The Heart Surgery Forum 2022-4663
25 (4), 2022 [Epub August 2022]
doi: 10.1532/hsf.4663

Online address: http://journal.hsforum.com

An Analysis of Total Arch Re-Replacement After Proximal Aortic Surgery

He Wang, MD, Yangyong Sun, MD, PhD, Jianhui Peng, MD, Libo Zhao, MD, Hongjie Xu, MD, PhD, Zhiyun Xu, MD, PhD, Guanxin Zhang, MD, PhD

Department of Cardiovascular Surgery, Changhai Hospital, The Naval Military Medical University, Shanghai, China

ABSTRACT

Background: After proximal aortic surgery, total arch replacement (TAR) may again be needed because of recurrent dissection or aneurysm. This paper analyzed the relevant data of this technology with hopes of improving cognition and treatment.

Methods: There were a total of 60 eligible cases of secondary TAR after proximal aortic surgery in our center from 2010 to 2020. The primary surgical procedures included aortic valve replacement (AVR), ascending aortic replacement, Bentall, hemi-arch replacement, and thoracic endovascular aortic repair (TEVAR). The data were analyzed using the IBM SPSS Statistics 23.0 for Windows™ and presented as the mean ± standard deviations and direct frequencies, as appropriate.

Results: The interval between two operations was 44.8±53.6 months, 24 cases (40%) underwent emergency operation, the recurrence of type A dissection included 51 cases, accounting for 85% of the causes of total arch re-replacement. In the second surgical procedures, the ascending + TAR + stented elephant trunk (SET) implantation accounted for 75.0%. The overall surgical success rate was 98.3%. Postoperative respiratory complications were the most common, including infection, pneumothorax and hemothorax in 21 cases (35.6%). The second most common complication was acute kidney injury (AKI) in six cases (10.2%), and neurological complications took place in three cases (5.1%). The 30-day mortality rate was 15.3% and the 1-, 3- and 5-year survival rates were 96.0%, 84.0%, and 76.0%, respectively.

Conclusions: The recurrence of dissection is the main cause of TAR after proximal aortic surgery, followed by aneurysm and the resurgical criteria for aneurysm needs to be unified. In addition to TAR, SET also is widely used. Despite high early mortality, its long-term prognosis is acceptable.

Received February 21, 2022; accepted March 21, 2022.

Correspondence: Zhiyun Xu, MD, PhD, and Guanxin Zhang, MD, PhD, Department of Cardiovascular Surgery, Changhai Hospital,168 Changhai Road, Shanghai 200433, China (emails: xuzhiyun_ch@163.com and zhanggx97@163.com).

INTRODUCTION

Being young, Marfan syndrome (MFS), incomplete removal of the lacerated tissue during the first operation, and aortic valve regurgitation all were independent risk factors for reoperation of the aorta [Suzuki 2018]. According to the statistics of the International Registry of Aortic Dissection (IRAD), the probability of recurrent dissection after cardiac surgery which results from iatrogenic injury is about 5%, of which 76% was Stanford type A and 24% was type B [Januzzi 2002]. In addition to the dissection, there are more aortic aneurysms [Nishi 2010], proximal vascular structure changes, aortic valve regurgitation, and hemodynamic cause aortic dilation. The success rate of intravascular repair of type A aortic dissection (TAAD) is desirable, but the ascending and descending have very different hemodynamic characteristics and anatomical structure in diameter. The incidence of postoperative leakage is approximately 14.3% [Zhang 2019]. The retrograde type A dissection (RTAD) was calculated at 2.5% with a high mortality rate of 37.1% [Chen 2017]. So, reoperation in patients treated with TAAD with interventional therapy is of higher rate and more urgent. Estrera and his colleagues calculated that 62% of reoperations after aortic dissection were performed with TAR [Estrera 2007]. The ascending + TAR + SET, also known as Sun's surgery, is a surgical strategy for treating arch involvement of TAAD after Bentall and other operations, especially for MFS patients [Sun 2011]. In the work, we also found that after proximal surgery, artificial vascular replacement in the arch was necessary to completely remove the pathological tissue, and stent implantation in the descending was necessary to close the distal pseudocavity for thrombosis. However, the history of cardiac surgery also acts as one of the important factors affecting prognosis [Rampoldi 2007]. Therefore, we analyzed the therapeutic effect of TAR after proximal aortic intervention.

METHODS

Patients' inclusion: We collected the information of 60 cases of TAR after proximal aortic surgery in our center from 2010 to 2020. This included 48 males (80%) with an average age of 52.5±12.3 years old. Among them, 41 (68.3%) patients had hypertension and 11 (18.3%) had Marfan syndrome. Patient consent for publication was obtained from all individuals involved in our study.

Proximal aortic surgery includes simple AVR in addition to artificial replacement of aortic root and ascending. The AVR

may change the anatomical morphology and blood flow state of normal root after surgery and also is a risk factor for dissection or aneurysm. The case breakdown is as follows: 18 cases (30%) of Bentall+ SET (including 5 cases of hemi-arch replacement), 4 cases (6.7%) of ascending replacement, ascending + hemi-arch replacement + SET in 1 case (1.7%), AVR in 6 cases (10.0%), and TEVAR in 31 cases (51.7%). (Table 1)

Reoperation: The median thoracic incision was used in all cases. Unilateral cerebral perfusion and deep hypothermia circulatory stop were performed, and intubation was established through the femoral artery and vein before thoracotomy because the pericardial adhesion of patients with previous thoracotomy was serious. Therefore, it was difficult to perform stripping again, which was prone to massive bleeding and other accidents. Extracorporeal circulation was established after ACT > 480sec, the proximal end of the heart was first treated. The root artificial vessels were removed, and the artificial aortic valve was retained. The quadrifurcated artificial vessels were anastomosed with the valve edge, and the coronary openings were examined. When the openings were affected by dissection, 4-0 propyl line was used to seal the openings, and collateral circulation was established through the great saphenous vein and artificial vessels. The left subclavicular artery and left carotid artery were blocked. Cerebral perfusion was established through the innominate artery, circulation was stopped after cooling to 26-28°C, the arch tissue and internal stent were completely cut off, descending aortic stent was retained and pruned proximal, and the appropriate stent was re-inserted. After release, the pseudocavity opening was completely occluded and anastomosed with the quadripartite artificial vessels. Then, the left subclavian artery, left carotid artery, and innominate artery were anastomosed in sequence, and open perfusion was performed after each anastomosis to reduce the ischemia time.

Table 1. Basic patient information

Variables	*N*	%
Male	48	80.0
Female	12	20.0
Age (years)	52.5±12.3	
Smoking	15	25.0
Marfan syndrome	11	18.3
Hypertension	41	68.3
Diabetes	3	5.0
NYHA class III–IV	9	15.0
Chronic renal failure	3	5.0
Coronary artery disease	3	5.0
Arrhythmia	3	5.0
First surgical approach		
Bentall+ SET	13	21.7
Bentall + hemi-arch replacement + SET	5	8.3
Ascending + hemi-arch replacement + SET	1	1.7
Ascending replacement	4	6.7
AVR	6	10.0
TEVAR	31	51.7

RESULTS

Etiology of reoperation: The recurrence of type A dissection was 51 cases (85.0%). According to the statistics of the location of the dissection, 31 cases (60.8%) were found between the aortic root and innominate artery, 14 cases (27.5%) were found between the innominate artery and left subclavian artery, and six cases (11.8%) were found at the distal end of the left subclavian artery. There were nine cases (15%) of aneurysms without intimal rupture but formed by obvious expansion of aortic tissue, including six cases (66.7%) of MFS, with a diameter of 50-80mm, 14 cases (23.3%) of aortic valve insufficiency, and four cases (6.7%) of acute cardiac tamping.

The reoperation data: The mean interval between the two surgeries was 44.8±53.6 months. Twenty-four cases (40.0%) underwent emergency surgery. Ascending + TAR + SET, that is, Sun's surgery was performed in 45 cases (75.0%), which was the most used surgical method. A total of 56 patients (93.3%) underwent SET. Among 11 patients with MFS, seven patients (63.6%) were treated with Sun's surgery, three (27.3%) were treated with Bentall + TAR + SET, and one (9.1%) underwent ascending + TAR. All femoral artery catheterization was performed, with 49 cases (81.7%) on the left and 11 cases (18.3%) on the right. The duration of cardiopulmonary intubation was 75-253min (149.9±33.8 min), duration of stop cycle was 13-68min (29.4±10.1min) refers to only cerebral perfusion, anal temperature 24.5-30.1°C (27.3±1.1°C) when circulation stops. (Table 2)

Early and long-term prognosis: One of the 60 patients died due to dissection rupture during operation, and the overall success rate was 98.3%. Postoperative respiratory complications were the most common, including infection, pneumothorax, and hemothorax in 21 cases (35.6%). The second was AKI in six cases (10.2%). Neurological complications were in three cases (5.1%), and secondary thoracotomy for bleeding took place in three cases (5.1%). Within 30 days after reoperation, nine patients died, a mortality rate of 15.3%. Five of the nine had liver and kidney failure, two had severe infections, one experienced heart failure, and one had cerebral hernia. (Table 3) The mean follow-up time of discharged patients was 46 months and the 1-, 3- and 5-year survival rates were 96.0%, 84.0%, and 76.0%, respectively. Cardio-cerebrovascular accident was the main cause of death.

DISCUSSION

TAAD and ascending aortic aneurysms are the chief culprits of primary proximal surgery and may require multiple treatments, with reoperation rates ranging from 8.7% to 13.5% [Nishi 2010; Geirsson 2007]. In 2018, the Nordic

Consortium for Acute Type A Aortic Dissection (NORCAAD) counted 1131 registered Aortic Dissection cases, with a 5-year reoperation rate of 5.0% [Pan 2018]. The ratio is as high as 38.3% for MFS patients [Bachet 1994]. On the other hand, aortic dissection occurred in 0.6% of patients after aortic valve replacement, and 9% of patients with aortic dissection had had aortic valve surgery [Prenger 1994; von Kodolitsch 1998]. The interval between two operations is long, with an average of 5-6 years [Hagan 2000]. Our calculations are like that. In general, the reoperation rate is low, and the time interval is long, so the sample size of these patients is relatively small, thus leading to few relevant reports.

The influence of the primary method on the second remains controversial. Some scholars believe that TAR and aortic root replacement can bring lower the reoperation rate [Rylski 2017; Halstead 2007; Rylski 2014]. HAGAN P G and his colleagues found that there was no significant difference in the incidence of reoperation among ascending aorta, hemiarch and total arch, and the extensive resection scope does not reduce the need for reoperation [Wang 2017; Concistrè 2012]. Extensive resection may lower the probability of reoperation in the future but prolong the duration of intraoperative organ ischemia. Regardless of the type of surgery and hemodynamic changes, the junction between natural and artificial vessels often is the first to be affected, especially in patients with connective tissue diseases.

Etiology of reoperation after aortic surgery: (1) The new aortic dissection involved the arch; (2) The aortic arch was severely expanded to a diameter of more than 5 cm; (3) Severe inner leakage or anastomotic leakage occurred at the proximal end of the descending aortic stent after the arch surgery; and (4) The artificial blood vessel of the previous arch surgery was infected [Sun 2019]. In our statistics, it was found that dissection was the main cause of secondary TAR because more than half of TEVAR surgeries were performed, and the rupture was more likely to occur in the proximal attachment area of the stent. The damage to the aortic wall caused by the scaffold itself was more common, which was mainly caused by high pressure of the ascending aorta and the imprecise coverage. Thirty-six-percent of the patients have communications in the aortic arch at the greater or lesser curvature [Hiratzka 2010; Erbel 2014]. The number of communications in the aortic arch as well the perfusion of the false lumen increases the growth rate of the aortic arch [Rylski 2017; Heo 2019]. Nicholas T et al. expounded the average annual growth rate for the distal contiguous aorta was 1.7 mm/y, the maximum aortic diameter increase is 2.8 mm/y, and the rate of reoperation within 10 years is about 7% [Kouchoukos 2018]. Aortic valve insufficiency can be secondary to root aneurysms. Surgical management rarely is required although arterial dilation after proximal surgery is common.

Therefore, aortic dilation after proximal surgery does exist and has a close association with self-connective tissue disease, but there is no definite conclusion on the indication of aneurysm reoperation after primary surgery. Some studies reported that arch surgery is considered only when its inner diameter reaches 50–60mm or the expansion speed exceeds 5 mm/year. Suzuki et al. reported the indications for dissection-related reoperation were dilatation of the thoracic aorta of 55mm or greater, rupture or impending rupture of the

Table 2. Operation data

Variables	*N*	%
Second operation		
TAR + SET	4	6.7
Bentall + TAR+ SET	7	11.7
Ascending + TAR+ SET	45	75.0
Ascending + TAR	4	6.7
Arterial cannulation option		
Left femoral artery + innominate artery or axillary artery	49	81.7
Right femoral artery + innominate artery or axillary artery	11	18.3
Venous cannulation option		
Superior and inferior vena cava	38	63.3
Femoral vein + superior vena cava	17	28.3
Left femoral vein + right atrium	1	1.7
Left femoral vein	1	1.7
Right atrium	3	5.0
CPB data		
Pharyngeal temperature (°C)	25.4±1.0	
Anal temperature (°C)	27.3±1.1	
Average flow (L/min)	0.7±0.2	
Total duration of cardiopulmonary (min)	149.9±33.8	
Duration of ascending aortic block (min)	85.0±27.6	
Duration of stop cycle (min)	29.4±10.1	

Pharyngeal temperature, anal temperature and average flow refers to the average data at the time of circulation cessation.

Table 3. Postoperative outcomes

Variables	*N*	%
Respiratory complications	21	35.6
Neurological complications	3	5.1
Renal function injury	6	10.2
Secondary thoracotomy	3	5.1
Death within 30 days	9	15.3

Respiratory complications include infection, pneumothorax and hemothorax, and neurological complications include spinal cord injury and cerebral hernia. Acute kidney injury is considered when Scr is greater than 1.5 times the normal value or kidney dialysis therapy is performed.

aorta, rapid dilatation of the aorta of greater than 5mm per half year [Suzuki 2018]. 2014 ESC guidelines introduced the criteria for the treatment of aortic aneurysms: (1) MFS with aortic root tumor and a maximum ascending aortic diameter of 50mm; (2) Patients with the maximum ascending aorta diameter of 55mm without other elastic tissue deficiency; (3) Patients with aortic arch aneurysms with the maximum aortic arch diameter of 55mm can be considered for surgical treatment; (4) Aortic arch repair can be considered for patients with aortic arch aneurysms with expansion near the aortic arch of the ascending aorta or descending aorta and with surgical indications [Bradley 2016]. We still use the recommended surgical criteria for primary aneurysms, and for patients with MFS, it is up to 50mm, aortic diameter increase >10 mm/year or less indications based on operator experience.

According to previous reports, after aortic surgery, in approximately 70% of patients, dissection extends beyond the ascending aorta and involves the aortic arch [Rylski 2014; Conzelmann 2016]. Immer et al. found that 86% of the aortic long-term expansion occurred in the aortic arch and proximal to the descending aorta [Fattouch 2009]. It seems the management of the arch during reoperation is very important. In cases in which an intimal tear was found in the transverse aorta, TAR was performed to exclude the intimal tear [Suzuki 2018]. An early study conducted by Estrera et al. reported 63 patients who underwent reoperation after previous type A dissection, the TAR near 62% [Estrera 2007].

TAR is the main surgical method, but re-open surgery is faced with problems, such as difficult tissue adhesion dissociation and bleeding control. It is especially difficult for some elderly patients with serious underlying diseases, and patients who need emergency treatment or have absolute contraindications to open surgery to tolerate the surgery. TEVAR can be used as an alternative treatment. The 2020 Society for Vascular Surgery Clinical Practice Guidelines for thoracic endovascular aortic repair recommended greater than 55mm as an indication of TEVAR [Upchurch 2021]. The early prognosis of TEVAR is better than that of open surgery, but the latter is with superior long-term prognosis. However, TEVAR cannot be used as a routine treatment, so open surgery should be preferred. Concomitant arch replacement was more frequently performed with the remodeling technique (28%) than with the reimplantation technique (13.3%) [David 2014]. In the reoperation, our aortic root and ascending aorta treatment accounted for 93.3%, which can effectively prevent thrombosis and other complications, and is considered as a safe way with good long-term results [Minami 2015]. We believe that the TAR+SET technique is feasible and efficacious for reoperation in patients who had previously folded-up proximal aortic surgery, especially for MFS patients [Sun 2011; Karck 2008]. Inoue et al. suggested that TAR surgery without SET is safe and effective, but its long-term outcome still need to be determined [Inoue 2018]. Therefore, 93.3% of our patients also underwent the FET to make the pseudoluminal thrombi and prepare for the stage 2 treatment. Sievers et al. explained that the long-term effects of different aortic valve retention and replacement were not different [Sievers 2018]. But we prefer to keep the artificial aortic valve in patients who have reoperation. The mean anal temperature was 24.5-30.1℃ (27.3±1.1℃) and the duration was 13-68min (29.4±10.1min), indicating that only the axillary artery maintained the cerebral blood flow, which was close to the value of TAR performed with the initial 4-bifurcation artificial vessels [Minatoya 2019].

Overall, in-hospital mortality was 0% and 12.0% after primary surgery for different types of secondary major vessel surgery [Kobuch 2012; Kimura 2015; Di Eusanio 2011]. We analyzed TAR surgery, which was a more complicated operation with difficult prognosis to control in the secondary mode. After reviewing the literature, we found that 30-day mortality was 13.6% under this condition [Sun 2019]. The 3- and 5-year survival rates of TAR with primary quadriforcated vascular prosthesis were 87% and 81%, respectively [Minatoya 2019]. With our results, the rupture of the dissection could not be repaired intraoperatively and nine deaths occurred within 30 days, a mortality rate of 15.3%. Respiratory complications are the most common, with bacterial culture and imaging for diagnosis basis; the second was AKI, and neurological complications were higher than the initial TAR, including two lower limb paraplegia and one cerebral hernia. The 1-, 3- and 5-year survival rates were 96.0%, 84.0% and 76.0%, respectively. Cerebrovascular accident and cardiac failure are still the common causes of death, which is related to long-term postoperative anticoagulant therapy and surgical strike. But the 5-year survival rate of Marfan syndrome is 100%, and youth and a thorough surgery make the prognosis of these patients better [Wang 2017]. In conclusion, the effect and safety of the surgery are acceptable.

Conclusions: The recurrence of dissection is the main cause of TAR after proximal aortic surgery, followed by aneurysm, and the resurgical criteria for aneurysm need to be unified. In addition to TAR, SET also is widely used, and it is safe and effective. The surgical conditions for the second TAR were similar with the first. Despite high early mortality, its long-term prognosis is acceptable.

ACKNOWLEDGEMENT

Thanks are extended to all those who contributed to data collection and surgery.

REFERENCES

Bachet JE, Termignon JL, Dreyfus G, et al. 1994. Aortic dissection. Prevalence, cause, and results of late reoperations. J Thorac Cardiovasc Surg.1082:199-205; discussion-6.

Bradley TJ, Alvarez NA, Horne SG. 2016. A practical guide to clinical management of thoracic aortic disease. Can J Cardiol. 321:124-30.

Chen Y, Zhang S, Liu L, et al. 2017. Retrograde type a aortic dissection after thoracic endovascular aortic repair: A systematic review and meta-analysis. J Am Heart Assoc. 69.

Concistrè G, Casali G, Santaniello E, et al. 2012. Reoperation after surgical correction of acute type a aortic dissection: Risk factor analysis. Ann Thorac Surg. 932:450-5.

Conzelmann LO, Weigang E, Mehlhorn U, et al. 2016. Mortality in patients with acute aortic dissection type a: Analysis of pre- and intraoperative risk factors from the german registry for acute aortic dissection type a (geraada). Eur J Cardiothorac Surg. 492:e44-52.

David TE, Feindel CM, David CM, Manlhiot C. 2014. A quarter of a century of experience with aortic valve-sparing operations. J Thorac Cardiovasc Surg. 1483:872-9; discussion 9-80.

Di Eusanio M, Berretta P, Bissoni L, et al. 2011. Re-operations on the proximal thoracic aorta: Results and predictors of short- and long-term mortality in a series of 174 patients. Eur J Cardiothorac Surg. 405:1072-6.

Erbel R, Aboyans V, Boileau C, et al. 2014. 2014 esc guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The task force for the diagnosis and treatment of aortic diseases of the european society of cardiology (esc). Eur Heart J. 3541:2873-926.

Estrera AL, Miller CC, 3rd, Villa MA, et al. 2007. Proximal reoperations after repaired acute type a aortic dissection. Ann Thorac Surg. 835:1603-8; discussion 8-9.

Fattouch K, Sampognaro R, Navarra E, et al. 2009. Long-term results after repair of type a acute aortic dissection according to false lumen patency. Ann Thorac Surg. 884:1244-50.

Geirsson A, Bavaria JE, Swarr D, et al. 2007. Fate of the residual distal and proximal aorta after acute type a dissection repair using a contemporary surgical reconstruction algorithm. Ann Thorac Surg. 846:1955-64; discussion -64.

Hagan PG, Nienaber CA, Isselbacher EM, et al. 2000. The international registry of acute aortic dissection (irad): New insights into an old disease. Jama. 2837:897-903.

Halstead JC, Meier M, Etz C, et al. 2007. The fate of the distal aorta after repair of acute type a aortic dissection. J Thorac Cardiovasc Surg. 1331:127-35.

Heo W, Song SW, Kim TH, et al. 2019. Differential impact of intimal tear location on aortic dilation and reintervention in acute type i aortic dissection after total arch replacement. J Thorac Cardiovasc Surg. 1582:327-38.e2.

Hiratzka LF, Bakris GL, Beckman JA, et al. 2010. 2010 accf/aha/aats/acr/asa/sca/scai/sir/sts/svm guidelines for the diagnosis and management of patients with thoracic aortic disease: A report of the american college of cardiology foundation/american heart association task force on practice guidelines, american association for thoracic surgery, american college of radiology, american stroke association, society of cardiovascular anesthesiologists, society for cardiovascular angiography and interventions, society of interventional radiology, society of thoracic surgeons, and society for vascular medicine. Circulation. 12113:e266-369.

Inoue Y, Matsuda H, Omura A, et al. 2018. Long-term outcomes of total arch replacement with the non-frozen elephant trunk technique for stanford type a acute aortic dissection. Interact Cardiovasc Thorac Surg. 273:455-60.

Januzzi JL, Sabatine MS, Eagle KA, et al. 2002. Iatrogenic aortic dissection. Am J Cardiol. 895:623-6.

Karck M, Kamiya H. 2008. Progress of the treatment for extended aortic aneurysms; is the frozen elephant trunk technique the next standard in the treatment of complex aortic disease including the arch? Eur J Cardiothorac Surg. 336:1007-13.

Kimura N, Itoh S, Yuri K, et al. 2015. Reoperation for enlargement of the distal aorta after initial surgery for acute type a aortic dissection. J Thorac Cardiovasc Surg. 1492 Suppl:S91-8.e1.

Kobuch R, Hilker M, Rupprecht L, et al. 2012. Late reoperations after repaired acute type a aortic dissection. J Thorac Cardiovasc Surg. 1442:300-7.

Kouchoukos NT, Kulik A, Castner CF. 2018. Clinical outcomes and rates of aortic growth and reoperation after 1-stage repair of extensive chronic thoracic aortic dissection. J Thorac Cardiovasc Surg. 1555:1926-35.

Minami H, Miyahara S, Okada K, et al. 2015. Clinical outcomes of combined aortic root reimplantation technique and total arch replacement. Eur J Cardiothorac Surg. 481:152-7.

Minatoya K, Inoue Y, Sasaki H, et al. 2019. Total arch replacement using a 4-branched graft with antegrade cerebral perfusion. J Thorac Cardiovasc Surg. 1574:1370-8.

Nishi H, Mitsuno M, Tanaka H, et al. 2010. Late reoperations after repair of acute type a aortic dissection. J Card Surg. 252:208-13.

Pan E, Gudbjartsson T, Ahlsson A, et al. 2018. Low rate of reoperations after acute type a aortic dissection repair from the nordic consortium registry. J Thorac Cardiovasc Surg. 1563:939-48.

Prenger K, Pieters F, Cheriex E. 1994. Aortic dissection after aortic valve replacement: Incidence and consequences for strategy. J Card Surg. 95:495-8; discussion 8-9.

Rampoldi V, Trimarchi S, Eagle KA, et al. 2007. Simple risk models to predict surgical mortality in acute type a aortic dissection: The international registry of acute aortic dissection score. Ann Thorac Surg. 831:55-61.

Rylski B, Hahn N, Beyersdorf F, et al. 2017. Fate of the dissected aortic arch after ascending replacement in type a aortic dissection†. Eur J Cardiothorac Surg. 516:1127-34.

Rylski B, Milewski RK, Bavaria JE, et al. 2014. Long-term results of aggressive hemiarch replacement in 534 patients with type a aortic dissection. J Thorac Cardiovasc Surg. 1486:2981-5.

Sievers HH, Richardt D, Diwoky M, et al. 2018. Survival and reoperation after valve-sparing root replacement and root repair in acute type a dissection. J Thorac Cardiovasc Surg. 1566:2076-82.e2.

Sun G, Sun L, Zhu J, et al. 2019. Efficacy of total aortic arch replacement combined with frozen elephant trunk in aortic reoperation. Med Sci Monit. 253998-4004.

Sun L, Qi R, Zhu J, Liu Y, Zheng J. 2011. Total arch replacement combined with stented elephant trunk implantation: A new "standard" therapy for type a dissection involving repair of the aortic arch? Circulation. 1239:971-8.

Suzuki T, Asai T, Kinoshita T. 2018. Predictors for late reoperation after surgical repair of acute type a aortic dissection. Ann Thorac Surg. 1061:63-9.

Upchurch GR, Jr., Escobar GA, Azizzadeh A, et al. 2021. Society for vascular surgery clinical practice guidelines of thoracic endovascular aortic repair for descending thoracic aortic aneurysms. J Vasc Surg. 731s:55s-83s.

von Kodolitsch Y, Simic O, Bregenzer T, et al. 1998. [aortic valve replacement as an independent predictive factor for later development of aortic dissection]. Z Kardiol. 878:604-12.

Wang H, Wagner M, Benrashid E, et al. 2017. Outcomes of reoperation after acute type a aortic dissection: Implications for index repair strategy. J Am Heart Assoc. 610.

Zhang L, Li Z, Li S, et al. 2019. Systematic review of endovascular repair of ascending aortic dissection. Catheter Cardiovasc Interv. 947:1018-25.