

Axillary Artery Perfusion in Acute Type A Aortic Dissection Repair

Bektas Battaloglu, M.D., Nevzat Erdil, M.D., and Vedat Nisanoglu, M.D.

Department of Cardiovascular Surgery, Inonu University, Turgut Ozal Medical Center, Malatya, Turkey

ABSTRACT ***Background:*** **We evaluated our experience with axillary artery perfusion technique in acute type A aortic dissection repair.** ***Methods:*** **Between September 2000 and July 2006, 41 consecutive patients with acute type A aortic dissection underwent surgical repair. In 35 of 41 patients (85.4%), arterial perfusion was performed through right axillary artery and in the remaining six patients (14.6%), arterial perfusion site was femoral artery. Indication for femoral artery perfusion was cardiac arrest and ongoing cardiopulmonary resuscitation in one and pulslessness of right upper limb in five patients. Mean age was 54.9 ± 15.3 (16 to 90 years) and 28 were male. Unilateral antegrade cerebral perfusion (perfusate temperature 22 to 25°C) through axillary artery was performed in all axillary artery perfused patients and in three patients who had femoral artery perfusion.** ***Results:*** **Five patients died postoperatively (hospital mortality 12.2%). All of them had evidence of single or multiple organ malperfusion preoperatively. We did not experience any new transient or permanent neurologic deficit after the procedure in the unilateral antegrade cerebral perfusion patients. Complications related to axillary artery cannulation were observed in two patients (5.3%). One patient with femoral artery cannulation experienced femoral arterial thrombosis, postoperatively.** ***Conclusions:*** **Right axillary artery cannulation for repair of acute type A aortic dissection is a simple and safe procedure. In the case of pulslessness of right upper limb, femoral artery is still the choice of cannulation site.** doi: 10.1111/j.1540-8191.2008.00754.x *(J Card Surg 2008;23:693-696)*

INTRODUCTION

Despite important developments in surgical technique, prosthetic materials, myocardial protection, and perioperative care, repair of acute type A aortic dissection is still associated with high mortality and morbidity.[1,2] Operative mortality and morbidity is mainly related to presence of perioperative organ malperfusion and intraoperative cerebral protection techniques.[3-6] Best technique for cerebral protection during this procedure is still a matter of controversy. Although cerebral protection with antegrade cerebral perfusion (ACP) technique seems to be physiologic and better than profound hypothermic circulatory arrest and retrograde cerebral perfusion, it is still not optimal because of the increased cluttering of operative field and the requirement of direct cannulation of arch vessels, which may have detrimental effect on the dissected and friable arteries.[7,8]

Single right axillary artery cannulation may provide both whole body and unilateral antegrade cerebral perfusion for repair of acute type A aortic dissection.[5,6] However, there are still some debates about this technique that require further evaluation. The choice of cannulation site in the presence of pulslessness or attenuation of the pulse of right upper limb and the necessity for arch vessels occlusion for unilateral ACP through axillary artery cannula and related possibility of detrimental effect on these vessels are among them. There is also a possibility of left cerebral hemisphere hypoperfusion with unilateral protection due to inadequate collateral circulation in the circle of Willis. The aim of present study was to evaluate our experience of single axillary artery perfusion technique in acute type A aortic dissection repair.

MATERIALS AND METHODS

Between September 2000 and July 2006, 41 consecutive patients with acute type A aortic dissection underwent surgical repair at Turgut Ozal Medical Center in Malatya, Turkey. A computerized clinical database was used to retrospectively review the patient characteristics. In 35 of 41 patients (85.4%), arterial perfusion was performed through right axillary artery and in the remaining six patients (14.6%), arterial perfusion site was femoral artery. Indication for femoral artery perfusion was cardiac arrest and ongoing cardiopulmonary resuscitation in one and pulslessness of right upper limb in five patients. Patient age ranged from 16 to 90 years (mean 54.9 ± 15.3). There were 28 men and two patients (4.9%) had undergone previous cardiac surgery. The diagnosis of acute type A aortic dissection was made by computed tomography and transthoracic and/or

Address for correspondence: Bektas Battaloglu, M.D., Department of Cardiovascular Surgery, Inonu University, Turgut Ozal Medical Center, Malatya 44315, Turkey. Fax: +90-422-3411180; e-mail: bbattaloglu@inonu.edu.tr

TABLE 1.
Operative Procedures

	N	%
Proximal repair:		
Supracoronary aortic graft	31	75.6
Modified Bentall procedure	10	24.4
Distal extent of repair:		
Ascending aortic replacement alone	7	17.1
Hemiarch replacement	30	73.2
Total arch replacement	4	9.8
Concomitant procedures:		
Coronary artery bypass grafting	4	9.8
Mitral valve replacement	1	2.5

transesophageal echocardiography. Sixteen patients (39%) had clinical signs of cardiac tamponade. Seven patients (17.1%) had new onset generalized or focal cerebral dysfunction; five of them were comatose and two were hemiplegic. Visceral ischemia was present in four patients (9.8%), renal ischemia in four patients (9.8%), lower limb ischemia in nine patients (21.9%), paraplegia in one patient (2.5%), and pulslessness of right upper limb in five patients (12.2%).

All operations were performed on an emergency basis. All patients underwent replacement of ascending aorta. In 34 patients, replacement of ascending aorta was extended to the hemi-arch or arch and four patients underwent total arch replacement. A modified Bentall operation was performed in 10 patients (24.4%) who had severe aortic valve insufficiency. In addition to the aortic replacement, isolated small intimal tears located around arch vessels orifice were primarily repaired in six patients using Teflon buttressed sutures. Concomitant procedures were coronary artery bypass grafting in four patients (9.8%) and mitral valve replacement in one patient (2.5%). Operative characteristics are presented in Table 1.

SURGICAL TECHNIQUE

For right axillary artery access, patients were placed in the supine position, with the upper limb in abduction at 90° and slight external rotation. Left radial or brachial artery pressure monitoring line was placed prior to induction of general anesthesia. Subpectoral approach was used for right axillary artery exposure. This technique has been described in detail previously.[9] Briefly, a longitudinal skin incision, 4 to 6 cm in length, was made parallel to the inferior border of pectoralis major and pectoralis major muscle is retracted upward and medially. The coracobrachial sheath was opened and the median nerve was exposed and mobilized laterally using a rubber tape. The axillary artery was then exposed. Rubber tapes were passed around the artery proximally and distally.

After heparin administration, axillary artery was cannulated with a 14, 17, or 21 Fr femoral arterial cannula that had multiple side holes and vented barbed connector (Medtronic DLP, Minneapolis, MN, USA). Femoral arterial cannulation was performed in six patients. In order to perform unilateral ACP, an 8 Fr catheter was inserted in the right upper brachial artery with a small incision (2 to 3 cm in length) in 3 of these patients, and the catheter was connected to the vented barbed connector of femoral arterial cannula. Femoral venous cannulation was performed in three patients who had undergone previous cardiac surgery and in those patients who were in cardiac arrest on arrival to the operating room. Once arterial cannulation was completed, median sternotomy was performed. In all patients except three, right atrial cannulation with a two-staged single venous cannula was performed. A single stage cannula was used for right atrial cannulation in addition to the femoral venous cannula in the remaining three patients. Cardiopulmonary bypass (CPB) was initiated and systemic cooling was accomplished. Ascending aorta was cross-clamped in its midportion. Cold-blood cardioplegia was used for myocardial preservation (blood/crystalloid cardioplegia ratio 4:1) using a Medtronic CardioTerm™ cardioplegia system. Blood cardioplegia was infused in retrograde fashion via the coronary sinus until cardiac arrest was established. Subsequently, intermittent retrograde cold-blood cardioplegia was administered every 20 minutes.

A longitudinal aortotomy was made in the ascending aorta. Aorta was then transected proximally according to location of the intimal tear. The diseased aortic wall was reinforced with two layers of Teflon felt and supracoronary anastomosis was performed using 3 to 0 polypropylene continuous sutures (n = 31). Aortic root replacement was performed when necessary using a modified Bentall procedure (n = 10). Once proximal anastomosis was completed, aortic arch, the innominate, and left common carotid artery was dissected away from the surrounding tissues and innominate and left common carotid arteries were exposed. In patients with right axillary artery perfusion, the flow rate of the CPB was decreased to a mean volume flow of 8 to 10 mL/kg/min (500 to 750 mL) when rectal temperature reached 22 to 25 °C and innominate and left common carotid arteries were clamped with soft vascular clamps. Thus, unilateral ACP was instituted. Aortic cross clamp was then removed. In three patients with femoral artery cannulation, for unilateral ACP the CPB flow was directed to the right brachial artery with a flow rate of 8 to 10w mL/kg/min. In these three patients, before unilateral ACP, arch vessels were inspected and the innominate artery was found intact. During circulatory arrest period, the brain was continuously perfused via the right axillary artery at a temperature of 22 to 25 °C. We did not clamp the left subclavian artery. A descending aortic vent was inserted through the aortic opening to evacuate pooled blood. The remaining three patients who were perfused through the femoral arterial cannula were cooled to 18 °C and deep hypothermic total circulatory arrest (TCA) was used. All distal anastomoses and arch reconstructions were performed with an open aortic anastomosis technique. After distal aortic repair was performed, the graft was cross-clamped and then systemic circulation was resumed by releasing clamps on the brachiocephalic vessels. Hot

TABLE 2.
Hospital Mortality

Patient No.	Age (Years)	Sex	Preoperative Organ Malperfusion	Arterial Perfusion Site	Operative Procedure	Cause of Death
1	62	Male	Visceral, renal, and lower limb ischemia	Axillary artery	Asc + hemiarch	Multiorgan failure
2	52	Male	Cerebral ischemia	Axillary artery	Asc + total arch + MVR	Cerebral ischemia and multiorgan failure
3	56	Female	Visceral ischemia	Axillary artery	Asc + hemiarch	Visceral ischemia
4	65	Female	Visceral ischemia	Axillary artery	Asc + hemiarch	Visceral ischemia
5	63	Male	Renal and lower limb ischemia	Axillary artery	Asc + total arch	Multiorgan failure

Asc = ascending; MVR = mitral valve replacement.

shot cardioplegia (500 mL) was administered prior to removal of aortic cross clamp.

RESULTS

Mean CPB time and aortic cross-clamp times were 177 ± 60.8 minutes and 81.03 ± 33.2 minutes, respectively. Mean period of unilateral ACP through the right axillary artery was 31.1 ± 16.4 minutes. The mean deep hypothermic TCA time was 29.8 ± 14.4 minutes in which we were not able to achieve ACP. Five patients died postoperatively with a hospital mortality of 12.2%. All of them had evidence of one or more organ malperfusion preoperatively. One patient had generalized cerebral ischemia and his neurological condition deteriorated postoperatively. The causes of hospital mortality are summarized in Table 2.

None of the patients experienced new transient or permanent neurologic deficits in the postoperative period. Lower limb ischemia did not recover postoperatively in one patient. This patient underwent surgical abdominal aortic fenestration. Postoperatively, two patients underwent laparotomy for visceral ischemia, and wide intestinal resection was performed in both of them, however, they did not survive. Re-exploration rate for bleeding or cardiac tamponade was 9.8% (four patients) and five patients (12.2%) required postoperative inotropic support. Complications related axillary artery cannulation occurred in two patients (5.3%); one required saphenous vein graft interposition for local axillary artery injury, and the other patient underwent thrombectomy for postoperative axillary artery thrombosis. One patient with femoral artery cannulation experienced femoral arterial thrombosis in the postoperative period.

DISCUSSION

Acute type A aortic dissection is a catastrophic disease that requires immediate surgical intervention. The main goal of surgery in acute type A aortic dissection is to prevent death from intrapericardial hemorrhage by resecting and replacing the diseased aorta with a graft.[1] The nature of this disease does not allow CPB via aortic cannulation. Thus, arterial cannulation for aortic dissection repair has been performed through the femoral artery for many years. Femoral arterial perfusion, however, causes retrograde flow, which is associated with several drawbacks. These are lower limb ischemia, propagation of a retrograde dissection with consequent neurologic or visceral organ ischemia, retrograde embolization of luminal debris, and wound complications.[10,11] Recently, axillary artery perfusion has been recommended to avoid from some of these complications.[4,12,13] Axillary artery perfusion provides some advantages including antegrade true lumen perfusion, cerebral protection without of any additional cannulation of brachiocephalic arteries, and use of moderate hypothermia instead of deep hypothermic TCA. There is also no need to recannulate the graft before reestablishing CPB. However, technical problems and complications of axillary artery canulation have been reported, including axillary artery injury up to 5% and malperfusion required to be switched to femoral cannulation.[14] In the present study, we did not experience perfusion problems such as low CPB flow due to axillary artery cannulation. Local arterial injury and thrombosis were the only complications related to axillary artery cannulation in our series.

Single axillary artery cannulation for whole body and unilateral antegrade cerebral perfusion is our first choice in acute type A aortic dissection repair. However, we did not perform this technique in all patients. In the cardiac arrest case, we preferred femoral arterial cannulation in order to institute CPB immediately. Although in such cases axillary artery cannulation is possible, it is difficult to access and to cannulate this artery during cardiopulmonary resuscitation. We also performed femoral arterial cannulation for CPB in five patients who had developed pulslessness of right upper limb. In these patients, we were reluctant for whole body perfusion through axillary artery cannula due to possible dissection involvement of this artery. However, optionally in three of these patients we inserted an 8 Fr cannula in the brachial artery to achieve unilateral ACP provided that the innominate artery was found intact during intraoperative examination. Although some considered pulselessness or attenuation of the pulse of the upper limb as a contraindication for ipsilateral cannulation,[15] Pasic et al.[13] reported that they had used right axillary artery for cannulation and CPB even in patients with no pulse or

decreased pulse due to dissection involvement with favorable results.

For performing unilateral ACP through the axillary artery, we clamped the innominate and left common carotid artery. However, we did not clamp left subclavian artery, because it is difficult to expose. Reported mean volume flow rate for unilateral ACP ranged from 10 to 15 mL/kg/min in previous studies.[4,6] We kept mean volume flow rate between 8 and 10 mL/kg/min, however, we did not exceed 750 mL/min in any patient. We started circulatory arrest and subsequent unilateral ACP when rectal temperature reached 22 to 25 °C due to the possibility of inadequate flow to the contralateral hemisphere.[5,16] In this study, we did not experience any new neurologic deficits in unilateral ACP-applied patients as well in three TCA patients. Research shows that unilateral cerebral perfusion through the axillary artery for arch surgery under moderate hypothermia (at 26 °C) is safe.[5,6] We are also convinced that perfusion at moderate hypothermia would be satisfactory for cerebral protection during unilateral ACP.

In conclusion, right axillary artery cannulation for repair of acute type A aortic dissection is a feasible and safe procedure with acceptable morbidity and mortality. Femoral arterial canulation should be kept in mind if there is evidence of pulslessness of right upper limb or when CPB is required before sternotomy.

REFERENCES

1. Ehrlich MP, Ergin MA, McCullough JN, et al: Results of immediate surgical treatment of all acute type A dissections. Circulation 2000;102(Suppl):III248-252.
2. Svensson LG, Crawford ES, Hess KR, et al: Dissection of the aorta and dissecting aortic aneurysms. Improving early and long-term surgical results. Circulation 1990;82(Suppl):IV24-38.
3. Yagdi T, Atay Y, Engin C, et al: Impact of organ malperfusion on mortality and morbidity in acute type a aortic dissections. J Card Surg 2006;4:363-369.
4. Moizumi Y, Motoyoshi N, Sakuma K, et al: Axillary artery cannulation improves operative results for acute type A aortic dissection. Ann Thorac Surg 2005;80: 77-83.
5. Tasdemir O, Saritas A, Kucuker S, et al: Aortic arch repair with right brachial artery perfusion. Ann Thorac Surg 2002;73:1837-1842.
6. Panos A, Murith N, Bednarkiewicz M, et al: Axillary cerebral perfusion for arch surgery in acute type A dissection under moderate hypothermia. Eur J Cardiothorac Surg 2006;29:1036-1039.
7. Hagl C, Ergin MA, Galla JD, et al: Neurologic outcome after ascending aorta–aortic arch operations: Effect of brain protection technique in high-risk patients. J Thorac Cardiovasc Surg 2001;121:1107-1121.
8. Di Eusanio M, Tan ME, Schepens MA, et al: Surgery for acute type A dissection using antegrade selective cerebral perfusion: Experience with 122 patients. Ann Thorac Surg 2003;75:514-519.
9. Haimovici H: The upper extremity. In Ascher E (ed.): Haimovici's Vascular surgery. Blackwell Publishing, New York, 2003:322-333.
10. Eugene J, Aronow WS, Stemmer EA, et al: Retrograde aortic dissection during cardiopulmonary bypass. Clin Cardiol 1981;4:356-359.
11. Van Arsdell GS, David TE, Butany J: Autopsies in acute type A aortic dissection. Surgical implications. Circulation 1998;98(Suppl):II299-304.
12. Whitlark JD, Goldman SM, Sutter FP: Axillary artery cannulation in acute ascending aortic dissections. Ann Thorac Surg 2000;69:1127-1129.
13. Pasic M, Schubel J, Bauer M, et al: Cannulation of the right axillary artery for surgery of acute type A aortic dissection. Eur J Cardiothorac Surg 2003;24:231-236.
14. Schachner T, Nagiller J, Zimmer A, et al: Technical problems and complications of axillary artery cannulation. Eur J Cardiothorac Surg 2005;27:634-637.
15. Neri E, Massetti M, Capannini G, et al: Axillary artery cannulation in type a aortic dissection operations. J Thorac Cardiovasc Surg 1999;118:324-329.
16. Merkkola P, Tulla H, Ronkainen A, et al: Incomplete circle of Willis and right axillary artery perfusion. Ann Thorac Surg 2006;82:74-79.