Original Article

Extracorporeal Circulation for Great Vessels Surgery: A Review of 131 Cases

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ABSTRACT

A retrospective analysis of 131 cases of major vascular surgery, mainly aneurysms of the ascending and descending aorta, was undertaken to determine whether use of different bypass methods chosen according to location of the individual lesions resulted in improved results.

For the 93 cases of ascending aortic aneurysm, the method for cardiac protection was improved by the use of continuous retrograde coronary sinus perfusion with cardioplegic blood. In sixteen cases with dissection involving the aortic arch, deep hypothermic circulatory arrest and continuous retrograde cerebral perfusion through the superior vena cava was employed for brain protection. The safe brain circulation arrest time was thus prolonged to the longest record of 81 minutes. Among the group of 93 cases, there were four operative and four hospital deaths, giving a mortality rate of 8.6% (8/93). For the 34 cases of descending aortic aneurysms, left heart bypass was employed to avoid ischemia of the heart, lungs, brain, and the abdominal organs; the operative mortality rate was 8.8% (3/34). In three cases of interrupted aortic arch, separate upper and lower body perfusion under deep hypothermia with low flow rate perfusion for the upper body provided the necessary conditions for radical surgery. In one patient with Budd-Chiari syndrome, a total corrective surgery was achieved under right heart bypass.

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INTRODUCTION

Surgical treatment of great vessels disease is accompanied with a high incidence of complications and operative mortality. Sometimes, it is problems due to extracorporeal circulation that causes fatality. This article reviewed 131 cases with either acquired diseases or congenital anomalies of the great vessels. The disease entities included 93 cases of aneurysm of the ascending aorta (AAA) (70.99%), 34 aneurysms of the descending aorta (ADA) (25.96%), one Budd-Chiari syndrome (BCS) (0.76%), and 3 cases of interruption of aortic arch (IAA) (2.29%). Different types of bypass techniques and protective measures of the important organs were adopted according to the type, site, and extent of the lesions or anomalies of the great vessels involved (Table 1).

Table 1: Different bypass techniques for great vessels surgery

Lesions	No. of Cases	Method of Bypass
Aneurysm of ascending aorta (AAA)	93	Routine CPB CRCSP blood cardioplegia 4:1 CRCP (n=16)
Aneurysm of descending aorta (ADA)	34	Left heart bypass
Interruption of aortic arch (IAA)	3	Separate upper and lower body bypass
Budd-Chiari syndrome (BCS)	1	Right heart bypass

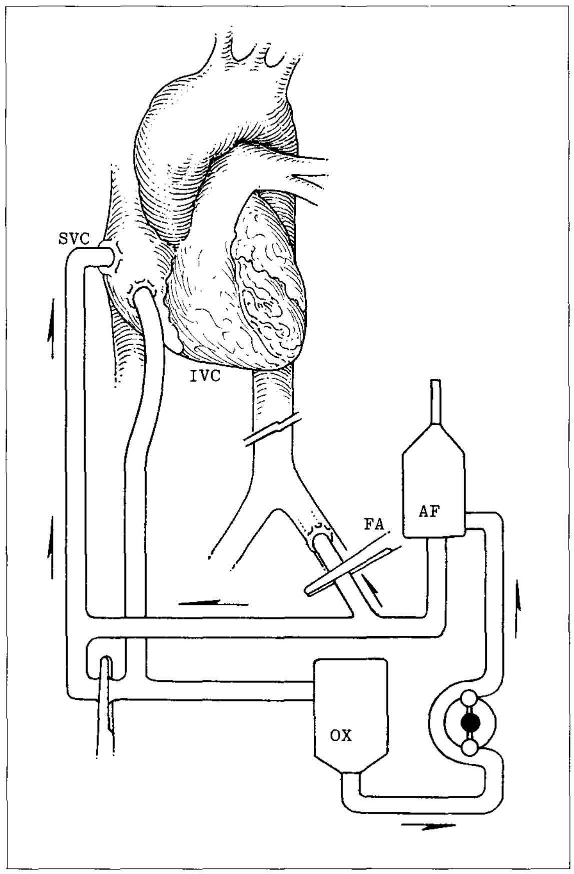
CRCSP: Continuous retrograde coronary sinus perfusion
CRCP: Continuous retrograde cerebral perfusion

MATERIALS AND METHODS

Aneurysm of the ascending aorta

The lesions in this series of 93 patients (with an average age of 38.9 ± 11 years) consisted of Marfan's syndrome and DeBakey I and II dissecting aneurysms. Except for three cases of simple aortic aneurysm, various degrees of aortic valve regurgitation with left ventricular enlargement and malfunction presented in the remaining patients. Routine moderate hypothermic cardiopulmonary bypass was used in all cases. The venous blood was drained out through either an atriocaval cannula or bicaval cannulae, and the oxygenated blood was returned through a cannula inserted into the aorta or the femoral artery. Myocardial protection was carried out by interrupted retrograde coronary sinus perfusion with crystalloid cardioplegia in the first 47 cases. In order to improve myocardial protection and lessen ischemic injury, the following 46 cases had cold retrograde blood cardioplegia (4:1) perfusion to begin and terminal warm blood (1). Deep hypothermic total circulatory arrest (DCHA) combined with retrograde cerebral perfusion (RCP) through the superior vena cava for brain protection (Figure 1) was used in 16 cases when the aortic dissection involved the right half or the whole arch. Ascending aorta replacement was done in two patients, total arch replacement in one, and the Bentall procedure in 90. The mean aortic cross-clamp time was 138 ± 38 min.

Figure 1: Diagram showing retrograde superior vena cava perfusion

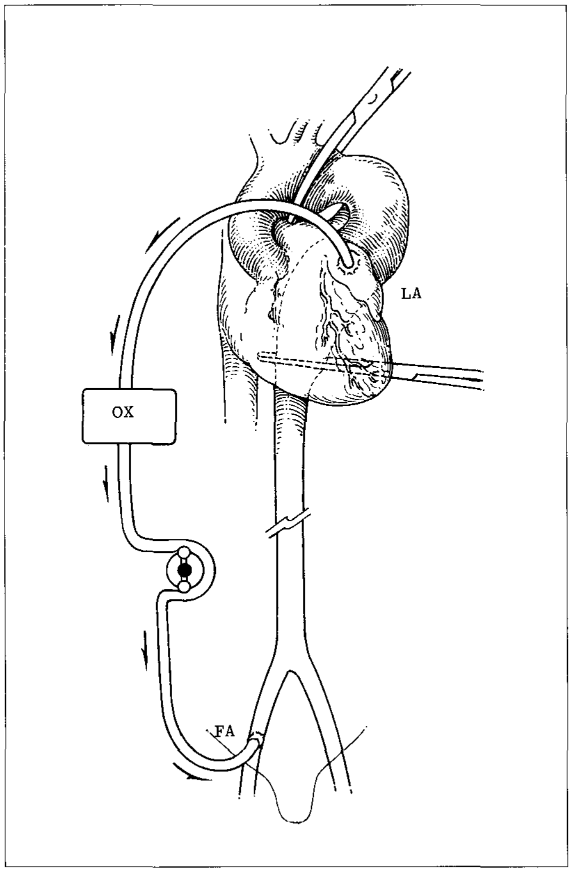


AF = Arterial Filter; FA = Femoral Artery; IVC = Inferior Vena Cava; OX = Oxygenator; SVC = Superior Vena Cava

Aneurysm of the descending aorta

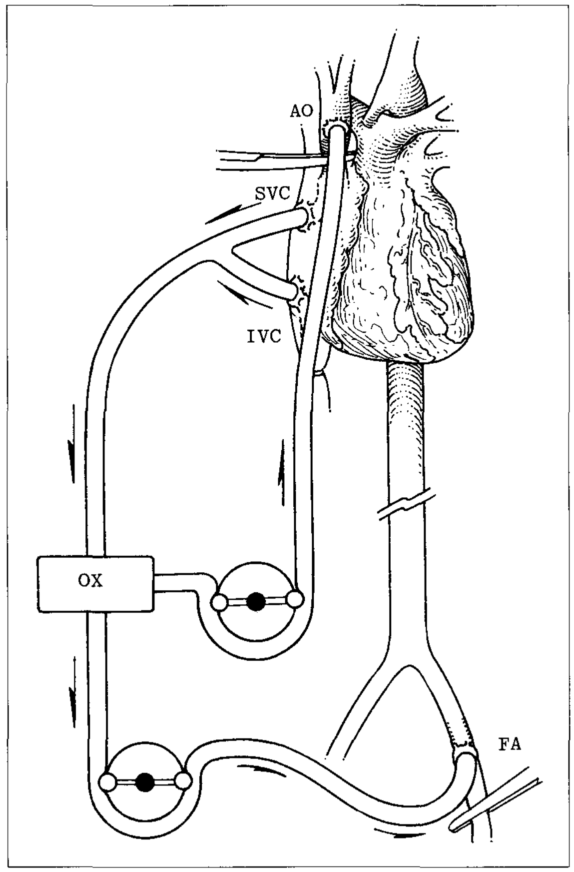
In this group of 34 patients with an average age of 45 ± 12 years, DeBakey III dissecting aneurysms presented in 29 cases, saccular aneurysms in three and false aneurysm in two. Left heart bypass from left atrium to femoral artery was used in all cases. A small size bubble oxygenator was used as a reservoir (Figure 2). The upper part of the body, the heart, lungs, and the brain had the blood supply from the heart. Distal to the descending aortic clamp including the abdominal organs, kidneys, the spinal cord and the lower extremities, the blood sup-

Figure 2: Diagram showing left heart bypass



FA = Femoral Artery; LA = Left Atrium; OX = Oxygenator

Figure 3: Diagram showing separate upper and lower body perfusion



AO = Aorta; FA = Femoral Artery; IVC = Inferior Vena Cava; OX; Oxygenator; SVC = Superior Vena Cava

ply was by the pump. The flow rate ranged from 25-50ml/kg/min, and was adjusted according to the mean arterial pressures measured in the upper and lower extremities, the central venous pressure and the level of blood reservoir. The urine output was an important parameter of lower body perfusion. The body temperature was controlled during bypass. The descending aorta was replaced by prosthesis in 32 cases, intercostal artery reimplantation in two, and partial resection of the thoracic aortic aneurysm with patch repair in two. The mean cross-clamp time of the descending aorta was 106 ± 31 min. There were 32 cases over 60 minutes, 25 cases over 90 minutes, and one case over 120 minutes.

Interrupted aortic arch

For three IAA (B) patients, separate perfusion technique combined with deep hypothermia was utilized during the procedure of reconstruction of the aortic arch. The upper body was perfused through an aortic arch cannula with a low flow rate, and the lower body with continuous adequate flow (Figure 3). The total bypass time lasted from 217-303 minutes.

Budd-Chiari syndrome

In the case of Budd-Chiari syndrome, inferior vena caval (IVA) bypass was established between the left femoral vein and the right atrium (Figure 4). A balloon tipped catheter was inserted through the right femoral vein and pushed up to the level just below the constriction of the inferior vena cava (IVC); the left femoral vein cannula drained blood, which was then pumped into the right atrium. Through a right thoracic incision, the constriction of the inferior vena cava was exposed and its lumen obstructed by inflation of the balloon on the tip of the catheter with fluid or air from below and cross-clamping of the IVC from above. Through monitoring of the mean arterial blood pressure and the mean venous pressure in the superior vena cava (SVC) and IVC, the bypass flow rate was gauged within 27-45 ml/kg/min. The occlusion time of the IVC was 55 minutes. The radical treatment was accomplished under the right heart bypass.

RESULTS

Aneurysm of ascending aorta

The rate of spontaneous recovery of heart beat was 21% (10/47) and 67% (28/46) in the crystalloid cardioplegia and continuous blood cardioplegia groups respectively ($p < 0.05$). The later group showed more stable hemodynamics than the earlier group postoperatively. The RCP time in 16 cases varied from 27-81 minutes. All patients of the group completely returned to consciousness within four hours after the operation. There were no detectable neurological defects postoperatively. The oxygen contents of retrograde cerebral perfusion blood and returned blood from the carotid artery are shown in Figure 5. The results indicated that fairly good cerebral oxygen consumption took place during RCP. From Figure 6, the blood lactic acid level in the jugular vein increased significantly in the DHCA control group. The overall mortality was 8.6%, including 4.3% postoperative death and 4.3% late death. In addition, open anastomosis of the aortic arch to the prosthesis can be done with safety under RCP.

Aneurysm of descending aorta

The operative mortality was 8.8% (3/34). In the early cases, two patients developed myeloplegia postoperatively. It was probably attributed to spinal ischemia, because the major intercostal artery arising from the resected long segment of the aneurysmal thoracic aorta was not reimplanted to the prosthesis.

Interrupted aortic arch

Air embolism occurred in one of the three patients due to technique failure. Nevertheless, all patients recovered and were discharged from the hospital without any sequelae.

Budd-Chiari syndrome

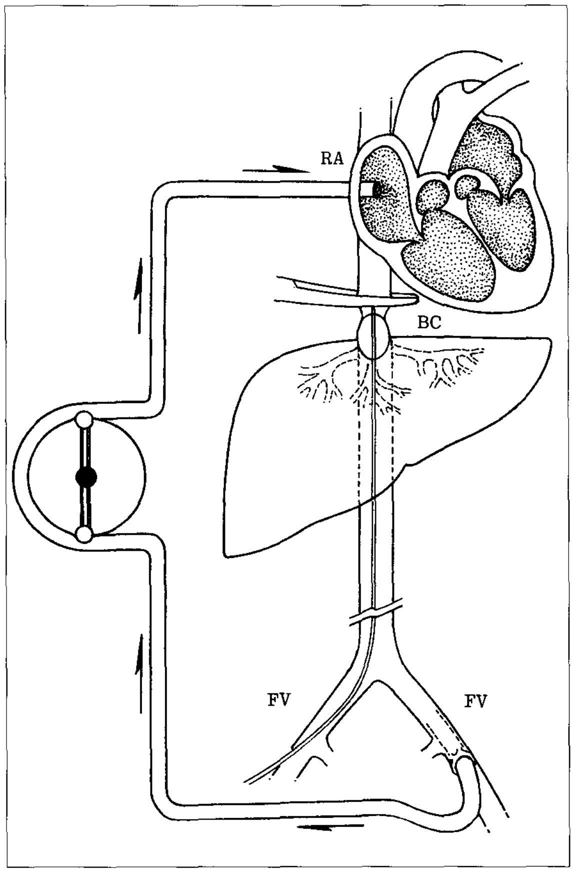
The result of the perfusion technique was satisfactory. Symptoms of obstruction of IVC disappeared after operation, and the patient was discharged from the hospital two weeks postoperatively.

DISCUSSION

Surgical treatment of the great vessel diseases or congenital anomalies are always accompanied by a high surgical mortality, caused not only by the complicated operative procedures, but also the ill effects of extracorporeal circulation of long duration. During the past 12 years, we have used different bypass techniques according to the type of surgical procedure and the need to protect the vital organs affected by the operative intervention. According to our experience, the following points are to be mentioned.

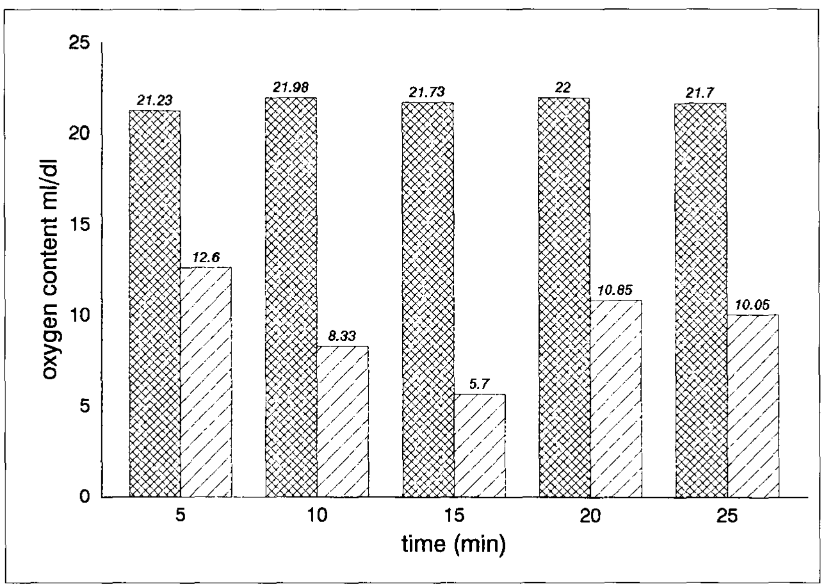
1. Myocardial preservation deserves more attention in cases of aneurysm of the ascending aorta, especially in those with

Figure 4: Diagram showing right heart bypass



BC = Balloon Catheter; FA = Femoral Artery; RA = Right Atrium

Figure 5: The difference in O_2 content between perfused blood and returned blood during CRCP

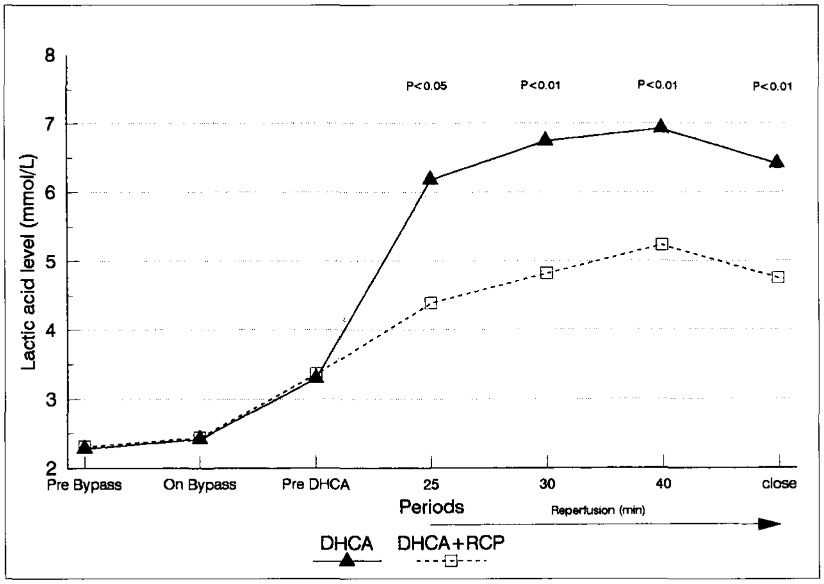


Perfused blood, Returned blood. Values shown as an average.

left ventricular hypertrophy or jeopardized left ventricular function. Our clinical results showed that continuous retrograde coronary sinus perfusion with blood cardioplegia cause less disturbance at the operative field than antegrade perfusion through the coronary ostia and give higher spontaneous resumption rates of heart beat after the release of the aortic cross-clamp.

2. Aortic arch reconstruction is always indicated when aneurysm disease involves the arch, when the false lumen of the dissection extends into the arch (2). DHCA has been widely used for arch surgery since 1975 (3); however, since a long period of circulatory arrest may cause neurologic injury, the general consensus is to try for under 45-60 mintues (4). In 1982, Mills first reported retrograde cerebral perfusion for the treatment of air embolism (5), and Lemole, Udda, Yasuura, and Sun reported retrograde cerebral perfusion for arch surgery (6-9). In 16 cases with aneurysm involvement of the right part of the aortic arch or the whole arch, our attention had focused on cerebral protection by means of retrograde cerebral perfusion with blood through the cannula of the superior vena cava during the period of DHCA (the longest time was 81 minutes). The laboratory results demonstrated that the cerebral oxygen uptake was fairly adequate and the aerobic metabolism was maintained. During RCP, open anastomosis of the aortic arch to the aortic prosthesis without clamping of the arch vessels can be safely performed.

Figure 6: Lactic acid from jugular vein



Values are shown as averages. RCP = Retrograde cerebral perfusion; DHCA = Deep hypothermic circulatory arrest

3. In three cases of IAA undergoing aortic arch reconstruction, separate upper and lower body bypass offered good protection of all the internal organs, including the spinal cord, from ischemia during occlusion of the aorta.

4. For great vessel surgery in general, partial bypass should be the first choice, and total CPB should be avoided. In cases of resection of the thoracic aorta, especially the descending part, left heart bypass is usually sufficient to protect the abdominal organs and the lower extremities if adequate bypass flow rate is adopted. Reimplantation of the major intercostal artery arising from the resected segment of the thoracic aorta should be seriously considered to avoid the occurrence of postoperative myeloplegia.

5. Although right heart bypass was widely used in only one case of BCS, our experience reminds us that its wide clinical application in similar patients is practical.

CONCLUSION

The choice of type of extracorporeal circulation together with myocardial protection (basic technique) for the surgical treatment of the great vessel diseases or congenital anomalies of the great vessels is determined by the location and extent of the related pathoanatomy, and the type of surgery to be performed. The guiding principle is that the basic technique should offer good exposure of the operative field without disturbance, and adequate protection of the internal organs including the brain and spinal cord.

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REFERENCES

1. Ingram JM, Traad EA. Technique: Continuous retrograde cardioplegia followed by warm blood antegrade infusion. J Extra-Corpor Technol. 1989; 21: 56-60.
2. Kimura T, Muraoka R, Chiba Y, et al. Effect of intermittent deep hypothermic circulatory arrest on brain metabolism. J Thorac Cardiovasc Surg. 1994; 108: 658-63.
3. Griepp RB, Stinson EB, Hollingsworth JF, et al. Prosthetic replacement of the aortic arch. J Thorac Cardiovasc Surg. 1975; 70: 1051-63.
4. Galloway AC, Colvin SB, Grossi EA, et al. Surgical repair of type A aortic dissection by the circulatory arrest-graft inclusion technique in sixty-six patients. J Thorac Cardiovasc Surg. 1993; 105: 781-90.
5. Mills, NL, Ochsner JL. Massive air embolism during car-

diopulmonary bypass: Cause, prevention, and management. J Thorac Cardiovasc Surg. 1980: 80: 708-17.
6. Lemole GM, Strong MD, Spagna PM. Improved results for dissecting aneurysm: Intraluminal sutureless prosthesis. J Thorac Cardiovasc Surg. 1982; 83: 249-55.
7. Udda Y, Mili S, Kusuharak K, et al. Surgical treatment of aneurysm or dissection involving the ascending aorta and aortic arch, utilizing circulatory arrest and retrograde cerebral perfusion. J Cardiovasc Surg. 1990; 31: 553-8.
8. Yasuura K, Ogawa Y, Okamoto H. Clinical application of total body retrograde perfusion to operation for aortic dissection. Ann Thorac Surg. 1992; 53: 655-8.
9. Sun YQ, Dong PQ, Yang CR, et al. Application of retrograde perfusion through superior vena cava during deep hypothermia circulatory arrest in operation of aortic aneurysm. Chinese J Thorac Cardiovasc Surg. 1994; 10: 25-27.