

Article

The Impact of Sun's Procedure on Postoperative Aortic Remodeling in Patients with Retrograde and Classic Type A Aortic Dissections

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Abstract

Background: This study aims to compare the impact of Sun's procedure on distal aortic remodeling in patients with acute Stanford type A aortic dissection (TAAD), including retrograde TAAD (RTAAD) and classical TAAD. The procedure's role in promoting distal aortic remodeling is assessed, along with potential differences in outcomes between the two subtypes of type A aortic dissection. **Methods:** A total of 76 patients diagnosed with TAAD, including 31 with RTAAD and 45 with classical TAAD were enrolled between November 2019 and May 2023. Using Carestream Image Suite V4, true and false lumen areas were retrospectively analyzed at five anatomical planes (pulmonary artery, abdominal trunk, superior mesenteric artery, left renal artery opening, and inferior mesenteric artery) preoperatively and three months postoperatively. Distal aortic remodeling outcomes were compared between the two groups. **Results:** Both the TAAD and retrograde type A aortic dissection (RTAAD) groups underwent Sun's procedure, consisting of total arch replacement, distal frozen elephant trunk technique, and ascending aorta replacement. In TAAD, the primary tear was excised through ascending aorta replacement, and stent expansion was used to enlarge the true lumen of the descending aorta. In RTAAD, stent grafts isolated the primary tear in the descending aorta and expanded the true lumen. No significant differences were observed between the groups in short-term distal aortic remodeling. There were no significant differences between the two groups in baseline characteristics, including sex, age, smoking history, hypertension, diabetes, coronary heart disease, and hyperlipidemia. **Conclusions:** These findings suggest that postoperative distal aortic remodeling may be influenced by factors beyond dissection type. Furthermore, Sun's procedure is an effective surgical approach for both TAAD and RTAAD patients.

Keywords

acute Stanford Type A aortic dissection; reverse tearing; Sun, s procedure; vascular remodeling

Introduction

Acute Stanford Type A aortic dissection (TAAD) (Fig. 1A1,A2) is a critical cardiovascular condition with a mortality rate approaching 50% within the first 48 hours of onset [1]. The Stanford classification is based on the location and extent of intimal tear, with Type A dissection involving an intimal tear within or extending to the ascending aorta [2]. A specific subtype, retrograde Stanford Type A aortic dissection (RTAAD) (Fig. 1B1,B2), occurs when the intimal tear originates below the left subclavian artery and propagates retrogradely to the ascending aorta and aortic arch [3]. RTAAD accounts for approximately 9% of all TAAD cases [3].

Current management of acute Type A aortic dissection typically involves emergency surgical intervention, as recommended by the 2014 European Association for Cardio-Thoracic Surgery (Class Ib recommendation) [4]. However, there is still controversy regarding the optimal treatments for RTAAD patients. Some studies [5] advocate for endovascular stent graft intervention in select cases. A Japanese study by Omura *et al.* [5], researchers treated eight elderly RTAAD patients with multiple organ dysfunction, including neurological, renal, respiratory, and circulatory impairments. Utilizing endovascular aortic repair, the authors achieved a 0% early mortality rate and favorable outcomes. However, more robust studies, particularly including multicenter, large-sample, and long-term follow-up designs are needed to verify these results.

An alternate proposal involves utilizing conservative management with timely intervention in select cases of RTAAD, based on key differences from traditional TAAD [6–8]. Unlike classical TAAD, where emergency surgical treatment is almost universally required due to the high risk of rupture, RTAAD patients may experience better prog-

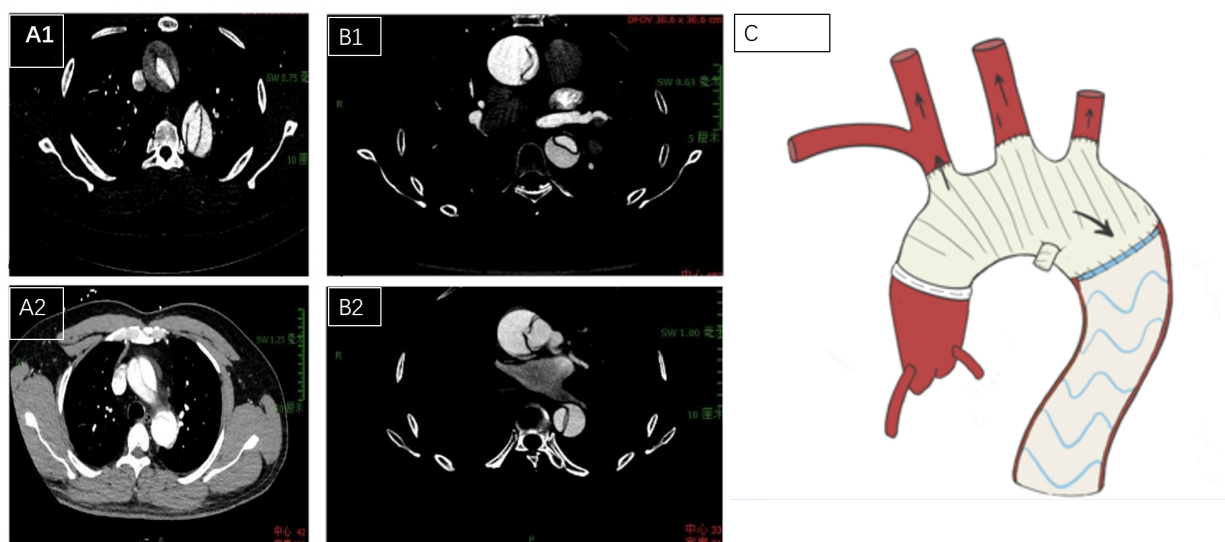


Fig. 1. Imaging and surgical approaches for RTAAD and classical TAAD. (A1,A2) Representative imaging of RTAAD, highlighting the retrograde propagation of the intimal tear from below the left subclavian artery to the ascending aorta. (B1,B2) Representative imaging of classical TAAD, characterized by an intimal tear originating in the ascending aorta. (C) Diagram of Sun's procedure, illustrating the replacement of the aortic arch with a four-branch artificial blood vessel and the implantation of an elephant trunk stent in the descending aorta for vascular remodeling. RTAAD, retrograde Stanford Type A aortic dissection; TAAD, Type A aortic dissection.

noses, particularly when thrombus formation in the false lumen of the ascending aorta promotes relative hemodynamic stability. In such cases, it has been suggested that observation paired with timely intervention may be more appropriate than immediate surgery. However, other researchers advocate for surgical treatment as the definitive approach for RTAAD patients.

In China, the most commonly used surgical method is the “stent elephant trunk” procedure, developed by Sun Lizhong and colleagues in 2003, also known as Sun's procedure [9] (Fig. 1C). This procedure involves replacing the aortic arch with a four-branch artificial blood vessel and implanting an elephant trunk stent in the distal descending aorta. The stent's expansive properties are used to seal the tear, dilate the vessel, and expand the true lumen, allowing closure of the false lumen and ultimately promoting vascular remodeling.

This study aims to assess postoperative vascular remodeling outcomes between RTAAD surgical treatment and conventional TAAD patients. By evaluating the efficacy of surgical treatments, we seek to provide a clinical reference for the surgical diagnosis and treatment of RTAAD patients.

Materials and Methods

General Information

This study retrospectively analyzed 76 patients diagnosed with acute Stanford Type A aortic dissection from

November 2019 to May 2023. The retrograde Stanford Type A aortic dissection (RTAAD) group comprised 31 cases, while the TAAD group had 45 cases. Patient demographics, including sex, age, smoking history, and previous medical history, were collected from the medical records. Carestream medical imaging software Image Suite V4 (Rochester, New York State, USA, Version number: 11.4.1.1011-vuep) was used to measure the true lumen, false lumen, and total lumen areas at various anatomical planes (pulmonary artery, abdominal trunk, superior mesenteric artery, left renal artery opening, and inferior mesenteric artery) based on perioperative computed tomography angiography (CTA) examinations. This study adhered to the Declaration of Helsinki throughout its entire course and was approved by the hospital's ethics committee (Approval No.: 20230927LL001).

Inclusion and Exclusion Criteria

Inclusion criteria were as follows: (1) Preoperative confirmation of acute Stanford Type A aortic dissection by CTA; (2) Postoperative survival exceeding 3 months with available postoperative CTA images; (3) No history of previous major cardiovascular surgery. Exclusion criteria included: (1) TAAD patients with involvement limited to the ascending aorta, without involvement of the aortic arch or distal aorta. (2) TAAD patients who did not undergo Sun's procedure combined with ascending aorta replacement.

Table 1. Baseline preoperative patient characteristics.

General	RTAAD group (n = 31)	TAAD group (n = 45)	t/ χ^2 value	p-value
Sex			0.040	0.841
Male	28 (90.3%)	40 (88.9%)		
Female	3 (9.7%)	5 (11.1%)		
Age	50.26 $\pm$ 10.04	51.93 $\pm$ 12.28	-0.628	0.532
Smoking			0.543	0.461
Yes	6 (19.4%)	12 (26.7%)		
No	25 (80.6%)	33 (73.3%)		
Hypertension			2.350	0.125
Yes	29 (93.5%)	35 (77.8%)		
No	2 (6.5%)	10 (22.2%)		
Diabetes				0.408
Yes	1 (3.2%)	0 (0.0%)		
No	30 (96.8%)	45 (100.0%)		
Coronary heart disease			<0.001	1.000
Yes	3 (9.7%)	4 (8.9%)		
No	28 (77.4%)	41 (91.1%)		
Hyperlipidemia			1.784	0.182
Yes	7 (22.6%)	4 (8.9%)		
No	24 (71.0%)	41 (91.1%)		
Postoperative true/false cavity >1			0.047	0.828
Yes	13 (41.9%)	20 (44.4%)		
No	18 (58.1%)	25 (55.6%)		

RTAAD, retrograde Stanford Type A aortic dissection; TAAD, Type A aortic dissection.

Surgical Groups and Procedures

The RTAAD group (31 cases) presented with retrograde tear starting from the chest/descending aorta (below the left subclavian artery) and extending in a retrograde manner to the ascending aorta. Intraoperatively, an elephant trunk stent covered the intimal tear. The TAAD group (45 cases) had the tear originating in the ascending aorta/aortic arch (closer to the left subclavian artery). Both groups underwent Sun's procedure. Statistical analysis was used to compare true lumen, false lumen, and total lumen sizes at different anatomical planes to assess vascular remodeling before and after surgery.

Statistical Methods

Statistical analysis was performed using SPSS 26 (IBM-SPSS Statistics, Chicago, IL, USA). Descriptive data were presented as mean $\pm$ standard deviation ($\bar{x} \pm S$). For normally distributed data with homogenous variances, paired-sample *t*-tests were used for intra-group comparisons, and independent-sample *t*-tests for inter-group comparisons. Non-normally distributed data were expressed as M (P25, P75), and comparisons were performed using the Mann-Whitney U test for inter-group and Wilcoxon signed-rank test for intra-group analyses. M means the median, and P25 and P75 refer to the 25th and 75th percentiles. Count data were presented as percentages (%), and the chi-square test, corrected chi-square test, or Fisher's exact probability test were used for inter-group comparisons of the total effective rate.

Results

Comparison of General Preoperative Data between Two Groups

This study included a total of 76 patients, with 31 in the RTAAD group, comprising 28 males and 3 females, and an average age of 50.26 $\pm$ 10.04. The TAAD group was comprised of 40 males and 5 females, with an average age of 51.93 $\pm$ 12.28. There were no significant differences in sex, age, smoking history, hypertension, diabetes, coronary heart disease, hyperlipidemia, or other general data between the two groups (*p* > 0.05). Refer to Table 1 for details.

Comparison of Intraluminal Areas in Different Segments of the Descending Aorta in Both Groups Preoperatively

There were no significant differences between the two groups in terms of intraluminal areas at the pulmonary artery, abdominal trunk, superior mesenteric artery, left renal artery opening, or inferior mesenteric artery planes preoperatively (*p* > 0.05). No significant differences were observed in the intraluminal areas (true lumen, false lumen, and total lumen) at these five planes before surgery. Refer to Table 2 for details.

Table 2. Preoperative comparison of lumen area segments of the descending aorta.

Variable		RTAAD group (n = 31)	TAAD group (n = 45)	t/z values	p-value
Pulmonary artery plane	Preoperative true lumen area (mm ²)	346.06 ± 156.42	421.98 ± 200.26	-1.852	0.068
	Preoperative false lumen area (mm ²)	609.46 (494.93, 711.63)	520.20 (369.92, 674.59)	-1.750	0.080
	Total preoperative area (mm ²)	945.18 ± 172.03	937.75 ± 228.93	0.153	0.879
Celiac trunk plane	Preoperative true lumen area (mm ²)	305.21 ± 98.49	338.79 ± 158.68	-1.137	0.259
	Preoperative false lumen area (mm ²)	441.58 (297.33, 493.53)	323.83 (165.96, 484.69)	-1.286	0.198
	Total preoperative area (mm ²)	714.80 ± 193.53	652.55 ± 172.13	1.473	0.145
Superior mesenteric artery level	Preoperative true lumen area (mm ²)	283.48 ± 92.65	301.22 ± 148.60	-0.64	0.524
	Preoperative false lumen area (mm ²)	338.10 (257.18, 440.91)	293.70 (126.27, 412.30)	-1.360	0.174
	Total preoperative area (mm ²)	628.08 ± 146.34	585.84 ± 153.42	1.201	0.233
Left renal artery opening	Preoperative true lumen area (mm ²)	232.88 ± 79.36	270.75 ± 129.01	-1.582	0.118
	Preoperative false lumen area (mm ²)	268.55 (185.30, 340.36)	229.46 (49.23, 303.96)	-1.711	0.087
	Total preoperative area (mm ²)	505.23 ± 120.59	481.72 ± 129.18	0.801	0.426
Inferior mesenteric artery plane	Preoperative true lumen area (mm ²)	211.66 ± 94.74	205.09 ± 101.97	0.285	0.777
	Preoperative false lumen area (mm ²)	176.77 (0.00, 201.81)	127.44 (0.00, 219.73)	-0.248	0.804
	Total preoperative area (mm ²)	348.28 ± 80.77	359.27 ± 155.71	-0.361	0.719

Comparison of Intraluminal Areas in Different Segments of the Descending Aorta in Both Groups Postoperatively

Postoperative comparisons of intraluminal areas in the pulmonary artery plane postoperatively showed no statistically significant differences between the two patient groups. Specifically, at the pulmonary artery plane, the true lumen ($p = 0.941$), false lumen ($p = 0.168$), and total lumen ($p = 0.142$) areas showed p values exceeding 0.05. Similar results were observed at the abdominal trunk plane (true lumen $p = 0.464$, false lumen $p = 0.747$, total lumen $p = 0.115$), superior mesenteric artery plane (true lumen $p = 0.420$, false lumen $p = 0.578$, total lumen $p = 0.122$), the left renal artery opening plane (true lumen $p = 0.797$, false lumen $p = 0.629$, total lumen $p = 0.900$), and inferior mesenteric artery plane (true lumen $p = 0.873$, false lumen $p = 0.594$, total lumen $p = 0.944$).

The ratio of the true lumen to the false lumen was consistently greater than 1 postoperatively in both groups, with a p value of 0.828 ($p > 0.05$), indicating no statistically significant difference. These findings suggest that the surgical outcomes, in terms of lumen remodeling, were similar across the two groups. Refer to Table 3 for details.

Discussion

For acute TAAD involving the ascending aorta, aortic arch, and distal aorta, Sun's procedure—total arch replacement with distal elephant trunk stent graft implantation combined with ascending aorta replacement—has become the standard surgical approach in China [10,11]. This technique, widely implemented across the Chinese Mainland, has demonstrated favorable clinical outcomes. Surgical strategies for TAAD involving the aortic arch differ

between domestic and international practices. In Western countries, most cardiac centers perform ascending aorta replacement combined with partial aortic arch replacement by default [12]. However, Chinese TAAD patients are generally younger and have a longer life expectancy compared to their Western counterparts, and partial aortic arch replacement is associated with a higher long-term risk of reoperation in this population [12]. Meta-analysis studies have indicated that, although total aortic arch replacement increases the complexity of surgery compared to partial aortic arch replacement, it does not increase operative mortality rates. Therefore, for institutions with established technical expertise, Sun's procedure is recommended as the preferred approach for aortic arch reconstruction in these patients.

Challenges in Managing RTAAD

In clinical practice, some patients present with acute RTAAD, where the intimal tear originates in the descending aorta distal to the left subclavian artery. The resulting hematoma propagates retrogradely to the aortic arch and descending aorta [13]. Surgical management of RTAAD remains a contentious issue. Some classify RTAAD as a form of acute TAAD, necessitating emergency surgical intervention with Sun's procedure [12]. Others advocate for a delayed approach, allowing the hematoma to stabilize before proceeding with endovascular isolation surgery. This approach is particularly recommended for elderly patients or those with significant comorbidities that elevate the risks of conventional open surgery [7]. For RTAAD with entry tears in the descending aorta, such as in elderly patients or those with severe preoperative organ dysfunction, including multi-organ failure who are not suitable for conventional open surgery, thoracic endovascular repair (TEVAR) has

Table 3. Postoperative comparison of lumen area segments of the descending aorta.

Variable		RTAAD group (n = 31)	TAAD group (n = 45)	t/z values	p-value
Pulmonary artery plane	Postoperative true lumen area (mm ²)	522.72 ± 91.75	521.05 ± 99.68	0.074	0.941
	Postoperative false lumen area (mm ²)	552.49 (375.70, 590.53)	434.65 (348.92, 570.40)	−1.380	0.168
	Total postoperative area (mm ²)	1045.57 ± 223.07	956.20 ± 279.00	1.485	0.142
Celiac trunk plane	Postoperative true lumen area (mm ²)	360.73 ± 157.51	335.17 ± 142.38	0.736	0.464
	Postoperative false lumen area (mm ²)	374.42 (296.00, 478.02)	373.70 (237.67, 479.58)	−0.323	0.747
	Total postoperative area (mm ²)	748.97 ± 192.22	683.30 ± 164.93	1.594	0.115
Superior mesenteric artery level	Postoperative true lumen area (mm ²)	324.17 ± 138.25	300.34 ± 116.86	0.811	0.420
	Postoperative false lumen area (mm ²)	338.53 (253.65, 442.56)	303.10 (106.27, 434.82)	−0.556	0.578
	Total postoperative area (mm ²)	645.04 ± 122.05	595.61 ± 143.49	1.566	0.122
Left renal artery opening	Postoperative true lumen area (mm ²)	260.16 ± 120.24	267.01 ± 108.77	−0.258	0.797
	Postoperative false lumen area (mm ²)	286.05 (179.30, 325.07)	237.39 (64.27, 345.88)	−0.484	0.629
	Total postoperative area (mm ²)	498.64 ± 118.31	495.01 ± 126.57	0.126	0.900
Inferior mesenteric artery plane	Postoperative lumen area (mm ²)	211.61 ± 86.08	208.38 ± 85.69	0.161	0.873
	Postoperative prosthetic lumen area (mm ²)	186.18 (0.00, 247.01)	148.15 (0.00, 238.94)	−0.533	0.594
	Total postoperative area (mm ²)	366.94 ± 95.40	369.17 ± 155.64	−0.071	0.944

emerged as a viable alternative surgical option. TEVAR offers a less invasive approach, reducing surgical stress and potentially improving outcomes in high-risk patients [5,14]. However, these patients require meticulous postoperative follow-up for complications, such as stent migration, false lumen expansion, or re-dissection [5,14].

Prognosis and Treatment Considerations

Distinct differences between RTAAD and classical TAAD influence prognosis and treatment strategies. Lopez-Marco *et al.* [15] found that compared to TAAD, RTAD rarely involves the aortic valve, coronary arteries, or aortic sinuses. This distinct difference in anatomical presentation may contribute to the relatively better prognosis observed in RTAD cases. Based on these findings, they advocate for a proactive treatment strategy for RTAD, emphasizing the importance of addressing the primary entry tear to reduce the risk of short-term and mid-term complications. Recommended approaches include total arch repair or frozen elephant trunk repair, when appropriate, with simultaneous management of distal perfusion insufficiency when necessary [15].

In our clinical experience, RTAAD presenting patients with concurrent pericardial effusion or hematoma-induced coronary artery compression often suffer from hemodynamic instability, which can lead to life-threatening cardiovascular events such as sudden death. Although not all patients exhibit these complications, every RTAAD case carries this risk. Based on these observations, our center advocates for emergency surgical treatment in RTAAD patients presenting with such high-risk features.

Intraoperative Stent Use and Insights from TEVAR in Aortic Dissection Management

Few studies have examined the use of intraoperative stents to isolate the distal descending aorta hematoma in TAAD or to manage primary rupture of the descending aorta in RTAAD, with the goal of promoting effective distal aortic remodeling. However, extensive research has explored correlations between acute Stanford B-type aortic dissection and Stanford A-type aortic dissection after TEVAR, including risk factors, morphological characteristics, surgical strategies, and postoperative aortic remodeling [13,15–17]. These findings provide a theoretical foundation for developing improved surgical strategies for managing acute RTAAD patients.

Distal Aortic Remodeling After TEVAR and Sun's Procedure: Insights and Gaps

Extensive literature has explored distal descending aortic vascular remodeling after TEVAR surgery for acute Stanford B-type aortic dissection, providing a solid scientific foundation for understanding remodeling processes in these cases [18,19]. Studies on TEVAR for acute RTAAD and distal aortic remodeling after TAAD repair have also been reported [20], but the limited number of cases prevents a definitive evaluation of its efficacy [21]. To address this gap, we analyzed vascular remodeling across different segments of the descending aorta—including the pulmonary artery plane, abdominal trunk, superior mesenteric artery, left renal artery opening, and inferior mesenteric artery plane—following Sun's procedure in TAAD and RTAAD patients. The primary objective was to assess the short-term remodeling effects of the descending aorta in patients who did not undergo resection of the descending aorta rupture.

In our study, we observed no significant preoperative differences between the two groups in terms of sex, age, hypertension, diabetes, coronary heart disease, or other factors influencing aortic remodeling. Additionally, the true lumen and false lumen dimensions were comparable between the groups before surgery. Postoperatively, the descending aorta in both groups showed a consistent pattern characterized by unchanged total lumen area, enlargement of the true lumen, and reduction of the false lumen. At the same time, no significant complications, such as internal leakage, vascular rupture, major bleeding, or death were observed. Short-term distal aortic remodeling outcomes were also similar between the two groups.

These results suggest that postoperative distal aortic remodeling may be influenced by factors other than just the type of dissection, and future research should further explore its underlying mechanisms. Furthermore, total aortic arch replacement combined with frozen elephant trunk surgery demonstrates strong clinical efficacy for RTAAD patients. For RTAAD patients with retrograde involvement of the ascending aorta and aortic arch, Sun's procedure remains a highly effective surgical approach, provided there are no significant surgical contraindications. Its use should be further promoted in clinical practice.

Limitations

This study is subject to some notable limitations. First, although the imaging reviews were conducted by experienced radiologists, inter-patient variability can still lead to errors. Second, this single center retrospective study of the RTAAD group is limited by a small sample size and short follow-up duration. Further validation of these findings requires multicenter studies with larger sample sizes and long-term follow-up to ensure robust conclusions.

Conclusions

In conclusion, this study found no significant differences in short-term distal aortic remodeling between patients with TAAD and RTAAD following total aortic arch replacement with frozen elephant trunk surgery. Both groups demonstrated comparable trends of true lumen enlargement, false lumen reduction, and stable total lumen areas, with no significant postoperative complications. These findings suggest that the surgical treatment strategies for TAAD and RTAAD may have similar short-term efficacy, postoperative distal aortic remodeling may be influenced by factors beyond dissection type. Furthermore, Sun's procedure is an effective surgical approach for both TAAD and RTAD patients. However, further multicenter studies with larger sample sizes and long-term follow-up are still needed to validate these results and to better understand the factors influencing postoperative aortic remodeling, as well as the

differences in the efficacy of Sun's procedure for different subtypes of type A aortic dissection.

Availability of Data and Materials

The datasets used in this study are available from the corresponding author upon reasonable request.

Author Contributions

Author JHX and Author CEL contributed equally to this work. JHX and CEL primarily contributed to data collection, data analysis, result interpretation, and manuscript writing. AK, CZL, DPH, YGF, and ZWL were mainly responsible for the conception and design of the study, as well as drafting the manuscript. ZL was mainly responsible for the conceptualization and design of the study. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study was carried out in accordance with the guidelines of the Declaration of Helsinki and this retrospective analysis was approved by the hospital's ethics committee (ethics approval number 20230927LL001) and preoperative patients and their families.

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Conflict of Interest

The authors declare no conflict of interest.

References

- [1] Levy D, Sharma S, Grigorova Y, Farci F, Le JK. Aortic Dissection. StatPearls. StatPearls Publishing: Treasure Island (FL). 2024.
- [2] Sherk WM, Khaja MS, Williams DM. Anatomy, Pathology, and Classification of Aortic Dissection. *Techniques in Vascular and Interventional Radiology*. 2021; 24: 100746. <https://doi.org/10.1016/j.tvir.2021.100746>.
- [3] Zhang H, Feng J, Zhu H, Xiao S, Liu M, Xu Y, *et al*. Single-branched stent-graft with on-table fenestration for endovascular repair of primary retrograde type A aortic dissection: A multicenter retrospective study. *Frontiers in Cardiovascular Medicine*. 2022; 9: 1034654. <https://doi.org/10.3389/fcvm.2022.1034654>.
- [4] Erbel R, Aboyans V, Boileau C, Bossone E, Di Bartolomeo R, Eggebrecht H, *et al*. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases. *Polish Heart Journal (Kardiologia Polska)*. 2014; 72: 1169–1252. <https://doi.org/10.5603/KP.2014.0225>.
- [5] Omura A, Matsuda H, Matsuo J, Hori Y, Fukuda T, Inoue Y, *et al*. Thoracic endovascular repair for retrograde acute type A aortic dissection as an alternative choice. *General Thoracic and Cardiovascular Surgery*. 2020; 68: 1397–1404. <https://doi.org/10.1007/s11748-020-01397-0>.
- [6] Kim JB, Choo SJ, Kim WK, Kim HJ, Jung SH, Chung CH, *et al*. Outcomes of acute retrograde type A aortic dissection with an entry tear in descending aorta. *Circulation*. 2014; 130: S39–S44. <https://doi.org/10.1161/CIRCULATIONAHA.113.007839>.
- [7] Kaji S, Akasaka T, Katayama M, Yamamuro A, Yamabe K, Tamita K, *et al*. Prognosis of retrograde dissection from the descending to the ascending aorta. *Circulation*. 2003; 108 Suppl 1: II300–II306. <https://doi.org/10.1161/01.cir.0000087424.32901.98>.
- [8] Sadamatsu K, Takase S, Sagara S, Ohe K, Nishi JI, Tashiro H, *et al*. Initial medical management in acute type A aortic dissection patients with a thrombosed false lumen in the ascending aorta combining intramural hematoma and retrograde dissection from the descending to the ascending aorta. *European Heart Journal. Acute Cardiovascular Care*. 2020; 9: S13–S20. <https://doi.org/10.1177/2048872618777724>.
- [9] Ma WG, Zhu JM, Zheng J, Liu YM, Ziganshin BA, Elefteriades JA, *et al*. Sun's procedure for complex aortic arch repair: total arch replacement using a tetrafurcate graft with stented elephant trunk implantation. *Annals of Cardiothoracic Surgery*. 2013; 2: 642–648. <https://doi.org/10.3978/j.issn.2225-319X.2013.09.03>.
- [10] Wu Y, Jiang R, Xu P, Wang G, Wang J, Yang S. Perioperative Results and Risk Factors for In-Hospital Mortality In Patients With Stanford Type A Aortic Dissection Undergoing Sun's Procedure - A Single Center Study. *The Heart Surgery Forum*. 2018; 21: E432–E437. <https://doi.org/10.1532/hsf.1909>.
- [11] Zhong L, Xiong H, Li J, He Y, Zhou H. Early outcomes of Sun's procedure in elderly patients with acute aortic dissection: a single-center retrospective study. *The Journal of International Medical Research*. 2022; 50: 3000605221109377. <https://doi.org/10.1177/03000605221109377>.
- [12] Branch of Major Vessel Surgery, Cardiovascular Surgery Branch, Chinese Medical Doctor Association. Chinese experts' consensus of standardized diagnosis and treatment for aortic dissection. *Chinese Journal of Clinical Thoracic and Cardiovascular Surgery*. 2017; 33: 641–654. (In Chinese) <https://doi.org/10.3760/cma.j.issn.1001-4497.2017.11.001>.
- [13] DiMusto PD, Rademacher BL, Philip JL, Akhter SA, Goodavish CB, De Oliveira NC, *et al*. Acute retrograde type A aortic dissection: morphologic analysis and clinical implications. *The Journal of Surgical Research*. 2017; 213: 39–45. <https://doi.org/10.1016/j.jss.2017.02.034>.
- [14] Kreibich M, Rylski B, Kondov S, Morlock J, Scheumann J, Kari FA, *et al*. Endovascular treatment of acute Type A aortic dissection-the Endo Bentall approach. *Journal of Visualized Surgery*. 2018; 4: 69. <https://doi.org/10.21037/jovs.2018.03.14>.
- [15] Lopez-Marco A, Adams B, Oo AY. Retrograde type A aortic dissection: a different evil. *Interactive Cardiovascular and Thoracic Surgery*. 2022; 35: ivac264. <https://doi.org/10.1093/icvts/ivac264>.
- [16] Zhao Y, Yao C, Yin H, Wang M, Li Z, Wang J, *et al*. Prognosis and Remodeling after Endovascular Repair for Acute, Subacute, and Chronic Type B Aortic Dissection. *Journal of Endovascular Therapy: an Official Journal of the International Society of Endovascular Specialists*. 2023; 30: 838–848. <https://doi.org/10.1177/15266028221098703>.
- [17] Ali-Hasan-Al-Saegh S, Halloun N, Scali S, Kriege M, Abualia M, Stamenovic D, *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*. 2023; 102: e32944. <https://doi.org/10.1097/MD.00000000000032944>.
- [18] Tang QH, Chen J, Yang H, Qin Z, Lin QN, Qin X. Factors Affecting False Lumen Thrombosis In Type B Aortic Dissection. *Arquivos Brasileiros De Cardiologia*. 2023; 120: e20220939. <https://doi.org/10.36660/abc.20220939>.
- [19] Zhong J, Osman A, Tingerides C, Puppala S, Shaw D, McPherson S, *et al*. Technique-Based Evaluation of Clinical Outcomes and Aortic Remodelling Following TEVAR in Acute and Subacute Type B Aortic Dissection. *Cardiovascular and Interventional Radiology*. 2021; 44: 537–547. <https://doi.org/10.1007/s00270-020-02749-2>.
- [20] Rathore KS. Distal Aortic Remodeling after Type A Dissection Repair: An Ongoing Mirage. *Journal of Chest Surgery*. 2021; 54: 439–448. <https://doi.org/10.5090/jcs.21.027>.
- [21] Kikuchi Y, Tsutsui M, Ishido K, Narita M, Ushioda R, Shirasaka T, *et al*. Case of rapid aortic remodeling after thoracic endovascular aortic repair for retrograde type A aortic dissection. *Journal of Surgical Case Reports*. 2022; 2022: rjac050. <https://doi.org/10.1093/jscr/rjac050>.