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Is axillary arterial cannulation better than femoral arterial cannulation?

Aksiller arter kanülasyonu femoral arter kanülasyonundan daha mı iyidir?

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Background: This study aims to compare axillary and femoral arterial cannulation strategies in aortic surgery.

Methods: Femoral artery cannulation (group F) was used in 88 (51.2%) and axillary artery cannulation (group A) was used in 84 (48.8%) of 192 patients. All patients had their aortic roots or one segment of their aortae replaced and/or repaired.

Results: The mean degree of hypothermia, mean duration of intensive care and length of hospital stay were lower in group A patients. The mortality rate was 8% (n=7) in group F and 3.6% (n=3) in group A (p=0.330). Seven patients (8%) in group F and 10 patients (11.9%) in group A had neurologic complications following surgery. Postoperative incidences of bleeding, pulmonary complications and infections were higher in group F. Logistic regression analysis showed that previous cardiac surgery and postoperative neurologic complications were independently related to the postoperative mortality.

Conclusion: Axillary artery cannulation is useful to decrease the operation time and use lesser degrees of hypothermia. Patients have less intensive care and hospital stays and also pulmonary and infectious complications and postoperative bleeding are reduced.

Key words: Aortic surgery; axillary cannulation; femoral cannulation.

Amaç: Bu çalışmanın amacı, aort cerrahisinde kullanılan aksiller ve femoral arter kanülasyon stratejilerinin sonuçlarını karşılaştırmaktır.

Çalışma planı: Çalışmaya alınan 192 hastanın 88'inde (%51.2) femoral arter kanülasyonu (grup F), 84'ünde (%48.8) ise aksiller arter kanülasyonu (grup A) kullanıldı. Tüm hastaların aort kökleri ve aortun en az bir segmentinin replasman veya onarım işlemleri uygulandı.

Bulgular: Ortalama hipotermi derecesi, yoğun bakım ve hastane kalış süreleri grup A'daki hastalarda daha düşük bulundu. Mortalite oranı grup F'de %8 (n=7) ve grup A'da %3.6 (n=3) oldu (p=0.330). Grup F'de yedi hastada (%8), grup A'da ise 10 hastada (%11.9) cerrahi sonrasında nörolojik komplikasyon gözlemlendi. Ameliyat sonrası kanama, pulmoner komplikasyon ve enfeksiyon oranları grup F'de daha yüksekti. Lojistik regresyon analizinde geçirilmiş kardiyak cerrahi ve ameliyat sonrası nörolojik komplikasyon görülmesi ameliyat sonrası mortaliteyle ilişkili bulundu.

Sonuç: Aksiller kanülasyon uygulamaları ameliyat süresinin kısalması ve daha az derinlikte hipotermi kullanılabilmesi açısından fayda sağlamaktadır. Hastaların yoğun bakım ve hastane kalış süreleri kısalmakta, ameliyat sonrası görülen kanama, enfeksiyon ve pulmoner komplikasyon oranı azalmaktadır.

Anahtar sözcükler: Aort cerrahisi; aksiller kanülasyon; femoral kanülasyon.

Cerebrovascular injury is a major cause of morbidity and mortality in open heart operations. This fact is more evident when the surgeon is working on the proximal aorta. It has been postulated that femoral arterial cannulation for a cardiopulmonary bypass is a major cause of these events, mainly by means of retrograde embolization.[1]

In our clinic, we started using the axillary artery for cannulation by the end of 2006 and began evaluating

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the outcome parameters of aortic surgical procedures that were done both by femoral and axillary arterial cannulation. The primary aim of this study is to evaluate these two strategies in terms of mortality and neurological complications and to determine the factors that influence these outcomes.

PATIENTS AND METHODS

The Institutional Ethics Committee approved this study. We performed aortic procedures on 172 patients between May 2000 and January 2009. We used the femoral artery as the arterial cannulation site in 88 patients (51.2%) and the axillary artery in 84 patients (48.8%). The mean ages of the patients were 53.8±13.2 (range, 20 to 77) years in group A (patients who were operated on with axillary artery cannulation) and 54.6±12.7 (range, 23 to 77) years in group F (patients who were operated on with femoral artery cannulation) (p=0.647). The patients' preoperative data is summarized in Table 1. The cannulation site was chosen according to the surgeon's preference. All patients had their aortic roots or at least one segment of their aortas replaced or repaired. In these 172 operations, we performed 245 procedures. Operation indications and the procedures are summarized in Table 2 and Table 3.

All operations were performed through a median sternotomy. Myocardial protection was instituted with retrograde and antegrade isothermic blood cardioplegia. Neither the presence of a peripheral vascular disease nor the pathology of the thoracoabdominal aorta was taken into consideration for the choice of the cannulation site.

In cases where circulatory arrest for distal aortic repair was necessary, brain protection was completed pharmacologically with thiopental and cortisone in addition to topical cooling of the head. In group F, retrograde cerebroplegia was used in selected cases; however, in group A, selective antegrade cerebroplegia was used when necessary.

Surgical method

The anesthetic protocols were the same for each group. Although most of the group A patients were operated on by the same surgical team, the femoral cannulation method was used by various colleagues in our institute. In the operations for group A, the axillary artery exposure for cannulation was obtained through a 6 to 10 cm incision just below the clavicle over its lateral two thirds. The fibers of the pectoralis major muscle were divided. The clavipectoral fascia was incised, exposing the pectoralis minor muscle, which was then divided or retracted laterally. In the dissection, the axillary vein was usually encountered first. The axillary artery was found to be superior and deep to the vein and was readily palpated. If approached directly, following the thoracoacromial trunk, the artery was easily exposed and was encircled by umblical tape. Proximal and distal control of the axillary artery was gained, and the umblical tape was passed through a tourniquet. In cases of direct axillary arterial cannulation, Satinsky clamps were placed proximal and distal to the cannulation site after the administration of heparin. A transversal incision was made, and the axillary artery was cannulated with either an 18- or 21-French straight arterial cannula. The tourniquet was tightened, and the cannula was tied to the tourniquet. Flow was evaluated through the cannula by back-bleeding, and if adequate, the cannula was connected to the arterial line and secured to the skin.

Table 1. Preoperative patient data

Parameters	Group F		Group A		*p*
	n	%	n	%	
Sex					
Male	62	58			
Female	26	26			0.841
NYHA Class					
Class I	3	3.4	19	22.6	
Class II	11	12.5	33	39.3	
Class III	35	39.8	26	31.0	0.0001
Class IV	39	44.3	6	7.1	
Previous cardiac surgery	2	2.3	3	3.6	0.677
Hypertension	81	92.0	63	75.0	0.003
Marfan syndrome	4	4.5	0	0	0.121
Diabetes mellitus	1	1.1	5	6.0	0.111
Coronary artery disease	5	5.7	7	8.3	0.494
Renal failure	0	0	3	3.6	0.114

NYHA: New York Heart Association.

Table 2. Operation indications

Indication	Group F		Group A		*p*
	n	%	n	%	
Ascending aorta aneurysm	78	88.6	51	60.7	0.0001
Aortic dissection	68	77.3	35	41.7	0.0001
Aortic valve pathology	27	30.7	16	19.0	0.265
Arcus aneurysm	5	5.7	4	4.8	0.359
Coronary artery disease	6	6.8	7	8.3	0.778
Mitral valve pathology	1	1.1	2	2.4	0.614
Congenital cardiac pathology	2	2.3	0	0	0.497

In direct cannulation of the axillary artery, the distal clamp on the axillary artery was left in place until the end of perfusion. Thus, radial artery monitoring was not made in this group of patients. In cases of side-graft cannulation, which was used in nine of the cases, an 8 mm Dacron graft was anastomosed to the axillary artery in an end-to-side fashion. The distal axillary clamp was not used in these cases, and arterial blood pressure monitoring via the right radial artery was possible throughout the operation. After median sternotomy, cannulation of the caval veins, insertion of the venting cannula via the right superior pulmonary vein, and insertion of the retrograde cardioplegia cannula via the coronary sinus were carried out. The brachiocephalic artery was explored and encircled with umblical tape. After the cross-clamp was placed and cardioplegia was delivered, the operation was performed. We tried to use moderate hypothermia in these operations. In cases with total circulatory arrest (TCA), the cross-clamp was removed after the proximal anastomosis had been done and the brachiocephalic artery had been clamped. The flow rates during the operations were maintained according to the right arterial blood pressure readings in cases where a side graft was used. Antegrade cerebral perfusion was maintained with a 500 cc/minute flow rate and was increased to 750 to 1000 cc/minute when necessary. At the end of the operation, the axillary artery was decannulated and repaired. During weaning from the bypass, warming was done from the axillary cannula unless a problem with flow was encountered. In cases with a side graft, the graft was excised just above the anastomosis and repaired with 6/0 prolene sutures. In direct cannulation of the axillary artery, 6/0 continuous prolene sutures were used to repair the artery.

In the operations for group F, the femoral artery exposure for cannulation was obtained through a 6 to 10 cm incision over the common femoral artery (CFA) in the inguinal region. After dissection, the CFA, the superficial femoral artery (SFA), and the deep femoral artery (DFA) were each encircled with umblical tape. Proximal and distal control of the CFA was gained, and the umblical tape was passed through a tourniquet. Satinsky clamps were placed proximal and distal to the

Table 3. Procedures

Procedures	Group F		Group A		*p*
	n	%	n	%	
Aortic segment replacement	85	70.2	83	67.0	0.587
Ascending aorta	62	51.2	66	53.2	1.000
Arcus	5	4.1	4	3.2	
Hemiarcus	15	12.4	9	7.3	
Elephant trunk	3	2.5	4	3.2	
Aortic root replacement	25	20.7	16	13.0	0.221
Flanged Bentall	24	19.8	16	13.0	
Xenogreft	1	0.8	–	–	
Aortic valve procedures	5	4.1	16	13.0	0.002
Aortic valve replacement	5	4.1	15	12.1	
Reconstruction	–	–	1	0.8	
Mitral valve replacement	1	0.8	2	1.6	1.000
Coronary artery bypass grafting	6	5.0	7	5.6	0.560
Total	121	100	124	100	

cannulation site after the administration of heparin. A transverse incision was made, and the femoral artery was cannulated with either an 18- or 21-French straight arterial cannula. The tourniquet was tightened, and the cannula was tied to the tourniquet. Flow was evaluated through the cannula by back-bleeding, and if adequate, the cannula was connected to the arterial line and secured to the skin. The distal clamp on the femoral artery was left in place until the end of perfusion. After the median sternotomy, the vena cavae were encircled with umblical tapes, and the cannulation of the caval veins, insertion of the venting cannula via the right superior pulmonary vein, and insertion of the retrograde cardioplegia cannula via the coronary sinus was completed. The umblical tape encircling the caval veins was passed through tourniquets. After the cross-clamp was placed and cardioplegia was delivered, the operation was performed. In cases with TCA, the cross-clamp was removed after the proximal anastomosis had been done. Before the application of cerebroplegia, the superior caval cannula was slightly advanced, and the tourniquets were tightened. Retrograde cerebral perfusion was maintained with a 250 cc/minute flow rate via the superior vena cava and increased to 400 to 500 cc/minute when necessary. The flow was adjusted according to the drainage from the carotid arteries. At the end of the operation, the femoral artery was decannulated and repaired with 6/0 continuous prolene sutures. During weaning from the bypass, warming was done from the femoral cannula unless a problem with flow was encountered.

Postoperative course and discharge

Postoperative follow-up and medications were smilar in both groups. Postoperative morbidity was defined as follows: renal morbidity as a significant or progressive increase in blood urea nitrogen (BUN) and creatinine values or the need for dialysis, and pulmonary morbidity as prolonged ventilation (over 24 hours postoperatively), re-intubation, pleural effusion, pneumothorax, and the need for pulmonary physiotherapy. Neurological morbidity was defined according to the Ergin et al.[2] report as permanent and transient dysfunction. A comparison of postoperative drainage was performed using the drainage from the chest tubes.

Statistical analysis

The definition of complications and methods of analysis were consistent with the guidelines issued by Edmunds et al.[3] The results were presented as mean ± standard deviation. Patients in group A and group F were compared according to their ages, cross-clamp, perfusion and TCA durations, intensive care unit (ICU), and hospital stays with a t-test for independent samples. Gender, the New York Heart Association (NYHA) functional class, and indication for procedure (i.e. aneurysm and/or dissection) were compared preoperatively with a chi-square test and Fisher's exact test where appropriate. Associated diseases such as coronary artery disease (CAD), hypertension (HT), and diabetes mellitus (DM) were also compared prior to the operation along with emergency surgery, prior history of cardiac operation, and perioperative variables, for example the use of TCA or postoperative morbidity. The entire population was analyzed with logistic regression in order to evaluate the patients for the factors affecting mortality and neurological complications postoperatively. For mortality, the following factors were analyzed as explanatory variables: preoperative factors (Marfan syndrome, HT, DM, CAD, emergency surgery, previous cardiac operation), intraoperative factors [site of cannulation (axillary versus femoral) and the use of TCA], preoperative diagnosis (aneurysm, dissection, aortic regurgitation), and the occurrence of postoperative neurological complications. The development of these complications was also evaluated by logistic regression with the following explanatory variables: preoperative factors (Marfan syndrome, HT, DM, CAD, emergency surgery, previous cardiac operation), intraoperative factors [site of cannulation (axillary versus femoral) and the use of TCA], and preoperative diagnosis (aneurysm, dissection, aortic regurgitation). The development of local complications was evaluated with logistic regression with the following explanatory variables: preoperative factors (aneurysm, dissection, aortic regurgitation, Marfan syndrome, HT, CAD, DM, emergency surgery, previous cardiac surgery, preoperative renal failure), intraoperative factors (site of cannulation and the use of TCA), and postoperative complications [bleeding, revision surgery for bleeding, low cardiac output syndrome (LCOS), the use of an intra-aortic balloon pump (IABP), postoperative renal failure, and pulmonary complications]. We used a 0.05 cut-off value for the regression calculations. A p value less than or equal to 0.05 was considered statistically significant for all comparisons. A commercial statistical software package SPSS for Windows (SPSS Inc, Chicago, IL, USA) version 17.0 was used for data analysis.

RESULTS

Demographic data and operation indications

As pointed out in Table 1, the significant differences between the two groups were the functional classes, incidence of emergency procedures, and number of patients with hypertension. According to the NYHA classification, the group F patients showed more restrictions than the group A patients, and the incidence

Table 4. Perioperative data

Indication	Group F		Group A		*p*
	n	%	n	%	
Emergency operation	68	77.3	35	41.7	0.0001
Total circulatory arrest	57	64.8	51	60.7	0.582
Postoperative morbidity	46	54.8	24	28.6	0.0001
In-hospital mortality	7	8.0	3	3.6	0.330

of hypertension was higher. The operation indications mostly differed for the incidence of ascending aortic aneurysm and aortic dissection, both of which occurred more in the group F patients. This is the main reason why the emergency operations were more frequent in this group.

Perioperative data

As listed in Table 3, the numbers of procedures in both groups were similar. The only significant difference was in the aortic valve procedures, which were more commonly performed in group A. In Table 4 we summarized some other perioperative parameters. Postoperatively, although the absolute number of deaths was higher in group F, there was no significant difference between the two groups. The number of patients who had any type and severity of postoperative complications was also higher in group F.

Comparing the operative variables (Table 5), the average duration of operations was higher in group F. The mean degree of hypothermia used in the operations was also deeper in the group F patients. Postoperatively, the mean durations of ICU and hospital stays were lower in the group A patients.

There were 10 patients with in-hospital mortality. Seven were in group F (8.0%), and three were in group A (3.6%), although this difference was not statistically significant. Postoperative complications are listed in Table 6. In group F, seven patients (8.0%) had neurological deficits postoperatively, four had transient neurological deficit (TND), and three had cerebrovascular event (CVE). In group A, 10 patients (11.9%) had neurological complications, eight had TND, and two had CVE, but the differences were not significant. As seen in Table 6, there were significant differences in postoperative bleeding (p=0.024), pulmonary complications (p≤0.0001), and postoperative infectious complications (p=0.004), all of which were higher in group F. In group A, we used side-graft cannulation for the first nine cases. However, after these first nine patients, we abandoned this technique as the local bleeding became a serious problem. The total number of patients who had any morbidity was also higher in group F.

Follow-up

The mean duration of follow-up was 4.34±2.03 years in group F (total of 351.4 patient/years) and 0.86±0.46 years in group A (total of 69.5 patient/years), and the difference was statistically significant when a comparison was made using an independent t-test (p=0.0001). There were no late mortalities in group A, and there were three patients who died after they were discharged in group F. The one, three and five-year survival rates were 98.8%±1.2%, 97.4%±1.8% and 95.4%±2.6% in group F, respectively. As the postoperative follow-up durations were different, Kaplan-Meier comparisons for survival could not be calculated.

Statistical analysis

The logistic regression analysis showed that previous cardiac surgery (OR= 50.0; 95% CI= 3.61000; p=0.004) along with postoperative neurological complications (OR=12.7; 95% CI=1.852,6; p=0.009) were independently

Table 5. Postoperative results

	Mean±SD	*p*
Cross-clamp duration (minutes)		
Group A	80.6±39.8	0.724
Group F	92.0±49.6	
Perfusion duration (minutes)		
Group A	144.3±58.6	0.297
Group F	181.1±87.6	
Operation duration (minutes)		
Group A	170.1±62.0	0.015
Group F	289.7±101.1	
Hypothermia (°C)		
Group A	26.4±3.0	0.002
Group F	21.4±3.7	
Cerebroplegia duration (minutes)		
Group A	32.3±25.0	0.311
Group F	32.9±18.6	
Intensive care unit stay (days)		
Group A	5.4±5.6	0.011
Group F	9.7±16.6	
Hospitalization (days)		
Group A	12.6±5.9	0.003
Group F	15.3±9.0	

SD: Standard deviation.

Table 6. Postoperative complications

Complication	Group F		Group A		*p*
	n	%	n	%	
Postoperative bleeding	4	4.8	13	14.8	0.024
Revision surgery for any cause	6	7.1	8	9.1	0.434
Local complications	1	1.2	2	2.3	1.000
Low cardiac output syndrome	2	2.4	4	4.5	0.682
Need for IABP support	1	1.2	3	3.4	0.621
Any neurologic deficit	10	11.9	7	8.0	0.449
Transient neurologic dysfunction	8	9.5	4	4.5	0.241
Cerebrovascular event	2	2.4	3	3.4	1.000
Renal complications	8	9.5	15	17	0.181
Pulmonary complications	14	16.7	42	47.7	<0.001
Pericardial effusion	4	4.8	6	6.8	0.747
Infection	4	4.8	17	19.3	0.004
Prosthetic valve endocarditis	0	0.0	1	1.1	1.000

IABP: Intra-aortic balloon pump counterpulsation.

related to the postoperative mortality. The site of cannulation was not found to be a significant risk factor, either for mortality or neurological complications. The other explanatory variables also did not show significant associations with neurological complications. The local complications had no significant independent predictors either.

DISCUSSION

Brain injury after cardiopulmonary bypass (CPB) is a spectrum of disorders with cognitive dysfunction at one end being most common and stroke on the other hand being most obvious.[4] Cerebral embolism and hypoperfusion are the primary suspects of these injuries,[4] which are more prevalent in the elderly.[5] Although many other sites have been proposed[6,7] to prevent these complications, the axillary artery for arterial inflow site in CPB gained popularity for a period of time, especially after the study reported by Sabik et al.[1]

There are several reports on this subject which attempt to compare the results and investigate the risk factors for the outcomes. Fusco et al.[8] reported that femoral cannulation is safe, but their study involved low numbers of patients cannulated in non-femoral sites. In the large series of patients operated on for ascending aortic aneurysm, Lakew et al.[9] reported no significant differences in neurological outcomes and found that the only independent predictor of neurological morbidity was hypercholesterolemia. Although the rates of neurological morbidity in these cases were lower for both the axillary and femoral groups than in our cases, they only had aneurysm patients in their series, and the emergency cases were lower in both groups compared with our patients. Similar to our series, they had longer CPB and cross-clamp durations but unlike our operations, they used TCA more often in the femoral group (Table 4).

In their detailed analysis on a large group of patients, Svensson et al.[10] reported lower rates of mortality and stroke compared with our analysis. They analyzed the data from the Cardiovascular Information Registry, which included 1318 patients involving large numbers of extensive aortic repairs, emergency procedures, and operations performed with TCA. Their analysis also failed to reveal a certain cannulation strategy as a risk factor, in spite of the propensity-matched analysis they used.[10] Among the many factors analyzed, they found one of the risk factors to be emergency operations. An important strength of their study was the large number of patients analyzed. This enabled the authors to run more explanatory variables through the complex statistical analyses. Another study by Moizumi et al.[11] reported the absence of axillary perfusion as an independent risk factor for mortality in operations for dissections. They had a mortality rate of approximately 15%, which may be considered as an acceptable limit since most of their patients were in the high risk category.

Femoral arterial cannulation is said to cause retrograde embolization, and this may be an important issue, especially in dissection patients.[7] The lack of significant differences between the neurological outcomes in our analysis does not allow us to reach a similar conclusion. However, the association of neurological complications with mortality may be a clue. Although there was no significant difference between our two groups in terms of mortality, the absolute number of mortalites in group F was higher, and the neurological complications seemed to be related to this situation, according to the results of the logistic regression analysis. Our results do not exactly support the hypothesis that axillary cannulation decreases neurological complications,[12] but they can be interpreted in favor of the axillary site since there were decreases in postoperative complications.

One of the important results of this study is the limitation of hypothermia. Hypothermia was deeper in group F, which may be one of the causes of the increased postoperative complications. Moderate hypothermia has also been favored by others in terms of safety in aortic operations.[13] Apart from using lesser degrees of hypothermia in group A, we also used selective antegrade cerebral perfusion which may also bias the data. This fact is also hard to randomize for this type of surgical study.

A literature review by Gulbins et al.[14] reported a trend towards the increased use of the axillary artery as a site of arterial inflow since better results in terms of death and neurological outcomes have occurred, especially in aortic arch surgery. The lack of randomization, as they pointed out, is an important issue which limits the value of comparisons in most of the studies. Our patient group also had disparities between the two groups, and femoral cannulation was more common in the more severe cases. However, the fact that the emergency operations in both of these groups were similar may outweigh this disparity. In recent years, we have more frequently used the axillary route, especially as we gained more experience. Another limitation is the lack of randomization, which may increase both the surgeon's and the analyst's biases, but this may be unavoidable in these kinds of surgical reviews. The significant difference in the rates of emergency operations is one of the consequences of this lack of randomization. Even though this is an important issue, considering that emergency operations have not been found to be significant in logistic regression analyses, our analysis seems to lose little in its accuracy. Another limitation of this study is the lack of comparisons between the survival rates of both groups. This is due to the fact that we started to use the axillary artery in 2006; therefore, the postoperative follow-up durations were different. There have been no late term mortalities in group A, which may be as a result of using the axillary artery. Because of this, we could not compare the post-discharge survivals for both groups.

In conclusion, the axillary artery is a safe site for cannulation. It helps the surgeon to decrease operation times and use lesser degrees of hypothermia. Patients have less time in the ICU while hospital stays along with pulmonary and infectious complications and postoperative bleeding are reduced.

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