TJVS Turkish Journal of Vascular Surgery

Turk J Vasc Surg.2026;35(1):14-22
DOI: 10.9739/tjvs.2025.11.069

Available online at www.turkishjournalofvascularsurgery.org

Original Article

Early outcomes of TEVAR: Spinal cord ischemia and reintervention rates in a single-center study

Mehmet Cahit Saricaoglu[1], Fatma Akca[2], Evren Ozcinar[1], Ali Ihsan Hasde[1], Salih Anil Boga[2], Ali Fuat Karacuha[1], Onur Buyukcakir[1], Cagdas Baran[1], Levent Yazicioglu[1], Sadik Eryilmaz[1]

[1]Ankara University, Faculty of Medicine, Department of Cardiovascular Surgery, Ankara, Türkiye
[2]Kırıkkale High Specialization Hospital, Department of Cardiovascular Surgery, Kırıkkale, Türkiye

Received: November 21, 2025 Accepted: January 25, 2026 Published online: March 04, 2026

Abstract

Aim: Thoracic endovascular aortic repair (TEVAR) is currently the preferred treatment for different pathologies of the thoracic aorta because of its technical advantages over open surgery. This single-center study analyzes early outcomes of TEVAR with a special focus on spinal cord ischemia (SCI) and reintervention rates and their relationship to patient and procedural variables.

Material and Methods: Data were retrospectively collected from patients who underwent TEVAR between February 2012 and August 2023. Patients were classified by pathology type: thoracic aortic aneurysms (n=97, 66.4%), type B aortic dissections (n=28,19.2%), traumatic aortic injuries (n=12, 8.2%), and other pathologies (n=9, 6.2%). Primary outcomes included SCI and reintervention rates at one year post-procedure; secondary outcomes included stroke, upper extremity ischemia, and 30-day mortality. The statistical analysis used univariate and multivariate logistic regression models as well as Kaplan-Meier survival analyses with subgroup comparisons between elective and urgent cases.

Results: A total of 146 patients were analyzed; 79.45% were male with an average age of 63.23±12.50 years. Of this population, 121 patients (82.9%) had elective procedures and 25 patients (17.2%) had urgent/emergent procedures; postoperative spinal cord ischemia developed in 11 patients (7.5%). The stroke rate was 13.7% (n=20).The 30-day mortality rate was significantly higher in patients undergoing urgent TEVAR compared to those undergoing elective procedures (32.0% vs. 13.2%, p=0.02). TEVAR-related reintervention was required within a year for 38 patients (26%).There are no independent predictors for spinal cord ischemia; however, the multivariate analysis shows that early reintervention has a strong association with diabetes mellitus (OR 3.2, 95% CI 1.3–7.8, p=0.01), history of smoking (OR 2.1, 95% CI 1.0–4.4, p=0.05), and lesions in distal zones (OR 2.4, 95% CI 1.1–5.2, p=0.03). Urgent cases showed a trend toward higher reintervention rates compared to elective procedures (40.0% vs. 23.1%, p=0.08).

Conclusion: This study demonstrates that the risk of reintervention is increased in cases with a history of diabetes mellitus, smoking, and aortic pathologies located in the distal thoracic zone. Urgent procedures carry higher morbidity and mortality risks but should be confirmed by larger randomized multicenter studies.

Keywords: Thoracic aorta, endovascular procedures ,spinal cord ischemia, reintervention, aortic aneurysm

INTRODUCTION

Thoracic endovascular aortic repair (TEVAR) has been the gold standard for treatment of diseases over the recent years. The major diseases of the thoracic aorta include thoracic aortic aneurysms, type B dissections, and traumatic ruptures; therefore, minimally invasive treatments have become more successful than open surgery. The main advantages are a significant decrease in perioperative morbidity and mortality, shorter hospital stays, and quicker returns to baseline functional status and daily activities. In parallel, improvements in vascular access techniques and device profiles together with growing institutional experience

CITATION
Saricaoglu MC, Akca F, Ozcinar E, Hasde AI, Boga SA, Karacuha AF, et al. Early outcomes of TEVAR: Spinal cord ischemia and reintervention rates in a single-center study. Turk J Vasc Surg.2026;35(1):14-22.

Corresponding Author: Fatma Akca, Kırıkkale High Specialization Hospital, Department of Cardiovascular Surgery, Kırıkkale, Türkiye
Email: akcaafatma@gmail.com

DOI: 10.9739/tjvs.2025.11.069

have moved TEVAR into a first-line procedure for anatomically appropriate patients [1-3].

Despite its successes, TEVAR is not without significant complications. Major adverse events include spinal cord ischemia (SCI), need for early or late reintervention, and various vascular and end-organ injuries. Access-site complications can occur as well as guidewire-related injuries, retrograde dissection and soft-tissue complications such as aortoesophageal and aortobronchial fistulae. Other potential problems are malperfusion plus renal failure; endoleaks plus graft-related complications that may cause stroke or upper-extremity ischemia or SCI. These prove possible effects on patient survival, quality of life, long-term durability; hence meticulous procedural planning, careful risk stratification accompanied by vigilant postoperative surveillance constitute essential components in TEVAR care [3,4].

SCI is a rare but devastating complication with high chances of permanent neurological deficits that usually occur due to low perfusion in the territory of the anterior spinal artery. Reported rates in literature range between 2% and 10%, influenced by factors such as extent of aortic coverage, baseline collateral circulation, existing vascular anatomy, and perioperative hemodynamic status. Early diagnosis followed by immediate treatment will help reduce associated morbidity and mortality. At the same time, primary reintervention is more frequently needed due to endoleaks, graft migration, or device-related failures; this fact constitutes a major impediment for long-term durability. The frequency and timing of secondary procedures are determined by pathology, complexity of procedure, device choice, and follow-up surveillance strategies. While multicenter registries will provide an overall view on long-term results, single-center experiences are very important in understanding better specific institutional protocols, patient characteristics, and direct factors leading to clinical success [5-10].

In particular, single-center analyses enable focused examination of risk factors for SCI and reintervention evaluation, institutional optimization strategies, collateral network preservation, cerebrospinal fluid drainage protocols, and distal perfusion planning, and assessment of their impact on patient-oriented outcomes. Clarification of these factors is necessary in order to improve the process of patient selection, provide an appropriate approach to the procedure, and manage postoperative care more effectively. The primary objective is to determine the incidence and identify risk factors for SCI and early reintervention after TEVAR in a consecutive cohort treated at a high-volume tertiary referral center. Secondary objectives are to evaluate contemporaneous outcomes including stroke, upper-extremity ischemia, and 30-day mortality, to compare outcomes between elective and urgent (or emergent) TEVAR procedures, to characterize patterns of endoleaks, graft-related complications, and subsequent reinterventions as well as assess their association with SCI and overall survival, to explore the influence on patient and procedural variables e.g. extent of aortic coverage, comorbidities, anesthesia type, adjunctive measures such as spinal drain use on adverse events and reintervention risk.

Pre-specified hypotheses are as follows: Increasing aortic coverage length and involvement of critical collateral vascular territories are independently associated with a higher risk of SCI and early reintervention following TEVAR. Urgent or emergent TEVAR procedures are hypothesized to be associated with significantly higher rates of SCI, stroke, and 30-day mortality compared with elective interventions, even after adjustment for baseline patient and procedural risk factors. In contrast, the implementation of standardized institutional protocols is expected to be associated with reduced reintervention rates and improved neurologic outcomes.

Though large registries provide valuable national or international perspectives, single center studies offer critical insights into how local practices, patient populations and procedural volumes translate into meaningful differences in risk. It is with this retrospective analysis that an attempt was made to highlight actionable predictors of SCI as well as early reintervention quantifying associated outcomes comparing elective versus urgent TEVAR performed in a controlled setting at a high-volume center. The findings will have potential implications for enhancing safety through guideline-based procedural planning protective strategies toward improving durability for TEVAR.

MATERIAL AND METHODS

Study Design and Population

This retrospective, single-center, observational cohort study was conducted at Ankara University Department of Cardiovascular Surgery, a high-volume tertiary care center. The study protocol was approved by the Ankara University the Institutional Review Board (Protocol number: 2024/720, Date: 14 March 2025) and conducted in accordance with the Declaration of Helsinki.

All consecutive patients who underwent TEVAR between February 2012 and August 2023 were identified from our institutional database. Inclusion criteria were: (1) age ≥18 years,(2) TEVAR procedure for any thoracic aortic pathology, complete medical records available, and minimum 30-day follow-up data. Exclusion criteria included: previous spinal cord injury or neurological deficit, concomitant abdominal aortic repair, hybrid procedures combining open and endovascular techniques, and incomplete procedural or follow-up data [1-4].

Patient and Pathology Classification, Anatomic Definitions

Data collection involved a thorough review of electronic medical records, focusing on demographic information, preoperative characteristics, procedural details, and postoperative outcomes. Patients were classified based on their primary aortic pathology and procedural urgency:

Thoracic Aortic Aneurysms (TAA): Fusiform or saccular dilatation >5.5 cm in diameter or >1.5 times the normal aortic diameter.

Type B Aortic Dissections: Stanford Type B dissections (complicated or uncomplicated), including chronic dissections with aneurysmal degeneration. In patients with type B aortic dissection, the timing of TEVAR was determined primarily by clinical presentation rather than symptom duration alone. Patients with life-threatening conditions—such as rupture, malperfusion, or instability—received immediate or urgent TEVAR within 24 hours.

Traumatic Aortic Injuries: Blunt aortic injuries presenting with intimal tear, pseudoaneurysm, or transection.

Penetrating Aortic Ulcers (PAU): Ulcerative lesions penetrating the internal elastic lamina, often associated with intramural hematoma. Patients with PAU were treated according to clinical stability and imaging findings. Symptomatic, complicated, or life-threatening PAU cases were managed urgently, whereas stable lesions without signs of rupture or progression were scheduled for elective TEVAR.

Other Pathologies: Aortic coarctation, mycotic aneurysms, and aortoesophageal fistulas.

Procedures were categorized as elective, which were scheduled for stable or chronic conditions, and urgent/emergent, which were performed within 24 hours or immediately for symptomatic, complicated, or life-threatening conditions, including cases with rupture or hemodynamic instability.

Aortic zones were defined according to the Ishimaru classification, with the proximal zone encompassing Zone 0-2 (ascending aorta to the left subclavian artery origin) and the distal zone covering Zone 3-4 (mid-descending aorta to the diaphragmatic aorta). Lesion lengths were measured using 3D reconstruction software RadiAnt DICOM Viewer Version 2025.2 (Medixant, Poznań, Poland) with centerline analysis. For aneurysms, the maximum diameter was measured from the proximal to distal extent of dilatation, while for dissections, the length was determined from the primary entry tear to the most distal extent of the false lumen. In traumatic injuries, the measurement included the injured segment plus 2 cm of proximal and distal landing zones.

Procedural Protocols and Outcome Definitions

Adjunctive Protective Measures

Prophylactic Cerebrospinal Fluid Drainage (CSFD) catheters were placed in high-risk patients meeting specific criteria: anticipated aortic coverage >200 mm, coverage of T8-L2 region (Adamkiewicz artery territory), previous abdominal aortic surgery, and absence of contraindications. CSFD pressure was maintained at 10-12 mmHg for 48-72 hours postoperatively.

Prophylactic carotid-to-subclavian bypass was performed in patients with dominant left vertebral artery, patent left internal mammary artery graft, inadequate collateral circulation, or anticipated coverage >15 cm, based on preoperative imaging assessment and multidisciplinary team discussion. In urgent and emergent cases, the same neuroprotective strategy was applied whenever feasible; however, the timing of intervention and the patient's hemodynamic status occasionally limited the ability to perform all prophylactic measures. In these situations, procedural priority was given to rapid aortic stabilization, and adjunctive protective strategies were individualized based on anatomical feasibility and clinical urgency.

Data Collection and Outcome Definitions

Demographic and clinical variables collected included:

- Demographics: Age, sex, body mass index
- Comorbidities: Hypertension (systolic blood pressure (BP) >140 mmHg or antihypertensive medication), diabetes mellitus (HbA1c >6.5% or antidiabetic medication), chronic kidney disease (eGFR ,glomerular filtration rate <60 mL/min/1.73 m²), chronic obstructive pulmonary disease (FEV1 <80% predicted or bronchodilator therapy),coronary artery disease (previous Myocardial Infarction,Percutaneous Coronary Intervention,Coronary Artery Bypass Grafting), cerebrovascular disease (previous stroke or Transient Ischemic Attack)
- Medications: Antiplatelet therapy, statins
- Procedural variables: Lesion location, length, number of stent grafts, procedure time, contrast volume, fluoroscopy time

The primary outcomes of this study were SCI, defined as new-onset paraplegia or paraparesis within 30 days confirmed by neurological examination, and early reintervention, defined as any secondary endovascular or surgical procedure related to the index TEVAR within 1 year. Secondary outcomes included stroke (new focal neurological deficit lasting >24 hours with imaging confirmation), upper extremity ischemia following left subclavian artery (LSA) coverage, 30-day all-cause mortality, and major adverse events, which comprised a composite endpoint of death, stroke, SCI, or urgent reintervention occurring within 30 days of the procedure. We hypothesized that reinterventions might be less frequent in elective cases and short segment lesions, while the risk of SCI might be increased in patients with long segments closed in the distal region.

Statistical Analysis

The continuous variables were presented as mean±standard deviation (SD) for normal data and median with interquartile range (IQR) for non-normal distributions after checking normality using the Shapiro-Wilk test. Absolute frequencies and percentages described categorical variables. Comparisons between groups used the Student's t-test or Mann-Whitney U test for continuous variables, while categorical ones used Chi-square or Fisher's exact test depending on data characteristics.

Binary outcomes such as SCI, early reintervention, and mortality at 30 days were first evaluated by univariate analysis. Variables with a p-value <0.20 entered into the multivariate logistic regression model. Because there are very few events of spinal cord ischemia (n=11), it should be noted that standard multivariate models can be biased due to sparse data; therefore, in this particular case, Firth's penalized likelihood regression will give more reliable estimates and avoid overestimation of odds ratios. The Hosmer-Lemeshow test assessed calibration of the model to the data.

Survival and freedom from reintervention events were estimated by Kaplan-Meier curves with comparisons done using the log-rank test. Cox proportional hazards regression was used in adjusted survival analyses to find independent risk factors. Missingness below 10% was handled through multiple imputation by fully conditional specification (chained equations) method to ensure robustness of data; however, patients whose key variable data had more than 20% missingness were excluded from final multivariate analyses. Stratified analyses were performed afterward based on differences in procedural urgency (elective versus urgent), primary pathology, and anatomical zones. A two-sided p-value <0.05 was considered statistically significant. All calculations were carried out with IBM SPSS Statistics version 29.0.2.0 (IBM Corp., Armonk, NY).

RESULTS

The data for 146 patients who underwent TEVAR between February 2012 and August 2023 were retrospectively analyzed. Of thes 146 patients, 116 (79.45%) were male, with an average age of 63.23±12.50 (Table 1).

Baseline characteristics are presented in Table 1. Hypertension was the most common comorbidity (124 patients, 84.9%), followed by coronary artery disease (71 patients, 48.6%) and smoking history (61 patients, 41.8%). Chronic kidney disease was present in 33 patients (22.6%), diabetes mellitus in 23 patients (15.8%), and chronic obstructive pulmonary disease (COPD) in 41 patients (28.1%).

Procedural characteristics are detailed in Table 2. The majority of procedures were elective(121 patients, 82.9%) versus urgent (25 patients, 17.2%). Mean lesion length was 24.7±9.8 cm, with longer coverage in dissection cases compared to aneurysms (28.4±11.2 cm vs 23.1±8.9 cm, p=0.02). Proximal zone landing was more common (108 patients,74.0%) than distal zone (38 patients, 26.0%).

Table 1. Demographics and preoperative characteristics of TEVAR patients (n=146)

Sex, male	116 (79.45%)
Age, years	63.23±12.50 (min=29 /max=85)
Hypertension	124 (84.9%)
COPD	41 (28.1%)
Chronic kidney disease	33 (22.6%)
Diabetes mellitus	23 (15.8%)
Coronary artery disease	71 (48.6%)
History of smoking	61 (41.8%)
Cerebrovascular disease	6 (4.1%)
Preoperative aspirin	85 (58.2%)
Preoperative statin	46 (31.5%)
Elective	121 (82.8%)
Urgent	25 (17.2%)

Data are presented as number (%) or mean±standard deviation unless otherwise indicated. Abbreviations: COPD, chronic obstructive pulmonary disease

Table 2. Operative details and early postoperative outcomes

Variable	Value
Pathology distribution (n, %)	
Thoracic aortic aneurysm	97 (66.4%)
Type B aortic dissections	28 (19.2%)
Traumatic aortic injury	12 (8.2%)
Penetrating aortic ulcer	6 (4.1%)
Other pathologies	3 (2.1%)
Procedural characteristics (n±SD)	
Total operation time, minutes	180.4±50.1
Lesion length ,cm	24.7±9.8
Number of stent grafts	1.8±0.9
Contrast volume , mL	145.2±38.7
Landing zone (n,%)	
Proximal zone (0-2)	108 (74.0%)
Distal zone (3-4)	38 (26.0%)
Adjunctive procedures (n ,%)	
Prophylactic CSFD	34 (23.3%)
Carotid-to-subclavian bypass	38 (26.0%)
LSA coverage without revascularization	15 (10.3%)
Early outcomes (n ,%)	
Stroke	20 (13.7%)
Spinal cord ischemia	11 (7.5%)

Data presented as number(%) or mean±standard deviation unless otherwise indicated. Abbreviations: CSFD:cerebrospinal fluid drainage, LSA:left subclavian artery

DOI: 10.9739/tjvs.2025.11.069

When the pathologies requiring TEVAR were examined, thoracic aortic aneurysms were the most common indication, accounting for 97 patients (66.4%). The remaining pathologies were distributed as follows: type B aortic dissections in 28 patients (19.2%), traumatic aortic injuries in 12 patients (8.2%), penetrating aortic ulcers in 6 patients (4.1%), and other pathologies including mycotic aneurysms and aortic coarctation in 3 patients (2.1%). This distribution reflects the diverse spectrum of thoracic aortic pathologies encountered in contemporary endovascular practice (Table 2/Figure 2).

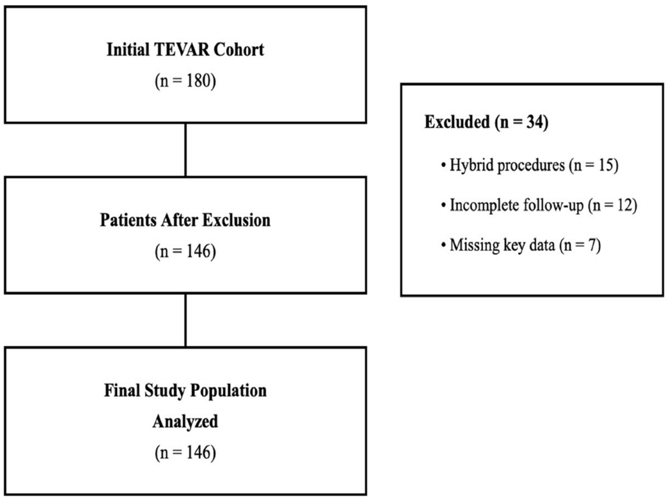

Figure 1. CONSORT-style flow diagram of patient selection for TEVAR study

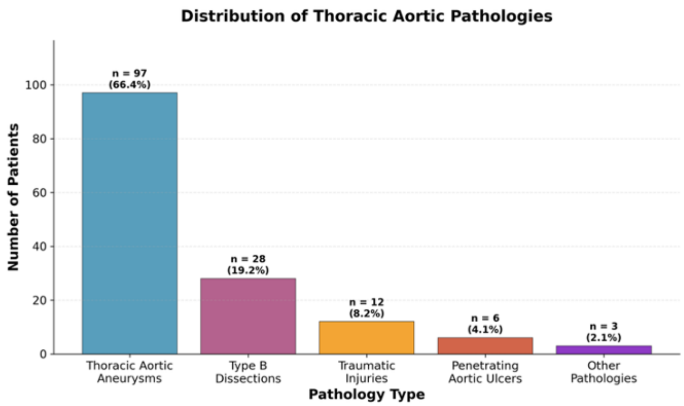

Figure 2. Distribution of thoracic aortic pathologies among the study population

Primary Outcomes

SCI was recorded in 11 patients (7.5%), with onset within 24 hours in 8 patients (72.7%) and delayed onset (24-72 hours) in 3 patients (27.3%).SCI was more numerically frequent among patients undergoing urgent procedures and those with longer aortic coverage involving distal zones but did not achieve statistical significance due to the small number of events. Complete paraplegia occurred in four patients while seven were left with paraparesis; recovery at thirty days post-procedure was noted for six individuals (54.5%). There were no significant associations between SCI and patient demographics, comorbidities, or procedural variables on univariate analysis (Table 3). Multivariate logistic regression confirmed no independent predictors of SCI in our cohort (all p>0.05).

Table 3. Demographics and preoperative characteristics of TEVAR patients (n=146)

Variables	Spinal cord ischemia		Early reintervention	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age	0.95 (0.89-1.01)	0.960	0.98 (0.94-1.01)	0.248
Female Sex	0.33 (0.08-1.31)	0.110	1.90 (0.60-6.22)	0.260
Hypertension	0.62 (0.39-9.85)	0.730	2.70 (0.43-17.7)	0.270
COPD	4.30 (0.68-27.7)	0.110	2.57 (0.92-7.10)	0.070
Chronic kidney disease	0.11 (0.009-1.38)	0.08	1.08 (0.35-3.30)	0.880
Diabetes melitus	4.90 (0.62-40.0)	0.130	3.20 (1.30-7.80)	0.010
Coronary artery disease	8.85 (0.79-98.8)	0.760	1.68 (0.59-4.8)	0.320
Smoking history	3.80 (0.60-24.3)	0.150	2.10 (1.00-4.40)	0.050
Cerebrovascular disease	2.36 (0.07-71.4)	0.620	0.59 (0.05-6.0)	0.660
Carotid-to-subclavian bypass	0.25 (0.01-5.15)	0.370	2.77 (0.91-8.4)	0.070
Distal zone lesion	13.85 (0.57-364.4)	0.110	2.40 (1.10-5.20)	0.030
Lesion length (centimeters)	0.97 (0.89-1.06)	0.610	0.90 (0.91-1.02)	0.290

p-value of less than 0.05 was considered statistically significant .Abbreviations:OR: odds ratio, CI: confidence interval, COPD: chronic obstructive pulmonary disease

 DOI: 10.9739/tjvs.2025.11.069

Reintervention within 1 year was required in 38 patients (26.0%). The majority of reinterventions involved additional stent graft placement in 29 patients (76.3%) to address issues such as endoleaks, inadequate seal, or disease progression; this reflects 76.3% of all reported cases during the follow-up period after initial treatment with TEVAR for thoracic aortic pathologies. Specific repairs for endoleaks were done on eight patients using various techniques classified under endovascular methods including stent graft optimization and balloon angioplasty; this amounts to 21.1%—Kaplan Meier survival analysis was conducted on one hundred forty-six patients undergoing TEVAR. Overall thirty-day survival was 82.9% with a 95% confidence interval from 75.7 to 88.1%—at twelve months follow-up, freedom from reintervention applied to 78.1% of these people meaning that about three-quarters did not get further secondary interventions during the study period (Figure 3/Figure 4).

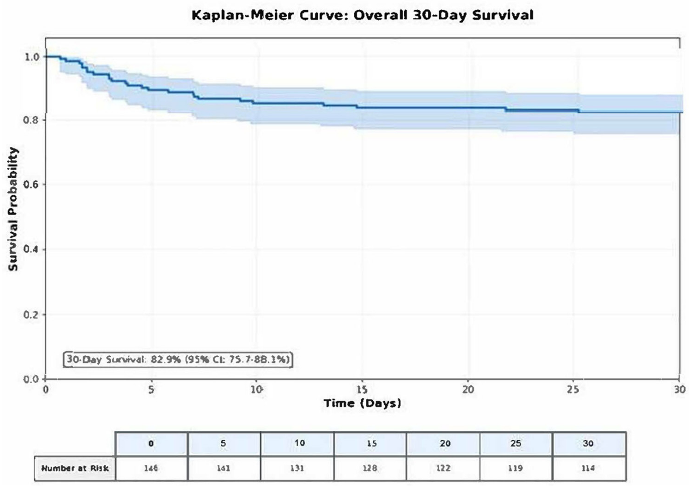

Figure 3. Kaplan-Meier curve showing overall 30-day survival in 146 patients undergoing TEVAR

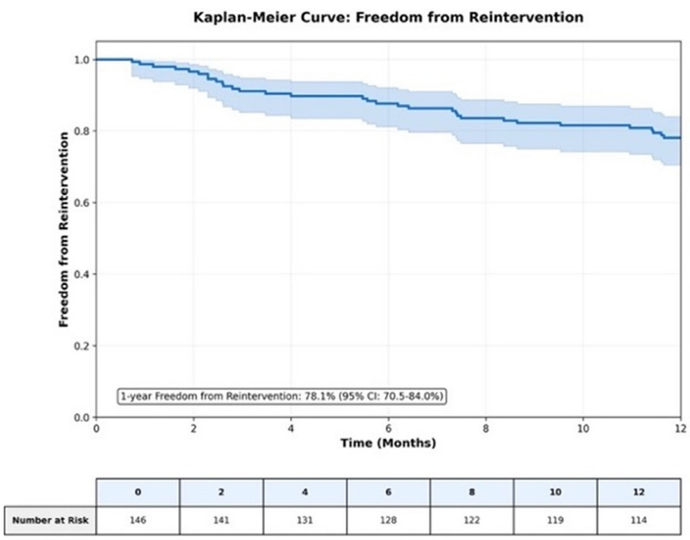

Figure 4. Kaplan-Meier curve for freedom from reintervention at 12-month follow-up

Multivariate logistic regression analysis identified three independent predictors of reintervention as detailed in Table 3. Diabetes mellitus was the most significant predictor with an odds ratio of 3.2, indicating that if a patient has diabetes, they are more than three times likely to require reintervention compared to those without diabetes (95% CI: 1.3-7.8; p=0.01). The other two independent predictors were lesions located in distal zones and smoking history with odds ratios of 2.4 and 2.1 respectively; this means that having either one increases the risk substantially but not as much as diabetes does.-This suggests that enhanced surveillance may be required for such patients along with possibly altering treatment strategies so as not to put them at high risk for requiring another intervention.

Secondary Outcomes

Overall 30-day mortality was 25 patients (17.1%). The leading cause of death was multi-organ failure in 12 patients (48.0%), followed by cardiac complications including myocardial infarction and heart failure in 6 patients (24.0%). Stroke-related mortality occurred in 4 patients (16.0%), while aortic-related complications including rupture and bleeding accounted for 3 deaths (12.0%).Thirty-day mortality was significantly higher in patients undergoing urgent TEVAR compared to those undergoing elective procedures (32.0% vs. 13.2%, p<0.05).

DISCUSSION

Over the past several decades, treatment options for diseases of the thoracic aorta have changed dramatically. At first, open and invasive surgical procedures were the primary methods of treatment. However, improvements in device technology and an enhanced understanding of aortic pathology have shifted the trend toward a greater preference for endovascular approaches. The initial report on thoracic endovascular aortic repair was published by Dake et al. in 1994; since then its application has been continuously rising with technological advancements and clinical experience acquired from practice [9,10].

Endovascular repair has become a cornerstone in the management of complex aortic presentations, including ruptured aneurysms and acute dissections. Extensive comparative data consistently demonstrate that TEVAR offers superior perioperative survival and lower morbidity profiles compared to traditional open surgery [9,10].In this retrospective analysis of 146 consecutive patients, we scrutinized early clinical outcomes and the key drivers of adverse events. Our results show that while the incidence of SCI (7.5%) remains consistent with established literature, the overall reintervention rate (26.0%) is influenced by a specific interplay of clinical and anatomical determinants. Notably, diabetes mellitus, smoking history, and distal aortic involvement emerged as independent predictors of the need for early secondary procedures. Moreover, the significantly higher morbidity and mortality rates observed in urgent cases highlight the profound clinical vulnerability of patients requiring emergency intervention.

According to the data from non-comparative, single-center, retrospective studies in the literature, there is no definitive information on preventing SCI. However, looking at the incidence rates, we see that SCI occurs in less than 10% of cases after TEVAR and has been reported to occur in 2-15% of cases after open repair [5,11,12]. Reflecting the results of a prospective, single-center 5-year study, the W.L. Gore TAG (W.L. Gore & Associates, Flagstaff, AZ,USA) pivotal trial reported a 2.9% incidence of SCI among 139 patients who had a repair of a descending thoracic aneurysm [12,13]. The Gore TAG trial exclusively enrolled patients with degenerative thoracic aneurysms, whereas our cohort included 19.2% dissection cases and 8.2% traumatic injuries, which may explain the higher SCI rate.

The risk profile for SCI following TEVAR is recognized to be multifactorial, with prior studies implicating variables such as the extent of aortic coverage, history of abdominal aortic surgery, perioperative hypotension, iliac artery injury, and coverage of the LSA [6]. In our cohort, however, multivariate logistic regression analysis did not demonstrate a statistically significant association between these factors and the occurrence of SCI ($p>0.05$), as presented in Table 3. This observation may, at least in part, be attributable to our institutional strategy of employing prophylactic CSFD in high-risk patients (23.3% of cases), an approach that has been shown in randomized trials to reduce SCI rates by up to 50% [7,14]. Current European Society for Vascular Surgery (ESVS) guidelines similarly recommend CSFD in the setting of extensive aortic coverage (>200 mm) or in patients with high-risk anatomical configurations, which is consistent with our institutional practice [15]. Acknowledging that CSFD itself carries procedure-related complication rates of approximately 0–7%—including headache, subdural hematoma, and suspected meningitis—we nonetheless consider that selective use of CSFD in patients at elevated risk for spinal cord ischemia may further optimize neurological outcomes after TEVAR.

Another outcome, early reinterventions in the TEVAR group, such as the need for follow-up CTA and additional grafts, can be considered a disadvantage of endovascular treatments due to the associated costs. Some authorities argue that TEVAR does not alter the natural history of the disease, suggesting that it is not superior to open surgery. It is also important to note that longer follow-up periods are needed to clear these concerns [16]. Our 1-year reintervention rate of 26.0% is higher than the 15-17% reported for isolated thoracic aneurysms but consistent with series including complex pathologies. Parsa et al. reported 23% reintervention rates in dissection cases, while Böckler et al. found 32% rates in complicated acute and chronic dissections [17,18]. Given that 19.2% of our cohort had dissection pathology, our overall reintervention rate appears reasonable.

Three independent predictors of 1-year reintervention emerged from multivariate analysis in our cohort: diabetes mellitus, smoking history, and distal zone lesions. Among these, it is particularly intriguing-and somewhat paradoxical-that diabetes mellitus was identified as the strongest predictor (OR 3.2, $p=0.01$). Recent meta-analyses have been interpreted to mean that diabetes might have a protective effect against the initial formation of aortic dissections and aneurysms [19-21]. The present study results suggest that this very same condition significantly increases risks for complications after endovascular repair. Several specific pathophysiological mechanisms could be invoked to explain such an association. Chronic hyperglycemia results in systemic endothelial dysfunction together with increased burdens of calcification within the aortic wall. These changes could impair both optimal radial force and long-term integration of an endograft into host vascular tissue, hence creating conditions for possible instability. Also, small vessel disease together with chronic inflammation in diabetic patients would compromise the normal remodeling process of the aorta after TEVAR. These microvascular changes could make these patients more vulnerable to incomplete sealing or graft-related failures that would require early secondary interventions due to endoleaks or disease progression.

In the same way, smoking history came out as a big predictor (OR 2.1, $p=0.05$), which matches its known bad effects on vascular healing, endothelial function, and long-term graft patency. Also, the link between distal zone lesions and reintervention (OR 2.4, $p=0.03$) probably shows the technical trouble of getting a good seal in the more tortuous and smaller-caliber distal thoracic aorta that often has type II endoleaks more often. Even if these results give important information, the complicated relationship between diabetes and endovascular outcomes needs more proof in larger studies from multiple centers with longer follow-up periods.

Isaac et al. reported a 30 day mortality rate of 4.2% in a cohort of 2.141 patients who underwent endovascular repair for thoracic aortic aneurysm in 2022. Beyond this series of predominantly stable aneurysms, Philip et al. documented a perioperative mortality of 6.1% for intact aneurysms, in contrast to a markedly higher rate of 28% in ruptured cases [22,23]. The 30-day mortality rate in our cohort (17.1%) is higher than reported in some elective-only series. However, this figure reflects our institution's status as a tertiary referral center. We frequently manage complex cases and unstable transfers from other facilities, often involving high-risk patients who are not suitable for conservative management or standard open surgery. Our sub-analysis reveals a stark contrast in outcomes based on the urgency of the procedure. The 30-day mortality rate was significantly higher in urgent cases (32.0%) compared to elective procedures (13.2%). This emphasizes that the clinical presentation at admission is a primary driver of early mortality, rather than the TEVAR procedure itself.

The timing of TEVAR in acute and hyperacute type B aortic dissection is still debated. In our experience, urgent intervention was mainly due to clinical instability and not temporal classification alone. The higher mortality and numerically increased reintervention rates seen in urgent cases probably reflect hostile anatomy, limited preoperative planning time, suboptimal landing zones inherent to acute presentations rather than the timing of the procedure.

Our stroke rate of 13.7% was higher than the 3–7% typically reported after TEVAR [24]. This likely reflects our institutional practice of LSA coverage in 36.3% of cases with prophylactic revascularization performed in only 26.0%. Upper-extremity ischemia occurred in 6.8% of patients, exclusively after LSA coverage without revascularization, which is consistent with published series and reinforces guideline recommendations to revascularize patients with dominant left vertebral arteries, patent left internal mammary grafts, or inadequate collateral circulation. In subgroup analyses, urgent procedures exhibited substantially higher early mortality than elective cases (32.0% vs 13.2%), in line with registry experience in acute aortic syndromes [25,26]. Our SCI rate of 7.5% is also comparable to contemporary reports from national datasets evaluating TEVAR-associated SCI [13]. Together, these findings situate our outcomes within real-world expectations while highlighting opportunities to mitigate neurologic events through selective LSA revascularization and standardized perioperative protocols. These findings validate our institutional outcomes within the contemporary TEVAR literature while underscoring the need for larger multicenter studies to establish evidence-based protocols for neurologic complication prevention.

Limitations

There are some limitations to this study which must be kept in mind while interpreting the results. The first limitation comes from the fact that it was designed as a retrospective single-center study and also because it used hospital-based follow-up records, thus creating an opportunity for selection and information bias. Another limitation is the relatively small size of the study population (n=146) described by a heterogeneous group of pathologies that included aneurysms, dissections, and traumatic injuries—though this does mirror real-world practice such heterogeneity can confound outcomes; moreover, limited sample size does not permit any extensive subgroup analyses regarding each specific pathology.

The fourth limitation is that very few SCI events were recorded (n=11); hence our multivariate models had low statistical power with wide confidence intervals for some variables such as distal zone lesions. These should therefore be considered exploratory findings. The last limitation concerns the outcomes captured in this study, which are valid only for mid-term follow-up (average one year). Therefore late survival rates and long-term durability of TEVAR in this cohort cannot be established yet. However, despite these limitations, it can still provide an interesting perspective on early clinical challenges related to TEVAR at a high-volume tertiary referral center.

CONCLUSION

In conclusion, even though TEVAR has become the most common method for treating diseases of the descending thoracic aorta, our experience in one center shows that big clinical challenges still exist. Early results in this group were mainly influenced by how urgent the procedure was and what existing health problems patients had. Importantly, diabetes, a past smoking habit, and lesions found in further parts of the thorax turned out to be very important predictors that greatly raise the chance of needing another operation soon after. Also, the much higher 30-day death and illness rates seen in urgent cases highlight the risks involved in emergency aortic repairs. Because this study was retrospective and had a rather small sample size, these results need to be approached with caution. More extensive studies are needed for validation of such risk factors as well as for perioperative neuroprotection strategy optimization; preferably such studies should be prospective and multicentric in nature. Until then, attention shall be focused on careful patient selection, close postoperative monitoring, and institutional benchmarking to strike an optimal balance between procedural safety and long-term durability.

Acknowledgments: The authors would like to express their sincere gratitude to the Ankara University Department of Cardiovascular Surgery family, including all resident physicians for their dedication, patience, and hard work, as well as the operating room staff, perfusionists, anesthesia team, intensive care unit personnel, ward staff, and all other colleagues who contributed, directly or indirectly, to patient care and this study. We also extend our special thanks to Ferhat Özsar for his moral support and presence throughout the clinical process and the preparation of this manuscript.

Ethics Committee Approval: It was received from the Ankara University the Institutional Review Board (Protocol number: 2024/720, Date: 14 March 2025).

Patient Consent for Publication: Not necessary for this manuscript.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: All authors contributed equally to the article.

Conflict of Interest: 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. Chen SW, Lee KB, Napolitano MA, Murillo-Berlioz A, Sattah A, Sarin S, et al. Complications and management of thoracic endovascular aortic repair. Aorta (Stamford). 2020;8:49-58.
2. Badran A, Elghazouli Y, Shirke MM, Al-Tawil M, Harky A, Ohri SK. Elective thoracic aortic aneurysm surgery: A tertiary center experience. Cureus. 2023;15:e39102.
3. Sattah AP, Secrist MH, Sarin S. Complications and perioperative management of patients undergoing thoracic endovascular aortic repair. J Intensive Care Med. 2018;33:394-406.
4. Grabenwöger M, Alfonso F, Bachet J, Bonser R, Czerny M, Eggebrecht H, et al. Thoracic endovascular aortic repair (TEVAR) for the treatment of aortic diseases: A position statement from the European Association for Cardio-Thoracic Surgery (EACTS) and the European Society of Cardiology (ESC), in collaboration with the European Association of Percutaneous Cardiovascular Interventions (EAPCI). Eur Heart J. 2012;33:1558-63.
5. Sugiura J, Oshima H, Yamauchi K, Inoue Y, Soma M, Fukuda Y, et al. The efficacy and risk of cerebrospinal fluid drainage for thoracoabdominal aortic aneurysm repair: A retrospective observational comparison between drainage and non-drainage. Interact Cardiovasc Thorac Surg. 2017;24:609-14.
6. Feezor RJ, Martin T, Beaver T, Sumpio B, Hartley G, Tzeng E, et al. Extent of aortic coverage and incidence of spinal cord ischemia after thoracic endovascular aneurysm repair. Ann Thorac Surg. 2008;86:1535-40.
7. Riambau V, Capoccia L, Böckler D, Brunkwall J, Czerny M, Tsilimparis N, et al. Spinal cord protection and related complications in endovascular management of type B dissection: LSA revascularization and CSF drainage. Ann Cardiothorac Surg. 2014;3:336-8.
8. Geisbüsch P, Hoffmann S, Akhyari P, Klöpfer A, Bollow A, Bruch C, et al. Reinterventions during midterm follow-up after endovascular treatment of thoracic aortic disease. J Vasc Surg. 2011;53:1528-35.
9. Cheng L, Xiang D, Zhang S, Zheng C, Wu X. Reintervention after thoracic endovascular aortic repair of uncomplicated type B aortic dissection. J Clin Med. 2023;12:1418.
10. Faure EM, Canaud L, Agostini C, Alric P, Gandet T, Benedetto U, et al. Reintervention after thoracic endovascular aortic repair of complicated aortic dissection. J Vasc Surg. 2014;59:327-33.
11. Scali ST, Greenberg RK, Reardon MJ, Bavaria JE, Mohamed Y, Makaroun MS, et al. National incidence, mortality outcomes, and predictors of spinal cord ischemia after thoracic endovascular aortic repair. J Vasc Surg. 2020;72:152-60.
12. Bavaria JE, Appoo JJ, Makaroun MS, Cambria RP, Marks MR, Lee WA, et al. Endovascular stent grafting versus open surgical repair of descending thoracic aortic aneurysms in low-risk patients: A multicenter comparative trial. J Thorac Cardiovasc Surg. 2007;133:369-77.
13. Farber MA, Lee WA, Starnes BW, Shennib H, Murray CK, Cambria RP, et al. Five-year outcomes with conformable GORE TAG endoprosthesis used in traumatic aortic transections. Ann Thorac Surg. 2022;113:1536-42.
14. Coselli JS, LeMaire SA, Conklin LD, Sakai T, Jones DR, Elefteriades JA, et al. Cerebrospinal fluid drainage reduces paraplegia after thoracoabdominal aortic aneurysm repair: Results of a randomized clinical trial. J Vasc Surg. 2002;35:631-9.
15. Riambau V, Böckler D, Brunkwall J, Cao B, Chiesa R, Coppi G, et al. Editor's Choice - Management of descending thoracic aorta diseases: Clinical practice guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg. 2017;53:452.
16. Son SA, Jung H, Lee KY, Choi SS, Kim JB, Park HS, et al. Long-term outcomes of intervention between open repair and endovascular aortic repair for descending aortic pathologies: A propensity-matched analysis. BMC Surg. 2020;20:266.
17. Parsa CJ, Schroder JN, Daneshmand MA, DiMusto PD, Olson MM, Greason KL, et al. Midterm results for endovascular repair of complicated acute and chronic type B aortic dissection. Ann Thorac Surg. 2010;89:97-102.
18. Böckler D, Schumacher H, Ganten M, Tengg-Kobligk H, Schwarzbach M, Fink C, et al. Complications after endovascular repair of acute symptomatic and chronic expanding Stanford type B aortic dissections. J Thorac Cardiovasc Surg. 2006;132:361-8.
19. Zhang L, Zhao Z, Zhang F, Zhou Y, Zhang H, Wang J, et al. Reintervention after endovascular repair for aortic dissection: A systematic review and meta-analysis. J Thorac Cardiovasc Surg. 2016;152:1279-88.e3.
20. Takagi H, Umemoto T, Iwata H, Miyata T, Watanabe Y, Fujita H, et al. Negative association of diabetes with thoracic aortic dissection and aneurysm. Angiology. 2016;67:229-36.
21. Theivacumar NS, Stephenson MA, Mistry H, Valenti D. Diabetics are less likely to develop thoracic aortic dissection: A 10-year single-center analysis. Ann Vasc Surg. 2014;28:427-32.
22. Goodney PP, Eldrup-Jørgensen J, Rigdon EE, Kent KM, Schanzer A, Cronenwett JL, et al. Survival after open versus endovascular thoracic aortic aneurysm repair in an observational study of the Medicare population. Circulation. 2011;124:2761-9.
23. Naazie IN, Patel V, et al. Risk calculator predicts 30-day mortality after thoracic endovascular aortic repair for intact descending thoracic aortic aneurysms in the Vascular Quality Initiative. J Vasc Surg. 2022;75:833-41.e1.
24. Rizvi AZ, Murad MH, Fairman RM, Erwin PJ, Montori VM. The effect of left subclavian artery coverage on morbidity and mortality in patients undergoing endovascular thoracic aortic interventions: A systematic review and meta-analysis. J Vasc Surg. 2009;50:1159-69.
25. Matsumura JS, Lee WA, Mitchell RS, Farber MA, Murad MH, Lumsden AB, et al. The Society for Vascular Surgery practice guidelines: Management of the left subclavian artery with thoracic endovascular aortic repair. J Vasc Surg. 2009;50:1155-8.
26. Evangelista A, Isselbacher EM, Bossone E, Rivello E, Myers PO, Chen J, et al. Insights from the International Registry of Acute Aortic Dissection: A 20-year experience of collaborative clinical research. Circulation. 2018;137:1846-60.