Endovascular therapy for thoracic and abdominal aortic emergencies

Torakal ve abdominal aortanın acil patolojilerinde endovasküler tedavi

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BACKGROUND
Emergent situations of both the thoracic and abdominal aortae are serious life-threatening situations. Endovascular stent graft repair offers an alternative to conventional operation for management of aortic diseases. Our aim was to report our experience with endovascular stent graft repair of thoracic and abdominal aortic emergencies.

METHODS
Between April 2004 and March 2007, endovascular stent graft repair was performed in 16 patients (13 males, 3 females; mean age 61.4±16.3; range 38 to 86 years). The emergent lesions were in the thoracic aorta in 8 patients and abdominal aorta in the remainder. The deployed stent graft systems were Talent-Medtronic (n=8) and Excluder-Gore (n=8).

RESULTS
Successful deployment of the stent grafts in the appropriate position was achieved in all patients. Hospital mortality occurred in 3 patients. There was no conversion to open surgery. The total number of endoleaks was 3 (18.75%).

CONCLUSION
Endovascular stent graft placement is a feasible and effective approach in the emergency treatment of patients with complicated emergent pathologies of both thoracic and abdominal aortae.

Key Words: Aortic aneurysm, abdominal/surgery; aortic emergencies; endovascular therapy; stents; morbidity.

AMAÇ
Torakal ve abdominal aortanın anevrizma rüptürü ve diseksiyon gibi acil patolojileri önemli derecede yaşamı tehdit ederler. Aortanın acil girişim gerektiren bu patolojilerinde endovasküler tedaviler konvansiyonel cerrahiye bir alternatif teşkil etmektedir. Çalışmada, endovasküler tedavilerin aortanın acil patolojilerindeki uygulanabilirliği araştırıldı.

GEREÇ VE YÖNTEM
Nisan 2004 ile Mart 2007 tarihleri arasında 16 hastaya (13 erkek, 3 kadın; ort. yaş 61,4±16,3; dağılım 38-86) acil olarak endovasküler yolla stent greft implantasyonu uygulandı. Lezyonların sekizi torakal, sekizi abdominal aortada idi. Sekiz hastaya *Gore Excluder Endoprosthesis*, sekiz hastaya *MedtronicVascular Talent Endoluminal Graft System* kullanıldı.

BULGULAR
Tüm hastalara implantasyon başarı ile uygulandı, hiçbir hastada açık cerrahiye dönüşüme ihtiyaç duyulmadı. Hastane mortalitesi üç hasta olarak gerçekleşti, üç hastada (%18,75) endoleak ile karşılaşıldı.

SONUÇ
Anevrizma ya da diseksiyon gibi acil girişim gerektiren aort patolojilerinde ameliyat öncesi ve sonrası morbidite ve mortalitenin düşük olması nedeniyle endovasküler stent implantasyonu efektif ve teknik olarak uygulanabilirliği yüksek olan bir yöntemdir.

Anahtar Sözcükler: Aortik anevrizma, abdominal/cerrahi; aortik acil patolojiler; endovasküler tedavi; stent; morbidite.

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The mortality rate in elective conventional open repair of aortic lesions is 5%, but this rate dramatically increases to over 50% in emergent conditions (such as aortic dissection, rupture of an aortic aneurysm).[1,2] The high rate of perioperative morbidity and mortality associated with conventional surgical repair of thoracic and/or abdominal aortic lesions, especially in the presence of emergent conditions, has forced clinicians to find alternative treatment options. Thus, endovascular stent-graft repair (EVAR) has gained worldwide acceptance in the treatment of aortic lesions. Recently, aortic stent graft deployment has been used not only in elective repairs but also in emergency settings.[3] It has been reported previously that morbidity and mortality decreased significantly with the use of EVAR.[3,4] The treatment of a ruptured abdominal aortic aneurysm was first described by the Nottingham group in 1994.[5]

MATERIALS AND METHODS

From April 2004 to November 2006, we deployed 16 endovascular stent grafts into either thoracic or abdominal aorta due to emergent situations. The mean age of patients was 61.4±16.3 years (38-86), and there were 13 males and 3 females. The approvals of the local ethics committee of our institution were obtained as well as a detailed written informed consent from all patients after providing information about all the procedures. The endovascular stent graft implantation time (the time from admission to the procedure), fluoroscopy time and duration of hospital stay were recorded. Hospital mortality was defined when mortality occurred in the first 30 days.

The common femoral artery was used for device insertion in all patients. Epidural anesthesia was used in 2 cases, local anesthesia combined with light sedation in 13 cases and general anesthesia in 1 patient. All stent graft implantations were performed in a digital subtraction angiography (DSA) suite (Multistar Plus, Siemens, Erlangen, Germany) by a team of cardiovascular surgeons, anesthetists and interventional radiologists. The contrast agent used was iopromide (Ultravist, 300 mg/ml, Berlin, Germany) and the mean volume given during the procedure was 120±65 ml (range 50-220 ml). Two types of stent-graft prothesis were used (Talent Endoluminal Spring Graft System, World Medical Corporation, Sunrise, FL, USA [n=8] and Excluder TM, W. L. Gore & Associates, Flagstaff, AZ, USA, [n=8]). Patients eligible for receiving a stent graft had to have at least a 1-to-2 cm long proximal and distal neck. Proximal and distal necks were examined carefully for mural thrombosis. The diameters of the stents were chosen as 15-20% wider than the aortic neck diameter measured in computed tomography (CT) scans. Diameter of the grafts used ranged from 26 to 38 mm and length from 100 to 230 mm (mean 143 mm). After deployment of the endoprosthesis in the selected location, a completion angiogram was performed. After control angiographies, arteriotomies were repaired with 6/0 prolene sutures. Vacuum drainage systems were placed in the operation areas. In 1 patient, aorto-uniiliac grafting and femorofemoral crossover bypass were needed due to embolization of the iliac artery.

All patients received prophylactic antibiotic therapy perioperatively (cefazolin sodium 2 g). In all cases, the common femoral artery was exposed through an inguinal incision for the access. A bolus of heparin (70 IU/kg) was administered. The contralateral femoral artery was percutaneously punctured for diagnostic aortography to determine the exact placement of the stent graft system. The Talent stent graft system was then passed over the guide wire into the appropriate position within the descending thoracic aorta or aortic arch under fluoroscopic guidance. After exact positioning, the sheath is moved downward, and stent graft deployment is achieved. Prograft stent (stents with string) system is placed into the vasculature through an introduction sheath. The stent graft itself is mounted on a placement catheter. Deployment of the stent graft is achieved by pulling on a string at the end of the placement catheter. During deployment, a mild systemic hypotension was induced pharmacologically by the anesthesiologist. After deployment of the endoprosthesis, a completion angiogram was performed in the selected location. After the control angiographies, arteriotomies were repaired with 6/0 prolene sutures. Vacuum drainage systems were placed in the operation fields.

In the follow-up period, control CT scans were evaluated on the postoperative 6th day, and at the 3rd, 6th and 12th months after the procedure.

Statistical analysis was performed with SPSS

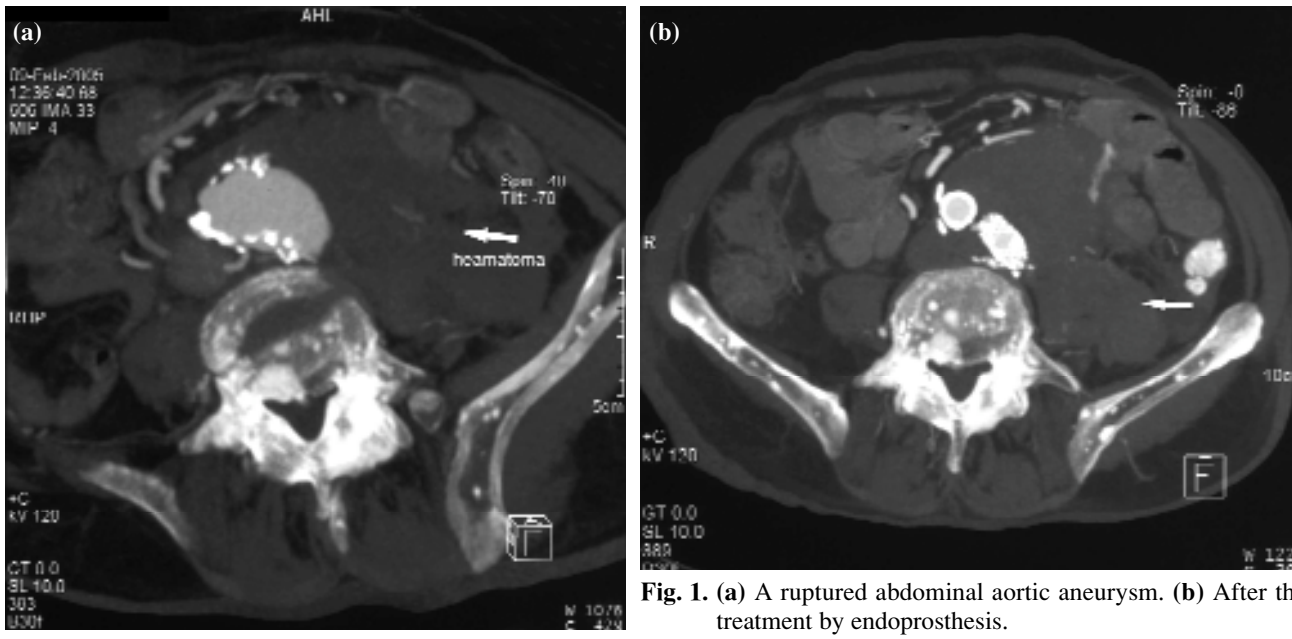

Fig. 1. **(a)** A ruptured abdominal aortic aneurysm. **(b)** After the treatment by endoprosthesis.

software version 10.0 (SPSS Inc, Chicago, IL). Clinical data was expressed as mean values ± standard deviation, percents.

RESULTS

The lesions were in the abdominal aorta in 8 patients and in the thoracic aorta in the remaining 8 patients. Among the lesions related with the abdominal aorta, there was a rupture of an abdominal aortic aneurysm in 7 patients and an abdominal aortic plaque rupture in 1 patient (Fig. 1a, b). Among the lesions related with the thoracic aorta, Stanford type B aortic dissections were present in 2 patients, rupture of thoracic aortic aneurysm in 2 patients, and blunt thoracic aortic trauma (which was clinically presented as pseudoaneurysm, traumatic aortic dissection and subtotal aortic rupture) in 4 patients. According to ASA classification (American Society of Anesthesiologists), 2 patients were in ASA II, 10 in ASA III, and 4 in ASA IV. The distribution of the lesions and other preoperative data are summarized in Table 1.

Technical success was obtained in all patients without any conversion to open surgery. Unilateral femoral cut-down was used in 11 and bilateral femoral cut-down in 5 patients. In 1 patient, aorto-uniiliac graft interposition and femorofemoral crossover bypass were needed.

The mean time of fluoroscopy was 21.1±7.6 min (range 12-40 min) and procedures had a mean duration of 68.1±29.4 min (range 40-150 min). All required packed red blood cells transfusion, and the mean volume of required blood products during the procedures was 3.75±2.88 units (range 1-12 units).

Three patients had pseudoaneurysm and contained rupture in the distal portion of the left subclavian artery due to the multi-system trauma caused by a car crash. One of them had serious multiple bone fractures associated with thoracic aorta pseudoaneurysm. He was taken into the intensive care unit. He was hypotensive and his hemoglobin and hematocrit levels were low (9 mg/dl - 27%). His rhythm was sinus tachycardia (rate 124/min). After volume and blood transfusion, hemodynamic stability was maintained. Seventy-two hours after admission to the emergency room, a Gore-Excluder endoprosthesis was implanted beginning from the distal portion of the left subclavian artery into the descending aorta (Fig. 2a, b). He was discharged from the hospital 15 days after the intervention.

In another patient, there was a traumatic thoracic aortic dissection. Vital signs were borderline when he admitted to the emergency room. CT scans revealed that he had a Stanford type B thoracic aortic dissection. After 12 hours, a Talent Valiant Thoracic Endoluminal Graft System (Medtronic AVE®, Santa Rosa, CA, USA) was implanted beginning from the

Table 1. Preoperative data

No	Lesion	Age	Sex	Status	ASA	Specific risk factors	Implantation time
1	Contained rupture below the left subclavian artery	38	M	Stable	II	Multiple bone fractures due to car crash	72nd hour
2	Pseudoaneurysm and periaortic hematoma	42	M	Stable	II	Bone fractures due to car crash	6th hour
3	Contained rupture below the left subclavian artery	48	M	Stable	III	Bone fractures due to car crash	6th hour
4	Ruptured abdominal aortic aneurysm	64	M	Stable	III	Hypertension	3rd hour
5	Acute type B dissection	56	M	Stable	III	Multi-organ dysfunction	48th hour
6	Ruptured thoracic aortic aneurysm	65	M	Unstable	IV	Previous aortic operation, hemothorax	3rd hour
7	Atherosclerotic plaque rupture, abdominal aorta	76	M	Stable	III	Previous CABG, hypertension	24th hour
8	Ruptured abdominal aortic aneurysm	72	M	Borderline	III	Hypertension	3rd hour
9	Ruptured abdominal aortic aneurysm	86	M	Borderline	IV	Previous CABG, hypertension	4th hour
10	Ruptured abdominal aortic aneurysm	75	F	Borderline	III	Hypertension	3rd hour
11	Acute type B dissection	58	M	Stable	III	Hypertension, hemiparesis	3rd hour
12	Traumatic thoracic aortic dissection and periaortic hematoma	38	F	Stable	III	Multiple bone fractures due to car crash	8th hour
13	Ruptured thoracic aortic aneurysm	80	M	Borderline	IV	Previous CABG, hypertension	3rd hour
14	Ruptured abdominal aortic aneurysm	76	F	Stable	III	Hypertension	2nd hour
15	Ruptured abdominal aortic aneurysm	74	M	Stable	IV	Hypertension, previous stroke	2nd hour
16	Ruptured abdominal aortic aneurysm	55	M	Stable	III	Hypertension, renal failure	2nd hour

CABG: Coronary artery bypass grafting.

distal portion of the left subclavian artery into the proximal descending aorta. His course in the intensive care unit was uneventful. He was discharged from the hospital 10 days after the intervention.

There were two patients with Stanford type B dissection. One of them had admitted to emergency room with hypertensive crisis (Blood Pressure 220/120). He was hospitalized and intravenous

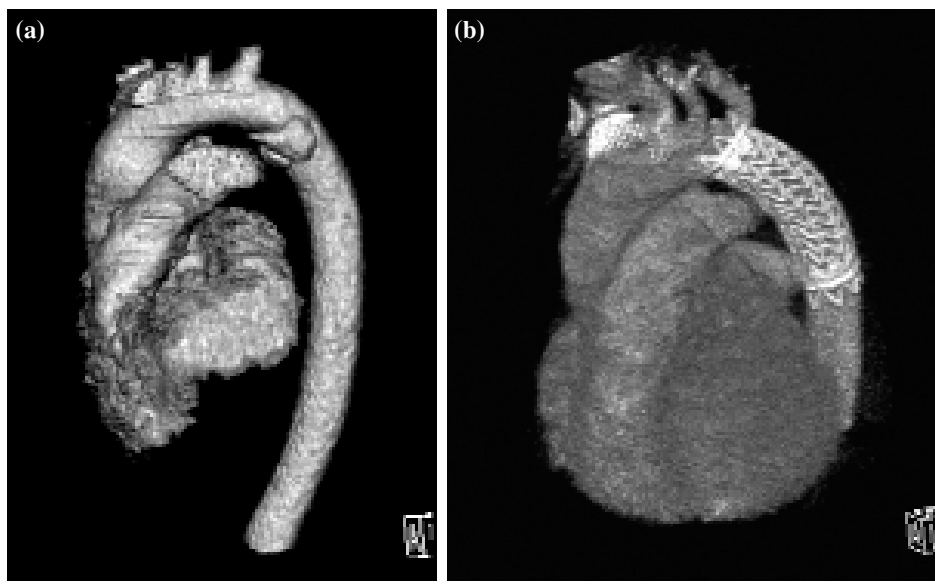

Fig. 2. (a) Pseudoaneurysm and contained rupture in the distal portion of left subclavian artery. **(b)** Implanted endoprosthesis beginning from the distal portion of the left subclavian artery into the descending aorta.

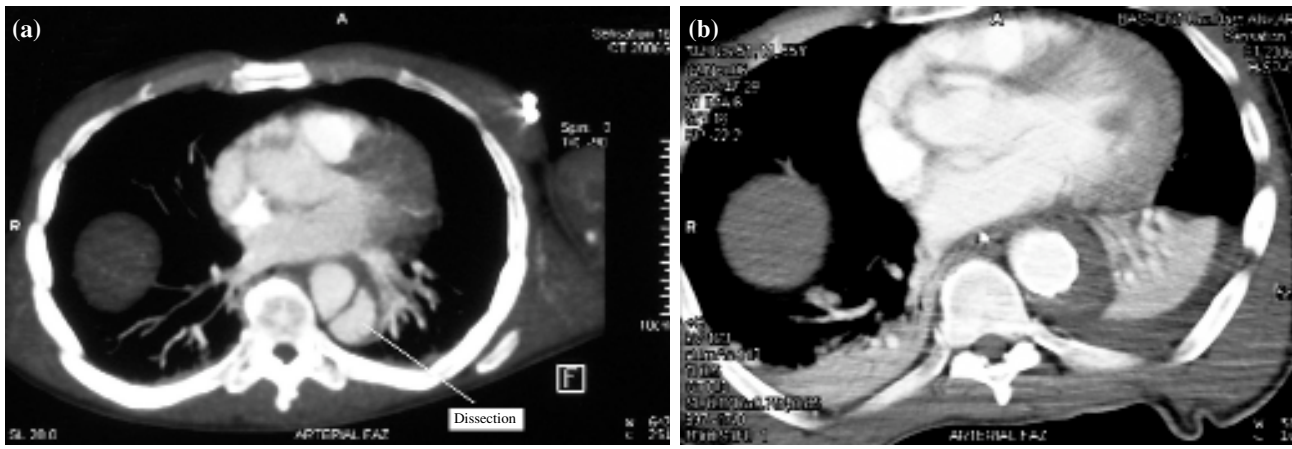

Fig. 3. **(a)** Stanford type B thoracic aortic dissection (arrow). **(b)** Implanted endoprosthesis beginning from the distal portion of the left subclavian artery into the descending aorta.

anti-hypertensive drugs were administered and the blood pressure was controlled. The CT scans revealed a Stanford type B dissection (Fig. 3a). We learned that the patient had chronic hypertension and an atherosclerotic background. He also had renal dysfunction (not dialysis-dependent, creatinine level: 3.5 mg/dl). In the 48th hour, a neurologic defect in the left lower extremity was observed associated with increased liver enzymes (SGOT: 2460 U/L, SGPT: 1870 U/L) and kidney enzymes (blood urea nitrogen: 78 mg/dl, creatinine 6.4 mg/dl). A GORE Excluder endoprosthesis was implanted beginning from the distal portion of the left subclavian artery into the descending aorta at the 72nd hour of hospitalization (Fig. 3b). He remained in the intensive care unit for 5 days and dialysis treatment was used 5 times. His liver and kidney functions dramatically improved after the procedure. He was transferred to a rehabilitation center in good condition but with right lower extremity hemiparesis after 10 days in the ward. The other patient was a 58-year-old male with Stanford type B and he admitted to emergency room with sudden onset back pain and his vital signs were borderline. A successful endovascular stent graft implantation was performed; however, in the first postoperative day a major bleeding was detected in one of the branches of the superior mesenteric artery. Despite surgical exploration 3 hours after admission, this patient died in the first postoperative day due to excessive bleeding.

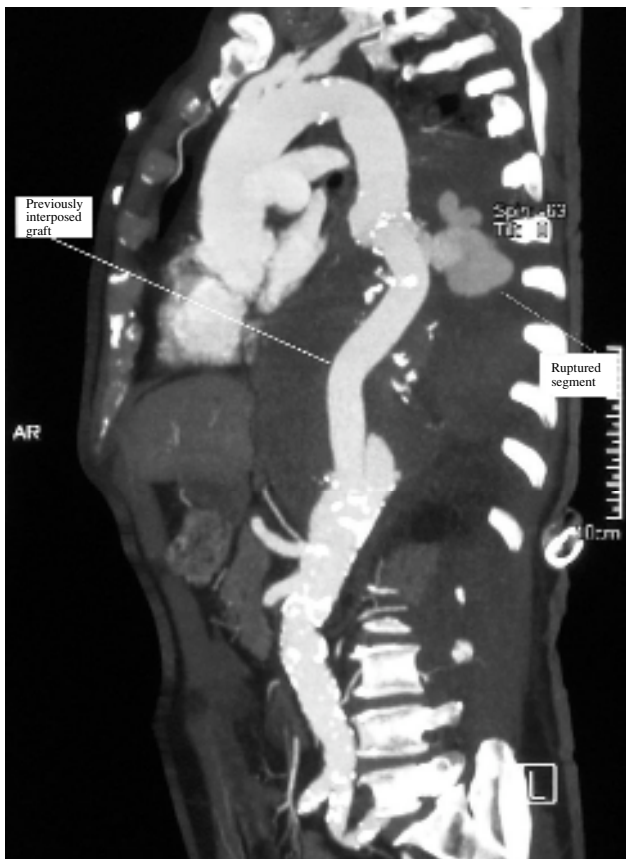

Fig. 4. Rupture of thoracic aorta in a patient who was previously operated in another center.

Another challenging patient was a redo patient who was operated 15 years before (aortic graft interposition in the descending thoracic artery) in another center in another country. He had chronic renal insufficiency and was under dialysis treatment (3 times per week). He was referred to us from another clinic due to thoracic aortic rupture.

We confirmed the rupture by CT angiogram (Fig. 4) There was a massive hematoma in the left hemithorax. The patient was urgently taken into the operating room and Valiant Thoracic Talent Endoluminal Graft System was implanted beginning from the distal portion of left subclavian artery into the descending aorta (just 1 cm above the truncus celiacus). After finishing the operation, a thoracic drain was inserted into the left hemithorax through the sixth intercostal space. A type III endoleak was detected (Fig. 5) and he was treated with another stent graft implantation. His hemodynamic status was unstable and the patient was intubated in the intensive care unit. This patient died on the seventh postoperative day due to multiple organ failure.

General anesthesia was preferred in 1 patient with multi-system trauma and another patient with thoracic aortic rupture; epidural anesthesia was preferred in 2 patients; and local anesthesia associated with sedation was preferred in 13 patients with ruptured abdominal aorta aneurysms. The perioperative and postoperative variables are summarized in Tables 2 and 3.

There was no intraoperative mortality. Hospital mortality occurred in 3 patients (18.75%). The

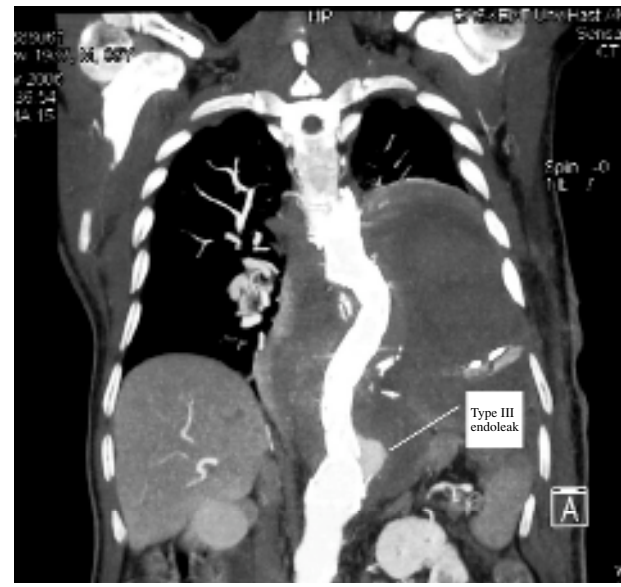

Fig. 5. After the treatment by endoprosthesis, type III endoleak is shown.

major causes of death were myocardial infarction, multiple organ failure and intraabdominal abundant bleeding. One patient died due to myocardial infarction on the fourth postoperative day.

There was only one neurological complication. In that patient, right lower extremity hemiparesis

Table 2. Operative data

No	Graft type	Size (mm)	No	A.T.	D.T. (min.)	C.V. (ml)	F.T. (min.)	B.T.	Endoleak
1	Gore Excluder	26x150	1	General	45	100	15	–	–
2	Medtronic Talent	26x150	1	Local + Sedation	40	110	18	–	–
3	Medtronic Talent	28x150	1	Local + Sedation	50	90	17	–	–
4	Gore Excluder	28x160x14	2	Local + Sedation	70	120	25	2	–
5	Gore TAG	28x150	1	Epidural	50	90	15	–	–
6	Medtronic Talent	44x150, 40x150, 38x150	3	Local + Sedation	120	180	35	4	Type I
7	Medtronic Talent	26x150	1	Local + Sedation	45	80	16	–	Type II
8	Gore Excluder	28x180x12	2	Local + Sedation	60	100	20	1	–
9	Gore Excluder	28x160x14	2	Local + Sedation	70	70	18	–	–
10	Gore Excluder	28x160x12	3	Local + Sedation	80	110	24	1	Type II
11	Medtronic Valiant	26x150	1	Epidural	50	60	16	–	–
12	Medtronic Valiant	26x150	1	Local + Sedation	50	80	18	–	–
13	Medtronic Valiant	36x150, 38x150	2	Local + Sedation	70	80	22	3	–
14	Gore Excluder	28x160x14	3	Local + Sedation	80	120	28	2	–
15	Gore Excluder	26x160x12	2	Local + Sedation	60	20	12	2	–
16	Medtronic Talent Aortouniiliac + fem - fem bypass	44x150, 36x180	2	Local + Sedation	150	200	40	2	–

AT: Anesthesia type; DT: Duration time; CT: Contrast volume; FT: Flouroscopy time; BT: Blood transfusion.

Table 3. Postoperative data

No	Technical success	Total blood transfusion unit	ICU stay (hr)	Hospital stay (day)	Status on discharge
1	100%	1	72	10	Alive without any complication
2	100%	1	48	7	Alive without any complication
3	100%	2	36	6	Alive without any complication
4	100%	5	24	5	Alive without any complication
5	100%	1	120	20	Alive with right hemiparesis
6	100%	8	144	7	Death due to multiple organ failure 7th day
7	100%	3	12	4	Alive without any complication
8	100%	4	12	4	Alive without any complication
9	100%	4	12	4	Death due to myocardial infarction on the 4th day
10	100%	3	12	4	Alive without any complication
11	100%	12	36	2	Death due to excessive bleeding after 36 hours
12	100%	1	12	5	Alive without any complication
13	100%	5	12	4	Alive without any complication
14	100%	3	12	5	Alive without any complication
15	100%	3	12	4	Alive without any complication
16	100%	4	12	4	Alive without any complication

was detected after endovascular stent grafting due to acute Stanford type B dissection.

The overall endoleak incidence was 25%. Type I endoleak was determined in 1 patient and type II endoleak in 2 patients. These patients are under follow-up. Type 3 endoleak was determined in 1 patient after EVAR treatment. He had undergone a descending aorta graft interposition operation in another center and admitted with thoracic aortic rupture. He was treated with another Valiant Thoracic Talent Endoluminal Graft System 4 days after the prior procedure.

DISCUSSION

Patients with life-threatening complications of acute pathologies of the descending and abdominal aortae are therapeutically more challenging. The definition of life-threatening complications is still a matter of debate, but usually includes contained rupture, malperfusion of visceral organs or extremities, hemorrhagic shock, rapid increase in aortic diameter, and refractory pain. There is still no consensus about the best treatment modality in these high-risk patients. Our clinic protocol is to keep the patient in stable condition (close follow-up in the intensive care unit, invasive monitoring, blood transfusion when needed, blood pressure control) and to perform the optimum therapy immediately (either stent grafting or surgery depending on the clinical status of the patient). In unstable patients with hypovolemic shock, we still prefer open surgery. When we believe that the patient's clinical condition will allow sufficient time to prepare the endovascular graft system (usually time is needed to measure the diameters, obtain the suitable graft, provide the angiography laboratory and interventional radiologist), we prefer to perform this less invasive modality. We also keep one of our operating rooms on stand-by for converting the procedure to a conventional open repair in the event of an unexpected clinical deterioration.

The conventional operation is still associated with substantial mortality and morbidity, which is chiefly related to systemic inflammatory response and multi-organ dysfunction.[6] This effect (which is a response to surgery) is exacerbated by several factors as follows: preoperative hypotension, damage to the collateral vasculature during surgical dissection, ischemia- reperfusion injury related with aortic cross-clamping, hypothermia due to prolonged periods of laparotomy, and coagulopathy due to massive transfusion. The stent graft procedure seems to be more advantageous for the patient than open surgery, with far less blood loss, less need for blood transfusion (25% - 65%), absence of aortic cross-clamping, absence of damage to the collateral vasculature, earlier extubation, shorter intensive care unit stays, earlier ambulation, and earlier

resumption of a regular diet.[7] Little experience exists with emergent endovascular stent grafting therapy in this high-risk group of patients within a short period of time after diagnosis.

Endovascular stent grafting was developed in the early 1990s, and the initial clinical use was in patients with abdominal aortic aneurysms. Shortly after, endoluminal stent placement was applied to patients with aneurysms of the thoracic aorta. The major goal of EVAR is to reduce mortality, morbidity, hospital stay and total amount of expenses. The complications of EVAR show some differences compared with conventional operations. Lacerations of the iliac artery, microembolization, stenosis and/or occlusion in the branches of the graft are more common in EVAR. On the other hand, cardiovascular, gastrointestinal, renal and infectious complications are more common in conventional operations. Endoleak is a specific method-related complication of the EVAR. In different series, the incidence of endoleak varied between 11-44%.[8] There is a strong correlation between the patent arteries arising from aneurysmal sac and endoleaks.[9]

Conventional operations for ruptured abdominal aortic aneurysm are a challenge for most surgeons due to bleeding and distortion of the anatomical structures. During control of the bleeding, duodenum, left renal vein, iliac veins and vena cava inferior may be damaged and this may result in increased morbidity. Increased experience and advantages of EVAR led us to ask: 'Why don't we use this approach for the treatment of ruptured abdominal aorta aneurysms?". In recent years, there have been encouraging studies reporting good results with endovascular stent graft treatment in patients with ruptured aortic aneurysms.[10-14]

This new approach was also used in patients with aortic dissections and other thoracic emergencies[15-17] as well as in other acute thoracic aortic syndromes.[18-21] There is consensus that in patients with uncomplicated acute type B aortic dissection, medical therapy is preferred to open surgical treatment, although there are ongoing prospective randomized trials to define the role of endovascular stent grafting in this setting.

During the last several years, evidence has accumulated that the outcome after endovascular stent grafting in patients with chronic dissections of the descending aorta shows favorable midterm results.[16] This is especially true for the elderly patient population with relevant comorbidities including hypertension, diabetes mellitus, renal disease, coronary artery disease, and obstructive lung disease. However, similar to any treatment option, endovascular stenting also carries some risks. The risks of the endoluminal approach include a secondary intimal tear as a result of the stent wires, stent dislocation leading to side branch occlusion and subsequent ischemia, perivascular leakage, vascular problems at the arterial site of access, and, rarely, rupture of the aorta. The incidence of these complications of stent grafting might be higher in the acute stage of complicated type B aortic dissections because the intima is weaker in these patients. Therefore, we aimed to wait for a few days in our patient with type B aortic dissection, but after the neurologic change and signs of organ malperfusion (worsening of liver and kidney functions) in the 48th hour of hospitalization, we decided to perform endovascular grafting and did not observe any complications related with the stent.

This study is a single center study, and a larger number of patients will give more definite results. However, we may conclude that endovascular stent graft placement is a feasible and effective approach in the emergency treatment of patients with complicated pathologies of both thoracic and abdominal aortae (such as acute type B dissection, traumatic rupture). The total procedure time is much shorter with only a small amount of blood loss when compared with open surgery. There is no need for circulatory arrest and cross-clamping of the aorta, with associated ischemia and potential reperfusion injury. Period of hospitalization and total amount of expenses are also less than with surgery. The endoluminal approach can avoid the major trauma of surgical therapy. This should help to bring the patients out of the acute life-threatening phase of this devastating disease. Keeping the patients stable until preparation of the endovascular graft system, an adequate graft bank and an experienced team have vital roles if EVAR is to be used for managing such life-threatening emergencies.

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