Isolated left vertebral artery and its consequences for aortic arch repair

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ABSTRACT

A left vertebral artery (LVA) originating directly from the aortic arch is the second most common supra-aortic branching anomaly. This isolated LVA can also terminate in the posterior inferior cerebellar artery without contributing to the circle of Willis, limiting treatment options, especially in cases with an incomplete circle. Here, we describe our consideration of the treatment options for a 79-year-old patient with a large distal aortic arch aneurysm combined with an isolated LVA and incomplete circle of Willis that may endanger adequate (intraoperative) cerebral perfusion. (J Vasc Surg Cases and Innovative Techniques 2019;5:369-71.)

Keywords: Aorta; Postdissection aneurysm; Left vertebral artery; Circle of Willis; Posterior inferior cerebellar artery

The supra-aortic vessels have several known branching patterns, such as a bovine trunk, in which the brachiocephalic trunk shares a common origin from the aortic arch with the left common carotid artery (LCCA), and an isolated left vertebral artery (LVA) originating directly from the aortic arch.[1,2] The continuation of the LVA may also vary, including hypoplasia or termination in the posterior inferior cerebellar artery (PICA) instead of merging with the basilar artery and hence contributing to the circle of Willis. A PICA termination is found in approximately one-third of all isolated LVA cases, risking posterior stroke when it is obstructed.[3] We describe our treatment considerations for an elderly patient with a large aortic arch aneurysm and an isolated LVA combined with an incomplete circle of Willis. The patient's relatives consented for publication.

CASE REPORT

A 79-year-old man with a symptomatic postdissection aneurysm of the distal aortic arch was transferred to our institution. The patient was known to have a Stanford type B aortic dissection (acute moment 15 years ago), hypercholesterolemia, and type 2 diabetes mellitus. The postdissection aneurysm had been stable for many years with adequate medical therapy but grew substantially during the last year, and the patient experienced pain between the shoulder blades with new-onset hypertension. The most recent computed tomography angiography study showed a 10-cm aneurysm, starting just distal from the left subclavian artery (LSA). In addition, an isolated LVA was noted proximal to the LSA (Fig 1). Magnetic resonance angiography performed to evaluate the continuation of the vertebral artery and cerebral vessels demonstrated an incomplete circle of Willis, with an absent right posterior communicating artery, hypoplastic left P1 and A1 segments, LVA terminating in the PICA, and regular-sized right vertebral artery (RVA) with a normal branching pattern (Fig 2). Endovascular treatment was excluded as an option because in addition to the LSA, the isolated LVA would need to be covered to gain a durable fixation of the stent graft, and obstruction of the LVA would risk cerebral malperfusion. Alternatively, aortic arch repair through a midsternal approach with frozen elephant trunk technique would also risk malperfusion of the cerebellum because the required selective cerebral perfusion of the small LVA would be challenging.

A final option consisted of the placement of an interposition graft through a left thoracotomy. The procedure was performed under general anesthesia with motor and somatosensory evoked potentials used for perioperative monitoring. The left lung was collapsed using a double-lumen endotracheal tube, and the aorta was exposed. Distal aortic perfusion was established by left-sided heart bypass, cannulating the left atrium as inflow and the left common femoral artery as outflow of the centrifugal pump. The proximal aorta was obliquely clamped just distal to the LVA, and the distal aorta was clamped at the level of the sixth thoracic vertebra. A Dacron aortic interposition graft of 28 mm was anastomosed from the distal aortic arch up to the fifth thoracic vertebra, using continuous Prolene 4-0 sutures supported with a felt strip. The left-sided heart bypass was disconnected, and the wound was closed over layers. The patient had an uneventful recovery and was transferred after 15 days. Computed tomography angiography 3 months postoperatively showed an uncomplicated repair (Fig 1).

DISCUSSION

Several variations are known in the branching pattern of supra-aortic branches. With an incidence of around 4%, an isolated LVA is the second most common

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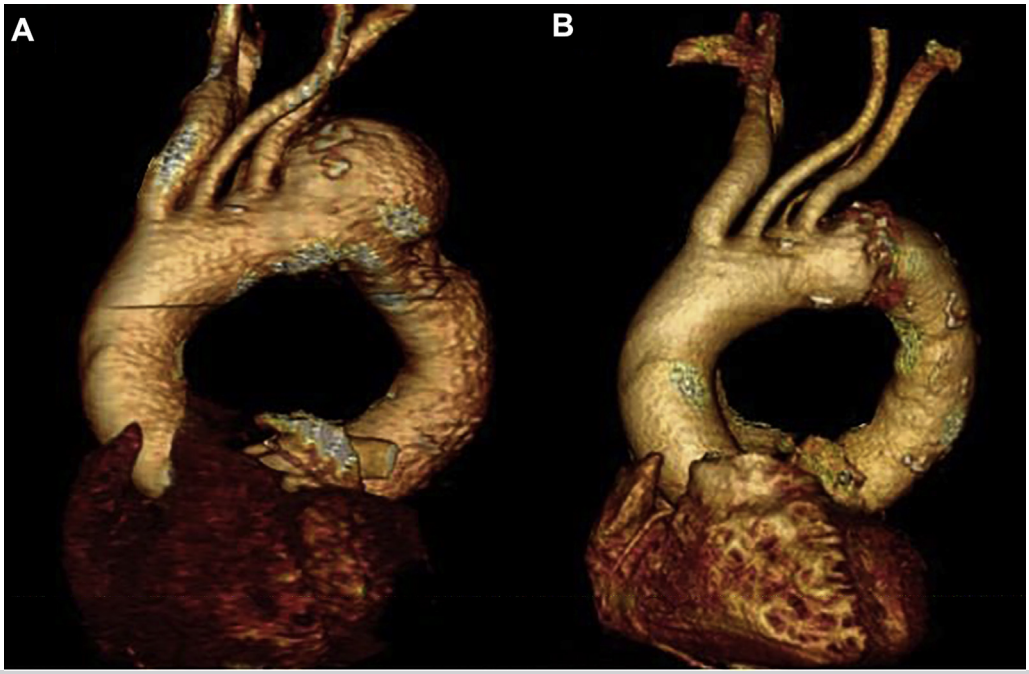

Fig 1. A, Three-dimensional reconstruction illustrating the anatomy with the isolated left vertebral artery (LVA) proximal to the left subclavian artery (LSA) and the aneurysm distally. **B,** Three-dimensional reconstruction 3 months after surgery with a satisfying result.

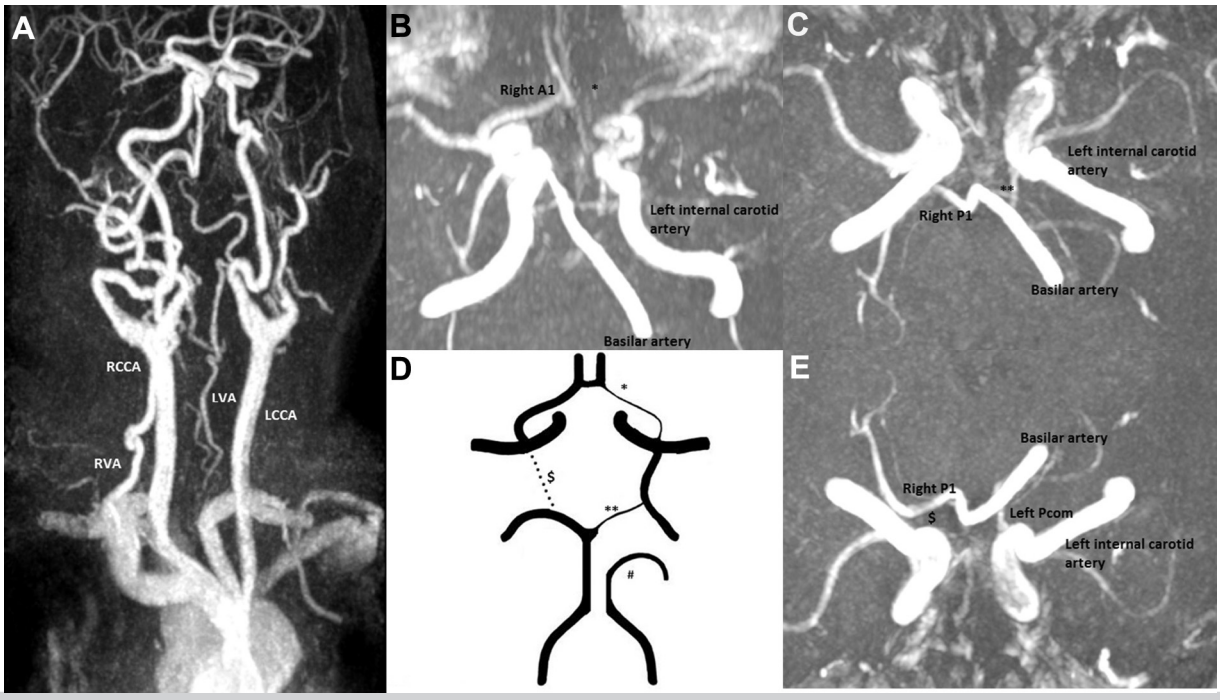

Fig 2. A, Magnetic resonance angiography image of the isolated left vertebral artery (*LVA*) originating from the aortic arch and continuing in the posterior inferior cerebellar artery (PICA) instead of merging with the right vertebral artery (*RVA*) and their relation with the left common carotid artery (*LCCA*) and right common carotid artery (*RCCA*). **B,** Proximal part of this patient's circle of Willis with an intact right A1 segment and the hypoplastic left A1 segment (*). **C,** Distal part of this patient's circle of Willis, with an intact right P1 branching from the basilar artery and hypoplastic left P1 (**). **D,** Scheme of this patient's circle of Willis displaying the LVA terminating in the PICA (#), the hypoplastic left P1 (**) and A1 segment (*), and the absent right posterior communicating segment ($). **E,** Part of the circle of Willis with an intact posterior communicating segment (*PCom*) from the left internal carotid artery and the absent right posterior communicating segment ($).

anomaly.[1,3] On encountering an isolated LVA, we routinely perform additional imaging to determine its termination before finally deciding on our treatment strategy because the LVA can terminate in the PICA, which occurs in 4.4% of the studied cases.[4] In the described case, endovascular treatment would have been preferred, considering the age of the patient. However, because of the short proximal neck, both the LSA and LVA would need to be covered to gain an adequate landing zone of the stent graft. First, acutely covering the LVA would lead to cerebellar malperfusion. Surgical revascularization is technically possible but also requires temporary obstruction of flow, risking stroke, and is complex because of the small size and its deep anatomic position (Fig 2, *A*). Second, the LSA would also need to be revascularized because no subclavian steal could be derived from the LVA, thereby risking left arm malperfusion. Surgical LSA revascularization would require temporary occlusion of the LCCA during anastomosis, risking left hemisphere malperfusion due to the absent right posterior communicating artery and hypoplastic left P1 and A1 segments (Fig 2, *B-E*). Alternatively, an LCCA shunt may be used, but this is technically hampered in the small arteriotomy.

Endovascular revascularization using a scallop or chimney was thought to risk a type IA endoleak due to the proximity of the aneurysm to the LSA or gutter formation, respectively,[5,6] excluding safe endovascular options for this patient. Next, open repair through a midsternal approach using a frozen elephant trunk technique was considered; this would require selective cerebral perfusion because deep hypothermic circulatory arrest alone would provide insufficient time for total aortic arch replacement. To avoid risking posterior stroke, the LVA (PICA) would need selective antegrade perfusion, potentially technically hampered by its small size. Finally, leaving an interposition graft through a left thoracotomy was a final treatment option for this patient.

The RVA may also be of importance when the LSA is covered by a stent graft. Hypoplasia of the RVA has been reported as a contraindication to coverage of the LSA during elective thoracic endovascular aortic repair.[7] In a postmortem study regarding the cerebral blood supply, hypoplasia of the RVA was found in 8.7% of autopsies,[8] risking posterior stroke when the LSA is simply occluded during thoracic endovascular aortic repair, particularly in incomplete posterior circle of Willis, which is found to exist in 56.5% of autopsies.[8]

An imaging study evaluating aortic arch anatomy showed the importance of being aware of the supra-aortic branching and circle of Willis variants in patients treated for thoracic aortic disease because they are significantly more common in these patients than in the overall population. LVA originating from the arch was found in 6.3% of the patients compared with 3.4% of the controls ($P < .001$).[2] Another study confirmed that the incidence of vertebral artery dissection is significantly higher in patients with an LVA originating from the arch.[9] A yet unknown association may exist between supra-aortic anomalies and thoracic aortic disease.

CONCLUSIONS

We describe our considerations in the treatment of an elderly patient with a large distal arch aneurysm, illustrating the importance of adequate preoperative imaging and careful weighing of potential consequences of intentional arterial occlusion by current endovascular, hybrid, or open repair options.

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