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Original Article

Early and mid-term results of endovascular repair for type B aortic dissections: A single tertiary center experience

Gorkem Yigit[1], Gokay Deniz[2], Sabir Hasanzade[3], Murat Gevrek[2], Ayla Ece Celikten[1], Naim Boran Tumer[2], Anil Ozen[2], Hakki Zafer Iscan[2]

[1]Hitit University Erol Olçok Education and Research Hospital, Department of Cardiovascular Surgery, Çorum, Türkiye
[2]Ankara Bilkent City Hospital, Department of Cardiovascular Surgery, Ankara, Türkiye
[3]Memorial Ankara Hospital, Department of Cardiovascular Surgery, Ankara, Türkiye

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Abstract

Aim: The utility of thoracic endovascular aortic repair (TEVAR) in Type B Aortic dissections (TBAD) continues to advance at a growing rate. The purpose of this research was to investigate our management strategy and early-mid-term outcomes of endovascular procedures for TBAD, in a single tertiary center.
Material and Methods: Sixty-six eligible TBAD patients (2 hyperacute complicated, 12 acute complicated and 52 uncomplicated) were enrolled in this single-center, retrospective cohort study between January 2016 and January 2023. The endpoints of the study were technical success, early and late morbidity and mortality, reinterventions throughout the follow-up period, as well as late open conversion.
Results: Technical success was achieved in all cases. Early mortality was seen in only 3 patients (4.5%). Only patients with one hyperacute and two acute complicated TBAD (cTBAD) had early death. There was one late mortality in an acute cTBAD patient, who developed retrograde type A dissection two months after TEVAR. The median follow-up period was 26.1±13.7 months. Six reinterventions were performed for extension of dissection or covering the entries distally (9.1%). No endoleak, graft infection or migration were observed. Open surgical repair was performed; however, the patient did not survive.
Conclusion: Early results of TEVAR in elective TBAD is trouble-free. Carrying the patients to the subacute phase seems to be the most suitable timing for TEVAR. Anti-stimulus and anti-hypertensive treatment with surveillance programme is mandatory for this patient cohort. Pre-emptive TEVAR has satisfactory results; however, long-term results are mandatory for further recommendations.

Keywords: Endovascular aneurysm repair, Type B aortic dissection, endovascular procedures

INTRODUCTION

Stanford type B aortic dissection (TBAD) is an undoubtedly fatal pathology with a 30- 40% five-year death rate [1].

Optimal medical therapy (OMT) in the hospital's intensive care unit (ICU) is critical during the acute phase of TBAD. Complications such as intimal tear and false lumen enlargement, retrograde type A dissection (RTAD), and acute rupture may be reduced with this therapy. Nevertheless, thoracic endovascular aortic repair (TEVAR) should be applied in the event of malperfusion, persistent pain, or other major complications [2-4].

TEVAR is now routinely performed in complicated TBAD (cTBAD) [3]. Current guidelines recommend that OMT should

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Corresponding Author: Gorkem Yigit, Hitit University Erol Olçok Education and Research Hospital, Department of Cardiovascular Surgery, Çorum, Türkiye
Email: drgorkemyigit@gmail.com

be considered for uncomplicated cases (uTBAD). However, considering the long-term outcomes of OMT alone doesn't appear to be sufficient [4]. However, the ideal treatment for uTBAD still remains unclear. According to the existing literature, pre-emptive TEVAR should be applied especially in high-risk cases that may cause complications related to the aorta [3]. Guidelines also recommended that uTBAD should be constantly managed with OMT controlling heart rate and blood pressure alongside pain management (Class 1C evidence) [1-4].

The real-world experience showed 20-65% of TEVAR procedures involve zone 2 sealing and need coverage of left subclavian artery (LSA) [5-7]. Elective LSA revascularization is recommended prior to TEVAR to minimize neuro-ischemic complication rates. Revascularization of supra-aortic major branches in TEVAR has alternative treatment choices [8-10]. Every technique has its unique pros and cons; therefore, the choice of treatment mostly depends on the clinical experience of the vascular surgeons in charge. Our treatment of choice is the SMFSG for all suitable anatomies since 2020.

We decided to retrospectively investigate management strategies for all TBADs whether in the hyperacute, acute, subacute or chronic period and the early to mid-term outcomes in our single tertiary center.

MATERIAL AND METHODS

Study Design

Sixty-six eligible TBAD patients were enrolled in this single-center, retrospective cohort study, between January 2016 and January 2023. Clinical details of those who underwent TEVAR at our department were recorded using the hospital's electronic database and outpatient clinic notes (2 hyperacute complicated, 12 acute complicated TBAD and 52 uncomplicated TBAD patients). TBAD was diagnosed using computed tomography angiography (CTA) and the Stanford classification criteria. All patients who had a diagnosis of complicated/uncomplicated TBAD who were anatomically suitable were included in the study. Uncomplicated TBAD was defined as no refractory pain, no uncontrollable blood pressure despite OMT, no malperfusion, no aortic rapid expansion or rupture.

Our management algorithm in acute TBAD was shown in Figure 1. Medtronic Valiant Captivia (Medtronic, Santa Rosa, Calif), Lifetech Ankura™ TAA Stent Graft System (Lifetech, Shenzen, China) were deployed in all patients. The patients were divided into four groups depending on the time period between symptom onset and TEVAR: Hyperacute (first 24 hours n=2), acute (1-14 days; n=12), subacute (15-90 days; n=40), and chronic (>90 days; n=12). CTA scans of the aorta were conducted regularly for the TEVAR group within 30 days following the operation, at one, six, and twelve months, and yearly thereafter.

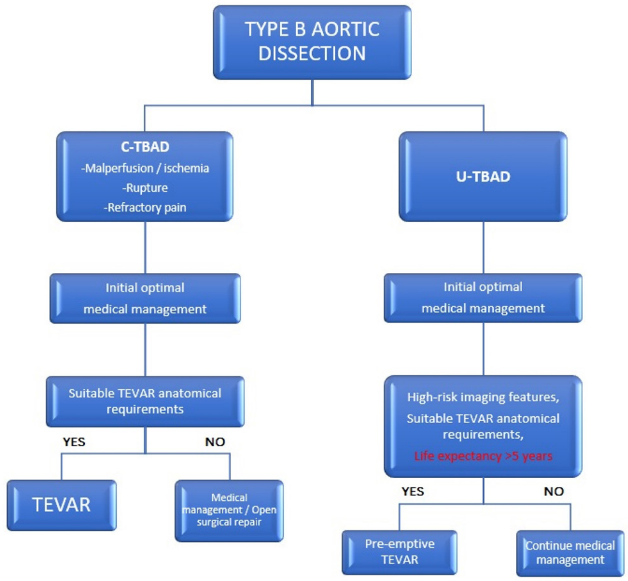

Figure 1. Management algorithm in acute TBAD. TBAD, type B aortic dissection; C-TBAD, complicated type B aortic dissection; U-TBAD, uncomplicated type B aortic dissection; TEVAR, thoracic endovascular aortic repair

All patients had high resolution multislice CTA preoperatively. A three-dimensional vascular imaging tool was used for procedure planning and device sizing (RadiAnt DiCOM viewer v2021.2(64 bit)). All the manual centerline measurements were made from the three-dimensional reconstructions of the CTA scans. The maximal aortic diameter, primary entry tear size, status of the false lumen, visceral arterial involvements, and extension of the dissection were evaluated. Clock position of each branch, diameter of the supra-aortic branches, and the distance between the branches were measured over the aortic axis in SMFSG patients. Total coverage of the aortic sealing zones was mandatory with an oversizing planned as 10-20%.

Ethical approval for this research was obtained from Ankara Bilkent City Hospital Clinical Research and Ethics Committee (14.05.2020/E1-20-603). Informed consent was obtained from all cases who were alive when this research was performed.

Operative Techniques

Standard TEVAR Procedure

The angiography suit was used for all TEVAR procedures. The same cardiovascular surgical team carried out all operations. The systemic arterial pressure was measured via a radial artery catheter. Anticoagulation was maintained throughout the operation by administering a heparin bolus (5,000 IU) at the onset of the femoral catheterization, with additional heparin when necessary to maintain an activation clotting time (ACT) of >200 sec. An anesthesiologist inserted the drainage set prophlactically if cerebrospinal fluid (CSF) drainage was required. Following TEVAR, the CSF pressure was kept between

8 and 10 cmH2O and was monitored for 24 to 72 hours. Due to the presence of TBAD, balloon angioplasty was not performed on the patients except on STABILISE technique patients. LSA or celiac artery may be sacrificed to provide an appropriate landing zone or assistive techniques may be performed for patency. In both landing zones, the stent graft diameter was 10% oversize than the descending aorta maximal dimension. For this reason, tapered or double tapered endografts were also used if available. LSA was covered with aortic extension in consideration, but no prophylactic or simultaneous revascularization was performed. When required, delayed LSA revascularization was carried out. Anesthesia management or a rapid pacing technique was used to maintain arterial blood pressure between 60 and 80 mmHg during the deployment. Rapid pacing technique was performed in four patients. A final angiogram was used to evaluate the stent graft positions and identify any immediate endoleaks or complication.

SMFSG Procedure

Previously published research has described the surgeon-modified fenestrated stent graft (SMFSG) technique [11]. The stent graft was unsheathed to approximately 4-5 cm for fenestration after the initial angiography of the aortic arch. With an 11-sized scalpel, the endograft material was fenestrated, and the struts were cauterized for any remaining fabric components. At least 10mm of graft material was left between the proximal side of the endograft and the fenestration to protect endograft integrity. After confirming that the fenestration was oriented toward the supra-aortic target area, the deployment was completed.

Follow up and Study Endpoints

CTA examinations were performed at 1, 6, and 12 months following surgery, as well as yearly thereafter. At regular intervals, patients underwent clinical and imaging evaluations. The endpoints of this study were technical success, early (30-day) and late morbidity and mortality, reinterventions throughout the follow-up period, as well as late open conversion following TEVAR.

Data and Statistical Analysis

The Kolmogorov-Smirnov test was used to examine the distribution of continuous variables. Non-normally distributed variables were expressed as median (range) and normally distributed variables as mean standard deviation (SD). Numbers and percentages were used to present categorical variables. Kaplan-Meier curves were generated to assess survival data. The Mann-Whitney U test and chi-square test were used to compare non-normally distributed demographic and perioperative characteristics. The log-rank test was performed to identify the differences between groups. The threshold for statistical significance was a p-value of ≤0.05. SPSS for Windows version 22.0 software was used for statistical analysis (SPSS Inc., Chicago, IL, USA).

RESULTS

Table 1 summarizes patients' baseline demographic and clinical characteristics. Overall, 55 (83.3%) patients were male, while 11 (16.7%) were female with a mean age of 56.2±7.9 years (range 49-82). The most common comorbidity/risk factor was hypertension (52 patients; 78.8%). The LSA was intentionally covered in ten (15.2%) patients, 2 (3%) of whom received carotid-subclavian bypass (CSB) immediately after the procedure because of a cerebrovascular event (CVE) and left arm ischemia. Mean deployed TEVAR graft length was 160±40 mm. For the initial TEVAR procedure 5 patients had two endografts (7.6%). A total of 10 patients (15.2%) underwent the SMFSG procedure (1 patient with acute, 9 patients with subacute or chronic TBAD), and 2 (3%) experienced Ch-TEVAR.

Table 1. Demographic and clinical patient characteristics

Features	n=66	(%)
Male gender	55	83.3
Female gender	11	16.7
Hyperacute TBAD	2	3
Acute TBAD	12	18.2
Subacute TBAD	40	60.6
Chronic TBAD	12	18.2
Hypertension	52	78.8
Diabetes mellitus	10	15.2
Chronic obstructive pulmonary disease	26	39.4
Hypercholesterolemia	34	51.5
Coronary artery disease	19	28.8
Chronic renal failure	3	4.5
Previous cerebrovascular event	2	3
Peripheral vascular disease	2	3
Elective cases	52	78.8
Emergency cases	14	21.2

TBAD: type B aortic dissection

On completion angiography, technical success was achieved in all cases, with no endoleaks. Early mortality was seen in only 3 patients (4.5%). Moreover, early mortality was observed only in patients with one hyperacute and two acute cTBAD. No early mortality was observed in the subacute and chronic uTBAD patients who had elective TEVAR. Distal stent graft induced new entry (SINE) development occurred in 1.5% of all cases.

Throughout the study period, one patient (1.5%) was lost to follow-up. The median follow-up period was 26.1±13.7 months (4-64 months). Six reinterventions were performed for extension of dissection or covering the entries distally (9.1%). The provisional extension to induce complete attachment (PETTICOAT) was performed in two patients (3%), STABILISE (stent-assisted balloon-induced intimal disruption and relamination in aortic dissection repair) in one (1.5%) patient and three standard

TEVAR extensions were performed. Open surgery was applied in two patients due to enlargement of the distal abdominal aorta (3%) in their 14th and 26th months of follow-up. No endoleak, graft infection or migration were observed. Complete thrombosis of false lumen was achieved in 26 patients (40.6%). One late mortality occurred in an acute cTBAD patient, who was in ASA status 4 during the initial procedure and who developed RTAD two months after TEVAR. Open surgical repair was performed; however, the patient did not survive. In total, six endovascular reinterventions and three open surgeries were carried out in the follow-up period in this patient cohort. Kaplan-Meier survival functions of complicated acute and uncomplicated subacute TBADs were given in Figure 2 (Log rank test p=0.014).

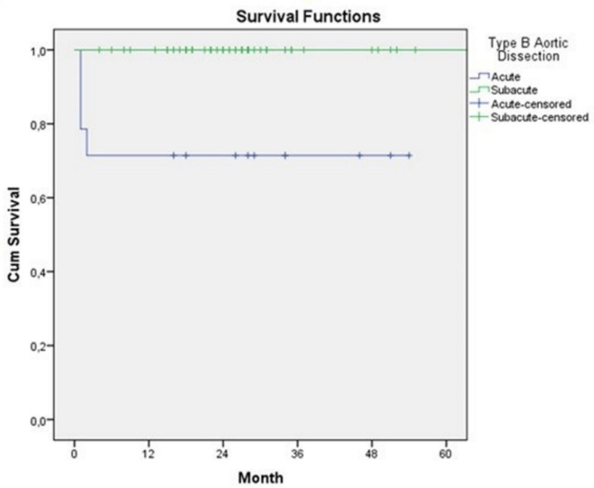

Figure 2. Survival functions of complicated acute and uncomplicated subacute TBADs

DISCUSSION

This study documents the outcomes of our patients with cTBAD at the acute period and the uTBAD patients who had pre-emptive TEVAR during subacute or chronic phase. Higher mortality and morbidity rates were compatible with the literature [4,12]. Our clinical principles in TBAD consists of cooling the fragile aorta to subacute period if possible, without malperfusion and perform TEVAR if there is high risk for aorta related complications in the subacute period where procedural morbidities are lower. Pre-emptive TEVAR should be applied especially in high-risk cases that may cause complications related to the aorta.

Survival rates after TEVAR in patients with TBAD were between 81.5% and 91.9% at one year and between 76% and 89.2% at five years [1,12-14]. Survival rates in medically treated individuals varied from 84% to 90.2% at one year and 60% to 86.8% at five years [1,12-14]. In our study, no mortality was observed in uTBAD cases during follow-up, while early and late mortality was observed only in hyperacute and acute cTBAD cases. Therefore, our findings are consistent with previous studies. As a consequence, the findings of our research are congruent with the findings of the INSTEAD trial, in which TEVAR increased survival for patients with uTBADs when compared to OMT alone [15].

Considering the risk of dissection progression while determining the clinical strategy in the management of TBAD, it is necessary to review TEVAR indications and develop patient-based strategies. The favorable outcomes were demonstrated by the outcomes of the ADSORB and INSTEAD-XL trials which showed that TEVAR of uTBADs in addition to OMT was related with enhanced five-year aorta-specific survival and delayed disease progression compared to OMT alone [15,16]. In particular, pre-emptive TEVAR may be appropriate in patients with high-risk features for uTBAD, such as refractory pain and/or hypertension, bloody pleural effusion, aortic diameter of >40 mm, evidence of malperfusion on imaging, entry tear on lesser curvature, or false lumen of >22 mm [3]. As the clinical strategy, OMT should be started immediately as the patient is admitted to the ICU. If there are no signs of malperfusion, the patient should be kept waiting until the subacute period, where operative and nonoperative complications seem to be the least and consecutive CTA examinations should be carried out. If there is a risk of false lumen enlargement, any progression condition or complication, pre-emptive TEVAR should be applied. As the recently dissected aorta is more fragile, and therefore risky regarding peri-operative complications, TEVAR was not preferred in the acute period if possible in our series.

TEVAR is associated with reintervention rates of up to 40%, owing mostly to aneurysmal growth of the distal dissected aorta [13]. The PETTICOAT technique offers good early-midterm results [17,18]. Nonetheless, some perfusion of the false lumen remains preserved, and the native aorta keeps growing distally to the stent graft [17,18]. The STABILISE technique gives good results, especially in eliminating the risk of malperfusion and the need for late reintervention [19]. However, there is still rupture risk associated with this procedure. Many treatments, such the Knickerbocker Technique, Candyplug, glue, and coil have also been developed in recent years to solve the issue of FL reperfusion at the stent-grafted descending aorta caused by distal reentry tears [20,21]. In our patient cohort, six reinterventions were performed for the extension of the dissection during the follow-up period. The PETTICOAT procedure was performed in 2 patients (3%), and open surgery was carried out in 2 patients because of enlargement of the abdominal aorta (3%). We prefer open surgery if there is a dissection flap and aneurysm formation instead of endovascular procedures.

Various post-procedure complications like RTAD, stroke, stent migration, spinal cord ischemia, and collapse have also been reported after TEVAR [22]. SINE is a severe problem associated with TEVAR in TBAD [23]. Although distal SINE due to the excessive oversizing of the distal stent graft is more common, the incidence of SINE following TEVAR can be up to 25% especially in the acute period [23]. In our cohort of 66 patients, one RTAD and one SINE was detected. Both patients experienced the initial TEVAR in urgent manners due to malperfusion in the acute period. The patient who experienced RTAD had an ascending and arcus aortic diameter of 38mm, and as he was a frail ASA 4 patient, an endovascular approach was preferred. Although depending on the availability of the endograft, we prefer tapered or double tapered thoracic endografts instead of straight ones if there was an excessive oversizing at the distal part. No graft infection or migration occurred throughout the follow-up.

Surgical CSB, carotid-subclavian transposition, carotid-axillary bypass, and endovascular methods such as chimney grafts, scallops, fenestrated grafts, and branched grafts are all feasible options for LSA revascularization in combination with TEVAR [24]. LSA revascularization is performed according to the surgeon's choice as routine, selective and symptom-based following TEVAR [24]. Based on the specific anatomical characteristics of each patient, we prefer selective LSA revascularization in our clinic. In this research, LSA was covered in 10 (15.2%) patients, two patients (3%) received chimney stents, 2 (3%) received CSB postoperatively because of CVE and left arm ischemia, and the other patients did not require revascularisation due to adequate vertebrobasilar circulation. One patient was lost on the postoperative third day due to malperfusion, the other patient was discharged without any complication. The SMFSG technique is our preferred method of treatment, and it is carried out on anatomically appropriate patients to maintain LSA endovascular patency while landing at zone 2 [11,25]. Ten fenestrated stent grafts were successfully implanted since 2020 and they were all patent in the mid-term follow-up period. However, one female patient who did not take any of her medications as she felt good experienced LSA occlusion in the first month asymptomatically. As there was no symptom and further complication, reintervention did not occur. When compared to the chimney technique, chimney has the oversizing dilemma with gutter endoleaks and type 1a endoleak where TBAD patients were not suitable to excessive oversizing.

In summary, we evaluated 66 consecutive patients who had TEVAR for TBAD. Interventions in the acute period were related to a rise in morbidity and mortality during hospitalization. This period has more immediate fatal complications from TBAD, like malperfusion and rupture. Furthermore, we think that SMFSG is the most suitable technique to revascularize LSA if the anatomy is suitable. It is safe, fast, economic and effective.

Limitations

This is a retrospective study and has a short follow-up period of around 2 years; a period of time which is too short to demonstrate the advantages of TEVAR with aortic remodeling and relatively small patient cohort of a single center.

CONCLUSION

TEVAR should be the first choice in the management and treatment strategy of cTBADs. OMT was the standard initial treatment for all cases with TBAD. In comparison to medical treatment alone, the combination of TEVAR and OMT appears to have a better outcome for aortic remodeling and aortic-related survival. Our study has a limited follow-up period to make a recommendation over the remodeling issue; however, it has a successful early outcome and satisfactory mid-term results. Until studies with large case series are published, patients with uTBAD should be treated on a patient basis. All patients with TBAD need strict surveillance for aortic complications and lifelong blood pressure control. The subacute period offers the most satisfactory results in a less complicated way. Also, we think that SMFSG is a safe, effective and economic technique to revascularize LSA.

Ethics Committee Approval: Ethical approval for this research was obtained from Ankara Bilkent City Hospital Clinical Research and Ethics Committee (14.05.2020/E1-20-603).

Patient Consent for Publication: Individual informed consent was waived due to retrospective design.

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

Author Contributions: All authors contributed equally to the article.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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