Original Article

The safety and prognostic evaluation of subsequent aortic surgery after thoracic endovascular aortic repair: a retrospective cohort study

Jie Liu[1,2#], Jun Ke[2#], Yingfei Lu[2], Kan Zhou[2], Changjiang Yu[2], Jianfan Zhen[2], Zhuohang Jiang[2], Jinlin Wu[2], Tucheng Sun[1,2]

[1]School of Medicine, South China University of Technology, Guangzhou, China; [2]Department of Cardiac Surgery, Guangdong Cardiovascular Institute, Guangdong Provincial People' s Hospital, Guangdong Academy of Medical Sciences, Guangzhou, China

Contributions: (I) Conception and design: J Wu, J Liu, J Ke; (II) Administrative support: J Wu, T Sun, C Yu; (III) Provision of study materials or patients: Y Lu, Z Jiang, J Liu; (IV) Collection and assembly of data: J Liu, J Ke, J Zhen; (V) Data analysis and interpretation: J Wu, J Liu, J Ke; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

[#]These authors contributed equally to the work.

Correspondence to: Jinlin Wu, MD. Department of Cardiac Surgery, Guangdong Cardiovascular Institute, Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, No. 106 Zhongshan Second Road, Guangzhou 510080, China. Email: wujinlin@gdph.org.cn; Tucheng Sun, MD. School of Medicine, South China University of Technology, No. 381, Wushan Road, Guangzhou 510641, China; Department of Cardiac Surgery, Guangdong Cardiovascular Institute, Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, No. 106 Zhongshan Second Road, Guangzhou 510080, China. Email: suntucheng@126.com.

Background: Thoracic endovascular aortic repair (TEVAR) is a widely employed clinical procedure for treating various aortic pathologies. However, some patients require subsequent surgical interventions post-TEVAR, particularly due to life-threatening complications such as aortic dissection. This study aimed to evaluate the safety and prognosis associated with additional aortic surgeries following TEVAR.

Methods: A retrospective analysis was conducted on 21 patients who underwent aortic surgery after TEVAR at Guangdong Provincial People's Hospital between September 2016 and August 2020. By compiling and reviewing perioperative data, we assessed surgical-related complications and survival rates.

Results: Among the 21 patients, 95.2% were male, with an average age of 53 years. Preoperative comorbidities included hypertension in 15 individuals, abdominal aortic aneurysm in one patient, and coronary heart disease in two patients. The primary complications of TEVAR were stent leakage and retrograde aortic dissection, with the latter being the predominant type in subsequent aortic surgeries. The mean duration of aortic clamping during surgery was 130.0 minutes, with a deep hypothermic circulatory arrest time of 8.5 minutes. Postoperatively, two patients suffered in-hospital mortality, one developed renal dysfunction, four required re-entry into the operating room for further treatment, and the average length of hospital stay was 20 days. Following discharge, 14.3% of patients experienced complications, with central nervous system symptoms being the most prevalent. Kaplan-Meier survival analysis indicated a 5-year survival rate of 85.7%.

Conclusions: Aortic surgical intervention following TEVAR is a safe therapeutic approach that can improve patient prognosis. However, meticulous management of the perioperative period is crucial for reducing the risk of complications and improving survival rates. This study provides valuable insights into aortic surgery post-TEVAR, but large-scale research is needed to validate these findings.

Keywords: Thoracic endovascular aortic repair (TEVAR); retrograde type A aortic dissection occurring at the proximal end of the TEVAR stent, as confirmed by computed tomography angiography (RTAD); surgical repair

Submitted Jan 11, 2024. Accepted for publication May 13, 2024. Published online Jun 18, 2024.
doi: 10.21037/jtd-24-71
View this article at: https://dx.doi.org/10.21037/jtd-24-71

© Journal of Thoracic Disease. All rights reserved.

Introduction

The treatment of aortic diseases involves meticulous clinical decision-making, requiring a delicate balance between surgical risks and patient prognosis. With the continuous advancement of thoracic endovascular aortic repair (TEVAR), an increasing number of patients are opting for this treatment modality (1). However, some patients who have undergone TEVAR may need to undergo open aortic surgery postoperatively, which can be caused by various reasons (2). Among these, retrograde type A aortic dissection occurring at the proximal end of the TEVAR stent, as confirmed by computed tomography angiography (CTA) (RTAD) is the focus of discussion in this article. In the current clinical treatment process, there is not yet a unified diagnostic and treatment plan for this group of patients. This requires us to conduct more in-depth research. Investigating the safety of open aortic surgery after TEVAR provides valuable insights for clinical practice, assisting surgeons in better assessing patient outcomes and formulating personalized treatment plans, ultimately contributing to the improvement of patient prognosis. We present this article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-71/rc).

Highlight box

Key findings

- Aortic surgery after thoracic endovascular aortic repair (TEVAR) is a safe and effective.

What is known and what is new?

- A proportion of patients who underwent TEVAR may require aortic surgery because of retrograde type A aortic dissection occurring at the proximal end of the TEVAR stent, as confirmed by computed tomography angiography (RTAD).
- This group of people should be regarded as having type A aortic dissection and require aggressive surgical procedures.

What is the implication, and what should change now?

- For patients who develop RTAD after TEVAR, it is crucial to actively pursue surgical intervention, which does not pose additional risks to the patients. Furthermore, for the existing TEVAR stents, it is necessary to properly trim the proximal crown portion of the stent graft. This modification creates an optimal area for anastomosis, thereby enhancing the reliability and effectiveness of the anastomosis.

Methods

Patients

From September 2016 to August 2020, Guangdong Provincial People's Hospital treated 21 patients who underwent repeat aortic surgery after TEVAR, with all cases confirmed through aortic CTA. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Review Committee of Guangdong Provincial People's Hospital (KY-Z-2022-218-01) and individual consent for this retrospective analysis was waived.

Definitions and follow-up

RTAD refers to aortic dissection occurring at the proximal end of the TEVAR stent, as confirmed by CTA. Myocardial dysfunction refers to a condition indicated by transthoracic echocardiography showing a left ventricular ejection fraction of less than 50%. Dialysis is required when kidney function falls below a critical level, typically when the glomerular filtration rate (GFR) is less than 15 mL/min/1.73 m^2 or when serum creatinine levels are significantly elevated above normal values. Core temperature refers to rectal temperature.

Patients are followed up annually by telephone, focusing on symptoms and their corresponding management.

Statistical analysis

Continuous variables were described as mean ± standard deviation or median (range), and categorical values as number (%). The Kaplan-Meier method was used to evaluate survival, and the "survival" package in R was used for plotting. Due to the limited number of cases in this study, descriptive statistics are mostly used rather than other statistical methods. This is an observational cohort retrospective study.

Operative techniques

The surgery was reported previously (3). Specially, during the exploration of the arch, the proximal anchoring area of the TEVAR stent was appropriately trimmed. In some patients where the stent was positioned too close to the proximal end (*Figure 1A*), a section of the covered stent

© Journal of Thoracic Disease. All rights reserved.

Figure 1 The CT image of the patient before the aortic surgery and the process of removing the proximal end of the TEVAR stent. (A) Transecting the aortic arch at the tip of the stent. (B) The tear was identified at the proximal end of the stent. (C) Wire scissors were used to remove the proximal end of the stent. (D) CT scan performed after TEVAR showed a new tear site in the proximal end of the stent. CT, computed tomography; TEVAR, thoracic endovascular aortic repair.

Figure 2 The distal end of the artificial blood vessel is sutured to the proximal anchoring zone of the frozen elephant trunk stent to complete the reconstruction of the aortic arch. (A) Inserting a frozen elephant trunk stent graft into the true lumen of the descending aorta. (B) The distal end of the artificial blood vessel was anastomosed to the descending aorta and the frozen elephant trunk stent. (C) The operation was completed. (D) CT scan was performed after the operation. CT, computed tomography.

was judiciously excised (*Figure 1B,1C*). *Figure 1D* shows the condition of the aortic arch computed tomography (CT) of an RTAD patient before undergoing aortic surgery. The aortic arch was then trimmed to the proximal end of the left common carotid artery opening, and a frozen elephant trunk (FET) stent was implanted distally (*Figure 2A*). The diameter of the elephant trunk stent was selected based on the diameter of the distal artery and the TEVAR

© Journal of Thoracic Disease. All rights reserved.

Table 1 Operative characteristics

Surgical-related information	Value
Acute phase (≤14 days)	19 (90.5)
Ascending aorta replacement + TAR + FET technique	17 (81.0)
Ascending aorta replacement + TAR	1 (4.8)
Ascending aorta + right half arch replacement	3 (14.3)
Additional procedures	
Aortic root replacement (Bentall procedure)	6 (28.6)
Aortic root replacement (Wheat procedure)	1 (4.8)
Aortic valve commissure resuspension	5 (23.8)
MVR	1 (4.8)
Ascending aorta-abdominal aortic bypass	1 (4.8)
Cardiopulmonary bypass time (min)	246.1±55.5
Aortic cross-clamp time (min)	130.0±38.6
Selective cerebral perfusion time (min)	8.5±7.7

Data are presented as n (%) or mean ± standard deviation. TAR, total arch replacement; FET, frozen elephant trunk; MVR, mitral valve replacement; SD, standard deviation.

Table 2 Patient demographics

Preoperative data	Value
Age (years)	53±11.41
Male gender	20 (95.2)
Smoker	6 (28.6)
Hypertension	15 (71.4)
Coronary artery disease	2 (9.5)
Abdominal aortic aneurysm	1 (4.8)
Aortic regurgitation ≥ moderate	5 (23.8)
Pericardial effusion	4 (19.0)
Symptoms	
Chest pain	9 (42.9)
Headache	2 (9.5)
Asymptomatic	12 (57.1)
Hemoglobin content (g/L)	113.3±22.7
White blood cell count (10^9/L)	9.1±3.1
Platelet count (10^9/L)	203.2±6.0
D-dimer (ng/mL)	4,139.5±2,824.7
Serum creatinine (μmol/L)	89.3±28.2

Data are presented as n (%) or mean ± standard deviation.

stent. Four-branch artificial blood vessels [Terumo (Tokyo, Japan) or Maquet (Rastatt, Germany)] were utilized to reconstruct the arch (*Figure 2B*). After completion of the distal anastomosis between the four branch vessels and the autologous aorta, one branch vessel was selected for arterial perfusion to restore distal circulation. After the distal stumps of the left subclavian artery, left carotid artery, and innominate artery were anastomosed to branch vessels, the rewarming process was commenced. The extracorporeal circulation pipeline was gradually weaned, and the operation was concluded (*Figure 2C*). *Figure 2D* shows the CT of an RTAD patient after undergoing aortic surgery. *Table 1* provides information related to the surgery.

Results

The average age of the patients was 53±11.41 years, and 20 individuals (95.2%) were male (demographic data presented in *Table 2*). The indications for the index TEVAR were 19 cases of type B aortic dissection (TBAD) and two cases of penetrating aortic ulcer. In five patients, TEVAR and chimney grafting implantation were simultaneously performed, with one case involving the left carotid artery and five cases involving the left subclavian artery. The median interval between the initial TEVAR surgery and RTAD was 5.0 months (range, 0.25–96 months). *Table 3* summarizes the relevant information of the TEVAR procedure.

Among all admitted patients, 19 individuals (90.5%) received treatment during the acute phase (within 14 days). Seventeen patients underwent ascending aorta replacement plus total arch replacement with elephant trunk stent implantation, one patient underwent only ascending aorta replacement plus total arch replacement, and three patients underwent ascending aorta plus right hemiarch replacement. Among them, 12 cases required aortic root repair, including six cases of Bentall procedure, one case of Wheat procedure, and five cases of aortic sinus repair. Additional procedures included one case of mitral valve replacement, two cases of mitral valvuloplasty, and one case of ascending aorta-femoral artery bypass. The mean cardiopulmonary bypass (CPB) time, aortic cross-clamp time, and selective cerebral perfusion (SCP) time were 246.1±55.5, 130.0±38.6, and 8.5±7.7 minutes, respectively. The median duration of mechanical ventilation was 2 days (range, 1–21 days). The mean duration of postoperative intensive care unit stay was 6.4±5.4 days and in-hospital stay was 20.0±10.9 days. Adverse events (death, cardiac

© Journal of Thoracic Disease. All rights reserved.

Table 3 Details of the index TEVAR

TEVAR-related information	Value
TEVAR indications	
Type B aortic dissection	19 (90.5)
Penetrating aortic ulcer	2 (9.5)
Proximal landing zone	
1	17 (81.0)
2	3 (14.2)
3	1 (4.8)
Time interval from TEVAR to RTAD (months)	5 [0.25–96]
≤14 days	1 (4.8)
>14 days–3 months	8 (38.1)
>3–12 months	7 (33.3)
>12 months	5 (23.8)
Chimney graft implantation	
Left common carotid artery	1 (4.8)
Left subclavian artery	5 (23.8)

Data are presented as n (%) or median [range]. TEVAR, thoracic endovascular aortic repair; RTAD, retrograde type A aortic dissection occurring at the proximal end of the TEVAR stent, as confirmed by CTA; CTA, computed tomography angiography.

Figure 3 Survival curves of patients in this study.

insufficiency, renal failure requiring dialysis) occurred in four cases (19.0%), including two cases of death during hospitalization, one case of cardiac insufficiency, and one case of renal failure requiring dialysis. Additionally, three patients were readmitted to the operating room for treatment twice due to anastomotic stenosis of aortic branch vessels, large postoperative pleural fluid volume, and delayed chest closure. Among the 19 surviving patients, one was lost to follow-up, while the follow-up data for the remaining 18 were available (*Figure 3*). The follow-up duration ranged from 38 to 85 months, with an average of 53.7±16.1 months. During the follow-up period, one patient experienced headache, one reported dizziness, one had renal dysfunction, and one developed a cerebral infarction. Specific details are listed in *Table 4*.

Discussion

Although RTAD is a rare complication after TEVAR, it poses significant and often fatal risks to patients. In the event of RTAD, nearly all patients require repeat aortic surgery, with an incidence of 0.9–6.8%, and the time interval between the initial TEVAR and the occurrence of RTAD varies (4-9). Apart from uncontrolled blood pressure, the inflammatory response induced by invasive procedures in the aorta appears to be a major factor (4). In this study, the shortest time interval between TEVAR and RTAD was less than one week, while the longest was 96 months, indicating that inflammation may persist in the mended aorta postoperatively, potentially spanning several years.

Among the patients who underwent TEVAR, five presented with chest and back pain as the initial symptom of RTAD, while another five exhibited ischemia of the central nervous system, renal, and digestive system. The remaining cases were identified during follow-up aortic CTA. This suggests that procedures and devices related to TEVAR carry the risk of causing RTAD. First, factors associated with TEVAR may lead to damage of the aorta. For example, during the delivery of guide wires and stents, the aorta may be susceptible to injury. The balloon dilation process following stent placement can also result in damage to the intima of the aorta, thereby exacerbating aortic inflammation and making it more susceptible to developing RTAD (10). Second, the choice of stent used during surgery is also an important contributing factor to the formation of RTAD (11). Typically, the selection of stent graft models is based on preoperative CTA and intraoperative imaging findings. To enhance the closure of the aortic entry tear and promote thrombosis of the false lumen, the chosen model is usually 10% larger or more than the measured diameter. However, oversized stent grafts impose greater wall stress on the inflamed and fragile aorta, making patients undergoing TEVAR more susceptible to adverse aortic-

© Journal of Thoracic Disease. All rights reserved.

Table 4 Characteristics of postoperative and follow-up

Postoperative Information	Value
Ventilation time (days)	2 [1–21]
Intensive care unit duration (days)	6.4±5.4
Postoperative in-hospital stay (days)	20.0±10.9
Adverse events	
Death	2 (9.5)
Myocardial dysfunction	1 (4.8)
Renal failure necessitating dialysis	1 (4.8)
Re-exploration for operation	4 (19.0)
Survival number after discharge	19 (90.5)
Adverse events after discharge	
Headache	1 (4.8)
Vertigo	1 (4.8)
Renal failure	1 (4.8)
Stroke	1 (4.8)

Data are presented as n (%), mean ± standard deviation or median [range].

related events postoperatively (10,12). Previous studies have indicated that selecting stents with diameters ranging from 0–5% larger than the diameter measured in the anchoring zone on preoperative CTA has achieved favorable outcomes in preventing the occurrence of RTAD (13,14). For asymptomatic RTAD patients, upon reviewing CTA during follow-up, we observed that a considerable number of patients exhibited varying degrees of aortic atherosclerosis. This suggests that potential aortic pathology is also a significant factor in RTAD (11,15).

Due to the extremely high mortality rate associated with type A aortic dissection, almost all patients included in this study underwent emergency surgery (≤14 days). The standard surgical approach involved a conventional ascending aorta replacement combined with total arch replacement through a midline thoracotomy. Additionally, 17 patients in this study underwent simultaneous implantation of a FET stent. One patient, with no dissection occurring in the aorta adjacent to the TEVAR stent, underwent only ascending aorta and aortic arch replacement. The remaining three cases, where the dissection was confined to the ascending aorta, did not undergo total arch replacement; instead, they underwent ascending aorta replacement combined with right hemiarch replacement. Previous studies have indicated that aortic arch replacement with FET implantation is highly advantageous for patients with RTAD, especially those at high surgical risk. This not only reduces procedural complexity but also significantly shortens the overall surgical duration (6,11,16,17). However, due to the presence of TEVAR stents and the complex anatomy of the aortic arch, adopting this technique has become more challenging, inevitably leading to prolonged CPB and surgical duration. Consequently, there is a significantly increased likelihood of postoperative complications, such as paraplegia, renal impairment, and gastrointestinal complications. In our study, following RTAD repair, one patient required renal replacement therapy through hemodialysis due to elevated blood creatinine levels, and two patients died during hospitalization. One case was attributed to uncontrollable infection resulting from a pre-existing aortic-esophageal fistula, while the other was due to postoperative cardiac dysfunction.

Based on our past experience, patients who develop RTAD after TEVAR surgery need to undergo surgery as soon as possible, which is consistent with the results of a previous single-center study (18). However, compared to patients who have not undergone TEVAR, there are several additional aspects that require attention during the aortic surgical procedure. First, it is necessary to remove the portion of the TEVAR stent proximal anchor, as the rigid and exposed proximal part is likely to abrade the anastomotic line of the distal end of the four-branch artificial blood vessel during aortic surgery, leading to the occurrence of anastomotic fistula. In addition, we only trim the exposed portion near the proximal end of the TEVAR stent while preserving the remaining distal part to maintain the effect of TEVAR. An increase in procedures involving the aortic arch typically requires longer periods of SCP. At this point, the strategy for cerebral protection becomes crucial. When necessary, bilateral antegrade cerebral perfusion can be implemented to ensure brain protection. Simultaneously, monitoring the patient's cerebral protection status through methods such as electroencephalography is advisable (19).

This study had certain limitations. As Guangdong Provincial People's Hospital is the largest cardiovascular disease center in South China, many surgical patients are transferred from other hospitals. In this study, only three patients underwent TEVAR at Guangdong Provincial People's Hospital. Consequently, we were unable to obtain relevant information for patients who underwent TEVAR

© Journal of Thoracic Disease. All rights reserved.

procedures at other hospitals. Establishing a separate research cohort for this subgroup of patients was also not feasible. Therefore, in this study, we only conducted descriptive analyses on patients with RTAD, and could not predict risk factors.

Conclusions

This study showed that aortic surgery after TEVAR is a safe and effective treatment method. However, multi-center large-sample studies and long-term follow-up are needed to enhance safety and durability to ensure that patients receive optimal treatment and prognosis.

Acknowledgments

Funding: This work was supported by the Science and Technology Projects in Guangzhou (Nos. 2023A04J0491 and 2023A04J0490), National Natural Science Foundation of China (No. 82200518), Outstanding Young Talent Trainee Program of Guangdong Provincial People's Hospital (No. KY012023331), Guangdong Provincial Medical Science and Technology Research Fund Project (No. A2022113), the National Natural Science Foundation of China (No. 82370473), and the funders had no role in study design, data collection, data analysis, data interpretation, and the writing of the report.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-71/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-71/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-71/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-24-71/coif). The authors have no 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). The study was approved by the Ethics Review Committee of Guangdong Provincial People's Hospital (KY-Z-2022-218-01) and individual consent for this retrospective analysis was waived.

Open Access Statement: This is an Open Access article distributed in accordance with the Creative Commons Attribution-NonCommercial-NoDerivs 4.0 International License (CC BY-NC-ND 4.0), which permits the non-commercial replication and distribution of the article with the strict proviso that no changes or edits are made and the original work is properly cited (including links to both the formal publication through the relevant DOI and the license). See: https://creativecommons.org/licenses/by-nc-nd/4.0/.

References

1. Yurekli I, Kestelli M, Cakir H. About Timing of TEVAR in Dissection. Ann Thorac Surg 2023;115:795.
2. Dun Y, Shi Y, Guo H, et al. The surgical management of retrograde type A aortic dissection after thoracic endovascular aortic repair. Interact Cardiovasc Thorac Surg 2020;30:732-8.
3. Sun LZ, Ma WG, Zhu JM, et al. Sun's procedure for chronic type A aortic dissection: total arch replacement using a tetrafurcate graft with stented elephant trunk implantation. Ann Cardiothorac Surg 2013;2:665-6.
4. Eggebrecht H, Thompson M, Rousseau H, et al. Retrograde ascending aortic dissection during or after thoracic aortic stent graft placement: insight from the European registry on endovascular aortic repair complications. Circulation 2009;120:S276-81.
5. Wang GQ, Qin YF, Shi ST, et al. Retrograde type A aortic dissection during or after thoracic endovascular aortic repair: a single center 16-year experience. Front Cardiovasc Med 2023;10:1160142.
6. Li B, Pan XD, Ma WG, et al. Stented elephant trunk technique for retrograde type A aortic dissection after endovascular stent graft repair. Ann Thorac Surg 2014;97:596-602.
7. Canaud L, Ozdemir BA, Patterson BO, et al. Retrograde aortic dissection after thoracic endovascular aortic repair. Ann Surg 2014;260:389-95.
8. Chen Y, Zhang S, Liu L, et al. Retrograde Type A Aortic Dissection After Thoracic Endovascular Aortic Repair: A Systematic Review and Meta-Analysis. J Am Heart Assoc

© Journal of Thoracic Disease. All rights reserved.

2017;6:e004649.
9. Cheng L, Xiang D, Zhang S, et al. Reintervention after Thoracic Endovascular Aortic Repair of Uncomplicated Type B Aortic Dissection. J Clin Med 2023;12:1418.
10. Bellos JK, Petrosyan A, Abdulamit T, et al. Retrograde type A aortic dissections after endovascular stent-graft placement for type B dissection. J Cardiovasc Surg (Torino) 2010;51:85-93.
11. Ali-Hasan-Al-Saegh S, Halloum N, Scali S, et al. A systematic review and meta-analysis of retrograde type A aortic dissection after thoracic endovascular aortic repair in patients with type B aortic dissection. Medicine (Baltimore) 2023;102:e32944.
12. Ma T, Dong ZH, Wang S, et al. Computational investigation of interaction between stent graft and aorta in retrograde type A dissection after thoracic endovascular aortic repair for type B aortic dissection. J Vasc Surg 2018;68:14S-21S.e2.
13. Liu L, Zhang S, Lu Q, et al. Impact of Oversizing on the Risk of Retrograde Dissection After TEVAR for Acute and Chronic Type B Dissection. J Endovasc Ther 2016;23:620-5.
14. Wen Q, Wu G, Ji Y, et al. Physician-Modified Endografts for the Treatment of Thoracic Aortic Pathologies Involving the Aortic Arch. J Endovasc Ther 2023. [Epub ahead of print]. doi: 10.1177/15266028231207023.
15. Ma T, Dong ZH, Fu WG, et al. Incidence and risk factors for retrograde type A dissection and stent graft-induced new entry after thoracic endovascular aortic repair. J Vasc Surg 2018;67:1026-1033.e2.
16. An Z, Song Z, Tang H, et al. Retrograde Type A Dissection after Thoracic Endovascular Aortic Repair: Surgical Strategy and Literature Review. Heart Lung Circ 2018;27:629-34.
17. Zhou J, Yao X, Guo B, et al. Surgical Treatment of Retrograde Type A Aortic Dissection After Thoracic Endovascular Aortic Repair. Int Heart J 2022;63:286-92.
18. Roselli EE, Abdel-Halim M, Johnston DR, et al. Open aortic repair after prior thoracic endovascular aortic repair. Ann Thorac Surg 2014;97:750-6.
19. Kamenskaya OV, Klinkova AS, Chernyavsky AM, et al. Deep Hypothermic Circulatory Arrest vs. Antegrade Cerebral Perfusion in Cerebral Protection during the Surgical Treatment of Chronic Dissection of the Ascending and Arch Aorta. J Extra Corpor Technol 2017;49:16-25.

Cite this article as: Liu J, Ke J, Lu Y, Zhou K, Yu C, Zhen J, Jiang Z, Wu J, Sun T. The safety and prognostic evaluation of subsequent aortic surgery after thoracic endovascular aortic repair: a retrospective cohort study. J Thorac Dis 2024;16(6):3732-3739. doi: 10.21037/jtd-24-71

© Journal of Thoracic Disease. All rights reserved.