Original Article

Does arterial cannulation site for aortic dissection repair impact surgical outcomes?

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Background: Establishing cardiopulmonary bypass remains critical to the successful repair of an acute type A aortic dissection. A recent trend away from femoral arterial cannulation has occurred in part due to concerns of stroke risk from retrograde perfusion to the brain. The purpose of this study was to determine if arterial cannulation site for aortic dissection repair impacts surgical outcomes.

Methods: A retrospective chart review was performed at Rutgers Robert Wood Johnson Medical School from January 1st, 2011 to March 8th, 2021. Of the 135 patients included, 98 (73%) underwent femoral arterial cannulation, 21 (16%) axillary artery cannulation, and 16 (12%) direct aorta cannulation. The study variables included demographic data, cannulation site, and complications.

Results: The mean age was 63.6±14 years, with no difference between the femoral, axillary, and direct cannulation groups. Eighty-four patients (62%) were male, with similar percentages amongst each group. The rates of bleeding, stroke, and mortality specifically due to the arterial cannulation did not significantly differ based on cannulation site. None of the patients had strokes that were attributable to cannulation type. No patients died as a direct complication of arterial access. The overall in-hospital mortality was 22%, similar between groups.

Conclusions: This study found no statistically significant different in rates of stroke or other complications based on cannulation site. Femoral arterial cannulation thus remains a safe and efficient choice for arterial cannulation in the repair of acute type A aortic dissection.

Keywords: Aortic dissection; aorta; cannulation

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Introduction

An acute aortic dissection is a lethal disease that requires prompt diagnosis and surgical intervention. It typically occurs when there is a tear in the intimal layer of the aortic wall, exposing the underlying media and thus creating a "parallel" false lumen in the aortic wall (1). An aortic dissection is one of the most challenging diseases for cardiac surgeons, because each surgical step can have a great impact on the ultimate outcome. A critical aspect of repairing aortic dissections is placing the patient on cardiopulmonary bypass. This requires cannulation of the venous and arterial system. In the majority of surgical cases, this involves cannulation of the right atrium for venous access and one of multiple arterial access sites. There are several arterial cannulation options for repair of an ascending aortic dissection repair, each with its advantages and disadvantages (1). It is the surgeon's responsibility to select the most appropriate option for each patient.

Table 1 Demographic data

Data item	Overall	Femoral cannulation	Axillary cannulation	Direction cannulation	P value
Number	135	98 [73]	21 [16]	16 [12]	–
Age (years)	63.6±14	62.6±14	65.9±17	63.4±14	0.763
Gender (male)	84 [62]	60 [61]	14 [67]	10 [63]	0.958
Ethnicity					
African American	28 [21]	25 [26]	3 [14]	0 (0)	0.017
Asian	13 [10]	8 [8]	3 [14]	2 [13]	
Hispanic	5 [4]	2 [2]	2 [10]	1 [6]	
Caucasian	77 [58]	55 [57]	9 [43]	13 [81]	
Other	10 [8]	6 [6]	4 [19]	0 [0]	
Body surface area (m^2)	2.00±0.31	2.03±0.33	1.90±0.25	1.97±0.22	0.2

The ethnicity of 2 patients was unable to be identified. Data are shown as n [%] or mean ± standard deviation.

The incidence of acute aortic dissection is approximately 3 cases per 100,000 per year (2,3). The location of the aortic tear determines the surgical approach and the timing of intervention for patients with aortic dissection. Classically, patients with an aortic tear in the ascending aorta, require immediate surgical intervention (4,5). Femoral arterial cannulation initially was the standard for arterial cannulation and had been established for cardiopulmonary bypass since the 1950's (6). Furthermore, arterial cannulation for type A aortic dissections has traditionally been achieved by femoral arterial access (7,8).

The possible arterial cannulation options for dissection repair include femoral artery, axillary artery, and direct ascending aorta cannulation. A recent trend away from femoral arterial cannulation has occurred in part due to concerns of stroke risk from retrograde perfusion to the brain. The rational hypothesized is that femoral arterial cannulation leads to increased stroke, and malperfusion, which can increase morbidity and mortality (9-11). This is believed to be a result of the retrograde blood flow through the femoral artery to the brain and the remaining body.

Ascending aortic dissections are a dynamic entity that may change at any time during the operation. Such a change may result in inadequate flow distribution leading to life-threatening conditions. The aorta is a conduit that extends from the left ventricle that delivers pulsatile blood distally to organs and distal tissues (12). Access to the aorta via arterial cannulation is critical to establishing cardiopulmonary bypass. The surgeon must be prepared to act quickly and efficiently to cannulate the arterial vessel. The purpose of this study was to determine if arterial cannulation site impacts surgical outcomes for repair of ascending aortic dissections. We present the following article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-576/rc).

Methods

A retrospective chart review was performed at Rutgers Robert Wood Johnson Medical School from January 1st, 2011 to March 8th, 2021. The study variables included demographic data, cannulation site, and complications. An analysis from the International Registry of Acute Aortic Dissections (IRAD) reported a mean age at presentation of 63 years and a male predominance of 61%, yielding an incidence of 16 per 100,000 in men (13,14). Similar to the IRAD data, the majority of the patients in the study were male (n=84, 62%) and the mean age was 63.6±14 years (*Table 1*). The ethnicity of 2 of the 135 total patients was unable to be identified.

All of the procedures were performed in the operative theater at a single academic institution. The entire patient group had a combination of central and peripheral cannulation for venous access. This included a single venous cannula in the right atrium as well as bicaval cannulation of the superior vena cava and inferior vena cava. Deep hypothermic circulatory arrest and unilateral antegrade cerebral perfusion were used in all the patients. The surgeon preference was used to determine how low the temperature was cooled to for circulatory arrest. The temperature ranged from as low as 20 to 28 degrees based

on the surgeon. Each patient had unilateral antegrade cerebral perfusion with the innominate artery being used to provide access. Cerebral oximetry was monitored in each case and if there were any issues then bilateral cerebral perfusion would be initiated.

A hemiarch aortic repair was used for all the type A aortic dissections. There was no aortic arch reconstructions performed however 20% of the cases required an aortic root reconstruction. The decision on arterial access for aortic cannulation was based on surgeon preference. Two of the four surgeons routinely used the femoral artery as the main arterial access site for cannulation. If there were any issues with the femoral artery then the contralateral femoral artery would be used. When the femoral artery was used for cannulation, antegrade cerebral perfusion was provided by a cannula placed directly into the innominate artery during circulatory arrest. Alternatively, the axillary or ascending aorta was cannulated. The two other surgeons would alternate between the axillary artery, central aorta, and femoral artery based on the anatomy of the patient and extent of dissections.

The rates of postoperative complication, mortality, and demographic data were reported. All of the patients were classified as Stanford Type A patients, which included ascending aortic involvement in each patient. There was a varied distribution of the extent of the distal involvement of the aorta in the group of patients. The primary influences for cannulation was based on (I) surgeon experience and training, (II) stability of the patient, (III) extent and complexity of the aortic dissection, and (IV) anatomy of the patient. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Rutgers University institutional review board and ethics committee (No. 2020000011). Individual consent for this retrospective analysis was waived.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation, and categorical variables were expressed as count (percentage). We utilized the Mann-Whitney U test for continuous variables and Chi-Square for categorical variables. The Kaplan-Meier survival analysis was used to estimate survival. P values less than 0.05 were considered statistically significant.

Results

Of the 135 patients included, 98 (73%) underwent femoral arterial cannulation, 21 (16%) axillary cannulation, and 16 (12%) direct aorta cannulation (*Table 1*). A total of 4 patients in the entire cohort of patients (2.9%) developed a stroke, however the stroke could not be directly attributed to the cannulation site. The diagnosis of stroke or cerebrovascular accident was defined by radiographic evidence and corroboration by the neurology consult service. The 4 stroke patients in the study group were all noted to have prolonged circulatory arrest times of more than 45 minutes and experienced prolonged hospitalizations. The findings of the study also shows that no patient within the study group had significant bleeding or any complication attributable to the femoral or any other arterial access cannulation site during repair of the aortic dissection. Furthermore, no patients died as a direct complication of arterial access.

The overall in-hospital mortality was 22%, which was similar between groups (*Table 2*). The data showed no correlation between arterial cannulation site and any complication. The majority of the patients undergoing repair in this study had femoral cannulation (73%) to establish arterial access for cardiopulmonary bypass. The demographic data from the study is consistent with the IRAD data (13,14) with the mean age of the patients with aortic dissections in the 60s and the majority of the patients' men. The results of this study could be applicable to all patients. The ethnic diversity is clearly present in this patient population (*Table 1*). Furthermore, there was no significant difference in body surface area amongst the patients.

Discussion

The data from our study shows that the arterial access site for cannulation does not impact surgical outcomes. There was no correlation between the cannulated artery and surgical complications. Although there were 4 patients that developed cerebrovascular accidents, there was no direct correlation with the arterial cannulation site. The findings show that traditional femoral artery cannulation did not result in worsening outcomes. There were no mortalities specifically related to the cannulation of the femoral artery or any of the alternative access sites. The distinct benefit of using the femoral approach includes easily accessible vessels, bilateral options, lack of a need for a graft, and ease of use. These findings have been supported previously however, this sample size is amongst the largest (7,8,15). Furthermore, the use of femoral arterial cannulation for procedures other than aortic dissection repair has also been

Table 2 Complications

Data item	Overall	Femoral cannulation	Axillary cannulation	Direction cannulation	P value
Bleeding from cannulation, n [%]	1 [1]	1 [1]	None	None	1
Stroke from cannulation, n [%]	0 [0]	None	None	None	
Mortality from cannulation	None	None	None	None	
In-hospital mortality, n [%]	30 [22]	22 [22]	3 [14]	5 [31]	0.468

supported (16). These findings are important because of the perceived limitations or concerns about the use of femoral artery cannulation.

The shift towards alternative access sites is an attempt to minimize malperfusion, and limit stroke (17). These findings are not seen in this study. The perceived advantages of the axillary artery and direct aortic cannulation have dominated the literature throughout the last several years. The benefits of antegrade perfusion, ability to provide antegrade cerebral perfusion, and prevention of malperfusion have all encouraged cardiothoracic surgeons to use the axillary artery for cannulation. Similarly, the advantages of direct central aortic cannulation, to avoid an additional surgical incision, and antegrade perfusion also dissuaded femoral arterial cannulation.

Although, the results of the study show no superiority in terms of access site and outcomes, choosing a vessel that is dissected or has any anatomic abnormalities could lead to complications. As a result, having multiple arterial access options is critical for the cardiothoracic surgeon. Growing evidence promotes the superiority of axillary artery cannulation because it preserves antegrade flow in the descending aorta, thereby reducing the risk for embolization, and facilitates the administration of selective antegrade cerebral perfusion (18). Furthermore, the axillary artery is recommended as the first choice for cannulation by the 2014 European Society of Cardiology Guidelines on the Diagnosis and Treatment of Aortic Diseases (class of recommendation I, level of evidence C) (4). Despite these reports, the findings of the study refute these studies and claims of dominance of the axillary artery approach.

The cannulation strategy should be individualized, because the extent of dissection and vessel anatomy vary among patients (5). Technical problems and complications may also occur during axillary cannulation (6), as not all cardiothoracic surgeons are familiar with axillary artery anatomy. Direct true lumen aortic cannulation technique is an effective and not time-consuming option to solve some of these emergency situations, because it can rapidly restore antegrade perfusion (2,19,20). It avoids most of the complications related to other cannulation sites such as perfusion of the false lumen, retrograde cerebral embolization, or plexus injury. It is useful in cases of circumferential dissection and in patients with relative contraindications for peripheral cannulation such as morbid obesity or peripheral arterial occlusion by atherosclerosis or by the dissection itself. One of the key issues unfortunately is that it is not a common approach and can lead to technical failures. The delay in arterial cannulation and potentially going on cardiopulmonary bypass could lead to an increase in patient death.

Finally, the femoral artery was the most commonly used arterial cannulation site in aortic dissection repair surgery before the introduction of axillary cannulation (7,8). Despite concerns that reversed flow may increase the risk of retrograde brain embolization, and organ malperfusion (9), femoral artery cannulation is still widely used by many surgeons with good outcomes (10,11,15). The results of this study support the use of femoral cannulation for aortic dissection repair with minimal complication risk. Moreover, the alternative access sites also demonstrated successful use indicating that arterial cannulation site has no impact on surgical outcomes. Because of these findings, arterial cannulation strategy should be determined by the patient's anatomy, surgeon experience, and stability of the patient. If a patient is unstable, the surgeon may not have the time for an axillary artery cut down and to suture a graft to the artery. The specific patient condition will determine the optimal arterial cannulation approach.

Although, the results of the study are compelling for the support of the femoral artery as an equivalent choice arterial access vessel, there are some limitations to the study. First, the study is a retrospective analysis and therefore all the inherent issues with this type of study exist. A follow up randomized controlled study will help provide additional information. Second, the sample size is not small at 135 patients, however, a larger sample size will further reinforce the findings. This is specifically true as the number of

patients with axillary artery and direct aortic cannulation were not large. Finally, additional operative details such as circulatory arrest time and cardiopulmonary bypass time would have been helpful to further analyze the patients.

Conclusions

Taken together, cardiothoracic surgeons should educate themselves on all arterial cannulation strategies, as no one approach is superior to the other. The findings of the study support the use of traditional femoral arterial cannulation to repair ascending aortic dissection. These results are significant because of the trend away from femoral cannulation by most cardiothoracic surgeons. The multiple concerns with femoral cannulation and perceived advantages of alternative access cases have encouraged surgical leaders to shy away from femoral cannulation. The results of this study should help support traditional femoral cannulation.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-22-576/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Rutgers University institutional review board and ethics committee (No. 2020000011). Individual consent for this retrospective analysis was waived.

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