Aortic arch aneurysm. Protection of the brain with antegrade selective cerebral perfusion

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(Ital Heart J 2000; 1 (Suppl 3): S117-S119)

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Introduction

Surgical repair of the aortic arch aneurysm still remains a complicated technical and tactical challenge in cardiovascular surgery. This is due, mainly, to the necessity of protecting the integrity of the central nervous system during the period of arch exclusion. Since the central nervous system is so exquisitely sensitive to anoxia, subsequent neurologic injury remains the most feared complication of aortic arch repair. Various techniques including deep hypothermic circulatory arrest (DHCA)[1], retrograde cerebral perfusion (RCP)[2] and antegrade selective cerebral perfusion (SCP)[3-5] have been introduced in order to protect the brain tissue from ischemic injuries. All methods have both advantages and disadvantages.

DHCA is the most common technique, but is associated with a limited safe time and a number of renal, pulmonary and coagulative complications due to hypothermia and prolonged cardiopulmonary bypass time[6-10].

RCP through the superior vena cava has been introduced to improve cerebral protection and to prolong the safe time of circulatory arrest, even though the mechanisms of the protective effect are not entirely understood[11-15]. Moreover the complications due to deep hypothermia and prolonged cardiopulmonary bypass time have remained largely unchanged.

In 1974, DHCA was first used in Bologna by Pierangeli et al.[1] in the treatment of an atherosclerotic aortic arch aneurysm. In November 1996 we began using SCP with moderately hypothermic circulatory arrest as a means to protect the brain during this surgery.

We reviewed our experience with SCP during surgical repair of thoracic aortic aneurysms.

Methods

Patient s profile. Between November 1996 and April 2000, 59 consecutive patients (44 males and 15 females, mean age 63.4 – 11 years, range 32-77 years) underwent operation on the aortic arch with the aid of antegrade SCP. Etiology of aneurysm was atherosclerotic or degenerative in 45 (76%), chronic post-dissection in 13 (22%), and left subclavian artery aneurysm in 1 (2%). Two patients (3.3%) were operated on urgently because of impending aneurysmal rupture.

Associated diseases included hypertension in 38 patients (64.4%), diabetes in 3 (5.1%), coronary artery disease in 18 (30.5%), chronic obstructive pulmonary disease in 12 (20.3%), chronic renal dysfunction, defined as a serum creatinine level > 2 mg/dl in 5 (8.5%). Twenty-four patients were smokers (40.7%). Symptomatic cerebral vascular disease was present in 9 patients (15.3%): 7 had transient ischemic attack and 2 had a stroke. Preoperative evaluation of cerebral circulation was performed in all elective cases with echo-Doppler and/or digital angiography.

Fourteen patients (23.7%) had undergone previous surgical procedures: ascending aorta replacement (AOR) in 2 patients, descending aorta replacement (DAR) in 2, AOR and aortic valve replacement (AVR) in 2, AOR and DAR and coronary artery bypass grafting (CABG) in 1, abdominal aortic aneurysm replacement in 2, AVR in 1, CABG in 3, CABG and AVR in 1.

Operative technique. Median sternotomy was used in 54 patients (91.5%) and median sternotomy plus left antero-lateral thoracotomy in 5 (8.5%). After systemic heparinization a standard cardiopulmonary bypass was instituted. The arterial cannula was inserted into the femoral artery and a single two-stage cannula was placed in the right atrium. The left side of the heart was vented through the right superior pulmonary vein. Myocardial protection was provided with cold crystalloid cardioplegia and topical cooling.

SCP, as described by Kazui et al.[5], was used in all cases in order to prevent ischemic brain damage during aortic surgery. As the patient was cooled down to 22-25 C of nasopharyngeal temperature, the systemic circulation was arrested and the ascending aorta or aortic arch wall was opened. With the patient in the Trendelemburg position, 15 F retrograde coronary sinus perfusion cannulae (Chase Medical Inc., Houston, TX, USA) were inserted into the brachiocephalic and left common carotid arteries through the aortic lumen. The left subclavian artery was clamped or occluded with a Fogarty catheter (IFM, Clearwater, FL, USA). Using a single roller-pump separated from the systemic circulation circuit, cerebral perfusion was initiated at 10 ml/min/kg of body weight and adjusted to maintain a right arterial pressure between 30 and 70 mmHg. Open distal aortic anastomosis was performed with a systemic blood flow of 0.5-1 l/min[16]. Graft replacement was used as the operative technique of aortic reconstruction in all cases. An overview of operative procedures is listed in table I. With respect to the extent of replacement, ascending aorta and hemiarch replacement was performed in 16 patients (27.1%), ascending aorta and total arch replacement in 18 (30.5%), total arch replacement and descending aorta in 3 (5.1%), complete thoracic aorta replacement in 3 (5.1%), total arch replacement in 19 (32.2%). In the case of total arch replacement, supra-aortic vessels were re-implanted using en bloq [17] or separated graft techniques.

Table I. Overview of operative procedures.

Procedure	Patients (n = 59)	%
Aortic arch replacement	19	32.2
Ascending aorta replacement	16	27.1
Ascending aorta + aortic arch replacement	18	30.5
Total thoracic aorta replacement	3	5.1
Aortic arch + descending aorta replacement	3	5.1
Bentall procedure	12	56
Aortic valve replacement	45	56
Coronary artery bypass grafting	45	56

Concomitant procedures included AVR in 20 patients (33.9%), modified Bentall procedure in 18 (30.5%), and CABG in 7 (11.9%).

Extracorporeal circulation data. The mean cardiopulmonary bypass time was 179.6 – 49.7 min (range 114-430 min), and the mean aortic cross-clamping time was 113.3 – 32.7 min (range 61-212 min). Complete circulatory arrest time, defined as the time between the systemic circulation suspension and the SCP beginning, was 3.7 – 1.8 min (range 1-10 min). The mean SCP time was 53 – 29 min (range 18-140 min).

Results

Early mortality. There were no operative deaths. Hospital mortality occurred in 4 patients (6.8%); 2 of them were operated on urgently for impending aneurysmal rupture. The causes of early death were multiple organ failure in all patients.

Early morbidity. Early morbidity included permanent neurological deficit in 1 patient (1.6%), transient neurological deficit, defined as postoperative agitation, lethargy or confusion with complete resolution of symptoms before discharge in 4 patients (6.8%), pulmonary dysfunction in 4 patients (6.8%), renal failure in 2 patients (3.3%), cardiac complications in 6 patients (13.8%), and bleeding in 5 patients (10.1%).

Discussion

A successful resection of thoracic aortic aneurysms bases itself on the technical objectives of brain and spinal cord protection from ischemic and embolic injury, avoidance of coagulopathy and hemorrhage, and prevention of myocardial damage during extracorporeal circulation. Therefore several techniques have evolved. The most common approach is DHCA. This technique presents the disadvantage of a limited safe time of circulatory arrest; furthermore, prolonged cardiopulmonary bypass time, required to cool and re-warm the patient, increases the risk of coagulative deficits, pulmonary complications, microembolisms and endothelial dysfunction[6-10].

RCP associated with DHCA was introduced to prolong the safe time of circulatory arrest. Efficiency and protective mechanisms of RCP still remain controversial[4,11-15]. However, this technique does not avoid complications associated with DHCA.

In November 1996 we started using SCP as described by Kazui et al.[5,16,18] with very encouraging results. SCP prolongs the safe time of circulatory arrest allowing more complex and time-consuming aortic arch reconstruction and may be used with moderate hypothermia reducing complications due to prolonged cardiopulmonary bypass time.

In our experience the technique of moderately hypothermic cardiopulmonary bypass with SCP during surgery of the thoracic aorta provides encouraging results with regard to cerebral and organ function preservation.

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