

# A Study of Endovascular Treatment of Acute Stanford Type B Aortic Coarctation with Inadequate Anchorage Zone

Minghui Gong<sup>1</sup>, Zhengdong Wan\*

The First Affiliated Hospital of Yangtze University, Jingzhou, China

Email: \*532047778@qq.com

**How to cite this paper:** Gong, M.H. and Wan, Z.D. (2025) A Study of Endovascular Treatment of Acute Stanford Type B Aortic Coarctation with Inadequate Anchorage Zone. *Journal of Biosciences and Medicines*, 13, 424-437.

<https://doi.org/10.4236/jbm.2025.134034>

**Received:** March 11, 2025

**Accepted:** April 21, 2025

**Published:** April 24, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

<http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

Aortic coarctation is a fatal cardiovascular disease. For Stanford type B aortic coarctation, aortic endovascular isolation (TEVAR) is currently the treatment of choice and is far less invasive than open surgery. Standard TEVAR involves the use of a stent graft to cover the proximal breach, which prevents the expansion of the false lumen and promotes its thrombosis, which in turn leads to therapeutic results. During implantation of endovascular grafts, Left Subclavian Artery (LSA) coverage has been associated with the development of a variety of complications, including stroke, spinal cord ischemia, upper extremity ischemia, etc. Therefore, the key to endoluminal treatment of aortic arch disease lies in the preservation or reconstruction of the branching arteries over the arch. Currently, most medical centers in China tend to reconstruct the LSA. This article provides a review of the methods and advantages and disadvantages of reconstructing the LSA in TEVAR, as well as a prospective view of reconstructing the supra-arch artery in the future.

## Keywords

Stanford Type B Aortic Coarctation, Aortic Endoluminal Isolation, Left Subclavian Artery, Reconstruction of the Superior Arch Artery

## 1. Introduction

Acute Aortic Dissection (AD) is a pathologic process in which, in response to a variety of risk factors, a tear occurs between the intima and the middle elastic membrane of the aorta, resulting in infiltration of blood into the middle region of the aortic wall, followed by a collateral and/or retrograde stripping along the vessel

\*Corresponding author.

wall, creating an intermural false lumen. This false lumen is interconnected by one or more ruptures that communicate with the true lumen of the aorta, constituting the characteristic structure of aortic coarctation [1]. Acute AD is known for its sudden onset, rapid progression, and extremely critical condition, and is extremely lethal if timely medical intervention is not provided. According to relevant statistics, the hourly mortality rate of untreated patients with acute AD can be as high as 1% to 2% after the onset of symptoms [2], and it is one of the most common acute critical illnesses in the field of vascular surgery. Typical clinical manifestations of acute AD include lacerating chest pain, sharp stabbing sensations, progressive hypoperfusion, and ischemic damage to end organs (e.g. heart, brain, kidneys, etc.) [3] [4].

The annual incidence of aortic coarctation is approximately 5 to 30 cases per 1 million people [5]. Distribution of Stanford typing: Stanford typing divides aortic coarctation into type A and type B. The aortic coarctation of the subclavian artery is the most common type of aortic coarctation. Of these, type B entrapments involve the aorta distal to the subclavian artery and account for 25% to 40% of all aortic entrapments. Studies have shown that the peak incidence of type A coarctation is around 50 years of age, whereas the peak incidence of type B coarctation is around 60 years of age [6]. In China's Mainland, the annual incidence of acute AD is reported to be about 2.8/100,000, with a slightly higher incidence of about 3.7/100,000 in males and a relatively lower incidence of about 1.5/100,000 in females, and the mean age of onset of the patients is 58.9 years [7]. It is worth noting that the disease progression of acute AD is extremely rapid, with mortality rates ranging from 50% to 68% within 48 hours of onset, and up to 90% within three months of onset [4] [7]-[9]. In a study by Zhao *et al.*, the middle-aged population is the most prevalent group of acute AD, and the average age of acute AD patients in China is 51.8 years, which is about 10 years younger than in Europe and the United States [10]. In addition, Xia *et al.*'s study also found that the onset of acute AD showed certain seasonal characteristics, with a relatively high incidence in winter and a relatively low incidence in summer. Meanwhile, their study also revealed a circadian rhythm variation in the onset of acute AD, with peak hours of onset at 9:00-10:00 a.m. and 16:00-17:00 p.m., and trough hours of onset at 2:00 a.m. and 3:00 a.m. [11].

In 2014, the European Society of Cardiology (ESC), in its newly released Guidelines for the Diagnosis and Treatment of Aortic Disease, clearly classified aortic coarctation into three phases based on the time of onset of the disease: the acute phase, defined as up to 14 days after the onset of the disease; the subacute phase, which is defined as the phase between 15 and 90 days after the onset of the disease between 15 and 90 days after onset; and the chronic phase, which is defined as a period of more than 90 days after onset. The definition of the acute phase in this classification, within 14 days of onset, is now widely recognized [12] [13].

Multiple clinical staging methods exist for acute AD. The earliest staging system was based on the location of the rupture and the extent of the entrapment in acute

AD, the DeBakey staging: type I refers to a primary rupture located in the ascending aorta or the aortic arch, and the extent of the entrapment extends from the ascending aorta to the abdominal aorta; type II refers to a primary rupture that is also located in the ascending aorta, but with entrapment confined to the internal part of the ascending aorta, with occasional involvement of the aortic arch; and type III is divided into two subtypes, of which type IIIa is located in the distal part of the LSA, while type IIIb has further entrapment. Two subtypes, in type IIIa, the primary breach is located distal to the LSA and the entrapment only involves the thoracic descending aorta, whereas in type IIIb the entrapment extends further distally to involve the abdominal aorta [14].

In 1970, Daily proposed the Stanford typology, which refers to the entrapment involving the ascending aorta as thoracic aortic aneurysm and aortic dissection (Type AAortic Dissection (TAAD)), which corresponds to DeBakey Types I and II, and the thoracic descending aorta and its more distal portion, which involve the left subclavian artery (LSA) and its more distal portion, as Type B Aortic Dissection (TBAD), which corresponds to DeBakey Type III, which is the most common form of aortic dissection. Left Subclavian Artery (LSA) and the thoracic descending aorta and its more distal entrapment are called Type B Aortic Dissection (TBAD), which corresponds to DeBakey Type III [8]. In recent years, academics have introduced the concept of “non-A, non-B” type of coarctation, which refers to acute AD in which the primary rupture is located in the aortic arch or the TBAD extends proximally to the aortic arch, which further enriches the connotation of Stanford’s classification [9]. By 2020, American scholars proposed a new partitioning method based on the anatomical characteristics of aortic coarctation, subdividing the aorta into 0 - 12 regions and anatomically staging acute AD accordingly [10]. However, despite the existence of these new staging methods, Stanford staging remains one of the most commonly used and widely accepted methods for staging aortic coarctation in current clinical practice.

TBAD accounts for about 25% to 40% of all acute AD patients [15] [16], TBAD involving the LSA is mainly characterized by hematoma, entrapment, rupture, and insufficient proximal anchorage zone, with the development of the technique of endoluminal isolation of laminar stenting, the reconstruction of the LSA is mainly performed by hybridization, chimney, open window, and branching stenting techniques, etc., but due to the complexity of the anatomical structure of this site, limitations of the apparatus itself, complications such as endoleak, anchorage zone injury, and reverse tear still exist in various surgical approaches [17] [18].

There is now an industry consensus on Thoracic Endovascular Aortic Repair (TEVAR) as the treatment of choice for acute complex TBAD [19]. Data from past studies have shown that patients tolerate relatively well to cover the LSA when TEVAR is performed, so some experts have advocated that reconstruction of the LSA is not required during the procedure. However, more and more clinical reports point out that direct closure of the LSA without reconstruction may affect the blood flow to the left vertebral artery, thus increasing the incidence of adverse

complications such as stroke and spinal cord ischemia [19]. In 1999, Dake *et al.* were the first to report the use of TEVAR in the treatment of TBAD [20]. Prior to the introduction of TEVAR, Aortic Arch Replacement (AORTIC ARCH REPLACEMENT) was the mainstay of treatment for thoracic aortic lesions. However, this procedure, which requires an open chest and uses invasive operations such as extracorporeal circulation under hypothermia and single-lung ventilation, has the drawbacks of high trauma, high risk, prolonged hospitalization, and many near- and mid-term complications. Therefore, it is not applicable to older patients or patients with more underlying diseases and has significant limitations [21]-[25]. The finding that TEVAR significantly reduces mortality and improves the long-term prognosis of patients in the treatment of complex TBAD compared with conventional surgical therapy is widely recognized [26] [27]. Compared with open surgery, TEVAR has the advantages of shorter operation and hospitalization time, fewer near-term complications, and lower mortality rate, and the 1-year and 5-year survival rates are no less than those of open surgery [28] [29]. With these advantages, TEVAR is becoming the procedure of choice for the treatment of thoracic aortic lesions [21]. Increasing evidence suggests that TEVAR not only effectively closes the dissection of the coarctation and reduces the occurrence of coarctation-related complications, but also promotes a favorable remodeling process of the aorta, which in turn reduces the risk of disease progression and aortic-related mortality [19] [30]. TEVAR has undoubtedly brought about a revolutionary change in the clinical management of TBAD. As a less invasive surgical procedure, TEVAR has gradually replaced traditional open-heart surgery in the treatment of TBAD by virtue of its minimally invasive nature, high safety, low complication rate, definitive therapeutic effect, and low perioperative mortality [19]. This shift not only improves patient outcomes, but also reduces surgical risks, resulting in a better prognosis and quality of life for patients. As a result, TEVAR has been more and more widely used in the treatment of TBAD [31]-[34]. By 2009, the American academic community reached a consensus on the necessity of intraoperative reconstruction of the LSA for TEVAR and incorporated it into clinical practice guidelines [35]. In 2018, The Society of Thoracic Surgeons (STSs) and the American Association of Thoracic Surgeons (AATSS) joined forces to form a guideline writing committee and develop the first-ever guidelines for the diagnosis and management of TBAD. The guideline clearly states that TEVAR is proposed in the guideline for complex hyperacute, acute, or subacute TBAD with rupture and/or poor perfusion, and that TEVAR is beneficial to the decussated structures of such entrapments [26]. Currently, the main approaches to reconstruct the LSA in TBAD involving the LSA are hybridization, chimney, open window, and branch stenting techniques, and the choice of the specific modality needs to be decided based on the anatomical specificity of the entrapment and the individual's wishes.

TEVAR is a minimally invasive procedure widely used for the treatment of complex aortic disease, but it faces many challenges regarding the complexity of

the anatomical region [36]. The complex anatomy of the thoracic aorta, especially in the region of the aortic arch, the curved morphology of the aortic arch and the presence of branching vessels (e.g. cephalic brachial trunk, left common carotid artery, and left subclavian artery) make accurate stent localization and deployment extremely difficult [37]. In addition, the fragility of the aortic wall and the length of the lesion area add to the complexity of the procedure. The success of the TEVAR procedure relies heavily on the design and alignment of the stent. The stent must precisely cover the lesion area while avoiding obstruction of branch vessels. However, due to the curvature of the aortic arch and the diversity of lesion areas, stent design and deployment often require highly individualized protocols [37]. A variety of complications may occur after TEVAR surgery, with stroke being one of the most serious. Studies have shown that stroke has emerged as a significant complication of TEVAR surgery, with risk factors including procedure duration, stent type, and patient's baseline health status, in addition to decreased postoperative renal function, which is a major concern, especially in prolonged procedures [38]. Although the effectiveness of TEVAR in the short term has been extensively studied, its medium- and long-term effects need to be further evaluated. Some studies suggest that TEVAR may lead to aortic remodeling in the medium and long term, which may affect the final outcome of the procedure [39].

## 2. Hybridization Surgery

Hybridization is an innovative surgical procedure that combines the advantages of endoluminal and surgical techniques to treat complex lesions in the aortic arch. The procedure begins with careful surgical reconstruction of the branch vessels in the aortic arch, followed by interventional techniques for delicate endoluminal repair. Depending on the stage of the procedure, hybridization is subdivided into staged hybridization and one-stage hybridization [40]. For aortic arch lesions that are difficult to be effectively reconstructed by endoluminal techniques alone, hybridization surgery opens up a new therapeutic avenue for surgeons. It not only simplifies the procedure of traditional complex open surgery, but also significantly reduces the use of extracorporeal circulation and deep hypothermic arrested circulation, which is pivotal for the treatment of high-risk patients [41]. Historically, early hybridization procedures often required staged, multiple procedures. However, with the continuous refinement of the technique, today most hybridization procedures can be successfully completed in a single period, except for a few special patients. Depending on the treatment of the aorta, hybridization surgery can be divided into hybrid full aortic arch repair surgery and hybrid partial aortic arch repair surgery. The former is indicated when the aortic arch is severely diseased and all branches need to be reconstructed or when an overlying stent is required to completely cover the opening of a partial branch of the arch. According to Piffaretti *et al.*, this procedure has achieved satisfactory outcomes in both the early and mid- and long-term periods, and the aortic-related mortality rate has remained

low. The latter, on the other hand, is indicated in the case of lesions in which the overlying stent is required to cover only part of the branching openings of the aortic arch. However, it is worth noting that, according to the literature, neurologic complications, especially stroke, need to be of particular concern in this category of procedures [42] [43]. Yoshitake *et al.* documented a 9.5% incidence of postoperative stroke. Cumulative survival rates at 1 and 2 years postoperatively were as high as 87.3% and 77.0% for patients who did not have a stroke, respectively, whereas the survival rates for stroke patients were substantially lower at 68.6% and 22.9% [44].

### 3. Chimney Technology

As a widely used technique in the current endoluminal therapy field, chimney technology is also known as parallel stent technology in the industry due to its advantages of easy assembly, high malleability, and affordability without the need for personalization. In a study by Lu *et al.*, the prerequisites for successful implementation of the chimney technique were that the angle between the aortic arch and the target branch vessel was less than 30° and that the aortic arch was relatively steep [45]. A Meta-analysis showed that the chimney technique demonstrated encouraging mid-term efficacy in the urgent management of aortic arch lesions [46]. Specifically, the technique involves the implantation of a coated or bare stent in the LSA, with the ends extending into the aorta and the LSA, forming a parallel structure to the aortic branching stent, which resembles a chimney [47]. Previous studies have shown that the chimney technique is not only feasible in the management of specific aortic arch lesions, but also effective in securing blood supply to the brain and the left upper extremity of patients [48]. However, it is worth noting that the chimney technique is also associated with the potential risk of endoleak and decreased stent patency in the long term. As the most common complication after TEVAR, endoleak is also the first factor leading to re-procedural intervention, and is statistically responsible for 33.2% of all cases requiring re-intervention [49] [50]. Endoleaks have been subdivided into five types based on their causes, of which type I endoleaks, *i.e.* proximal endoleaks, which originate from the perfusion of blood flow from the main fissure to the false lumen, are the most common type of endoleak after TEVAR. Overseas for the early incidence and long-term patency of type I endoleak in chimney technique, a study by Ahmad *et al.* revealed that the early incidence was 9.4%, while the long-term patency rate was as high as 92.9% [51]. A study by Bosiers *et al.* also pointed out that the intra-operative incidence of endoleak in the chimney technique was 10.5%, but the long-term patency rate climbed up to 98% [52]. Domestic scholars concluded by Meta-analysis that the perioperative incidence of endoleak in the chimney technique was 21%, while the patency rate of branch vessels remained at 93% [53]. In addition, chimney stents may also face the problem of stent compression, and although such cases are rare, some studies have shown that the patency rate of chimney stents can still be up to 96% within two years [54].

#### 4. Window Technology

Reconstruction of LSA using the windowing technique is both a safe and efficient method [55]. There are two main types of this technique, *in situ* and *ex vivo* [56] [57]. The *in situ* windowing technique involves a retrograde puncture through the left-sided artery after the stent has covered the LSA, which in turn ruptures the membrane of the main stent. Subsequently, balloon dilatation and implantation of an additional stent are utilized to achieve a windowing effect and ensure that the blood supply to the LSA is preserved. Various methods of dissection are available, including guidewire dissection, laser dissection, and balloon puncture needle dissection, but all of these methods present technical challenges. Critically, the debris generated during dissection is difficult to manage and may lead to arterial embolization, and the act of dissection itself may shorten the life of the stent. In addition, stent release can lead to complications such as cranial ischemia if blood flow to branch arteries is blocked. In contrast, the extracorporeal windowing technique involves pre-designed openings in the stent to correspond to the LSA based on the patient's unique anatomy and precise preoperative measurements to ensure unobstructed blood supply to the LSA and maintain normal blood flow [58] [59]. Although the extracorporeal opening technique is also technically challenging, its significant advantage is that it eliminates the rupture step and therefore avoids complications such as embolization due to arterial occlusion by rupture debris. No large number of cases have been reported, and a few sporadic reports in the literature suggest that the complication rate of the extracorporeal preopening technique is low, although a risk of stroke has been reported [60] [61].

#### 5. Branching Stent Technology

Branch stenting is a technique that uses an integrated single-branch aortic-coated stent to seal the dissection and simultaneously complete the hemodialysis of the LSA. Overseas reports on branch stenting have demonstrated its excellent clinical outcomes. Inoue *et al.* were the first to introduce branch stenting and successfully utilized this technique to treat a case of TBAD involving an LSA opening, achieving remarkable efficacy [62]. Rousseau *et al.* performed Valiant Mona LSA branch stenting in 9 patients with a 100% success rate and no complications such as death, left arm ischemia, paraplegia, rupture of the entrapment, intermediate open surgery, or secondary endoluminal surgery, and none of the stent grafts were occluded, torsioned, fractured, or dislocated [48]. Huang *et al.* used Casto branch stents to treat 21 patients with TBAD, and the procedure was also 100% successful, and periprocedural mortality was 0.7%. and the perioperative mortality rate was 0, with only 1 intraoperative endoleak event. After 1 year of follow-up, no complications such as paraplegia, cerebral infarction, left upper extremity ischemia, or rupture of the lamina were detected, the pseudoluminal thrombosis was good, and the branch vessels remained patent [63]. Jing *et al.* reported in a multicenter, prospective clinical trial that 73 patients with TBAD underwent Castor stenting, and the procedural success rate was as high as 97%, with an endoleak rate of 5%. Among them, only

1 patient unfortunately passed away during hospitalization, and no other major complications occurred [64]. Castor stent has been widely used in many hospitals across the country since it became available in China in 2017, and many studies have proved that the Castor stent has a satisfactory recent outcome in the treatment of TBAD, with a high degree of safety and no serious complications [65] [66]. Yang *et al.* further demonstrated that the single-branch aortic stent has a definite effect of endoluminal isolation in the treatment of TBAD through an in-depth analysis of 11 cases of TBAD patients treated with single-branch aortic stent [67]. Lu *et al.* pointed out that Castor single-branch stent can be better used for endoluminal treatment of TBAD involving LSA, and has certain advantages in the treatment of acute phase [45]. Li *et al.* compared patients with TBAD involving the LSA treated with Castor branching stent with chimney stent both had a higher surgical success rate, which was beneficial to remodeling the aorta, expanding the true lumen, and promoting thrombosis of the false lumen, but Castor branching stent had a lower incidence of endoleak in the postoperative period [68]. In a Meta-analysis by Zhang *et al.*, it was confirmed that Castor single-branch stent endoluminal repair of LSA-involved TBAD achieved better success rate and branch artery patency [69]. National studies have shown that single-branch stenting in patients with LSA-involved TBAD has demonstrated a high technical success rate, a low incidence of endoleak, a low morbidity and mortality rate, and a high patency rate [64].

Anatomical adaptation is one of the key factors in choosing a reconstruction technique for the left subclavian artery. Different techniques may be suitable for different anatomical structures. For example, Carotid-LSA Bypass and *In Situ* Fenestration (ISF) have their own advantages and disadvantages in terms of anatomical adaptability. The former is suitable for patients with more complex anatomy, whereas the latter is more suitable for patients with better vascularization [70]. Surgical complexity has a direct impact on the success of the procedure and postoperative recovery; *in situ* openings are generally considered to be shorter but more technically demanding, whereas bypasses, although relatively simple to perform, may require a longer recovery time [70]. Long-term clinical outcomes are an important indicator of the success of reconstructive techniques, and studies have shown that *in situ* openings excel in terms of long-term patency rates and patient survival, whereas bypasses may be associated with complications such as graft occlusion or infection in some cases [70].

## 6. Future Outlook

1) Optimization of materials and technologies: biodegradable stents: exploring biodegradable material stents to reduce long-term foreign body reaction; 3D printed customized stents: customized branch stents combined with patients' anatomical features to improve adaptability. 2) Intelligence and precision: artificial intelligence-assisted planning, using AI to predict the path of sandwich progression and optimize the position of stent release; molecular imaging technology, real-time intraoperative

assessment of hemodynamics to reduce the risk of endoleak. 3) Multidisciplinary collaboration mode: the synergy between chest pain centers and Multidisciplinary Teams (MDTs) is becoming more and more important. Multidisciplinary collaboration mode: the synergy between chest pain centers and Multidisciplinary Teams (MDTs) is becoming more and more important, significantly.

## 7. Shortening the Treatment Time

In summary, hybridization, chimney surgery, open window surgery, and branch stenting have all made significant progress in the treatment of TBAD involving the LSA. Each of these surgical procedures has its own characteristics and is suitable for patients with different conditions. Endoluminal isolation with overlay stenting has evolved from a single technique to an individualized protocol incorporating multiple techniques in the treatment of TBAD involving the LSA. The application of branched stents with composite techniques has significantly improved the prognosis, but the long-term efficacy still needs to be supported by more evidence-based medical evidence. In the future, advances in material science, imaging technology, and artificial intelligence will further drive the field toward precision and minimal invasiveness.

## Funding

The article has no funding support.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

- [1] Tchana-Sato, V., Sakalihan, N. and Defraigne, J.O. (2018) Aortic Dissection. *Revue Médicale de Liège*, **73**, 290-295.
- [2] Gawinecka, J., Schnrath, F. and von Eckardstein, A. (2017) Acute Aortic Dissection: Pathogenesis, Risk Factors and Diagnosis. *Swiss Medical Weekly*, **147**, w14489. <https://doi.org/10.4414/smw.2017.14489>
- [3] Sen, I., Erben, Y.M., Franco-Mesa, C. and DeMartino, R.R. (2021) Epidemiology of Aortic Dissection. *Seminars in Vascular Surgery*, **34**, 10-17. <https://doi.org/10.1053/j.semvascsurg.2021.02.003>
- [4] Hiratzka, L.F., Bakris, G.L., Beckman, J.A., *et al.* (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 Aortic Disease: Executive Summary. 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. *Catheterization and Cardiovascular Interventions*, **76**, E43-E86.

- [5] Levy, D., Sharma, S., Grigorova, Y., *et al.* (2025) Aortic Dissection. StatPearls Publishing.
- [6] Pál, D., Szilágyi, B., Berczeli, M., Szalay, C.I., Sárdy, B., Oláh, Z., *et al.* (2020) Ruptured Aortic Aneurysm and Dissection Related Death: An Autopsy Database Analysis. *Pathology & Oncology Research*, **26**, 2391-2399. <https://doi.org/10.1007/s12253-020-00835-x>
- [7] Lombardi, J.V., Hughes, G.C., Appoo, J.J., Bavaria, J.E., Beck, A.W., Cambria, R.P., *et al.* (2020) Society for Vascular Surgery (SVS) and Society of Thoracic Surgeons (STS) Reporting Standards for Type B Aortic Dissections. *The Annals of Thoracic Surgery*, **109**, 959-981. <https://doi.org/10.1016/j.athoracsur.2019.10.005>
- [8] Hughes, G.C. (2015) Management of Acute Type B Aortic Dissection; ADSORB Trial. *The Journal of Thoracic and Cardiovascular Surgery*, **149**, S158-S162. <https://doi.org/10.1016/j.jtcvs.2014.08.083>
- [9] Antonello, M., Menegolo, M., Maturi, C., Dall'Antonia, A., Lepidi, S., Frigo, A.C., *et al.* (2013) Intentional Coverage of the Left Subclavian Artery during Endovascular Repair of Traumatic Descending Thoracic Aortic Transection. *Journal of Vascular Surgery*, **57**, 684-690.E1. <https://doi.org/10.1016/j.jvs.2012.08.119>
- [10] Zhao, X., Wang, B.Z., Jiang, P.P., *et al.* (2019) Correlation between Temporal Characteristics of Aortic Coarctation and Moon Phase. *Journal of Xinjiang Medical University*, **42**, 573-577.
- [11] Xia, L., Li, J.H., Zhao, K., *et al.* (2015) Incidence and In-Hospital Mortality of Acute Aortic Dissection in China: Analysis of China Health Insurance Research (CHIRA) Data 2011. *Journal of Geriatric Cardiology*, **12**, 502-506.
- [12] Li, J., Tong, X., Wang, K., *et al.* (2020) Effect of TEVAR Procedure on the Efficacy and Aortic Remodeling Morphology in Patients with Non-Simultaneous Stanford Type B Aortic Coarctation. *Hebei Medical*, **26**, 1685-1689.
- [13] Jang, H., Kim, M., Kim, G.M., Won, J.Y., Ko, Y., Choi, D., *et al.* (2017) Risk Factors for Stent Graft-Induced New Entry after Thoracic Endovascular Aortic Repair for Stanford Type B Aortic Dissection. *Journal of Vascular Surgery*, **65**, 676-685. <https://doi.org/10.1016/j.jvs.2016.09.022>
- [14] De Baakey, M.E., Henly, W.S., Cooley, D.A., Morris, G.C., Crawford, E.S. and Beall, A.C. (1965) Surgical Management of Dissecting Aneurysms of the Aorta. *The Journal of Thoracic and Cardiovascular Surgery*, **49**, 130-149. [https://doi.org/10.1016/s0022-5223\(19\)33323-9](https://doi.org/10.1016/s0022-5223(19)33323-9)
- [15] Xia, L., Huang, L., Feng, X., Xiao, J., Wei, X. and Yu, X. (2020) Chronobiological Patterns of Acute Aortic Dissection in Central China. *Heart*, **107**, 320-325. <https://doi.org/10.1136/heartjnl-2020-317009>
- [16] Munshi, B., Ritter, J.C., Doyle, B.J. and Norman, P.E. (2020) Management of Acute Type B Aortic Dissection. *ANZ Journal of Surgery*, **90**, 2425-2433. <https://doi.org/10.1111/ans.16270>
- [17] Guo, Y., Cong, C., Yang, N., *et al.* (2017) Progress in the Pathogenesis of Aortic Dissection. *Medical Review*, **23**, 2339-2343.
- [18] Chen, Y., Chen, Y. and Tao, R. (2016) Interpretation of the 2014 ESC Guidelines for the Diagnosis and Treatment of Aortic Disease. *Journal of Cardiovascular and Cerebrovascular Disease*, **14**, 435-437.
- [19] Terzi, F., Gianstefani, S. and Fattori, R. (2018) Type B Aortic Dissection. *Journal of Cardiovascular Medicine*, **19**, e50-e53. <https://doi.org/10.2459/jcm.0000000000000594>

- [20] Dake, M.D., Kato, N., Mitchell, R.S., Semba, C.P., Razavi, M.K., Shimono, T., *et al.* (1999) Endovascular Stent-Graft Placement for the Treatment of Acute Aortic Dissection. *New England Journal of Medicine*, **340**, 1546-1552. <https://doi.org/10.1056/nejm199905203402004>
- [21] Cooper, M.A. and Upchurch, G.R. (2019) The Society of Vascular Surgery Practice Guidelines on the Care of Patients with Abdominal Aortic Aneurysms. *JAMA Surgery*, **154**, 553-554. <https://doi.org/10.1001/jamasurg.2019.0566>
- [22] Akiyama, K., Orime, Y., Wakui, S., Nakamura, T., Shiono, M. and Hata, M. (2016) Less Invasive Quick Open Stenting using a J Graft Open Stent for Distal Arch Aneurysms. *The Thoracic and Cardiovascular Surgeon*, **64**, 330-332. <https://doi.org/10.1055/s-0035-1546299>
- [23] Cao, P., De Rango, P., Czerny, M., Evangelista, A., Fattori, R., Nienaber, C., *et al.* (2012) Systematic Review of Clinical Outcomes in Hybrid Procedures for Aortic Arch Dissections and Other Arch Diseases. *The Journal of Thoracic and Cardiovascular Surgery*, **144**, 1286-1300.E2. <https://doi.org/10.1016/j.jtcvs.2012.06.013>
- [24] Milewski, R.K., Szeto, W.Y., Pochettino, A., Moser, G.W., Moeller, P. and Bavaria, J.E. (2010) Have Hybrid Procedures Replaced Open Aortic Arch Reconstruction in High-Risk Patients? A Comparative Study of Elective Open Arch Debranching with Endovascular Stent Graft Placement and Conventional Elective Open Total and Distal Aortic Arch Reconstruction. *The Journal of Thoracic and Cardiovascular Surgery*, **140**, 590-597. <https://doi.org/10.1016/j.jtcvs.2010.02.055>
- [25] Boyle, J.R. (2010) Note-Taking Skills of Middle School Students with and without Learning Disabilities. *Journal of Learning Disabilities*, **43**, 530-540. <https://doi.org/10.1177/0022219410371679>
- [26] MacGillivray, T.E., Gleason, T.G., Patel, H.J., Aldea, G.S., Bavaria, J.E., Beaver, T.M., *et al.* (2022) The Society of Thoracic Surgeons/American Association for Thoracic Surgery Clinical Practice Guidelines on the Management of Type B Aortic Dissection. *The Annals of Thoracic Surgery*, **113**, 1073-1092. <https://doi.org/10.1016/j.athoracsur.2021.11.002>
- [27] Han, H., Luo, M. and Shu, C. (2022) Interpretation of the American College of Thoracic Surgeons/Society for Thoracic Surgery Guidelines for the Clinical Management of Type B Aortic Coarctation. *Chinese Journal of Thoracic and Cardiovascular Surgery*, **29**, 820-827.
- [28] Stone, W.M., Ricotta, J.J., Fowl, R.J., Garg, N., Bower, T.C. and Money, S.R. (2011) Contemporary Management of Aberrant Right Subclavian Arteries. *Annals of Vascular Surgery*, **25**, 508-514. <https://doi.org/10.1016/j.avsg.2011.02.012>
- [29] Nelson, M.L. and Sparks, C.D. (2001) Unusual Aortic Arch Variation: Distal Origin of Common Carotid Arteries. *Clinical Anatomy*, **14**, 62-65.
- [30] Waterford, S.D., Chou, D., Bombien, R., Uzun, I., Shah, A. and Khojnejzhad, A. (2016) Left Subclavian Arterial Coverage and Stroke during Thoracic Aortic Endografting: A Systematic Review. *The Annals of Thoracic Surgery*, **101**, 381-389. <https://doi.org/10.1016/j.athoracsur.2015.05.138>
- [31] İnce, İ., Altınay, L., Huseynov, S., Zobu, M.Ş., Şahin, E., Ersoy, Ö., *et al.* (2022) Mid-Term Results of Left Carotid-Subclavian Bypass in Patients Undergoing Zone 2 TEVAR. *Brazilian Journal of Cardiovascular Surgery*, **37**, 721-726. <https://doi.org/10.21470/1678-9741-2021-0597>
- [32] Ramdon, A., Patel, R., Hnath, J., Yeh, C. and Darling, R.C. (2020) Chimney Stent Graft for Left Subclavian Artery Preservation during Thoracic Endograft Placement. *Journal of Vascular Surgery*, **71**, 758-766. <https://doi.org/10.1016/j.jvs.2019.05.049>

- [33] Qiao, Y., Fan, J., Ding, Y., Zhu, T. and Luo, K. (2019) A Primary Computational Fluid Dynamics Study of Pre- and Post-TEVAR with Intentional Left Subclavian Artery Coverage in a Type B Aortic Dissection. *Journal of Biomechanical Engineering*, **141**, Article ID: 111002. <https://doi.org/10.1115/1.4043881>
- [34] Matsumura, J.S., Lee, W.A., Mitchell, R.S., Farber, M.A., Murad, M.H., Lumsden, A.B., *et al.* (2009) The Society for Vascular Surgery Practice Guidelines: Management of the Left Subclavian Artery with Thoracic Endovascular Aortic Repair. *Journal of Vascular Surgery*, **50**, 1155-1158. <https://doi.org/10.1016/j.jvs.2009.08.090>
- [35] Matsumura, J.S. and Rizvi, A.Z. (2010) Left Subclavian Artery Revascularization: Society for Vascular Surgery® Practice Guidelines. *Journal of Vascular Surgery*, **52**, 65S-70S. <https://doi.org/10.1016/j.jvs.2010.07.003>
- [36] Fan, W., Tan, J., Shi, W., Rong, J. and Yu, B. (2021) A Systematic Review of Total Thoracic Endovascular Aortic Repair in Treatment of Kommerell Diverticulum Combined with Right-Sided Aortic Arch. *Medical Science Monitor*, **27**, e930031. <https://doi.org/10.12659/msm.930031>
- [37] Derycke, L., Avril, S. and Millon, A. (2023) Patient-Specific Numerical Simulations of Endovascular Procedures in Complex Aortic Pathologies: Review and Clinical Perspectives. *Journal of Clinical Medicine*, **12**, Article 766. <https://doi.org/10.3390/jcm12030766>
- [38] Zhou, Y., Wang, J., Zhao, J., Huang, B., Yuan, D. and Wang, T. (2023) Randomised Controlled Trial to Evaluate the Effect of Contrast Material Dilution on Renal Function in Patients after Endovascular Aortic Repair: Rationale and Design for the CULTURE Trial. *BMJ Open*, **13**, e069804. <https://doi.org/10.1136/bmjopen-2022-069804>
- [39] Tanius, A., Boitano, L., Canha, L., Chou, E.L., Wang, L.J., Latz, C., *et al.* (2021) Thoracic Aortic Remodeling with Endografting after a Decade of Thoracic Endovascular Aortic Repair Experience. *Journal of Vascular Surgery*, **73**, 844-849. <https://doi.org/10.1016/j.jvs.2020.06.120>
- [40] Wei, Y., Chang, Q., Yu, C., *et al.* (2011) One-Stage Hybridization Surgery for Descending Aortic Lesions Involving the Distal Aortic Arch. *Chinese Journal of Thoracic and Cardiovascular Surgery*, **18**, 99-103.
- [41] Buczkowski, P., Puslecki, M., Stefaniak, S., Juszkat, R., Kulesza, J., Misterski, M., *et al.* (2019) Off Pump Hybrid Extra-Anatomic Techniques for Aortic Arch Repair—Own Experience. *Journal of Thoracic Disease*, **11**, 2305-2314. <https://doi.org/10.21037/jtd.2019.06.10>
- [42] Piffaretti, G., Trimarchi, S., Gelpi, G., Romagnoni, C., Ferrarese, S., Tozzi, M., *et al.* (2020) Hybrid Repair of Extensive Thoracic Aortic Aneurysms. *European Journal of Cardio-Thoracic Surgery*, **58**, 940-948. <https://doi.org/10.1093/ejcts/ezaa178>
- [43] Lin, H., Du, Y., Yu, C., Qian, X., Sun, X., Tian, C., *et al.* (2018) Single Stage Hybrid Repair for DeBakey Type I Aortic Dissection in High Risk Patients. *European Journal of Vascular and Endovascular Surgery*, **56**, 363-372. <https://doi.org/10.1016/j.ejvs.2018.05.023>
- [44] Yoshitake, A., Hachiya, T., Okamoto, K., Kitahara, H., Kawaguchi, S., Nakatsuka, S., *et al.* (2016) Postoperative Stroke after Debranching with Thoracic Endovascular Aortic Repair. *Annals of Vascular Surgery*, **36**, 132-138. <https://doi.org/10.1016/j.avsg.2016.02.039>
- [45] Lu, Q. and Jing, Z. (2011) Endoluminal Treatment of Dilated Aortic Arch Disease. *Surgical Theory and Practice*, **16**, 126-129.
- [46] Patel, H.J., Dake, M.D., Bavaria, J.E., Singh, M.J., Filingier, M., Fischbein, M.P., *et al.* (2016) Branched Endovascular Therapy of the Distal Aortic Arch: Preliminary Results

- of the Feasibility Multicenter Trial of the Gore Thoracic Branch Endoprosthesis. *The Annals of Thoracic Surgery*, **102**, 1190-1198.  
<https://doi.org/10.1016/j.athoracsur.2016.03.091>
- [47] Saito, N., Kimura, T., Odashiro, K., Toma, M., Nobuyoshi, M., Ueno, K., *et al.* (2005) Feasibility of the Inoue Single-Branched Stent-Graft Implantation for Thoracic Aortic Aneurysm or Dissection Involving the Left Subclavian Artery: Short- to Medium-Term Results in 17 Patients. *Journal of Vascular Surgery*, **41**, 206-212.  
<https://doi.org/10.1016/j.jvs.2004.11.030>
- [48] Rousseau, H., Revel-Mouroz, P., Saint Lebes, B., Bossavy, J., Meyrignac, O. and Mokrane, F. (2019) Single Aortic Branch Device: The Mona LSA Experience. *The Journal of Cardiovascular Surgery*, **60**, 81-90. <https://doi.org/10.23736/s0021-9509.18.10665-3>
- [49] Zhang, L., Zhao, Z., Chen, Y., Sun, Y., Bao, J., Jing, Z., *et al.* (2016) Reintervention after Endovascular Repair for Aortic Dissection: A Systematic Review and Meta-Analysis. *The Journal of Thoracic and Cardiovascular Surgery*, **152**, 1279-1288.E3.  
<https://doi.org/10.1016/j.jtcvs.2016.06.027>
- [50] Zhang, L., Zhou, J., Lu, Q., Zhao, Z., Bao, J. and Jing, Z. (2014) Potential Risk Factors of Re-Intervention after Endovascular Repair for Type B Aortic Dissections. *Catheterization and Cardiovascular Interventions*, **86**, E1-E10.  
<https://doi.org/10.1002/ccd.25733>
- [51] Ahmad, W., Mylonas, S., Majd, P. and Brunkwall, J.S. (2017) A Current Systematic Evaluation and Meta-Analysis of Chimney Graft Technology in Aortic Arch Diseases. *Journal of Vascular Surgery*, **66**, 1602-1610.E2.  
<https://doi.org/10.1016/j.jvs.2017.06.100>
- [52] Bosiers, M.J., Donas, K.P., Mangialardi, N., Torsello, G., Riambau, V., Criado, F.J., *et al.* (2016) European Multicenter Registry for the Performance of the Chimney/Snorkeel Technique in the Treatment of Aortic Arch Pathologic Conditions. *The Annals of Thoracic Surgery*, **101**, 2224-2230. <https://doi.org/10.1016/j.athoracsur.2015.10.112>
- [53] Li, Y., Hu, Z., Wang, J., Zhang, Y., Chen, Z. and Zhang, H. (2018) Endovascular Chimney Technique for Aortic Arch Pathologies Treatment: A Systematic Review and Meta-Analysis. *Annals of Vascular Surgery*, **47**, 305-315.  
<https://doi.org/10.1016/j.avsg.2017.09.006>
- [54] Pecoraro, F., Lachat, M., Cayne, N.S., Pakeliani, D., Rancic, Z., Puipe, G., *et al.* (2017) Mid-Term Results of Chimney and Periscope Grafts in Supra-Aortic Branches in High Risk Patients. *European Journal of Vascular and Endovascular Surgery*, **54**, 295-302.  
<https://doi.org/10.1016/j.ejvs.2017.06.014>
- [55] Hogendoorn, W., Schlösser, F.J.V., Moll, F.L., Sumpio, B.E. and Muhs, B.E. (2013) Thoracic Endovascular Aortic Repair with the Chimney Graft Technique. *Journal of Vascular Surgery*, **58**, 502-511. <https://doi.org/10.1016/j.jvs.2013.03.043>
- [56] Huang, W., Ding, H., Jiang, M., Liu, Y., Huang, C., Yang, X., *et al.* (2019) Outcomes of Chimney Technique for Aortic Arch Diseases: A Single-Center Experience with 226 Cases. *Clinical Interventions in Aging*, **14**, 1829-1840.  
<https://doi.org/10.2147/cia.s222948>
- [57] Liu, F., Zhang, W., Wang, G., Yuan, T., Shu, X., Guo, D., *et al.* (2019) Long-Term Outcomes of Balloon-Expandable Bare Stent as Chimney Stent in Thoracic Endovascular Aortic Repair for Supra-Aortic Branches Reconstruction. *Journal of Thoracic Disease*, **11**, 1261-1268. <https://doi.org/10.21037/jtd.2019.04.15>
- [58] Zhu, J., Zhao, L., Dai, X., Luo, Y., Fan, H., Feng, Z., *et al.* (2018) Fenestrated Thoracic Endovascular Aortic Repair Using Physician Modified Stent Grafts for Acute Type B Aortic Dissection with Unfavourable Landing Zone. *European Journal of Vascular and*

- Endovascular Surgery*, **55**, 170-176. <https://doi.org/10.1016/j.ejvs.2017.11.012>
- [59] Qin, J., Zhao, Z., Wang, R., Ye, K., Li, W., Liu, X., *et al.* (2017) *In Situ* Laser Fenestration Is a Feasible Method for Revascularization of Aortic Arch during Thoracic Endovascular Aortic Repair. *Journal of the American Heart Association*, **6**, 1-11. <https://doi.org/10.1161/jaha.116.004542>
- [60] Tsilimparis, N., Debus, E.S., von Kodolitsch, Y., Wipper, S., Rohlfes, F., Detter, C., *et al.* (2016) Branched versus Fenestrated Endografts for Endovascular Repair of Aortic Arch Lesions. *Journal of Vascular Surgery*, **64**, 592-599. <https://doi.org/10.1016/j.jvs.2016.03.410>
- [61] O'Callaghan, A., Mastracci, T.M., Greenberg, R.K., Eagleton, M.J., Bena, J. and Kuramochi, Y. (2014) Outcomes for Supra-Aortic Branch Vessel Stenting in the Treatment of Thoracic Aortic Disease. *Journal of Vascular Surgery*, **60**, 914-920. <https://doi.org/10.1016/j.jvs.2013.12.053>
- [62] Inoue, K., Sato, M., Iwase, T., Yoshida, Y., Tanaka, T., Tamaki, S., *et al.* (1996) Clinical Endovascular Placement of Branched Graft for Type B Aortic Dissection. *The Journal of Thoracic and Cardiovascular Surgery*, **112**, 1111-1113. [https://doi.org/10.1016/s0022-5223\(96\)70115-0](https://doi.org/10.1016/s0022-5223(96)70115-0)
- [63] Huang, H., Jiao, Y., Zhang, Y., Zhu, Y., Liu, Z., Qiao, T., *et al.* (2017) Implantation of Unibody Single-Branched Stent Graft for Patients with Type B Aortic Dissections Involving the Left Subclavian Artery: 1-Year Follow-Up Outcomes. *Cardiovascular and Interventional Radiology*, **40**, 1678-1686. <https://doi.org/10.1007/s00270-017-1748-4>
- [64] Jing, Z., Lu, Q., Feng, J., Zhou, J., Feng, R., Zhao, Z., *et al.* (2020) Endovascular Repair of Aortic Dissection Involving the Left Subclavian Artery by Castor Stent Graft: A Multicentre Prospective Trial. *European Journal of Vascular and Endovascular Surgery*, **60**, 854-861. <https://doi.org/10.1016/j.ejvs.2020.08.022>
- [65] Zhou, M. and Fu, W. (2022) Chinese Expert Consensus on the Diagnosis and Treatment of Stanford Type B Aortic Coarctation. *Chinese Journal of Vascular Surgery (Electronic Version)*, **14**, 119-130.
- [66] Mehta, M., Darling, R.C., Taggart, J.B., Roddy, S.P., Sternbach, Y., Ozsvath, K.J., *et al.* (2010) Outcomes of Planned Celiac Artery Coverage during TEVAR. *Journal of Vascular Surgery*, **52**, 1153-1158. <https://doi.org/10.1016/j.jvs.2010.06.105>
- [67] Yang, J., Fu, W., Xu, X., *et al.* (2014) Single-Branch Aortic Stenting for Stanford Type B Aortic Coarctation: An Analysis of 11 Cases. *Chinese Journal of Practical Surgery*, **34**, 1167-1170.
- [68] Li, H., Chen, J., Zhong, R., *et al.* (2023) Application of Castor Branch Stent in the Treatment of Stanford Type B Aortic Coarctation Involving the Left Subclavian Artery. *Practical Chinese and Western Medicine Clinic*, **23**, 68-71.
- [69] Zhang, H., Liu, L.B., Zhang, Y., *et al.* (2023) Meta-Analysis of Castor Single-Branch Stent for Left Subclavian Artery Reconstruction in Endoluminal Treatment of Stanford Type B Aortic Dissection. *Chinese Journal of Vascular Surgery (Electronic Edition)*, **15**, 230-237.
- [70] Ozcinar, E., Dikmen, N., Baran, C., Buyukcakil, O., Kandemir, M. and Yazicioglu, L. (2024) Comparative Retrospective Cohort Study of Carotid-Subclavian Bypass versus *in Situ* Fenestration for Left Subclavian Artery Revascularization during Zone 2 Thoracic Endovascular Aortic Repair: A Single-Center Experience. *Journal of Clinical Medicine*, **13**, Article 5043. <https://doi.org/10.3390/jcm13175043>