Outcome of thoracic endovascular aortic repair in complicated type-B dissections

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Background
Complicated type-B dissections are catastrophic aortic lesions. Thoracic endovascular aortic repair (TEVAR) is less invasive than open surgery in treating these lesions. Morbidity and mortality are less in TEVAR than in surgery. The anatomical and clinical suitability need to be assessed in each patient. Institutional experience may also influence the outcome.
Purpose
The aim of this study was to evaluate the efficiency and safety of TEVAR in treating complicated type-B-dissection patients. These results are also compared between DeBakey type-IIIa and type-IIIb dissections.
Patients and methods
This is a prospective, nonrandomized, dual-center cohort study. Fifteen patients with complicated type-B aortic dissections were treated with TEVAR. The study was performed in two tertiary referral centers. It began in July 2015 and ended in May 2017. Six of the 15 patients suffered from DeBakey IIIa dissections, while nine of the 15 patients suffered from DeBakey IIIb dissections. The dissection onset was acute in one (6%) patient, subacute in two (13%) patients, and chronic in 12 (80%) patients. Follow-up computed tomography angiography was done 1 month, 6 months, and 1 year after the procedure.
Results
All-cause and aorta-specific mortality were both 0%. TEVAR caused false lumen thrombosis in 87% of cases. The endograft patency rate was 100%. The aortic diameter did not increase further in 87%. Device migration did not occur in any patient. Type IA endoleak occurred in one (6%) patient. Postimplantation syndrome occurred in one (6%) patient. Groin-wound infection occurred in one (6%) patient. A groin hematoma occurred in two (13%) patients. No strokes, paraplegia, or retrograde type-A dissections occurred.
Conclusion
TEVAR leads to excellent aorta-specific survival and delayed disease progression. TEVAR is safe and efficient in treating complicated type-B aortic dissection. There are no differences between DeBakey IIIa and IIIb dissections in the safety and efficiency of TEVAR.

Keywords:
aortic dissection, stent graft, thoracic endovascular aortic repair, type B

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Introduction

The mortality rate of acute type-B aortic dissections ranges from 10 to 70% in the first 30 days [1]. Stanford type-A dissections include the ascending aorta, while type B originates in the descending aorta. The DeBakey classification further divides descending aortic dissections into class IIIa, which terminates above the diaphragm, and class IIIb, which extends below the diaphragm.

Thoracic endovascular aortic repair (TEVAR) is indicated in complicated type-B aortic dissections. Malperfusion of viscera, kidneys, or extremities is the most common complication. Complications, including rupture, impending rupture, aneurysm more than 4.5 cm, or rapid expansion, are obvious indications for TEVAR. Patients with uncontrolled hypertension, persistent abdominal pain, or chest pain are also considered for TEVAR.

Optimal medical therapy is the treatment of choice in uncomplicated type-B dissections [2]. About 70% of type-B dissections are uncomplicated. Antihypertensive and anti-impulse medications lower the 30-day mortality to 10%.

Uncomplicated type-B dissections with radiologic predictors of complications should be considered for TEVAR [3]. The predictors include partially thrombosed false lumen, false lumen diameter more than 22 mm, elliptic true lumen combined with round false lumen, single-entry tear, and entry tear size more than 10 mm, entry tear at the concavity of the distal aortic arch. All of these findings seem to pressurize the false lumen.

Patients and methods

Study design

This is a prospective, nonrandomized, dual-center cohort study. Ethics approval of the study protocol was obtained from the Ethical Committee of the Faculty of Medicine at Cairo University Hospital. Committee's reference number is not applicable. The need for informed consent to participate in this study was waived due to the retrospective nature of the study. The primary outcome is the all-cause mortality. The secondary outcomes are aorta-specific mortality, complications, and further increase in aortic diameter.

Study population

Fifteen patients with complicated type-B aortic dissection were selected for repair according to the guidelines and criteria of the Society for Vascular Surgery and the International Society for Cardiovascular Surgery [4]. They were treated with TEVAR in the period from July 2015 to May 2017. Six of the 15 patients suffered from DeBakey IIIa dissections, while nine of the 15 patients suffered from DeBakey IIIb dissections.

Inclusion criteria are organ or limb malperfusion, intractable pain, aneurysm of 55 mm or more, intractable hypertension, and impending rupture. Exclusion criteria are a collagen vascular disease, a proximal landing zone less than 2 cm or containing a mural thrombus, and an aortic arch more than 44 mm in diameter or containing a mural thrombus or a dissection membrane.

Planning

Demographic data collection, laboratory investigations, and radiological assessment were done for all patients. TEVAR was planned using computed tomography (CT) angiography with three-dimensional reconstructions of 1-mm slices. Image-processing techniques allowed proper measurements. The scans included the pathology itself, the ascending aorta, origin of supra-aortic trunks, aortic arch, descending and abdominal aorta, and access vessels.

Stent grafts were oversized by 10% of the proximal landing zone to obtain optimal sealing. The stent grafts were chosen long enough to cover the primary entry tear and allow re-expansion of the true lumen. Excessive lengths were avoided to preserve the origins of the intercostal arteries to avoid paraplegia. The diameters are shown in Table 1.

The E-vita (Jotec, Hechingen, Germany) stent graft has an innovative release system that provides full control and deployment accuracy. It was selected for patients with tortuous thoracic aortas. A tapered form of this device was selected for patients with discrepancies in the diameters of the proximal and distal landing zones. The Zenith TX2 (Cook Inc., Bloomington, Indiana, USA) stent-graft delivery system has a hydrophilic coating and is very flexible. It was chosen for patients with tortuous iliac arteries. The Valiant (Medtronic, Minneapolis, Minnesota, USA) stent graft has a special Xcelerant technology-releasing system. This allows a deployment that is precise and stable in cases with severe angulation of the aortic arch. The Gore TAG (W.L. Gore & Associates, Flagstaff, Arizona, USA) stent graft is deployed from the middle outward to decrease its deployment time. Strong aortic flow forces may distort and displace the endograft during deployment. It was selected to avoid stent-graft misplacement in patients with intractable hypertension.

Procedure

All patients received general anesthesia. Respiration was arrested during stent-graft deployment. Heparin 5000 IU and broad-spectrum antibiotics were

Table 1 Morphological criteria

Cases	DeBakey type	Proximal landing-zone diameter (mm)	Distal landing-zone diameter (mm)	Maximum transverse diameter (mm)
1	IIIb	30	23	61
2	IIIa	36	31	52
3	IIIb	29	21	63
4	IIIa	37	33	64
5	IIIb	32	27	62mm
6	IIIb	33	24	78
7	IIIa	37	29	80
8	IIIa	36	32	45
9	IIIb	32	23	50
10	IIIa	38	34	76
11	IIIa	39	31	73
12	IIIb	30	24	65
13	IIIb	34	28	58
14	IIIb	31	23	53
15	IIIb	35	29	62
P value		0.001	0.002	0.479

administered before insertion of the stent graft. A spinal needle lumbar puncture was done before induction of general anesthesia. About 10 ml of cerebrospinal fluid were aspirated from all patients. Paraplegia was prevented by maintaining a mean intraoperative blood pressure between 90 and 100 mmHg. Anemia was corrected. Naloxone, steroids, barbiturates, mannitol (12.5 g), and oxygen were given. Vasodilators were avoided because they steal perfusion from the spinal cord.

Wire access was gained into the true lumen. The primary entry tear was covered with the endograft. The true lumen re-expanded restoring distal aortic blood flow. The proximal landing zone was ballooned only if endoleak occurred. Rapid reversal of the general aaesthesia and the muscle relaxant was performed to assess the patient for paraplegia in the operating room before transfer to the ICU. Lumbar cerebrospinal fluid-drain insertion in the operating room is necessary if there are signs of paraplegia.

Postprocedure

Recovery after TEVAR was quick. All patients spent at least 24 h in the ICU after the procedure. Blood pressure was optimized and comorbidities were controlled. The median systolic pressure of 130 mmHg was achieved using the intravenous beta-blockers atenolol and metoprolol. The calcium-channel blocker verapamil was also used. Hypotension was avoided for fear of paraplegia. Most patients were mobilized early.

Follow-up CT scans were done 1 month after the procedure, 6 months, 12 months, and annually thereafter. All patients were maintained on clopidogril 75 mg once daily and simvastatin 40 mg once daily after the procedure.

Statistical analysis

The data were statistically described in terms of means, medians and ranges, or frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Mann–Whitney *U* test for independent samples because of the small-sample size of each group. χ^2 test was performed for comparing categorical data. Exact test was used when the expected frequency was less than 5. Two-sided *P* values less than 0.05 were considered statistically significant. Statistical calculations were done using the computer program IBM SPSS (Statistical Package for the Social Science; IBM Corp., Armonk, New York, USA) release 22 for Microsoft Windows.

Results

The baseline characteristics of the patients are shown in Table 2. DeBakey IIIa-dissection patients were older than type-IIIb patients. There was a high prevalence of hypertension and hyperlipidemia in both types. Many of the patients in both types were smokers. The indications for TEVAR are shown in Table 3. These indications were all present on initial admission of the patients. Multiple indications were present in nine (60%) patients. There were no malperfusions in the type-IIIa group because the dissections ended proximal to the visceral aortic branches.

The mean length of the aorta covered by the stent graft was 172 mm. One stent graft was used for every patient. The E-vita stent graft was used in five (33%) patients. The Zenith TX2 stent graft was used in another five (33%) patients. The Valiant stent graft was used in four (27%) patients. The Gore TAG stent graft was used in one (0.07%) patient. Device selection is shown in Table 4. The proximal landing was in zone 2 in seven

Table 2 Timing of presentation and demographics

	DeBakey IIIa (*N*=6) [*n* (%)]		DeBakey IIIb (*N*=9) [*n* (%)]		*P* value
Acute (first 14 days)	1	16	0	0	0.405
Subacute (14–90 days)	1	16	1	11	0.405
Chronic (after 90 days)	4	66	8	89	0.405
Mean age	74 (63–82)		62 (55–76)		0.000
Male sex	5	83	7	78	0.693
Hypertension	4	66	7	78	0.905
Hyperlipidemia	3	50	6	67	0.914
Diabetes mellitus	1	17	2	22	0.693
Ischemic heart disease	2	33	2	22	0.905
Active smoking	3	50	4	44	0.751
Pulmonary disease	1	16	2	22	0.693
Peripheral vascular disease	2	33	2	22	0.905

Table 3 Indications for thoracic endovascular aortic repair

Presentations	DeBakey IIIa (*N*=6) [*n* (%)]		DeBakey IIIb (*N*=9) [*n* (%)]		*P* value
Visceral malperfusion	0	0	1	11	0.833
Lower-limb ischemia	0	0	2	22	0.642
Renal malperfusion	0	0	1	11	0.833
Intractable pain	2	33	3	33	0.576
Aneurysmal dilatation	3	50	7	78	0.914
Intractable hypertension	0	0	6	67	0.041
Impending rupture	2	33	0	0	0.278

Table 4 Device selection

Cases	DeBakey type	Type	Proximal landing	Proximal diameter (mm)	Distal diameter (mm)	Length
1	IIIb	Zenith TX2	Zone 3	32	32	150
2	IIIa	Zenith TX2	Zone 3	40	40	170
3	IIIb	Evita	Zone 3	33	25	150
4	IIIa	Evita	Zone 1	40	36	170
5	IIIb	Evita	Zone 2	36	33	170
6	IIIb	Valiant	Zone 2	36	36	207
7	IIIa	Evita	Zone 1	38	30	170
8	IIIa	Zenith TX2	Zone 2	40	40	170
9	IIIb	Valiant	Zone 2	36	36	207
10	IIIa	Valient	Zone 3	42	42	200
11	IIIa	Evita	Zone 2	42	34	170
12	IIIb	TAG	Zone 3	32	32	150
13	IIIb	Zenith TX2	Zone 2	38	38	170
14	IIIb	Valiant	Zone 2	35	35	150
15	IIIb	Zenith TX2	Zone 3	40	40	170
P value		0.599	0.599	0.004	0.235	0.332

(47%) patients (Fig. 1), zone 3 in six (40%) patients (Fig. 2), and zone 1 in two (13%) patients (Figs 3 and 4). This was to achieve a minimum healthy proximal landing zone of 20 mm. No left subclavian to left common carotid arterial transpositions or bypasses were performed. Aortic arch zone 1 is at the left common carotid origin, zone 2 is at the left subclavian origin, and zone 3 is just distal to the left subclavian origin.

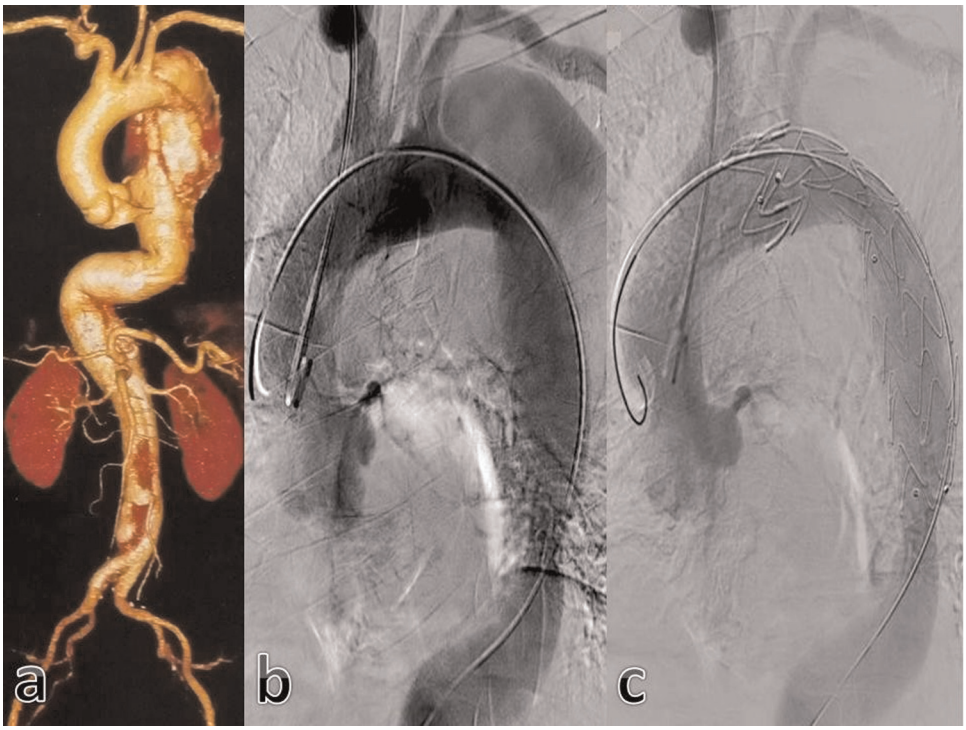
Procedures

The mean of duration of the procedure was 2±0.5 h. The estimated blood loss was 100±50 ml. None of the patients needed intraoperative blood transfusion. A Pigtail catheter was introduced in a 6-F sheath in the right brachial artery in five (33%) patients due to dissection or unfavorable anatomy of the contralateral femoral artery. The endograft was introduced from the right groin in 13 (87%) cases and from the left groin in two (13%) cases.

Extra-anatomical debranching of the aortic arch was done in two (13%) patients (shown in Figs 3 and 4). The proximal landing was in zone 1 in these patients because of the proximal location of their primary entry tears. The ostia of their left common carotid and left subclavian arteries were covered by the endograft. This provided a healthy sealing zone of at least 20 mm. Carotid–carotid pretracheal bypasses were created using 8-mm ringed PTFE grafts (shown in Figs 3d and 4d). They were staged 2 weeks before TEVAR in both patients. This delay was well-tolerated due to the chronic nature of their dissections. The proximal left common carotid arteries were ligated from the neck incisions in both patients to prevent competitive flow and type-II endoleak (shown in Figs 3b and 4b). The origins of the left subclavian arteries were covered by the endograft without ligation, plugging, or coiling of their origins. This caused no type-IA or type-II endoleaks on completion angiography and on follow-up CT angiography (shown in Figs 3c and 4c). They had no upper-limb ischemic symptoms.

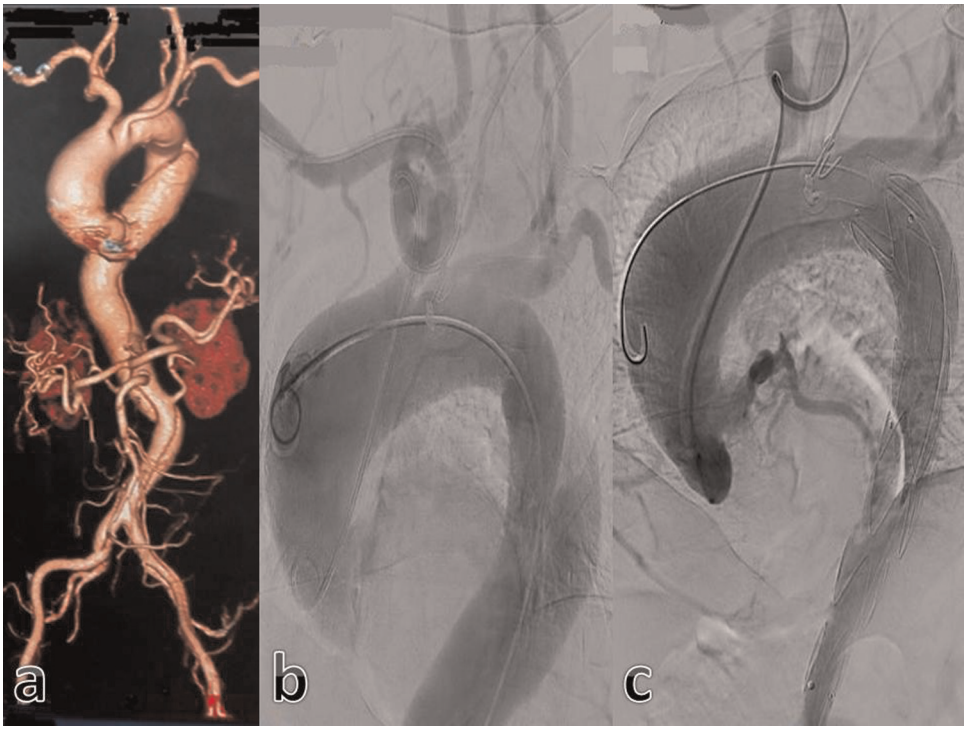
The malperfusion resolved upon covering of the primary entry tear in the two (13%) patients that had lower-limb ischemia, in the patient (6%) that had renal ischemia, and in the patient (6%) that had visceral ischemia. This was due to redirection of the blood flow from the false to the true lumen causing re-expansion of the true lumen and collapse of the false

Figure 1



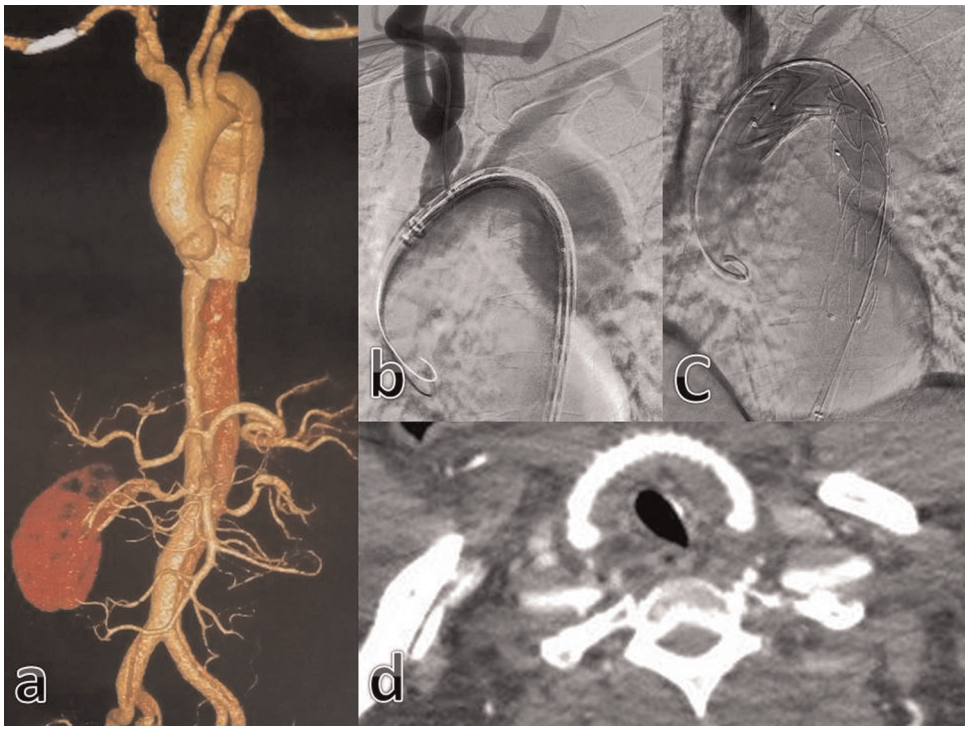
One of the patients with proximal landing in zone 2. (a) The preoperative CT 3D reconstruction of the aorta showing the dissection. (b). The predeployment angiogram showing the true and false lumens. (c) The postdeployment angiogram showing exclusion of the false lumen while covering the origin of the left subclavian artery. 3D, three dimensional; CT, computed tomography.

Figure 2



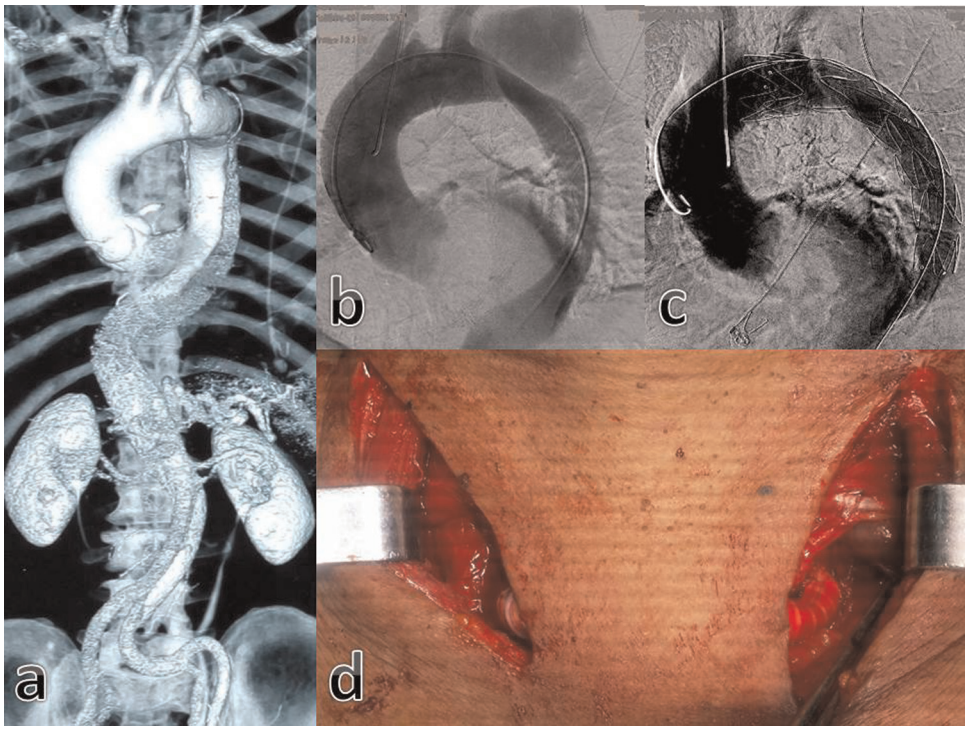
One of the patients with proximal landing in zone 3. (a) The preoperative CT 3D reconstruction of the aorta showing the dissection. (b) The predeployment angiogram showing the true and false lumens. (c) The postdeployment angiogram showing exclusion of the false lumen without covering the origin of the left subclavian artery. 3D, three dimensional; CT, computed tomography.

Figure 3



The first patient with proximal landing in zone 1. (a) The preoperative CT 3D reconstruction of the aorta showing the dissection. (b) The predeployment angiogram showing the carotid–carotid bypass and the ligated left common carotid artery. (c) The postdeployment angiogram showing exclusion of the false lumen. (d) A coronal CT image showing the pretracheal carotid–carotid bypass. 3D, three dimensional; CT, computed tomography.

Figure 4



The second patient with proximal landing in zone 1. (a) The preoperative CT 3D reconstruction of the aorta showing the dissection. (b) The predeployment angiogram showing the ligated left common carotid artery. (c) The postdeployment angiogram showing exclusion of the false lumen. (d) An intraoperative photograph showing the two ends of the pretracheal carotid–carotid bypass in the two longitudinal neck incisions. 3D, three dimensional; CT, computed tomography.

Table 5 Morbidity

Complications	Debakey IIIa (*N*=6) [*n* (%)]		DeBakey IIIb (*N*=9) [*n* (%)]		*P* value
Endoleak type IA	1	16	0	0	0.833
Postimplantation syndrome	0	0	1	11	0.833
Wound infection	0	0	1	11	0.833
Groin hematoma	1	16	1	11	0.642

lumen. The dissections at the ostia were dynamic and not static. No fenestrations or stenting of the ostia were needed to correct the malperfusion.

One (6%) patient showed type-IA endoleak upon completion angiography that resolved by inflation of the proximal landing zone by a 40-mm Cauda aortic balloon.

Postoperative complications

One (6%) patient developed postimplantation syndrome. He suffered from mild fever, headache, leukocytosis, and elevated acute-phase reactants. These manifestations resolved after 3 days of serial blood counts and nonsteroidal anti-inflammatory medications. There was no growth in his blood culture. The right-groin cut-down incision showed superficial infection in one (6%) patient. It was treated by debridement, antibiotics, and repeated dressings. Small hematomas developed in the right groins of two (13%) patients. They resolved with medical treatment only. None of the 15 patients developed postoperative stroke, paraplegia, or device migration, or retrograde type-A dissection. No reinterventions were needed for any of the patients. The complications of the procedures are shown in Table 5.

Follow-up

Follow-up CT angiography was done 1, 6, and 12 months postimplantation for all patients. They had no dissection-related complications. There were no aorta-specific or all-cause mortalities. All endografts were patent. There were no device migrations. Partial thrombosis of the false lumen occurred in two (13%) patients, both were DeBakey IIIb. Further aortic growth was less than 5 mm per year in these patients. Complete thrombosis with no further increase in aortic diameter occurred in 13 (87%) patients.

Discussion

TEVAR is a safe and effective treatment for type-B dissections. It has lower morbidity and mortality than open repair [5–7] and this increased the indications for intervention. Repair is indicated for all patients with complicated type-B dissection manifested by impending rupture, uncontrolled hypertension, malperfusion syndrome, or unrelenting pain [8]. The indications for intervention in patients with uncomplicated dissection are less obvious but include aneurysmal degeneration and rapid expansion (>5 mm/6 months). The treatment of choice for patients with uncomplicated type-B dissection is medical management.

Optimal medical therapy is control of blood pressure and comorbidities. It does not have optimal results [8]. It fails in 20–40% of patients, leading to aneurysmal degeneration or aortic rupture requiring surgery [9]. In the Investigation of Stent-grafts in Aortic Dissection (INSTEAD) study, 20.6% of patients treated medically were converted to endovascular or surgical treatment due to aortic dilatation more than 6 cm [9].

Two (13%) of our patients complained of ischemic claudication pain due to involvement of their iliac arteries in the dissection. They improved substantially after closing the primary tear and thrombosis of false lumen. In a case series of 325 patients, Cambria *et al*. [10] reported a similar figure of 12% presenting with leg ischemia of varying severity. Ischemia resolved after central correction of dissection in 50% of patients, it resolves spontaneously before intervention in 13% of patients. Leg ischemia was a marker of extensive nature of dissection because 70% died before intervention.

The primary goal of TEVAR is thrombosis of the false lumen with re-expansion of the true lumen [11,12]. This is attained by deploying the stent graft across the proximal intimal tear diverting blood flow away from the false lumen into the true lumen.

Type-IA endoleak occurred in one (6%) of our patients. It was evident on completion angiography. The dye leaked around the proximal end of the graft, entered the tear, and filled the false lumen. It resolved by ballooning of the proximal end of the graft,

achieving proper sealing. This event occurred in a case using Zenith TX2 stent graft. One (6%) patient developed postimplantation syndrome. It resolved with supportive treatment after 3 days. Mild groin hematoma occurred at common femoral artery surgical exposure site in two (13%) cases. They resolved by conservative treatment. There was a superficial groin infection in one of the cases. It was cured by antibiotics and dressings.

Early endoleak was 26% in the VALOR trial, 3.6% in the TAG study, and 4.8% in the STARZ study and in the European collaborators on Stent-graft Techniques for abdominal aortic Aneurysm Repair (EUROSTAR) registry. Endoleaks were present in 4% of TAG and TX2 patients and in 12% of Talent patients after 1 year of follow-up. In the TAG study, ~4% of patients continued to have an endoleak for 5 years [13]. Endoleaks are less with second-generation and third-generation devices that have better conformability. The TAG study reported a majority of type-I and type-III endoleaks. The other two studies had a majority of type-II endoleaks [14].

Fortunately, we had no mortality, stroke, paraplegia, or incidence of retrograde type-A dissections in our study. We used oversizing of only 10% to balance between adequate sealing and avoiding retrograde type-A dissection. About 40-mm or larger endografts were deployed in six (40%) of our patients. An ascending-aorta diameter of more than 40 mm is a predictor of retrograde type-A dissections. It shows a higher incidence of this complication (4.8 vs. 0.9%, P=0.047) [15]. The incidence of retrograde type-A dissections is greatly increased with the association of dissection and an ascending aortic diameter more than or equal to 40 mm. This incidence further increased to 25% when associated with using zone 0 as a proximal landing zone for the endograft.

In the European collaborators on Stent-graft Techniques for abdominal aortic Aneurysm Repair (EUROSTAR)/United Kingdom registry, 131 patients with aortic dissections were treated with stent grafts. These dissections were 5% proximal, 81% distal, and 14% not classified. The 30-day mortality was 8.4%, and the paraplegia rate 0.8% [16].

A meta-analysis of all early-published series of stent-graft repair for aortic dissection (prior to 2005) identified 609 patients. It reported a 30-day mortality rate of 5.3% and a neurologic complication rate of 2.9% [11]. A review of the Medicare population showed that between 2004 and 2007, the number of dissection patients treated with TEVAR increased fivefold. Their 30-day mortality was 9.1 versus 21% for surgery (P<0.0001) [17]. In an industry-sponsored trial with 19 acute type-B-dissection patients, 79% presented with rupture or malperfusion. Their 30-day mortality was 16%, their stroke rate was 21% but with no paraplegia [18]. The Study of Thoracic Aortic type B Dissection using Endoluminal Repair (STABLE) trial involved 40 patients. Their 30-day mortality was 5%, their stroke rate was 7.5%, and their paraplegia rate was 2.5% [19].The Society for Vascular Surgery Outcomes Committee reported the results of TEVAR in 85 patients with acute complicated type-B dissections from five centers. The 30-day mortality was 10.6%, the stroke rate was 9.4%, and the paraplegia rate was 9.4% [20].

The Investigation of Stent-grafts in Aortic Dissection (INSTEAD) was a prospective, randomized, multicenter trial performed in Europe. It compared stent grafting with medical therapy for the treatment of subacute or chronic, uncomplicated type-B aortic dissection. The study randomized 140 patients to medical or stent-graft therapy. There was no difference in 30-day mortality between the two groups. The 1-year mortality was higher in the TEVAR patients (3% medical vs. 8.7% TEVAR, P=0.16). False-lumen thrombosis occurred in 91.3% of patients in the stent-graft group, compared with 19.4% in the medically treated group (P<0.001) [21]. This remodeling decreases the 5-year mortality in the TEVAR group to 11.2% compared with 20.3% in the medically treated group.

Limitations of this study

The rate of stroke in our study was 0%. The rate of paraplegia was 0%. The mortality in our study was 0%. This is probably due to the small number of cases enrolled in our study and due to the chronic nature of their dissections. Most patients presented late due to delayed diagnosis and the lengthy process of obtaining financial coverage. These results may be also influenced by the short follow-up period of 1 year. These are all considered limitations to this study.

Conclusion

We remain strong proponents of treating type-B dissection with endovascular stent grafts combined with optimal medical management. TEVAR promotes postoperative false-lumen thrombosis.

TEVAR remains the treatment of choice for complicated type-B dissections. It has low morbidity

and mortality. Covering of the primary intimal tear redirects blood flow away from the false lumen and into the true lumen. This is usually sufficient to resolve malperfusion syndromes. We demonstrated no difference between DeBakey IIIa and IIIb dissections regarding the efficiency and safety of TEVAR.

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Conflicts of interest
There are no conflicts of interest.

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