MYOCARDIAL PROTECTION: A CLINICAL COMPARISON OF COLD BLOOD CARDIOPLEGIA AND COLD CRYSTALLOID CARDIOPLEGIA

Riaz Anwar Khan, Sohail Aslam, Abdul Malik, Abid Aslam Awan, Khalid Rehman, Hamid Ahmad, Taskeen Ahmed, Javed Nawab, Syed Murad Ali, Nayyar Waseem, Jalal Khan, Parvez Mannan

Department of Cardiovascular Surgery, Postgraduate Medical Institute, Lady Reading Hospital, Peshawar

ABSTRACT

Objective: To assess the clinical outcome of two groups of patients by using cold blood cardioplegia and cold crystalloid cardioplegia for myocardial protection in open heart surgical cases.

Material and Methods: This study was conducted from July 1993 to Dec 2004. Clinical data was retrieved from hospital records of the patients who underwent any open heart surgery. Patients were divided into two groups. Group A: included patients treated from July 1993 to December 2002, and cold crystalloid cardioplegia was used. Group B: included patients operated from Jan 2003 to Dec 2004, and cold blood cardioplegia was used for myocardial protection. Data was analyzed in both groups by using Chi Square test.

Results: There was no significant difference in terms of cross clamp time, bypass time in the two groups. Spontaneous recovery of cardiac rhythm after declamping was 19.39% in Group A and 72% in Group B. Need for electrical cardioversion after declamping in Group A was 72% and 18% in Group B. The incidence of post clamp ventricular fibrillation was 18.85% in Group A and 7.27% in Group B. Operative mortality was 6.06% in Group A and 4.84% in Group B. Mean duration of mechanical ventilatory support was 16.42 hours in Group A and 5.59 hours in Group B. Mean duration of inotropic support to keep systolic blood pressure > 100 mmHg was 31 hours in Group A and 10 hours in Group B.

Conclusion: Cold blood cardioplegia provides a better myocardial protection as compared to cold crystalloid cardioplegia.

Keywords: Crystalloid Cardioplegia, Blood Cardioplegia, Myocardial Protection, Open Heart Surgery.

INTRODUCTION

Myocardial protection has a key role in the outcome of cardiac surgery and the blood cardioplegia has been increasingly used in clinical practice. Many patients referred for cardiac surgery have threats of ischemia. The degree of myocardial injury is proportional to the duration of ischemia. However, the duration of protected surgical ischemia associated with aortic cross clamp and cardioplegia does not demand the same anxiety as techniques of myocardial preservation increases the tolerance to ischemia.

Cardiac function depends upon a continuous supply of oxygen; the conventional term of ischemia had been an imbalance between myocardial oxygen supply and demand. The capacity of any cardioplegic solution is to prevent ischemic damage during surgery and to allow total recovery to a normal heart. This should be the minimum requirement of any cardio-protective technique used in cardiac surgical operations.

The aim of myocardial protection is to have good results in cardiac surgery by rapid induction of electromechanical diastolic arrest of the heart and to maintain the myocardium in a state of minimal metabolic requirement. Discoveries are made in response to a need and evolution of technique and, myocardial preservations is no exception. John Gibbon in 1953 when successfully closed an atrial septal defect using cardiopulmonary bypass in a protected heart, led the start of modern era of cardiac surgery. Lillehe wrote “a physician at the bedside of child dying with intracardiac anomaly as recent as 1952 could only pray for recovery”.

Denis Melrose and his colleagues in
DEMOGRAPHIC DETAILS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>CRYSTALLOID Group &quot;A&quot;  (July 1993 to Dec 2002)</th>
<th>BLOOD Group &quot;B&quot;  (Jan 2003 to Dec 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Patients</td>
<td>297</td>
<td>165</td>
</tr>
<tr>
<td>Age Range (Years)</td>
<td>05 - 65 years (mean 39 years)</td>
<td>12 - 72 years (42 years)</td>
</tr>
<tr>
<td>Sex</td>
<td>Male: 163 (54.88%) Female: 134 (45.11%)</td>
<td>Male: 89 (53.93%) Female: 76 (46.06%)</td>
</tr>
</tbody>
</table>

Table 1

England achieved rapid and reproducible ventricular arrest by using intra-coronary infusion of potassium. This method was associated with higher incidence of myocardial necrosis which was attributed to high potassium concentration in the solution. The journey of optimal cardioplegia solution continued when in 1976 Hearse and colleagues introduced famous Saint Thomas solution (crystalloid) with inclusive knowledge of physiology and chemistry of myocardial cells subjected to ischemia, cardioplegic arrest and subsequent reperfusion. Gerald Bucberg 1979, demonstrated blood based potassium solutions which has advantages over the crystalloid cardioplegia solution, with greater oxygen carrying capacity of blood, superior buffering action by the blood proteins, improved microvascular flow, erythrocyte free radical scavengers, which may reduce oxygen mediated injury during reperfusion. Blood cardioplegia also reduces myocardial edema because of protein content of the blood, which gives naturally occurring onconicity. This study was conducted to assess the clinical outcome of two groups of patients by using cold blood cardioplegia and cold crystalloid cardioplegia for myocardial protection in open heart surgical cases.

MATERIAL AND METHODS

This study was carried out in the department of cardiovascular surgery, Postgraduate Medical Institute, Lady Reading Hospital Peshawar from July 1993 to December 2004. Clinical data was collected from patient records, who underwent open heart surgery for mitral valve replacement, mitral valve repair, aortic valve replacement, coronary artery bypass grafting, atrial septal defect closure, right ventricular outflow tract repair, ventricular septal defect closure. Techniques of myocardial preservation during surgery and then clinical outcome were compared by using cold crystalloid cardioplegia and cold blood cardioplegia in these patients. Patients were divided into two groups, Group A (n=297): included patients treated from July 1993 to December 2002 where cold crystalloid cardioplegia was used for myocardial preservation and Group B (n=165) included patients treated from January 2003 to December 2004 where cold blood cardioplegia was used. Data was analyzed in both groups regarding age, sex, New York Heart Association Status (NYHA), echo findings, preoperative cardiac rhythm during surgery, total coronary bypass time, electrical cardioversion after declamping, spontaneous recovery of rhythm after declamping, perioperative arrhythmia and use of inotropes while coming off bypass.

In the intensive care unit after operation, duration of ventilatory support, use of inotropic

CARDIAC STATUS

<table>
<thead>
<tr>
<th>NYHA Functional Class</th>
<th>Group “A” (n = 297)</th>
<th>Group “B” (n = 165)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>89 (29.96%)</td>
<td>61 (36.96%)</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>III</td>
<td>185 (62.28%)</td>
<td>99 (60.00%)</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>IV</td>
<td>23 (07.74%)</td>
<td>05 (03.03%)</td>
<td>P &gt; 0.05</td>
</tr>
</tbody>
</table>

CARDIAC RHYTHM

| SIRUS                | 125 (42.08%)        | 61 (36.96%)         | P > 0.05|
| Atrial Fibrillation  | 172 (57.91%)        | 104 (63.03%)        | P > 0.05|

ECHO

| Fractional Shortening < 25 | 57 (19.19%) | 22 (13.33%) | P > 0.05 |
| Fractional Shortening > 25 | 240 (80.80%) | 143 (86.66%) | P > 0.05 |

Table 2
support to keep systolic blood pressure over 100 mmHg, use of anti-arrhythmic drugs to control arrhythmias and operative mortality was compared in the two groups.

All the cases underwent general anesthesia with standard median sternotomy. Routine cardio pulmonary bypass with single aortic and bicaval venous cannulae or two stage single venous return cannula were used. Cold crystalloid cardioplegia was used in Group A, where as oxygenated cold blood cardioplegia was used in Group B, to arrest the heart. Oxygenated blood was delivered from the arterial line of a bypass machine on full flow and temperature down to 30° 28°C and Saint Thomas cardioplegia solution used with K+ of 16 mmol/litr was added and delivered antegrade, once the aortic cross clamp was applied. In both the techniques cardioplegia was repeated after every 30 minutes of cross clamp. Findings of two groups were compared and statistically analyzed by Chi Square Test and P value less than 0.05 was considered significant.

RESULTS

This study comprised of 462 patients. Group A (n=297): included patients in whom cold crystalloid cardioplegia was used for myocardial preservation and group B (n=165) included patients in whom cold blood cardioplegia was used. Male sex was predominant in both groups, 54% versus 45% (Table 1). There were no difference in NYHA status of patient in two groups and so was preoperative cardiac rhythm (Table 2). There was no significant difference in cardiac function status in the two groups. During surgery there was no significant difference between cross clamp time in two groups i.e. 57 minutes versus 69 minutes. Mean bypass time was 95 minutes in group A versus 82 minutes in group B, which shows no significant difference. There was significant difference in recovery of cardiac rhythm after declamping which was more in group B (72%) as compared to group A (28%) (Table 3). Similarly electrical cardioversion was needed in 72% of patients in group A as compared to 19.39% in group B after declamping. There was also significant difference in post clamp ventricular fibrillation, which was more in group A (18%) as compared to group B (7.27%). There was no significant difference in the use of inotropes while coming off bypass in group A (93%) and group B (87%). Mortality was almost the same in two groups with no significant difference i.e. group A

POST-OPERATIVE PARAMETERS IN TWO GROUPS

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group “A” (n = 297)</th>
<th>Group “B” (n = 165)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilatory Support (Hrs)</td>
<td>12 - 36 hours</td>
<td>03 - 13 hours</td>
<td>P &lt; 0.05</td>
</tr>
<tr>
<td></td>
<td>mean = 16.42 hours</td>
<td>mean = 5.59 hours</td>
<td></td>
</tr>
<tr>
<td>Duration of Inotropic support to mean systolic Bypass &gt; 100 in first hour</td>
<td>12 - 52 hours</td>
<td>04 - 29 hours</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td></td>
<td>mean = 31 hours</td>
<td>mean = 10 hours</td>
<td></td>
</tr>
<tr>
<td>Use of Renal Dose Dopamine</td>
<td>63 (21.21%)</td>
<td>14 (08.48%)</td>
<td>P &gt; 0.05</td>
</tr>
<tr>
<td>Mortality</td>
<td>18 (06.06%)</td>
<td>8 (04.84%)</td>
<td>P &gt; 0.05</td>
</tr>
</tbody>
</table>
(6.06%) and group B (4.84%).

**DISCUSSION**

The postoperative haemodynamic stability, the course of cardiac rhythm and the clinical outcome are considered as parameters for assessing, how well the myocardium is protected during surgery. The use of cardioplegia solutions to arrest heart during operation is superior to continuous coronary perfusions or intermittent ischemia in reducing myocardial damage.

These days, wide variety of potassium based solutions are being used by most of the cardiac surgeons. In one of the survey, 28% of surgeons used crystalloid and 72% use blood cardioplegia. Different centers claimed that they are giving the best results. In our study, the use of blood cardioplegia showed better outcome as compared to crystalloid cardioplegia. Barner and Engleman in their review of randomized series comparing crystalloid cardioplegia with blood cardioplegia, noted an increased incidence of myocardial damage, increased use of inotropes and depression of myocardial function postoperatively in crystalloid group. There was also higher incidence of conduction defect reported by groups using crystalloid cardioplegia. Lately in coronary artery bypass grafting patch trial which enrolled a high risk group of coronary artery disease patients with ejection fraction of less than 36%. Patients were randomized into cold crystalloid and cold blood cardioplegia group. This was only done for coronary artery bypass grafting, where as in our series, it was not randomized and more over we included valvular and congenital heart disease patients, apart from coronary artery disease. They also concluded that cold blood cardioplegia protects heart in a better way then cold crystalloid cardioplegia.

Caputo and his colleagues compared cold blood versus cold crystalloid cardioplegia for the repair of ventricular septal defect in pediatric heart surgery. They compared myocardial adenine and purine both from right ventricular biopsies and postoperative serum troponin level and lactate release were measured apart from the clinical parameters. They also concluded that cold blood cardioplegia is associated with less metabolic myocardial ischemia and reperfusion injury, when compared with cold crystalloid cardioplegia.

Another study from Izmir analyzed the glucose and oxygen consumption of myocardium during arrested heart in blood cardioplegia and crystalloid cardioplegia group apart from other clinical parameters. This study also concluded that there is more oxygen and glucose utilization by the myocardium in the crystalloid cardioplegia group.

The clinical parameters were comparable to our study. However, we were lacking the comparison of biochemical profiles. It has also been reported in their series that the returning of spontaneous sinus rhythm may be one of the signs of good myocardial protection by blood cardioplegia as is evident in our series as well (72% vs. 19.39%). Similarly in another study, which compared cold crystalloid cardioplegia with cold blood cardioplegia, it was found that CK-MB is raised in crystalloid cardioplegia group as compared to blood cardioplegia group after aortic clamp was released.

The versatility of blood cardioplegia provides the cardiac surgeon with an extremely powerful tool to treat the jeopardized myocardium actively as well as to prevent ischemic damage. No exogenous blood is needed to deliver blood cardioplegia, as the blood is taken from the oxygenator during operation when the patient blood mixes with the clear priming fluid. The expense of depriving the patient of potential benefits of blood cardioplegia outweighs the monetary cost of its use.

**CONCLUSION**

We conclude that cold blood cardioplegia is a superior method for myocardial protection during cardiac surgery as compared to cold crystalloid cardioplegia. Use of blood as a vehicle for cardioplegia results in a better outcome of these cardiac surgery patients due to well protected cardiac tissues during aortic cross clamping. Cold blood cardioplegia provides better myocardial metabolic status resulting in less chance of arrhythmias and low use of inotropic agents postoperatively.

**REFERENCES**

5. Follett D, Klaus F, Becker H, Mulder L, Buckberg GD. Superiority of cold blood over


Address for Correspondence:
Dr. Riaz Anwar Khan
Associate Professor
Department of Cardiovascular,
Postgraduate Medical Institute,
Lady Reading Hospital, Peshawar