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Comparison of the Outcomes between Axillary and Femoral Artery Cannulation for Acute Type A Aortic Dissection

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Background: At present, many surgeons prefer axillary artery cannulation because it facilitates antegrade cerebral perfusion and may diminish the risk of cerebral embolization. However, axillary artery cannulation has not been established as a routine procedure because there is controversy about its clinical advantage. **Materials and Methods:** We examined 111 patients diagnosed with acute type A aortic dissection between January 2000 and December 2009. The right axillary artery was cannulated in 58 patients (group A) and the femoral artery was cannulated in 53 (group F). The postoperative outcomes were retrospectively reviewed and compared between the two groups. **Results:** There were 46 male and 65 female patients with a mean age of 58.9±13.1 years (range, 26 to 84 years). The extent of aortic replacement in both groups did not differ. There were 8 early deaths (7.2%) and 2 late deaths (1.8%). The mean follow-up duration was 46.0±32.6 months (range, 1 month to 10 years). Transient neurologic dysfunction was observed in 11 patients (19.0%) in group A and 14 patients (26.4%) in group F. A total of 11 patients (9.9%) suffered from a permanent neurologic dysfunction. Early and delayed stroke were observed in 6 patients (10.3%) and 2 patients (3.4%), respectively, in group A as well as 2 patients (3.8%) and 1 patient (1.9%), respectively, in group F. There were no statistical differences in the cannulation-related complications between both groups (3 in group A vs. 0 in group F). **Conclusion:** There were no differences in postoperative neurologic outcomes and cannulation-related complications according to the cannulation sites. The cannulation site in an aortic dissection should be carefully chosen on a case-by-case basis. It is important to also pay attention to the possibility of intraoperative malperfusion syndrome occurring and the subsequent need to change the cannulation site.

Key words: 1. Aorta, surgery
2. Axillary artery
3. Femoral artery
4. Cardiopulmonary bypass
5. Cannulation

INTRODUCTION

The femoral artery has been used as an arterial cannulation site for cardiopulmonary bypass (CPB) surgery when the ascending aortic cannulation is not suitable, as in acute Stanford type A aortic dissection. The main advantage of this

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method has been the avoidance of direct manipulations of the ascending aorta [1]. However, it has been reported that femoral cannulation has increased complications such as retrograde embolization and malperfusion of the true lumen in treating type A aortic dissections [1,2]. In the late 1990s, the axillary or subclavian artery was introduced as an alternative site for an arterial cannulation in patients requiring aortic arch surgery and type A aortic dissection. Subsequently, axillary artery cannulation has been described as more beneficial than femoral cannulation for the repair of type A aortic dissection [3-5]. At present, many surgeons prefer axillary artery cannulation, especially in patients with type A aortic dissection, because it facilitates antegrade cerebral perfusion and reduces the risk of cerebral embolization [3-6]. However, whether the axillary artery should be used routinely in type A aortic dissection surgery has been controversial [1,7,8]. In this study, we evaluated the impact of the arterial cannulation site on the perioperative results after acute type A aortic dissection surgery, especially regarding the potential for postoperative retrograde embolism and intraoperative malperfusion syndrome.

MATERIALS AND METHODS

Between January 2001 and December 2009, 111 consecutive patients underwent surgery for acute type A aortic dissection at our hospital. The femoral artery for arterial cannulation was used in 53 patients (group F) and the axillary artery in 58 patients (group A). Operations were performed by three individual surgeons.

There were 46 male and 65 female with a mean age of 58.9±13.1 years (range, 26 to 84 years). In five patients (4.5%), preoperative neurologic symptoms such as transient ischemic attack and transient drowsy mentality had developed. The clinical characteristics of the patients are detailed in Table 1.

Table 1. Preoperative characteristics of the two groups

	Axillary (n=58)	Femoral (n=53)	p-value
Male:female	26:32	20:33	0.56
Age (yr)	57.0±13.8	61.1±12.2	0.10
Concomitant disease			
Hypertension	36	35	0.69
Marfan syndrome	4	2	0.68
Smoking	13	7	0.23
Neurologic events	1	4	0.19
Malperfusion			
Cerebral	1	4	0.19
Visceral	2	0	0.50
Lower extremity	2	0	0.50
Cardiac tamponade	5 (8.6%)	11 (20.8%)	0.10

1) Surgical techniques

To avoid a malperfusion, all patients were evaluated for occlusive disease and dissection of femoral and axillary arteries by comparing radial and femoral arterial blood pressure and oxymetric data, as well as computed tomography images. The affected arteries should not be cannulated if a significant stenosis and dissection are identified in the preoperative examinations.

Before 2003, femoral cannulation was selected, preferably via the right femoral artery, if dissection was absent in the right iliac artery. In femoral cannulation, after a purse-string suture is placed on the exposed femoral artery, a 17 Fr or 18 Fr percutaneous femoral arterial cannula is inserted into the femoral artery by using the Seldinger technique.

We have been using the axillary artery in acute type A aortic dissection since 2003 as the arterial cannulation site if the patient has stable vital signs. In this method, the axillary artery was exposed via an infraclavicular approach. The pectoralis major muscle was split. After clamping of the vessel and longitudinal arteriotomy, either direct cannulation with a 17 Fr or 18 Fr percutaneous femoral arterial cannula or an end-to-side anastomosis of an 8 mm Hemashield graft was performed. We have also been using the femoral artery in acute type A aortic dissection as the cannulation site if the patient was hemodynamically unstable.

The arterial pressure of the radial and femoral arteries and transesophageal echocardiography (TEE) were routinely monitored by an anesthesiologist. After the cardiopulmonary bypass was initiated, we routinely compared the pressures of the radial and femoral arteries, and evaluated the area ratio of the true lumen and false lumen in the descending aorta with TEE to detect an initial occurrence of intraoperative malperfusion. We changed the arterial cannulation site if we suspected that the patients had malperfusion syndrome caused by inadequate perfusion.

During aortic surgery, our brain protection methods were deep hypothermia concomitant with retrograde cerebral perfusion or selective antegrade cerebral perfusion. Also, neuroprotective drugs such as thiopental and steroid were administered and the head was cooled with a topical ice-package.

2) Definition of clinical parameters

Early mortality was defined as in-hospital death. Transient neurologic dysfunction was defined as the occurrence of postoperative confusion, agitation, and delirium without focal neurologic symptoms. Permanent neurologic injury was defined as the new onset of focal injury (stroke) or global dysfunction (coma) after a surgical repair with and without morphological correlates in a brain computed tomography or magnetic resonance image. Early stroke was defined as permanent neurologic injury being evident after the emergence from anesthesia. Delayed stroke was defined as permanent neurologic injury after first awaking from surgery without a neurological deficit.

3) Statistical analysis

Statistical analysis was performed with SPSS ver. 18.0 (SPSS Inc., Chicago, IL, USA). Continuous variables are expressed as mean±standard deviation. Categorical variables are expressed as percentages. After testing for normality of distribution, continuous variables were compared using the Student's t-test. Categorical variables were compared using the chi-square test or Fisher's exact test as appropriate. Long-term survival rates in each group were analyzed with the Kaplan-Meier method. The results were considered statistically significant at p-values of less than 0.05.

RESULTS

The ascending aorta was replaced in all cases. The most frequent extent of aortic replacement in both groups was ascending aorta replacement only. The extent of aortic replacement did not differ between the two groups (p=0.8). The detailed operative procedures are shown in Table 2.

The cardiopulmonary bypass time and aortic cross clamp time were longer in group F. However, total circulatory arrest time and cerebral perfusion time were not different in the two groups. The lowest rectal temperature was lower in group F. During the first years of this study, systemic cooling had been considered to be adequate for hypothermic circulatory arrest when the rectal temperature had reached 18°C, but rectal temperature has been maintained between 23°C and 27°C for hypothermic circulatory arrest since 2004. The detailed operative data are shown in Table 2.

Table 2. Surgical data

	Axillary (n=58)	Femoral (n=53)	p-value
Extent of aortic replacement			0.70
Ascending aorta±hemiarch	44 (75.9)	42 (79.2)	
Ascending aorta+arch	2 (3.4)	4 (7.5)	
Ascending aorta+root	8 (13.8)	4 (7.5)	
Ascending aorta+AVR	4 (6.9)	3 (5.7)	
CPB time (min)	168.7±48.4	188.6±52.2	0.04
ACC time (min)	85.4±30.9	98.4±32.5	0.03
TCA time (min)	23.9±3.2	38.2±21.0	0.30
No cerebral perfusion	6 (10.3)	12 (22.6)	0.12
Cerebral perfusion	52 (89.7)	41 (77.4)	
ACP	34	24	
RCP	1	10	
Cerebral perfusion time (min)	32.8±17.8	30.9±14.8	0.63
Lowest rectal temperature (°C)	24.4±3.1	21.7±2.5	$<$0.01

Values are presented as number (%) or mean±standard deviation. AVR=aortic valve replacement; CPB=cardiopulmonary bypass; ACC=aortic cross clamp; TCA=total circulatory arrest; ACP=antegrade cerebral perfusion; RCP=retrograde cerebral perfusion.

The consciousness time and mechanical ventilation time after operation were 19.7±29.5 and 53.9±61.0 hours in group A, and 33.1±63.3 and 62.2±55.0 hours in group F, respectively. The postoperative length of stay in the intensive care unit was 7.4±5.6 days in group A and 8.3±6.4 in group F. There were no statistically significant differences in the postoperative outcome of the two groups (Table 3).

There were 3 early deaths in group A and 5 in group F. Three patients died of sepsis on postoperative day 7, 11, and 25, respectively. The other 2 patients died of multi-organ failure, subsequent to a postoperative low cardiac output on postoperative day 5 and 12, respectively. Another 2 patients died of aortic rupture on postoperative day 3 and 30, respectively, and 1 patient died of disseminated intravascular coagulation and postoperative bleeding on postoperative day 1.

Table 3. Postoperative outcomes and complications

	Axillary (n=58)	Femoral (n=53)	p-value
Recovery of consciousness (hr)	19.7±29.5	33.1±63.3	0.35
Ventilator (hr)	53.9±61.0	62.2±55.0	0.47
ICU stay (day)	7.4±5.6	8.3±6.4	0.46
Discharge time (day)	24.1±22.9	21.7±12.4	0.51
Early mortality	3 (5.2)	5 (9.4)	0.48
Late mortality	2 (3.4)	0	0.50
Neurologic complications			
Transient neurologic dysfunction	11 (19.0)	14 (26.4)	0.37
Permanent neurologic injury	8 (13.8)	3 (5.7)	0.21
Early stroke	6 (10.3)	2 (3.8)	0.27
Delayed stroke	2 (3.4)	1 (1.9)	1.00
Re-sternotomy for bleeding control	5 (8.6)	2 (3.8)	0.44
Mediastinitis	2 (3.4)	0	0.50
Myocardial infarction	1 (1.7)	0	1.00
Tracheostomy	2 (3.4)	4 (7.5)	0.42
Hemodialysis	2 (3.4)	2 (3.8)	1.00
Cannulation related complications			
Malperfusion (conversion)	1 (1.7)	0	1.00
Arterial injury	2 (3.4)	0	0.50

Values are presented as mean±standard deviation or number (%). ICU=intensive care unit.

Except for these 8 patients, all patients received follow-up care and the mean follow-up duration was 46.0±32.6 months (range, 1 month to 10 years). There were 2 late deaths (1.8%) during the follow-up period. One patient, an 81-year-old female, died suddenly 1 week after discharge. The other patient had liver cirrhosis, end stage renal disease, and suffered from bacterial mediastinitis. He was hopelessly discharged on postoperative day 106 and died of chronic illness 1 month after discharge.

Transient neurologic dysfunction was observed in 11 patients (19.0%) in group A and 14 patients (26.4%) in group F. A total of 11 patients (9.9%) suffered from a permanent neurologic dysfunction. Early and delayed stroke was observed in 6 patients (10.3%) and 2 patients (3.4%) in group A as well as 2 patients (3.8%) and 1 patient (1.9%), respectively.

Five patients with preoperative cerebral malperfusion recovered without postoperative neurologic deficit or sequelae. In group A, the axillary artery was injured in 2 patients during cannulation. The axillary artery was cannulated directly in 1 patient and with a side graft in 1 patient. In 1 patient in whom direct cannulation of the axillary artery was performed initially, the cannulation site was changed to the ascending aorta because we suspected malperfusion syndrome. In contrast, no patients had cannulation-related complications in group F. All related postoperative complications are shown in Table 3.

DISCUSSION

During surgery for type A aortic dissection, cerebrovascular injury is one of the major causes of morbidity and mortality [5,9]. Possible causes for this neurologic complication, such as malperfusion, cerebral embolism, and global ischemia during deep hypothermic circulatory arrest are currently being discussed [1,3,9,10]. The attempt to avoid neurologic complications has directed the attention of surgeons toward the arterial cannulation site.

Femoral artery cannulation has been used for CPB since the 1950s and the femoral artery has been the primary site for arterial cannulation in surgery for type A aortic dissection [11,12]. However, femoral artery cannulation has been associated with a greater risk of stroke in some patient groups, particularly those with concurrent thoracoabdominal aortic or iliac aneurysmal disease. This was probably due to atherosclerotic debris or thrombus in these segments that had been pumped from these aneurysms or dissection sites retrograde to the brain [12-15]. In addition, retrograde perfusion through the femoral artery may further exacerbate dissected intimal flaps and determine organ malperfusion, progressive arch vessel compromise, and neurologic injury [2,4,12]. Previous studies have reported an incidence of malperfusion syndrome with femoral cannulation of 2.5% to 13% [1,7,12]. However, in our study, there was no significant difference in the early stroke incidence of the two groups. We also did not experience any malperfusion syndrome caused by inadequate retrograde perfusion.

We did not perform femoral artery cannulation in patients who had severe atherosclerosis in the thoracoabdominal aorta.

In addition, we cannulated the femoral artery under the guidance of TEE in order to confirm the insertion of the guidewire into the true lumen. TEE also provides information about the adequacy of perfusion through the descending aortic true lumen during cardiopulmonary bypass. We strongly believe that those strategies helped us avoid the occurrence of malperfusion syndrome in the femoral artery cannulation group. Recently, the theoretical advantages of axillary artery cannulation in ascending aorta and arch surgery have become apparent. These possible advantages include a decreased risk of stroke from embolic material, a lower likelihood of malperfusion with aortic dissection, and less disruption of the atheroma or calcified plaques. Also, the major advantage of axillary artery cannulation is that continuous blood flow to the brain is provided by means of selective antegrade cerebral perfusion during the steps where a bloodless field is required for the operation [3-6,10,15,16]. For these reasons, many surgeons prefer cannulating the axillary artery instead of the femoral artery. However, in our experience there was a tendency toward greater rates of permanent neurologic injury in patients with axillary artery cannulation than in those with femoral artery cannulation (13.8% vs. 5.7%, p=0.37), although the small number does not have a statistical impact. Nevertheless, this leads us to believe that axillary artery cannulation for CPB is not always more cerebroprotective than femoral artery cannulation.

Furthermore, axillary artery cannulation requires a more precise technique and is more time consuming than femoral cannulation. The complications of this technique, such as axillary artery injury, brachial plexus injury, low CPB flow, and arm ischemia, are becoming well-known with increased use. Our experience with axillary artery cannulation in this study revealed artery injury in 2 (3.4%) patients. In the literature, these complications have ranged between 0% and 5% [17,18]. In our series, malperfusion occurred in 1 (1.7%) patient and the cannulation site was changed from the axillary artery to the ascending aorta. However, no patients with femoral cannulation had cannulation-related complications.

CONCLUSION

There were no differences in postoperative neurologic outcomes or cannulation-related complications between the two groups in our study. Axillary artery cannulation was not shown to be superior to femoral cannulation. The optimal cannulation site for repair of acute type A aortic dissection is still controversial because of the lack of any randomized prospective trials. The cannulation site in aortic dissection should always be carefully chosen on a case-by-case basis depending on several factors (e.g., the extent of the dissection, impairment of the true lumen, severity of atherosclerotic aneurysm of the thoracoabdominal aorta). Furthermore, it is important that precise attention is paid to the occurrence of intraoperative malperfusion syndrome and the need to change the cannulation site during surgery.

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