Antegrade-Retrograde Cold Blood Cardioplegia versus Antegrade Cardioplegia on Myocardial Function after Tetralogy of Fallot Repair

Masoumali Masoumi MD, Feridoun Sabzi MD, Zahra Jalili MD, Fereshteh Keshavarz MSc, Mostafa Ghanbari MSc and Gholamreza Abdoli, MSc

Abstract

Background- Antegrade and retrograde infusion of cardioplegia may provide more homogenous distribution of cardioplegia, especially in cases of coronary artery disease, but it has not been tested in tetralogy of Fallot repair. The purpose of this study was to compare antegrade and intermittent antegrade-retrograde cardioplegia on myocardial function following total correction of tetralogy of Fallot.

Methods- Fifty-two patients were non-randomly studied in two groups for a comparison between operational results after using the two said methods. In the antegrade-retrograde method (group A), 15-20 ml/kg cold blood cardioplegia was infused antegrade, followed by 8-10 ml/kg of retrograde infusion. Antegrade-retrograde route of infusion was repeated every 20 minutes (10 ml/kg and 8 ml/kg, respectively). In the antegrade group (group B), 15-20 ml/kg of cold blood cardioplegia was infused, followed by 10 ml/kg in repeated doses every 20 minutes. Important variables of myocardial performance were compared in the two groups.

Results- The two groups had similar preoperative characteristics (age, sex, body mass index). The mortality was 1 (3.8%) in group A and 5 (19%) in group B (P<0.05). Postoperative infusion of epinephrine and the dosage used were higher in group B (P<0.022), but the duration of its use was not different. Need for dobutamine, its dosage and duration of use were different in group B (P<0.002, P<0.007 and P<0.001, respectively). Dopamine infusion, dosage and duration were significantly different in the two groups (P<0.011, P<0.034 and P<0.011, respectively). Significant differences for ventilatory support were seen in the two groups (P< 0.043), but ICU stay in the two groups was not significantly different.

Conclusion- In light of our findings, it is concluded that there is a significantly better postoperative myocardial performance and lower mortality following antegrade-retrograde cardioplegia. We consequently recommend it as a routine method for myocardial protection in non-infantile repair of tetralogy of Fallot ***(Iranian Heart Journal 2006; 7 (1): 15-20).***

Key words: cardioplegia ■ myocardial protection ■ tetralogy of Fallot ■ congenital heart surgery

Antegrade cardioplegia has been extensively used to protect the heart during cardiac surgery.

In the presence of coronary arterial stenosis or occlusion and aortic regurgitation, antegrade delivery of cardioplegic

Received June 27, 2005; Accepted for publication Nov. 29, 2005.
From the Department of Cardiac Surgery, Imam Ali Heart Center, Kermanshah University of Medical Sciences, Kermanshah, Iran
Corresponding address: M. Masoumi, MD., Imam Ali Heart Center, Shaheed Beheshti Ave, Kermanshah, Iran
Email:mmasoumi@kums.ac.ir Tel:0831-8360752 Fax: 0831-8360043

solution is compromised, leading to a decrease in myocardial protection.[1,2]
Retrograde cardioplegia (with delivery of cardioplegic solution through the coronary sinus) has been used as an alternative to protect the jeopardized myocardium because of coronary atherosclerosis, but The distribution of retrograde cardioplegia is inhomogeneous, and only 25% to 80% of retrograde cardioplegia appears to be nutritive.[3,4,5,6,7] These problems of distribution may be overcome by combining antegrade and retrograde cardioplegia. Most cardiac surgeons now use a combination of antegrade and retrograde cardioplegia during coronary artery bypass graft surgery (CABG),[2,8,9] and many surgeons have studied the effect of antegrade-retrograde cardioplegia in congenital and valvular heart surgeries, especially reoperations.[9-12] To the best of our knowledge, this method has not been thus far used in surgical repair of tetralogy of Fallot, except in a group of congenital heart diseases including 13 cases of tetralogy of Fallot.[1] On the other hand, in tetralogy of Fallot, especially in old age groups (non-infants), the diameter of the aorta increases by time, and it is possible that some of the cardioplegia may regurgitate via the dilated annulus of the aorta, especially during the second and third cardioplegic infusions, where a rigid VSD patch may change the anatomy of the aortic annulus.
As it seems that the rate of low cardiac output after surgical repair of tetralogy of Fallot in old age groups is high, it is possible that the antegrade delivery of cardioplegia may not be satisfactory for myocardial protection. The combination of antegrade and retrograde cardioplegia may, therefore, improve the delivery of the solution. This study was conducted to compare the efficacy of antegrade and retrograde cold blood cardioplegia versus antegrade cold blood cardioplegia in the surgical repair of tetralogy of Fallot.

Methods

This study was conducted as a prospective, non-randomized trial to study the effect of antegrade-retrograde cardioplegia on myocardial function during surgical repair of tetralogy of Fallot. First, a pilot study was performed on 10 patients in order that a comparison could be made between the important early results of the operations with antegrade cardioplegic protection, which was the routine method before. According to the results, the sample volume was determined as 26 cases in each group. The patients having undergone surgery consecutively for tetralogy of Fallot repair from July 2001 to December 2003 (group A) constituted the cases.
And the same number of patients having had the operation consecutively before that time (over a-two year period) with the routine method of antegrade cardioplegic infusion comprised the control group (group B).
The need for inotropes (adrenaline, dobutamine and dopamine); the doses of these inotropic agents and the duration of their infusion times; length of intensive care (ICU) stays; and early (30 day) mortality and ventilatory support time were the variables compared in the two groups as clinical criteria for myocardial performance. Cardiopulmonary bypass and cross-clamping time of the aorta were also compared in the two groups.
Two cardiac surgeons performed all these operations with the same method.
The Research Committee of Kermanshah University of Medical Sciences approved this study, and informed consent was obtained from all the patients.

Operative technique

Median sternotomy was done in all the patients.
Total cardiopulmonary bypass (CPB) was established using double venous cannulas and ascending aortic cannulation, moderate

systemic hypothermia (rectal temperature, 28°C) and hemodilution during CPB. The pump flow was between 2.0 and 2.5 L/min/m^2, and mean arterial pressure was kept between 50 to 80 mmHg during CPB. In cases with a history of systemic to pulmonary shunt, following cannulation and before the starting of CPB, the shunt was closed. After establishing CPB and starting hypothermia, cardiac arrest was achieved with an initial antegrade infusion of cold blood cardioplegia (15-20 ml/kg, at 200-230 ml/min). By opening the right atrium, the retrograde cardioplegic infusion (8-10 ml/kg, at 140-160 ml/min) was done by direct injection with DLP infant retrograde cardioplegic catheter (manually inflated). Aortic root was vented during the retrograde infusion of the cold blood cardioplegic solution. Cold blood cardioplegia was a mixture of 3 parts of 5^o C St.-Thomas cardioplegic solution with one part of 28^o C pump blood. We did not use a manometer for pressure monitoring of the retrograde infusion. Antegrade and retrograde infusion of cardioplegia were repeated every 20 minutes during aortic cross clamp. It was possible to switch the direction of infusion and venting the aortic root during retro perfusion by using two 3-way stopcocks and connection of the proximal 3-way stopcock to the retrograde catheter and the distal one to the antegrade catheter. The surgery technique in the two groups was the same except for retrograde infusion of cardioplegia in group A. At the end of operation, the pressures of the right ventricle, left ventricle, ascending aorta and pulmonary artery were measured. If the results indicated that an operation was incomplete, other modifications were performed. Early mortality of the patients was regarded as any mortality during the first month after operation. A need for inotropic agents was regarded as the use of more than 5 μg/kg/min of dobutamine or dopamine, or more than 1μg/min of epinephrine infusion for more than one hour for the establishment of the patient's normal hemodynamics.

Statistical analysis was performed using the statistical package program. The paired student T-test and X^2 test were used to compare the clinical variables. Multiple analyses of variance were used to test time-dependent changes in the measured variables. Significance was assumed when the P value was less than 0.05.

Results

Twenty-six patients were studied in each group. The patients of the two groups were compared in two subgroups according to their ages (from 1-10 or more than 10 years old). The mean age of group A was 8.73±5 years old, and the mean age of group B was 7±3.37 years old. In group A, 18 (69.2%) patients were less than 10 years old and 8 (30.8%) were more than 10 years old. In group B, 21 (80.8%) patients were less than 10 years old and 5 (19.2%) patients were more than 10 years old. The two groups had similar preoperative characteristics with no significant differences in age, sex and body mass index. At operational evaluation, the pulmonary valve stenosis was severe in 22 cases (84.6%) in each group, and the main pulmonary trunk was stenotic in 23 (88.46%) in each group. In all the patients of the groups, there was severe subvalvar pulmonary stenosis. One patent ductus arteriosus (PDA) and one case of severe aortic insufficiency (AI) were the coexisting cardiac anomalies in group A. There were two cases of PDA and one case of double-chamber right ventricle as coexisting cardiac anomalies in group B. In all 23 cases of main pulmonary stenosis in each group, the annulus of the valve was opened, and the right ventricular outflow tract was repaired by pericardial patch. The perfusion and aortic cross clamp times were longer in group A (Table I).

Table I: Comparison of perfusion and aortic cross clamp times in the two groups

	Group A	Group B	P-value
Pump Time	99.1±16.4	130.3±43.3	0.001
aortic cross clamp time	50.9±13.2	69.5±31.4	0.009

After the operations, none of the patients in the two groups had complete heart block (CHB). Two cases in group B, however, had right bundle branch block. According to postoperative echocardiography findings, there was severe pulmonary insufficiency (PI) in 3 (14.33%) patients in each group,, but in the rest of the cases in the two groups, it was mild to moderate. In 19 (73%) cases of group A and 20 (77%) cases of group B, mild PS was reported, but the peak gradient across the valve was less than 25 mmHg in all cases. The mortality was 1 (3.8%) in group A and 6 (23%) in group B (P<0.03). All cases of mortality were in the 1-10- year-old groups. The need for inotropic agents, epinephrine, dobutamine and dopamine; and their dosage and duration in the two groups were compared. As shown in Tables II, III and IV, the usage differences in terms of dosage and duration were significant in the two groups, except for the duration of epinephrine use, which was not significant. There was a significant difference for ventilatory support in the two groups (P<0.043), but stay-in-the ICU in the two groups was not significantly different (Table V).

Table II: Need for adrenaline, dosage and duration of use in the two groups

		Group A	Group B	P-value
Need for Epinephrine	Yes	6 (23.1%)	14 (53.8%)	0.022
	no	20 (76.9%)	12 (46.2%)	
Duration	1-24 Hours	3 (11.5%)	8 (30.8%)	N.S
	>24 Hours	3 (11.5%)	6 (23.1%)	
	No need	20 (76.9%)	12 (46.2%)	
Dosage	1-10 µg/min/Kg	6 (23.1%)	14 (53.8%)	0.022
	>10 µg/min/Kg	0	0	
	No need	20 (76.9%)	12 (46.2%)	

Table III: Need for dobutamine, dosage and duration of use in the two groups

		Group A	Group B	P-value
Need of Dobutamine	yes	14(53.8%)	24(92.3%)	0.002
	no	12(46.2%)	2(7.7%)	
Duration	1-24 Hours	5(19.2%)	7(26.9%)	0.007
	>24	9(34.6%)	17(65.4%)	
	No need	12(46.2%)	2(7.7%)	
Dosage	5-20 µg/min/Kg	13(50%)	15(57.7%)	0.001
	>20 µg/min/Kg	1(3.8%)	9(34.6%)	
	No need	12(46.2%)	2(7.7%)	

Table IV: Need for dopamine, dosage and duration of use in the two groups

		Group A	Group B	P-value
Need of Dopamine	yes	0	6(23.1%)	0.011
	no	26(100%)	20(76.9%)	
Duration	1-24 Hours	0	2(7.7%)	0.034
	>24	0	4(15.4%)	
	No need	26(100%)	20(76.9%)	
Dosage	5-20 µg/min/Kg	0	6(23.1%)	0.011
	>20 µg/min/Kg	0	0	
	No need	26(100%)	20(76.9%)	

Table V: Ventilatory support time and stay in ICU in the two groups

	Group A (Hour)	Group B (Hour)	P-value
ventilatory support times (Hour)	28.9±16.8	64.6±84.2	0.043
Stay in ICU (Hour)	74.6±46.2	91.5±93.1	N.S

Discussion

This study indicates that the use of antegrade-retrograde cardioplegia is more effective for myocardial protection than antegrade cardioplegia in surgical repair of TF. As the results of the study indicate, the need for inotropic agents, the dosage and the duration of usage and the mortality rate in the control group were higher than those in the study group. The duration of ventilatory support was different in both groups. All of the above-mentioned variables are clinical indices for postoperative ventricular performance.

The results of this study support the investigations of Tian et al., who performed an experimental study on isolated pig hearts and compared the results of antegrade-retrograde versus antegrade cardioplegia after the occlusion of the anterior descending artery. They concluded that simultaneous antegrade-retrograde cardioplegia significantly improved myocardial perfusion in the jeopardized area of the myocardium. Lee et al. in a study on explanted hearts compared the effect of antegrade-retrograde cardioplegic delivery and concluded that sequential infusion of antegrade-retrograde cardioplegia had a better effect in comparison to all other routes of cardioplegic infusion. On the other hand, Ericsson et al. indicated that use of simultaneous antegrade-retrograde cardioplegia did not change global left ventricular function in comparison to the antegrade route. Cernainau et al. maintained that the route of cardioplegia administration was not a determinant of clinical outcome. In another study Jegarden et al. showed that there were no differences in the outcome of antegrade vs. antegrade-retrograde cardioplegic infusion. To our knowledge, the antegrade-retrograde infusion of cardioplegia has not been tested widely in tetralogy of Fallot. Nonetheless, according to the investigation of Buckberg and his colleagues, the results of this method in congenital heart disease were satisfactory. On the other hand, using retrograde cardioplegia in these cases is simple and safe, because the right atrium is usually opened and the catheter is directly placed into the ostium of the coronary sinus. As the pilot study showed a significant increase in ventricular performance after antegrade-retrograde cardioplegia, we selected our control group from the patients who had undergone surgery previously, and we believe this is the only limitation of the study.

Conclusion

To summarize, this study demonstrated the effect of antegrade-retrograde cardioplegia on myocardial function after TF repair. We believe that this is a convenient method for myocardial protection, especially in cases of severe aortic dilatation and overriding, and we recommend it as a method of choice in non-infantile TF repair.

References

1. Drinkwater DC Jr, Cushen CK, Laks H, Buckberg GD**.** The use of combined antegrade-retrograde infusion of blood cardioplegic solution in pediatric patients undergoing heart operations: J Thorac Cardiovasc Surg 1992; Nov 104 (5): 1349-55.

2. Norati F, Renzulli A, DeFeo M, Santarpino G, Gregorio R, Biondi A, Cerasuolo F, Cotrufo M. Does antegrade blood cardioplegia alone provide adequate myocardial protection in patients with left main stem disease**?** J Thorac Cardiovasc Surg. 2003; Nov; 126 (5): 1345-51.

3. Tian G, Shen J, Su S, Sun J, Xiang Bo, Oriaku GL, Sunders JK, Salerno TA, Deslauriers R. Assessment of retrograde cardioplegia with magnetic resonance imaging and localized 31P spectroscopy in isolated pig hearts. J Thorac Cardiovasc Surgery 1997; 114 (1): 109-116.

4. Bezon E, Mondine P, Karaterki A, Barra JA, Left ventricular distribution of retrograde cardioplegia. Should the interventricular posterior vein be occluded in the coronary sinus? Ann Cardiol Angiol 1996; 45 (9): 495-502.

5. Kaukoranta PK, Lepojakrvi MV, Kiviluoma KT, Ylitalo KV, Peuhkurinen KJ. Myocardial protection during antegrade versus retrograde cardioplegia. Ann Thorac Surg. 1998; 66 (3): 755-761.

6. Tian G, Xiang B, Dai G, Li G, Sun J, Summers R, Deslauriers R. Retrograde cardioplegia. J Thorac Cardiovasc Surg 2003 Apr; 125 (4): 872-80.

7. Winkelmann J, Aronson S, Young CJ, Fernandez A, Lee BK. Retrograde-delivered cardioplegia is not distributed equally to the right ventricular free wall and septum. J Cardiothorac Vasc Anesth 1995; 9 (2): 135-139.

8. Gates RN, Lee J, Laks H, Drinkwater DC Jr, Rhudis E, Aharon AS, Chung JY, Chang PA. Evidence of improved microvascular perfusion when using antegrade and retrograde cardioplegia. Ann Thorac Surg 1996; 62 (5): 1388-91.

9. Beyersdorf F, Allen B, Buckberg GD. Myocardial protection with integrated blood cardioplegia. In: Franco KL, Verrier ED, (eds). Advanced Therapy in Cardiac Surgery. Ontario, B.C. Decker Inc, pp: 38-50, 1999.

10. Urrea MS, Herrera V, Santibanez JA. The versatility of anterograde/retrograde cardioplegia in heart surgery. Arch Inst Cardiol Mex 1993; Sep-Oct; 63 (5): 411-3.

11. Drinkwater DC, Laks H, Buckberg GD. A new simplified method of optimizing cardioplegic delivery without right heart isolation. Antegrade/retrograde blood cardioplegia: J Thorac Cardiovasc Surg 1990 Jul; 100 (1): 56-63; discussion 63-4.

12. Buckberg GD, Drinkwater DC, Laks H. A new technique for delivering antegrade/retrograde blood cardioplegia without right heart isolation: Eur J Cardiothorac Surg 1990; 4 (3): 163-7; discussion 16.