

Total Circulatory Arrest and Retrograde Cerebral Perfusion During Ascending Aorta and Arch Surgery

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Background: The purpose of this study was to evaluate the impact of Retrograde Cerebral Perfusion (RCP) on the outcome of patients submitted to ascending aorta or aortic arch surgery.

Methods: Between January 1999 and December 2003, 32 patients underwent operations on the ascending aorta and aortic arch or both. Patients were divided into two groups A and B. Group A included 15 patients who underwent operations on the ascending aorta and aortic arch using deep hypothermic circulatory arrest (DHCA) alone, while the other 17 patients of group B underwent operations on the ascending aorta and aortic arch using (DHCA) and retrograde cerebral perfusion (RCP). The mean age was 53.3 ± 10.5 years for patients in group A where it was 54.2 ± 11.6 years in group B. They underwent operations on the ascending aorta and aortic arch or both for acute aortic dissection (type A) (11 patients 73.3% in group A & 15 patients, 88.2% in group B) or chronic aneurysm of the ascending aorta and aortic arch (4 patients (26.6%) & 2 patients (11.7%) in group A and B respectively). Six patients (40%) in group A and 7 patients (41.2%) in group B went to the operating room on emergency basis while the remaining patients were elective. All patients were submitted to deep hypothermia (nasopharyngeal temperature = 18°C), total circulatory arrest (mean = 35.6 ± 12 min. & mean = 36 ± 11.2 min.) for group A & B respectively, and retrograde cerebral perfusion via the superior vena cava (mean = 29.5 ± 10.9) for group B patients only. Bentall procedure was performed in ten patients in each group while supracoronary tube graft replacement of ascending aorta was done in 5 (33.3%) and 7 (41.2%) patients in group A and B respectively. Aortic arch or hemiarch replacement was performed in 3 patients (20%) in group A and in 5 patients (29.4%) in group B. Associated coronary artery bypass grafting was done for 2 patients (11.7%) in group B only. The ICU stay and hospital stay for group A patients were 3.5 ± 1.1 days and 13.2 ± 3.1 days respectively; whereas that for group B patients were 3.1 ± 1 days and 11 ± 2.5 days respectively.

Results: All patients in both groups were similar with regard to the presence of preoperative risk factors, age, emergent status and indications for operation. There were three (20%) hospital deaths in group A patients versus two (11.7%) deaths in group B patients. The incidence of transient neurologic dysfunction was not significantly different between DHCA alone (3 patients = 20%) and DHCA with RCP (3 patients = 17.6%). There was no permanent neurological deficit in group B patients while in group A patients, there were 2 patients with stroke, one died on the 7th day and the other recovered with permanent hemiplegia.

Conclusion: Systemic deep hypothermia (18°C) and retrograde cerebral perfusion are easy to establish, safe and may improve brain protection during ascending aorta and aortic arch surgery.

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One of the challenges presented to the cardiovascular surgeon during the repair of ascending aorta and transverse arch is the provision of both cardiac and cerebral protection. Cardiopulmonary bypass (CPB) and circulatory arrest made graft replacement of the ascending aorta and the aortic arch easier. A safe circulatory arrest period, however, has been difficult to quantify. Circulatory arrest for less than 30 minutes appears to be safe and it is associated with a higher incidence of stroke if it exceeds 45 minutes, whereas circulatory arrest periods more than 65 minutes are associated with increased mortality(1).

In 1964, Borst and colleagues(2) reported the use of deep hypothermic circulatory arrest to repair a traumatic aneurysm of the distal aortic arch. In 1970s, Griep and associates(3) established the value of this technique for resection and grafting of more extensive aneurysms of the aortic arch. Currently, some surgeons use it routinely in all cases of aortic dissection(4). Mills and Ochsner (5) in 1980 first used retrograde cerebral perfusion (RCP) through the superior vena cava in a patient to treat a major air embolus and prevent brain damage. By 1986, Ueda and colleagues (6) had developed the clinical application of RCP as it is currently used for brain protection during circulatory arrest period. We report our clinical experience using both deep hypothermic circulatory arrest and retrograde cerebral perfusion in managing this challenging problem.

Patients and Methods

Between January 1999 and December 2003, 32 patients underwent operations on the ascending aorta and aortic arch or both. Patients were divided into two groups A and B. Group A included 15 patients who underwent operations on the ascending aorta and aortic arch using deep hypothermic circulatory arrest (DHCA) alone, while the other 17 patients of group B underwent operations on the ascending aorta and aortic arch using (DHCA) and retrograde cerebral perfusion (RCP).

The male/female ratio is 12/3 and 15/2 in group A and B respectively. The mean age was 53.3±10.5 (range, 32 to 70) years for patients in group A where it was 54.2±11.6 (range, 32 to 71) years in group B. Emergency operation was performed for 6 patients (40%) in group A and for 7 patients (41.2%) in group B and the rest of operations were elective. The aortic pathology and preoperative data were listed in table 1.

Table 1: Preoperative data

Characteristics	Group A (DHCA)	Group B (DHCA&RCP)
Total number	15	17
Age (years)	53.3±10.8	54.2±11.6
Male/Female	12/3	15/2
Hypertension	10 (66.6%)	14 (82.4%)
Diabetes Mellitus	9 (60%)	11 (64.7%)
Pulmonary disease	2 (13.3%)	2 (11.7%)
Acute type A dissection	11 (73.3%)	15 (88.2%)
Chronic aneurysm	4 (26.6%)	2 (11.7%)
Emergency operation	6 (40%)	7 (41.2%)

DHCA: deep hypothermic circulatory arrest. RCP: retrograde cerebral perfusion.

Operative Technique

Operations were performed through a median sternotomy and total cardiopulmonary bypass (CPB) with DHCA. As for the site of arterial cannulation for CPB, the ascending aorta and the femoral artery were used in cases of group A, while in patients of group B, the right axillary artery, the innominate artery and the femoral artery were used.

Cardiopulmonary Bypass and Retrograde Cerebral Perfusion

A standard cannulation technique was adopted for all the cases, allowing the option of retrograde cerebral perfusion if judged necessary. The basic perfusion circuit comprised a 1/2-inch venous line and a 3/8-inch arterial segment. Cannulation for cardio-pulmonary bypass was undertaken with separate superior vena cava (SVC) and inferior vena cava (IVC) cannulas and a left ventricular vent, returning the blood to the arterial inflow line. A parallel 1/4-inch cannula was connected between the arterial return and the SVC cannula by means of Y connections primed and clamped at both ends. Bypass was instituted with non-pulsatile flows of 2.4L.min⁻¹, and a mean arterial pressure of 50 to 60 mmHg was maintained by intermittent use of alpha stimulants. The patients were cooled to a nasopharyngeal temperature of 18°C with gradual reduction in the systemic flow as the nasopharyngeal temperature decreased. Cooling was done over 45 minutes and may be more in patients of group B while in patients of group A it was done over variable periods of time which are usually less than

30 minutes. In group B patients the distal anastomosis between the aorta and the vascular prosthetic graft was performed using the open technique (no aortic cross clamp), whereas in group A patients it was done while the aorta was cross clamped.

When RCP was used in patients of group B, the SVC cannula was snared (using Nylon tape) to isolate the SVC from the general circulation. RCP was initiated at 200 ml/min up to 300 to 400 ml/min to keep the central venous pressure around 25 to 30 mmHg.

This pressure was measured by separate single-lumen left internal jugular venous cannula isolated from any drug infusions. During the period of circulatory arrest and at the same time with RCP, the femoral arterial cannula was used to infuse arterial blood in the lower half of the body by a rate of 300 to 500 ml per minute to keep the descending aorta and its branches relatively full of blood, this technique was only done for patients of group B. The IVC cannula was left opened to allow free venous drainage from the lower half of the body and coming blood from the arch vessels ostia was returned to the blood reservoir by pump suction from within the open aortic arch (figure. 1).

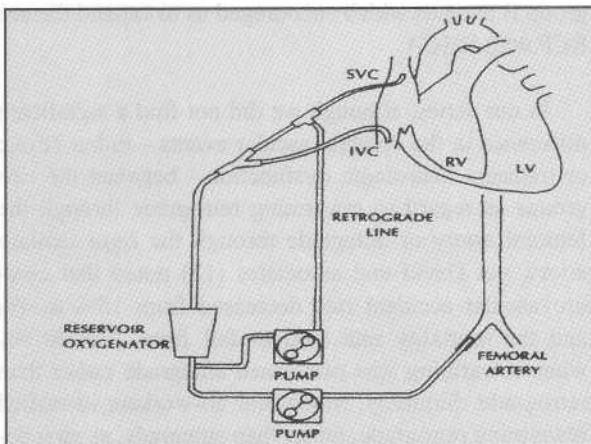


Figure 1: Diagram showing cannulation for cardiopulmonary bypass and retrograde cerebral perfusion. SVC= superior vena cava. IVC=inferior vena cava. RV=right ventricle. LV=left ventricle.

Rewarming was done retrogradely, through the femoral artery, in all patients of group A, while in patients of group B, it was done antegradely through the previously cannulated right axillary or innominate artery.

Bentall operation (replacement of the aortic valve and ascending aorta with reimplantation of the coronary arteries) was performed in 10 patients in each

group while supracoronary tube graft replacement of ascending aorta was done in 5 (33.3%) and 7 (41.2%) patients in group A and B respectively. Aortic arch or hemiarch replacement was performed in 3 patients (20%) in group A and in 5 patients (29.4%) in group B. Associated coronary artery bypass grafting was done for 2 patients (11.7%) in group B only.

The mean cardiopulmonary bypass time and circulatory arrest time were almost equal in both groups (126±32 minutes for group A versus 130±28 minutes for group B) (35±12 minutes for group A versus 36±11 minutes for group B). The mean retrograde cerebral perfusion time for group B patients was 29±10 minutes. Table 2 shows the operative characteristics of both groups. The ICU stay and hospital stay for group A patients were 3.5±1.1 days and 13.2±3.1 days respectively; whereas that for group B patients were 3.1±1 days and 11±2.5 days respectively (figure. 2)

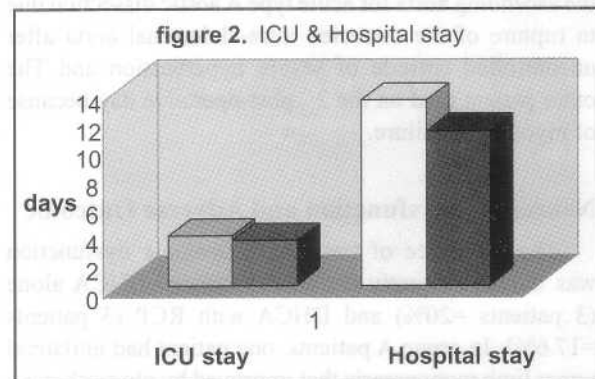


Table 2: Operative characteristics.

Characteristics	Group A (DHCA)	Group B (DHCA&RCP)
Bentall procedure	10 (66.6%)	10 (58.2%)
Supra-coronary tube graft	5 (33.3%)	7 (41.2%)
Arch & hemiarch replacement	3 (20%)	5 (29.4%)
Associated CABG		2 (11.7%)
Total pump time	126.6±32.8 min.	130±28.9 min.
Total circulatory arrest time	35.6±12 min.	36±11.2 min.
RCP time		29.4±10.9 min.

CABG: coronary artery bypass grafting. RCP: retrograde cerebral perfusion.

Results

All patients in both groups were similar with regard to the presence of preoperative risk factors, including hypertension, diabetes mellitus, renal impairment, pulmonary disease and peripheral vascular disease. The groups were also similar in age, emergent status and indications for operation. Important preoperative characteristics were listed in table 1.

Mortality and Morbidity

We have three (20%) hospital deaths in group A patients versus two (11.7%) deaths in group B patients. In group A patients, one patient died intraoperative because of uncontrollable bleeding and the other two patients, one died on the 7th postoperative day because he did not regain his consciousness at all due to extensive cerebral infarction, while the other one died after 3 weeks due to mediastinitis. For patients of group B, we had one patient died 15 days after uncomplicated replacement of the ascending aorta for acute type A aortic dissection due to rupture of the dissected intra-abdominal aorta after uncontrolled episode of severe hypertension and The other patient died on the 2nd post-operative day because of myocardial failure.

Neurologic Dysfunction and Adverse Outcome

The incidence of transient neurologic dysfunction was not significantly different between DHCA alone (3 patients =20%) and DHCA with RCP (3 patients =17.6%). In group A patients, one patient had unilateral upper limb monoparesis that improved by physiotherapy and the other two patients had delayed consciousness recovery due to brain oedema. On the other side 2 patients suffered post-operative confusion and psychosis for few days and disappeared spontaneously without treatment and the third patient had post-operative paraplegia that was improved completely after 3 months.

There was no permanent neurological deficit in group B patients while in group A patients, there were 2 patients with stroke, one died on the 7th day and the other recovered with permanent hemiplegia.

Discussion

Experimental studies have shown that RCP supplies only 20% to 25% of the metabolic requirements of the brain as most of the blood is shunted through the collaterals before it reaches the capillaries of the brain; however, when combined with topical cooling, RCP helps maintain cerebral hypothermia and has a flushing effect to remove air from the cerebral vascular bed (7&8). On

the basis of these findings and the favorable clinical results, many centers have advocated the routine use of RCP during DHCA(9,10&11).

Bavaria and associates (12) reported that RCP decreased mortality rate from 38% to 7% and stroke rate from 48% to 0%. Many other workers - (Coselli & LeMaire(13); Ehrlich and colleagues(14) and Safi and colleagues(15) - also reported dramatic improvement in their results using supplemental RCP with DHCA compared to DHCA alone.

In the current study, we found no significant difference between DHCA alone and DHCA with RCP with regard to operative mortality (20% versus 11.7%) and transient neurologic dysfunction (20% versus 17.6%). These findings support the hypothesis that RCP remains optional during the procedures involving the arch, as long as the core body temperature is low (16). RCP may be mandatory, however, when using circulatory arrest under only moderate systemic hypothermia (temperature = 19 to 28, mean of 23). This technique was introduced by the Toronto group (17) in which, RCP was necessary to keep the brain cool during the brief periods of hypothermic circulatory arrest (HCA). However, the stroke rate was 13.3% in group A patients and 0% in group B patients which encouraged us to expand the use of RCP with DHCA.

In our series, although we did not find a significant difference in the cerebrovascular events - either stroke or transient neurologic dysfunction - between the two groups as regard to rewarming retrograde through the femoral artery or antegrade through the right axillary artery, yet David and associates (18) noted that cerebrovascular accident rate decreased from 15% to 4% and the mortality rate tend to fall from 20% to 9% when rewarming was performed antegrade rather than retrograde. Similarly, Moon and co-workers identified rewarming retrograde, rather than antegrade, as an independent risk factor for transient neurologic dysfunction (19%). It is important to note, however, that these findings may have been influenced by the initial decision to cannulate through the femoral artery in patients believed to have significant proximal atheromatous aortic disease. The more frequent use of axillary artery cannulation in appropriate patients can eliminate the need to reposition the inflow arterial cannula during rewarming and may improve the neurologic recovery.

Finally, the Mount Sinai group (20) stated that early clinical and laboratory results regarding RCP for thoracic aortic surgery were promising. However, it is un-

clear whether RCP provides effective cerebral perfusion, metabolic support, washout of embolic material, or improved neurological and neuropsychological outcome. Nevertheless, RCP remains in common use worldwide.

In conclusion systemic deep hypothermia (18°C) and retrograde cerebral perfusion are easy to establish, safe and may improve brain protection during ascending aorta and aortic arch surgery, however, more time and patients are required for better evaluation.

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