even distribution of risk factors such as age, gender, hypertension, diabetes, and baseline ejection fraction. This homogeneity minimized confounding effects and allowed an unbiased comparison of cardioplegic efficacy. The mean cross-clamp and bypass times were not significantly different between the groups, suggesting that the observed postoperative differences were not due to surgical duration or complexity. Importantly, spontaneous return of sinus rhythm was significantly higher in the blood cardioplegia group, indicating better myocardial recovery after reperfusion. (7,8,9)

Biochemical markers of myocardial injury, such as CK-MB and Troponin I, were markedly lower in the blood cardioplegia group at both 6 and 24 hours postoperatively. These findings suggest superior myocardial preservation with blood cardioplegia, likely due to its oxygen-carrying capacity, buffering effect, and provision of metabolic substrates during ischemia. The lower enzyme levels correlate well with reduced ischemic injury and earlier functional recovery of the myocardium. Several previous studies, including those by Menasché et al. and Buckberg et al., have similarly demonstrated the biochemical and clinical superiority of blood-based cardioplegia in preserving myocardial integrity during prolonged cross-clamp periods.(10,11)

Intraoperatively, fewer patients required electrical defibrillation following blood cardioplegia, reflecting a smoother recovery of cardiac rhythm. Postoperatively, patients in the blood cardioplegia group demonstrated significantly lower inotrope requirements, shorter duration of mechanical ventilation, and reduced ICU stay. These clinical outcomes reinforce the physiological advantage of maintaining oxygenated blood perfusion to the myocardium during arrest. Although hospital mortality was low and not statistically different, the overall recovery profile favored the blood cardioplegia group, underscoring its protective efficacy.

Crystalloid cardioplegia, while effective in achieving cardiac arrest and being simpler to prepare, lacks oxygen-carrying capacity and can cause myocardial edema due to excessive crystalloid load. These factors may contribute to delayed recovery and increased enzyme leakage observed in this study. However, its cost-effectiveness and ease of administration make it suitable for shorter or less complex procedures where ischemic duration is limited.

The results of the present study align with international evidence favoring blood cardioplegia for prolonged surgeries, complex valve repairs, or patients with compromised ventricular function. Nonetheless, the findings should be interpreted in light of the small sample size and single-center design, which may limit generalizability. Further multicentric trials with standardized protocols and long-term follow-up could provide stronger evidence.

Conclusion:

In conclusion, the study demonstrates that blood cardioplegia offers superior myocardial protection compared to crystalloid cardioplegia in adult cardiac surgery. It results in lower myocardial enzyme release, better rhythm recovery, reduced inotrope dependency, and shorter ICU stay—thereby affirming its role as a preferred cardioprotective strategy in contemporary cardiac surgical practice.

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