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Case Report

Surgical Repair of an Isolated Giant Aortic Arch Aneurysm in an 11-Year-Old Girl: A Case Report

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Abstract

Background: Aortic arch aneurysms are exceedingly rare in children and are typically associated with connective tissue disorders, aortitis, infection, or trauma. Their management is challenging due to limited evidence guiding operative and perioperative strategies. This case describes the successful surgical repair of an isolated giant aortic arch and descending aorta aneurysm in a child, emphasizing key considerations for planning and execution. **Case:** An 11-year-old girl presented with a one-month history of exertional chest pain. Computed tomography (CT) revealed a 42 × 36 mm saccular aneurysm involving the distal aortic arch and proximal descending aorta, accompanied by an aberrant left subclavian artery (LSCA). Three-dimensional (3D) CT reconstruction and 3D-printed modeling facilitated operative planning. Through a left posterolateral thoracotomy and without cardiopulmonary bypass, the aneurysm was partially resected, preserving the recurrent laryngeal nerve, and the arch was reconstructed using a 14-mm Dacron graft. Cross-clamp time was 15 minutes. The patient recovered uneventfully and was discharged on postoperative day 3. Histopathology showed degeneration of the aortic wall without inflammation. **Conclusions:** This case highlights the importance of comprehensive preoperative imaging, individualized clamping strategy selection, and meticulous protection of adjacent structures in pediatric aortic arch aneurysm repair. These principles, consistent with approaches used for complex arch pathology, contribute to optimizing surgical safety and outcomes in this rare population.

Keywords: aortic arch aneurysm; surgical repair; children; cardiovascular imaging

1. Introduction

Aortic aneurysms are extremely rare in the pediatric population and are typically associated with underlying conditions such as connective tissue disorders, aortitis, infection, trauma, or complications following catheter-based interventions [1,2,3]. The pathological features of aortic aneurysms vary depending on their location and may lead to severe complications, including intramural hematoma, aortic dissection, or aortic valve regurgitation [4]. Given the potentially life-threatening nature of these lesions, their management remains complex and challenging. Here, we report a case of an isolated giant aortic arch and descending aorta aneurysm in an 11-year-old girl, successfully treated with a tailored surgical approach.

2. Case Presentation

An 11-year-old girl (height: 145 cm, weight: 35.4 kg) was referred to our hospital with a one-month history of recurrent chest pain that began after a soccer match. The pain was exacerbated by physical activity and relieved by rest. She had no history of trauma, infection, previous surgery, asthma, or hereditary disease. Physical examination was unremarkable. Blood pressure measurements were 95/67 mmHg (left upper extremity), 102/64 mmHg (right upper extremity), 106/64 mmHg (left lower extremity), and 95/51 mmHg (right lower extremity). Oxygen saturation was 98% in the left upper and lower extremities and the right upper extremity, and 99% in the right lower extremity.

Chest radiography revealed a localized mass in the left upper mediastinum (Fig. 1A). Transthoracic echocardiography (TTE) showed distortion of the aortic arch and descending aorta; however, the descending aorta could not be adequately visualized. Except for a patent foramen ovale, overall cardiac anatomy and function were normal, including the tricuspidal aortic valve. A cardiac computed tomography (CT) scan was subsequently performed and revealed a saccular aneurysm measuring 42 × 36 mm in the distal aortic arch, immediately distal to the origin of the left common carotid artery (LCCA), compared with 22 mm of ascending aorta and 14 mm of descending aorta in di-

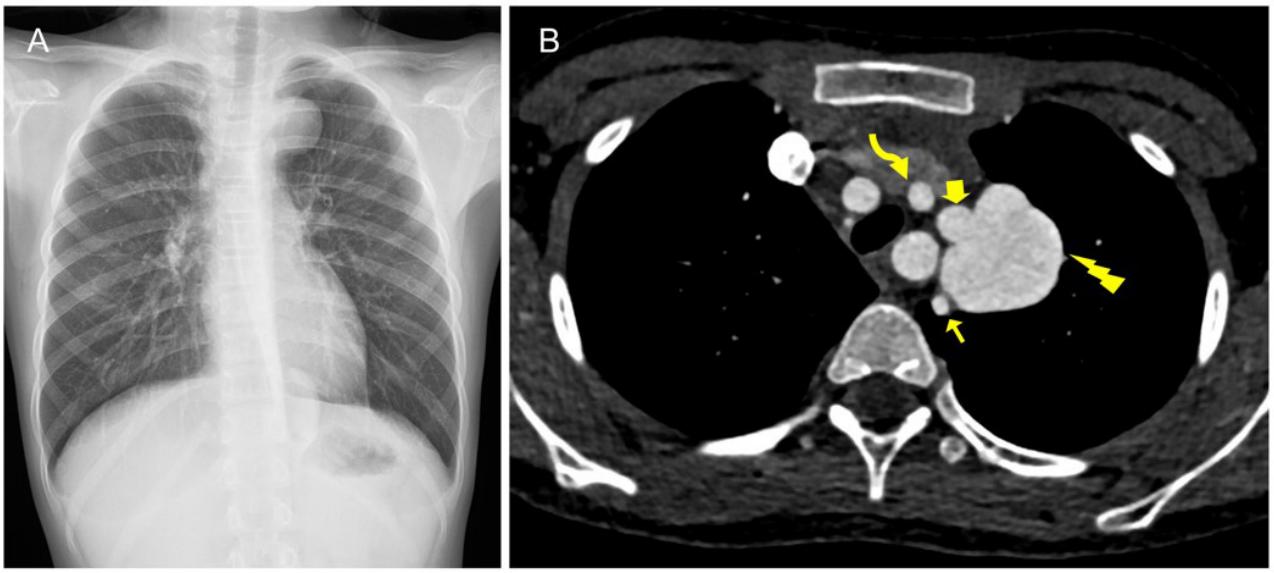

Fig. 1. Preoperative chest radiography and transverse CT image. (A) Chest radiograph demonstrating a prominent aortic knob. (B) Transverse CT image showing a saccular aneurysm (lightning symbol), an aberrant left subclavian artery (thin arrow), the aortic arch (thick arrow), and the left common carotid artery (curved arrow). CT, computed tomography.

ameter, respectively. An aberrant left subclavian artery (LSCA) arose from the right side of the descending aorta and coursed posterior to the aneurysm before reaching the left side. No additional dilatation of the thoracic aorta was observed (Fig. 1B). Three-dimensional (3D) CT reconstruction (Fig. 2A,B) and 3D-printed modeling (Fig. 2C,D) enhanced preoperative visualization and facilitated precise operative planning for aneurysm resection and aortic reconstruction.

Through a left posterolateral thoracotomy via the third intercostal space, a pulsatile protrusion was observed. After careful dissecting of the mediastinal pleura, a large saccular aneurysm involving the distal aortic arch and proximal descending thoracic aorta was exposed, with a narrow neck and marked wall tension (Fig. 3A). Following mobilization of the adjacent tissues, the major arch vessels, including the brachiocephalic trunk and LCCA, were identified. The LSCA was confirmed to originate aberrantly from the distal descending aorta. Under normothermic conditions and without cardiopulmonary bypass, the aneurysm was isolated by cross-clamping the aortic arch immediately distal to the origin of the LCCA and the proximal LSCA distal to the aneurysm. The aneurysm sac was then opened, revealing a smooth inner surface without calcification. To prevent injury to the recurrent laryngeal nerve, which coursed closely along the aneurysmal wall, only the irregular and diseased portions of the aneurysm were resected (Fig. 3B). A 14-mm Dacron graft was interposed to reconstruct the distal aortic arch and proximal descending aorta (Fig. 3C). Total cross-clamp time was 15 minutes, after which the patient was transferred to the cardiac intensive care unit.

The postoperative course was uneventful. The patient was extubated on postoperative day 1 and discharged home on day 3 without spinal cord complications and neurological complications, including hoarseness or phrenic nerve dysfunction. Histopathologic examination revealed localized degeneration of the aortic wall with disruption of the internal elastic lamina and mucoid degeneration with hyalinization, without evidence of inflammatory cell infiltration. Postoperative TTE revealed no anastomotic aneurysm formation, and the graft showed neither kinking nor stenosis.

At 1-month follow-up, TTE demonstrated unobstructed flow across the graft–native aorta anastomoses with a mild pressure gradient of 15 mmHg. The patient remained asymptomatic, with complete resolution of chest pain. The planned surveillance protocol includes TTE at 1, 3, 6, and 12 months postoperatively, with cardiac CT imaging at 6 and 12 months. After the first postoperative year, annual TTE and CT imaging will be performed for long-term follow-up.

3. Discussion

Surgical repair of aortic arch aneurysms in children is particularly challenging because of the rarity of the condition and the absence of robust evidence to guide operative and perioperative strategies. In our case, tailored surgical strategy supported by detailed multimodal preoperative imaging and meticulous intraoperative management resulted in an excellent outcome without neurological complications.

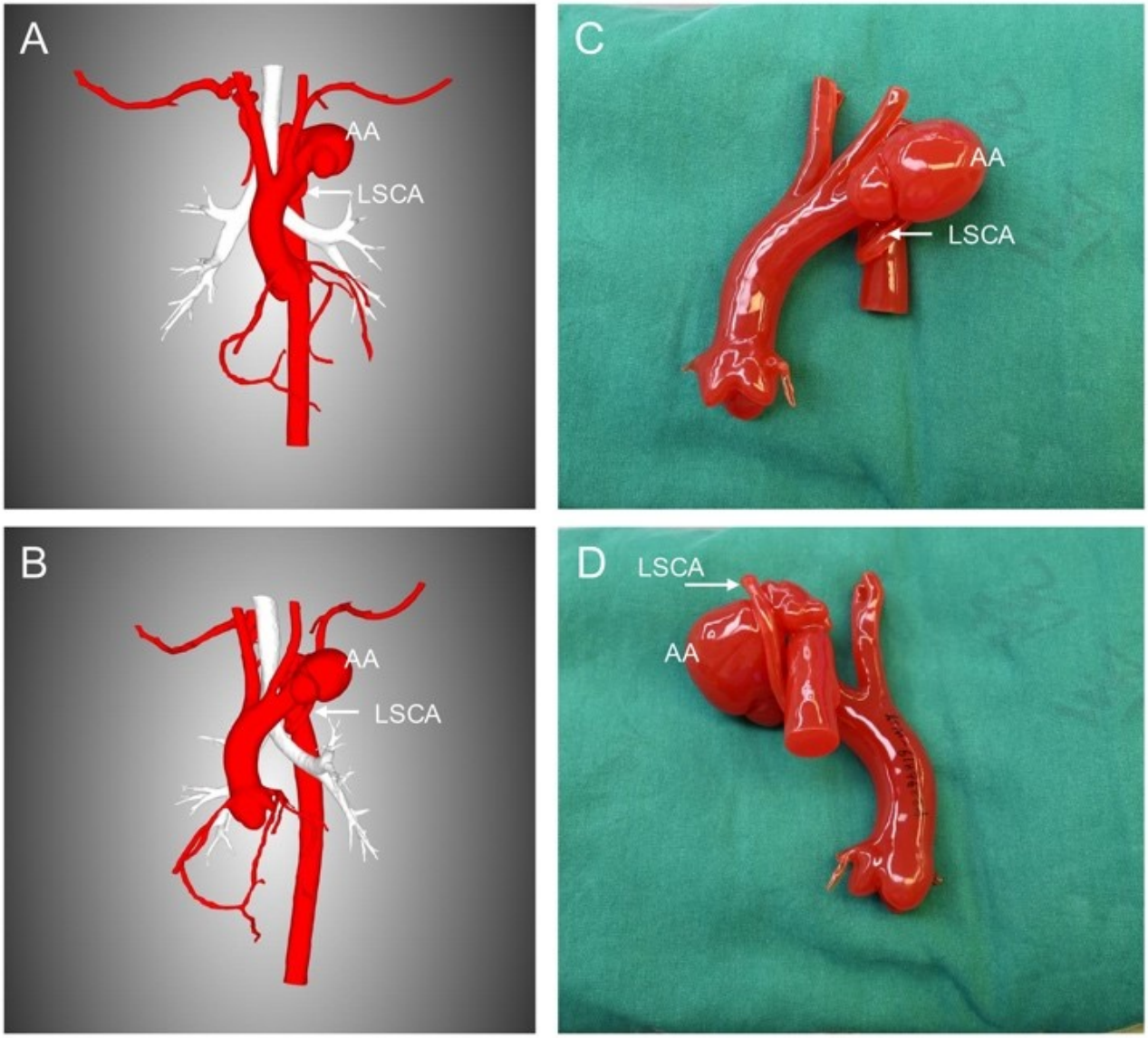

Fig. 2. 3D CT reconstruction and 3D-printed modeling of the aortic aneurysm. (A) Anterior view of the 3D CT reconstruction. (B) Lateral view of the 3D CT reconstruction. (C) Lateral view of the 3D-printed model. (D) Posterior view of the 3D-printed model. AA, aortic aneurysm; LSCA, left subclavian artery; CT, computed tomography; 3D, three-dimensional.

This case highlights three important considerations for operative planning in complex arch pathology. First, meticulous anesthesia management is essential. In our center, continuous blood pressure monitoring in both the right upper and lower extremities is routinely employed for pediatric coarctation repairs, and we applied the same strategy in this patient. This practice allows precise evaluation of perfusion gradients and enables controlled reduction of upper-body hypertension during cross-clamping. Airway management in left thoracotomy must also be individualized. Double-lumen tubes provide excellent surgical exposure and reduced lung injury by allowing single-lung ventilation, but their use is limited in infants due to size constraints [5,6]. Single-lumen tubes are therefore preferred in younger children; however, they provide comparatively poorer exposure and may increase the risk of lung injury when towel compression is required for adequate visualization.

Second, operative planning must carefully address perfusion and clamping strategies which were similarly emphasized in prior discussions of complex arch anatomy and aneurysm repair [7]. In a patient with a single carotid artery, whose anterior cerebral circulation depends entirely on that vessel, regional cerebral perfusion is critical to avoid ischemic injury. In contrast, for patients with bilateral carotid arteries, several approaches may be considered when clamping the segment between the carotid artery and the aneurysm: (1) closed proximal anastomosis with left heart bypass; (2) proximal clamp placement with

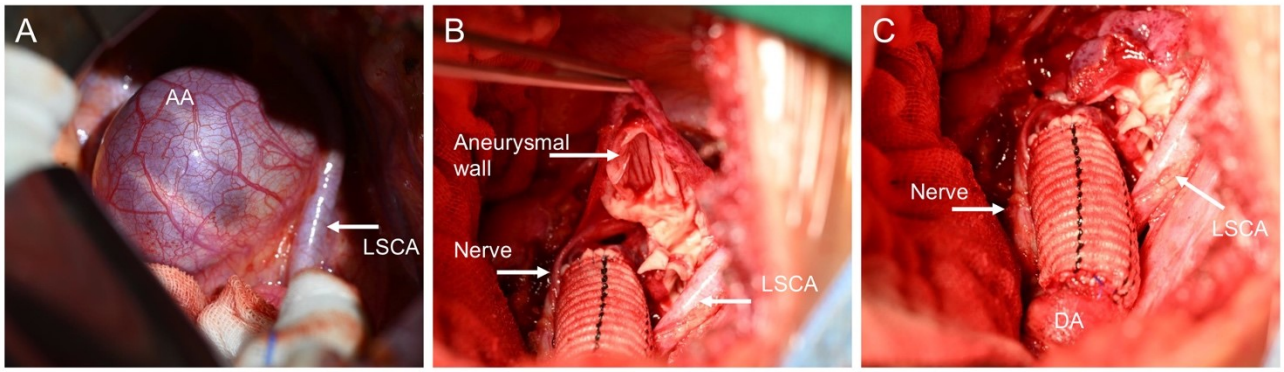

Fig. 3. Intraoperative findings and surgical reconstruction. (A) Intraoperative view of the saccular aneurysm demonstrating significant wall tension and the aberrant LSCA. (B) Partial resection of the aneurysmal wall to preserve adjacent vital structures. The recurrent laryngeal nerve was observed coursing closely along the aneurysm and running parallel to the graft. (C) The reconstruction of the distal aortic arch and proximal descending aorta using a Dacron graft. AA, aortic aneurysm; LSCA, left subclavian artery; DA, descending aorta.

Table 1. Review of the literature on aortic aneurysm repair in the pediatric population.

Authors	Publication year	Age/gender	Surgical plan	Perfusion	Outcomes
Takeshita M, et al. [1]	2019	10-year-old girl	The ascending aorta, aortic arch, and descending thoracic aorta were replaced using a 20-mm J-Graft via median sternotomy plus left thoracotomy	Antegrade cerebral perfusion	Successfully treated without complications
Li W, et al. [10]	2021	1-month-old boy	Hemiarch and ascending aorta was replaced using a 14-mm aortic homograft via median sternotomy	Not mentioned	Successfully treated without complications
Cvitkovic T, et al. [3]	2022	3-month-old girl	Aneurysm was resected, and the aorta was reconstructed with a glutaraldehyde-treated autologous pericardial patch via median sternotomy	Antegrade cerebral perfusion	Successfully treated without complications
Vashkeba V, et al. [9]	2023	13-year-old girl	Left subclavian artery was reimplanted via left supraclavicular approach; aneurysm was excised via median sternotomy	Antegrade cerebral perfusion	Successfully treated without complications

ascending-descending aortic bypass; (3) deep hypothermia circulation arrest (DHCA); and (4) repair without cardiopulmonary bypass, particularly when the aneurysm does not involve the proximal arch [8]. Although left heart bypass or ascending–descending aortic bypass may reduce circulatory arrest time, and DHCA may provide favorable operative conditions, these techniques require additional cannulation and anastomoses, potentially increasing operative complexity and postoperative bleeding risk. Recent reports of pediatric aortic aneurysm repair (Table 1, Ref. [1,3,9,10]) indicate that most patients underwent surgery with antegrade cerebral perfusion or DHCA, often via median sternotomy or combined sternotomy and left thoracotomy, with favorable early and midterm outcomes [1,3,9]. When anticipated circulatory arrest exceeds 30 minutes, antegrade cerebral perfusion is recommended for neurological protection [11]. Furthermore, bilateral antegrade cerebral perfusion has been associated with a lower risk of cerebrovascular events compared with DHCA alone during prolonged circulatory arrest (≥30 minutes) [12]. Limiting aortic cross-clamp duration to within 30 minutes has also been shown to reduce the risk of spinal cord injury in aortic arch surgery [13].

In the present case, 3D CT reconstruction and 3D-printed modeling enabled precise mapping of the aneurysm morphology, adjacent structures, and optimal clamp positioning, confirming that aneurysm resection and aortic reconstruction could be safely completed within an accept-

able ischemic interval. The aorta was therefore cross-clamped distal to the LCCA and proximal to the LSCA, preserving antegrade cerebral perfusion through the bilateral carotid arteries. With this clamp configuration, cerebral blood flow was not expected to be significantly compromised; the primary hemodynamic concern was upper-body hypertension during clamping, which was effectively managed by the anesthesia team. Although proximal clamping of the LSCA may have resulted in partial reduction of upper-body perfusion, the short duration of clamping did not induce significant dysfunction, and cerebral perfusion was maintained. A limitation of this approach is that near-infrared spectroscopy cerebral oximetry was not utilized for intraoperative neurological monitoring.

Consequently, graft interposition was successfully performed without cardiopulmonary bypass, with a total cross-clamp time of 15 minutes. Nevertheless, extracorporeal circulation equipment was fully primed and kept on standby throughout the procedure to ensure immediate availability in the event of hemodynamic or neurological compromise.

Third, preservation and protection of adjacent structures are critical. Although wider dissection may facilitate exposure, it increases the risk of injuring fragile tissues such as lymphatic vessels, increasing the likelihood of postoperative chylothorax or collateral arteries, which may increase bleeding risk. In this case, part of the aneurysmal wall was intentionally preserved due to its intimate relationship with the recurrent laryngeal nerve, as complete resection carried a substantial risk of nerve injury. Additionally, careful management during cross-clamp release is essential. Gradual release of the Potts clamp after partial occlusion of the Dacron graft helps prevent sudden systemic washout of accumulated acidic metabolites, thereby reducing the risk of circulatory collapse.

A limitation of this case report is the absence of genetic testing, which could have provided further evaluation for heritable aortic disease and improved understanding of the patient's natural history, associated risks, and implications for personalized management of the patient and her family. Genetic testing was proposed but declined by the patient's parents.

4. Conclusions

This case illustrates the critical importance of comprehensive preoperative imaging, thoughtful selection of perfusion and clamping strategies, and meticulous protection of adjacent structures in the surgical management of pediatric aortic arch aneurysms. Adherence to these operative planning principles, well established in the repair of complex arch pathology, facilitated a safe and effective repair in this rare presentation.

Availability of Data and Materials

All data reported in this paper will also be shared by the lead contact upon request.

Author Contributions

ZWC and YZ conceived and designed the study. ZWC and ZRP were responsible for data collection. SJZ and YFL performed the imaging analysis. ZRP, SJZ and YFL contributed to data verification. ZWC, SSW, JMC and YZ contributed to interpretation of the clinical data and surgical planning. ZWC, SSW and YZ performed the surgical procedure and provided surgical expertise. ZWC and ZRP drafted the initial manuscript. JMC, SSW and YZ supervised the overall research process. JMC, SSW and YZ revised the manuscript. 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 and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was conducted in accordance with the Declaration of Helsinki. The research protocol was approved by the Ethics Committee of Guangdong Provincial People's Hospital (Guangdong Academy of Medical Sciences) (Approval No. GDREC2019338H). Written informed consent for publication of this case report and the accompanying images was obtained from the patient's legal guardian.

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Conflicts of Interest

The authors declare no conflicts of interest.

Declaration of AI and AI-Assisted Technologies in the Writing Process

During the preparation of this work the authors used ChatGpt-4.0 in order to check spell and grammar. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.31083/HSF48803.

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