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Ipsilateral Subclavian Steal in Association with Aberrant Origin of the Left Vertebral Artery from the Aortic Arch

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Five cases are reported of left subclavian steal syndrome associated with anomalous origin of the left vertebral artery from the aortic arch. In all five instances blood flow at the origin of the left vertebral artery was in an antegrade direction contrary to that usually reported in this condition. The distal subclavian artery was supplied via an extensive collateral network of vessels connecting the vertebral artery to the thyrocervical trunk.

If a significant stenosis or occlusion is present within the left subclavian artery proximal to the origin of the left vertebral artery, the direction of the blood flow within the vertebral artery will reverse toward the parent vessel (retrograde flow). This phenomenon occurs when a negative pressure gradient of 20–40 torr exists between the vertebral-basilar artery junction and the vertebral-subclavian artery junction [1–3].

We describe five cases of subclavian steal confirmed by angiography where a significant stenosis or occlusion of the left subclavian artery was demonstrated in association with anomalous origin of the left vertebral artery directly from the aortic arch. In all five cases blood flow at the origin of the left vertebral artery was in an antegrade direction contrary to that more commonly reported in the subclavian steal syndrome.

Materials and Methods

The five patients were all 44–58-year-old men. Three sought medical attention for symptoms specifically related to the left arm. In the other two cases, the presence of subclavian steal was found during a workup for generalized vascular disease. In the four cases where Doppler indices were performed, a blood pressure differential of 20 mm Hg or more was present between the two arms. All five patients underwent arch aortography. In four cases a high grade stenosis of the left subclavian artery was found while in the fifth case the subclavian artery was occluded. The left vertebral artery arose directly from the aortic arch in all five instances (figs. 1A and 2A). In all five patients, an extensive collateral network of vessels joined the vertebral artery to the thyrocervical trunk (figs. 1B and 2B). Contrast medium (and presumably blood) was carried via the collateral network from the left vertebral artery to the thyrocervical trunk and then to the subclavian artery distal to the obstructing lesion. In all cases the left vertebral artery was visualized distal to the area of anastomoses and supplied blood to the basilar circulation although the caliber of the vessel diminished beyond the anastomoses.

All five patients had extensive extracranial vascular disease involving the carotid arteries as well as in the subclavian artery. In four cases bypass procedures were recommended. In three instances a left carotid–left subclavian bypass shunt was accomplished without incident. In the fourth case, the patient suffered an untoward incident during his left carotid endarterectomy so that his remaining surgery was deferred (table 1).

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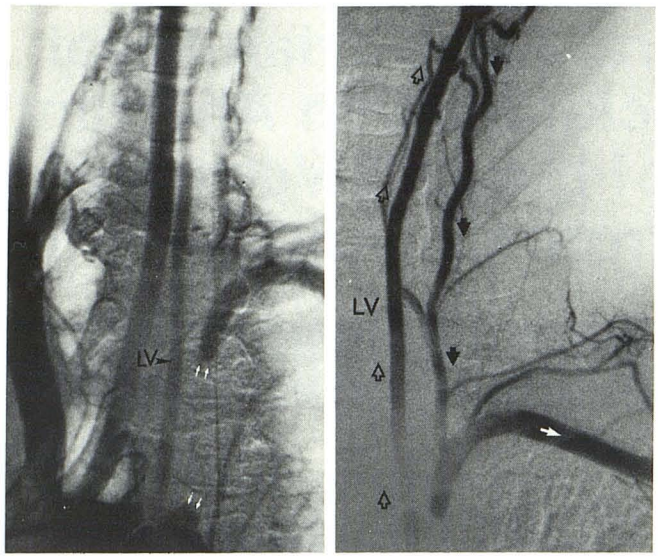

Fig. 1.—Case 1, 44-year-old man with 3 year history of tingling, numbness, and weakness with exertion of left arm. **A**, Aortic arch injection. Total occlusion of left subclavian at origin (*arrowheads*). Left vertebral artery (LV) arises from aortic arch. **B**, Selective left vertebral angiogram (*open arrows*). Filling of distal subclavian artery via extensive collateral network from vertebral artery to thyrocervical trunk (*closed arrows*).

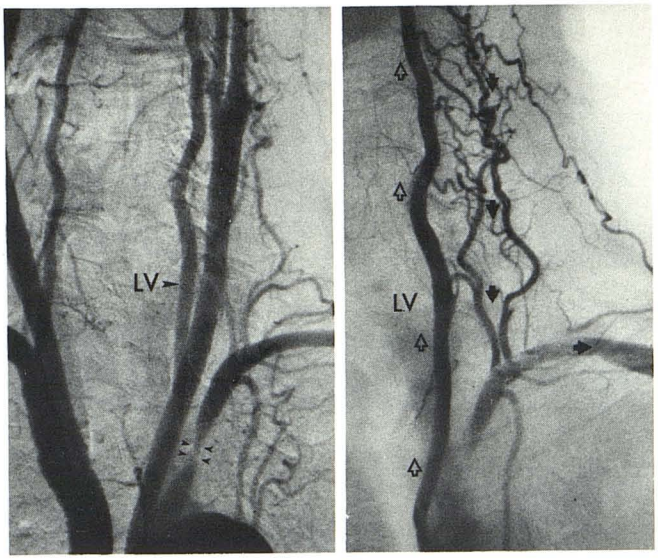

Fig. 2.—Case 2, 51-year-old man with syncope and blurring of vision. **A**, Aortic arch study. High grade stenosis of proximal left subclavian artery (*small arrowheads*). Left vertebral artery (LV) arises directly from aortic arch (its origin is obscured by overlying left carotid artery). **B**, Selective left vertebral angiogram (*open arrows*). Filling of distal subclavian artery via collateral flow from vertebral artery to thyrocervical trunk (*closed arrows*).

Discussion

The most common cause of the subclavian steal syndrome is a large atherosclerotic plaque partly or totally occluding the lumen of that artery [4]. Other causes include Takayasu arteritis, cervical spondylosis, traumatic occlusion, or aortitis [5–7]. Congenital causes include aortic arch hypoplasia, coarctation, or interruption and right aortic arch anomalies, usually with subclavian atresia [8]. Subclavian steal may also occur following a Blalock-Taussig shunt or repair of an aortic coarctation [9].

In 1967 Mueller and Hinck [10] described one patient with bilateral subclavian artery obstruction occurring distal to the origin of the vertebral arteries. Both vertebral arteries supplied blood flow to their respective arms via extensive collateral vessels to the thyrocervical trunks. The authors appropriately entitled this the *thyrocervical steal.*

Bloch et al. [11] described one patient who required a ligation of the right subclavian artery distal to the origin of the vertebral artery following a gunshot wound to the right axilla. Blood was "stolen" from the right vertebral artery to supply the arm via muscular collaterals to the ascending and deep cervical arteries. Kobinia et al. [12] refer to occlusion of the subclavian artery distal to the origin of the vertebral artery as a *type two subclavian artery lesion.* In one such case blood was drained from the vertebral artery to supply the homolateral arm. The patient did not have any neurologic symptoms presumably due to the large afferent vertebral artery.

Origin of the left vertebral artery from the aortic arch is a congenital anomaly said to occur in 2.4%–5.8% of cases [13]. While the exact incidence of the subclavian steal is unknown, involvement of the subclavian artery in patients with extracranial cerebrovascular disease is uncommon. Of 6,534 patients admitted to the joint study of cerebrovascular insufficiency due to extracranial vascular occlusive disease only 168 (2.5%) fulfilled the criteria of subclavian steal [14]. In view of these uncommon sets of circumstances it is not surprising that subclavian steal associated with anomalous origin of the left vertebral artery has not been previously reported. Why it should have occurred in five patients seen at our institutions within a 2 year period is unknown.

In these patients the rich collateral network of collateral vessels between the vertebral artery and the thyrocervical trunk provide the main pathway circumventing the subclavian lesion. This is type 1B of the *cervical arterial collateral network* of Bosniak [15]. While additional collateral vessels originating from the external carotid artery supply significant amounts of blood to the arm, the vertebral-thyrocervical trunk pathway dominated in our cases.

Arch aortography will demonstrate the anomalous origin of the left vertebral artery. Close inspection of the early arterial radiographs is necessary to properly evaluate the altered anatomy. The origin of the left vertebral artery may be obscured by the cervical spine or the overlying left carotid artery. Subtraction prints are helpful. In those instances where the subclavian artery is not occluded, contrast will flow into the distal subclavian artery from two directions (fig. 1B).

Selective injection of the anomalous vertebral artery will show the extensive collateral network between the vertebral artery and the thyrocervical trunk. Selective injection of the other neck vessels should be done to exclude other foci of cerebrovascular disease. These vessels will often provide additional collateral flow to the distal subclavian artery.

TABLE 1: **Subclavian Steal: Summary of Cases**

Case No.	Age (years)	Signs and Symptoms	Doppler Blood Pressure (mm Hg)	Angiographic Findings	Surgery/Outcome
1	44	3 year history tingling, numbness, and weakness with exertion of left arm	Right, 120; left, 70	Total occlusion left subclavian artery; left vertebral artery arises from aortic arch; distal left subclavian artery fills via collateral flow through thyrocervical trunk	Left carotid–left subclavian bypass Good
2	51	8 month history of back pain, intermittent claudication, syncope, blurring of vision	Right, 120; left 100	90% stenosis left subclavian artery; left vertebral artery arises from aortic arch; distal left subclavian artery fills via collateral flow through thyrocervical trunk	No surgery
3	58	Intermittent left arm claudication and dizziness, left subclavian and left carotid bruit	Right, 175; left, 105	High grade long segment stenosis left subclavian artery; left vertebral artery arises from aortic arch; collateral flow to distal left subclavian artery via thyrocervical trunk; ulcerated plaque left carotid artery	Left carotid endarterectomy; left carotid–left subclavian bypass Good
4	52	Dizziness and arm claudication	Right, 120; left, 94	Tight stenosis proximal left subclavian artery; left vertebral artery arises from aortic arch; collateral flow to distal subclavian artery via thyrocervical trunk	Left carotid–left subclavian bypass Good
5	52	Amaurosis fugax, weakness and numbness right arm and face; left carotid bruit	Not done	Short segment tight stenosis origin left subclavian artery; left vertebral artery arises from aortic arch; 80% stenosis right carotid artery, ulcerated plaque left carotid artery, collateral flow to distal left subclavian artery via thyrocervical trunk	Left carotid endarterectomy Poor

Note.—All the patients were men.

The arm dysfunction seen with the subclavian steal syndrome results from decreased perfusion of the extremity. The neurologic dysfunction occasionally also present usually results from the extensive cerebrovascular disease involving the carotid circulation as well as the vertebrobasilar system. If blood flow is diverted from the basilar artery in sufficient quantities, both arm and neurologic symptoms can occur. Usually these symptoms are seen in patients in whom the blood flow at the origin of the vertebral artery has been reversed due to a significant lesion in the subclavian artery proximal to the origin of the vertebral artery.

Our cases suggest that it is not the direction of the blood flow in the vertebral artery per se that determines if a subclavian steal is to occur, but rather the amount of blood that is left to supply the basilar artery and its tributaries once the steal has occurred. Even though the left vertebral artery arose directly from the aortic arch and the blood flow was normally antegrade, enough blood was diverted to the subclavian artery from the anomalous left vertebral artery via the extensive collateral network in the neck for the steal syndrome to occur. In most patients with the subclavian steal syndrome it is the contralateral vertebral artery that supplies the blood stolen from the basilar artery. In the cases reported here it is the ipsilateral vertebral artery that does the stealing, hence the name *ipsilateral subclavian steal*.

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