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Original Article

Clinical outcomes of endovascular repair in ruptured aortic pathologies: A single center experience with TEVAR and EVAR procedures

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Abstract

Aim: Aortic ruptures are critical vascular emergencies with high mortality rates, typically involving the thoracic and abdominal regions. This study aims to evaluate the clinical outcomes of Thoracic Endovascular Aortic Repair (TEVAR) and Endovascular Aneurysm Repair (EVAR) procedures in patients with ruptured thoracic and abdominal aortic pathologies, focusing on mortality, morbidity, and complications.

Material and Methods: This retrospective, single-center study included 32 patients treated with endovascular interventions for ruptured aortic pathologies between 2019 and 2024. Fourteen patients with thoracic aortic rupture received TEVAR, while eighteen with abdominal aortic rupture underwent EVAR. The causes of rupture were classified as aortic transection (due to trauma), type-3 dissection, aneurysm, pseudoaneurysm, aorto-enteric fistula, and iatrogenic perforation. Demographic and clinical data, procedural details, and post-operative outcomes were collected and analyzed.

Results: The primary causes of rupture included aortic transection (50%) in the TEVAR group and aneurysm (56.2%) in the EVAR group. Mortality rates were 14.3% in the TEVAR group and 27.8% in the EVAR group, while morbidity rates were 7.1% and 16.7%, respectively. Intensive care unit (ICU) and ward stays were significantly longer in the TEVAR group. Follow-up imaging showed normal results in 100% of TEVAR patients and in 88.9% of EVAR patients; endoleak was observed in 11.1% of the EVAR group ($p<0.05$). In the logistic regression analysis, the presence of complications was identified as a significant risk factor for mortality (OR=3.06, 95% CI: 1.04–8.97; p=0.04).

Conclusion: TEVAR and EVAR are effective endovascular treatment modalities that provide high efficacy and safety in managing ruptured aortic pathologies, especially in emergency settings. The capability to perform hybrid procedures promptly in urgent cases underscores the adaptability and rapid applicability of endovascular therapies. Despite the inherent challenges of ruptured aortic pathologies, our study emphasizes the clinical importance of TEVAR in thoracic and EVAR in abdominal aortic ruptures, offering valuable insights that enhance the current literature.

Keywords: Ruptured aorta, endovascular repair, thoracic endovascular aortic repair, endovascular aneurysm repair, aortic aneurysm

INTRODUCTION

Aortic ruptures are serious, life-threatening vascular emergencies that can involve both the thoracic and abdominal regions. These pathologies generally result from aortic dissection, aneurysmatic dilatation, or traumatic rupture due to external forces [1,2]. Conditions such as these, which develop from structural weakening or sudden traumatic injury to the aortic wall, are characterized by severe internal bleeding, rapidly developing hemodynamic instability, and a substantial risk of mortality if left untreated [3]. Literature highlights that untreated ruptured abdominal aortic aneurysms carry an exceptionally high mortality risk, with survival outcomes remaining challenging

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even when intervention is provided, especially if not delivered promptly [4,5]. The critical nature of these cases underscores the importance of rapid and accurate diagnosis, as well as the timely implementation of effective intervention strategies. Swift detection and decisive, well-coordinated response efforts are essential components in improving patient survival rates in cases of aortic rupture, where every moment can significantly influence the outcome [6,7].

In the past, these cases were usually treated with open surgical interventions, whereas treatment approaches have changed significantly in recent years with the development of endovascular repair techniques [8,9]. Thoracic Endovascular Aortic Repair (TEVAR) for thoracic aortic pathologies and Endovascular Aneurysm Repair (EVAR) for abdominal aortic aneurysms have proven their efficacy in the management of ruptured aortic pathologies. TEVAR and EVAR are less invasive than conventional open surgery and offer the advantage of reducing perioperative mortality and morbidity rates, especially in patients with severe comorbidities or hemodynamic instability. Improvements in these techniques, along with the development of stent graft technology and increased operator experience, have increased the success rates of endovascular treatment options and made these treatment approaches applicable to a wider range of patients [10-12].

In emergency interventions, endovascular procedures significantly shorten the preparation time required for the operation compared to open surgery [13,14]. Considering that mortality in ruptured aortic pathologies increases rapidly with each hour, a short preparation time for intervention is of vital importance. In addition, endovascular procedures can be completed in a shorter time than open surgery and blood loss during the procedure is less. All of these factors play a significant role in reducing the post-procedural mortality and morbidity rates of endovascular interventions and make this method more attractive, especially in patients who are hemodynamically unstable or have severe comorbidities.

Despite the advantages of endovascular techniques, the management of ruptured aortic pathologies remains complex [15]. In particular, factors such as the diversity of anatomical features, extent of pathology, difficulties in bleeding control, and location of the tear are key factors that affect the success rate and safety of endovascular procedures. In addition to these challenges, common complications in ruptured aortic cases, especially endoleak, difficulty in stent graft placement and post-procedural extravasation, can affect patient outcomes [16,17].

However, there is limited information in the literature on the applicability of endovascular interventions in acute and traumatic cases [18,9]. Especially in complex pathologies such as aortic transections due to trauma such as traffic accidents or falls from a height, the results of endovascular treatment strategies are uncertain and both short-term and long-term outcomes in such cases need to be investigated in more detail. In this study, we analyzed the clinical outcomes of patients undergoing TEVAR and EVAR for ruptured aortic pathologies and evaluated the efficacy and safety of endovascular treatments.

MATERIAL AND METHODS

This retrospective, observational, single-center study was conducted at our Cardiovascular Surgery Clinic in Ankara Bilkent City Hospital. The study received ethical approval from Ankara Bilkent City Hospital Medical Research Scientific and Ethical Evaluation Board No. 1 (Approval No: TABED 1-24-638) on 09/10/2024. The ethical appropriateness of the study was unanimously approved by the board. Due to the retrospective analysis, patient data were anonymized, and only descriptive data were included in the study.

A total of 32 patients who underwent endovascular treatment for ruptured aortic pathologies between 2019 and 2024 were analyzed. Of these patients, 14 patients with thoracic aortic rupture underwent TEVAR, while the remaining 18 patients with abdominal aortic rupture underwent EVAR. Since the patients were treated as emergencies, most of the demographic data were obtained from patient relatives or medical records. The graft type used in all endovascular procedures was limited to the (LifeTec) brand. The same brand and model graft was utilized for both TEVAR and EVAR procedures, and therefore, the impact of different graft types on clinical outcomes was not evaluated. Graft selection was based on the type of pathology and anatomical suitability.

Adult patients aged 18 years and older were included in the study. Inclusion criteria required that patients underwent TEVAR or EVAR for ruptured thoracic or abdominal aortic pathology, the intervention was performed between 2019 and 2024, and adequate preoperative and postoperative data were available in the hospital information system. Patients with incomplete preoperative or postoperative data, those who succumbed to their condition prior to emergency intervention, and patients under the age of 18 were excluded from the study. These criteria were established to ensure the reliability and consistency of the study results.

Data Collection

Demographic and clinical data were obtained retrospectively from the hospital information system. Since the patients included in the study were treated as emergencies, most of the demographic data were obtained from the relatives of the patients or hospital medical records. Collected data included age, gender, preoperative medical history, traumatic etiology, cause of aortic rupture, procedural details, and postoperative outcomes. Among

the patients included in the study, there were no patients who had previously undergone surgery for another reason. Therefore, surgical history information was not included in addition to demographic data.

Causes of Rupture and Group Definitions

Patients were classified according to the location of aortic rupture (thoracic or abdominal), with TEVAR performed for thoracic and EVAR for abdominal ruptures. The causes of rupture included aortic transection, type-3 dissection, aneurysm, pseudoaneurysm, aorto-enteric fistula, and iatrogenic perforation. Endovascular procedures were primarily conducted through a femoral incision with femoral artery access, often performed under local anesthesia. The TEVAR and EVAR groups were analyzed separately in the statistical analyses. Zone 3, which is anatomically appropriate, was used in all patients for TEVAR procedures. Subclavian artery occlusion was not required in any patient.

Outcome Measures

The primary outcome measures included mortality, morbidity, and length of intensive care and ward stays. Mortality was defined as all deaths occurring within 30 days after the procedure or during hospitalization. Morbidity includes postoperative complications, including endoleak, extravasation, infection, thrombosis, renal failure, and pulmonary complications. In order to evaluate postoperative structural complications, findings such as endoleak and extravasation were analyzed using control computed tomography (CT) scans.

Imaging findings of ruptured aortic pathologies and endovascular interventions are given in Figure 1.

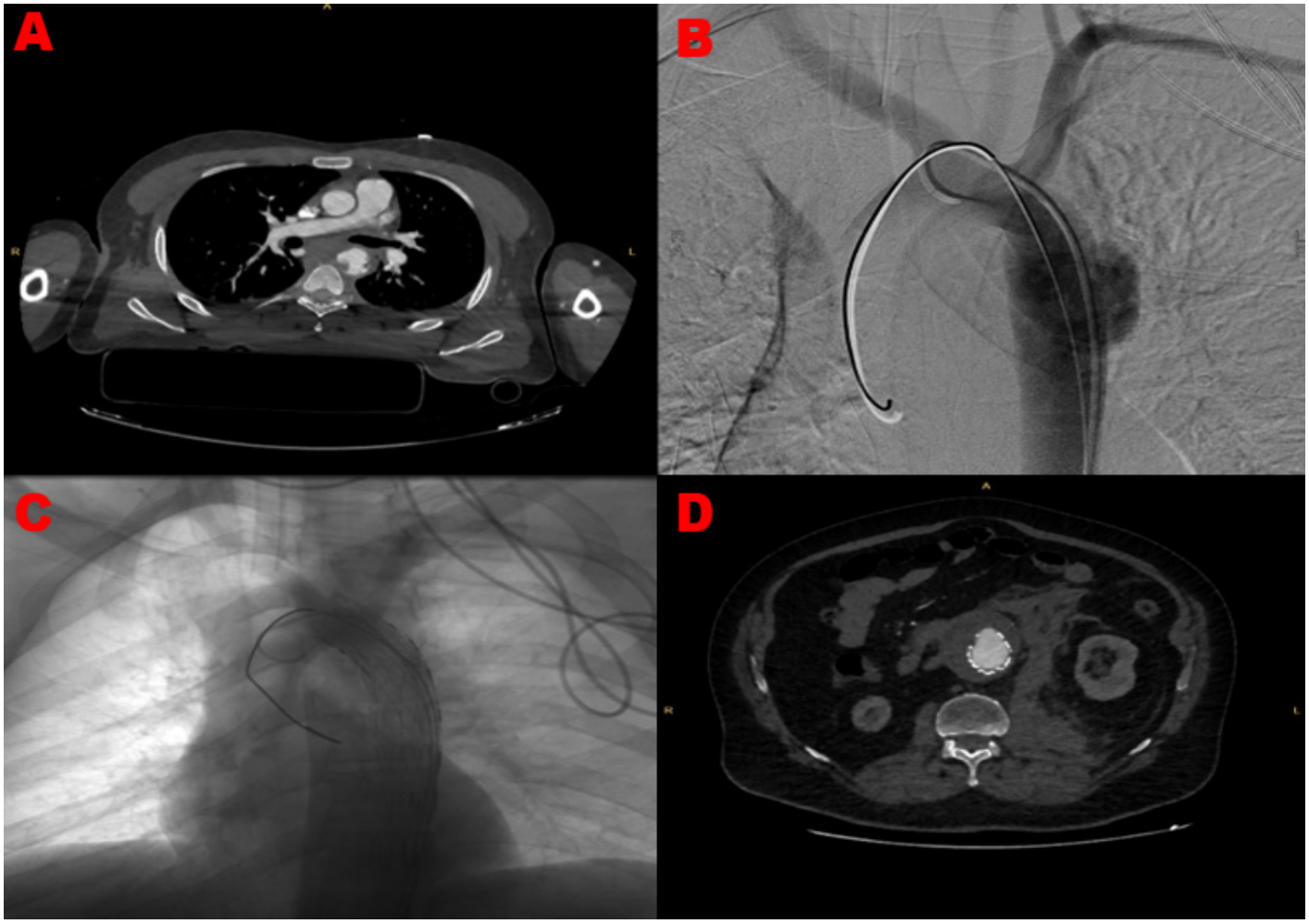

Figure 1. Imaging findings and endovascular interventions in patients with ruptured aortic pathologies; **A.** Axial CT scan showing a ruptured thoracic aorta due to traumatic aortic transection following a traffic accident; **B.** Digital Subtraction Angiography (DSA) image displaying the ruptured thoracic aorta with aortic transection; **C.** Post-TEVAR image of the same patient, demonstrating the endovascular repair of the thoracic aorta; **D.** Axial CT scan showing a ruptured abdominal aorta with successful endovascular aneurysm repair (EVAR) placement

Statistical Methods

Statistical analyses were conducted using SPSS software (IBM SPSS Statistics, Version 25.0, IBM Corp., Armonk, NY, USA). Continuous variables were presented as means and standard deviations (SD), while categorical variables were summarized as frequencies and percentages. The normality of continuous variables was evaluated using the Shapiro-Wilk test. For normally distributed continuous variables, comparisons between the TEVAR and EVAR groups were made using independent samples t-tests; for non-normally distributed data, the Mann-Whitney U test was applied. The Chi-square test was employed to assess the relationship between categorical variables, such as hypertension, diabetes, and mortality. Logistic regression analysis was performed to examine the influence of factors including age, hypertension, trauma type, and complications on mortality risk. A p-value of <0.05 was considered statistically significant for all tests.

RESULTS

In this study, a total of 32 patients underwent endovascular intervention due to ruptured aortic pathologies. Patients were divided into two groups based on the type of rupture: those with thoracic aortic ruptures, treated with TEVAR, and those with abdominal aortic ruptures, treated with EVAR. Each group was assessed separately for mortality, morbidity, and complication rates.

As shown in Table 1, the demographic characteristics of both groups were similar, with no significant differences in age distribution, gender, hypertension, diabetes, coronary artery disease, or chronic obstructive pulmonary disease (COPD) rates.

Table 1. Demographic and clinical characteristics (TEVAR and EVAR groups)

Characteristic	TEVAR (n=14)	EVAR (n=18)	p-value
Age (years, mean±SD)	62.3±13.2	58.6±15.1	0.27
Gender (Male, %)	43.8	56.0	0.65
Hypertension (%)	85.7	88.9	0.79
Diabetes (%)	21.4	27.8	0.62
Coronary artery disease (%)	14.3	22.2	0.48
COPD (%)	28.6	22.2	0.66

In Table 2, it is shown that in the TEVAR group (n=14), 50% of the causes of rupture were due to aortic transection, followed by aneurysm at 21.9%. In the EVAR group (n=18), the most common cause of rupture was aneurysm at 56.2%, with pseudoaneurysm and aorto-enteric fistula observed at 12.5% and 6.3%, respectively. Additionally, a 6.3% incidence of Type-3 dissection was identified in the EVAR group.

Table 2. Causes of rupture (TEVAR and EVAR groups)

Cause of rupture	TEVAR group (n=14)	EVAR group (n=18)	Total percentage (%)
Aortic transection	7	0	21.9
Type-3 dissection	2	1	9.3
Aneurysm + type-3 dissection	1	0	3.1
Aneurysm	3	15	56.2
Pseudoaneurysm	0	1	3.1
Aorto-enteric fistula	0	1	3.1
Iatrogenic perforation	1	0	3.1

As shown in Table 3, clinical outcomes differed between the TEVAR and EVAR groups in terms of mortality, morbidity, and length of hospital stays. Mortality was observed in 14.3% of the TEVAR group and in 27.8% of the EVAR group. Morbidity rates were 7.1% in the TEVAR group and 16.7% in the EVAR group. Additionally, intensive care unit (ICU) and ward stay durations were longer in the TEVAR group compared to the EVAR group. In terms of follow-up findings, normal CT results were observed in 100% of the TEVAR group and in 88.9% of the EVAR group. No endoleak or extravasation was noted in the TEVAR group, while endoleak was observed in 11.1% of the EVAR group, with these patients under close follow-up. No cases of extravasation were reported in either group. Endoleak development was observed in 11.1% (2 patients) of patients who underwent EVAR. All endoleaks were classified as Type II endoleaks. These patients were followed up only with clinical and radiologic follow-up and no secondary intervention was performed. No endoleak-related complications were detected during follow-up.

Table 3. Clinical outcomes, hospital stays, and follow-up findings (TEVAR and EVAR groups)

Characteristic	TEVAR group (n=14)	EVAR group (n=18)	p-value
ICU stay (days)	5.8±2.1	4.1±1.5	0.03
Hospital stay (days)	7.2±3.0	5.5±2.6	0.04
Mortality rate (%)	14.3	27.8	0.67
Morbidity rate (%)	7.1	16.7	0.52
Normal follow-up CT (%)	100	88.9	—
Endoleak (%)	0	11.1	0.68

Logistic regression analysis was performed to evaluate factors influencing mortality, including age, hypertension, type of trauma, and presence of complications. As shown in Table 4, the development of complications was found to be a significant risk factor for mortality (p=0.04). Other variables did not show a statistically significant impact on mortality. In our study, traumatic aortic transection was detected in 50% (7 patients) of the patients who underwent TEVAR. These traumas were caused by traffic accidents (5 patients, 35.7%) and falls from height (2 patients, 14.3%). All patients with traumatic etiology were exposed to blunt trauma. There were no patients with traumatic etiology in the EVAR group.

The complications observed in our study included renal failure (3 patients, 9.4%), pulmonary complications (2 patients, 6.3%), and infection (1 patient, 3.1%). Renal failure was the most fatal complication, resulting in mortality in two patients. Pulmonary complications and infection contributed to mortality in one patient each. Other complications, such as bleeding and endoleak, were observed but did not lead to mortality.

Table 4. Logistic regression analysis of mortality-associated factors

Variable	Coefficient (B)	Standard error	p-value	OR (odds ratio)	95% CI for OR
Age	0.03	0.02	0.07	1.03	0.99-1.07
Hypertension (present)	0.45	0.31	0.14	1.57	0.85-2.91
Traumatic etiology	0.28	0.25	0.26	1.32	0.81-2.15
Complication development	1.12	0.55	0.04	3.06	1.04-8.97

Mortality risk factors, including age, hypertension, trauma type, and complication development, are presented in Figure 2. Complication development was identified as a significant predictor of increased mortality risk.

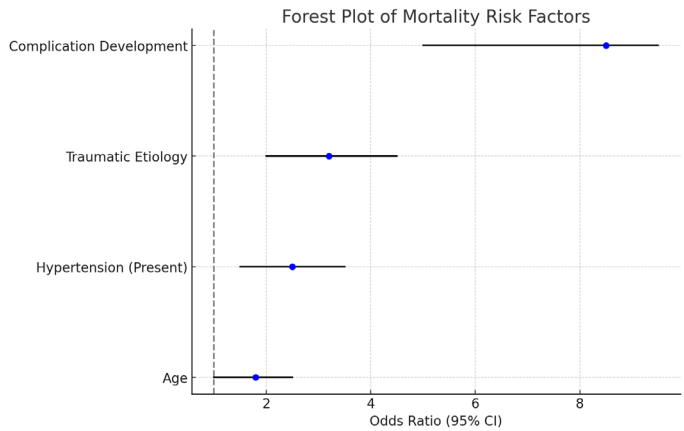

Figure 2. This plot displays the odds ratios (OR) and 95% confidence intervals for factors associated with mortality among patients with ruptured aortic pathologies. Key risk factors, including age, hypertension presence, traumatic etiology and complication development, were assessed. Complication development showed a significant association with increased mortality risk (OR=3.06, 95% CI: 1.04–8.97), indicating its strong impact on patient outcomes

DISCUSSION

In this study, we retrospectively evaluated the clinical outcomes of TEVAR and EVAR procedures for managing ruptured aortic pathologies. Both treatments demonstrated high efficacy and safety, with TEVAR proving particularly advantageous for thoracic aortic ruptures and EVAR offering significant benefits for abdominal aortic ruptures. Mortality, morbidity, and complication rates observed align with the literature on endovascular interventions for life-threatening aortic conditions, reinforcing the value of these less invasive techniques in emergency settings [19,20].

Ruptured aortic pathologies present as complex cases with a high mortality risk, necessitating urgent intervention. Literature emphasizes that in traumatic aortic ruptures, mortality rates rise exponentially within hours, underscoring the critical importance of timely diagnosis and intervention [21]. Consistent with these reports, our study found that high-energy traumas such as traffic accidents and falls frequently resulted in aortic transections, for which rapid diagnosis and treatment played a decisive role in patient survival. Since TEVAR offers a less invasive alternative to open surgery, it has emerged as an essential treatment option in such traumatic cases [22]. In our study, similar findings were

observed, particularly with TEVAR's role in managing thoracic aortic injuries, aligning with Uğuz et al.'s emphasis on patient selection and minimizing procedural invasiveness. This supports the position that endovascular techniques should be prioritized for patients with acute thoracic aortic syndromes, especially those at high risk for open surgery complications [23].

In addition, statistical differences were observed between the TEVAR and EVAR groups in terms of ICU and hospital stay durations, with TEVAR patients requiring significantly longer ICU stays (p=0.03). This difference may be attributed to the higher clinical complexity and the prevalence of traumatic etiologies in the TEVAR group, which often necessitate more intensive perioperative management. These findings are consistent with existing literature, which highlights the increased challenges associated with thoracic aortic pathologies compared to abdominal ones. Tailored management strategies focusing on the specific needs of each group could further optimize outcomes and resource utilization.

Our findings also corroborate evidence from large-scale trials [24,25]. Nienaber et al. demonstrated that TEVAR combined with medical therapy significantly enhanced aortic remodeling and reduced aortic-related mortality over a five-year period, although it did not impact overall survival. This is further supported by the Acute Dissection Stent graft OR Best medical treatment (ADSORB) Trial, where TEVAR with best medical treatment promoted favorable remodeling and reduced false lumen size without immediate survival benefits, highlighting its role in preventing future complications. These findings underscore the potential of TEVAR as a critical intervention for managing thoracic aortic dissections, particularly in patients for whom conventional surgery poses a greater risk.

In cases of abdominal aortic aneurysmal rupture, EVAR is advantageous due to lower perioperative morbidity and mortality relative to open surgery, as noted in the literature [26]. In our study, low complication rates were observed in patients undergoing EVAR for abdominal aortic ruptures, although endoleak and extravasation complications highlight the necessity for thorough postoperative monitoring. Some research in the literature [27,28,12], which investigated the combined use of bare-metal and covered stents, further support EVAR's efficacy, showing that this approach reduces false lumen perfusion and promotes favorable aortic remodeling in type B dissections, reducing long-term complications.

Our study also revealed that patients who had undergone previous endovascular interventions occasionally experienced re-rupture at the original site, likely due to endoleak. Successful re-endovascular interventions were performed in these cases, highlighting the adaptability of repeat TEVAR and EVAR in addressing complications. Specifically, two patients in the TEVAR group required repeat interventions due to re-rupture, with one resulting in mortality post-procedure. Conversely, in the EVAR group, repeat procedures effectively managed recurrent ruptures without mortality, further underscoring EVAR's role in high-risk patient groups requiring reintervention.

Hybrid procedures, combining open surgical debranching with TEVAR or EVAR, proved effective in managing complex aneurysmal cases, demonstrating flexibility and rapid deployment potential even under emergency conditions. The findings of Uğuz et al. [23] similarly underscore the importance of tailored endovascular treatment strategies, particularly in acute thoracic aortic syndromes, where endovascular techniques can provide significant benefits in terms of safety and recovery time.

The causes of rupture in our study were diverse, including traumatic aortic transection, type-3 dissection, aneurysm, pseudoaneurysm, aorto-enteric fistula, and iatrogenic perforation. Each pathology presents unique mechanisms of aortic wall compromise, necessitating individualized endovascular approaches. The primary access for these procedures is through a femoral incision, generally under local anesthesia, allowing rapid, minimally invasive intervention without the delays and risks associated with general anesthesia—particularly advantageous in emergency scenarios compared to open surgical methods.

Our study has limitations. The retrospective design relies on the accuracy of existing records, which may introduce data gaps, as much of the patient information was obtained from relatives or hospital documentation. Furthermore, our limited sample size may restrict the generalizability of these results, particularly for rarer pathologies. Additionally, the grouping of diverse aortic pathologies, including trauma, dissection, and aneurysm, presents a methodological limitation of our study. Each condition has unique clinical characteristics, and future studies could benefit from further subgroup analyses to evaluate these conditions independently. Future prospective studies with larger cohorts will enhance the reliability and applicability of our findings.

CONCLUSION

In conclusion, our study highlights the effectiveness and safety of TEVAR and EVAR in managing ruptured aortic pathologies. These endovascular techniques offer essential treatment options, improving survival and minimizing complication risks in specific patient populations. Furthermore, the successful application of sequential hybrid interventions underscores the adaptability of endovascular therapies in emergency settings. Given the high-risk nature of this patient group, vigilant postoperative monitoring and timely reinterventions are crucial. Our findings contribute to the growing body of evidence supporting TEVAR for traumatic thoracic pathologies and EVAR for aneurysm-related abdominal ruptures, emphasizing their roles in modern vascular management.

Ethics Committee Approval: This study received ethical approval from the 1st Scientific and Ethical Review Committee for Medical Research (TABED) of Ankara Bilkent City Hospital on 09.10.2024, with decision number TABED 1-24-638. The study was reviewed and unanimously approved in terms of ethical considerations.

Patient Consent for Publication: Consent was obtained from all of the patients.

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 to the study conception and design. Material preparation, data collection, and analysis were performed by Muhammet Fethi Saglam, Emrah Uguz, Kemal Esref Erdogan, Huseyin Unsal Ercelik, Murat Yucel, Mete Hidiroglu, Murat Canyigit and Erol Sener. The first draft of the manuscript was written by Muhammet Fethi Saglam, Emrah Uguz, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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