Original Article

Outcomes of thoracic endovascular aortic repair with fenestrated surgeon-modified stent-grafts for type B aortic dissection involving the aortic arch: a multicenter retrospective study

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Background: Thoracic endovascular aortic repair (TEVAR) with fenestrated surgeon-modified stent-grafts (f-SMSGs) is becoming an option for treating type B aortic dissection (TBAD) involving the aortic arch. This study aimed to evaluate the outcomes of this technique.

Methods: A retrospective multicenter study was conducted, involving consecutive patients from three medical centers in China who underwent TEVAR with f-SMSG for TBAD. A new technique called "Lu's direction-turnover technique" was employed to align the fenestrations with supra-aortic vessels.

Results: From March 2016 to January 2020, 117 patients diagnosed with TBAD were deemed eligible for inclusion. The technical success rate was 94% (n=110). The estimated 30-day survival rate was 97.4% [95% confidence interval (CI): 94.5% to 100.0%], with freedom from re-intervention estimated at 95.7% (95% CI: 92.0% to 99.4%). The median follow-up period was 27 months (interquartile range, 19 to 35 months). The estimated survival rate at 27 months was 94.9% (95% CI: 90.8% to 98.9%) and the rate of freedom from re-intervention was 91.5% (95% CI: 86.3% to 96.6%). Cases of retrograde type A aortic dissection, stroke and endoleaks were documented. Five cases of retrograde type A aortic dissection were documented, with three occurring within 30 days and one during the follow-up. Four cases of stroke were recorded, with one occurring within 30 days and three during the follow-up. Furthermore, eleven cases of endoleaks were recorded, with one occurring within 30 days and ten during the follow-up.

Conclusions: Clinically acceptable technical success and prognosis were observed in a cohort with TEVAR with f-SMSG for the treatment of TBAD involving the aortic arch, which necessitated revascularization of the supra-aortic vessels. Further comparative studies are required to validate the benefits of this approach.

Keywords: Fenestrated surgeon-modified stent-graft (f-SMSG); type B aortic dissection (TBAD); thoracic endovascular aortic repair (TEVAR); supra-aortic vessels; aortic arch pathologies

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Introduction

With the development of endovascular techniques and related devices, thoracic endovascular aortic repair (TEVAR) has become a preferred treatment for type B aortic dissection (TBAD) (1). Nevertheless, the utilization of TEVAR in cases involving aortic arch or even a retrograde tear into the ascending aorta continues to present numerous challenges and difficulties. The primary issue pertains to the necessity of crossing specific branch arteries to acquire an adequately healthy landing zone (LZ), necessitating the revascularization of supra-aortic vessels to restore branch blood supply. How to preserve the blood supply of these supra-arch branches, and to expedite and simplify the procedure and as well as minimizing complications such as stroke, retrograde type A dissection (RTAD), and endoleaks, are critical considerations within the realm of endovascular techniques.

Highlight box

Key findings

- The technique of treating type B aortic dissection (TBAD) involving the aortic arch using thoracic endovascular aortic repair (TEVAR) with fenestrated surgeon-modified stent-grafts (f-SMSGs) achieves clinically acceptable technical success and prognosis. In addition, we introduced a new technique called "Lu's direction-turnover technique", which contributed to aligning the fenestration with supra-aortic vessels.

What is known and what is new?

- TEVAR with f-SMSG has become a common treatment for TBAD involving the aortic arch; however, the outcomes and serious complications are yet to be evaluated.
- The estimated survival rate at 30 days was 97.4%, and the estimated survival rate at 27 months was 94.9%.
- The spatial transformation of fenestrations ("Lu's direction-turnover technique") during the crossing of the aortic arch mitigates the challenges associated with aligning fenestrations with target arteries and reduces cerebral hypoperfusion time, thereby reducing the risk of stroke.
- Retrograde type A dissection (RTAD) is most likely to occur when the landing zone is in the area where the ascending aorta meets the aortic arch and is more likely to occur within 30 days after surgery.
- The oversize rate of stent grafts is relevant to RTAD and it was recommended by 0% to 5% in this article.

What is the implication, and what should change now?

- Detailed pre-operative measurement, precise fenestration design, and accurate stent graft modification are key to successful revascularization of aortic arch branch arteries.
- Larger sample size and longer follow-up study should be conducted in the future.

In comparison to alternative techniques, fenestrated surgeon-modified stent-graft (f-SMSG) offers several advantages, such as reduced surgical duration and absence of stroke. Simultaneously, the paramount importance of this technique lies in guaranteeing the accurate design and placement of fenestrations. The pivotal technique has been implemented in three medical centers across China, and this study aimed to evaluate the outcomes. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-829/rc).

Methods

Study cohort patient population

This study was a retrospective cohort study and the protocols were approved by the Ethics Committee (EC) of Naval Medical University, Hong Kong University Shenzhen Hospital and Nanjing University Medical School (No. of ethics approval: IRB2022-YX-132-01). Prior to any operation, informed consents were obtained from all patients.

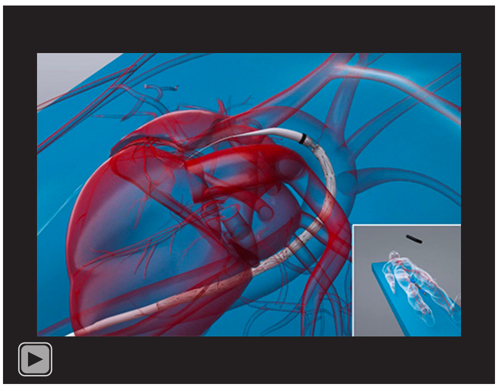
Retrospective data were collected from three centers in China mentioned above. The indications for TEVAR treatment of TBAD are acute or subacute aortic dissection (AD) in non-hereditary connective tissue disease, as well as chronic AD with a rapid increase in the diameter of the dissection (>10 mm per year), unrelieved pain, dissection rupture or premonitory rupture, and severe ischemia of supra-aortic vessels (2). The indication for utilizing a f-SMSG in TEVAR procedures is that the coverage of supra-aortic vessels origins to establish a suitable LZ. The proximal and distal LZ in the aorta were measured to be greater than 10 to 15 mm on the inner curvature (3). Preoperative computed tomography angiography (CTA) was conducted on all patients to evaluate the viability of TEVAR. The criteria for participant inclusion and exclusion are succinctly outlined in *Table 1*. Patients with complicated TBAD and those with uncomplicated TBAD with high-risk features underwent TEVAR. Demographic, anatomic, intraoperative, and postoperative information were obtained from a regularly updated database. Subsequent CTA were conducted at the time of discharge, after 6 months, after 12 months, and annually thereafter for follow-up purposes.

Fenestration design

Previous literature has provided information regarding the

Table 1 Inclusion and exclusion criteria

Inclusion criteria
1. Patients with type B aortic dissection, which means including any aortic dissection with an entry tear originating in zone 1 or distal
2. Without involvement of the visceral arteries
Exclusion criteria
1. Combined with aortic aneurysms
2. Without involvement of the supra-aortic vessels
3. Intermural hematomas or penetrating ulcers



Video 1 Stent graft reset after making fenestrations.

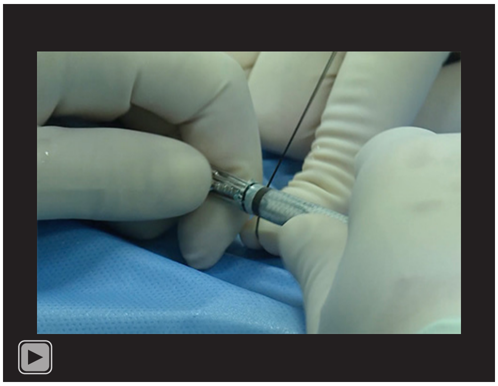
selection of the stent graft and the design of fenestration (4). The oversizing rate ranged from 0% to 5%. For small curvature lesions, without worrying about long-term displacement and endoleaks, a large fenestration can be created according to the range of involvement of the LZ. A large fenestration is advantageous in preserving the unobstructed flow of the branch arteries, facilitating alignment without the insertion of a bridging stent within the fenestration, resulting in cost and time savings, and mitigating the risk of long-term re-stenosis and occlusion of the bridging stent. In cases involving lesions located on the greater curvature, the creation of a small fenestration, tailored to the diameter of the branch arteries, is recommended to prevent endoleaks and distant displacement. Large fenestrations are employed when the risk of endoleak is low. For instance, a large fenestration may be utilized for the left common carotid artery (LCCA) if the proximal end of the lesion is situated 5 mm distal to the origin of the left subclavian artery (LSA). In scenarios involving the simultaneous revascularization of two arteries using a large fenestration, the long diameter of the fenestration should be calculated as the sum of the distances between the origins of the two arteries and their respective long diameters. The short diameter of the fenestration should be approximately equivalent to the short diameters of the arteries or may exceed them by 1–2 mm.

Bridging stents are used to prevent branch artery occlusion or to treat AD involving supra-aortic vessels. Precise and effective placement of a bridging stent necessitates the passage of the guidewire through a pre-established fenestration, either from the femoral artery traversing the aorta to access the supra-aortic vessel, from the supra-aortic vessel through the fenestration into the aorta in a retrograde manner, or by bidirectional apposition with a snare device. Sometimes the guidewire travels outside the main stent and erroneously appears to have traversed the fenestration, necessitating confirmation through the utilization of multi-angle fluoroscopy, guidewire rotation, and catheter angiography. These bridging stents are equal to or 10% to 20% larger than the fenestration and insert into the branches for 15 to 20 mm (5). Subsequent to the successful establishment of the guidewire channel, the introduction of a peripheral covered stent can be facilitated. Should stenosis persist following the deployment of the stent, post-balloon dilatation is required. The following bridging stents were utilized in the study: Fluency (CR Bard, Murray Hill, NJ, USA; n=32), E-luminexx (CR Bard; n=3), Viabahn (WL Gore, Flagstaff, AZ, USA; n=2), Omnilink Elite (Abbott, Abbott Park, IL, USA; n=2), and Complete SE (Medtronic, Minneapolis, MN, USA; n=1).

Operation and fenestration technique

Previously, the procedure has been described in detail (4). In summary, all surgeries were conducted in a hybrid operation room under general anesthesia. Valiant Captivia (Medtronic) devices were utilized and modified in all cases. Subsequently, the operators implanted stent grafts and created fenestrations using a scalpel or electrotome. Only the specific segment requiring alteration were unsheathed. The f-SMSG was then delivered through a common femoral artery cutdown.

Once the fenestrations were prepared, the stent graft was reinserted into the sheath (*Video 1*). Upon introducing the conveying system, the white point on the front grip was aligned perpendicular to the ground, ensuring that the fenestrations were oriented in the same direction. In order to prevent the rotation of the conveying system during



Video 2 Lu's direction-turnover technique.

the advancement of the stent graft, the front grip must be held tightly. The "Lu's direction-turnover technique" is used for intraoperative maneuvers. Specifically, when the conveying system enters the body via the femoral artery, the fenestration position is maintained in the vertical orientation (6 o'clock) while the patient is in a supine position. Upon entry into the descending aorta, the fenestration position is situated on the posterior wall of the aorta. As the delivery system traverses the aortic arch, the fenestration position is positioned near the greater curvature of the aortic arch and transitions to 12 o'clock, directed towards the head. It is important to note that the stent does not undergo rotation but rather undergoes a "flip" motion, transitioning from a backward to an upward orientation, specifically from 6 to 12 o'clock (*Video 2*). If the diameter of the stent graft at the distal LZ exceeded that of the aorta by 10%, a distal restrictive stent graft would be deployed prior to the stent graft, ensuring that the oversized portion of the main aortic stent graft was adequately covered.

Definition and postoperative evaluation

Initial technical success refers to the achievement of several specific criteria, including the successful entry into the arterial system through the femoral, external iliac, common iliac, the successful insertion and positioning of the device at the intended location without the need for open surgery or resulting in death within 24 hours, precise alignment between all fenestrations and target arteries, absence of a type I or III endoleak as detected by angiography, and the presence of an unobstructed stent graft. The secondary technical end points were also reported, including procedure time, blood loss, fluoroscopy time, contrast load, range and average number of days spent in an intensive care unit (ICU), and hospital length of stay (6).

Statistical analysis

Categorical variables were represented using absolute numbers and percentages, while continuous variables were reported as mean ± standard deviation or as median and interquartile ranges (IQRs) in cases of skewness. The Kaplan-Meier method was employed to present overall survival and freedom from re-intervention rates. The follow-up period was defined as the time of the most recent clinical follow-up for assessing survival, re-intervention, and complications. Statistical analyses were conducted using SPSS (version 21.0; SPSS, Inc., Chicago, IL, USA).

Results

Baseline characteristics

From March 2016 to January 2020, a total of 117 patients diagnosed with TBAD from three centers in China were included in this study. These patients underwent TEVAR with f-SMSG. The median age of the patients was 53 years (IQR, 46 to 65 years). The most prevalent comorbidities were hypertension (84.6%), smoking history (41.9%), diabetes mellitus (10.3%), history of coronary heart disease (7.7%) and stroke (6.8%). Detailed information about baseline characteristics is listed in *Table 2*, and detailed information about preoperative diagnosis is listed in *Table 3*.

Perioperative outcomes

The median duration of hospital stay was 11 days (IQR, 8 to 16 days), while the median duration of ICU stay was 1 day (IQR, 1 to 1 day). The median cost of the procedure was $21,322 (IQR, $18,659 to $26,656). A total of 132 fenestrations were performed to revascularize 144 supra-aortic vessels. Detailed information about fenestration strategy is listed in Table S1. Technical success was achieved in 110 cases, accounting for 94% of the total (*Figure 1*). During the surgical procedure, a patient presented with retrograde type A aortic dissection (RTAD) and underwent an open procedure (the Bentall operation, total arch replacement, and the frozen elephant trunk technique) for ascending aorta replacement. Another patient experienced lower limb ischemia during the operation, necessitating concurrent iliac artery stent implantation.

The combined 30-day death and stroke rate was 2.6% (n=3). Among the three patients who experienced

Table 2 Baseline characteristics

Characteristic	Patients (n=117)
Age (years)	53 [46–65]
Male	101 (86.3)
Comorbidity	
Hypertension	99 (84.6)
Smoking history	49 (41.9)
Diabetes mellitus	12 (10.3)
Coronary heart disease	9 (7.7)
Stroke	8 (6.8)
Hyperlipidemia	1 (0.9)
History of cancer	2 (1.7)
Previous endovascular repair	2 (1.7)
Mitral insufficiency	1 (0.9)
Atrial fibrillation	2 (1.7)
Frequent premature ventricular	1 (0.9)
Peripheral arterial disease	2 (1.7)
Chronic obstructive pulmonary disease	6 (5.1)
Renal dysfunction	4 (3.4)
Renal failure	1 (0.9)
Gout	3 (2.6)

Data are presented as median [interquartile range] or n (%).

Table 3 Detailed information about preoperative diagnosis

Characteristic	N (%)
Location of proximal entry tear	
Zone 1	0 (0.0)
Zone 2	10 (8.5)
Zone 3	43 (36.8)
Zone 4	25 (21.4)
Censored data	39 (33.3)
Chronicity classification	
Hyperacute, <24 hours	2 (1.7)
Acute, 1–14 days	80 (68.4)
Subacute, 15–90 days	23 (19.7)
Chronic, >90 days	12 (10.3)

mortality within 30 days, one succumbed to multiple organ dysfunction syndrome (MODS), another to a major stroke, and the third to RTAD. The first patient, who had undergone a large fenestration for LCCA and LSA, died due to severe pulmonary infection and subsequent respiratory failure leading to MODS. The estimated survival rate at 30 days was 97.4% [95% confidence interval (CI): 94.5% to 100.0%], while the estimated rate of freedom from mortality and morbidity at 30 days was 93.2% (95% CI: 88.5% to 97.8%).

The incidence of stroke within 30 days was 0.85% (n=1), resulting in the demise of the patient. The estimated free from stroke at 30-day period was 99.1% (95% CI: 97.5% to 100.0%). The patient, who had a small fenestration for LSA, was successfully extubated 6 hours post-surgery. However, at the 24-hour mark, the patient experienced a sudden cardiac arrest, requiring resuscitation for a duration of fifty minutes. This event led to a severe anoxic injury of the brain, ultimately the patient's family abandoned treatment.

The 30-day re-intervention rate was 4.3% (n=5). Among the patients, four individuals underwent open surgery due to RTAD. Out of these four patients, three experienced successful recoveries following the operation, while one passed away. One patient required re-intervention due to type Ia endoleak, which was addressed through spring coil embolization. The estimated freedom from re-intervention at 30 days was 95.7% (95% CI: 92.0% to 99.4%), while the estimated freedom from endoleaks at 30 days was 99.1% (95% CI: 97.5% to 100.0%). Detailed information about perioperative outcomes is listed in *Table 4*. Detailed information about patients with RTAD is listed in Table S2.

Follow-up outcomes

Median follow-up was 27 (IQR, 19 to 35) months. The combined death and stroke rate was 4.4% (n=5). Throughout the follow-up period, 3 (2.6%) patients died, including two deaths related to aortic complications (one due to rupture of aorto-oesophageal fistula and hemoptysis, and the other due to rupture of dissected aorta), and one death unrelated to the aorta (hemorrhagic stroke). The former experienced vomiting blood and massive hemoptysis without obvious cause 3 months after surgery, and was diagnosed with aorto-oesophageal fistula (middle and lower esophagus) with surrounding infectious lesions upon admission. The patient's family refused invasive rescue and the patient died on the day of admission. The latter

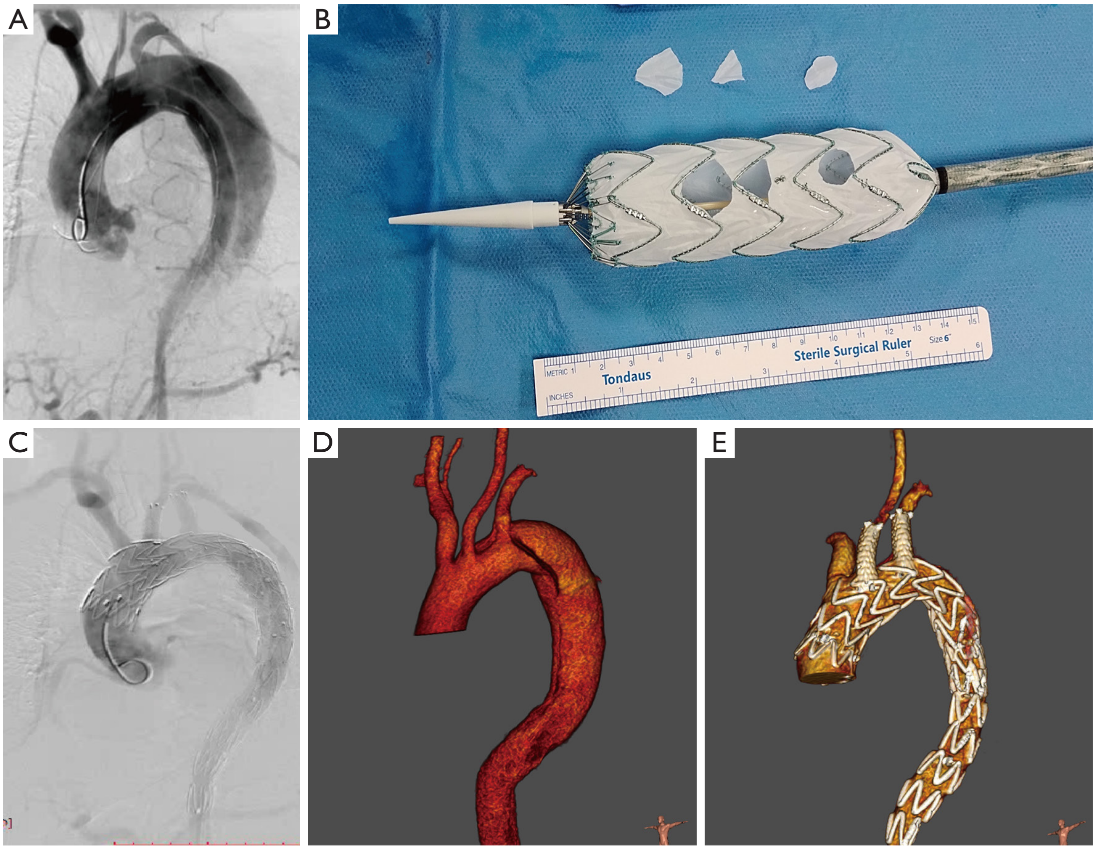


Figure 1 TEVAR with fenestrated surgeon-modified stent-graft (A) DSA before treatment of a type B aortic dissection with (B) a fenestrated surgeon-modified triple stent-graft, and (C) DSA after deployment of the stent graft, showing complete exclusion of the pathologies and patency of the supra-aortic vessels, with bridging stent grafts in the LCCA and LSA. (D) Three-dimensional CTA reconstruction before treatment of an aortic arch dissection with a fenestrated surgeon-modified single stent-graft, and (E) CTA reconstruction after treatment, with bridging stent grafts in the LCCA and LSA. TEVAR, thoracic endovascular aortic repair; DSA, digital subtraction angiography; LCCA, left common carotid artery; LSA, left subclavian artery; CTA, computed tomography angiography.

experienced a dissection rupture two months post-surgery. The estimated survival rate at 27 months was 94.9% (95% CI: 90.8% to 98.9%). The incidence of stroke was 2.6% (n=3). The estimated rate of freedom from stroke at 27 months was both 96.6% (95% CI: 93.2% to 99.9%).

Five patients (4.4%) required re-intervention, with four undergoing re-intervention for endoleaks. These included one case of type Ia endoleak treated with spring coil embolization, two cases of type II endoleak managed with a covered extension cuff deployed over the affected attachment site in one patient and spring coil embolization in the other, and one case of type III endoleak treated with a covered extension cuff deployed over the affected attachment site. Another six patients with type Ia endoleak did not receive re-intervention. Additionally, two patients experienced hemorrhagic strokes. One patient underwent carotid artery stenting for an ischemic stroke. The estimated rate of freedom from re-intervention at 27 months was 91.5% (95% CI: 86.3% to 96.6%). The estimated rate of freedom from endoleaks at 27 months was 90.6% (95% CI: 85.2% to 96.0%). More detailed information on follow-up outcomes is shown in *Table 5* and *Figure 2*. We used the day of surgery as the starting time point.

Discussion

Technical essentials of alignment between fenestrations and supra-aortic vessels

The accuracy of *in-vitro* fenestration relies on precise preoperative measurement and design. The accuracy of

Table 4 Perioperative outcomes

Outcome	Patients (n=117)
Technical success	105 (89.7)
Operation time (min)	60 [45–80]
Blood loss (mL)	20 [10–30]
Contrast use (mL)	100 [80–120]
Heparin use (mg)	30 [30–40]
Fluoroscopy time (min)	20 [15–25]
Thirty-day mortality	3 (2.6)
Thirty-day reintervention	5 (4.3)
Thirty-day complications	8 (6.8)
RTAD	5 (4.3)
Stroke	1 (0.85)
Endoleaks (type Ia)	1 (0.85)
MODS	1 (0.85)
Pleural effusion	1 (0.85)
Lower limb ischemia	1 (0.85)

Data are presented as n (%) or median [interquartile range]. RTAD, retrograde type A aortic dissection; MODS, multiple organ dysfunction syndrome.

Table 5 Follow-up outcomes of 114 patients

Outcome	Patients (n=114)[†]
Follow-up time (months)	6 [6–12]
Mortality	3 (2.6)
Aortic related deaths	2 (1.8)
Non-aortic related deaths	1 (0.9)
Reintervention	5 (4.4)
Complications	10 (8.8)
Stroke	3 (2.6)
Hemorrhagic stroke	1 (0.9)
Ischemic stroke	2 (1.8)
Type Ia endoleak	7 (6.1)
Type II endoleak	2 (1.8)
Type III endoleak	1 (0.9)
Rupture of aorto-oesophageal fistula	1 (0.9)
Rupture of dissected aorta	1 (0.9)

Data are presented as median [interquartile range] or n (%). [†], 3 patients died in the perioperative period.

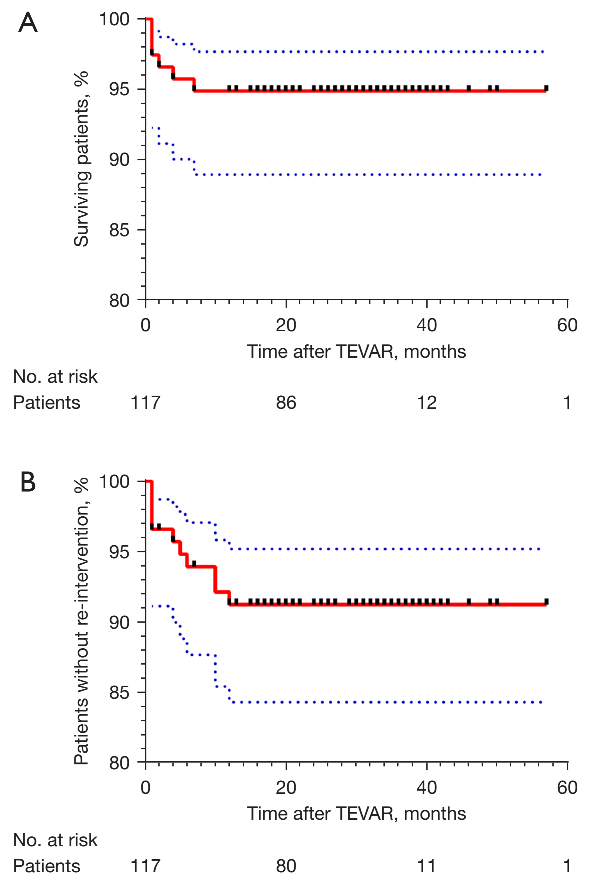


Figure 2 Cumulative Kaplan-Meier estimates for freedom from (A) mortality and (B) reintervention in 117 patients treated with fenestrated surgeon-modified stent-grafts for TEVAR. TEVAR, thoracic endovascular aortic repair.

CTA images used for preoperative measurements requires less than 1 mm layer thickness. Currently, commonly used software includes Teracond, Endosize, and so on. The measurements encompass the diameter of individual aortic segments, the angle of and the length of the greater curvature side of the aortic arch, the diameter, position and angle of the branch arterial origin, and the distance between the origins on the greater curvature side. Since the relative positions of fenestrations are fixed, only one of them needs to be aligned and the rest are automatically aligned. The axial position is determined by the screen markers and stent struts. Given the fixed relationship between the stent struts and the fenestrations, no additional markers are required to indicate the position of the fenestrations (7). Failure of alignment can be remedied by the addition of a chimney stent, which increases the risk of postoperative endoleaks.

There were only two cases of fenestrations failure to align the branch arteries in this study. In one case, a chimney stent was added intraoperatively, and in the other case, the RTAD led to open surgery one month later.

Usage of bridging stents and endoleaks

The use of oversized bridging stents serves to prevent occlusion and stenosis of the branch artery, ensuring its continued patency. It can also be used to seal aortic intimal tear near the fenestration and to re-dilate the true lumen in some cases. Oversized bridging stents also act as anchors to keep the aortic stent in place and prevent it from migrating. The use of a bare stent primarily serves the first two purposes, provided that the proximal LZ is adequate and there is no concern about endoleaks. If there is a risk of endoleak with an insufficient LZ, a covered stent must be used. A total of 45 bridging stents were implanted in this study, including 11 bare stents and 34 covered stents.

Endoleaks after TEVAR of AD have been widely reported, with a rate of 33.2% reported in the available literature (8). Persistent endoleaks can lead to unfavorable thrombosis (9). In our study, a lower rate of endoleaks was observed, at 9.4%, suggesting that the incidence of this complication was reduced under our treatment approach. The highest incidence of type Ia endoleaks was observed. The perioperative incidence of type Ia endoleaks was 0.85% (n=1), and during the follow-up period, type Ia endoleaks were observed in 6.1% (n=7) of patients.

RTAD after surgery

As mentioned previously (7), the progression of RTAD requires aortic pressure to exceed the capacity of the vessel wall, which emphasizes the importance of a thorough understanding of the interaction between the stent graft and the vessel wall. The incidence of RTAD after TEVAR ranges between 1.3% and 2.5% (10). In this study, the incidence was 4.3% (n=5), with a mortality rate of 20% (one in five cases). It is most likely to occur when the LZ is in the area where the ascending aorta meets the aortic arch, and all 5 cases of RTAD in this study occurred at this site. This may be due to the sharp angle of the junction of the ascending aorta and the aortic arch, where blood flow undergoes a large turn, which not only generates a greater shear force, but also a greater impact force on the stent. If the head end of the stent is located in this area, this can lead to greater stent impingement and abrasion on the wall, which in turn can lead to an increased incidence of RTAD.

The oversize is also closely related to RTAD because oversized stents cause greater radial support to the diseased vessel wall, leading to dilatation and intimal damage. In previous practice, an oversize of 15–20% was commonly utilized, but in this study, it was restricted to 0–5%. Ma *et al.* (11). demonstrated that higher oversize corresponded to greater stress on the vessel wall, with a 15% oversize resulting in twice the stress compared to a 0% oversize. This suggests that if 0% oversize keeps the stent stable for a long time, it may have the lowest complication rate compared with other oversizes.

A previous study reported an odds ratio of 10.0 (95% CI: 4.7–21.9) for acute AD and 3.4 (95% CI: 1.3–8.8) for chronic AD in relation to the development of RTAD (12). Patients who receive TEVAR in the acute phase have an increased incidence of RTAD because of the high vulnerability of the vessel wall at this time. Four of these five patients had acute AD and one had subacute AD.

Stroke after surgery

Stroke continues to be a significant and concerning complication associated with TEVAR. According to the findings of Swerdlow *et al.* (13), a range of 2.9% to 4.3% of patients undergoing TEVAR experienced cerebrovascular accidents, resulting in a mortality rate of one-third. In our study, the incidence of stroke was 4.3% (n=5), with a mortality rate of 50% (two out of four patients). Notably, two out of three patients who suffered from ischemic stroke had a prior history of cerebral infarction, while the remaining patients had undergone LCCA-LSA bypass surgery. Poor alignment between the fenestrations and the branch arteries may also lead to inadequate cerebral perfusion, which may result in severe and irreversible stroke and ultimately death. Our approach allows for precise and rapid alignment, so the risk of stroke is greatly reduced.

Limitations

This study is characterized as a retrospective analysis featuring a limited sample size. The absence of a control group for comparing the f-SMSG with alternative techniques is noteworthy. Additionally, the follow-up duration was relatively brief, and certain data points were absent.

Conclusions

This retrospective analysis presents the multicenter experience of using a f-SMSG for TEVAR. The study demonstrates that this approach yields feasible and acceptable outcomes. Thorough preoperative assessment, meticulous fenestration planning, and precise modification of the stent graft are crucial for achieving success. "Lu's direction-turnover technique" mitigates the challenges associated with aligning fenestrations with target arteries and reduces cerebral hypoperfusion time, thereby reducing the risk of stroke. The relatively high occurrence of RTAD emphasizes the significance of considering the interaction between the vessel wall and the stent graft when selecting the proximal LZ. The use of bridging stent instead of chimney stent in this study resulted in a significant reduction in the risk of endoleaks. However, additional follow-up studies are necessary to validate the long-term durability and efficacy of this technique.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-829/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-829/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-829/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-829/coif). All authors report that this study was supported by the National Natural Science Foundation of China (No. 82270510). The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was a retrospective cohort study and the protocols were approved by the Ethics Committee (EC) of Naval Medical University, Hong Kong University Shenzhen Hospital and Nanjing University Medical School (No. of ethics approval: IRB2022-YX-132-01). Prior to any operation, informed consents were obtained from all patients.

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