Aberrant right subclavian artery: a novel approach and an overview of operative techniques

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ABSTRACT

An aberrant right subclavian artery (ARSA) is a rare variation of normal anatomy occurring in 0.5% to 1.8% of the population. No current guidelines are available regarding ARSA management, and surgical intervention should be evaluated carefully. Moreover, symptomatic patients with a dominant left arch and aberrant ARSA require a surgical approach from the right side of the chest for ligation and division of the aberrant artery at its origin on the aorta. The ARSA can then be reimplanted onto the right common carotid artery via a supraclavicular incision. The extensive mobilization in the chest allows for easy reimplantation in the supraclavicular region and eliminates reliance on the collateral circulation. Postoperative monitoring is reliable and easy with radial pulse examinations. (J Vasc Surg Cases Innov Tech 2023;9:101327.)

Keywords: Aberrant right subclavian artery; Congenital cardiac surgery; Vascular surgery

An aberrant right subclavian artery (ARSA) is a rare variation of normal anatomy. In most cases, the right subclavian artery arises from the brachiocephalic artery, the first major aortic branch. However, in 0.5% to 1.8% of the population, the right subclavian artery originates directly from the aorta, distal to the left subclavian artery, acting as a fourth aortic branch, taking a variable course, and passing posterior, between, or anterior to the esophagus and trachea.[1,2] Depending on the vessel's size and course, it can lead to compression of the trachea and esophagus by the right subclavian artery. Patients with this rare anatomic variant are often asymptomatic but can experience symptoms of dyspnea, stridor, and dysphagia, similar to those associated with vascular rings and double aortic arches.[3] Furthermore, the ARSA can be associated with a broad base, known as the Kommerell diverticulum, which can undergo aneurysmal degeneration and has the potential for rupture.[4]

The incidence of this vascular anomaly is rare; thus, surgical correction requires thoughtful consideration because no current guidelines are available regarding ARSA management. The surgical approach is unique in that it requires ligation and division from the right side of the chest.[5] A number of studies have reported adults with this diagnosis and the recommended repair. However, in the present report, we focus on a younger, adolescent and pediatric population. Given this paucity of literature guidance, we present two cases of ARSA repair. Each case highlights a novel operative technique surgeons can consider when evaluating the surgical options for ARSA repair. Both patients provided written informed consent for the report of their case details and imaging studies.

CASE REPORT

Patient 1. The first patient is an 18-year-old woman with chronic dysphagia. After an extensive workup and multiple clinic appointments, an echocardiogram revealed an ARSA. A follow-up esophagram showed a narrowing of the proximal thoracic esophagus at the level of the aortic arch, with a posterior compression. These findings of an ARSA and esophageal compression were confirmed by advanced imaging modalities, showing the ARSA running posterior to and compressing the esophagus, with its base dilated to 18 mm (Figs 1 and 2). Both vertebral arteries were evaluated and noted to be of even caliber. Following interdisciplinary discussions, the patient was brought to the operating room for hybrid repair with cardiac and vascular surgery teams.

The patient was inducted with general anesthesia, and a left radial arterial line was placed. She was then positioned in the left lateral decubitus position. A minimal incision muscle-sparing thoracotomy was performed through the fourth intercostal spaced on the right side. The ARSA was easily identified in close proximity to the azygous vein. Its course was dissected circumferentially toward its origin on the aorta, taking care not to injure the phrenic nerve or esophagus. The right bronchus and trachea were located, and the dense tissue surrounding them was freed. The Kommerell diverticulum was identified at the origin of the ARSA from the aorta. Distally, the ARSA was freed high into the apex of the thoracic cage, fully mobilizing the vessel. Heparin was then

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2468-4287

https://doi.org/10.1016/j.jvscit.2023.101327

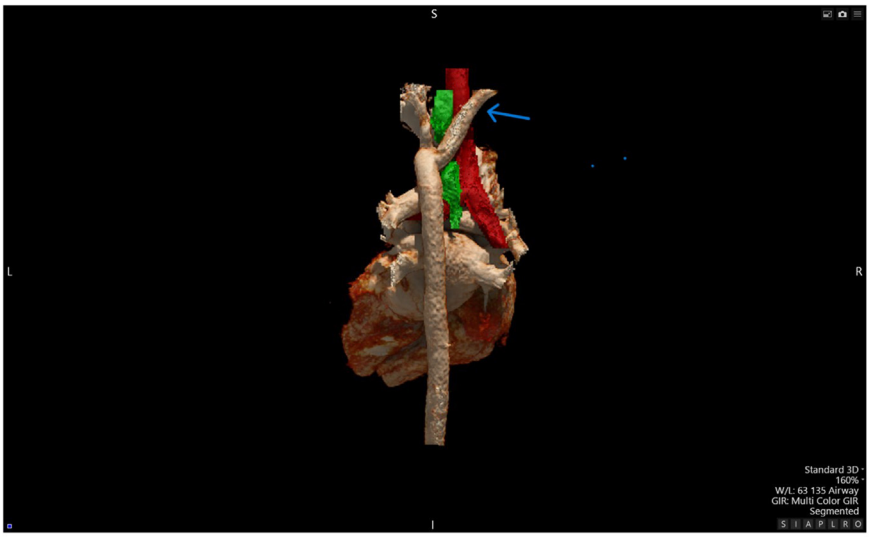

Fig 1. Three-dimensional reconstruction of a computed tomography scan. *Blue arrow* indicates the aberrant right subclavian artery (ARSA); *green shading,* the esophagus; and *red shading,* the pulmonary tree.

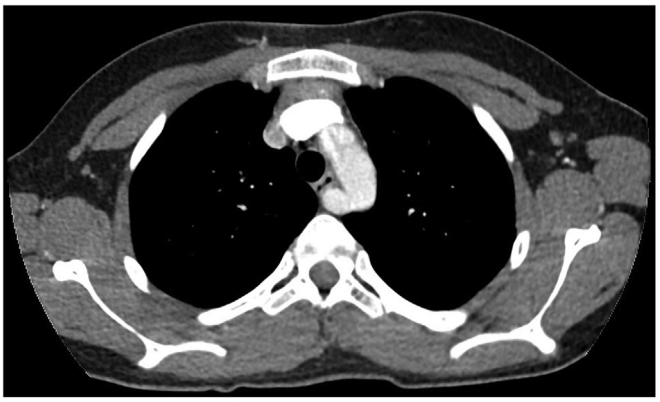

Fig 2. Preoperative computed tomography angiogram showing the aberrant right subclavian artery (ARSA) coursing posterior to and compressing the esophagus.

administered, and, after a 3-minute wait, an Endo GIA stapler (Medtronic) was used to ligate and divide the aberrant artery at the proximal end, flush with the aorta, thereby obliterating the diverticulum of Kommerell. A chest tube was placed in the right pleural space, and the chest was then closed in the standard fashion.

The patient was repositioned supine, and the right side of the neck and supraclavicular area were prepared and draped. A transverse incision was made just above the clavicle. Careful dissection of the common carotid and subclavian arteries was performed, ensuring the vagus nerve in the right side of the neck was identified and protected. One important consideration to be cognizant of is the increased likelihood of encountering a nonrecurrent recurrent laryngeal nerve in these patients during the supraclavicular incision. Dissection of the ARSA was comprehensive, allowing for identification of the vertebral artery and mammary artery. After the right subclavian artery was fully mobilized in the neck, the proximal portion of the artery was easily pulled into the neck incision site (Fig 3).

Reimplantation onto the right carotid artery was performed via an end-to-side anastomosis. Clamps were placed on the common carotid artery, and a longitudinal arteriotomy was performed on the lateral aspect, which was enlarged using an aortic punch. The subclavian artery was then anastomosed directly onto the carotid artery using 6-0 Prolene suture. Before the completion of this anastomosis, the carotid artery was forward and back bled and flushed with heparinized saline. The clamps were then removed, and hemostasis was ensured. A radial pulse was confirmed via palpation, the wound was closed around a Penrose drain, and the patient was extubated in the operating room.

The patient was discharged on postoperative day 4, tolerating oral foods with no evidence of dysphagia. Computed tomography angiography obtained 6 months postoperatively showed patent right subclavian artery flow with no evidence of stenosis (Fig 4). The patient reported complete resolution of dysphagia and an ability to eat a variety of consistencies.

Patient 2. The second patient is a 13-year-old girl with a 4-month history of dysphagia. A chest computed tomography scan revealed a left-sided aortic arch with an ARSA coursing retropharyngeally, with mild narrowing of the posterior aspect of the esophagus distal to the aortic arch (Fig 2). The patient was then taken to the operating room for a planned video-assisted thoracoscopic surgery (VATS) takedown of the ARSA.

The patient was placed in the left lateral decubitus position. Two 5-mm thoracoscopic port sites were placed in the fourth intercostal space, one just posterior to the scapular tip and the second along the same rib space more anteriorly. Following the mid-axillary line inferiorly, a 12-mm port was placed. Beginning on the lateral border of the ARSA, the pleural reflection

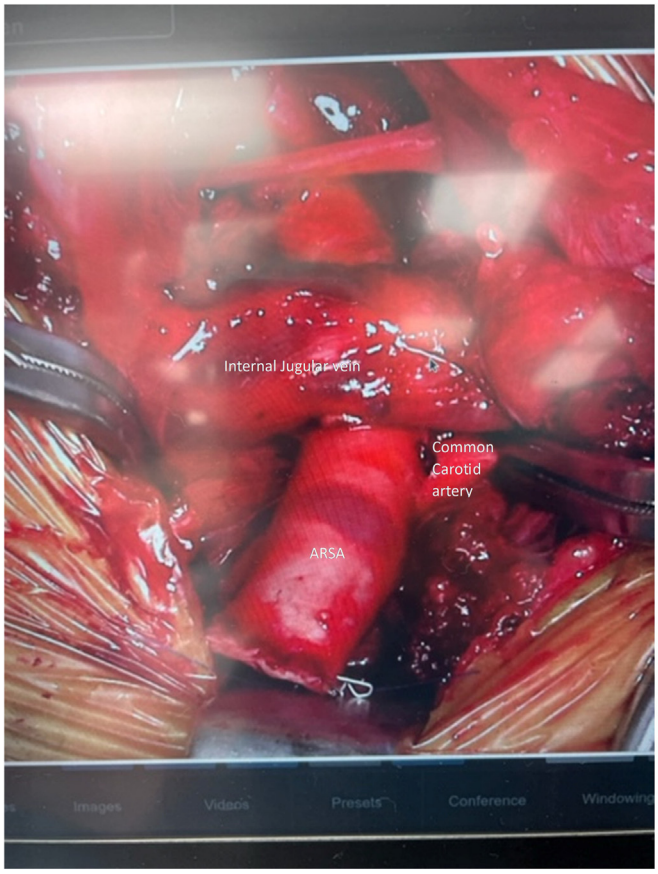

Fig 3. Intraoperative photograph showing the stapled end of the subclavian artery pulled through the chest, beneath the internal jugular vein.

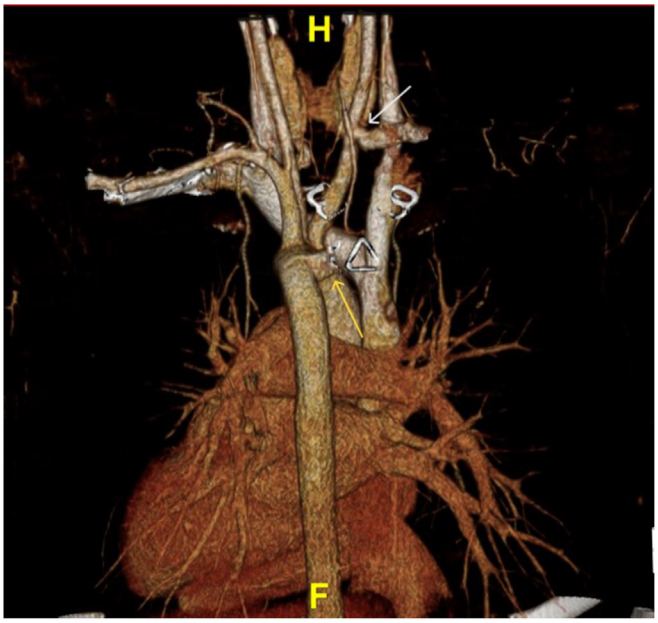

Fig 4. Posterior view of postoperative computed tomography angiogram. *Yellow arrow* indicates the stump of the native origin of the ARSA at the aorta; and *white arrow,* the transposed subclavian artery to common carotid artery on the right. H indicates the direction of the head, F indicates the direction of the foot.

was freed vertically. Moving medially, the vessel was dissected free as it ran parallel to the esophagus. At this point, the dissection became very impeded and tenuous, and it was determined unsafe to continue. A limited anterior lateral thoracotomy was then made to facilitate dissection, ligation, and division of the vessel. The neck dissection and reimplantation proceeded in the same fashion as that for patient 1, with successful collaboration between the vascular and cardiac surgery teams. Her postoperative course was significant for a chyle leak in the chest. After conservative therapy failed, the patient underwent thoracic duct ligation and mechanical pleurodesis, with complete resolution. This is a rare complication, with a reported occurrence of 1.5% to 7.6% after congenital cardiac surgery.[6] The 3-month follow-up duplex ultrasound scan showed patent flow with no evidence of stenosis. The patient reported no dysphagia since her repair.

DISCUSSION

At present, three main options for surgical repair of an ARSA are available: open repair, thoracic endovascular aortic repair (TEVAR), and hybrid repair. The choice of approach depends on the vascular anatomy and patient size, symptoms, acuity, and body habitus.

Open repair has been the traditionally preferred treatment modality for an ARSA.[7] This can be performed via right lateral thoracotomy, right-sided VATS, or, in rare cases, median sternotomy. A right-sided thoracotomy is preferred over a left, because a left thoracotomy results in less favorable exposure of the vessel at its origin and also impeding full mobilization of the aberrant vessel's intrathoracic course.[8] One of the main advantages of the open repair technique is the aided visualization the ARSA's origin. If the anatomy is particularly challenging, the use of hypothermic circulatory arrest can be implemented.[9] The resulting operation could require aortic arch reconstruction, which has been shown to be associated with a statistically significant increase in the length of hospital stay, prolonged mechanical ventilation, and pneumonia.[10]

The TEVAR technique has been increasing in popularity during the past 20 years. Techniques vary, but many require remote access of the subclavian artery via a supraclavicular incision and endovascular access, typically via a femoral artery catheter.[11] A covered stent graft is used to occlude the origin of the ARSA. This technique does not revascularize the artery and relies on the collateral circulation for perfusion. Such a large reliance on the collateral circulation for an important source of blood flow has made this approach less favored, especially in younger patient populations. Additionally, this technique will not completely obliterate the origin of the ARSA and, thus, carries a risk of residual esophageal compression.

Finally, in this population, the use of a TEVAR device could be precluded by anatomic considerations and graft size availability.

The hybrid approach to ARSA repair is new and branches off the TEVAR technique. The same femoral artery access is used, with a covered stent graft occluding the origin of the ARSA. An additional deep supraclavicular incision is then made, facilitating a carotid artery to subclavian artery bypass. This approach allows for preservation of the blood flow through the artery and does not rely on the collateral circulation. Additionally, unlike in the TEVAR-only technique, the carotid—subclavian bypass ensures no residual esophageal compression. The TEVAR approach and this hybrid technique have been shown to have outcomes similar to those with the open repair, with no significant increase in mortality or complications.[6] Concerns with this hybrid approach are related to occlusion and leak of the transposed artery; however, studies have shown reintervention rates similar to those with other techniques.[12]

The techniques used for our patients represent a combination of open and hybrid repair of an ARSA. Vascular and cardiothoracic surgeons collaborate to properly ligate and divide the subclavian artery at its origin and reimplant the artery onto the carotid artery. This approach uses the arch visualization of the open approach and the revascularization possible with the hybrid, without the need for graft material. Similar to the hybrid approach, the need for hypothermic arrest and aortic arch reconstruction is eliminated. Additionally, transection of the subclavian artery facilitates direct subclavian artery to carotid artery transposition, instead of a carotid artery to subclavian artery bypass using a conduit. This is possible by the long length achieved by mobilizing the subclavian artery along its entire course.

Finally, similar to the hybrid technique, our combined approach eliminates the reliance on the collateral circulation seen with the TEVAR technique. Postoperative monitoring of these patients is reliable and easy with radial pulse examinations. This double-open technique does, however, still require either a thoracotomy incision or VATS approach.

An ARSA is a rare condition that provides a unique challenge for surgeons. The limited incidence and lack of published guidelines necessitates the need for investigation and discussions in the field on how best to treat these patients. Through collaboration between vascular and cardiothoracic surgery teams, we achieved success for our pediatric and adolescent patients.

DISCLOSURES

None.

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Submitted Jul 10, 2023; accepted Aug 28, 2023.