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Original Article

Axillary Artery Cannulation for Surgery on the Hostile Aorta

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Abstract **Operative repair of the aortic arch or operation on the unfavorable condition of the ascending aorta is a challenging surgery. A series of axillary artery cannulation on the difficult aortic surgery at Ramathibodi Hospital was reported. Overall results as well as cannulation related complications were analyzed. Axillary artery cannulation makes difficult aortic surgery safer with acceptable complication rates.**

Key words: **aortic surgery, axillary artery cannulation, cerebral perfusion**

Introduction

To repair the aortic arch or to operate on the unfavorable condition of the ascending aorta for example, acute type A aortic dissection, calcified aorta or redo-sternotomy is a challenging surgery. Furthermore, if the aortic arch is planned to be open, classically, deep hypothermia circulatory arrest is unavoidable[1]. If the duration of cerebral ischemic time is more than 45 minutes, even under deep hypothermia, serious neurodeficit would happen[2,3]. By using axillary artery cannulation, the brain is continuously perfused and lower body circulatory arrest could be short with lower body perfusion under mild-hypothermia. We reported our series of axillary artery cannulation on the difficult aorta and assessed over all results as well as cannulation related complications.

Materials and Methods

From January 2007 to December 2008, seven patients with difficult conditions of the ascending aorta were operated at Ramathibodi Hospital by a single surgeon (W.W.) with the same technique (regional cerebral perfusion through the right axillary artery with lower body perfusion). Of these, one patient of chronic type A aortic dissection was operated with different technique (regional cerebral perfusion through the innominate artery with lower body perfusion) therefore, total number of the patients in this report was 6. Demographic data, mortality, morbidity were recorded.

Operative Techniques

All patients, except patient No. 5 and 6, in this

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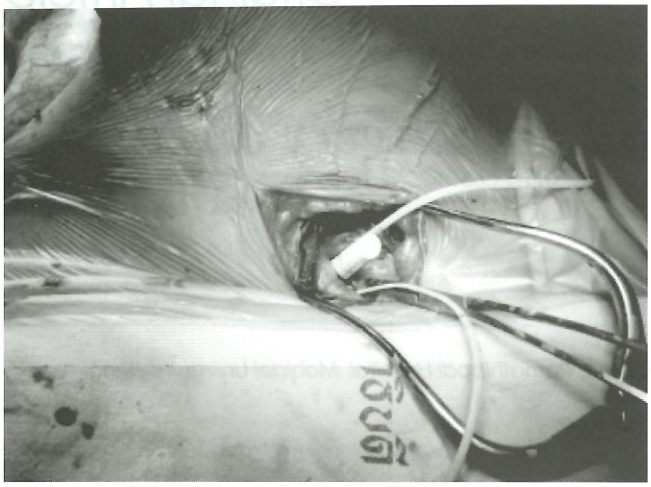

Figure 1 Pictured from the head of the patient, a piece of GORTEX® graft was anastomosed to the right axillary artery (now laterally occluded). The free end of the graft functions as a port to perfuse the brain which perfusion pressure was measured from the right radial artery.

report underwent complex aortic surgery with two arterial inflows (patient No. 5 and 6 underwent surgery with single right axillary artery cannulation): right axillary artery and single (right or left) common femoral artery. To perfuse the brain while the aortic arch was opened, the right axillary artery was exposed via infraclavicular incision and bridged to the heart lung machine with a segment of GORTEX® graft, Figure 1. Simultaneously, while the aortic arch was open; the lower body was perfused with another arterial cannulation through the common femoral artery, with inflated No. 24 Foley's catheter as an internal clamp in the descending aorta through the open arch. Venous drainage was performed through the right atrium. However, in patient No. 5, lower body perfusion was not applied because of hemodynamic instability; she was perfused with single arterial cannula via the right axillary artery with moderate hypothermia.

According to Wozniak et al 1999[4] and Pacini et al 2007[5], mean blood pressure of 40-70 mmHg of the right radial artery under 25-28 C is adequate for the brain perfusion under innominate artery perfusion. The mean right radial artery pressure of the patients in this series was kept above 50 mmHg while the left common carotid and the left subclavian artery were temporarily occluded. With both arterial inflows, blood flow from the heart lung machine was able to be maximized not less than 2.5 $L/m^2/min$ in all patients.

In patient No. 5 and 6, lower body perfusion was not used while the aortic arch was opened. In those cases, lower bodies were protected from ischemia with low temperature only. However, the brain was continuously perfused antegradely through the right axillary artery. Other perfusion details were in Table 1.

Results

Of these six patients, there were four women and two men. The median age was 60 years old (23-76). Diagnosis was made in five cases of type A aortic dissection and one case of ruptured aortic arch aneurysm. Other demographic data were described in detail in Table 2.

Cardiopulmonary bypass time ranges from 124 minutes (patient No. 5) to 379 minutes (patient No. 1). There were two fatal cases, i.e. patient No. 5 and 6, however, the cause of death in patient No. 6 is from other causes rather than cardiovascular.

Patient No. 5 could not be weaned off from cardiopulmonary bypass after technically successful operation and passed away in the operating room. It

Table 1 Detail of cardiopulmonary bypass

Patient	Diameter of the graft bridged to the axillary artery	Size of axillary cannula	Size of the femoral canula	Lowest temperature	Bypass Time (min)
1	8 mm	18 Fr	22 Fr	25	379
2	8 mm	18 Fr	22 Fr	21	332
3	6 mm	16 Fr	16 Fr	32	275
4	6 mm	16 Fr	20 Fr	25	278
5	8 mm	7 mm	-	28	124
6	6 mm	18 Fr	-	22	201

Table 2 Demographic data of the patients

Patient	Gender	Age	Weight	Diagnosis	Underlying Diseases	Operation
1	F	50	55	Acute type A dissection	-	BT + ET
2	M	59	-	Acute type A dissection	HT	HTAVR + ET
3	F	23	72	Acute type A dissection	Marfan's Syndrome with pregnancy	BT
4	M	62	86	Chronic type B (aortic arch)	Post ascending aneurysm-ectomy, HT, Renal Cell Carcinoma	ET + TEVAR in the same operation
5#	F	76	55	Ruptured Aortic Aneurysm (aortic arch)	HT	ET
6#	F	61	36	Acute type A dissection	Hypopharyngeal Carcinoma (wide spreading)	BT

HT = Hypertension, ET = Elephant trunk operation, BT = Bentall's operation, #dead case

was believed that she had suffered from prolonged hypotensive state preoperatively from ruptured aneurysm. ICU stay and hospital stay were reported in Table 3.

All except patient No. 5 and 6 were discharged home with favorable conditions. Patient No. 5 died intraoperatively and Patient No. 6 died 4 months postoperatively which was not cardiovascular related problem. Patient No. 2 developed perioperative type B aortic dissection at the thoracoabdominal aorta that made him paraparetic temporarily. However, with proper rehabilitation, he could walk without any walking aid and no bowel-bladder symptom. Complications were summarized in Table 4.

Follow up was completed in all survived patients until July 2009, patients Number 1 underwent further endovascular repair without any complication.

Table 3 Hospital stay and ICU stay

Patient	ICU stay	Hospital stay after operations
1	7	12 days
2	5	26 days
3	6	12 days
4	6	15 days
5#	-	-
6#	2	4 months

#dead case

Discussion

Operations of the ascending aorta-aortic arch complex have never been easy. Traditionally, while the arch is opened, all three arch vessels need to be occluded to prevent air emboli and the circulation to the whole body has to be stopped while the arch is being sutured. Although deep hypothermia is a protective factor of ischemic injury, it has a limitation. If the brain is not perfused for more than 45 minutes, even under temperature of 15-18 °C, permanent brain injury is believed to happen[2,3]. Forty five minutes is a limiting factor. Other than deep hypothermic circulatory arrest, there are other ways to lessen chance of the ischemic insults: retrograde cerebral perfusion through the SVC, selective brain perfusion on the arch vessel(s). Hagel et al[6] in 2001 concluded that unmodifiable factors such as age, concomitant operations or disease related conditions affect neurodeficit postoperatively. Furthermore, if the other parts of the aorta needed to be fixed for example, aortic root or the aortic valve, the operation would be much more time consuming. Most reports[6-8] were done under experienced aortic surgeons, therefore the results conducted by their teams are unquestionably excellent. However, in the case that there is no world-class aortic surgery team at the hospital, a more reliable, reproducible way of surgical practice should be performed. There are reports about axillary artery cannulation dealing with challenging aortic conditions with very good results[9-12].

We believed that regional cerebral perfusion through the right axillary artery with lower body perfusion was the way of practice while the aortic arch was opened to perform the elephant trunk procedure or the ascending aorta was quite unhealthy. In all

Table 4 Complications in all cases of axillary artery cannulation

Patient	Bleeding that needs surgical correction	Renal failure that needs diasysis	Neuro-deficit	Pulmonary complications	Pericardial effusion	Brachial plexus injury	Others
1	N	N	N	N	N	N	N
2	N	N	Paraparesis, fully recovered	N	N	N	Permanent vocal cord paralysis
3	N	N	N	N	N	N	N
4	N	N	N	N	N	N	N
5#	N/A	N/A	N/A	N/A	N/A	N/A	N
6#	N	N	N	Pulmonary metastasis	N	N	N

N/A = data not available, #dead case

survived cases, ICU stay is about a week and they are all recovered from any difficulty in the follow up period, except true vocal cord paralysis in patient No. 2. Focusing on the Foley's catheter as an internal aortic clamp, if it was placed properly in the descending thoracic aorta, the lower body perfusion is presumed to be continuous (lower body circulatory arrest was less than a minute when the internal clamp was being positioned.).

Conclusion

Axillary artery cannulation makes difficult aortic surgery more surgeon-friendly. Although the numbers of the patients in this series are small, single vessel perfusion to the brain (right common carotid artery and right vertebral artery) is believed to be safe even in the elderly. However, if the situation is allowed to investigate the degree of carotid stenosis preoperatively, it should be done.

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