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

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Abstract

Objective: To compare the application and outcome of femoral and axillary arterial cannulation in adult type A aortic dissection surgery.

Methods: 108 patients underwent type A aortic dissection surgery were divided into as the femoral artery cannulation group (n=53) and the axillary artery cannulation group (n=55) according to intraoperative arterial cannulation. General condition, cardiopulmonary bypass time and postoperative major complication retrospectively reviewed and compared between. Multivariate logistic analysis models were used to identify the independent predictors of risk factors of death.

Result: Operative mortality was not influenced by cannulation site (18.1% for axillary cannulation *vs*. 15.1% for femoral cannulation. Multivariate logistic analysis showed that age (age≥70 years) and extracorporeal cardiopulmonary bypass time (CPB≥250 min) were independent risk factors for surgical death. Early stoke, renal injury and cognitive dysfunction were comparable between the groups.

Conclusion: The outcomes of femoral *versus* axillary arterial cannulation in patients with acute type A aortic dissection are comparable. The choice of arterial cannulation site should be individualized based on different patient risk profiles. In addition, pre-operative hemodynamic instability, CPB time and body mass index (BMI≥30kg/m^2) are independent risk factors of operative death.

Keywords: Type a aortic dissection surgery; Cannulation; Outcome

Introduction

Acute Aortic Dissection type A (AADA) is a life threatening medical condition with a high mortality rate and more postoperative complications of cardiovascular emergency, surgical treatment is the only way to save the patients. Sun's procedure (total arch replacement using 4-branched graft with implantation of a special stented graft in the descending aorta) is widely used because of its good surgical results, and arterial cannulation is the first successful operation of the implementation [1,2]. The femoral artery and axillary are commonly used for artery cannulation. In recent years, with the improvement of surgical techniques, surgical mortality and postoperative complications of patients were gradually decreased. Meanwhile, the location of the arterial cannulation is changed from the femoral artery to the axillary artery [3]. Although some heart centers still choose femoral artery as a choice of arterial cannulation site for aortic dissection, studies have confirmed that reverse blood flow in the femoral cannulation leads to increased risk of retrograde embolization, dissection in patients with atherosclerosis, and of brain or organ mal-perfusion in those operated for type A acute aortic dissection [4]. Benedetto [5] through the meta-analysis found that central cannulation surgery may be better than the peripheral cannulation in the short term, but the latest guideline has not yet been provided for the use of the axillary artery as a cannulation site during dissection surgery because the data is from non-random experiments, and is thus jeopardized by several sources of bias [6]. The aim of this study was to investigate whether the axillary artery cannulation was superior to the femoral artery in patients with type A aortic dissection.

Patients and Methods

A total of 108 patients underwent aortic surgery for type A aortic dissection between January 2015 and June 2017. Patients who had history of cerebrovascular disease, severe carotid artery stenosis and combined other organ complications (liver and kidney dysfunction) were excluded from the study in order to reduce undesired bias. Among them 55 cases were axillary artery cannulation and 53 cases were femoral artery cannulation. This study was approved by the Institutional Review Board at Nanjing Medical University in compliance with Health Insurance Portability and Accountability Act regulations and the Declaration of Helsinki. The Institutional Review Board waived the need for individual patient consent.

Surgical technique

Anesthetic technique and monitoring was the same as that used for other cardiac surgical procedures, except for the placement of bilateral radial arterial lines. Invasive monitoring included the use of a pulmonary artery catheter and a left radial-femoral arterial line to allow measurement of systemic perfusion pressures during CPB. A Foley catheter with a temperature probe was inserted to measure bladder temperature. This was used as our indicator of core body temperature. Electroencephalogram monitoring was routinely performed in all cases. Intraoperative transesophageal

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Table 1: Preoperative characteristics of the two groups.

	Axillary (n=55)	Femoral (n=53)	p-value
Male/Female	32/23	29/24	0.8
Age (yr)	54.8±9.9	53.8±7.9	0.1
Body Weight (kg)	67.7±7.8	68.5±5.9	0.3
Hypertension	45	41	0.2
Diabetes	7	10	0.32
Smoking	23	21	0.7
High cholesterol Hemodynamic instability	15	13	1
	3	8	0.001

echocardiography was used in all patients. The HL-20 (Maquet, Hirrlingen, Germany) was used for CPB. The extracorporeal circuit was primed using 200-220 ml of a solution that included donor red blood cells (to maintain an hematocrit of at least 30%), 20% albumin, sodium bicarbonate, mannitol and heparin. CPB was performed with a flow of 2.0-2.8 L.kg. min with about 40 min of prior cooling to a nasopharyngeal temperature of 25˚C, with a temperature gradient not exceeding 10˚C. The blood gases were maintained in an alpha-stat strategy, with a target pCO_2 of 40mmHg. The goal core body temperature was variable and depended upon several factors, including age, preoperative renal function, aortic pathology and the complexity of the planned aortic arch reconstruction.

Deep Hypothermic Circulatory Arrest (DHCA) was carried out when the nasopharyngeal temperature reached the goal temperature. Selective Ante Grade Cerebral Perfusion (SACP), with a flow of 5-8 mL.kg.min, was performed through the right axillary artery or femoral artery. The left common carotid artery, the left subclavian artery and the descending aorta were clamped after the start of SACP. Depending on the individual anatomy, aortic arch reconstruction used procedures such as ascending aorta replacement, right arch replacement and Bentall and Sun’s procedure.

Statistical analysis

SPSS20.0 software was used for statistical analysis. Comparison between the two groups we used independent samples t test, the comparison between multiple groups using variance analysis. Count data in the rate or composition ratio, the comparison between groups using chi-square test. For mortality risk factor distribution a univariate analysis was performed. All significant parameters from the univariate analysis were included in a multivariate logistic regression. P<0.05 for the difference was statistically significant.

Results

Preoperative demographics of subjects

One hundred and eight patients comprised the statistical analysis population. The axillary artery group had 55 patients with 32 males while 53 patients with 29 males in femoral artery group. The median age was similar in both groups: 54.8±9.9years in axillary artery group and 53.8±7.9 years in femoral artery group. Medical histories included hypertension, Diabetes Mellitus (DM), preoperative diagnosis, body mass index, smoking and high cholesterol. There was no difference in the above characteristics of the patients in the two groups. Pre-OP hemodynamic instability was more common in the femoral artery group than the axillary artery group, which may be due to sudden cardiovascular events (malignant arrhythmia, acute left heart failure) needing emergent surgery and femoral artery cannulation for CPB is faster than axillary artery cannulation (Table 1).

Table 2: Surgical data ACC: Aortic Cross Clamp; LBT: Lowest Bladder Temperature; SACP: Selective Antegrade Cerebral Perfusion.

	Axillary (n=55)	Femoral (n=53)	p-value
ACC time (min)	116.7±43.8	113.4±48.5	0.80
SACP (min)	24.7±6.0	25.4±5.7	0.41
CPB time (min)	267.3±23.7	265.7±24.5	0.2
LBT (˚C)	25.1±1.2	24.8±1.1	0.78

Table 3: Characteristics of deaths.

	Death group (n=18)	Survical group (n=90)	P- value
Hemodynamic instability	9	3	<0.001
Age (yr)	69.2±8.5	60.2±7.8	<0.001
BMI	28.3±2.5	26.8±3.6	<0.001
CPB (min)	252.8±28.9	229.8±36.2	<0.001

Operative data

Due to the emergent surgery needing more posterior parallel circulation time, patients in the femoral cannulation group frequently had a more prolonged CPB time, compared to the axillary cannulation group. In addition, the aortic clamp time, cerebral perfusion time and the lowest bladder temperature were comparable in both groups (Table 2).

Mortality

The overall mortality was 16.7%. Operative mortality was not influenced by cannulation site (18.1% for axillary cannulation *vs.* 15.1% for femoral cannulation .The demographics of deaths were showed in Table 3.

Postoperative events

Transient neurologic dysfunction was observed in 11 patients (20.0%) in axillary cannulation group and 10 patients (18.8%) in femoral cannulation group. A total of 5 patients suffered from a permanent neurologic dysfunction in two groups. Early stroke occurred in 4 patients (7.27%) in axillary cannulation group *versus* 3 patients (5.6%) in femoral cannulation group. There were no significant differences in the postoperative anesthetized recovery time (37.5±25.9 *vs.* 36.9±26.1) hours, intubation time (62.7±7.2 *vs.* 64.4±6.0) hours, length of stay in the ICU (8.1±2.2 *vs.* 8.5±2.1) days and postoperative neurologic dysfunction of two groups (Table 4). There were no statistically significant differences in the postoperative outcome of the two groups.

As to cannulation-related complications, there was no malperfusion syndrome and only an axillary artery was injured in axillary cannulation group.

Multivariate analysis

In multivariate logistic regression analysis, hemodynamic instability (Odds Ratio [OR] = 1.79, 95% Confidence Interval (CI)=1.33-2.48, p=0.002), age ≥70 years (OR=1.37, CI=1.25-1.81, p<0.001, BMI ≥30kg/m^2 (OR=1.37-1.55, p<0.001) and prolonged

Table 4: Postoperative events.

	Axillary (n=55)	Femoral (n=53)	p-value
Postoperative awake time (h)	37.5±25.9	36.9±26.1	0.1
Extubation time (h)	62.7±7.2	64.4±6.0	0.39
Length of ICU stay (d)	8.1±2.2	8.5±2.1	0.49
Neurologic injury	11/55	10/53	0.34
Death	10 (18.1%)	8 (15.1%)	0.42
Early stoke	4	3	0.45
Arterial injury	1	0	-
Renal injury	5	6	0.51

Table 5: Independent preoperative risk factors for operative mortality.

	Standardized β	OR	95% CI	p-value
Hemodynamic instability	0.049	1.79	1.33~2.48	0.002
Age (≥70 years)	0.72	1.37	1.25~1.81	<0.001
BMI (≥30 kg/m²)	0.19	1.23	1.37~1.55	<0.001
CPB (≥250 min)	0.078	1.77	1.26~2.11	<0.001

CPB time CPB ≥250 min (OR=1.77, 95% CI=1.26-2.11, p <0.001) emerged as independent predictors of operative mortality (Table 5). Cannulation site was not found to be an independent predictor of mortality.

Discussion

Due to aortic dissection operation involving DHCA, cerebral protection is the key of surgery, and post-operative neurological complications affect the prognosis of patients. Actually, the use of axillary artery cannulation with selective ante grade cerebral perfusion is commonly used in the cerebral protection strategy [7]. Based on this, the axillary artery is the site of choice for arterial cannulation according to findings of this study and to the literature [8,9]. Although usually well tolerated, axillary cannulation has been associated with serious complications, including brachial plexus injury, arm ischemia, dissection, mal-perfusion during CPB [10]. Currently, selection of cannulation site is still controversial, and all centers suggesting the arterial cannulation site for patients undergoing surgical repair of an acute Type A aortic dissection should be chosen on a case-by-case basis.

At present there is no universal agreement on the impact of arterial cannulation on the survival rate of patients [11]. Some scholars believe that femoral artery cannulation significantly increases the mortality of patients, while other data show that femoral artery cannulation lead to favorable clinical outcomes and effectively reduces the operative mortality [12]. Our statistics show no difference in the rate of operative mortality and early shock (hypotension, malignant arrhythmia and low cardiac output syndrome).

Post-operative neurological dysfunction is a common and serious complication. The studies showed that the incidence is between 16% and 28% [13]. Our center uses moderate hypothermia with selective ante grade cerebral perfusion for brain protection. Although there are studies showing that axillary arterial cannulation is superior to femoral artery intubation in terms of brain protection, there are also objections [14,15]. Moreover, our data also show that axillary artery cannulation is not a better brain protection strategy than the femoral artery.

Univariate and multivariate logistic regression analysis was performed to characterize risk factors for operative mortality. Hemodynamic instability, prolonged CPB time and BMI are the independent risk factors for death. Hemodynamic instability associated with heart failure or myocardial injury with the huge trauma from surgery, easily lead to postoperative low cardiac output syndrome, resulting in malignant arrhythmia or multiple organ failure and death. Longer CPB times aggravate the inflammatory response, leading to ischemia of vital organs (kidney, gastrointestinal), disruption of the blood clotting process which further affects the prognosis of the patient. Obese patients, in addition to the inflammatory response caused by obesity itself, are prone to inadequate perfusion intra-operatively, thus causing generalized edema and multiple organ ischemia [16].

In order to prevent the various risks associated with reverse blood flow, we discontinued femoral artery cannulation for patients with severe atherosclerotic disease in the thoracic aorta. In addition, as with other researchers [3], we used the transesophageal echocardiography to guide the femoral artery into the aorta and measure blood flow to assess perfusion during the CPB, which can effectively reduce the occurrence of low perfusion phenomenon.

Axillary artery exposure is technically more demanding requiring a longer time, which increases the risk of axillary artery-related complications (malperfusion syndrome and artery injured). Recently reports observed the incidence of artery-related complications is 1-1.5% [17]. One case of cannulation-related syndrome occurred as a result of axillary artery cannulation as compared to none in the femoral artery cannulation group.

Recently, scholars have suggested that the right axillary artery and simultaneous femoral artery cannulation is safe and feasible for aortic arch replacement [18].

Comment

The arterial cannulation site was not significantly related to stroke, mortality rates and neurologic outcomes. The arterial cannulation site for CPB during acute aortic dissection repair should be individualized based on several factors (e.g., the extent of the dissection, impairment of the true lumen, severity of atherosclerotic aneurysm of the thoracoabdominal aorta). Age (age≥70) years, CPB time (≥250min) and BMI (≥30kg/m²) are strong risk factors for mortality.

Limitation

This report has several limitations. First, the retrospective, non-randomized nature of the study requires caution when interpreting the results. Second, the choice of cannulating a central or peripheral vessel was mainly driven by the experience of the surgeon rather than objective parameters. Additionally, the diagnosis of neurological events in this category of patients is often subjective, which may have introduced a detection bias into the study.

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