Turk Gogus Kalp Dama 2014;22(2):312-319
doi: 10.5606/tgkdc.dergisi.2014.8529

Original Article / Özgün Makale

Endovascular management of acute complicated type B aortic dissection: adjunct procedures

Akut komplike tip B aort diseksiyonlarında endovasküler tedavi: İlave işlemler

Oğuz Yılmaz,[1] Harun Arbatlı,[1] Fürüzan Numan,[2] Hasan Ardal,[1] Naci Erciyes Yağan,[1] Fatih Gülşen,[3] Bingür Sönmez[1]

Institution where the research was done:
Department of Cardiovascular Surgery, Şişli Memorial Hospital, İstanbul, Turkey

Author Affiliations:
Departments of [1]Cardiovascular Surgery and [2]Invasive Radiology, Şişli Memorial Hospital, İstanbul, Turkey;
[3]Department of Radiology, Cerrahpaşa Faculty of Medicine, İstanbul, Turkey

Background: This study aims to evaluate the results of endovascular treatment (TEVAR) and the contribution of adjunct procedures in acute complicated type B aortic dissections.

Methods: Thirty patients (26 males, 4 females; mean age 55.2±14.7 years, range 24 to 86 years) with acute complicated type B dissection underwent endovascular treatment. The dissection was complicated by malperfusion in eight patients (26.7%), impending rupture in four (13.3%), uncontrollable hypertension in 12 (40%), and severe treatment-resistant pain in six (20%). Self-expanding stent-grafts (Talent® and Valiant®, Medtronic Inc.) were used. Ostium of the left subclavian artery was covered intentionally in 19 patients (63.3%). Additional stenting was necessary in eight patients (26.7%). Of a total of 12 bare metal stents used in these patients, stents were inserted in the renal arteries in six (20%), iliac arteries in three (10%), and celiac arteries in two (6.7%) patients. Median follow-up was 55 months (range, 25 to 99 months).

Results: The mean number of stent-grafts implanted was 1.42 (range, 1 to 3). One patient had inadvertent partial closure of the left common carotid artery ostium due to proximal migration of the stent-graft which caused no early neurological complications. Right hemiplegia occurred 15 months later due to his discontinuation of the anticoagulant therapy in the same patient. In another patient with visceral malperfusion, early laparoscopic exploration following the stenting of the celiac and the left renal arteries revealed no ischemia of the bowels. One patient with postoperative angina pectoris required stenting of the right coronary artery. There was no stroke in any patients, while reversal of paraplegia was observed in one patient early after the procedure. The mean lengths of intensive care unit and hospital stays were 3.2±3.4 and 9.8±7.1 days, respectively. There was no 30-day mortality. The one-year survival rate was 96.7%.

Conclusion: Although endovascular treatment of complicated type B aortic dissections has a high success rate, TEVAR may not be the sole solution. Findings of malperfusion should be carefully sought in the early postoperative period. The adjunct procedures such as stenting of the visceral arteries or open surgical revascularization should always be considered particularly in young patients.

Keywords: Endovascular procedure; malperfusion; stent; type B aortic dissection.

Amaç: Bu çalışmada akut komplike tip B aort diseksiyonlarında endovasküler tedavinin (TEVAR) sonuçları ve ilave girişimsel işlemlerin katkıları değerlendirildi.

Çalışma planı: Akut komplike tip B aort diseksiyonlu 30 hastaya (26 erkek, 4 kadın; ort. yaş 55.2±14.7 yıl; dağılım 24-86 yıl) endovasküler tedavi uygulandı. Hastaların sekizinde malperfüzyon (%26.7), dördünde rüptür riski (%13.3), 12'sinde kontrol edilemeyen hipertansiyon (%40) ve altısında tedaviye dirençli şiddetli ağrı (%20) vardı. Kendiliğinden genişleyen stent-greftler (Talent® and Valiant®, Medtronic Inc.) kullanıldı. Hastaların 19'unda (%63.3) sol subklaviyan arter ağzı bilerek kapatıldı. Sekiz hastada (%26.7) ilave stentleme gerekli oldu. Bu hastalarda toplam 12 adet çıplak metal stent kullanılmış olup, hastaların altısında (%20) renal arterlere, üçünde (%10) iliyak arterlere ve ikisinde de (%6.7) çölyak artere uygulandı. Ortalama takip süresi 55 ay (dağılım 25-99 ay) idi.

Bulgular: İmplant edilen ortalama aortik stent-greft sayısı 1.42 (dağılım, 1-3) idi. Bir hastada stent-greftin proksimale migrasyonu neticesinde sol ana karotis arter ağzı kısmen kapandı, ancak bu herhangi bir erken nörolojik komplikasyona neden olmadı. Aynı hastanın 15 ay sonra kendiliğinden antikoagülan tedavisini kesmesi sonucunda sağ hemipleji gelişti. Viseral malperfüzyonlu diğer bir hastada, çölyak ve sol renal arterlerin stentlenmesinden sonra yapılan erken laparoskopik eksplorasyonda bağırsak iskemisi olmadığı görüldü. İşlem sonrası anjina pektoris gelişen bir hastada ise, sağ koroner arterin stentlenmesi gerekti. Hiçbir hastada inme gözlenmezken, parapleji ile gelen bir hastada işlemin hemen ardından paraplejinin düzeldiği görüldü. Ortalama yoğun bakım ve hastane kalış süreleri sırasıyla 3.2±3.4 ve 9.8±7.1 gündü. Otuz gün içerisinde hiçbir hasta kaybedilmedi. Bir yıllık sağkalım oranı %96.7 idi.

Sonuç: Komplike tip B aort diseksiyonlarında endovasküler tedavinin başarı oranları yüksek olmasına rağmen, TEVAR tek başına bir çözüm olmayabilir. İşlemden hemen sonra malperfüzyon bulguları dikkatle gözlenmelidir. Viseral arterlerin stentlenmesi veya açık cerrahi revaskülarizasyon gibi ilave girişimler özellikle genç hastalarda göz önünde bulundurulmalıdır.

Anahtar sözcükler: Endovasküler işlem; malperfüzyon; stent; tip B aort diseksiyonu.

Available online at
www.tgkdc.dergisi.org
doi: 10.5606/tgkdc.dergisi.2014.8529
QR (Quick Response) Code

Received: April 10, 2013 *Accepted*: July 22, 2013

Correspondence: Oğuz Yılmaz, M.D. Şişli Memorial Hastanesi, Kalp ve Damar Cerrahisi Kliniği, 34385 Okmeydanı, İstanbul, Turkey.
Tel: +90 212 - 322 67 92 e-mail: dr.oguzyilmaz@yahoo.com

The prevalence of acute type B aortic dissections is expected to increase parallel to the life expectancy in the global population, and the in-hospital survival rate after medical therapy is 90% who undergo this procedure if it is uncomplicated.[1] However, complicated acute type B dissection is still a challenging clinical entity, with open surgery still having a high mortality rate ranging from 4.8-8.8%, even in experienced major institutions.[2,3] Thoracic endovascular aneurysm repair (TEVAR) eliminates the need for a thoracotomy, single lung ventilation, and aortic cross-clamping while offering a less invasive mode of therapy for this highly vulnerable group of patients. In this retrospective study, we evaluated the endovascular treatment of acute complicated type B dissection, prevalence of malperfusion syndrome, and contribution of adjunct procedures.

PATIENTS AND METHODS

Thirty patients (26 males, 4 females; mean age 55.2±14.7 years; range 24 to 86 years) were treated for acute complicated type B dissection via the endovascular approach between 2003 and 2009 at our facility. One of the patients had been diagnosed with Marfan syndrome and had undergone an operation for acute type A dissection five years earlier. The clinical issues complicating the dissection are listed in Table 1. In addition, eight patients (26.7%) were admitted with malperfusion syndrome, and the other preoperative patient characteristics are listed in Table 2.

We generally applied the criteria listed by Shimono et al.[4] for selecting patients suitable for TEVAR, which included the following: *(i)* a primary entry tear within the descending aorta proximal to the 10th thoracic vertebra, *(ii)* a location at least 1 cm distal to the orifice of the left subclavian artery (LSA), *(iii)* the absence of severe dilatation (>38 mm in diameter) or a severe atherosclerotic change of the landing zone for stent grafting, *(iv)* no evidence of severe aortic regurgitation, *(v)* no evidence of coronary artery or aortic arch branch ischemia, and *(vi)* femoral and iliac arteries of sufficient size and quality.

Table 1. Clinical issues complicating type B dissection

	Number of patients
Thoracic aortic rupture	0
Suspicion of impending rupture	4
Visceral and/or peripheral ischemia	8
Mesenteric ischemia	4
Renal ischemia	2
Heart failure (pseudocoarctation)	1
Lower extremity ischemia	2
Paraplegia	1
Uncontrollable hypertension	12
Severe therapy-resistant pain	6

Meticulous control of each patient's blood pressure was achieved by beta-blockers (ß-blockers), calcium antagonists, and nitroglycerin, and the blood creatinine, liver enzyme, and lactate levels were closely monitored. Coronary angiography and aortography were carried out for all hemodynamically stable patients prior to intervention, and transesophageal echocardiography (TEE) was used when necessary.

Spinal drainage was also considered depending on the clinical state of the patient, coverage of the LSA by the stent graft, perfusion of the internal iliac arteries, and length of the stent-grafted aortic segment. Furthermore, a wake-up test was performed in the early postoperative period for the majority of the patients, and drainage of the cerebrospinal fluid (CSF) was necessary in three patients preoperatively.

General anesthesia was preferred in all but one patient. A pigtail catheter was inserted through the left axillary artery to perform the diagnostic angiography and as a landmark for the LSA ostium. The better common femoral artery was surgically exposed, and if the iliac arteries were also dissected, another catheter/sheath was inserted through the true lumen by direct vision via an arteriotomy and then confirmed by fluoroscopy and TEE. In addition, aortography was performed to localize the primary tear and evaluate the true lumen collapse and perfusion of the branch vessels. Either the self-expanding Talent™ or Valiant® thoracic stent graft systems (Medtronic Inc., Minneapolis, MN, USA) were used for all of patients (Table 3), and during deployment, the systolic blood pressure was lowered to 60-70 mmHg. The left subclavian arterial ostium was covered intentionally in 19 of the patients (63.3%), and a cerebral angiographic work-up, including the circle of Willis, was done in all of those with predicted LSA coverage, except for the first two patients. Moreover, completion angiography was performed to ensure complete sealing and adequate repair.

The main goals of the procedure were to cover the primary tear site, direct the blood flow into the true lumen, relieve the true lumen compression, and ameliorate the antegrade flow to the main branch vessels.

In cases of static obstruction, bare metal stents were used to recanalize the visceral vessels or the iliac branches, and this type of adjunct procedure was

Table 2. Preoperative characteristics in patients (n=30)

Variables	n	%	Mean±SD
Age (years)			55.2±14.7
Gender			
Male	26	86.7	
Female	4	13.3	
Hypertension	24	80	
Previous cerebrovascular accident	1	3.3	
Peripheral vascular disease	1	3.3	
Renal failure*	2	6.7	
Diabetes mellitus	2	6.7	
Ischemic heart disease	3	10	
Chronic obstructive pulmonary disease	3	10	
Previous cardiovascular operation	3	10	
Bentall operation	1		
Type A aortic dissection repair	2		

SD: Standard deviation; * Serum creatinine level >2.0 mg/dl.

necessary in eight patients (26.7%) and involved a total of 12 stents [in the renal arteries in six (20%), in the iliac arteries in three (10%), and in the celiac arteries in two patients (6.7%)] (Table 4).

The results of contrast enhanced computed tomography (CT) and chest X-rays were routine one month after the procedure. Additionally, chest X-rays, magnetic resonance imaging (MRI), and CT with or without contrast media were obtained individually according to the false lumen thrombosis and the creatinine levels of the patients at the postprocedural third and sixth months. Transesophageal echocardiography was also helpful in evaluating false lumen patency in some patients with renal impairment. The median follow-up period was 55.0 months (range 25-99 months).

RESULTS

The mean time from the onset of symptoms to the procedure was 7.4±4.8 hours, and the mean number of implanted stent grafts was 1.42 (range 1-3). This number decreased over time due to the production of longer stent grafts in the later stages of the study period.

The ostium of the LSA was intentionally covered in 19 patients (63.3%) to create a healthy proximal landing zone. Inadvertent partial closure of the left common carotid artery ostium occurred in one patient because of the proximal migration of the stent graft, but this did not cause any early neurological complications. Early Doppler ultrasonography (USG) revealed a non-compromised flow of the carotid artery in this patient, and he was discharged on oral anticoagulant therapy. However, right hemiplegia occurred 15 months later due to his discontinuation of the anticoagulant.

In one patient with static obstruction of the celiac, superior mesenteric (SMA), and right renal arteries, the primary entry tear was covered by two stent grafts, but the dynamic obstruction of the left renal artery did not resolve after this intervention. An initial angiographic evaluation revealed no flow in all of these branches. The celiac and the left renal arteries were then stented, but the SMA and the right renal arteries could not be catheterized despite strenuous efforts (Figure 1).

Table 3. Operative strategies

Variables	n	%	Mean	Range
Stent graft devices				
Medtronic Talent™	7	23.3		
Medtronic Valiant®	22	73.3		
Medtronic Valiant® with Captivia DS*	1	3.3		
Stent graft devices deployed			1.42	1-3
Coverage of left subclavian artery	19	63.3		

* Medtronic Valiant stent graft with a new Delivery System (DS) featuring a tip-capture mechanism.

Table 4. Arteries stented with bare metal stents in patients (n=8)

Arteries stented	n	%
Unilateral renal	3	10
Unilateral iliac	1	3.3
Bilateral iliac	1	3.3
Celiac + unilateral renal	2	6.7
Unilateral iliac + unilateral renal	1	3.3

Early laparoscopic exploration revealed no ischemia of the bowels. The serum creatinine levels then increased to 3.5 mg/dl but fell back and stabilized to approximately 2.0 mg/dl. This patient was discharged on the 10th postoperative day.

Additionally, we intervened a 46-year-old male patient who had been admitted seven hours after the onset of back pain with paraplegia and a total collapse of the true lumen of the abdominal aorta. A spinal drainage catheter was inserted prior to urgent stent grafting, and there was a total neurological recovery after two weeks. He also had severe chest pain with ST elevation on the fourth postoperative day, and angiography revealed severe stenosis of the right coronary artery (RCA), which was then primarily stented.

We also noted a type A aortic dissection in a 62-year-old female who was then taken for urgent surgery. Neither CT nor angiography could accurately locate the primary entry site, and it was actually determined that it was a retrograde type B dissection. The ascending aorta was then repaired, and two stent grafts were implanted within the descending aorta under TEE guidance. She was discharged on the 10th postoperative day without any complications.

One patient suddenly expired in another hospital 74 days after a successful TEVAR procedure. The death was attributed either to a pulmonary embolism or a probable retrograde extension of the dissection towards the ascending aorta, which measured 48 cm in diameter.

We also found one patient with Marfan syndrome who presented with acute left leg ischemia and back

Figure 1. (a) Computed tomography and **(b)** magnetic resonance imaging sections showing the stented left renal artery (white arrow), and the celiac trunk stent (asterisk). Note that the renal artery was revascularized with two stents (stent-in-stent) due to the incomplete coverage of the dynamic obstruction with the first stent. **(c)** Digital subtraction angiography image showing the partial filling of the false lumen in the left renal artery during the procedure. Note that only the left renal artery was visible at this stage of the procedure.

pain. His ascending aorta had been replaced five years previously after a type A dissection. Computed tomography showed a type B dissection with true lumen collapse in the abdominal aorta along with partial occlusion of the celiac and SM arteries. There was also a sinus of Valsalva aneurysm (SVA) with moderate aortic and mild mitral insufficiency. Two stent grafts for the descending aorta and two bare-metal stents for both common iliac arteries were then implanted. Control CT confirmed the good positioning of all of the stents as well as the perfusion of the visceral organs, but the false lumen was patent within the abdominal aorta. The patient developed congestive heart failure two weeks later due to acute progression of the valvular disease. An echocardiogram showed moderate-severe aortic and moderate mitral regurgitation with left ventricular strain. Both valves were replaced six weeks later as a redo surgery, and he was discharged uneventfully. Two years later, a Bentall procedure was performed as a third redo for an aortic root aneurysm. Moreover, this patient was also scheduled for surgery on the abdominal aorta when he expired at another hospital due to the rupture of this abdominal aortic aneurysm.

DISCUSSION

The endovascular approach is the preferred method to treat or ameliorate the life-threatening complications associated with acute type B dissection. However, no randomized trials comparing open surgery to TEVAR exist because of the sudden onset of the disease.

The success of the treatment for type B dissections may be dependent on the anatomy, extent of pathology, individual clinical experience, and surgical setting. However, retrospective studies have pointed out that this type of repair has a more benign course than conventional surgery.[5-7]

Complicated type B dissection of the aorta is a very special subset of aortic pathologies that requires urgent decision-making and intervention. One of the primary objectives of this study was to focus attention on the fact that early detection of complications connected with this procedure is vital. In addition, everything possible should be done to successfully make an early diagnosis so that treatment of malperfusion can begin.

Even when the main goals are achieved technically, it is still vital to monitor end-organ perfusion, especially in the early period, since this determines survival. Thus, we believe that during the procedure, not only is recanalizing the true lumen necessary, but it is also extremely important to aggressively search for signs and symptoms of malperfusion since early stenting may save the lives of these patients.

The patient in our study with Marfan syndrome died 29 months after the procedure because of the aggressive progression of the disease. Stent graft implantation in Marfan patients is controversial[8,9] because the radial forces of the grafts on an aorta with less elastic fibers and a weaker wall structure yield an unpredictable outcome. In this patient, TEVAR was performed as a salvage procedure for the complicated dissection because open repair would have presented a greater risk considering the patient's valvular pathologies.

We prefer general anesthesia for the meticulous control of hemodynamic variables. However, in one patient, the procedure was performed under local anesthesia because the primary entry site was quite distal to the LSA orifice.

In our patient population, the average age of the patients with malperfusion was 45.3±10.8, which is considerably younger than those without malperfusion (59.1±14.3). This is compatible with Mehta's study of patients in the International Registry of Acute Aortic Dissection (IRAD), which emphasized the lower incidence of malperfusion and limb ischemia in the elderly.[10] That same study also revealed a less frequent false lumen patency (37.7% vs. 57.1%) in the same two patient groups, but a larger average diameter of the descending aorta and more frequent rupture in the elderly. This may be caused by age-dependent differences in the aortic wall structure in type B dissection. Younger patients probably have a genetic propensity toward the advanced medial degeneration of the aorta in contrast to the atherosclerotic, calcified structure, which partially maintains the wall integrity, in the elderly.

Dias et al.[11] reported the early results of TEVAR in 31 acute complicated type B aortic dissection patients and noted that the in-hospital mortality rate was 16% while the overall mortality rate was 35% after 22 months of follow-up. Six deaths occurred after 30 days. Two of these were related to stent grafts and the other four were associated with cardiac issues. Furthermore, neurological complications were also reported as paraplegia in one patient (3.2%) and stroke in five others (16.1%).

One of the largest series was reported by Szeto et al.[5] In that study, the primary tear was successfully covered in 97.1% of the patients, and the 30 day mortality rate was 2.8%. The major complication

Table 5. Hospital morbidity and mortality

Variables	n	%	Mean±SD
Morbidity			
Cerebrovascular accident	0		
Spinal cord ischemia	1		
Transient (full recovery)*	1		
Permanent	0		
Renal failure**	0		
Vascular access	0		
Number of days in intensive care unit			3.2±3.4
Number of days in hospital			9.8±7.1
Mortality			
30-day/in-hospital	0	0	
One-year survival	29	96.7	

SD: Standard deviation; * This patient presented with paraplegia which reversed after the intervention. This was not related to the procedure; ** Permanent hemodialysis.

rates were also quite acceptable, with 2.8% suffering a stroke, 2.8% permanent renal failure, and 2.8% permanent spinal cord ischemia.

In our patient group, the primary success rate, defined as the coverage of the primary tear and rerouting the blood flow mainly into the true lumen, was 100%. Moreover, no in-hospital mortality or neurological complications were noted (Table 5).

In the one patient who expired on the 74th day after the procedure due to the large diameter of the ascending aorta, retrograde dissection was considered as a possible cause of death, but the exact reason could not be clearly determined since the patient died at another clinic and the request to perform an autopsy was declined. In a similar series of 28 patients, Neuhauser et al.[12] reported "retrograde type B dissection" (they classified it as retrograde type A) in five of their patients (17.9%), with three of those being related to the procedure. They even gave the following warning: *"One must be aware that this complication can occur not only during the procedure, but even days, weeks, or months following stent graft implantation, a fact that seems to be underreported"*. The authors ascribed the high incidence rate to the insufficient longitudinal flexibility of the stent grafts, especially the Talent™ stent graft (Medtronic Inc., Minneapolis, MN, USA), which was unable to adapt well to the curve of the aortic arch and the Gore Excluder® system (W.L. Gore & Associates, Inc., Flagstaff, AZ, USA). Repeated balloon dilatation of the proximal sealing zone was also considered as another probable cause for the abnormally high incidence rate. We believe that this second theory is more logical; therefore, we avoided balloon dilatation in all our cases due to the extremely fragile nature of the dissected tissue.

Coronary angiography and aortography were routinely performed in hemodynamically stable patients at our facility, and postoperative impending myocardial infarction (MI) was treated by primary stenting in one patient. Hence, we believe that a cardiac evaluation should also be performed in these patients as soon as they are stabilized, either before or after TEVAR.

To achieve the best results, digital subtraction angiography (DSA) should be used instead of conventional angiography, a detailed measurement of the aneurysm dimensions in relation to the graft material should be performed, and an individually tailored approach should be undertaken. Early detection of complications and prompt decision-making for intervention are essential for overcoming any complications that may arise. The length of time from when a patient entered our facility to when the stent graft was implanted usually did not exceed two hours in our study group. The waiting period was only extended in borderline cases because of the need to evaluate a patient's response to appropriate medical therapy aimed at meticulous blood pressure control.

The LSA was liberally covered in our patients (63.3%) because of the proximity of the primary tear site. In addition, except in the first few cases, posterior cerebral circulation was always evaluated prior to intervention if LSA coverage was considered.

Wire access in the true lumen may be difficult to achieve in aortic dissections. If the common femoral

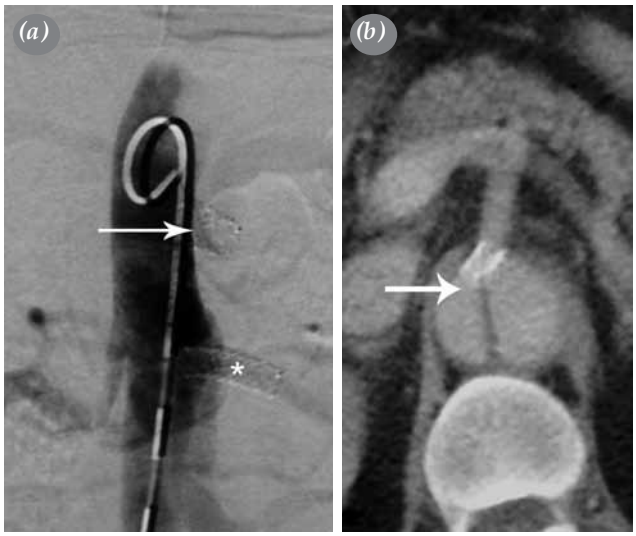

Figure 2. (a) Digital subtraction angiograpy and **(b)** computed tomography image of a 57-year-old male patient with type B aortic dissection treated with three endovascular stent grafts. The celiac trunk (arrow) and left renal artery (asterisk) were stented. Also, note the extension of the stent through the true lumen into the celiac trunk.

artery is involved, our normal protocol is to introduce the sheath and the guidewire system through an open femoral arteriotomy after differentiating the true lumen, with fluoroscopy and TEE being used for guidance if necessary. Other groups also prefer intravascular ultrasound (IVUS) for this purpose.[5]

Spinal cord ischemia is a devastating complication considering the possibility of a potentially less well-developed collateral arcade in this acute setting. Hence, spinal drainage is important, especially in the early course, and this was performed in the three patients for whom LSA ostium coverage was considered who had concomitant limb ischemia.

In patients with no limb ischemia or peripheral neurological deficits, preoperative spinal drainage was not performed, even if LSA coverage was considered. An early wake-up test was used instead. Furthermore, some authors have reported the use of an electroencephalogram and somatosensory evoked potential for neuromonitoring in high-risk patients.[13-15]

Two meta-analyses have been conducted concerning TEVAR, but neither indicated the exact number of adjunct procedures that were performed for acute complicated type B aortic dissection.[6,7] The rate of adjunct revascularization procedures in our patient population was 26.7%, which is considerably higher than most other series. This could be explained by the younger mean age of our patient group together with our extreme efforts to ameliorate malperfusion, and we believe this approach is responsible for the success rate in this group of patients (Figure 2).

In patients with signs of visceral organ ischemia, an explorative laparotomy is usually necessary rather than waiting for clear clinical and biochemical signs, and this was performed on one patient in this study for a few hours after the procedure in order to show satisfactory perfusion.

The absence of any perioperative neurological complications in our series was remarkable. This might have been the result of the perioperative angiographic work-up of the posterior cerebral vessels, prophylactic spinal drainage for those patients suspected of having simultaneous hypoperfusion of the hypogastric arteries and the LSA, and minimal manipulation within the aortic arch.

Conclusion

Early detection of complications in acute type B aortic dissection definitely improves the outcome of TEVAR. The rate of malperfusion seems to be higher in younger patients than the elderly, and it is possibly higher than what has been reported in the literature. Thoracic endovascular aneurysm repair may not be the sole solution for complicated acute type B aortic dissection patients, but our findings indicate that it has good results. In addition, it is also crucial that careful attention be paid to the possible presence of malperfusion syndrome, especially in the early postoperative period. Finally, adjunct procedures, such as stenting the orifices of the visceral arteries or open surgical revascularization, should always be kept in mind when performing TEVAR for complicated type B aortic dissections, particularly in young patients.

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. Hagan PG, Nienaber CA, Isselbacher EM, Bruckman D, Karavite DJ, Russman PL, et al. The International Registry of Acute Aortic Dissection (IRAD): new insights into an old disease. JAMA 2000;283:897-903.
2. Kouchoukos NT, Masetti P, Rokkas CK, Murphy SF, Blackstone EH. Safety and efficacy of hypothermic cardiopulmonary bypass and circulatory arrest for operations

on the descending thoracic and thoracoabdominal aorta. Ann Thorac Surg 2001;72:699-707.
3. Coselli JS, LeMaire SA, Miller CC 3rd, Schmittling ZC, Köksoy C, Pagan J, et al. Mortality and paraplegia after thoracoabdominal aortic aneurysm repair: a risk factor analysis. Ann Thorac Surg 2000;69:409-14.
4. Shimono T, Kato N, Yasuda F, Suzuki T, Yuasa U, Onoda K, et al. Transluminal stent-graft placements for the treatments of acute onset and chronic aortic dissections. Circulation 2002;106:I241-7.
5. Szeto WY, McGarvey M, Pochettino A, Moser GW, Hoboken A, Cornelius K, et al. Results of a new surgical paradigm: endovascular repair for acute complicated type B aortic dissection. Ann Thorac Surg 2008;86:87-93.
6. Eggebrecht H, Nienaber CA, Neuhäuser M, Baumgart D, Kische S, Schmermund A, et al. Endovascular stent-graft placement in aortic dissection: a meta-analysis. Eur Heart J 2006;27:489-98.
7. Parker JD, Golledge J. Outcome of endovascular treatment of acute type B aortic dissection. Ann Thorac Surg 2008;86:1707-12.
8. Marcheix B, Rousseau H, Bongard V, Heijmen RH, Nienaber CA, Ehrlich M, et al. Stent grafting of dissected descending aorta in patients with Marfan's syndrome: mid-term results. JACC Cardiovasc Interv 2008;1:673-80.
9. Nordon IM, Hinchliffe RJ, Holt PJ, Morgan R, Jahangiri M, Loftus IM, et al. Endovascular management of chronic aortic dissection in patients with Marfan syndrome. J Vasc Surg 2009;50:987-91.
10. Mehta RH, Bossone E, Evangelista A, O'Gara PT, Smith DE, Cooper JV, et al. Acute type B aortic dissection in elderly patients: clinical features, outcomes, and simple risk stratification rule. Ann Thorac Surg 2004;77:1622-8.
11. Dias NV, Sonesson B, Koul B, Malina M, Ivancev K. Complicated acute type B dissections--an 8-years experience of endovascular stent-graft repair in a single centre. Eur J Vasc Endovasc Surg 2006;31:481-6.
12. Neuhauser B, Greiner A, Jaschke W, Chemelli A, Fraedrich G. Serious complications following endovascular thoracic aortic stent-graft repair for type B dissection. Eur J Cardiothorac Surg 2008;33:58-63.
13. Cheung AT, Pochettino A, McGarvey ML, Appoo JJ, Fairman RM, Carpenter JP, et al. Strategies to manage paraplegia risk after endovascular stent repair of descending thoracic aortic aneurysms. Ann Thorac Surg 2005;80:1280-8.
14. Gutsche JT, Cheung AT, McGarvey ML, Moser WG, Szeto W, Carpenter JP, et al. Risk factors for perioperative stroke after thoracic endovascular aortic repair. Ann Thorac Surg 2007;84:1195-200.
15. McGarvey ML, Cheung AT, Szeto W, Messe SR. Management of neurologic complications of thoracic aortic surgery. J Clin Neurophysiol 2007;24:336-43.