A COMPARISON OF CRYSTALLOID AND BLOOD INDUCTION CARDIOPLEGIA IN LOW - RISK PATIENTS UNDERGOING CORONARY ARTERY BYPASS GRAFTING

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ABSTRACT

Objective: Improvements in the application of cardio protective methods in open-heart surgery have been associated with decreased operative mortality, lowered incidence of perioperative myocardial infarction and improved cardiac functions.

Material and Methods: One hundred consecutive patients undergoing their first elective coronary artery bypass grafting were prospectively randomized to receive either cold crystalloid cardioplegia (Group A, n: 50) or cold blood cardioplegia (Group B, n: 50). Patients in group A received initial cold crystalloid cardioplegia, patients in group B received initial cold blood cardioplegia that was a mixture (4:1) of the oxygenated blood of the patient and hyperkalemic crystalloid concentration. In both groups, following the inital cardioplegia, cold blood cardioplegia every 20 minutes and finally warm blood cardioplegia (37°C) was performed before the removal of the aortic cross clamp.

Results: In both groups, the baseline patient characteristics did not differ. During the cardiopulmonary bypass, blood transfusion was applied to the bypass circuit 11 patients in group A and 2 patients in group B because of low hemoglobin level ($p<0.001$). Following removal of the aortic cross clamp, the incidence of spontaneous defibrillation in group A was lower than in group B ($p<0.001$). Creatin kinase isoenzyme MB level at the 12th hour postoperatively was significantly higher in group A than in group B ($p<0.01$). Perioperative MI was in three patients in group A and 1 patient in group B, (p: not significant). The incidence of atrial fibrillation, ventricular extrasystole and low cardiac out-put was similar in both groups.

Conclusion: Cold blood induction performs better myocardial protection and faster myocardial recovery than the cold crystalloid induction cardioplegia in low-risk patients undergoing coronary artery bypass grafting.

Key Words: Cardioplegia, Antegrade, Protection, CABG

INTRODUCTION

Improvements in the application of cardio-protective methods in open-heart surgery, have been associated with decreased operative mortality, lowered incidence of perioperative myocardial infarction and improved cardiac functions. Today different cardio-protective strategies are available for myocardial protection.

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The most used are crystalloid or blood cardioplegia, antegrade or retrograde, or a combination of the two.

The distribution of the cardioplegic solution is important in patients with coronary artery disease (1, 2). In previous studies with crystalloid cardioplegia, a prolonged cross-clamp technique provided more homogenous çooling, decreased cardiac creatine kinase (CK) isoenzyme release, and allowed for earlier metabolic recovery than the traditional cardioplegic technique (3, 4).

In many studiest the useful effect of cold blood cardioplegia over crystalloid cardioplegia was noted in patients with diminished left ventricular function undergoing coronary artery bypass grafting (5-8). But it does not exist in patients with good left ventricular function (9-13).

The aim of this prospective, randomized study was to compare the use of crystalloid and cold blood induction followed by cold blood cardioplegia and terminated by warm reperfusion in low-risk patients undergoing elective coronary artery bypass grafting (CABG).

MATERIAL AND METHODS

Patient selection: One hundred consecutive patients undergoing first elective CABG were prospectively randomized to receive either cold crystalloid cardioplegia (Group A, n: 50) or cold blood cardioplegia (Group B, n: 50). Patients with unstable angina pectoris, emergency procedures, re-interventions, concomitant procedures such as valve replacement were not included in the study. Preoperative characteristics including age, gender, risk factors, number of vessel disease and parameters of left ventricular function were summerized in Table I. Ventricular performance score (VPS) as seen in Table I is a scoring system of the left ventricular function due do wall motions of seven segments at the left and right oblique ventriculography (normal: 1, hypokinesia: 2, akinesia: 3, diskinesia: 4, aneurysm: 5).

Surgical procedures: Cardiopulmonary bypass (CPB) was performed with membrane oxygenator and non-pulsatile roller pump. Moderate hypothermia (rectal temperature 30-32°C) was used and 2.4-lt/min/m2 flow rates were maintained during bypass. Myocardial protection was supported with topical ice slush as an adjunct to cardioplegia. In all operations, conduit for bypass were included, saphaneous veins or left internal mammary artery (LIMA) or a combination of the two. During the CPB if the hemoglobin level was below 7 gr/dl, blood transfusion was applied to the bypass circuit.

Cardioplegia procedures: Patients in group A received inital antegrade cold crystalloid cardioplegia (St Thomas II solution, +4°C, 15 ml/kg, potassium level: 16mEq/lt). Patients in group B received inital antegrade cold blood cardioplegia (+4°C, 15 ml/kg, potassium level: 20 mEq/lt) that was a mixture (4:1) of the oxygenated blood of the patient and hyperkalemic crystalloid concentration. In both groups, following the initial cardioplegia, cold blood cardioplegia (+4°C, 500 ml, potassium level: 10 mEq/lt) every 20 minutes and finally warm blood cardioplegia (37°C) was performed before the removal of the aortic cross clamp (ACC). In both groups, the effectiveness of cardioplegia was based on the state of the electromechanical activity of the heart. If electromechanical activity of the heart had been observed before warm blood cardioplegia administration, an additional dose of cold blood was given.

Cardiac enzyme release and myocardial infarction: Before the operation and at 4 hours and 12 hours after the operation creatin kinase - isoenzyme MB (CK-MB) was measured in all patients (CK-MB Stat Immunoassay, Elecsys). Diagnostic criteria for peroperative myocardial infarction were new Q waves of 0.04 mm or more, or a reduction in R waves of more than 25% in at least 2 leads in electrocardiography (ECG), or CK-MB level more than 50 IU/L.

In the peroperative or early postoperative period, patients were considered to have low cardiac output (LCO) whenever the systolic blood pressure was lower than 90 mmHg and mixed venous O2 saturation lower than 60%, despite adequate preload and optimal afterload. Also during the hospital stay, patients who showed atrial fibrillation (AF) and ventricular extra systole needing treatment (more than 6 extra systole per minute) were recorded in both groups.

Statistical Analysis

The data in both groups are expressed as the mean ± the standard error of the mean. A p value of less than 0.05 was considered significant. Statistical analysis among groups was made using an analysis of variance.

RESULTS

Baseline patient characteristics: Mean age was 56.7±9.1 years in group A and 56.7±8.7 years in group B (Table I). Gender and incidence of hypertension, diabetes mellitus, and smoking were similar in both groups. Furthermore there were no statistically significant differences in the parameters of the left ventricular function and in the extent of coronary artery disease in both groups.

Table I: Preoperative characteristics

	Group A (n: 50)	Group B (n: 50)	P
Age (years)	57.6±9.1	56.7±8.7	NS
Gender (male)	40/50	44/50	NS
Hypertension %	34	32	NS
Diabetes %	32	34	NS
Smoking %	48	50	NS
Vessel disease (n)	2.3±0.7	2.2±0.8	NS
EF %	60.14±11.9	59.9±9.3	NS
VPS	8.4±1.8	8.4±1.3	NS
LVEDP (mmHg)	12.1±5.1	13.4±5.7	NS

EF: Ejection fraction, VPS: Ventricular performance score, LVEDP: Left ventricular enddiastolic pressure.

Operative variables: Number of grafts per case, ACC time, CPB time was similar in both groups. Following removal of the ACC, the incidence of spontaneous activation in group B was higher than in group A (76% in group B, 30% in group A, p<0.001). In addition, during the CPB, 11 patients in group A, 2 patients in group B needed blood transfusion (p<0.01). Myocardial temperature was measured with a thermistor needle in four segments of the heart following the initial dose of cardioplegia and there was no significant difference between the myocardial temperatures of the two groups (Table II).

Cardiac enzyme release and myocardial infarction: As seen in figure 1; postoperative levels of CK-MB were above normal or preoperative levels, but no significant differences between the crystalloid and blood groups were found for the preoperative (2,2±0,9 IU/L in Group A and 2,3±1,0 IU/L in Group B) and at first postoperative (22,4±8,6 IU/L in Group A and 20,2±7,9 IU/L in Group B) measurement values. Creatin kinase-MB level at the postoperatively 12th hour was significantly higher in group A than in group B (17.3±4.6 IU/L in group A, 12.0±3.5 IU/L in group B, p<0.01). In three patients in group A and 1 patient in group B, perioperative MI was detected (p: not significant, Table III).

Table II: Operative variables

	Group A	Group B	P
Graft per case	3.0±1.2	2.9±1.2	NS
ACC time (min)	35.8±13.6	32.7±10.4	NS
CPB time (min)	64.0±21.2	62.2±18.1	NS
Myocardial temp. (°C)			
RV free wall	15.6±0.9	13.5±2.2	NS
Septum	14.8±1.0	17.0±2.4	NS
Inferior	16.3±1.0	18.1±1.6	NS
LV postero-lateral	13.8±0.8	15.5±1.6	NS
Spontan. defibrillation	30%	76%	<0.001
Pace maker use	3/50	-	NS
Blood transfusion to bypass circuit	11/50	2/50	<0.01

ACC: Aortic cross clamp, CPB: Cardiopulmonary bypass, RV: Right ventricle, LV: Left ventricle

Complications: Twelve patients (24%) in group A, and 6 (12%) patients in group B needed different doses of inotrophic support because of the LCO either intraoperatively or postoperatively (p: not significant). The incidence of AF was 18% in group A and 10% in group B (p: not significant). Ventricular extrasystole (VES) was 28 % in group A, and 14% in group B (p: not significant). There was no mortality in either group (Table III).

Table III: Complications

	Group A	Group B	P
Peroperative MI %	6	2	NS
LCO %	24	12	NS
AF %	18	10	NS
VES %	28	14	NS

MI: Myocardial infarction, LCO: Low cardiac output, AF: Atrial fibrillation, VES: Ventricular extra systole

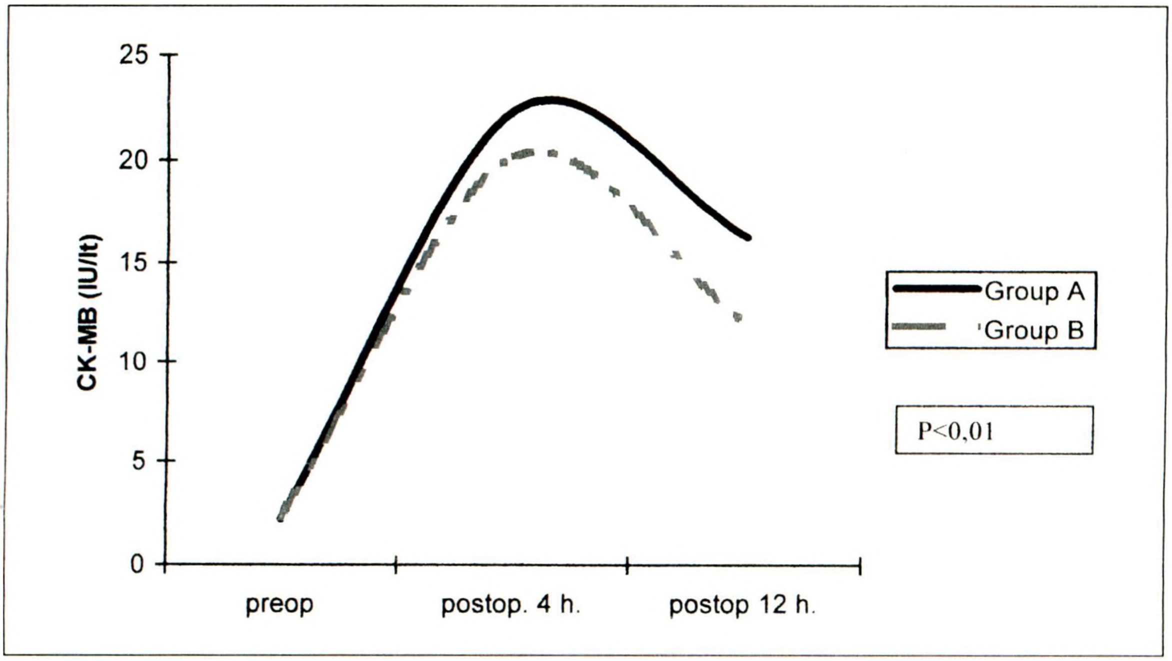

Fig.1 : Cardiac enzyme release

DISCUSSION

Today, 98% of surgeons use potassium based cardioplegic solutions in myocardial protection (14, 15). Robinson and colleagues showed that; blood cardioplegia was used by 72% of the surgeons whereas crystalloid cardioplegia was used by 22 % (15). Blood cardioplegia increases myocardial oxygen uptake, replenishes depleted energy stores and improves myocardial function in patients undergoing cardiac operations (16). Previous clinical studies have shown the superiority of blood cardioplegia over crystalloid cardioplegia, especially in patients with diminished left ventricular function and high-risk patients undergoing CABG (5-8). In the study of Brat and et al, it is emphasized that blood cardioplegia was associated with more operative stability and a reduction in postoperative morbidity. Therefore authors concluded that blood cardioplegia is superior to crystalloid cardioplegia in patients with an ejection fraction of < 35% (8). However, the superiority of blood cardioplegic techniques over crystalloid cardioplegia in low-risk patients is still controversial (9-13). In most studies the level of cardiac enzyme release is considered an essential marker of myocardial protection. In the study of Caputo M. and et al. There was no difference in releasing of cardiac Troponin T and Troponin I when either crystalloid or blood cardioplegia was used (12). However, Pichon H and et al found significantly higher Troponin I release in the crystalloid cardioplegia group than in the blood cardioplegia group (17). In our study, CK-MB level at the 12th hour postoperatively was significantly higher in group A than in group B (17.3±4.6 IU/L in group A, 12.0±3.5 IU/L in group B, $p<0.01$). This result shows that myocardial protection is better and recovery is faster in group B than in group A. Probably, spontaneous defibrillation of the heart following removal of the ACC has been used as an indicator of myocardial protection (18, 19). Following the removal of the ACC, 30% in group A and 76% in group B showed spontaneous activation ($p<0.001$). There were other data which could reveal that the indirect parameters of myocardial protection were less frequent but not significant in either group. Myocardial infarction was 4 % in group A, 2 % in group B, inotrop use in different doses due to LCO was 24% in group A, 12% in group B, AF 18% vs. 10% and treatment needed VES was 28% vs. 14%.

Limitations of the study: Cardiac enzyme release, myocardial oxygen and lactate extraction and myocardial biopsy are essential markers of myocardial protection when cardioplegic arrest is used. In this study only cardiac enzyme release was used to determine myocardial injury. This factor limited our study.

In conclusion; two different cardio-protective methods were compared in low-risk and homogenous patients in this study. The overall myocardial protection observed in the present study was satisfactory in both groups of patients with crystalloid and blood cardioplegia. There were no statistically significant differences in many parameters, including operative and postoperative values in both groups. However, the level of CK-MB was significantly higher and also the incidence of spontaneous defibrillation was significantly lower in group A than in group B postoperatively. Therefore, it may be assumed that; cold blood cardioplegia provides better myocardial protection and faster myocardial recovery than cold crystalloid cardioplegia in low-risk patients undergoing first elective CABG.

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