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Effect of Cardioplegic Solution on Cardiovascular Parameters - An Experimental Study in Dogs

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ABSTRACT

Background: With improvement in anaesthesia and perfusion techniques, better understanding of cardiopulmonary kinetics, advanced surgical techniques, open heart surgery became safer with lesser mortality and morbidity. The present study was conducted on mongrel dogs with a view to evaluate the effects of two cold cardioplegic solutions on cardiovascular parameters. **Methods:** In present study twelve dogs were used. The dogs were randomly assigned to the experimental groups, dogs were divided into 2 groups: Kirsch solution and Bretschneider solution. In both groups, left ventricular hemodynamic variables were measured by a combined pressure-volume conductance catheter. **Results:** Kirsch solution composed of magnesium asparate 2.5%, potassium hydrochloride, 0.3% and sorbitol in 4.5%. The composition of Bretschneider solution. It comprised of sodium, potassium, magnesium, glucose, procaine, mannitol and CH+ with group I, HR found to be 122.4 1/ml, MAP was 89.5 mmHg, CO was 2.1 1/min, CBF was 42.3 ml/min, MPO was 0.9 ng/ml and nitrile was 1.3 ng/ml. In group II, HR found to be 132.4 1/ml, MAP was 76.4 mmHg, CO was 1.8 1/min, CBF was 26.5 ml/min, MPO was 4.3 ng/ml and nitrile was 0.7 ng/ml. The difference was non- significant (P> 0.05). **Conclusion:** Authors found that both cardioplegic solutions had equal effect on cardiovascular parameters in dogs.

Keywords: Cardioplegic solutions, Cardiovascular, Dog.

INTRODUCTION

Legallois is believed to be the pioneer to predict in the year 1812 that life could be supported with the aid of an approximately constituted and pumped perfusate.[1] Since then continued efforts were made to understand and master extra corporeal circulation.[2] The development of modern cardiopulmonary bypass techniques began in 1934, with De Bakeys invention of the roller pump. Sir John H Gibbon succeeded in accomplishing the first total cardiopulmonary bypass in cats in 1937. With improvement in anaesthesia and perfusion techniques, better understanding of cardiopulmonary kinetics, advanced surgical techniques, open heart surgery became safer with lesser mortality and morbidity.[3] Nevertheless there are large numbers of instances when valiant efforts by the cardiac surgeon, perfusionist and anaesthesiologist failed to revive the heart after bypass and the whole procedure looked a wasted effort. In quite a few cases due to reasons beyond comprehension, the patient could not be weaned off cardiopulmonary bypass.[4] The arrested heart either remained in a systole or produced low to no output in the post-operative period. Most of these patients had something in common i.e. something had happened during operation which had led to irreversible damage to the myocardium, which had led to irreversible damage to the myocardium, which refused to function normally. This has made one think why a heart with corrected intra-cardiac defect and improved coronary circulation, could not function better as expeted.[5] The aim of the present study was to conduct an experimental work on mongrel dogs with a view to evaluate the effects of two cold cardioplegic solutions on cardiovascular parameters.

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MATERIALS AND METHODS

In present study, twelve dogs were used. The experiments were approved by the Ethical Committee. After the dogs were randomly assigned to the experimental groups, dogs were divided into 2 groups: Kirsch solution and Bretschneider solution. The solution was injected as per instruction.

In both groups, left ventricular hemodynamic variables were measured by a combined pressure-volume conductance catheter. Results thus obtained were subjected to statistical analysis. P value less than 0.05 was considered significant.

RESULTS

Table 1: Cardioplegic solution Kirsch composition

Serial No	Composition	Percentage
1	Magnesium asparate	2.5%
2	Potassium hydrochloride	0.3%
3	Sorbitol	4.5%

[Table 1] shows that Kirsch solution composed of magnesium asparate 2.5%, potassium hydrochloride 0.3% and sorbitol in 4.5%.

Table 2: Cardioplegic Bretschneider solution composition

Composition	Solution 1	Solution 2
Sodium	50 to 60 mmol/L	10 mmol/L
Potassium	1.5 to 2 mmol/L	5 mmol/L
Magnesium	0.5 to 2.5 mmol/L	1.0 mmol/L
Glucose	0.5 to 1 mmol/L	0.5 to 0.8 mmol/L
Procaine	0.2 %	0.2 %
Mannitol	320 mo sm	320 mo sm
CH+	34.81 mmol/L	39.81 mmol/L

[Table 2] shows composition of Bretschneider solution. It comprised of sodium, potassium, magnesium, glucose, procaine, mannitol and CH+.

Table 3: Haemodynamic parameters

Parameters	Group I	Group II	P value
HR (1/min)	122.4	132.4	0.4
MAP (mmHg)	89.5	76.4	0.12
CO (1/min)	2.1	1.8	0.6
CBF (ml/min)	42.3	26.5	0.01
MPO (ng/ml)	0.9	4.3	0.02
Nitrile (ng/ml)	1.3	0.7	0.05

[Table 3] shows that with group I, HR found to be 122.4 1/ml, MAP was 89.5 mmHg, CO was 2.1 1/min, CBF was 42.3 ml/min, MPO was 0.9 ng/ml and nitrile was 1.3 ng/ml. In group II, HR found to be 132.4 1/ml, MAP was 76.4 mmHg, CO was 1.8 1/min, CBF was 26.5 ml/min, MPO was 4.3 ng/ml and nitrile was 0.7 ng/ml. The difference was non-significant (P> 0.05).

DISCUSSION

Cardiopulmonary bypass is a complex problem understanding of which is far from complete. There seems to be a derangement in the metabolism of myocardium as a result of acute stress emerging from the abnormalities of perfusion, biochemical state of the cell, cellular respiration, effects of neurological or hormonal stimuli and various drugs and surgical trauma on already diseased myocardium as an independent factor or as various incomprehensible permutations and combinations of some of the factors.[6]

Various techniques have been employed over the years to protect the heart from ischaemic injury during cardiopulmonary bypass. In early years of cardiac surgery myocardial protection was achieved by potassium citrate arrest, and by bathing the heart in a saline slush as an earliest from of cold cardioplegic technique during cardiopulmonary bypass.[7] The aim of the present study was to conduct an experimental work on mongrel dogs with a view to evaluate the effects of two cold cardioplegic solutions on cardiovascular parameters.

In this study, Kirsch solution and Bretschneider solution was used in dogs. We found that in group I, HR found to be 122.4 1/ml, MAP was 89.5 mmHg, CO was 2.1 1/min, CBF was 42.3 ml/min, MPO was 0.9 ng/ml and nitrile was 1.3 ng/ml. In group II, HR found to be 132.4 1/ml, MAP was 76.4 mmHg, CO was 1.8 1/min, CBF was 26.5 ml/min, MPO was 4.3 ng/ml and nitrile was 0.7 ng/ml.

Myocardial necrosis resulting from extremely high osmolarity and hyperkalemia of cardioplegic solution led to disrepute of the cardioplegic technique until 1970's when better understanding and safer methods were advocated. The fundamental tenets of the use of cardioplegic solution for myocardial preservation during cardioplegic solution for myocardial preservation during cardiopulmonary bypass are (i) complete and rapid electromechanical arrest with concomitant hypothermia soon after induced ischaemia following aortic cross clamping, reduces oxygen demand of myocardium, (ii) provides a substrate for anaerobic metabolisms (iii) Myocardial cell protection by membrane stabilization.[8]

Veres et al,[9] found that the use of Custodiol-N cardioplegic solution improved coronary blood flow (58 ± 7 ml/min vs. 26 ± 3 ml/min) and effectively prevented cardiac dysfunction after cardiac arrest. In addition, the myocardial ATP content ($12{,}8 \pm 1{,}0$ µmol/g dry weight vs. $9{,}5 \pm 1{,}5$ µmol/g dry weight) and plasma nitrite ($1{,}1 \pm 0{,}3$ ng/ml vs. $0{,}5 \pm 0{,}2$ ng/ml) were significantly higher after application of the new cardioplegic solution. Furthermore, plasma myeloperoxidase level ($3{,}4 \pm 0{,}4$ ng/ml vs. $4{,}3 \pm 2{,}2$ ng/ml) significantly decreased in Custodiol-N group.

Although, hypothermic cardiac arrest is a widely accepted protective concept, recently, it has been shown that cold temperature and ischemia/ reperfusion may lead to definitive myocyte and endothelial injury mainly mediated by an iron-dependent formation of reactive oxygen species (ROS).[10]

CONCLUSION

Authors found that both cardioplegic solutions had equal effect on cardiovascular parameters in dogs.

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