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INTRA-OPERATIVE HEMODILUTION DURING MITRAL VALVE REPLACEMENT SURGERY USING ST THOMAS VS DEL NIDO CARDIOPLEGIA- A SINGLE CENTRE STUDY.

Cardiac Surgery

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ABSTRACT

Aim To assess the hemodilution during mitral valve surgery performed using St Thomas cardioplegia versus Del Nido cardioplegia. We also compared the volume of cardioplegia required, cross clamp time and cardiopulmonary bypass (CPB) time in each group.

Methods and Materials Patients admitted between the period of January 2015 to June 2018 for mitral valve disease were included in this retrospective study. Patients were divided into two groups each comprising of 50 patients according to type of cardioplegia received during surgery.

Results The hemodilution was much lesser in the patients who underwent mitral valve surgery using St Thomas cardioplegia (Haematocrit 26.3 ± 2.5%) as compared to those patients underwent the same surgery using del Nido Cardioplegia (Haematocrit 24.8 ± 2.2%). The volume of cardioplegia, cross clamp time and cardiopulmonary bypass time was less with del Nido cardioplegia as compared to St. Thomas cardioplegia (922.6 ± 95.4 vs 1854 ± 228.1 ml; 65.5 ± 8.2 vs 71.52 ± 8.8 minutes and 99.3 ± 13.1 vs 110.6 ± 14.6 minutes respectively).

Conclusion The use of St Thomas Cardioplegia in patients during mitral valve replacement surgery has less hemodilution on CPB as compared to del Nido cardioplegia. But the patients who received del Nido cardioplegia has less requirement of number and volume of cardioplegia required during surgery with shorter cross clamp and CPB time.

KEYWORDS

Cardioplegia, del Nido, St. Thomas, hemodilution

INTRODUCTION

Hemodilution during cardiopulmonary bypass (CPB) was introduced to reduce the use homologous blood and now use of crystalloid priming solution is norm during CPB. Though the hemodilution during CPB decreases the homologus blood requirements and reduces the blood viscosity, haematocrit less than 22% leads to serious complications like renal failure, stroke, myocardial infarction, low cardiac output syndrome, pulmonary edema, sepsis, bleeding and multiorgan failure (1). There are several factors that affects the degree of hemodilution during CPB like patient's weight, sex, prebypass haematocrit, volume of crystalloid cardioplegia, cardiopulmonary bypass circuit volume and prime volume (2). The del Nido cardioplegia is more dilute (1:4, blood: crystalloid) than traditional 4:1 blood cardioplegia, but it provides longer period of cardiac arrest before a subsequent dose is needed.

The purpose of this study is to evaluate the effect of multidose St Thomas blood cardioplegia and long acting more crystalloid del Nido cardioplegia on hemodilution. We also compared cardioplegia number and volume requirements, cross clamp time and cardiopulmonary bypass during mitral valve replacement surgery.

MATERIALS AND METHODS

Patients who underwent elective isolated mitral valve replacement surgeries between January 2014to June 2018 were chosen in the study. Inclusion criteria were all adult patients who underwent elective mitral valve replacement surgery. Patients with body weight less than 35 kg, diabetes, renal failure, previous open heart surgery and preoperative haematocrit less than 30% were excluded. They were divided into two groups based on the type of cardioplegia administered during the surgery.

In group A, we included the patient who received St Thomas cardioplegia (n=50) and in group B, we included the patient who received del Nido cardioplegia solution (n=50) for myocardial protection. All procedures were performed using a standard general anaesthesia protocol, median sternotomy approach, cardiopulmonary bypass with systemic hypothermia (28 to 30.C) and valve replacement with either mechanical or bioprosthetic valve.

The CPB circuits were primed with 1200 ml crystalloid (Ringer Lactate) including additives of mannitol, sodium bicarbonate and heparin for both groups. But it's our routine practice to discard 100ml of volume before connecting the tubing to cannula for patients who received del Nido cardioplegia.

Cardioplegia protocol:

Myocardial protection was achieved either with St Thomas or del Nido cardioplegia as follows. In both the groups the heart was arrested with an induction dose of cold (4.C) cardioplegia using antegrade delivery. At our institute St Thomas cardioplegia was prepared from commercially available St. Thomas solution based concentrate. One ampule of 20ml solution contains about 16 mmol of potassium, 16 mmol of magnesium and 1 mmol of procaine. It was added along with 20 ml Soda bicarbonate, 20 ml Mannitol in 4:1 ratio of blood (oxygenated pump blood) to crystalloid. The induction dose of St Thomas cardioplegia was given immediately after aortic cross-clamping in the dose of 20ml/kg (maximum arresting dose limited to1000 ml for patient larger than 50 Kg). The subsequently re-administered dose was prepared from oxygenated pump blood without addition of crystalloid and given at dose of 10ml/kg after every 20 -25 minutes except for the rare occurrence of electrical activity (maximum re-dose dose limited to 500 ml for patient lager than 50 Kg).

The crystalloid component of del Nido cardioplegia were prepared with 1000 ml of Plasma-Lyte A solution to which 13 ml potassium chloride (2 mEq/ml), 13 ml sodium bicarbonate, 4 ml Magnesium sulphate (50%), 16 ml Mannitol (20%), 6.5 ml Lidocaine (2%). It was given immediately after aortic cross-clamping in 1:4 ratio of blood (oxygenated pump blood) to crystalloid ratio at dose of 20 ml/kg (maximum arresting dose limited to1000 ml for patient lager than 50 Kg), with typical re-dose after 90 minutes at dose of 10ml/kg.

Transfusion protocol:

The blood / packed red blood cells were added to pump reservoir only when the intraoperative nadir haematocrit on cardiopulmonary bypass were less than 22%.

RESULTS:

A total 100 patients underwent isolated mitral valve replacement procedures. Group A includes 50 patients who underwent surgery with St Thomas based cardioplegia with average age 42.7 (± 11.6) years. This group included 31 (62%) females and 19 (38%) males. The average body weight, body surface area (BSA) and haematocrit after induction of anaesthesia was 48 (± 9.1) kg, 1.4 (± -0.1) and 40.9 (± 4.9) respectively. The group B includes 50 patients who received del Nido cardioplegia during surgery with average age, weight, BSA, and haematocrit after induction of anaesthesia was of 41.3 (± 12.6) years, 49.1 (± 8.1) Kg, 1.5 (± 01) m2, 40.1 (± 5.3) respectively (Table No. 1).

TABLE 1. Preoperative observations

Observations	Group A St Thomas cardioplegia	Group B del Nido cardioplegia	Test	p-value
Age	42.7 ± 11.6	41.3 ± 12.6	Unpaired t test	0.559
Gender (male)	19 (38%)	18 (36%)	Chi square test	0.836
Gender (Female)	31 (62%)	32 (64%)		
Weight (Kg)	48 ± 9.1	49.1 ± 8.1	Unpaired t test	0.532
Body Surface Area (BSA m2)	1.4 ± 0.1	1.5 ± 0.1	Unpaired t test	0.055
Haematocrit (%) after induction of anaesthesia	40.9 ± 4.9	40.1 ± 5.3	Unpaired t test	0.412

Priming volume for group A and group B was 1200ml and 1100 ml. All patients in group B required only single dose of del Nido cardioplegia with average volume of 846.2 (± 248.4) ml, whereas in group A 90% patients received three and remaining 10% patients received four St Thomas based blood cardioplegia with average volume of 1854 (± 228.1) ml. Four patients in group B and two patients in group A received hemoconcentrator on CPB. The lowest haematocrit observed on CPB was significantly lower in Group B (24.7 ± 1.9) than group A 26.3 ± -2.5). The cross clamp time CPB time in group A was 71.5 & 110.6 minutes while in group B, it was 65.5 and 99.3 minutes (Table No. 2).

TABLE 2. Intraoperative Observations.

Observations		Group A. St Thomas cardioplegia	Group B. Del Nido cardioplegia	Test	P value
Haematocrit on CPB (%)		26.3 ± 2.5	24.8 ± 2.2	Unpaired t test	0.0017
Intraoperative Blood/RBC transfusion	No	46 (90%)	44 (88%)	Chi square test	0.505
	Yes	4 (8%)	6 (12%)		
Number of Cardioplegia	1	Nil	50 (100%)	NA	NA
	3	45 (90%)	Nil		
	4	5 (10%)	Nil		
Volume of Cardioplegia (ml)		1854 ± 228.1	922.6 ± 95.4	Unpaired t test	<0.0001
Urine output on CPB (ml)		1126.5 ± 189.7	1146.8 ± 243.7	Unpaired t test	0.643
Cross-clamp time (min)		71.52 ± 8.8	65.5 ± 8.2	Unpaired t test	0.0005
CPB time (min)		110.6 ± 14.6	99.3 ± 13.1	Unpaired t test	<0.0001

DISCUSSION

Cardioplegic arrest is the mainstay of myocardial protection during cardiac surgery with cardiopulmonary bypass (CPB). It is the safe and effective method to maintain electomechanical cardiac quiescence with preservation of myocardial function during cardiac surgery. A variety of cardioplegia solutions are being used today to arrest the heart and choice of solution varies from institute to institute.

St. Thomas solution was developed in St Thomas hospital, London by Hearse et al. which provided reliable cardiac arrest with reasonable myocardial protection. (3). This is one of the commonly used cardioplegia but needs to be given repeatedly over short interval during cardiac surgery to maintain cardiac arrest and myocardial protection. In 1990s, Pedro del Nido and his team at the University of Pittsburgh developed cardioplegia solution to meet the specific needs of the immature myocardium in paediatric cardiac surgery. Modifications have been made to the original solution and it is now referred to as del Nido cardioplegia. Although the formulation was originally developed for use in paediatric and infant patients, its use for adult cardiac surgery has been expanding (4). It is more dilute (1: 4, blood: crystalloid) and provides a long period of arrest before a subsequent dose is needed as compared to the traditional 4: 1 blood cardioplegia.

Predisposing factors for hemodilution and increased blood transfusion requirements includes - preoperative anaemia, old age, female gender, low body surface area, renal failure, CPB time and crystalloid cardioplegia (5,6,7 8). Priming volume is the amount of of fluid added to prime the oxygenator, tubing's, filters and venous reservoir before connecting them to aortic and venous cannulas. Hemodilution during CPB results from mixing of patient's blood with crystalloid or colloid used in CPB prime. This along with patient's pre-bypass haemoglobin level, largely determines the haematocrit value on pump. Crystalloid cardioplegia causes more intraoperative hemodilution than blood cardioplegia (8). In our study we also found significant hemodilution on CPB with del Nido cardioplegia than with St. Thomas blood cardioplegia. Hazards of intraoperative hemodilution anaemia and blood transfusions were extensively studied. Habib et al (1) found strong systematic associations between severity of hemodilution on CPB and serious complications affecting most major vital organs. Defoe et al (9) showed lower haematocrit during CPB were associated with increased risk of in-hospital mortality and failed separation or return to bypass after attempted separation from bypass.

The del Nido cardioplegia when compared with traditional blood cardioplegia, has shorter cross-clamp and CPB time and less cardioplegia re-dosing time (10). In our study we also found that del Nido cardioplegia group had less number and volume of cardioplegia required during surgery with lesser cross clamp and CPB time. The shorter cross-clamp time and CPB time in del Nido group were attributed to reduced cardioplegia re-dosing time without interrupting the surgical work.

CONCLUSION

The use of St Thomas Cardioplegia in patients requiring mitral valve surgery has less hemodilution during CPB. But the patients who received del Nido cardioplegia have less number and volume of cardioplegia required during surgery with shorter cross-clamp and CPB time.

Limitation

This is a single centre, retrospective study with small sample size. In this study only intraoperative observations are assed.

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