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Research Article

Comparison of the effects of femoral and axillary artery cannulation on ischemic cerebral injury in acute type A aortic dissection surgery: A retrospective study

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ABSTRACT

Background: Acute Type A Aortic Dissection (ATAAD) is a life-threatening condition requiring emergency surgical intervention. This retrospective study evaluates the impact of femoral and axillary arterial cannulation techniques on ischemic neurological damage and mortality.

Materials and Method: A total of 60 patients who underwent emergency surgery for ATAAD between 2016 and 2021 were analyzed. Patients were divided into two groups based on the arterial cannulation technique: Group A (axillary cannulation) and Group F (femoral cannulation). Preoperative, intraoperative, and postoperative variables were compared between the groups. The primary outcome was incidence of ischemic cerebral injury and secondary outcomes included 30-day all-cause mortality, intensive care unit and hospital length of stay and postoperative complications.

Results: There were no statistically significant differences between the two groups in terms of ischemic cerebral injury (p=0.13). There was no significant difference in 30-day mortality between the groups (p= 0.27). Logistic regression analysis revealed that the cannulation type was a risk factor for ischemic cerebral injury development (OR [95% CI]; 119.034 [1.612–8791.314], p=0.029).

Conclusions: Our findings indicate that the type of cannulation may be a risk factor for the development of ischemic cerebral injury. Further studies are needed to determine the optimal arterial cannulation technique for improving outcomes in ATAAD surgery.

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1. Introduction

Acute aortic syndromes (AAS) are among the most life-threatening cardiovascular pathologies. The most severe clinical condition of AAS is Acute Type A Aortic Dissection (ATAAD), which has an incidence of approximately 0.003-0.007% per year [1]. Most patients are hypertensive males aged 50-70 years with a history of smoking. ATAAD, if not treated with emergency surgery, has a very high mortality rate [2]. If untreated within the first 2 days, the hourly mortality rate is 1-2%, and by the end of the second week, only 5% of untreated patients remain alive. The most common causes of mortality include organ malperfusion, aortic rupture, and pericardial tamponade [3]. According to current guidelines, the gold standard treatment for ATAAD is surgical intervention. However, diagnosing aortic dissection is challenging due to its varied clinical presentations and requires differentiation from other conditions such as pulmonary embolism, myocardial infarction, cerebrovascular

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events, and acute abdomen [4]. Despite advancements in surgical techniques and cerebral protection methods, the 30-day surgical mortality rate for ATAAD remains approximately 20% [5]. The primary goal of surgical treatment is to redirect blood flow to the true lumen, preventing the malperfusion of organs (coronary, cerebral, visceral, and extremity) caused by blood flow into the false lumen [6]. Ischemic cerebral injury (ICI) is one of the most feared complications following surgical treatment of ATAAD and significantly impacts postoperative morbidity and mortality rates. The main causes of ICI include inadequate cerebral protection, thromboembolic events, global ischemia, and the application of hypothermic circulatory arrest (HCA).

In this study, we aim to compare two commonly used arterial cannulation techniques—axillary and femoral—in terms of their impact on 30-day mortality and early postoperative complications, particularly ischemic cerebral injury, in patients undergoing emergency surgical treatment for ATAAD.

2. Materials and Method

The study was conducted in aortic surgery referral center at Samsun Ondokuz Mayis University Hospital. Ethical approval was obtained from the Institutional Review Board of Ondokuz Mayıs University (Ethics Committee Approval No: 2021/428). Due to the retrospective nature of the study, informed consent was not obtained. Hospital records of 60 patients who underwent emergency surgical treatment for ATAAD between 2016 and 2021 were retrospectively reviewed. Patients presenting with symptoms for less than 14 days were classified as ATAAD. The diagnosis was confirmed using intravenous contrast-enhanced 3D computed tomographic angiography and transthoracic echocardiography, and further verified intraoperatively. Both the Stanford and De Bakey classifications were used to describe aortic dissections. Only patients with Acute Type A (Stanford) or Type 1 (De Bakey) aortic dissection were included. Patients under 18 years of age, those without anesthesia records or clinical data, and those who underwent elective ATAAD surgery were excluded. Basic demographic and morphometric characteristics, as well as surgical, intraoperative, and postoperative information, were obtained from electronic medical records. Patients were divided into two groups based on the choice of arterial cannulation: Group A (axillary cannulation) and Group F (femoral cannulation). The selection of arterial cannulation was based on the hemodynamic status of the patient. Axillary cannulation was preferred in hemodynamically stable patients, while femoral cannulation was used in unstable patients or those requiring urgent cardiopulmonary bypass.

The primary outcome was incidance of ischemic cerebral injury (defined as focal brain injury with a permanent functional deficit confirmed on computed tomography scan). Secondary outcomes included 30-day all-cause mortality, length of stay in the intensive care unit and hospital, and postoperative complications.

2.1. Data collection

Preoperative variables included age, gender, weight, comorbidities, prior cardiac surgeries, EuroSCORE, creatinine, glomerular filtration rate, ejection fraction, and pulmonary arterial pressure. Intraoperative variables comprised cardiopulmonary bypass (CPB) time, cross-clamp (CC) time, total circulatory arrest (TCA) time, concurrent procedures (coronary bypass, aortic valve replacement), venous cannulation site, and cerebral protection strategies (antegrade cerebral perfusion, retrograde cerebral perfusion, deep hypothermia). Postoperative variables included mortality, new-onset cerebral events, inotrope requirement (noradrenaline, dobutamine, adrenaline), renal failure status (need for hemodialysis), low cardiac output status, duration of intubation, ICU stay, hospital stay, erythrocyte transfusion requirements, apheresis platelet requirements, cryoprecipitate requirements, random platelet needs, Fresh frozen plasma needs, and reoperation for bleeding.

2.2. Surgical technique

Aortic dissection was diagnosed by contrast-enhanced computed tomography. In ATAAD surgery, CPB plays a vital role in preventing malperfusion and ensuring continuous perfusion without interruption. For this urgent procedure, the choice of cannulation type was determined by the surgical team based on the patient's hemodynamic condition during the preoperative period. After median sternotomy and systemic heparinization, CPB was initiated through cannulation of either the non-dissected femoral artery or the right axillary artery, using direct or Seldinger techniques. In this study, patients were categorized based on the cannulation type into the femoral artery (Group F) or axillary artery (Group A) groups. In our institution, axillary artery cannulation is performed through an "end-to-side" graft attached to the axillary artery. This technique, which is slightly time-consuming, is performed at the start of the procedure and is preferred for hemodynamically stable patients. For hemodynamically unstable patients, direct femoral cannulation is chosen, allowing for rapid initiation of surgery. Venous return was achieved via right atrium or femoral vein cannulation. Moderate systemic hypothermia (nasopharyngeal temperature of 22–26 °C) and myocardial protection with intermittent antegrade and/or retrograde ısothermic blood cardioplegia were employed. Surgery was conducted using the open distal anastomosis technique, with cerebral protection provided by selective antegrade cerebral perfusion. The anatomy of aortic dissection was classified according to the Stanford classification. Patients with Stanford Type A dissections were included in the study. Due to the high variability in hemodynamic parameters—particularly end-organ damage—that can occur from diagnosis to the operating room, patients were retrospectively evaluated using the Penn classification to ensure homogeneity and reduce heterogeneity due to preoperative hemodynamic variations. Patients classified as Penn Class Aa and Ab were retrospectively included. This approach allowed

for a clearer assessment of the impact of perfusion techniques and cerebral protection strategies on outcomes.

For axillary cannulation, a transverse incision was first made in the right infraclavicular region. After dissecting through the pectoralis major and pectoralis minor muscles, the axillary artery was exposed and palpated adjacent to the axillary vein, with caution taken to avoid nerve damage to the brachial plexus located in the same anatomical area. A nylon tape was used to encircle the axillary artery. Vascular clamps were placed proximal and distal to the planned cannulation site, and a vertical arteriotomy was performed. An end-to-side anastomosis with an 8 mm x 5 cm Dacron graft was created. An 18-21F cannula was inserted into the side graft and secured with silk sutures. Backflow was observed from the arterial cannula, confirming effective function, and the cannula was sutured to the skin before the vascular clamps on the axillary artery were released. Following median sternotomy, right atrial venous cannulation was performed. Femoral cannulation was conducted using the Seldinger or direct technique. In terms of cerebral protection, the axillary cannulation group received antegrade cerebral perfusion, while the femoral cannulation group received deep hypothermia.

2.3. Anesthesia management

Upon arrival in the operating room, standard ASA (American Society of Anesthesiologists) monitoring was used, which included five-channel electrocardiography, pulse oximetry, direct arterial and central venous pressure monitoring, cerebral oxygen monitoring (near infrared spectroscopy/NIRS), urinary catheter, and rectal temperature monitoring. Preoperative, intraoperative, and postoperative management followed the institutional standardized cardiac anesthesia protocol. Induction was achieved with intravenous (iv) midazolam (0.05-to-0.1 mg/kg), fentanyl (2-to-5 mcg/kg iv), thiopenthal sodium (4-to-5 mg/kg iv), and rocuronium (1 mg/kg iv). During maintenance, O2/air (FiO2 0.40), 1%-to-2% sevoflurane, and iv fentanyl infusion (2-5 mcg/kg/h) were used. A TEE probe (McGrath MAC; Aircraft Medical, Edinburgh, UK) was inserted gently. Patients were ventilated using a volume-controlled mode, with an inspired oxygen fraction of approximately 0.6 and a positive end-expiratory pressure of 5 cmH2O. End-tidal CO2 values were maintained between 33 and 38 mmHg. At the end of surgery, all patients received 0.05 mg/kg morphine IV and were transferred to the ICU while intubated.

3. Statistical Analyses

Data were analyzed using IBM SPSS Version 23. The Shapiro-Wilk test was used to assess the normality of data distribution. Categorical variables were compared between groups using the Chi-square and Fisher's Exact tests. For comparisons of continuous variables, the Independent Samples t-test was used for normally distributed data, and the Mann-Whitney U test was applied for non-normally distributed data. Results were presented as mean ± standard deviation and median (minimum-maximum) for continuous variables, and frequency (percentage) for categorical variables. A significance level of $p<0.05$ was considered statistically significant.

4. Results

During the study period, data from patients who underwent emergency surgical treatment for ATAAD were evaluated. The study was completed with 60 patients who met the study protocol criteria. It was observed that arterial cannulation was performed using the axillary cannulation method in 49 patients (81.6%) and the femoral cannulation method in 11 patients (18.4%). The demographic and clinical characteristics of the patients, ATAAD type, and systemic diseases according to the cannulation method are summarized in Table 1. A higher incidence of diabetes mellitus was found in patients with femoral cannulation (63.6% vs. 30.6%, p=0.04), while a higher incidence of aortic insufficiency was observed in the group with axillary cannulation (100% vs. 81.8%, (p=0.02). The surgery duration, CPB time and CC time were similar between the groups. As expected, TCA for cerebral protection was applied more frequently in Group A compared to Group F (n [%], 49 [100] vs. 6 [54.5], p<0.01, respectively]. There were no statistically significant differences between the two groups in terms of ischemic cerebral injury (p=0.13) (Table 2). Also, postoperative renal replacement therapy, mechanical ventilation requirement, ICU stay, hospital stay, or mortality. The perioperative variables according to arterial cannulation are summarized in Table 2.

Logistic regression analysis revealed that the cannulation type was a risk factor for ischemic cerebral injury development (OR [95% CI]; 119.034 [1.612–8791.314], p=0.029). Factors affecting ischemic cerebral injury development are summarized in Table 3. Coronary artery disease (OR [95% CI]; 0.050 [0.004–0.555], p=0.015], ejection fraction (OR [95% CI]; 0.856 [0.742–0.988], p=0.034], and Euroscore (OR [95% CI]; 0.643 [0.416–0.994], p=0.047] were found to be associated with mortality. Factors affecting mortality development are summarized in Table 4.

5. Discussion

This single-center retrospective study evaluated the outcomes of patients who underwent emergency surgical treatment for ATAAD. The primary objective was to investigate the effect of two different peripheral arterial cannulation techniques (axillary vs. femoral) on 30-day hospital mortality and early postoperative complications, with a particular focus on ischemic cerebral injury. Our findings indicated that the type of cannulation was a risk factor for the development of ischemic cerebral injury. Additionally, coronary artery disease, ejection fraction, and Euroscore were identified as factors associated with increased mortality.

Table 1. Patient characteristics according to groups.

	Group A (n=49)	Group F (n=11)	p
Age (year) mean ± SD	60.3 ± 12.9	63.0 ± 10.6	0.54
Sex (woman) n (%)	16 (32.7)	3 (27.3)	0.72
BMI (kg/m^2) mean ± SD	28.3 ± 4.9	28.9 ± 5.0	0.90
Systemic Disease n (%)			
Diabetes Mellitus	15 (30.6)	7 (63.6)	0.04*
Hypertension	49 (100)	11 (100)	-
COPD	8 (16.3)	3 (27.3)	0.39
CAD	38 (77.6)	7 (63.6)	0.33
CRF	10 (20.4)	3 (27.3)	0.61
Penn Classification			0.93
Penn Aa	35 (71.4)	8 (72.7)	
Penn Ab	14 (28.6)	3 (27.3)	
Valve Disease n (%)			
Aortic Insufficiency	49 (100)	9 (81.8)	0.02*
Mitral Insufficiency	28 (57.1)	7 (63.6)	0.69
Mitral Insufficiency	23 (46.9)	6 (54.5)	0.64
EF (%) mean ± SD	55.2 ± 7.7	54.0 ± 9.1	0.96
PAP (mmHg) mean ± SD	27.3 ± 8.6	29.7 ± 7.1	0.32
Euroscore mean ± SD	7.2 ± 2.9	8.4 ± 3.4	0.21

* Statistically significant difference; EF: Ejection Fraction; CAD: Coronary Artery Disease; CRF: Chronic Renal Failure; COPD: Chronic Obstructive Pulmonary Disease; PAP: Pulmonary Artery Pressure; BMI: Body Mass Index

Table 2. Perioperative variables according to groups.

	Group A (n=49)	Group F (n=11)	p
Surgical time (min) mean ± SD	350.1 ± 61.5	361.8 ± 83.4	0.54
CPB duration (min) mean ± SD	205.3 ± 65.2	253 ± 93	0.09
CC duration (min) mean ± SD	118.8 ± 47.5	164 ± 84.2	0.09
Inotropes n (%)			
Intraoperative Transfusion (IU) median (IQR)			
ES	7 (5)	8 (3)	0.52
FFP	6 (4)	7 (2)	0.04*
Apheresis Platelet	2 (1)	0 (2)	<0.01*
Random Platelet	0 (6)	6 (0)	0.03*
Cryoprecipitate	0 (0)	0 (0)	0.63
TCA n (%)	49 (100)	6 (54.5)	<0.01*
Cerebral protection n (%)			<0.01*
ASP	48 (98)	-	
BASP	1 (2)	-	
RSP	-	1 (9.1)	
Low CO n (%)	16 (32.7)	6 (54.5)	0.17
Resternotomy n (%)	3 (6.1)	1 (9.1)	0.72
RRT n (%)	7 (14.3)	2 (18.2)	0.74
Ischemic Cerebral Injury n (%)	5 (10.2)	3 (27.3)	0.13
Mechanical Ventilation (days) median (IQR)	1 (2)	2 (11)	0.32
ICU (days) median (IQR)	3 (3)	3 (10)	0.77
Hospital duration (days) median (IQR)	10 (11)	10 (13)	0.81
Mortality n (%)	18 (36.7)	6 (54.5)	0.27

* Statistically significant difference; CPB: Cardio Pulmoner Bypass; CC: Cross clamp; ES: Erythrocyte Suspension; FFP: Fresh Frozen Plasma; TCA: Total Circulatory Arrest; IABP: Intraaortic Balloon Pump; RRT: Renal Replacement Therapy; ICU: Intensive Care Unit

Table 3. Effect of variables on the development of ischemic cerebral injury.

	Beta	SE	OR (95% CI)	p
Type of Cannulation	4.779	2.195	119.034 (1.612 8791.314)	0.029*
Diabetes Mellitus	1.338	1.722	3.811 (0.130 111.319)	0.437
Coronary Artery Disease	1.042	1.264	0.353 (0.030 4.204)	0.410
COPD	2.200	1.685	9.025 (0.332 245.552)	0.192
CRF	0.757	1.513	0.469 (0.024 9.096)	0.617
Ejection Fraction	0.008	0.055	1.008 (0.905 1.121)	0.890
Pulmonary Artery Pressure	0.128	0.093	1.137 (0.948 1.363)	0.168
Euroscore	0.479	0.289	1.614 (0.917 2.842)	0.097
Duration of Surgery	0.016	0.024	0.984 (0.939 1.032)	0.513
CPB Duration	0.026	0.026	1.027 (0.976 1.080)	0.307
CC Duration	0.002	0.020	0.998 (0.959 1.039)	0.933
Surgical Revision	23.523	15187.888	1643… (0.000 -)	0.999

* Statistically significant difference; OPD: Chronic Obstructive Pulmonary Disease; CRF: Chronic Renal Failure; CPB: Cardio Pulmonary Bypass; CC: Cross Clamp

Table 4. Effect of variables on mortality.

	Beta	SE	OR (95% CI)	p
Type of Cannulation	1.069	1.261	0.343 (0.029 4.060)	0.396
Diabetes Mellitus	0.247	1.106	0.781 (0.089 6.828)	0.823
Coronary Artery Disease	3.004	1.232	0.050 (0.004 0.555)	0.015*
COPD	0.332	1.073	1.393 (0.170 11.407)	0.757
CRF	1.198	0.937	3.315 (0.528 20.817)	0.201
Ejection Fraction	0.155	0.073	0.856 (0.742 0.988)	0.034*
Pulmonary Artery Pressure	0.024	0.045	0.976 (0.893 1.066)	0.593
Euroscore	0.441	0.222	0.643 (0.416 0.994)	0.047*
Duration of Surgery	0.007	0.019	1.007 (0.970 1.045)	0.721
CPB Duration	0.023	0.019	0.978 (0.942 1.014)	0.223
CC Duration	0.005	0.013	0.995 (0.970 1.021)	0.709
Surgical Revision	1.951	1.584	7.034 (0.316 156.741)	0.218
Type of Cannulation	1.278	1.127	0.278 (0.031 2.537)	0.257

* Statistically significant difference; COPD: Chronic Obstructive Pulmonary Disease; CRF: Chronic Renal Failure; CPB: Cardio Pulmonary Bypass; CC: Cross Clamp

Despite advancements in emergency department, radiology, anesthesiology, and cardiovascular surgery practices, and improvements in medical technology, the surgical mortality of ATAAD remains high. The primary reasons for this are delays in diagnosis, increased risk of organ malperfusion, and the absence of an ideal cerebral/systemic perfusion strategy during the HCA period. Among the 60 patients included in our study, the 30-day hospital mortality rate was 36.7% vs 54.5% in the groups. This rate was higher than expected, possibly due to delays in surgical intervention. Most of the patients in our cohort were referred from hospitals in nearby provinces, leading to increased risks of complications such as aortic rupture and pericardial tamponade.

There is still no ideal peripheral arterial cannulation technique that can provide optimal cerebral/systemic perfusion during emergency surgical treatment of ATAAD. Although many retrospective studies suggest the superiority of axillary cannulation for cerebral protection compared to femoral cannulation, no significant difference in 30-day hospital mortality and major postoperative complications has been demonstrated. Xia et al. [7], in their review, emphasized that the choice of arterial cannulation in patients with ATAAD should be individualized. In the same study, they noted that the ideal arterial cannulation technique should provide rapid and adequate perfusion flow, prevent organ malperfusion, avoid triggering the expansion of aortic dissection or rupture, and be capable of sufficient antegrade cerebral perfusion for cerebral protection. The authors specifically highlighted that double arterial cannulation (DAC)—combining axillary/innominate and femoral artery cannulation—is more reliable for maintaining both cerebral and systemic circulation and is effective in preventing intraoperative malperfusion. However, they pointed out that the main drawback of DAC is the increased number of incisions and prolonged operative time.

Etz et al. [8], in a study reporting the outcomes of a series of 400 patients who underwent surgery for ATAAD, found a hospital mortality rate of 20.3%. There was no significant difference in hospital mortality or

postoperative stroke rates between the axillary and femoral cannulation groups. The study highlighted that the 10-year survival rate was significantly higher in the axillary cannulation group (antegrade perfusion) compared to the femoral cannulation group (retrograde perfusion) (71% vs. 51%). The authors indicated that retrograde perfusion of the true lumen was an independent risk factor for late mortality. Gokalp et al. [9] demonstrated that both femoral and axillary arterial cannulation methods can be safely used in patients with Acute Type A Aortic Dissection, as long as cerebral protection strategies are prioritized. The choice of cannulation method should be guided by the patient's specific medical condition, with consideration for factors such as vascular anatomy, comorbidities, and the urgency of the procedure. Additionally, the surgeon's experience and preference may influence the selection of the technique. This highlights the importance of individualized treatment approaches in complex cases, ensuring that patient safety and optimal outcomes are achieved. Ren et al. [10], in a meta-analysis of nine studies comparing axillary and femoral cannulation for ATAAD, which included a total of 715 patients, found that axillary cannulation was associated with better early mortality and postoperative stroke outcomes compared to femoral cannulation. However, the authors recommended that arterial cannulation strategy should be tailored to individual patient characteristics. They emphasized the need for high-quality, randomized, prospective, and multicenter studies before axillary cannulation can be routinely recommended as the standard technique for ATAAD surgery.

This study has several limitations that must be considered. First, as a single-center retrospective study, the findings may not be generalizable to other institutions with different surgical techniques, patient populations, or perioperative care protocols. The sample size, while reasonable, limits the statistical power of the analysis, particularly when examining rare postoperative complications such as ischemic cerebral injury or mortality. Additionally, the study did not account for potential confounding factors such as preoperative medical optimization, the time from symptom onset to surgery, and variations in the clinical condition of patients at presentation, all of which may influence outcomes. Furthermore, the lack of randomization and the reliance on retrospective data collection increase the potential for selection bias, and specific details of the surgical techniques used may vary slightly among surgeons, despite similar overarching approaches.

6. Conclusions

In conclusion, this study suggests that both axillary and femoral arterial cannulation methods can be used safely in the emergency surgical treatment of ATAAD, with no significant difference in 30-day hospital mortality or major postoperative complications between the two techniques. However, our findings indicate that the type of cannulation may be a risk factor for the development of ischemic cerebral injury, highlighting the need for careful selection of the cannulation method. Furthermore, factors such as coronary artery disease, ejection fraction, and Euroscore were associated with increased mortality, emphasizing the importance of individualized treatment approaches. Future studies should focus on larger, randomized, multicenter trials to further refine the optimal arterial cannulation strategy for improving both early and long-term outcomes in ATAAD surgery.

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Conflict of Interest

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Author Contributions

All of the authors made substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data; were involved in drafting the manuscript or revising it critically for important intellectual content; and gave final approval of the version to be published.

Data Availability

The datasets created and/or analyzed during the current study are not publicly available, but are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This study was approved by the institutional review board of Ondokuz Mayıs University (Ethics Committee Approval No: 2021/428). Written informed consent was obtained from the participants. All methods were performed in accordance with relevant guidelines and regulations.

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