Original Research Article

Comparison of isothermic and cold cardioplegia in cardiac surgery in Salem District

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International Archives of Integrated Medicine, Vol. 6, Issue 3, March, 2019.
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Available online at http://iaimjournal.com/
ISSN: 2394-0026 (P) **ISSN: 2394-0034 (O)**
Received on: 03-03-2019 **Accepted on:** 09-03-2019
Source of support: Nil **Conflict of interest:** None declared.
How to cite this article: Pon. A. Rajarajan. Comparison of isothermic and cold cardioplegia in cardiac surgery in Salem District. IAIM, 2019; 6(3): 266-271.

Abstract

Background: Perioperative myocardial damage is one of the most common causes of morbidity and mortality after heart surgery. The improvement of the technique of myocardial preservation has contributed greatly to significant advances in cardiac surgery. However, serious questions remain regarding the use of warm versus cold cardioplegia, blood versus crystalloid cardioplegia, antegrade versus retrograde delivery and intermittent versus continuous perfusion. Cardioplegic solution is the means by which the ischemic myocardium is protected from cell death. This is achieved by reducing myocardial metabolism through a reduction in cardiac workload and by the use of hypothermia. Chemically, the high potassium concentration present in most cardioplegic solutions decreases the membrane resting potential of cardiac cells. The normal resting potential of ventricular myocytes is about -90 mV.

Materials and methods: The study was conducted in the Department of Cardiothoracic Surgery, Government Mohan Kumaramangalam Medical College Hospital from 2016-2017. Thirty patients were selected and divided into two equal groups. Group I, Isothermic blood cardioplegia, patients were cooled to 30˚C, and cardioplegia given at the same temperature as circulating blood in cardiopulmonary bypass and repeated at 20 minutes. The cardioplegic heat exchanger was not utilized in the cardiopulmonary bypass circuit. In group II, conventional cold cardioplegia, patients were cooled to 28-30˚C. Cardioplegia was given at 7-10˚C and was repeated every 30 minutes. To assess myocardial metabolic activity, myocardial oxygen consumption (MVO_2), myocardial glucose uptake, myocardial lactate, and acidosis were measured, using arterial and coronary venous blood samples.

Results: Mean cardiopulmonary bypass time was significantly shorter receiving isothermic blood cardioplegia (69 v/s 96 minutes). Serum lactate after cardiopulmonary bypass in isothermic blood

cardioplegia was lower (1.9 v/s 2.9). There was less metabolic acidosis in the isothermic group (pH 7.37 v/s 7.34). Glucose uptake was higher in the isothermic group. Myocardial contractile function was slightly better in the isothermic group (Ejection Fraction -62 v/s 60 %).

Conclusion: The aim of myocardial protection during heart surgery was to preserve myocardial function while providing a bloodless and motionless operating field. In the early stage, myocardial protection was obtained by decreasing myocardial oxygen demand as a consequence of hypothermia. Although intermittent cold cardioplegia perfusion is associated with excellent clinical outcomes in cardiac surgery, this standard technique results in myocardial hypothermia, ischemia and a delay in the recovery of postoperative myocardial metabolism and function. Myocardium utilizes more oxygen and glucose after isothermic cardioplegia, but lactate and acid production were less.

Key words

Cardiopulmonary bypass, Surgery, Myocardial glucose uptake, Myocardial lactate, Myocardial acidosis, Ejection fraction.

Introduction

Perioperative myocardial damage is one of the most common causes of morbidity and mortality after heart surgery. The improvement of the technique of myocardial preservation has contributed greatly to significant advances in cardiac surgery [1]. However, serious questions remain regarding the use of warm versus cold cardioplegia, blood versus crystalloid cardioplegia, antegrade versus retrograde delivery and intermittent versus continuous perfusion. The debate over the optimal temperature of cardioplegia during cardiac surgery has been one of the most important aspects of myocardial protection [2]. Early cardioplegic techniques used cold crystalloid solutions to initiate and maintain cardiac arrest during heart surgery, and it remained as a cornerstone of cardiac surgical practice since its introduction in the early 1950s [3]. Although it could lower myocardial oxygen demands and the risk of ischaemic damage, cold cardioplegia might inhibit myocardial enzymes and result in the delay in metabolic and functional cardiac recovery after surgery [4]. In the hope of maximizing intra-operative myocardial protection, warm blood cardioplegia was first introduced in the 1970s and the technique of warm induction followed by cold cardioplegia or terminal warm cardioplegia reperfusion (hot-shot) was clinically applied and found to be effective for myocardial protection. Thereafter, continuous and intermittent perfusions of warm blood cardioplegia were introduced in the 1980s and proved to provide excellent myocardial protection during heart surgery [5]. Numerous randomized controlled trials (RCTs) have been conducted to compare warm cardioplegia with cold cardioplegia for myocardial protection, but the outcomes of these trials remained inconclusive [6]. The objective of this study was to systematically review RCTs in which warm cardioplegia was compared with cold cardioplegia for heart surgery. Despite the benefits of hypothermia, there are major disadvantages to this modality of myocardial protection [7]. In this prospective study, we compare isothermic blood cardioplegia with conventional cold blood cardioplegia for myocardial metabolic activity, myocardial protection, and contractile function [8].

Materials and methods

The study was conducted in the Department of Cardiothoracic Surgery, Government Mohan Kumaramangalam Medical College Hospital from 2016-2017. Thirty patients were selected and divided into two equal groups. Group I, Isothermic blood cardioplegia, patients were cooled to 30˚C, and cardioplegia given at the same temperature as circulating blood in cardiopulmonary bypass and repeated at 20 minutes. The cardioplegic heat exchanger was not utilized in the cardiopulmonary bypass

circuit. In group II, conventional cold cardioplegia, patients were cooled to 28-30˚C. Cardioplegia was given at 7-10˚C and was repeated every 30 minutes.

Technique

Cardioplegia Induction on the Donor Graft Harvesting of the donor graft begun with a perfusion of cold crystalloid solution (Plegisol; Abbott Laboratories, North Chicago, IL) infused through an aortic catheter fixed to the donor's aorta with a pursestring of 4-0 polypropylene suture. This catheter was left in place after cardiectomy. The heart was excised and then placed in a sterile plastic box with cold saline solution (Ringer solution) and transferred in an isothermic container maintaining a constant temperature between 4" to 6°C without ice contact (Transplanthermm; Cardicorp SA) [9].

Blood Cardioplegia Circuit

The blood cardioplegia technique needs a specific circuit A disposable blood cardioplegia delivery system (Dideco-Shiley Inc) with a separate in-line heat exchanger to obtain and maintain the temperature of the perfusate at an appropriate level was used. The circuit was connected to the oxygenator (bubble or membrane) at the coronary outlet. A soft bag (1.2 L) contains the cardioplegic solution and serves as a bubble trap. The heat exchanger was of the pediatric type, with an Accepted for publication Oct 23, 1991. This technique of blood cardioplegia and warm reperfusion during heart transplantation provided an improvement in heart preservation when compared with standard crystalloid solution. A temperature probe connector allows monitoring of the cardioplegic solution temperature. An injection port allows drug administration. The circuit is connected to the cardiotomy reservoir to facilitate its debubbling [10].

Blood Cardioplegia

In the operating room, on arrival of the graft, cardiopulmonary bypass was immediately started on the recipient. The first dose of blood cardioplegia was prepared and stored in the soft bag of the extracorporeal circuit during the excision of the recipient's heart. The solution was recirculated in the closed circuit to lower its temperature to 8˚ to 10°C. After despairing of the donor's heart and aorta, infusion of blood cardioplegia is started through the aortic catheter used previously for crystalloid cardioplegia [11]. In a group, I, Isothermic blood cardioplegia, patients were cooled to 30°C and cardioplegia was given at the same temperature as a perfusate in cardiopulmonary bypass and repeated at 20 minutes interval if required. Since the maximum oxygen consumption is during the terminal phase of cardioplegic arrest two different time intervals were selected for warm and cold blood cardioplegia. The cardioplegic heat exchanger was not utilized in the cardiopulmonary bypass circuit. In group II, the conventional cold cardioplegia, patients were cooled to 28-30°C. Cardioplegia was given at 7-10°C and was repeated every 30 minutes if required. Cases which were included in this study are Atrial Septal Defect, Ventricular Septal Defect, and Tetralogy of Fallot. To assess myocardial metabolic activity, myocardial oxygen consumption (mvO_2), myocardial glucose uptake, myocardial lactate, and acidosis were measured using arterial and coronary venous blood samples. Arterial samples were obtained from the cardioplegia line. Coronary venous blood samples were obtained directly from coronary sinus just before beginning and just before the end of the first cardioplegia. Subsequent samples are taken just before giving next cardioplegia and just before releasing cross-clamp. Each blood sample was assayed for hemoglobin (Hb), the partial pressure of oxygen (pO2), carbon dioxide (pCO2), pH, oxygen saturation(O2 sat), lactate and glucose levels. Myocardial oxygen consumption was then calculated by simply multiplying the oxygen extraction value by the flow rate of blood cardioplegia (mvO2 =O2 Ext x flow). The change of temperature is a continuous dynamic process during cardioplegic arrest, hence we calculated the oxygen content and variables at a standardized 37°c. Myocardial lactate levels were calculated as lactate value of

coronary venous effluent minus the lactate value of the cardioplegic solution. In the postoperative period, all patients were monitored for arrhythmia, need for inotropic support and Ejection Fraction for myocardial function [12].

Statistical analysis

All data were expressed as mean ± standard deviation or as percentages. Statistical significance was tested for with paired and unpaired Student's t-test or $\chi 2$ test and a P value of less than 0.05 was taken to be significant.

Results

Patient characteristics and intraoperative data were similar in the two groups, Cardioplegic infusion rates; aortic root pressures were similar in both groups. Both groups were compared in various aspects. The median age was 38±12.5 years in cold cardioplegia group whereas it was 50±10.7 months in the isothermic group. M: F ratio was 15:10 in group I and 13:12 in group II. Median Weight was 80.25±7.2 Kgs in group I compared to 13 ± 6.8 in group II

The calculated values for myocardial O2 Consumption and glucose uptake were higher in the isothermic group compared to cold cardioplegia group. Myocardial lactate production was greater in cold cardioplegia group. Ejection fraction was slightly better in isothermic cardioplegia group. Even though the values are different in two groups, they are not statistically significant (**Table – 1, 2**).

Table – 1: Comparison of mean aortic X clamp time and mean cardiopulmonary bypass time in two groups.

	Cold cardioplegia Group - I	**Isothermic cardioplegia Group – II**
Mean CPB time (in minutes)	96.27 ±49.47	69.81 ±19.02
Mean arotic cross clamptim (minutes)	34.63 ±21.48	29.45 ±12.2

Table - 2: Comparison of O2 extraction, myocardial lactate, glucose extraction and EF in two groups.

	Cold cardioplegia Group - I	**Isothermic cardioplegia Group –II**
Oxygen Consumption	4.01 ± 4.3	5.79 ± 4.6 (mL /dL)
Lactate Levels (mmols/L)	2.9 ±1.3	1.9 ± 0.85
Glucose Extraction (mg/dL)	8.4±5.6	9.2±4.2
Ejection Fraction (%)	60.7±2.3	62 ±3.2

P value – not significant

Discussion

When myocardial protection is successful during cardiac surgery, its direct effect on postoperative cardiac function, recovery, and complications can be observed. Even though off-pump surgery has recently become more popular, the vast majority of coronary revascularization is still performed via an on-pump procedure [13]. Reperfusion after cardioplegic arrest-induced myocardial ischemia may cause irreversible cellular changes, and damage caused by reperfusion may occur in all cardiac operations requiring the temporary cessation of coronary circulation. This may contribute to the impairment of postoperative cardiac performance and eventually may lead to myocardial fibrosis that can occur after cardiac surgery [14]. During the cardioplegic arrest, the aim is to reduce cellular metabolism and boost cellular energy storage by avoiding myocardial damage. Furthermore, in response to the changes in temperature and composition of the cardioplegia, different perfusion procedures can

be adopted to improve coronary distribution [15]. Warm and tepid blood cardioplegia are supposed to offer better protection for the cellular enzyme systems and reduce cellular swelling and myocardial edema. Decreasing temperatures during cardiopulmonary bypass no doubt decreases tissue metabolism but causes intracellular swelling, sodium accumulation, impairment of oxygen dissociation, a decrease in membrane fluidity, inhibition of calcium uptake in the sarcoplasmic reticulum [16]. The net benefits of cold cardioplegia in comparison to tepid cardioplegia is questionable because hypothermia has some adverse effects like ventricular fibrillation, arrhythmias, promotion of rouleau formation, and potential for phrenic nerve damage, It has been shown that the utilization of glucose and ATP generation are decreased to a greater degree [17]. Several studies suggested that hypothermic cardioplegia may damage the myocardium and vascular endothelium. In our experience average time of cardiopulmonary bypass in cold cardioplegia is 96 minutes and that in isothermic cardioplegia 69 minutes [18]. Time interval on cardiopulmonary bypass before applying cross-clamp and after releasing of cross-clamp is very less as the time spent in cooling and rewarming of the patient was minimal. Postoperative hemodynamic stability, the need for inotropic support and postoperative ejection fraction and clinical outcome are considered as the indicators used in assessing how well myocardium is protected [19]. However, myocardial metabolic measurements have been reported to be better indicators. Myocardium utilizes more oxygen and more glucose while producing less lactate when cardioplegia temperature is increased to circulating blood temperature. This aerobic state of myocardial metabolism during isothermic cardioplegia might be the reason for early recovery observed in the hearts. The results of our study have demonstrated that a cardioplegic heart consumes more glucose and oxygen while producing less lactate during isothermic [20].

Conclusion

This technique of blood cardioplegia and warm reperfusion provided an improvement in heart preservation when compared with standard crystalloid solution. Retrospective Myocardium utilizes more oxygen and glucose after isothermic cardioplegia, but lactate and acid production were less, the, however, the operative outcome was not different. Cardiac recovery was significantly better with blood cardioplegia when compared with standard crystalloid myocardial protection. We described herein the technique of blood cardioplegia delivery as we routinely use it in clinical heart transplantation.

Acknowledgments

Authors would like to thank the Cardiothoracic Surgery Department faculty, Govt. Mohan Kumaramangalam Medical College, Salem for their humble support to complete the research work.

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