

## Our early and mid-term results in thoracic aorta pathologies undergoing endovascular repair

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### ABSTRACT

**Objectives:** This study aims to present early and mid-term results of thoracic endovascular aortic repair.

**Patients and methods:** A total of 24 male patients (mean age 63.5 years; range, 31 to 80 years) who underwent endovascular aortic repair in our clinic due to a descending thoracic aortic aneurysm or acute aortic syndrome between December 2011 and January 2017 were retrospectively analyzed. Data including demographic characteristics, pre-procedural additional diagnoses, mortality and morbidity data, length of intensive care unit and hospital stays, amount of blood products used, and complications were recorded.

**Results:** The mean follow-up was 42.7 (range, 22 to 60) months, the mean length of intensive care unit stay was one (range, 1 to 3) day, and the mean length of hospital stay was 5.5 (range, 4 to 30) days. The mean amount of erythrocyte suspension applied during the procedure was 0.4 (range, 0 to 3) Unit. Post-procedural acute kidney failure developed in two and transient paraplegia in three patients. Endoleak was detected in three patients during follow-up. Peri-procedural mortality occurred in one patient. The operative mortality rate (mortality within the first 30 days) was 8% and the total mortality rate was 17%.

**Conclusion:** The advantages of endovascular aortic repair include short intensive care and hospital stays, low blood product use, the ability to perform regional anesthesia in high-risk comorbid patients, and a low operative mortality rate. Our study results suggest that thoracic endovascular aortic repair is a promising and valid therapeutic technique with reduced complications rates, particularly for patients with comorbidities.

**Keywords:** Aortic diseases, endovascular techniques, thoracic aorta.

Open surgical repair (OSR) for graft replacement in the treatment of diseases of the descending thoracic aorta is regarded as a permanent therapeutic method providing the most optimal long-term reliability results.<sup>[1]</sup> The principal disadvantages of OSR include a long operative time, aortic clamping, problems associated with the kidneys or respiratory system in the postoperative period, and neurological complications including cerebral embolic events or spinal cord damage.<sup>[1,2]</sup> Thoracic endovascular aortic repair (TEVAR), which has become increasingly popular in recent years, is a promising technique in the treatment of these diseases. Numerous studies have shown that TEVAR, a less invasive procedure than OSR, is

associated with decreased morbidity and mortality, particularly in the early period.<sup>[3-6]</sup> Other important advantages of TEVAR include low-dose heparin use, a short intervention time, less blood product use, and shorter hospital stays. On the other hand, there are also studies maintaining that five-year reintervention rates are much higher in patients undergoing TEVAR, compared to OSR, and that despite a significant increase in cost with TEVAR, long-term mortality rates of these two approaches are similar.<sup>[7,8]</sup>

In the present study, we report our early and mid-term results of TEVAR in the light of literature data.

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## PATIENTS AND METHODS

This retrospective cohort study included a total of 24 male patients (mean age 63.5 years; range, 31 to 80 years) who underwent TEVAR due to a descending thoracic aortic aneurysm or acute aortic syndrome (AAS) at Recep Tayyip Erdoğan University, Medical Faculty Hospital, Turkey between December 2011 and January 2017. Data were retrieved from archives and outpatient clinic follow-up records. A written informed consent was obtained from each patient. The study protocol was approved by the local Ethics Committee (No. 2017/130, Date: 08/09/2017). The study was conducted in accordance with the principles of the Declaration of Helsinki.

All patients underwent a 3 mm section with contrast computed tomography (CT) to investigate their suitability for the procedure. The location and size of the lesion, presence of malperfusion, presence of calcification or thrombus in the vessel wall, and the structure of the iliac and femoral arteries were examined. Once the requisite measurements were performed, the site where the graft was to be attached to the proximal and distal healthy vessel wall was identified. The graft diameter was 10 to 30% greater than the healthy vessel diameter in these regions. Intervention was applied in patients with a descending thoracic artery diameter of  $\geq 5.5$  cm or of AAS. The procedures were performed by a team consisting of two cardiovascular surgeons and an anesthetist under appropriate sterilization conditions in the interventional radiology unit. General anesthesia was administered in 10 hemodynamically unstable patients with impaired general condition. These were intubated in the emergency department or intensive care unit (ICU) during preparation for surgery. Spinal anesthesia and sedation support were administered to all the other patients. A cerebrospinal fluid (CSF) drainage catheter (Integra Lifesciences, Plainsboro, New Jersey, USA) was installed in elective patients before surgery through the lumbar third and fourth vertebral spaces for medulla spinalis perfusion and to prevent spinal cord ischemia findings such as paraplegia. Following graft placement, the mean arterial pressure was maintained above 90 mmHg using intravenous fluid infusions and/or intravenous vasopressors. The CSF pressure was continuously monitored and was kept below 10 mmHg by means of drainage, when required. A mean 36 mL CSF was drained intraoperatively. The CSF drainage catheters were installed under emergency conditions in three patients taken for surgery without emergency catheter placement and developing postoperative paraplegia in the ICU. A mean 82 mL CSF was drained within the

first 24 h postoperatively, and a mean 60 mL on the second day. Lumbar drainage catheters were removed at the end of the postoperative 48 h. Following catheter removal, the mean arterial pressure was maintained at approximately 80 mmHg by means of intravenous fluid infusions, vasopressors, and glycerol trinitrate support. Neurological findings in patients developing paraplegia resolved with the CSF drainage protocol. No permanent neurological deficit occurred in any patient. Vascular access was achieved by open surgical exploration through the unilateral femoral artery and with the installation of a guidewire from the other femoral artery. The axillary artery was used to insert the guidewire in four cases in which difficulty was experienced in accessing the true lumen. The stent-graft was implanted following administration of 100 IU/kg bolus heparin. In case of prolonged procedure, additional heparin was administered at 1000 IU/h. Following implantation of the proximal stent graft starting from the distal left subclavian artery, control aortography was performed to assess graft patency and potential leaks. We were obliged to close the supra-aortic branches in the region of the proximal junction of the endovascular graft in patients with lesions involving the arcus aorta. A hybrid procedure involving surgical reconstruction of the supra-aortic branches and endovascular lesion repair was, therefore, performed. In patients with leakage in the proximal (type 1A) or distal (type 1B) stent-graft, better placement was established by inflating the aortic balloon. The TAG® (W.L. Gore & Associates Inc., Flagstaff, Arizona, USA) stent grafts were used in nine patients and TALENT® (Medtronic Inc., Minneapolis, Minnesota, USA) stent grafts in 15 patients. All patients were observed in the ICU after the procedure. Analgesic, beta-blocker, and clopidogrel therapies were initiated in addition to blood pressure regulation. Monitoring was continued on the ward, once patients achieved suitable clinical status. Subsequent follow-ups were performed at one, six, and 12 months and annually, thereafter. Complications such as endoleak and graft migration were investigated at follow-up visits using contrast thoracic CT. Additional outpatient monitoring was performed in patients with complications. Mortality within the first 30 days following the procedure was defined as operative mortality.

### Statistical analysis

Statistical analysis was performed using the SPSS for Windows version 14.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed

**Table 1. Baseline characteristics of patients**

	n	%	Median	Min-Max
Age (year)			64	31-80
Gender				
Males	24	100		
Smoking	20	83		
Diabetes mellitus	9	38		
Obesity	4	17		
Chronic obstructive pulmonary disease	7	29		
Hypertension	21	88		
Coronary artery disease	8	33		
Chronic renal failure	2	8		
Atrial fibrillation	3	13		

Min: Minimum; Max: Maximum.

in mean  $\pm$  standard deviation (SD) and number (n) and percentage, %) for categorical data. Normality of distribution for continuous variables was evaluated using the Kolmogorov-Smirnov test. A  $p$  value of  $<0.05$  was considered statistically significant.

## RESULTS

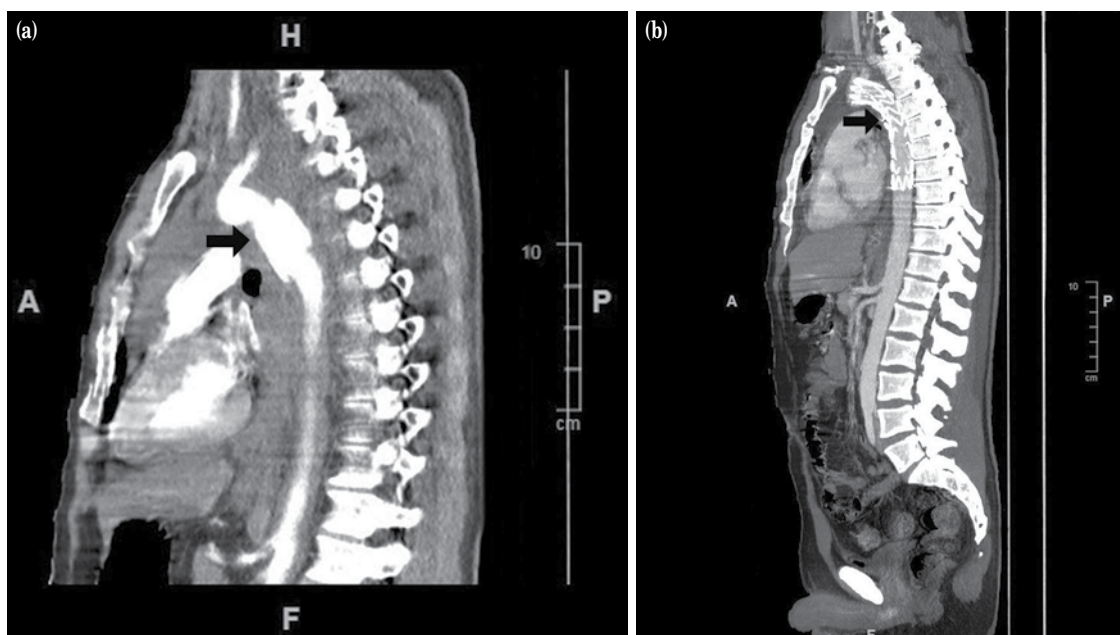
Baseline preoperative characteristics and additional diagnoses of the patients are shown in Table 1. The procedure was performed under elective conditions in seven patients with a non-ruptured aneurysm in the descending aorta. The procedures were performed under emergency conditions in 10 patients with type B dissection-related

**Table 2. Diagnosis of patients**

Diagnosis	n	%
Non-ruptured aneurysm of the descending aorta	7	29
Ruptured aneurysm of the descending aorta	5	21
Complications associated with type B dissection	10	42
Malperfusion	3	13
Suspected rupture/hemorrhage	4	17
Uncontrollable hypertension	2	8
Severe refractory pain	1	4
Intramural hematoma	1	4
Traumatic aortic transection	1	4

complications (i.e., malperfusion, treatment-resistant pain, uncontrollable hypertension, and rupture risk), in five with a ruptured aneurysm, in one with an intramural hematoma, and in one with an aortic transection caused by a traffic accident (Table 2). Pre- and post-procedural CT images of the patient with aortic transection are shown in Figure 1a and 1b. The mean length of stay in the ICU was one (range, 1 to 3) days, and the mean length of hospital stay was 5.5 (range, 4 to 30) days. One stent graft was used on average per patient. The mean length of the stent grafts employed was 18.7 cm. A mean 0.4 (range, 0 to 3) Unit of erythrocyte suspension was used during the treatment.

The mean length of follow-up was 42.7 (range, 22 to 60) months. Type 1B endoleak developed in the first year after the procedure in two patients



**Figure 1.** (a) A computed tomography image before TEVAR showing aortic transection due to a traffic accident. (b) A computed tomography image after TEVAR showing endograft placement. TEVAR: Thoracic endovascular aortic repair.

Table 3. Complications and mortality rates		
Diagnosis	n	%
Endoleak	3	13
Transient paraplegia	3	13
Acute kidney failure	2	8
Prolonged mechanical ventilation*	2	8
Healing problem in femoral incision	2	8
Mortality during intervention	1	4
Operative mortality**	2	8
Total mortality	4	17
Mortality in emergency cases	3	18
Mortality in elective cases	1	14

\* Longer than 48h, \*\* Mortality in the first 30 days.

and in the second year in another patient. No additional procedures were performed in these cases, and endoleaks resolved during follow-up. Healing problems in the femoral incision line were observed in two patients. The incision lines closed late in these patients possibly due to delayed scar tissue formation, as both were diabetics. Mortality occurred in four patients. Rupture developed in the right common iliac artery in one patient with an aneurysm in the arcus aorta and descending thoracic aorta, and this patient died during the procedure. The two patients who died within the first 30 days were those with the American Society of Anesthesiologists (ASA) Class IV taken for emergency surgery due to a ruptured aneurysm of the descending thoracic artery. These patients, in hypovolemic shock and taken intubated from the emergency department for procedures, died within the first two days in the ICU due to multiorgan failure. Mortality from respiratory failure occurred in one patient with chronic obstructive pulmonary disease operated under emergency conditions due to dissection and rupture in the descending thoracic aorta in the first year of follow-up. Complication and mortality rates of the patients are presented in Table 3.

DISCUSSION

Surgical procedures to the descending thoracic aorta are necessary in the presence of aneurysms or pathologies causing AAS.<sup>[1,2]</sup> Treatment can be planned under elective conditions to eliminate the risk of rupture of intact aneurysms with a diameter of ≥5.5 cm.<sup>[8,9]</sup> However, emergency treatment is required in the presence of AAS, which involves a high risk of mortality which increases with every hour of delay in treatment. The term AAS is used to describe all life-threatening thoracic aortic pathologies

accompanied by complications such as malperfusion and rupture with aortic dissection, traumatic aortic transection, intramural hematoma, and ruptured aneurysm of the descending aorta.<sup>[1,10]</sup> Despite all the many advances in surgical techniques and intensive care monitoring, OSR to the descending thoracic artery under emergency conditions still involves high morbidity and mortality rates.<sup>[1,3-5]</sup> Thoracic endovascular aortic repair has emerged as the result of a search for a method for reducing OSR-related risks, particularly in elderly and comorbid patients, and has recently been widely applied for the treatment of descending aorta pathologies.<sup>[1,7,11-14]</sup>

Several opinions have been proposed based on previous studies comparing the clinical outcomes of OSR and TEVAR in pathologies of the descending aorta.<sup>[7]</sup> One study investigating perioperative (first 30 days) and five-year survival in the elective repair of thoracic aorta aneurysms reported lower perioperative mortality rates in TEVAR compared to OSR, although the difference was not statistically significant. In addition, five-year survival was reported to be much poorer in the TEVAR group, with TEVAR being described as a method still in the process of technological improvement.<sup>[8]</sup> A similar study from the United Kingdom reported comparable operative mortality rates for intact aneurysms in the two methods, although survival rates after five years were poorer with TEVAR than with open surgery.<sup>[7]</sup> Higher reintervention rates after TEVAR and treatment costs were also reported. The aforementioned study also showed that similar analyses for ruptured aneurysms of the thoracic aorta were performed in very few cases, and that no significant advantage was found in the survival rates for TEVAR in the early period. The authors, therefore, concluded that the idea of transition to the endovascular method in the treatment of descending thoracic aorta aneurysms was not confirmed.<sup>[7]</sup>

In another study of 8,967 patients (92% undergoing OSR and 8% TEVAR), Hughes et al.<sup>[3]</sup> reported a 46% decrease in the mortality rates with TEVAR, compared to OSR. The authors also found age to be an independent predictor of mortality in OSR, a one-year increase in age being associated with a 4% increase in mortality rates. Other researchers also demonstrated that TEVAR was a safe and effective method in the elective repair of aneurysms of the descending thoracic aorta with significantly lower mortality rates than OSR.<sup>[15,16]</sup> One such study reported an operative mortality rate of 7.6% in patients undergoing TEVAR, compared to 15.1%

in patients undergoing OSR. Numerous studies of acute descending thoracic aorta pathologies have also emphasized that TEVAR is a safe and appropriate therapeutic method with lower operative mortality rates, compared to OSR.<sup>[1,7,8,16]</sup> Periprocedural mortality occurred in one of seven patients undergoing TEVAR under elective conditions due to an aneurysm of the thoracic aorta. An aneurysm involving the entire arcus aorta and the proximal descending aorta was present in this patient who underwent previous ascending aorta graft replacement. In the first session, the body of the 16×8-mm Y-graft was anastomosed in an end-to-site fashion to the old ascending aorta graft using a side-clamp after re sternotomy. One leg of the Y-graft was anastomosed in an end-to-end fashion to the left common carotid artery, while the other was anastomosed in an end-to-end fashion to the left subclavian artery. Subsequently, the proximal part of another 10-mm Dacron graft was anastomosed in an end-to-side fashion to the trunk of the Y-graft, and the distal part of the Dacron graft was anastomosed in an end-to-end fashion to the innominate artery. In this way, the entire arcus branches were moved to the ascending aorta. A long area was achieved for the installation of the proximal endovascular graft. The TEVAR procedure was planned in the second session two weeks later. During the procedure, the rigid wire was unable to be forward to the arcus aorta. The right common artery was torn due to all the forces being directed toward the iliac artery during manipulations. Unfortunately, the patient died during the operation, despite switching to open surgery. Mortality was also observed in the first 30 days following the procedure in two of 17 patients in whom we performed TEVAR under emergency conditions due to AAS and in the first year in another patient.

With advances in the endoluminal treatment of aortic aneurysms, iliac artery injuries have occurred resulting from traction caused by large sheaths and delivery devices which need to be passed through the iliac vessels. Current delivery systems have improved dramatically compared with the first-generation devices.<sup>[14,17]</sup> However, even after careful preoperative evaluation, involuntary iliac artery rupture can cause morbidity and mortality. A combination of calcification, tortuosity, and diminished caliber may lead to rupture, even if the diameter of the iliac artery is acceptable. Due to the use of a larger size graft and the need for forward to the arcus aorta, the risk of arterial artery rupture is higher during TEVAR than with endovascular abdominal aneurysm repair (EVAR).<sup>[17]</sup> Several studies have reported a risk of

iliac artery rupture during TEVAR of 8 to 20%.<sup>[17]</sup> It has been also shown that switching to open surgery for repair in the event of an iliac artery rupture is associated with 11 to 22% higher mortality, compared to endovascular repair techniques.<sup>[17,18]</sup> However, to be able to repair iliac artery ruptures occurring during TEVAR using endovascular methods, the requisite materials have to be prepared beforehand. Of note, this raises a logistic problem for centers such as ours located in the periphery of the country. Since firms in our region have no fixed warehouses or suppliers, cases can be performed by means of communications established with suppliers in large centers. Logistic problems refer that difficulties may be experienced due to lack of equipment in emergency cases or in the event of unexpected complications.

Several studies have reported that TEVAR has been applied to older patients with preoperative comorbidity factors increasing the risk of mortality, such as chronic obstructive pulmonary disease, diabetes mellitus, and chronic kidney failure, compared to OSR.<sup>[3,4,19-21]</sup> Nonetheless, significant decreases were observed in the postoperative respiratory, neurological, and cardiac complications in patients undergoing TEVAR.<sup>[3,4,15-21]</sup> Hughes et al.<sup>[3]</sup> reported significantly lower neurological, respiratory, and cardiac complications and shorter mean lengths of stay in the ICU in patients undergoing TEVAR, compared to OSR. Ertugay et al.<sup>[1]</sup> reported renal complications in three undergoing TEVAR under emergency conditions due to AAS, respiratory complications in three, and cardiac complications in three patients. While acute kidney failure occurred in one of our elective patients in our clinic, no complications occurred in the other elective patients. Neurological complications developed in three of our patients whom we operated under emergency conditions due to AAS, renal complications in one, and respiratory complications in two.

Several studies have reported higher mid- and long-term reintervention rates and, therefore, higher treatment costs in patients undergoing TEVAR.<sup>[4-8]</sup> von Allmen et al.<sup>[7]</sup> reported aorta-related reintervention rates of 23.1% in TEVAR and 14.3% in OSR during five-year follow-up. However, some authors reported that, although the reintervention rates were higher in TEVAR, this did not increase mortality, and all-cause mortality rates were similar to those in patients undergoing OSR.<sup>[3,15]</sup> It was also shown that TEVAR-related complications such as endoleak and stent graft migration could be corrected with lifelong follow-up and appropriate treatment methods.<sup>[22]</sup>

No reintervention was required during a mean follow-up period of 42.7 months in patients undergoing TEVAR in our clinic, and type 1B endoleak in three patients resolved without requiring any intervention.

Limitations of the present study include the retrospective, single-center design with a small sample size. Nonetheless, we believe that our results would provide to the current literature on this topic.

In conclusion, our study results suggest that thoracic endovascular aortic repair is a promising and valid therapeutic technique with reduced complications rates, particularly for patients with comorbidities.

#### Declaration of conflicting interests

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

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