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Original Article

Does the type of aortic pathology affect periprocedural outcomes in patients undergoing thoracic endovascular aortic repair?

Serdar Bademl, Mustafa Selcuk Atasoy

Bursa City Hospital, Department of Cardiovascular Surgery, Bursa, Türkiye

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Abstract

Aim: To examine whether the type of aortic pathology affects periprocedural outcomes in patients undergoing thoracic endovascular aortic repair (TEVAR).

Material and Methods: This retrospective observational cohort study included 47 TEVAR patients in total. Based on the kind of aortic pathology, the patients were categorized into three groups: Group 1 (n=23) included patients with type B aortic dissection (TBAD), Group 2 (n=14) included patients with descending thoracic aortic aneurysm (DTAA), and Group 3 (n=10) included patients with thoracic aortic mural thrombus (TAMT). Preprocedural basic clinical features, procedural data, and postprocedural outcomes and complications were compared between the groups.

Results: The study population consisted of 36 males and 11 females, with a mean age of 62.48±14.2 years. Most of the patients in Groups 1 and 2 were male (82.6% and 92.8%), while 40% of the patients in Group 3 were male, and this difference was statistically significant. Compared to patients in other groups, individuals in Group 2 were significantly older and exhibited a higher incidence of chronic obstructive pulmonary disease and coronary artery disease. Group 3 required thromboembolectomy more frequently during the postprocedural period. In terms of other postprocedural outcomes, complications and mortality, there were no significant differences between the groups.

Conclusion: Our study demonstrated that the type of aortic pathology did not significantly influence periprocedural outcomes in patients undergoing thoracic endovascular aortic repair (TEVAR). The TEVAR procedure can be effectively performed in suitable patients with various pathologies of the descending thoracic aorta.

Keywords: Aortic aneurysm, aortic dissection, aortic mural thrombus, clinical outcomes, thoracic endovascular aortic repair

INTRODUCTION

Although significant advancements have been provided in the interventional treatment of thoracic aortic diseases in recent years, peri-interventional mortality and morbidity rates still remain high [1,2]. Nowadays, endovascular treatment options have gained increased popularity, and thoracic endovascular aortic repair (TEVAR) has become a commonly preferred treatment method in descending aortic pathologies. However, the results of TEVAR are still controversial. Many studies have highlighted advanced age, urgency, rupture status, and additional diseases of the patients as risk factors for poor outcomes after TEVAR [3,4].

There are few studies in the literature on whether the type of underlying aortic pathology affects periprocedural outcomes in patients undergoing TEVAR, and the results of these studies are conflicting [4-6]. In this study, the preprocedural clinical characteristics and postprocedural early and mid-term results of the patients undergoing TEVAR procedure were analyzed according to the type of aortic pathologies, and whether type of aortic pathology affected the periprocedural outcomes was investigated in this patient group.

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Corresponding Author: Serdar Badem, Bursa City Hospital, Department of Cardiovascular Surgery, Bursa, Türkiye
Email: serdarbadem1976@gmail.com

MATERIAL AND METHODS

Study Population And Design

This observational cohort study retrospectively examined patients who underwent TEVAR surgery at a tertiary referral hospital in Türkiye between August 2019 and July 2024. Our study cohort consisted of 47 individuals who had undergone TEVAR surgery as a result of descending thoracic aortic disease. The patients were classified into three group based on the nature of the disease descending the aorta. Patients with type B aortic dissection (TBAD) made up Group 1 (n=23), descending thoracic aortic aneurysm (DTAA) patients made up Group 2 (n=14), and thoracic aortic mural thrombus (TAMT) patients made up Group 3 (n=10). Medical information of the patients were obtained from hospital records. Preprocedural basic demographic and clinical characteristics of the patients, comorbidities, procedural data, postprocedural complications, early and mid-term results were analyzed and then compared between the groups. Patients who had heart surgery, such as valve replacement or repair, coronary artery bypass, type A aortic dissection, aortic rupture, and open aortic surgery cases, as well as patients whose data could not be acquired, were excluded from the study. The local ethics committee authorized the study protocol, and the research was carried out in compliance with the principles of Declaration of Helsinki (date/no: 04.09.2024/2024-14/1).

The defined "TBAD" was used in this study to describe a dissection including an intimal rip in the descending segment of the aorta, which may extend into the abdomen and begins distal to the left subclavian artery (LSA). Patients with symptomatic organ malperfusion as well as patients without symptoms with a dissected aorta diameter of at least 50 mm underwent the TEVAR procedure. DTAA was defined as dilatation of the descending thoracic aorta greater than 55 mm, rapid increase (more than 10 mm per year), and/or symptomatic patients. TAMT was defined as mobile or immobile thrombus findings on CT imaging that occur without atherosclerotic occlusive disease or aneurysm and usually develop secondary to hypercoagulopathy.

Preprocedural Evaluation

Before surgery, all patients underwent imaging using 1-mm slice-thick computed tomography angiography (CTA) to evaluate the thoracic, abdominal, and visceral branches of the aorta. RadiAnt DiCOM viewer v2021.2 (64-bit) was the three-dimensional vascular imaging tool used for procedure planning and device sizing. The manuals were all derived from the three-dimensional reconstructions of CTA scans. In all patient groups, the maximum diameter of the aorta, the relationship between the descending aorta and the aortic arch, the condition of the dominant left vertebral artery, the status of the visceral and iliac arteries, the diameters of the proximal landing zone (PLZ) and distal landing zone (DLZ), the location and size of the primary entry tear in the TBAD group, the status of the false lumen, the extent of dissection, and the location and length of the thrombus in the TAMT group were evaluated. Consequently, the aortic sealing zone, endograft diameter increase, and endograft length were computed, and the placement area of the endograft at the proximal and distal ends in the intact vascular segment was measured. It was planned for the endograft diameter increase (oversize) to be roughly 20% greater in DTAA patients than the target aortic diameter, and 15-20% greater in TBAD and TAMT patients than the target aortic diameter. In order to choose the PLZ region, a sufficient intact aortic tissue distance (>2 cm) has to be established. Some patients needed LSA occlusion for this.

Procedural Technique and Postprocedural Approach

Once the required sterilizing conditions were supplied, a team comprising a cardiovascular surgeon and an anesthesiologist carried out all procedures in the angiography laboratory. The choice of anesthesia technique in patients was made before the TEVAR procedure and by considering the experience of the team as well as the characteristics of the patient. Generally, a general anesthesia method was preferred to keep high blood pressure under control during the opening of the endograft in the aortic lumen and to prevent endograft migration that would occur due to this. Sedation and regional anesthesia were preferred for patients with poor general condition, severe organ malperfusion and hemodynamic instability to avoid complications of general anesthesia. The right or left common femoral artery was used for endovascular graft access. When obtaining a target activating clotting time (ACT) of >200 seconds by administration of 100 IU/kg unfractionated heparin, the retrograde endovascular graft was sent and opened in the appropriate position. Optimal placement of the endograft in DTAA patients and exclusion of aneurysm, closure of the access tear in TBAD patients and termination of the endoluminal relationship of the thrombus in TAMT patients were ensured. In all patients, Stent-graft Endurant™ II (Medtronic, Santa Rosa, CA, USA) covered with polyethylene terephthalate (PET) material was used as the endovascular graft. All patients underwent control aortography following the procedure to assess endoleaks and graft patency. At the end of the procedure, the femoral arteries were primarily repaired. In cases where patients had hemodynamic instability and clinical complaints in the early postprocedural period, they were checked with emergency CTA. In patients without any symptoms, clinical and imaging follow-up was performed with CTA at 1, 6, and 12 months after the procedure. The TEVAR procedure was performed using the same method in all groups. In all groups that underwent the TEVAR procedure, low molecular weight heparin and acetylsalicylic acid (ASA) were started during their hospital stay after the procedure, unless there was a contraindication. They were followed up with ASA after discharge.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (IBM® SPSS Statistics for Windows, Version 23.0, Armonk, NY, USA). The Oneway ANOVA test was employed to compare homogeneously distributed continuous variables, while the Welch ANOVA test was utilized for non-homogeneously distributed continuous variables. Post hoc tests were used in multiple comparisons between the groups for continuous variables that were found to be significant. Specifically, the Bonferroni test was used for homogeneously distributed significant continuous variables, and the Tamhane test was applied for non-homogeneously distributed significant continuous variables. Categorical variables were compared using the Chi-square or Fisher's exact tests. When it comes to continuous variables, homogeneous data were displayed as mean±standard deviation, whereas non-homogeneous variables were displayed as median (minimum-maximum). Numbers (percentages) were used to represent categorical variables. A statistically significant result was defined as a p value of less than 0.05.

RESULTS

The study population consisted of 36 males and 11 females, with a mean age of 62.48±14.2 years. The median age of patients in Group 2 was significantly higher than in Groups 1 and 3. While most of the patients in Groups 1 and 2 were male (82.6% and 92.8%), 40% of the patients in Group 3 were male, and this difference was statistically significant in terms of gender. Patients in Group 2 were found to have significantly more coronary artery disease (CAD) and chronic obstructive pulmonary disease (COPD) than patients in Groups 1 and 3. Patients in Group 2 had more smoking habits than those in Group 3. The difference in smoking among the other groups was not significant. In terms of other preprocedural baseline demographic, clinical characteristics and comorbid diseases, there were no significant differences between the groups (Table 1).

Table 1. Preprocedural baseline demographic and clinical characteristics

	Grup 1 TBAD n=23	Grup 2 DTAA n=14	Grup 3 TAMT n=10	P value
Age (years)	64 (19-87)	69 (55-91)	63 (48-75)	**0.03***
Gender (male)	19 (82.6%)	13 (92.8%)	4 (40%)	**0.01***
Height (cm)	171.04±8.7	170.43±8.7	165.80±4.5	0.22
Weight (kg)	83.5±10.7	85.8±10.8	83.3±13.3	0.80
BMI (kg/m²)	28.8±4.9	29.7±4.8	30.43±5.3	0.66
DM	2 (8.7%)	5 (35.7%)	4 (40%)	0.053
Hypertension	17 (73.9%)	11 (78.5)	6 (60%)	0.58
CAD	3 (13%)	9 (64.2%)	1 (10%)	**0.002***
CHF	1 (4.3%)	1 (7.1%)	0 (0%)	1.00
COPD	1 (4.3%)	5 (35.7%)	0 (0%)	**0.02***
CVE	2 (8.7%)	2 (14.2%)	2 (20%)	0.63
CRF	2 (8.7%)	4 (28.5%)	0 (0%)	0.13
Smoking	9 (39.1%)	10 (71.4%)	1 (10%)	**0.01***

BMI: body mass index, COPD: chronic obstructive pulmonary disease, CAD: coronary artery disease, CHF: congestive heart failure, CRF: chronic renal failure, CVE: cerebrovascular events, DTAA: descending thoracic aortic aneurysm, DM: diabetes mellitus, PAD: peripheral artery disease, TAMT: thoracic aortic mural thrombus, TBAD: type B aortic dissection; *Bold p values indicate statistical significance; → Continues variables were presented as mean±standard deviation or median (minimum-maximum) while categorical variables were presented as number (percentage)

The average widest aortic diameter of the patients in Group 2 was found to be significantly larger compared to Group 1 and Group 3. Zone 3 of the aorta was chosen as PLZ in most of the patients in Group 1 and in nearly half of the patients in Group 2 and Group 3. In terms of PLZ, a significant difference was detected in the patients in Group 1 compared to the other groups. General anesthesia was applied to most of the patients in Group 1 and Group 2 (86.7% and 85.7%) and to 40% of patients in Group 3, and this difference was statistically significant in terms of the type of anesthesia. Type I endoleak was observed in five (21.7%), three (21.4%) and one (10%) patients in Group 1, Group 2 and Group 3, respectively. There was no significant difference between the groups in terms of type I endoleak development. In terms of other procedural data, there were no significant differences between the groups (Table 2).

Table 2. Procedural data of the groups

	Grup 1 TBAD n=23	Grup 2 DTAA n=14	Grup 3 TAMT n=10	P value
PLZ diameter	30.8±4.7	33.1±5.6	28.1±3.1	**0.04***
Widest aortic diameter	50.2±12.7	73.3±18.7	43.4±9.3	**0.00***
Endograft length	112.9±28.7	104.1±59.8	94.6±33.5	0.49
DLZ diameter	31.1±4.3	32.6±3.8	27.8±3.7	**0.02***
Entry point (right FA)	19 (82.6%)	12 (85.7%)	9 (90%)	1.00
Additional procedure (balloon, extension stent, etc.)	5 (21.7%)	4 (28.5%)	1 (10%)	0.52
PLZ (zone 3)	21 (91.3%)	8 (51.7%)	5 (50%)	**0.01***
General anaesthesia	20 (86.7%)	12 (85.7%)	4 (40%)	**0.01***
Procedure time (min)	70.1±28.4	60.8±9.2	68.6±14.5	0.38
Conversion to open surgery	1 (4.3%)	0 (0%)	0 (0%)	1.00
LSA closure	1 (4.3%)	1 (7.1%)	1 (10%)	0.78

DLZ: distal landing zone, DTAA: descending thoracic aortic aneurysm, FA: femoral artery, LSA: left subclavian artery, PLZ: proximal landing zone, TAMT: thoracic aortic mural thrombus, TBAD: type B aortic dissection; *Bold p values indicate statistical significance; → Continues variables were presented as mean±standard deviation or median (minimum-maximum) while categorical variables were presented as number (percentage)

Two of the patients (20%) in Group 3 required thromboembolectomy in the early postprocedural period while thromboembolectomy was not required in patients in other groups. In terms of thromboembolectomy requirement, the difference in Group 3 was statistically significant. After the discharge during the overall follow-up period, wound infection in the groin occurred in four patients in Group 1 and in none of the patients in other groups. In terms of wound infection, this difference was not statistically significant. No graft migration and thrombosis and mortality was observed in any patient during the follow-up period. In terms of other postprocedural outcomes, complications and mortality, there were no significant differences between the groups (Table 3).

Table 3. Follow-up outcomes of the groups

	Grup 1 TBAD n=23	Grup 2 DTAA n=14	Grup 3 TAMT n=10	P value
Thromboembolectomy	0 (0%)	0 (0%)	2 (20%)	**0.04***
Development of ARF	3 (13%)	2 (14.2%)	1 (10%)	1.00
CVE	1 (4.3%)	0 (0%)	0 (0%)	1.00
Paraplegia	0 (0%)	0 (0%)	0 (0%)	1.00
Cerebrospinal fluid drainage	0 (0%)	0 (0%)	0 (0%)	1.00
Upper limb ischemia	0 (0%)	0 (0%)	0 (0%)	1.00
ICU time/day	1.9±1.4	2.0±2.3	1.3±0.4	0.55
Hospitalization time/day	6.1±3.6	6.2±7	3.6±2.4	0.31
Blood product use	4 (17.3%)	3 (21.4%)	1 (10%)	0.88
In-hospital mortality	1 (4.3%)	0 (0%)	0 (0%)	0.51
Wound infection	4 (17.3%)	0 (0%)	0 (0%)	0.17
Type I endoleak	5 (21.7%)	3 (21.4%)	1 (10%)	0.79
Graft migration	0 (0%)	0 (0%)	0 (0%)	1.00
Graft thrombosis	0 (0%)	0 (0%)	0 (0%)	1.00
Mortality	0 (0%)	0 (0%)	0 (0%)	1.00

ARF: acute renal failure, CVE: cerebrovascular events, DTAA: descending thoracic aortic aneurysm, ICU: intensive care unit, TAMT: thoracic aortic mural thrombus, TBAD: type B aortic dissection; *Bold p values indicate statistical significance; → Continues variables were presented as mean±standard deviation or median (minimum-maximum) while categorical variables were presented as number (percentage)

DISCUSSION

Cardiovascular surgeons have recently turned to endovascular methods in the treatment of thoracic aortic diseases due to the high mortality and morbidity rates of conventional surgical treatments. TEVAR, which is a less invasive procedure, remains to be the preferred method due to the high frequency of early-term complications after surgical repair for descending thoracic aortic aneurysms. The procedure revealed that individuals with DTAA tend to be older and are more likely to have cardiovascular disease and chronic lung disease compared to those with TBAD. The study also showed that the in-hospital mortality and all postoperative complication rates were higher in TBAD compared to DTAA [4]. In our study, it was observed that the demographic data of TBAD and DTAA patients who underwent the TEVAR procedure were similar to those in the aforementioned study. However, there were no significant differences in postprocedural complications and mortality rates.

While the majority of patients in Group 1 and Group 2 were male, more than half of the patients in Group 3 were female, and the difference was statistically significant. Although we found a statistically significant difference, we do not think that there is any causal relationship between TAMT and female gender. This statistical difference may be related to the relatively small number of patients.

In the literature, early and mid-term reintervention due to endoleak or graft migration was shown in 14-16% of DTAA patients treated with TEVAR procedure [7,8]. In our study, three (21.4%) of DTAA patients developed endoleaks and the endoleaks were closed with secondary procedures. Graft migration was not seen in any patient. In one (7.1%) patient in the DTAA group, the LSA was closed because the aneurysm sac was very close to the LSA, and since the patient did not develop any neurological or ischemic complications during the follow-up, there was no need for revascularization.

Patients with acute TBAD can usually be followed with medical treatment if there are no complications. On the other hand, problems like rupture or malperfusion call for urgent attention. The in-hospital mortality rate after conventional surgical intervention is quite high in TBAD patients [9]. Therefore, the TEVAR procedure, which is significantly less invasive than open repair, has recently become more popular for the management of TBAD. Harky et al. [10] strongly recommended the TEVAR procedure in complicated TBAD cases in their meta-analysis study consisting of 18193 patients and nine studies. It is mandatory to find and close the aortic intimal inlet tear with endovascular procedures for TBAD repair. Closure of intimal inlet tear provides relief of aortic false lumen flow, stops aneurysmal dilatation and prevents aortic rupture. In our study, conventional surgery was not used in TBAD patients and endoleaks were closed early with secondary procedures in 5 (21.7%) patients due to the development of endoleaks. Endograft migration was not observed in any patient. Since the aortic intimal tear started from the region close to the aortic arch and/or LSA, LSA was closed in 1 (4.3%) patient to place the proximal attachment site of the endograft on the healthy aortic wall. Since no neurological or ischemic complications developed in the patient whose LSA was closed, revascularization was not needed.

TAMT is a rare and difficult-to-diagnose condition that occurs without atherosclerotic occlusive disease or aneurysm and is usually due to hypercoagulopathy. It is an important non-cardiogenic embolism source that frequently causes complications such as acute extremity ischemia and has a high mortality rate. Anticoagulant, open surgical thrombectomy, endovascular repair, and a combination of these techniques can be used as treatment options. In recent years, surgical intervention has been left in the background in TAMT treatment due to its high mortality and morbidity. Mayermann et al. [11] showed in their study on 66 patients that endovascular treatment is a useful first-line option in patients with TAMT. TEVAR has been preferred because it is a less invasive interventional treatment option, especially in patients with TAMT located distal to the subclavian artery. In our study, we diagnosed TAMT in ten patients and all of them underwent TEVAR procedure. Only two (20%) patients had lower extremity embolism after the TEVAR procedure and underwent early thromboembolectomy.

Although the TEVAR procedure is a new procedure compared to conventional surgery, serious complications may occur. Some of these complications include endoleak development, endograft migration, conversion to open surgery, endograft infections, cerebral and peripheral embolic events. The most common of these complications is endoleak development and continues to be the primary reason for subsequent interventions. Endoleak is the continuous flow of blood between the aortic wall and the stent graft for any reason [12]. Scali et al. [13] showed that endoleak development is the most common secondary intervention reason in the early and late periods after the TEVAR procedure in their study on 585 patients. It has been reported in the literature that the incidence of endoleak after the TEVAR procedure varies between 5% and 36% [14,15]. A total of nine (19.1%) patients in all groups developed periprocedural endoleak. In the early and mid-term, endoleaks developed in three (21.4%) patients in the DTAA group, five (21.7%) patients in the TBAD group, and one (10%) patient in the TAMT group. There was no statistical significance for endoleak development among all three groups. In all groups, in patients who developed endoleaks, balloon dilatation was performed within the endograft to support sealing and in selected patients with appropriate anatomy, an extension stent was placed to prevent endoleak formation. Six of the patients who developed intraprocedural endoleaks underwent aortic balloon dilatation and three underwent aortic balloon dilatation and extension stent graft placement. No endoleak was detected

in control imaging. Although the incidence of periprocedural endoleak was relatively low in our study, it is important to closely follow these patients clinically and radiologically, as endoleak development continues to be a lifelong risk factor in patients undergoing TEVAR procedure.

It has been reported in the literature that LSA closure is generally required in 40% of patients undergoing TEVAR procedure to create an adequate landing zone and to ensure stent-graft sealing [16]. Revascularization of LSA can be performed in appropriate patients to prevent the risk of postoperative spinal cord ischemia and stroke by increasing blood flow through the left vertebral artery. There are also studies showing that it is performed to prevent left upper extremity ischemia or vertebrobasilar insufficiency [16,17]. Therefore, detailed evaluation of cerebrovascular anatomy with CTA is important. Although the Society for Vascular Surgery guideline has recommended routine LSA revascularization in TEVAR procedures requiring LSA closure [18], meta-analysis studies have shown that it does not reduce the incidence of stroke after TEVAR procedure [19,20]. In our study, the endograft was placed under the LSA in the majority of patients in all groups, and only three (6.3%) patients underwent LSA closure (one (7.1%) patient in the DTAA group, one (4.3%) patient in the TBAD group, and one (10%) patient in the TAMT group).

Paraplegia and paraparesis due to spinal cord ischemia (SCI) are also important complications during the periprocedural period of endovascular interventions performed for descending aortic pathologies. Zhang et al. [21] in a meta-analysis of 34 studies covering 3561 patients (2671 DTAA and 890 TBAD), the SCI rate was between 1.80% and 5.73%, and routine prophylactic cerebrospinal fluid (CSF) drainage was not recommended to prevent spinal cord ischemia during TEVAR. In another meta-analysis including 43 studies and 7168 patients, permanent SCI developed at a rate of 2.2% after TEVAR procedure performed due to DTAA, and they recommended CSF drainage, protection from hypotension, and mild hypothermia [22]. We did not routinely use CSF drainage in our study groups. No neurological complications due to postprocedural SCI developed in our patients in all groups. However, CSF drainage application was always kept in mind by our surgical and anesthesia team and we were aware that we were ready to perform CSF drainage at an early stage in case of neurological complications. We also protected our patients from hypotension to prevent SCI. Based on the results of our study, we recommend that routine CSF drainage should not be performed to prevent SCI, but it should be kept in mind for high-risk patients, and that hypotension should be avoided and mild hypothermia should be applied.

We attribute our low complication rates in all groups to the fact that early complications related to the endograft after the TEVAR procedure (endoles, endograft migration or collapse, endograft kinking and/or stenosis) are managed in the angiography unit, and the patients are removed without any problems and followed closely in the postoperative ICU.

Study Limitations

Our study had several limitations. The primary limitations were its single-center design, the retrospective nature of data collection, the relatively small sample size, the limited scope of data analysis, and the absence of mid- and long-term clinical outcomes.

CONCLUSION

In conclusion, the TEVAR procedure can be effectively performed in appropriate patients with various pathologies of the descending thoracic aorta. We demonstrated that the type of aortic pathology did not affect the periprocedural outcomes in the patients undergoing TEVAR procedure. However, further prospective studies with larger patient groups are needed to confirm our findings and provide more robust scientific evidence.

Ethics Committee Approval: The Bursa City Hospital Scientific Research Ethics Committee authorized the study protocol, and the research was carried out in compliance with the principles of Declaration of Helsinki (date/no: 04.09.2024/2024-14/1).

Patient Consent for Publication: Since this study was a retrospective study based on hospital records, informed consent was not required from patients before participating in the study.

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

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REFERENCES

1. Verzini F, Gibello L, Varetto G, Frola E, Boero M, Porro L, et al. Proportional meta-analysis of open surgery or fenestrated endograft repair for post dissection thoracoabdominal aneurysms. J Vasc Surg. 2021;74:1377-85.e9.

2. Liu D, Luo H, Lin S, Zhao L, Qiao C. Comparison of the efficacy and safety of thoracic endovascular aortic repair with open surgical repair and optimal medical therapy for acute type B aortic dissection: A systematic review and meta-analysis. Int J Surg. 2020;83:53-61.

3. Iyengar A, Goel NJ, Kelly JJ, Han J, Brown CR, Khurshan F, et al. Predictors of 30-day readmission and resource utilization after thoracic endovascular aortic repair. Eur J Cardiothorac Surg. 2020;58:574-82.

4. Hasan IS, Brown JA, Serna-Gallegos D, Aranda-Michel E, Yousef S, Wang Y, et al. Association of thoracic aortic aneurysm versus aortic dissection on outcomes after thoracic endovascular aortic repair. J Am Heart Assoc. 2023;12:e027641.

5. Ertugay S, Posacıoğlu H, Parıldar M, Eygi B, Bozkaya H. Thoracic endovascular aortic repair for acute pathologies of descending thoracic aorta. Türk Göğüs Kalp Damar Cerrahisi Dergisi. 2013;21:37-41.

6. Bortone AS, De Cillis E, D'Agostino D, de Luca Tupputi Schinosa L. Endovascular treatment of thoracic aortic disease: four years of experience. Circulation. 2004;110:II262-7.

7. Patterson B, Holt P, Nienaber C, Cambria R, Fairman R, Thompson M. Aortic pathology determines midterm outcome after endovascular repair of the thoracic aorta: report from the Medtronic Thoracic Endovascular Registry (MOTHER) database. Circulation. 2013;127:24-32.

8. Foley PJ, Criado FJ, Farber MA, Kwolek CJ, Mehta M, White RA, et al. VALOR Investigators. Results with the Talent thoracic stent graft in the VALOR trial. J Vasc Surg. 2012;56:1214-21.e1.

9. Meccanici F, Gökalp AL, Thijssen CGE, Mokhles MM, Bekkers JA, van Kimmenade R, et al. Male-female differences in acute thoracic aortic dissection: a systematic review and meta-analysis. Interact Cardiovasc Thorac Surg. 2022;34:616-27. Erratum in: Interact Cardiovasc Thorac Surg. 2022;34:941.

10. Harky A, Chan JSK, Wong CHM, Francis N, Grafton-Clarke C, Bashir M. Systematic review and meta-analysis of acute type B thoracic aortic dissection, open, or endovascular repair. J Vasc Surg. 2019;69:1599-609.e2.

11. Meyermann K, Trani J, Caputo FJ, Lombardi JV. Descending thoracic aortic mural thrombus presentation and treatment strategies. J Vasc Surg. 2017;66:931-6.

12. Daye D, Walker TG. Complications of endovascular aneurysm repair of the thoracic and abdominal aorta: evaluation and management. Cardiovasc Diagn Ther. 2018;8:S138-56.

13. Scali ST, Beck AW, Butler K, Feezor RJ, Martin TD, Hess PJ, et al. Pathology-specific secondary aortic interventions after thoracic endovascular aortic repair. J Vasc Surg. 2014;59:599-607.

14. Shah AA, Barfield ME, Andersen ND, Williams JB, Shah JA, Hanna JM, et al. Results of thoracic endovascular aortic repair 6 years after United States Food and Drug Administration approval. Ann Thorac Surg. 2012;94:1394-9.

15. Orelaru F, Monaghan K, Ahmad RA, Amin K, Titsworth M, Yang J, et al. Midterm outcomes of open repair versus endovascular descending thoracic aortic aneurysm repair. JTCVS Open. 2023;16:25-35.

16. Feezor RJ, Martin TD, Hess PJ, Klodell CT, Beaver TM, Huber TS, et al. Risk factors for perioperative stroke during thoracic endovascular aortic repairs (TEVAR). J Endovasc Ther. 2007;14:568-73.

17. Murphy EH, Stanley GA, Ilves M, Knowles M, Dimaio JM, Jessen ME, et al. Thoracic endovascular repair (TEVAR) in the management of aortic arch pathology. Ann Vasc Surg. 2012;26:55-66.

18. 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.

19. Hajibandeh S, Hajibandeh S, Antoniou SA, Torella F, Antoniou GA. Meta-analysis of left subclavian artery coverage with and without revascularization in thoracic endovascular aortic repair. J Endovasc Ther. 2016;23:634-41.

20. von Allmen RS, Gahl B, Powell JT. Editor's choice. Incidence of stroke following thoracic endovascular aortic repair for descending aortic aneurysm: a systematic review of the literature with meta-analysis. Eur J Vasc Endovasc Surg. 2017;53:176-84.

21. Zhang Z, Zhou Y, Lin S, Xiao J, Ai W, Zhang WW. Systematic review and meta-analysis of association of prophylactic cerebrospinal fluid drainage in preventing spinal cord ischemia after thoracic endovascular aortic repair. J Vasc Surg. 2022;75:1478-89.e5.

22. Dijkstra ML, Vainas T, Zeebregts CJ, Hooft L, van der Laan MJ. Editor's Choice - spinal cord ischaemia in endovascular thoracic and thoracoabdominal aortic repair: review of preventive strategies. Eur J Vasc Endovasc Surg. 2018;55:829-41.