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Aberrant Right Vertebral Artery Originating From the Descending Thoracic Aorta, With Simultaneous Left Vertebral Artery Takeoff From the Aortic Arch

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Abstract

Aberrant origination of the vertebral arteries is a rare phenomenon, and those involving the right vertebral artery are exceedingly rare. In this case report, we present the third documented case of an aberrant right vertebral artery originating directly from the descending thoracic aorta, and the first case where there is a simultaneous aberrant left vertebral artery arising from the aortic arch. Anatomical background, embryological development, and potential pathological presentations in addition to clinical considerations unique to our case are discussed as well.

Keywords: Aorta, neuroradiology, variant anatomy, vascular, vertebral artery

Introduction

The vertebral arteries are major arteries of the head and neck arising from the posterosuperior aspect of the left and right subclavian arteries, respectively, and supply 20% of blood flow to the brain.[1] Anatomically, the vertebral artery is divided into 4 segments: from its origin to the transverse foramen of the C6 vertebral body (extraosseous or V1 segment), its ascending course through the transverse foramen of C6 to C1 (foraminal or V2 segment), a transitional segment from the transverse foramen of the atlas along the superior aspect of the C1 ring into the dura mater via the foramen magnum (extraspinal or V3 segment), and a final superomedial intracranial course behind the clivus to unite with the contralateral vertebral artery in forming the basilar artery near the pontomedullary border (intradural/intracranial or V4 segment).[2]

Understanding the embryological development of the vertebral arteries helps in further appreciating their anatomy. During embryological development, 6 sets of matched aortic arches undergo selective apoptosis and regression with the remaining branch vessels eventually constituting the aortic arch and great vessels.[3] After initial establishment of the internal carotid system, the vertebrobasilar system develops by necessity due to increased demand for nourishment from the enlarging fetal brain, which by then has exhausted the reserve capacity of the internal carotid system.[4] Formation of the vertebral arteries then starts to occur from the distal end of the seventh dorsal intersegmental artery off of the primitive cervical dorsal aorta and successively anastomose from C7 to C1 in a longitudinal fashion.[3] Although the basic branching pattern of the vertebrobasilar system is independent of brain development, the course of these arteries become secondarily "corrected" by the growing brain and atlantooccipital joint.[5]

Due to the segmental nature of their development and multiple opportunities for aberrant anastomoses from C7 to C1, the vertebrobasilar system is prone to anatomical variations, which can manifest as asymmetrical size of the right and left vertebral arteries, duplication, fenestration, or aberrant origination.[6,7] Aberrant origination of the left vertebral artery (LVA) is far more common than the right vertebral artery (RVA). An autopsy series review of 12 patients with known aberrant vertebral origins revealed all aberrant vertebral arteries to be left sided in origin, predominantly arising from the aortic arch (83.3%) and less commonly from the left common carotid and left external carotid arteries (8.3% for each).[8] A meta-analysis by Shi-Min Yuan in 2016 of several large autopsy series and among patients who had undergone cerebral angiography revealed direct aortic origination of the LVA as the most frequent anatomic vertebral artery variant with a prevalence of 2.4-5.8%, while aberrant RVA origin was too rare to characterize.[9] Of the few incidental cases of aberrant RVA origin, most have been described branching directly from the right common carotid artery.[1,9] Unilateral vertebral artery origination anomalies are also more common than those involving both vertebral arteries, with bilateral involvement accounting for less than 3% of total aberrant vertebral artery origins.[1,9] Outside of the

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Figure 1. Right lateral view cinematic rendering of the arterial vasculature of the head and neck region clearly demonstrating RVA takeoff from a portion of the proximal descending thoracic aorta (orange arrow). RVA, right vertebral artery.

above-mentioned branching patterns, other variant vertebral artery origin sites are exceedingly rare, especially those involving the RVA (<1%).[10-14]

In this case report, we present a 54-year-old male with an incidentally discovered aberrant RVA originating directly from the descending thoracic aorta, an anatomical variant that has only been documented twice within the literature, and the first case where there is a simultaneous aberrant LVA arising from the aortic arch.[15,16]

Case Presentation

Clinical Findings

A 54-year-old male with a history of human immunodeficiency virus, hypertension, and remote anterior cerebral artery aneurysm rupture status-post surgical clipping presented from a skilled nursing facility for altered mental status suspicious for relapse of toxoplasmosis encephalitis infection known from a prior admission. Emergency department computed tomography (CT) head without contrast demonstrated evolving right basal ganglia edema and increasing hydrocephalus necessitating a neurosurgery consultation for external ventricular drain placement evaluation.

Imaging Findings

A follow-up CT angiogram of the head and neck demonstrated an aberrant origin of the RVA taking off directly from the posteromedial aspect of the proximal descending thoracic aorta at the level of T3-T4 with a retroesophageal course distally. The aberrant RVA enters the right foramen transversarium of the C7 vertebral body, coalescing normally with the LVA for constitution of the basilar artery and posterior intracranial circulation (Figure 1-3). There was no hemodynamically significant flow-limiting stenoses or vascular calcifications along any portion of the aberrant RVA. No pathological consequences or sequelae were apparent.

Additionally, a simultaneous aberrant LVA was visualized arising directly from the aortic arch between the left common carotid artery and left subclavian artery on this CT angiogram as well (Figure 4A). Remaining origination of the brachiocephalic, left common carotid, and subclavian arteries were within normal anatomical limits (Figure 4B).

Discussion

Aberrant origin of either vertebral artery is uncommon, and aberrant RVA origination from any region other than the right common carotid artery is exceedingly rare.[1,10-13] In fact, there have been only 2 documented case reports of an RVA originating directly from the descending thoracic aorta and no documented cases of any patient with a simultaneous aberrant origin of the LVA arising from the aortic arch.[15,16]

Discovery of vertebral artery variants is often incidental on imaging, without acute symptomatic presentation. Although there are no generalizable pathologic predispositions for patients with vertebral artery anomalies, some variant anatomy relating to origin and course, kinking, pathological tortuosity, and aneurysmal formations can alter hemodynamic blood flow and predispose some patients to developing cerebrovascular events.[6,7] A previous comprehensive literature review revealed that although patients with aberrant vertebral artery origins were largely asymptomatic, 5.5% were associated with attributable neurological symptoms.[9] Additionally, this review revealed that 0.8% of patients with aberrant origin vertebral arteries demonstrated vertebral artery dissections.[9]

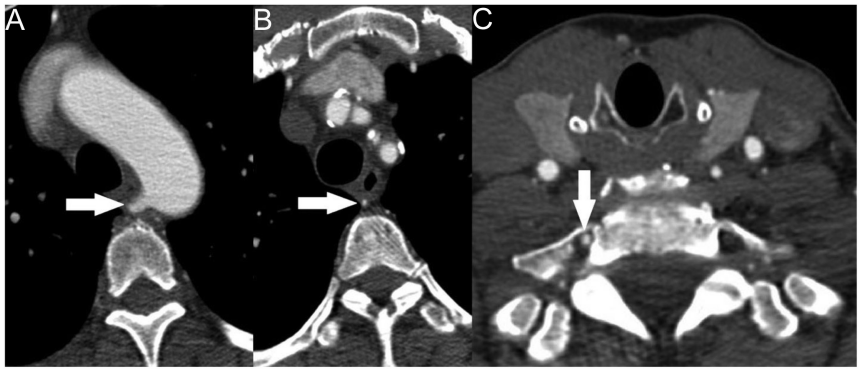

Figure 2. (A) Axial CTA images of upper thorax and neck demonstrate the aberrant RVA arising from the posteromedial aspect of proximal descending aorta at the level of T3-T4 with (B) a retroesophageal course and (C) entering the right foramen transversarium of the C7 vertebral body. RVA is denoted by a white arrow. RVA, right vertebral artery; CTA, computed tomography angiography.

Figure 3. Post-processed coronal view of the neck via vessel tracking algorithm depicts the entire course of the aberrant RVA which is unremarkably opacified. RVA, right vertebral artery.

Specific origination site of the artery itself may also lead to unique presentations on a case-by-case basis as well. For example, a Chinese study in 2015 demonstrated a statistically significant association between direct origin of the vertebral artery from the aortic arch and type B aortic dissections.[17] Hence, it is reasonable to infer that if our patient with the aberrant RVA takeoff from the descending thoracic aorta were to have presented with a type B aortic dissection, intracranial manifestations involving the posterior cerebral circulation may be the initial presenting symptom if the dissection extended to involve the origin of the aberrant RVA. In this case, it would be deft for the radiologist and clinician to have a higher index of suspicion for type B aortic dissection if conventional imaging of the head and neck were initially unrevealing.

Apart from the potential clinical presentations specific to aberrant RVA from the descending thoracic aorta, precautions for pre-surgical and pre-endovascular planning involving the head, neck, and chest should be mandatory. Knowledge of the above-described variant will significantly affect surgical and endovascular approach to management. This is of utmost importance to avoid accidental dissection and non-specific embolization of the RVA during endovascular interventions and to prevent arteriotomy, ligation, or other unintended RVA damage in any open surgical or video-assisted thoracoscopic approach.[1,12-14] Case reports of injury in patients with aberrant vertebral artery origins who had undergone corpectomy and anterior surgical approach to the cervical spine have been previously documented, with 1 instance leading to a fatal

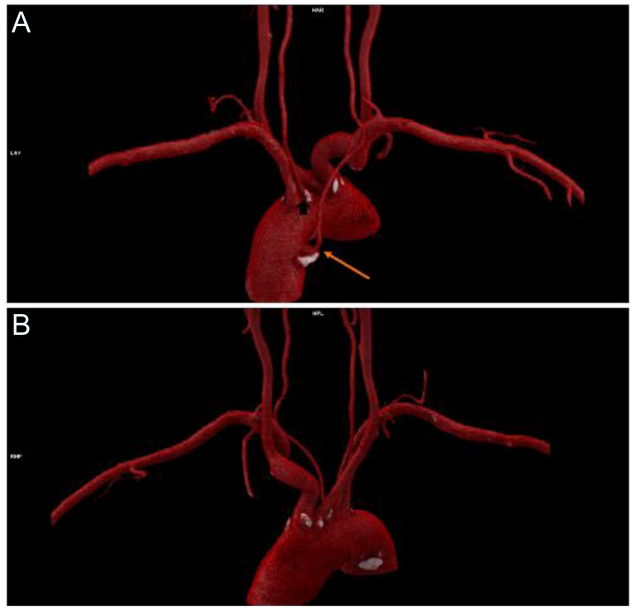

Figure 4. (A) Posterior view cinematic rendering of the aortic arch demonstrating RVA originating from the posterior aspect of the proximal descending thoracic aorta distal to the takeoff of the left subclavian artery (orange arrow) and the LVA arising directly from the aortic arch superior surface between the left common carotid and subclavian arteries (black arrowhead). (B) Anterior view cinematic rendering of the aortic arch demonstrating the normal anatomy of the brachiocephalic, left common carotid, and left subclavian artery origins. RVA, right vertebral artery; LVA, left vertebral artery.

subarachnoid hemorrhage.[18,19] In such cases, pre-interventional mapping with CT angiogram should be extended inferiorly to include the mid-chest until all intracranial artery origin points are clearly defined.

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