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Role of Thoracic Endovascular Aortic Repair in Aortic Dissections – Factors Affecting Outcome

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ABSTRACT

Background: Thoracic endovascular aortic repair (TEVAR) is increasingly employed in managing both residual type A and type B aortic dissections. This study aimed to evaluate short- and midterm outcomes following TEVAR and identify factors influencing technical success, complications, and reintervention across different healthcare systems.

Methods: A dual-centre observational study was conducted on consecutive patients with aortic dissection who were treated with TEVAR between October 2022 and September 2024 at two institutions: Mansoura University 'MU' (Mansoura, Egypt) and Ludwig Maximilian University 'LMU' Hospital (München, Germany). Patients with residual type A and acute, subacute, or chronic type B dissections were included. The primary endpoints were technical success, 30-day mortality and reintervention. The secondary endpoints were aortic remodeling, follow-up survival, and freedom from reintervention.

Results: Fifty-two patients were included, with 42 males (80.8%) and a mean age of 62.7 ± 10.5 y. Technical success was achieved in 51 patients (98.1%), with 30-day reintervention and mortality rates of 7.7% and 3.8%, respectively. The follow-up period (13.8 ± 7.2 m) recorded 9 reinterventions and 5 mortalities. Positive remodeling was achieved in 73.1% of the patients. Kaplan–Meier estimates at 12 months showed overall and aortic-related survival of 95.4% and 100%, and freedom from overall and aortic-related reintervention at 84.8% and 86.9%, respectively.

Conclusion: TEVAR is effective in achieving favorable short- and midterm outcomes in aortic dissection across healthcare systems. Complicated dissections, higher BMI, and clinical malperfusion were associated with worse early outcomes. Persistent false lumen perfusion at discharge predicted follow-up mortality, whereas additional intraoperative procedures reduced late aortic reinterventions.

KEYWORDS: TEVAR; endovascular; dissection; factors; malperfusion; outcome.

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BACKGROUND

Thoracic endovascular aortic repair (TEVAR) has become the primary management method for residual chronic type A and type B aortic dissections given its minimally invasive nature and reduced perioperative risk compared with open repair. [1, 2] The principle of TEVAR is to cover the proximal major aortic entry tear with a stent graft. Coverage of the tear redirects blood flow into the true lumen, thus potentially resolving malperfusion and reducing the risk of rupture of the false lumen in acute entities. [3] Closure of the primary tear also facilitates thrombosis and subsequent regression of the false lumen and re-expansion of the true lumen, a late effect known as aortic remodeling. [4]

Despite advances in TEVAR, long-term durability and the factors influencing outcomes remain areas of active investigation. This study aimed to evaluate the outcomes of aortic dissection after TEVAR at two different centers within two different health institutions, whether it is residual type A dissection or acute, subacute, or chronic type B dissection. In addition, the study sought to identify factors influencing these outcomes.

PATIENT AND METHODS

An observational study was carried out on consecutive patients with aortic dissection (AD) who were treated with TEVAR between October 2022 and September 2024. The institutions involved were the Departments of Vascular Surgery at Mansoura

University 'MU' (Mansoura, Egypt) and at Ludwig Maximilian University 'LMU' Klinikum (München, Germany).

The study included prospective data from MU between October 2022 and September 2024 and retrospective data from a prospectively filled database from LMU between October 2022 and September 2023. Ethical approval for the study was provided by the local ethical board of both institutions (MU: MD.22.09.694, LMU: 23-0749).

Trial registration: Prospective data (MU: Oct 2022–Sep 2024); retrospective data (LMU: Oct 2022–Sep 2023). Ethical approvals: MU (MD.22.09.694), LMU (23-0749).

Patients who underwent TEVAR for residual type A aortic dissection and acute, subacute, and chronic type B aortic dissections were included. Patients with type A aortic dissection, patients with genetic aortic syndromes or connective tissue disorders, and patients who did not comply with the follow-up protocol were excluded.

Demographic and preoperative clinical data, including comorbidities, symptoms, and indications for surgery, were collected. Procedure-related details, complications, and reinterventions were collected from electronic medical records. Informed consent was obtained from all prospective patients for permission to operate and use their clinical records for research purposes. All the data were anonymized; therefore, consent from retrospective data was unnecessary. The study was conducted in accordance with the Declaration of Helsinki and the STROBE guidelines. [5]

The diagnosis of AD was based on CT-angiography (CTA), and the diagnosis of malperfusion was based on the patient's presenting symptoms and/or radiological confirmation. Aortic dissection was categorized by the onset of symptoms and classified as per the reporting standards into hyperacute (<24 h), acute (1–14 days), subacute (15–90 days), and chronic (>90 days). [6] The chronic subgroup included patients with residual type A dissection who underwent delayed endovascular repair. Treatment indications included high-risk features (refractory pain, refractory hypertension, bloody pleural effusion, aortic diameter >40 mm, radiographic malperfusion, readmission, entry tear on the aortic lesser curve, and false lumen diameter >22 mm) [6], malperfusion, rupture, and rapid aortic growth > 5 mm in 6 months. Both elective and urgent procedures were included, with urgent procedures including complicated aortic dissections and those who underwent treatment within 48 hours of presentation.

Technical success was defined as the successful implantation of TEVAR, with the exclusion of the entry tear and the absence of type Ia or type III endoleak at the final intraoperative angiography. The thirty-day outcomes collected included postoperative renal impairment, which was defined as a decrease ≥ 20% of the baseline eGFR, myocardial infarction (MI), stroke/transient ischemic attack (TIA), spinal cord ischemia (SCI), reinterventions, and mortality. Positive aortic remodeling was defined as a reduction in the total aortic diameter > 5 mm. Stable remodeling was defined as a change of < 5 mm, and negative remodeling was defined as an increase in total aortic diameter > 5 mm. [6] Thirty-day adverse events were defined as the composite outcome of 30-day respiratory complications, (MI), stroke/TIA, SCI, new-onset dialysis, reintervention, and mortality. The follow-up protocol included clinical examination and CTA imaging within 30 days and 6 months and annually thereafter.

Endovascular procedure: The procedures were performed in a hybrid operating room with a fixed imaging system via trans-femoral arterial access. TEVAR was performed via the use of commercially available thoracic stent grafts **(Zenith TX2 Cook Medical; Bloomington, IN** and **Ankura Thoracic Stent Graft; Lifetech Scientific, Shenzhen, China)**. The length of the aortic coverage treatment was at the discretion of the operator. Oversizing at the proximal and distal landing zones was typically limited to < 10%. In cases of significant mismatch between proximal and distal landing zones, we employed multiple stent grafts, including tapered devices when appropriate. Specifically, distal sizing was based on the mean true lumen diameter at the intended distal landing zone, measured using centerline reconstructions or multiplanar reformatted CTA images. Stent sizing was carefully tailored to around 10% oversizing to prevent d-SINE. Adjunctive branch vessel stenting was performed using bare metal and covered stents in cases of malperfusion. Alternatively, dissection membrane fenestration or electroseptotomy can be performed when feasible.

LSA revascularisation was ensured except in emergency cases or in hemodynamically unstable patients. Several LSA revascularisation methods have been employed, commonly left carotid subclavian bypass using PTFE or Dacron grafts and, less often, fenestrated (in situ needle fenestration) procedures. Controlled cardiac reduction was performed before TEVAR deployment if necessitated by the operator via the Munich Valsalva Implantation Technique (MuVIT) [7] or using other reported techniques (IVC balloon occlusion, rapid pacing, drug induced, etc.).

Endpoints: The primary endpoints were technical success and 30-day outcomes in terms of mortality and morbidity (MI, stroke/TIA, SCI, renal impairment and new-onset dialysis, mesenteric and extremity ischemia, and the presence of endoleak). The secondary endpoints were aortic remodeling, overall survival, and freedom from reintervention during the follow-up. The outcomes were further analyzed according to the onset of symptoms (acute/subacute/chronic) and between uncomplicated high-risk patients and complicated patients.

Statistical analysis: Data was analyzed via SPSS (Statistical Package for Social Sciences) version 26. Qualitative data were presented as numbers and percentages. Quantitative data were tested for normality via the Kolmogorov–Smirnov test and then described as the means and standard deviations for normally distributed data and medians and interquartile ranges for nonnormally distributed data. Pearson's chi-square test and Fisher's exact test were used for analyzing categorical variables, and Student's t test was used for continuous variables. The Mann–Whitney U test was used for the analysis of nonparametric continuous variables. Logistic regression was performed for multivariate analysis. Significance was determined at the $p < 0.05$ level. Kaplan–

Meier curves were generated to analyze follow-up mortality and reinterventions.

Extensive statistical analysis was carried out to identify factors affecting outcomes. However, owing to the low number of adverse events observed, the statistical power was limited, which affected the ability to detect significant relationships.

RESULTS

General ***Cohort***

A total of 52 patients were included in the study, with a mean age of 62.7 ± 10.5 years, and 80.8% were males (42/52). Detailed demographics and baseline characteristics are presented in Table 1.

Most patients were ASA Class 3 (67.3%). Urgent cases constituted 26.9% (14/52), with clinical malperfusion being the most common indication (11/14). The three remaining patients included two with uncontrolled pain and one with true lumen collapse at visceral level (radiological malperfusion). Forty-three patients had type B AD, whereas 9 had residual type A AD. The majority of type B AD cases were subacute (53.8%). There were no patients with vertebral artery anomalies coming off the aortic arch. The details are listed in Table 2.

Operative details

LSA revascularization was performed mostly via left carotid-subclavian bypass in 23 patients (44.2%). Most debranching procedures were performed before TEVAR deployment (93.5%). In situ needle fenestration was performed on 3 patients. 9 patients had previous cervical debranching where 8 had three supra-aortic vessel reconstruction and one had debranching to the IA and LCC with concomitant left CSB. General anesthesia was commonly used in 48 patients (92.3%), and local anesthesia was used in 4 (7.7%). Spinal drainage was employed in 5 patients (9.6%). Controlled cardiac reduction output was employed in 15 patients (28.8%), 13 with MuVIT, 1 with drug-induced occlusion, and 1 with IVC balloon occlusion. This is summarized in Table 2.

Technical success was achieved in 51 patients (98.1%). Technical failure occurred in one patient where the proximal TEVAR had kinking with slow-forming type Ia endoleak treated with coil embolization. The median operative time was 123 minutes, the median fluoroscopy time was 19 minutes, the median contrast dose was 220 mL, and the median radiation dose area product was 914 cGy/cm^2. The median duration of the ICU stay was 2 days (0–5), and the total hospital stay was 12 days (8–21). A summary of the operative details and hospital stay data is provided in Table 3. Additional procedures were performed in 16 patients. Four patients underwent LRA stenting (one with dissection flap electroseptotomy via the cheese wire technique in the abdominal aorta), one with an LCC stent, one with a CT stent, one with SMA angioplasty with subsequent stenting and left CIA stenting, and one with SMA stenting via a physician-modified TEVAR procedure where the CT was chronically occluded and had an additional right CIA stent. One patient had an RRA stent, one had a right CIA stent, and two patients had PETTICOAT stenting (one had an additional LRA stent). One had a plug inserted at a pseudoaneurysm of the previous surgically reconstructed ascending aorta for type A AD, and one had dissection flap fenestration at the abdominal aorta level with a right CIA stent. Two patients underwent endarterectomy and patch angioplasty of the femoral arteries due to severe calcification. Five patients with chronic dissection underwent staged repair with a planned second intervention for thoracic false lumen occlusion, three of whom had physician-modified candy plug and two of whom had ASD plug.

Outcomes (Table 4)

Perioperative complications were experienced by 15 patients (28.8%). The complications included 3 respiratory-related complications (2 pneumonia and 1 respiratory failure requiring tracheostomy), 1 major stroke and 1 TIA, 3 SCIs (1 pareses, 1 delayed partial paraplegia, and 1 delayed complete paraplegia), and 1 new-onset dialysis that was permanent. Access vessel complications were recorded in 8 patients; 6 were treated surgically, and two were followed up with a conservative approach. The 6 treated patients included three cases of access bleeding (two following the failed percutaneous closure technique and one for hematoma evacuation), two with femoral occlusion (one with further SFA PTA and stenting), and one with femoral endarterectomy and patch angioplasty. None of the patients who had CSF spinal drainage (5) had paraesthesis/paralysis of the lower limbs.

The 30-day period included 4 reinterventions (7.7%) where one patient experienced retrograde type A AD and underwent surgical reconstruction of the ascending aorta, aortic arch and coronary artery ostia; one case of PETTICOAT stenting for renovisceral malperfusion followed by laparotomy for suspected aortic rupture; one case of mesenteric ischemia that required ileal resection; and one case of femoral pseudoaneurysm. For mortality, there were 2 patients (3.8%), one secondary to aortic rupture with multiorgan failure and one due to a bleeding duodenal ulcer.

The follow-up period of 13.8 ± 7.2 months included 9 interventions (17.3%) and 5 deaths (9.6%). Four patients underwent thoracic false lumen occlusion with a candy plug (one had additional LSA coiling for type II endoleak). Three patients underwent FEVAR for ongoing abdominal aorta degeneration with aneurysm formation. One patient underwent an open surgical repair for infrarenal postdissection abdominal aortic aneurysm, and one patient underwent carotid-subclavian bypass for left upper limb claudication. The follow-up mortality data included one patient who died during open surgical repair of a postdissection infrarenal aortic aneurysm and four patients with non-identified aortic-related causes.

Positive aortic remodeling was observed in 38 patients (73.1%), remained unchanged in 12 patients (23.1%), and 2 patients experienced negative remodeling with an increased total aortic diameter (3.8%). Kaplan–Meier curves demonstrating overall and aortic survival and freedom from overall and aortic reinterventions are provided in Figures 1 and 2. Figures 3 and 4 illustrate a

patient with type B aortic dissection with positive remodeling within 6 months.

Factors

Univariate analysis revealed that the intake of beta-blockers was associated with fewer 30-day reinterventions (p .008). Complicated dissections were significantly associated with 30-day mortality (p .027). Thirty-day adverse events were associated with higher BMI, complicated dissections, clinical malperfusion, urgent setting, non-intake of beta blockers, and percutaneous femoral access. Positive remodeling was adversely affected by dyslipidemia (p .016).

Overall follow-up reinterventions were more common in patients with dyslipidemia and no positive remodeling. Follow-up aortic reinterventions were more common in patients with dyslipidemia and those who did not have additional intraoperative procedures. Overall mortality during follow-up was associated with intraoperative debranching, increased total operative time, increased fluoroscopy time, increased contrast doses, and persistent thoracic false lumen perfusion at discharge. The findings that were found to be significantly associated with different outcomes with p values < .05 are summarized in Table 5. Multivariate analysis revealed that no factors were significantly related to the outcomes, likely because of the study's small cohort size and low number of adverse events.

Significant differences were found among the three dissection onset groups. The urgent setting and complicated dissections were more common in the acute group (p .020 and p .030, respectively). Controlled CO reduction was more common in the acute dissection group of patients (p .027). The proximal landing diameter was also greater in the acute cohort (p .031). The total operative and fluoroscopy times were longer in the subacute cohort. Acute dissection patients had longer ICU stays (p .001), but there were no significant differences in the duration of total hospital stay. The incidence of complications and the 30-day and follow-up outcomes did not differ among the three groups. (Table 6)

Compared with uncomplicated high-risk dissection patients, urgent dissections were more common in the complicated cohort (p .001). More medical complications were associated with complicated dissections (p .012). Thirty-day adverse events and mortality were significantly associated with complicated dissections but were similar regarding 30-day reinterventions. The follow-up outcomes were similar between the two groups. (Table 7)

DISCUSSION

Thoracic endovascular aortic repair (TEVAR) has emerged as a cornerstone in the treatment of both residual type A and type B aortic dissections. While the procedure is well-established in acute settings, its durability and outcome predictors, particularly in heterogeneous clinical populations, remain an area of active investigation. [1, 2] Our study, which included patients treated at two tertiary centers, aimed to evaluate short- and midterm outcomes and to identify procedural and patient-related factors associated with complications and survival.

With a technical success rate of 98.1% and a 30-day mortality rate of 3.8%, our findings are consistent with major studies, such as INSTEAD-XL and ADSORB, confirming the procedural safety and reproducibility of TEVAR in various clinical contexts [8,9]. Positive aortic remodeling occurred in 73.1% of our cohort, a key surrogate for long-term procedural success. This aligns with the ADSORB trial, which demonstrated significant aortic remodeling in 63% of patients undergoing TEVAR [9]. Remodeling is especially crucial in preventing aneurysmal degeneration and subsequent reintervention. In our study, a lack of positive remodeling was associated with increased follow-up reinterventions. These findings reinforce previous evidence that incomplete aortic remodeling may predict poorer long-term outcomes [6,8,9].

We found that patients with higher BMI, complicated dissections, clinical malperfusion, and urgent presentation had a significantly higher rate of 30-day adverse events. These results support earlier studies showing that patient-related and anatomical risk factors substantially impact short-term outcomes following TEVAR. [3,10] Notably, complicated dissections were associated with increased 30-day mortality (p .027), emphasising the importance of early risk identification and aggressive perioperative optimisation in high-risk cases. [3,10]

Intraoperative strategies significantly influenced follow-up outcomes. Additional procedures such as adjunctive stenting, dissection membrane fenestration, and false lumen occlusion were associated with reduced rates of aortic-related reinterventions. These findings are in line with the STABLE trial and other reports recommending comprehensive anatomical correction at the index procedure to enhance long-term durability. [11] This also underscores the benefit of individualised procedural planning, particularly in patients with persistent perfusion or complex aortic morphology. [4,6]

Beta-blocker intake was associated with fewer 30-day reinterventions (p .008), reinforcing the central role of optimal medical management in aortic dissection. This is consistent with previous data showing improved outcomes in patients treated with beta-blockers after TEVAR. [12,13] These medications are well-established in guideline-based therapy for aortic dissection [14], and registry data from IRAD further support their role in reducing long-term mortality. [15]

Persistent thoracic false lumen perfusion at discharge was significantly associated with higher follow-up mortality. This observation reflects a known risk factor for continued aortic degeneration and late rupture, as previously highlighted in TEVAR outcome studies. [8,9] Our results suggest that patients with incomplete exclusion of the false lumen should be closely monitored and may benefit from adjunctive endovascular interventions or planned reintervention.

Finally, apart from medical complications, there was no difference between different operative details and outcomes when uncomplicated high-risk and complicated patients were compared. This finding highlights the importance of high-risk features

that favor this category of patients for treatment. A study by Herajärvi and colleagues revealed that early repair of high-risk aortic dissection may reduce long-term morbidity and mortality. [16]

LIMITATION OF THE STUDY

The limitations of the study include the small sample size and the midterm follow-up period, which may have resulted in additional mortality and/or reinterventions. The study's relatively small cohort size limited the ability to draw definitive conclusions from multivariate analysis. Future studies with larger sample sizes may better detect subtle variations in outcomes across different patient demographics or clinical characteristics. Discrepancies in the study period between the two centers were attributed to challenges in obtaining approval from one center, which limited data collection during the extended timeframe. Additionally, no patients with known genetic diseases or connective tissue disorders were included. Furthermore, the inclusion of chronic and residual type A dissections introduces heterogeneity, particularly concerning remodeling potential and timing of intervention. Conducting the study at two institutions may have introduced variability in procedural techniques and postoperative care, which could have potentially influenced the outcomes.

CONCLUSION

TEVAR is effective in achieving favorable short- and midterm outcomes in aortic dissection across healthcare systems. Complicated dissections, higher BMI, and clinical malperfusion were associated with worse early outcomes. Persistent false lumen perfusion at discharge predicted follow-up mortality, whereas additional intraoperative procedures reduced late aortic reinterventions.

DECLARATIONS

Ethics approval and consent for participation: Informed consent was obtained from patients participating in the prospective limb, and in case of incompetency, informed consent was obtained from the guardians. Anonymization of the data was ensured for those in the retrospective limb. Ethical approval for the study was provided by the local ethical board of both institutions (MU: MD.22.09.694, LMU: 23-0749).

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests: NT is a proctor and receives institutional grants from Cook Medical. All the other authors have no conflicting interests.

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Authors' contributions: All authors have made substantial contributions to the study as follows: Ahmed Azhar Ali (AAA): Conceptualization, study design, data collection, statistical analysis, manuscript drafting, and final approval. Ehab M. Saad (EMS): Data collection, methodology, manuscript review, and final approval. Nikolaos Tsilimparis (NT): Supervision, methodology validation, critical revision of the manuscript, and final approval. Tamer Khafagy (TK): Data interpretation, manuscript editing, and final approval. Jan Stana (JS): Methodology, manuscript review, and final approval. Nikolaos Konstantinou (NK): Manuscript review, and final approval. Maximilian Pichlmaier (MP): Revision of the manuscript and final approval. Mohamed Shokri AbdelGawad (MSA): Supervision, manuscript review, and final approval. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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ABBREVIATIONS

AD = Aortic Dissection
ASA = American Society of Anesthesiologists
CFA = Common Femoral Artery
CIA = Common Iliac Artery
CO = Cardiac Output
Cr = Creatinine
CSB = Carotid Subclavian Bypass
CT = Coeliac Trunk
CTA = Computed Tomography Angiography
eGFR = estimated Glomerular Filtration Rate
EVAR = Endovascular Aneurysm Repair
FEVAR = Fenestrated EVAR
ICU = Intensive Care Unit
LRA = Left Renal Artery
LCC = Left Common Carotid
LSA = Left Subclavian Artery
MI = Myocardial Infarction
MuVIT = Munich Valsalva Implantation Technique
PETTICOAT = Provisional Extension To Induce Complete Attachment
PTA = Percutaneous Transluminal Angioplasty
PTFE = Polytetrafluoroethylene
RRA = Right Renal Artery
SCI = Spinal Cord Ischemia
SFA = Superficial Femoral Artery
SMA = Superior Mesenteric Artery
TEVAR = Thoracic Endovascular Aortic Repair
TIA = Transient Ischemic Attack

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TABLES AND FIGURES

	N=52
Demographics	
Age (y)	62.7 ± 10.5
Sex (Male)	42 (80.8%)
BMI (kg/m^2)	27.5 ± 4.5
Baseline characteristics	
Hypertension	33 (63.5%)
CAD	9 (17.3%)
Dyslipidemia	10 (19.2%)
Smoker	11 (21.2%)
COPD	4 (7.7%)
Diabetes Mellitus	1 (1.9%)
Renal impairment	2 (3.8%)
Dialysis	1 (1.9%)
Serum Cr (mg/dL)	1.0 (0.8 – 1.3)
eGFR (mL/min/1.73m^2)	71 (54 – 89)
Stroke/TIA	2 (3.8%)
PAD	3 (5.8%)
Previous AAA open repair	1 (1.9%)
Previous EVAR	2 (3.8%)
Medication	
Aspirin	19 (36.5%)
Clopidogrel	4 (7.7%)
Warfarin	2 (3.8%)
DOAC	5 (9.6%)
Beta-blockers	22 (42.3%)

Table 1. Demographics and baseline characteristics of the study cohort.

AAA: Abdominal Aortic Aneurysm, BMI: Body Mass Index, CAD: Coronary Artery Disease, CKD: Chronic Kidney Disease, COPD: Chronic Obstructive Pulmonary Disease, Cr.: Creatinine, DOAC: Direct Oral Anticoagulant, eGFR: estimated Glomerular Filtration Rate, EVAR: Endovascular Aortic Repair, PAD: Peripheral Arterial Disease, TIA: Transient Ischemic Attack.

	N=52
Status	
Elective	38 (73.1%)
Urgent	14 (26.9%)
ASA score	
Class 2	2 (3.8%)
Class 3	35 (67.3%)
Class 4	15 (28.8%)
Preoperative details	
Type of dissection	
Residual Type A	9 (17.3%)
Type B	43 (82.7%)

Symptom/Dissection onset	
Acute	12 (23.1%)
Subacute	28 (53.8%)
Chronic	12 (23.1%)
Complicated	
Uncomplicated high risk	43 (82.7%)
Complicated	9 (17.3%)
Clinical malperfusion	11 (21.2%)
Radiological malperfusion	28 (53.8%)
Types of radiological malperfusion	
Renal	10
Mesenteric	6
Extremities	4
Multiple	8
Ascending aorta diameter (mm)	36 ± 8
Proximal landing zone diameter	31 ± 5
Distal landing zone diameter	30 ± 7
Bovine arch	2 (3.8%)
High angulation	1 (1.9%)
Severe iliac calcification	3 (5.8%)
Iliac tortuosity	5 (9.6%)

Table 2. Patient status and aortic dissection details.

ASA: American Society of Anesthesiologists.

	N=52
LSA Revascularisation	
Cervical debranching	32 (61.5%)
Left CSB	23
Other	9
Fenestration (In situ needle fenestration)	3 (5.8%)
Timing of debranching	
Before TEVAR	29 (93.5%)
During TEVAR	2 (6.5%)
Endovascular operative details	
Anesthesia (General)	48 (92.3%)
Percutaneous femoral access	31 (59.6%)
Intraoperative SBP reduction	30 (57.7%)
Controlled CO reduction:	15 (28.8%)
MuVIT	13
Drug-induced	1
IVC balloon occlusion	1
Spinal drainage	5 (9.6%)
Number of endografts/patient	1.8 ± 0.6
Scallop (LCC)	2 (3.8%)
Endograft proximal diameter (mm)	38 ± 5
Endograft distal diameter (mm)	33 ± 6
Endograft length (mm)	199 (159 – 233)
Additional procedures	16 (30.8%)
Additional aortic procedures	14 (26.9%)
LCC stent	1
CT stent	1
SMA angioplasty & stent + Left CIA stent	1
SMA PM fenestration & stent + Rt CIA stent	1
LRA stent	3
RRA stent	1
Rt CIA stent	1
PETTICOAT	1
PETTICOAT + LRA stent	1
Dissection flap fenestration & Rt CIA stent	1
Dissection flap electroseptotomy (cheese wire technique) + LRA stent	1
Pseudoaneurysm plug	1
Operative outcomes	

Technical success	51 (98.1%)
Endoleak at final angiography	2 (3.8%)
Persistent FL perfusion at final angiography	20 (38.5%)
Total operative time (mins)	123 (74 – 251)
Fluoroscopy time (mins)	19 (12 – 36)
Contrast dose (mL)	220 (150 – 310)
Radiation dose (cGy/cm^2)	914 (545 – 1861)
Immediate reintervention	5 (9.6%)
Aortic-related	2
Access-related	3
Hospital stay (days)	
ICU stay	2 (0 – 5)
Total hospital stay	12 (8 – 21)

Table 3. Operative details and hospital stay.

CO: Cardiac Output, CIA: Common Iliac Artery, CSB: Carotid Subclavian Bypass, CT: Coeliac Trunk, CTA: Computed Tomography Angiography, FL: False Lumen, ICU: Intensive Care Unit, IVC: Inferior Vena Cava, LCC: Left Common Carotid, LRA: Left Renal Artery, MuVIT: Munich Valsalva Implantation Technique, PETTICOAT: Provisional Extension To Induce Complete Attachment, PM: Physician-modified, RRA: Right Renal Artery, SMA: Superior Mesenteric Artery, TEVAR: Thoracic endovascular Aortic Repair.

	N=52
30-day outcome	
Complications (n patients)	15 (28.8%)
Medical complications	
Respiratory	3 (5.8%)
Stroke/TIA	2 (3.8%)
SCI	3 (5.8%)
New-onset dialysis	1 (1.9%)
Access vessel complications	8 (15.4%)
Endoleak	2 (3.8%)
Persistent thoracic false lumen perfusion	18 (34.6%)
Serum Cr (mg/dL)	1.0 (0.8 – 1.2)
eGFR (mL/min/1.73m^2)	79 (54 – 93)
Reintervention	4 (7.7%)
Mortality	2 (3.8%)
30-day adverse events	11 (21.2%)
Follow up outcome	
Duration (months)	13.8 ± 7.2
Remodeling	
Positive	38 (73.1%)
Stable	12 (23.1%)
Negative	2 (3.8%)
Endoleak	1 (1.9%)
Persistent thoracic false lumen perfusion	12 (23.1%)
Reintervention	9 (%)
Aortic-related	8
FL occlusion	4
FEVAR	3
Post dissection AAA	1
Mortality	5 (9.6%)
Aortic-related	1
During open repair for AAA	1

Table 4. 30-day and follow-up outcomes.

AAA: Abdominal Aortic Aneurysm, Cr: Creatinine, eGFR: estimated Glomerular Filtration Rate, FEVAR: Fenestrated Endovascular Aneurysm Repair, FL: False Lumen, SCI: Spinal Cord Ischemia, TIA: Transient Ischemic Attack.

	Event		p value
	Positive	**Negative**	
30-day reintervention	**4**	**48**	
Beta-blocker intake	0	22 (45.8%)	.008
30-day mortality	**2**	**50**	
Complicated	2 (100%)	7 (14%)	.027
30-day adverse events	**11**	**41**	

BMI	30.8 ± 4.9	26.0 ± 3.5	.003
Complicated	5 (45.5%)	4 (9.8%)	.014
Clinical malperfusion	5 (45.5%)	6 (14.6%)	.041
Urgent setting	7 (63.6%)	7 (17.1%)	.005
Beta-blocker intake	4 (36.4%)	18 (43.9%)	.049
Percutaneous femoral access	10 (90.9%)	21 (51.2%)	.034
Positive remodeling	**38**	**14**	
Dyslipidemia	4 (10.5%)	6 (42.9%)	.016
Follow-up reintervention	**9**	**43**	
Dyslipidemia	5 (55.6%)	5 (11.6%)	.008
Positive remodeling	4 (44.4%)	34 (79.1%)	.048
Follow-up aortic reintervention	**8**	**44**	
Dyslipidemia	5 (62.5%)	5 (11.4%)	.004
Additional procedures	0	16 (36.4%)	.047
Follow-up mortality	**5**	**47**	
Intraoperative debranching	2 (40%)	0	.022
Total operative time	294 (238 – 412)	110 (72 – 176)	.014
Fluoroscopy time	42 (34 – 58)	18 (11 – 35)	.030
Contrast dose	377 (313 – 443)	200 (150 – 300)	.010
Persistent FL perfusion at discharge	4 (80%)	14 (29.8%)	.043

Table 5. Univariate analysis of significant factors associated with different outcomes.

BMI: Body Mass Index, FL: False Lumen.

	Acute (N=12)	**Subacute (N=28)**	**Chronic (N=12)**	p value
Age (y)	62.6 ± 13.2	61.9 ± 10.1	64.3 ± 9.1	.830
Sex (Male)	9 (75%)	24 (85.7%)	9 (75%)	.620
Dissection onset to TEVAR (median, range, days)	5 (14)	42 (75)	150 (509)	.001
Urgent setting	7 (58.3%)	5 (17.9%)	2 (16.7%)	.020
Complicated	5 (41.7%)	2 (7.1%)	2 (16.7%)	.030
Controlled CO reduction	9 (75%)	18 (64.3%)	3 (25%)	.027
PLZ diameter	33.1 ± 5.1	33.1 ± 4.1	28 ± 5.4	.031
DLZ diameter	28.2 ± 4.2	28.9 ± 8.3	32.4 ± 8.2	.353
Total operative time	100 (90 – 140)	300 (166 – 350)	76 (60 – 150)	.006
Fluoroscopy time	16 (12 – 19)	42 (19 – 61)	16 (7 – 22)	.010
Radiation dose	759 (478 – 1009)	1237 (611 – 2264)	1570 (447 – 7150)	.234
Contrast dose	227 (150 – 303)	300 (170 – 400)	174 (104 – 263)	.064
30-day outcomes				
ICU stay (days)	5 (3 – 14)	2 (1 – 3)	0 (0 – 1)	.001
Total hospital stay (days)	20 (12 – 24)	10 (8 – 15)	8 (5 – 16)	.067
Medical complications	5 (41.7%)	6 (21.4%)	4 (33.3%)	.401
Type of complications				
Respiratory	1 (8.3%)	0	2 (16.7%)	.106
Stroke/TIA	1 (8.3%)	1 (3.6%)	0	.566
SCI	1 (8.3%)	2 (7.1%)	0	.614
New dialysis	0	1 (3.6%)	0	.646
Access complications	2 (16.7%)	4 (14.3%)	2 (16.7%)	.972
Persistent FL perfusion	4 (33.3%)	9 (32.1%)	5 (41.7%)	.840
Reintervention	1 (8.3%)	2 (7.1%)	1 (8.3%)	.987
Mortality	1 (8.3%)	1 (3.6%)	0	.566
30-day adverse events	3 (25%)	5 (17.9%)	3 (25%)	.821
Follow up outcomes				
Remodeling				.125
Positive	6 (50%)	23 (82.1%)	9 (75%)	
Stable	6 (50%)	4 (14.3%)	2 (16.7%)	
Negative	0	1 (3.6%)	1 (8.3%)	
Persistent FL perfusion	3 (25%)	5 (17.9%)	4 (33.3%)	.558
Reintervention	2 (16.7%)	4 (14.3%)	3 (25%)	.712
Aortic-related	1	4	3	.513

Mortality	0	5 (17.9%)	0	.093
Aortic-related	0	1	0	.646

Table 6. Outcomes according to the onset of dissection.

CO: Cardiac Output, DLZ: Distal Landing Zone, FL: False Lumen, ICU: Intensive Care Unit, PLZ: Proximal Landing Zone, SCI: Spinal Cord Ischemia, TIA: Transient Ischemic Attack.

	Uncomplicated high risk N = 43	**Complicated N = 9**	p value
Age (y)	62.9 ± 10.0	61.8 ± 13.1	.775
Gender (Males)	34 (79.1%)	8 (88.9%)	.670
Urgent	7 (16.3%)	7 (77.8%)	.001
Total operative time (mins)	121 (72 – 241)	165 (117 – 299)	.254
Fluoroscopy time (mins)	21 (12 – 54)	18 (11 – 30)	.953
Radiation dose (cGy/cm^2)	774 (425 – 1596)	910 (571 – 1650)	.666
Contrast dose (mL)	253 (155 – 300)	305 (199 – 396)	.580
ICU stay (days)	2 (1 – 5)	3 (0 – 5)	.681
Hospital stay (days)	13 (8 – 22)	18 (11 – 22)	.533
Access complication	6 (14.0%)	2 (22.2%)	.615
Medical complications	9 (20.9%)	6 (66.7%)	.012
30-day reintervention	2 (4.7%)	2 (22.2%)	.134
30-day mortality	0	2 (22.2%)	.027
30-day adverse events	6 (14.0%)	5 (55.6%)	.014
Follow-up Remodeling			.220
Positive	33 (76.7%)	4 (44.4%)	
Stable	8 (18.6%)	5 (55.6%)	
Negative	2 (4.7%)	0	
Follow-up reintervention	7 (16.3%)	2 (22.2%)	.645
Aortic-related	7	1	1.000
Follow-up mortality	5 (11.6%)	0	.573
Aortic-related	1	0	1.000

Table 7. Outcomes in uncomplicated high-risk versus complicated aortic dissection.

ICU = Intensive Care Unit.

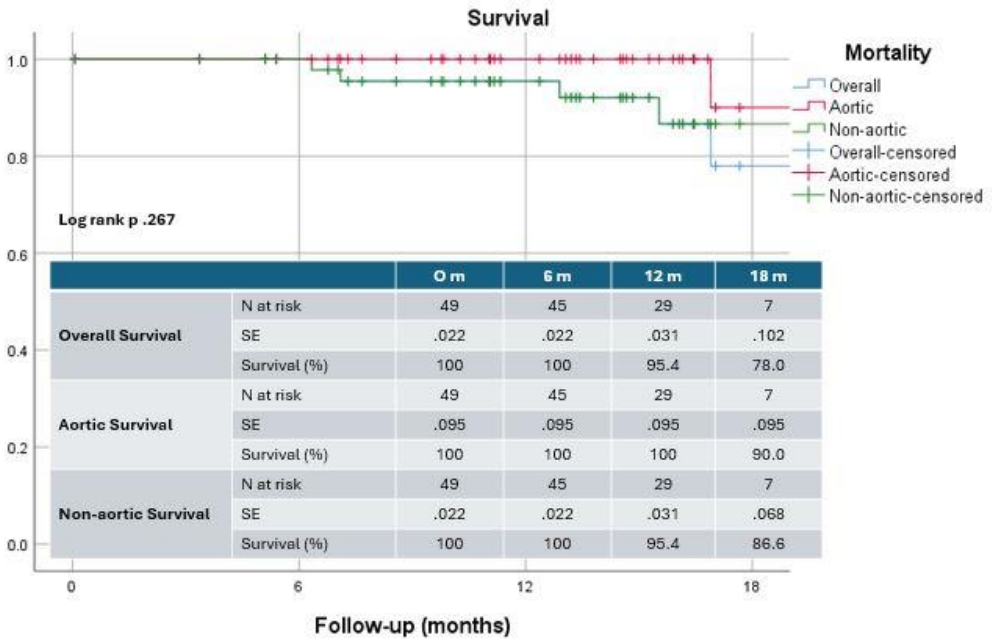
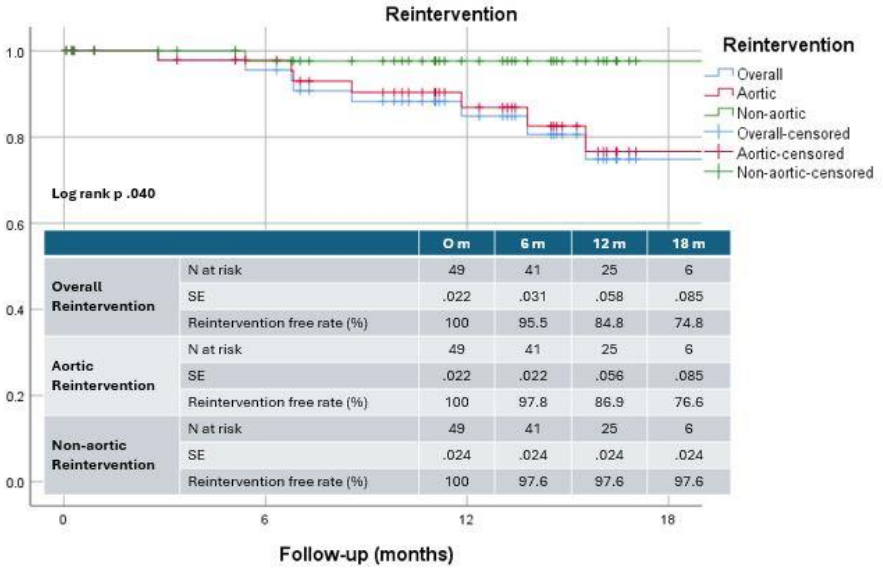


Figure 1. Kaplan–Meier curves for overall survival and aortic-related survival.



		0 m	6 m	12 m	18 m
Overall Reintervention	N at risk	49	41	25	6
	SE	.022	.031	.058	.085
	Reintervention free rate (%)	100	95.5	84.8	74.8
Aortic Reintervention	N at risk	49	41	25	6
	SE	.022	.022	.056	.085
	Reintervention free rate (%)	100	97.8	86.9	76.6
Non-aortic Reintervention	N at risk	49	41	25	6
	SE	.024	.024	.024	.024
	Reintervention free rate (%)	100	97.6	97.6	97.6

Figure 2. Kaplan–Meier curves with freedom from overall and aortic-related reinterventions.

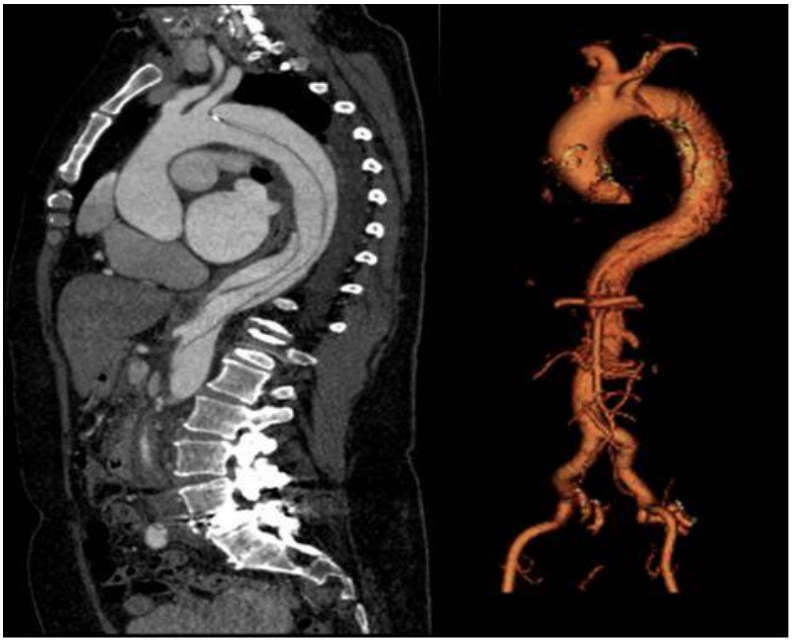


Figure 3. Preoperative CT scan of a patient with type B aortic dissection.

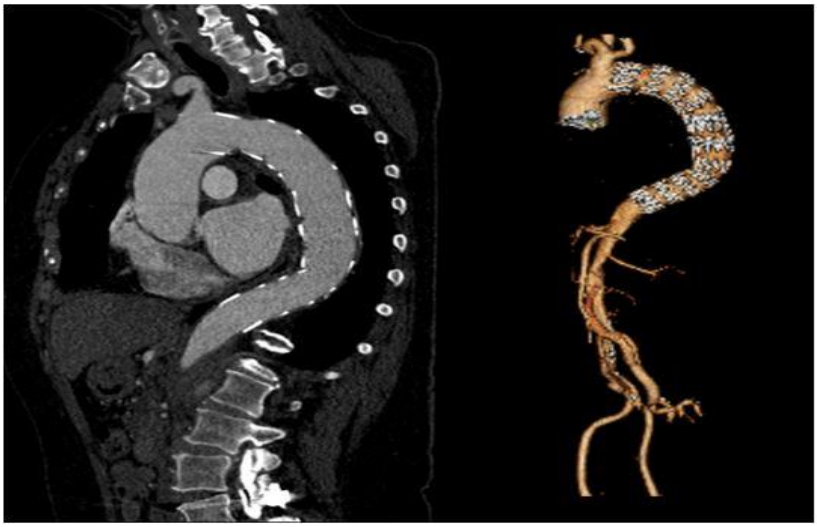


Figure 4. Six-month follow-up CT scan with positive remodeling.