Türk Göğüs Kalp Damar Cerrahisi Dergisi
Turkish Journal of Thoracic and Cardiovascular Surgery

Early results of surgery for acute type A aortic dissection without using neurocerebral monitoring

Nöroserebral izlenme yapılmadan uygulanan akut tip A aortik diseksiyon cerrahisinde erken sonuçlar

Nevzat Erdil,[1] Ender Gedik,[2] Feray Erdil,[2] Vedat Nisanoğlu,[1] Bektaş Battaloğlu,[1] Özcan Ersoy[2]

Department of [1]Cardiovascular Surgery, [2]Anesthesiology and Reanimation,
Medicine Faculty of İnönü University, Malatya

Background: This study aimed to determine if the routine use of unilateral antegrade cerebral perfusion during repair of acute type A aortic dissection can eliminate the need for intraoperative neurophysiologic monitoring.

Methods: Between September 2000 and December 2009, 66 consecutive patients with acute type A aortic dissection underwent surgical repair in our clinic. In 57 patients (86.4%), arterial perfusion was provided through a right axillary artery cannula and in the remaining nine patients (13.6%) the arterial perfusion site was the femoral artery.

Results: Postoperative hospital mortality was 13.6% (n=9). Postoperative hemorrhage or tamponade requiring resternotomy occurred in seven patients (10.6%). Nine patients (13.6%) required postoperative inotropic support. Postoperative atrial fibrillation was observed in six patients. Mean intensive care unit stay and hospital stay were 5.1±4.4 days (range, 2 to 26 days) and 10.8±8.9 days (range, 7 to 60 days), respectively. Mean extubation time was 15.4±13.9 hours (range, 7 to 74 hours). One of the surviving patients experienced new transient neurological deficits in the postoperative period.

Conclusion: Unilateral antegrade selective cerebral perfusion techniques may provide reliable brain protection and reduce cerebral complication rates without the use of routine cerebral monitoring devices, even for longer periods of circulatory arrest during surgery of acute type A aortic dissection.

Key words: Anaesthesia; aortic rupture; brain protection; cerebral perfusion; surgery.

Amaç: Bu çalışmada, akut tip A aortik diseksiyon onarımı sırasında tek taraflı anterograd serebral perfüzyonun rutin kullanımıyla, ameliyat sırası nörofizyolojik izlenme gereksiniminin ortadan kalkabileceği belirlendi.

Çalışma planı: Eylül 2000 ve Aralık 2009 tarihleri arasında, kliniğimizde akut tip A aortik diseksiyonu ile cerrahi onarım yapılan ardışık 66 hasta çalışmaya alındı. Arteryel perfüzyon, 57 hastada (%86.4) sağ aksiller arterden, geri kalan dokuz hastada (%13.6) ise femoral arter bölgesinden kanülasyonla sağlandı.

Bulgular: Ameliyat sonrası hastane mortalitesi %13.6 (n=9) idi. Ameliyat sonrası hemoraji ya da tamponad nedeniyle yedi (%10.6) hastaya yeniden sternotomi gerçekleştirildi. Ameliyat sonrası dokuz hasta (%13.6) inotropik destek aldı. Ameliyat sonrası altı hastada atriyal fibrilasyon saptandı. Ortalama yoğun bakım ünitesi kalış süresi ve hastane kalış süresi sırasıyla 5.1±4.4 (dağılım 2-26) gün ve 10.8±8.9 (dağılım 7-60) gün idi. Ortalama ekstübasyon zamanı 15.4±13.9 (dağılım 7-74) saat idi. Ameliyat sonrası dönemde yaşayan hastalardan birinde yeni geçici nörolojik defisitler gelişti.

Sonuç: Akut tip A aortik diseksiyon cerrahisi sırasında, tek taraflı anterograd selektif serebral perfüzyon teknikleri, rutin serebral monitörizasyon cihazları kullanılmadan uzun süren sirkülatuvar arrest dönemlerinde bile güvenli beyin koruması ve azalmış serebral komplikasyon oranı sağlayabilir.

Anahtar sözcükler: Anestezi; aortik rüptür; beyin koruma; serebral perfüzyon; cerrahi.

Acute type A aortic dissection represents an emergency situation that requires immediate surgical intervention to prevent aortic rupture and possible death. Despite advances in surgical techniques and strategies, operations for acute type A aortic dissections are still associated with high mortality rates, especially in the presence

Received: February 5, 2010 *Accepted*: March 1, 2010

Correspondence: Nevzat Erdil, M.D. İnönü Üniversitesi Tıp Fakültesi Kalp ve Damar Cerrahisi Anabilim Dalı, 44000 Malatya, Turkey.
Tel: +90 422 - 341 06 60 / 3909 e-mail: nerdil@inonu.edu.tr

of perioperative organ malperfusion.[1] Postoperative neurological damage has been a major problem for acute type A aortic dissection.[2,3]

Neurological complications associated with this injury significantly increase the incidence of morbidity and mortality.[4] The presence of a neurological deficit preoperatively has been associated with hospital mortality rates as high as 58% giving rise to the question of whether or not emergent surgery is prudent in this patient population.[5,6]

Cerebral protection techniques described in the literature include deep hypothermic circulatory arrest, retrograde cerebral perfusion and antegrade selective cerebral perfusion.[7,8] Recently, the use of unilateral selective antegrade cerebral perfusion has been gaining popularity in the repair of aortic arch aneurysm or dissections.[9-12] Various cerebral monitoring techniques, including the use of electrophysiology, ultrasound, oxygen saturation, or near infrared spectroscopy are available.[4]

The aim of this study was to evaluate our experience for antegrade cerebral perfusion technique without the use of a neurophysiologic monitoring technique in acute type A aortic dissection repairs.

PATIENTS AND METHODS

Between September 2000 and December 2009, 66 consecutive patients with acute type A aortic dissection underwent surgical repair at our clinic. In 57 of 66 patients (86.4%), arterial perfusion was performed through the right axillary artery and this single arterial access enabled both whole-body perfusion during cardiopulmonary bypass (CPB) and unilateral antegrade cerebral perfusion (UACP). In the remaining nine patients (13.6%) the arterial perfusion site was the femoral artery. Unilateral antegrade cerebral perfusion (via an 8 Fr catheter in the right upper brachial artery) was performed in four of the nine femoral artery cannulation patients. The remainder of the patients[5] underwent surgical intervention without UACP. Demographic and clinical data are presented in table 1. All patients were operated on an emergency basis immediately after the diagnosis was established. Computed tomography and echocardiography were the common modality of definitive diagnosis, and transesophageal echocardiography was used as a confirmation test, when possible.

Anesthetic and perfusion protocol

In the operating room, veins on both arms were cannulated with 16-G catheters after a five-lead electrocardiogram and SpO_2 monitoring. Blood pressure was monitored with a left radial or brachial arterial line and a double lumen catheter in the right internal jugular vein was used for central vein pressure monitoring under local anesthesia. Rectal and nasopharyngeal temperature was monitored for all patients (Drager PM 8040-Cato, Lübeck, Germany).

The technique of anesthesia was standardized for all patients. Anesthesia was induced with intravenous 0.1 mg/kg lidocaine, 0.1-0.3 mg/kg midazolam and 10-20 µg/kg fentanyl. Vecuronium, 0.1 mg/kg, was used to facilitate endotracheal intubation. Anesthesia was maintained with 20-40 µg/kg fentanyl and isoflurane 0.2-2%, whereas N_2O was not used. Doses of the anesthetics used were adapted to maintain optimal anesthetic and surgical conditions, while maintaining hemodynamic stability. Throughout the operation, fentanyl 5 µg/kg was administered as a standard application

Table 1. Demographic and clinical characteristics of patients*

	n	%
Mean age (years)	54.2±14.8	(16-90)
Male/female	48/18	
Body surface area (m^2)	1.84±0.18	(1.48-2.25)
Marfan syndrome	4	6.1
Previous cardiac operation	3	4.5 (1 AVR and 2 CABG)
Severe aortic insufficiency	18	27.3
Shock	24	36.4
Cardiac tamponade	27	40.9
Visceral ischemia	4	6.1
Renal ischemia	6	9.1
Cerebral ischemia	9	13.6
Spinal chord ischemia	1	1.5
Lower limb ischemia	11	16.7
Right upper limb ischemia	7	10.6
Cardiopulmonary resuscitation	2	3.03

*: Data are presented as mean ± standard deviation, number of patients and percentage; AVR: Aortic valve replacement; CABG: Coronary artery bypass graft.

before the incision and sternotomy, and at the beginning of CPB. Hypertension was treated by increasing the concentration of isoflurane or with nitroglycerine or nitroprusside, as appropriate. Hypotension was corrected with intravascular volume replacement or epinephrine, as indicated. Isoflurane 0.2-1% was administered during the entire period of CPB.

Roller pump and membrane oxygenator were used for extracorporeal support. The patients who underwent UACP were cooled to a rectal temperature of 22-26 °C. To increase the tolerance of the neurologic tissue for ischemia, the patients' heads were packed in ice bags for topical head cooling and intravenous methylprednisolone 500 mg and mannitol 1 g/kg were given to all patients immediately before circulatory arrest. The patients were placed in a head-down tilt position for hypothermic circulatory arrest (HCA) and unilateral antegrade cerebral perfusion. Hypothermic circulatory arrest was performed after achieving a rectal temperature of 18-20 °C in patients who were perfused through the femoral artery cannula. Hemotocrit was maintained at more than 20-25% during CPB.

Surgical technique

Our arterial and venous cannulation technique has been described in detail previously.[11] The ascending aorta was cross-clamped and cold blood cardioplegia was delivered continuously in a retrograde manner to achieve cardiac arrest. Subsequently, intermittent retrograde cold blood cardioplegia was administered in every 20 minutes. In 55 patients with UACP, during the period of systemic circulatory arrest, the brain was continuously perfused via the right axillary artery at a temperature of 22-25 °C with a mean volume flow of 8-10 ml/kg/min (500-750 ml). Nine patients who were perfused only through the femoral arterial cannula were cooled to 20 °C and deep hypothermic total circulatory arrest was used as a neuroprotective strategy without UACP. All distal anastomoses and arch reconstructions were performed with an open aortic anastomosis technique. Operative data is shown in table 2. Nitroglycerine infusion of 1-3 µg/kg/min was given after rewarming depending on the blood pressure. Postoperative sedation was provided with midazolam infusion if necessary. Neurological outcomes and postoperative complications were evaluated and recorded in the intensive care unit.

Definitions

Postoperative low cardiac output syndrome was defined as a cardiac index lower than 2 L/min/m^2 and the need for inotropic agents. Renal failure was defined as prolonged oliguria or anuria with elevated blood urea nitrogen and creatinine levels requiring forced diuresis or hemofiltration.

Cerebral malperfusion was diagnosed by the new-onset neurological deficit, either focal or a generalized dysfunction; such as confusion, disorientation, dysarthria, hemiplegia, and paraplegia and was diagnosed clinically and confirmed by cerebral computed tomography. Multiorgan dysfunction syndrome was defined as severe dysfunction of two or more organ systems.

Data were expressed as mean ± standard deviation (SD) and number of patients and percentage. Because the aim of the study was to determine the neurologic outcome and because low mortality and neurologic events occurred, we did not perform a statistical analysis.

RESULTS

Postoperative mortality was 13.6% (n=9). Preoperative organ malperfusion was present in all nine patients that died. Visceral ischemia was noted in three patients; cerebral ischemia was present in two patients; myonephropatic metabolic syndrome occurred in two patients; and, one patient suffered multiorgan failure. One patient who suffered from cardiac arrest was immediately resuscitated then underwent the operation and died intraoperatively.

Mean intensive care unit stay and hospital stay were 5.1±4.4 days (range, 2 to 26 days) and 10.8±8.9 days (range, 7 to 60 days), respectively. Mean extubation time was 15.4±13.9 hours (range, 7 to 74 hours). The eight patients who were not suitable for immediate extubation were sedated with midazolam infusion and were extubated later.

Preoperative cerebral ischemia was present in nine patients. Of the seven surviving patients, four patients had complete resolution of their preoperative neurologic deficit. In the remaining three patients, preoperative neurological dysfunction persisted; however, there was

Table 2. Operative procedures*

	n	%
Proximal repair		
Supracoronary aortic graft	48	72.7
Modified Bentall procedure	18	27.3
Distal extent of repair		
Ascending aortic replacement alone	12	18.2
Hemiarch replacement	47	71.2
Aortic arch replacement	7	10.6
Concomitant procedures:		
Coronary artery bypass grafting	6	9.1
Mitral valve replacement	1	1.5

*: Data are presented as number of patients and percentage.

a new transient neurologic deficit in the postoperative period in one patient.

Postoperative hemorrhage or tamponade requiring resternotomy occurred in seven patients (10.6%) and nine patients (13.6%) required postoperative inotropic support. Postoperative atrial fibrillation treated with amiodarone infusion was seen in six patients (9%).

Lower limb ischemia did not recover postoperatively in one patient (1.5%). Postoperatively, two patients (3%) underwent laparotomy for visceral ischemia, and died despite full support.

Complications related to axillary artery cannulation occurred in two patients (3%). One patient (1.5%) with femoral artery cannulation experienced femoral arterial thrombosis in the postoperative period.

DISCUSSION

Aortic dissection surgery is one of the life saving emergent procedures. For that reason, the operation should be completed with minimal complications in optimal conditions. The use of neurophysiologic monitoring techniques involving cerebral blood flow and oxygen saturation measurements, and electrical activity of both peripheral and central nervous systems have allowed clinicians to assess the function of these structures intraoperatively.[4] The ideal technique for monitoring the nervous system during dissection repairs would be a continuous, objective method of rapidly assessing perfusion, oxygenation, and activity. The equipment should be portable, compact, reliable, and easy to use, and the results should be accurate and reproducible. Technicians should be experienced and have certifications in the monitoring techniques that are being performed. Various monitoring techniques, including the use of electrophysiology, ultrasound, or near infrared spectroscopy are available.[4] We did not use any of the neurophysiologic monitoring systems in our study and did not experience any new permanent neurologic deficits among our cohort. We believe that UACP technique via the right axillary artery minimized these complications. There is general agreement that volatile anesthetics reduce ischemic cerebral injury. Isoflurane neuroprotection has been demonstrated in a variety of experimental models of ischemia.[13] We also think that our anesthetic technique with isoflurane may also support cerebral protection.

The cerebral protection methods currently used for aortic surgery are profound HCA, retrograde cerebral perfusion, and antegrade selective cerebral perfusion. Although refinements continue to be made and results are getting better, brain injury is known to occur in association with all cerebral protection techniques suitable for these operations.[14] Many aortic surgeons favor hypothermic circulatory arrest during arch replacements. However, this technique provides the surgeon with only a limited time to carry out the aortic repair, and neurologic complications have been correlated with the use of deep hypothermic circulatory arrest.[3] The technique also requires the prolongation of CPB to rewarm the patient, which can cause some complications. Retrograde cerebral perfusion was, and still is, used by some groups as an adjunct to hypothermic circulatory arrest to enhance cerebral protection during thoracic aortic surgery. It remains unclear whether retrograde cerebral perfusion provides effective cerebral perfusion, metabolic support, washout of embolic material, and improved neurologic and neurophysiologic outcome.[15] Recently, the use of selective antegrade cerebral perfusion has been gaining popularity in the repair of aortic arch aneurysms or dissections.[9,10] We have also performed antegrade perfusion via the right axillary artery in acute type A dissection because of the following considerations: *(i)* unique arterial cannulation site; *(ii)* avoidance of any additional manipulation of the brachiocephalic arteries; *(iii)* antegrade flow pattern of the CPB; *(iv)* continuous antegrade cerebral perfusion; *(v)* use of moderate hypothermia for both brain and lower body; and *(vi)* limited circulatory arrest of the lower body.

The concept of unilateral selective cerebral perfusion may raise concerns about the adequacy of preservation of the contralateral hemisphere. The visual confirmation of the returning blood through the left common carotid and subclavian arteries during antegrade perfusion is a valuable indicator for contralateral hemispheric perfusion.[9] We observed return of blood in all patients and considered this evidence of adequate perfusion of the contralateral hemisphere in all patients.

During the aortic dissection surgery some additional techniques may increase tolerance for cerebral ischemia and reduce injury. We used mannitol and metylprednisolone to protect the brain against ischemic injury. Mannitol is well known to reduce cerebral edema after ischemia. Mannitol can also scavenge free radicals and thus reduce the degree of tissue damage caused by superoxide radicals.[16] To increase the tolerance of the neurologic tissue for ischemia, the patients' heads were also packed in ice bags for topical head cooling. By means of antegrade selective cerebral perfusion (ASCP), the repair time can be safely prolonged as compared to deep HCA with or without retrograde cerebral perfusion, allowing more complex repairs to be performed.[12,17] Research shows that unilateral cerebral perfusion through the axillary artery for arch surgery under moderate hypothermia is safe.[18,19] We are also convinced that perfusion at moderate hypothermia would be satisfactory for cerebral protection during unilateral antegrade cerebral perfusion.

In conclusion, one of the cerebral monitoring techniques may be used in aortic surgery if feasible. But ASCP via the axillary artery and other cerebral protection techniques may provide reliable brain protection and reduce cerebral complication rates without routine cerebral monitoring devices, even for longer periods of repair during surgery for acute type A aortic dissection.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Yagdi T, Atay Y, Engin C, Mahmudov R, Tetik O, Iyem H, et al. Impact of organ malperfusion on mortality and morbidity in acute type A aortic dissections. J Card Surg 2006;21:363-9.
2. Kawahito K, Adachi H, Yamaguchi A, Ino T. Early and late surgical outcomes of acute type A aortic dissection in patients aged 75 years and older. Ann Thorac Surg 2000;70:1455-9.
3. Pansini S, Gagliardotto PV, Pompei E, Parisi F, Bardi G, Castenetto E, et al. Early and late risk factors in surgical treatment of acute type A aortic dissection. Ann Thorac Surg 1998;66:779-84.
4. Kohl BA, McGarvey ML. Anesthesia and neurocerebral monitoring for aortic dissection. Semin Thorac Cardiovasc Surg 2005;17:236-46.
5. Bavaria JE, Pochettino A, Brinster DR, Gorman RC, McGarvey ML, Gorman JH, et al. New paradigms and improved results for the surgical treatment of acute type A dissection. Ann Surg 2001;234:336-42.
6. Lynch DR, Dawson TM, Raps EC, Galetta SL. Risk factors for the neurologic complications associated with aortic aneurysms. Arch Neurol 1992;49:284-8.
7. Tabayashi K, Ohmi M, Togo T, Miura M, Yokoyama H, Akimoto H, et al. Aortic arch aneurysm repair using selective cerebral perfusion. Ann Thorac Surg 1994;57:1305-10.
8. Yasuura K, Okamoto H, Ogawa Y, Matsuura A, Asakura T, Seki A, et al. Resection of aortic aneurysms without aortic clamp technique with the aid of hypothermic total body retrograde perfusion. J Thorac Cardiovasc Surg 1994;107:1237-43.
9. Ozatik MA, Küçüker SA, Tülüce H, Sarıtaş A, Sener E, Karakaş S, et al. Neurocognitive functions after aortic arch repair with right brachial artery perfusion. Ann Thorac Surg 2004;78:591-5.
10. Jacobs MJ, de Mol BA, Veldman DJ. Aortic arch and proximal supraaortic arterial repair under continuous antegrade cerebral perfusion and moderate hypothermia. Cardiovasc Surg 2001;9:396-402.
11. Battaloglu B, Erdil N, Nisanoglu V. Axillary artery perfusion in acute type A aortic dissection repair. J Card Surg 2008;23:693-6.
12. Hagl C, Ergin MA, Galla JD, Lansman SL, McCullough JN, Spielvogel D, et al. Neurologic outcome after ascending aorta-aortic arch operations: effect of brain protection technique in high-risk patients. J Thorac Cardiovasc Surg 2001;121:1107-21.
13. Head BP, Patel P. Anesthetics and brain protection. Curr Opin Anaesthesiol 2007;20:395-9.
14. Strauch JT, Spielvogel D, Lauten A, Lansman SL, McMurtry K, Bodian CA, et al. Axillary artery cannulation: routine use in ascending aorta and aortic arch replacement. Ann Thorac Surg 2004;78:103-8.
15. Reich DL, Uysal S, Ergin MA, Griepp RB. Retrograde cerebral perfusion as a method of neuroprotection during thoracic aortic surgery. Ann Thorac Surg 2001;72:1774-82.
16. Hirotani T, Kameda T, Kumamoto T, Shirota S. Aortic arch repair using hypothermic circulatory arrest technique associated with pharmacological brain protection. Eur J Cardiothorac Surg 2000;18:545-9.
17. Di Eusanio M, Tan ME, Schepens MA, Dossche KM, Di Bartolomeo R, Pierangeli A, et al. Surgery for acute type A dissection using antegrade selective cerebral perfusion: experience with 122 patients. Ann Thorac Surg 2003;75:514-9.
18. Panos A, Murith N, Bednarkiewicz M, Khatchatourov G. Axillary cerebral perfusion for arch surgery in acute type A dissection under moderate hypothermia. Eur J Cardiothorac Surg 2006;29:1036-9.
19. Taşdemir O, Saritaş A, Küçüker S, Ozatik MA, Sener E. Aortic arch repair with right brachial artery perfusion. Ann Thorac Surg 2002;73:1837-42.