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Case Review

Subclavian steal syndrome: a case report and review of advances in diagnostic and treatment approaches☆,☆☆,★

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ABSTRACT

Using recently developed diagnostic and treatment methods, we successfully diagnosed and treated a case of subclavian steal syndrome. Syncope and left upper arm weakness suggested ischemia of the cerebral and left upper arm circulation. Volume-plethysmographic blood pressure measurements clarified the differences between the upper arms simultaneously. A high-resolution Doppler instrument revealed a retrograde left vertebral artery waveform, indicating subclavian steal syndrome. Aortography demonstrated proximal left subclavian artery occlusion. The patient was treated with stent implantation via a femoral approach using the latest equipment. Advances in diagnostic and treatment approaches for this syndrome are reviewed in connection with this case.

Summary: We present a case of subclavian steal syndrome successfully diagnosed using the latest technology and treated with stent implantation. The syndrome and its treatment are reviewed.

1. Introduction

Subclavian steal syndrome, first reported by Contomi and then by Reivich [1,2], is a phenomenon involving flow reversal in a branch of the subclavian artery that results from a hemodynamically significant ipsilateral occlusion or marked stenosis of the proximal subclavian artery. In this disorder, termed subclavian steal syndrome by Fisher, blood siphons from the contralateral vertebral artery into the opposite vertebral artery, thus "stealing" blood from the basilar artery [3]. Subclavian stenosis, however, is most often asymptomatic and does not require specific therapy, other than that directed at the underlying etiology [4,5]. In some patients, subclavian steal syndrome can present with symptoms of arterial insufficiency afflicting the brain, typically manifesting as transient brain ischemia [5]. Precise determination of blood pressure (BP) differences between the arms and retrograde flow in the vertebral artery is essential for diagnosing subclavian syndrome [6,7]. Finally, aortography is used to confirm subclavian artery steal syndrome. Previously, percutaneous angioplasty with a balloon catheter was used to relieve the subclavian artery stenosis [8,9]. Because of the limitations of this technique, currently stent implantation is typically used to treat the subclavian stenosis [10]. Herein, we report a case of subclavian steal syndrome diagnosed and treated successfully using recently developed diagnostic tools and treatment devices. Furthermore, a mini-review of subclavian syndrome and the recent advances in its diagnosis and treatment is provided.

2. Case Presentation

A 68-year-old man was admitted with complaints of repeated syncope lasting several seconds, dizziness when tilting his head back, and numbness in the left upper arm while working. On admission, his height and weight were 172 cm and 79 kg, respectively. Bradycardia was not observed, with a heart rate of 78 beats/min. His BP in the left arm was 87/59 mmHg. He was alert without symptoms on admission, and a neurological examination showed no abnormalities. Physical examination of the heart and lungs did not show any abnormal findings. A 12-lead electrocardiogram (ECG) presented Q waves in leads II, III, aVF, and V5-6, without ST segment elevation. Laboratory tests showed elevated serum creatinine, elevated triglycerides, and slight anemia, without creatinine kinase elevation. Two-dimensional echocardiography revealed slight left ventricular dilatation and hypokinesis of the intraventricular septum and left ventricular apex with preserved total left ventricular contraction. Brain computed tomography did not show any abnormal findings.

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Because of the low BP in the left arm, the BP was measured simultaneously and precisely in both arms and both legs using a volume-plethysmographic pressure analytical apparatus (Forum BP-203RPEIII, Omron Colin Co. Ltd, Tokyo, Japan), and differences in BP between the right (160/87 mmHg) and left (137/85 mmHg) arms were revealed. In addition, low BP in the lower extremities was observed (Table 1).

The flow velocities of the carotid and vertebral arteries were measured automatically using a high-resolution angle-independent Doppler system with a multifrequency transducer (4–7 MHz) (Aplio ™, Toshiba Medical Systems Corp., Tokyo, Japan) with the appropriate size transducer. After gray-scale and color Doppler imaging of the carotid and vertebral arteries, representative Doppler spectral waveforms were obtained in the common carotid artery, internal carotid artery, and vertebral arteries. Sampling the vertebral arteries was performed in the mid portion of the extracranial segment of the artery. The measured angle of intonation was less than 60°. ECG tracings were synchronized with the pulsed and the adverse current flow in the left vertebral artery (Fig. 1, Table 1), which demonstrated the subclavian steal phenomenon. An aortogram demonstrated occlusion of the proximal left subclavian artery (Fig. 2). A coronary arteriogram revealed obstruction of the right coronary artery.

We revascularized the occlusion site of the subclavian artery via a femoral approach (Fig. 3). We did not utilize distal protection of the vertebral artery, because retrograde flow of the vertebral artery was confirmed [9]. First, for advancing the catheter, a 45 cm long 8 French vascular introduction sheath (Super Arrow-Flex Sheath™, Teleflex Medical Japan, Ltd., Tokyo) was used to cross the severely crooked external iliac artery. A 90 cm long 6 French guiding sheath (Flexor Ansel™, Cook Japan, Co. Ltd., Tokyo) was introduced into the proximal left subclavian artery lesion. Through the inner lumen of this Flexor Ansel guiding sheath, a 6 French JR4 coronary catheter (Brite Tip™, Cordis, Johnson & Johnson, New Brunswick, NJ) was introduced at the proximal left subclavian artery and a 0.035-inch guidewire (Radifocus, TERUMO Corporation, Tokyo, Japan) crossed the occlusion site. Next, the JR4 coronary catheter was advanced to the distal lesion of the stenosis, guided by the guidewire. Next, the guidewire was exchanged for a 0.018-inch wire (Truefinder super hard™, Zeon Medical Inc., Tokyo, Japan). The JR4 catheter was removed. A 3 mm diameter, 20 mm long balloon (Jackal™, KANEKA Medix, Osaka, Japan) was advanced along with the 0.018-inch guidewire, and predilation of the stenosis was performed. After predilation, crossing the stenosis with an 8 mm diameter, 27 mm long balloon-expandable stent (Express™, Vascular LD Peripheral Stent System™, Boston Scientific Japan, Tokyo, Japan) was attempted and resulted in failure. Predilation with a larger balloon, which was 6 mm in diameter and 20 mm long (Jackal™), was performed again. Using the JR4 catheter, the 0.018-inch guidewire was exchanged for a 0.035-inch guidewire (Radifocus, TERUMO) and the stent was successfully positioned at the stenosis lesion. After stent implantation, considerable luminal diameter loss was observed. We inflated the stent using an inflation pressure of 14 atm. Finally, the stenosis was relieved to an acceptable extent.

After stenting, the patient's symptoms were completely diminished with no difference in BP between the left and right arms.

Subsequently, he underwent coronary bypass grafting to treat three-vessel coronary artery disease with angina symptoms. The origin of the left internal mammary artery was located distal to the implanted stent, and the possibility of stent restenosis could not be completely eliminated. If the left internal mammary artery were grafted to the coronary artery, it is possible that coronary-subclavian steal syndrome may arise through the left internal mammary artery graft if restenosis occurred [11,12]. Therefore, the right internal mammary artery was used as the main graft to the left anterior descending coronary artery. In addition, an aortocoronary saphenous vein graft to the right coronary artery bypass was performed. The left internal mammary artery was isolated free from the left subclavian artery and used for a free graft bypass from a saphenous vein graft (end-to-side anastomosis) to the left circumflex coronary artery.

Furthermore, femoro-popliteal bypass was performed due to stenosis of the arteries in the lower extremities during the several months after subclavian artery stenting.

3. Discussion and Mini-Review

We reported a case of subclavian steal syndrome in association with generalized arteriosclerosis that presented with syncope, dizziness when tilting the head back, and numbness in the left-upper arm while working. The patient was diagnosed using recently developed advanced diagnostic tools and successfully treated using improved revascularization methods and devices.

3.1. Criteria

The criteria for subclavian steal syndrome are 1) evidence of subclavian or innominate artery occlusion or marked stenosis, 2) retrograde vertebral flow, and 3) patency of both vertebral and the basilar arteries [5]. The present case fulfilled these criteria.

3.2. Symptoms

In a study examining 1114 patients with subclavian artery or innominate artery occlusion demonstrated by arteriography, only 168 patients (15%) met the criteria for subclavian steal syndrome stated above [5]. Among the patients who met the criteria, 95% (159 patients) had symptoms and 18% (30 patients) presented syncope. The most common symptom was vertigo, and syncope was less common. Another study of 500 patients with asymptomatic neck bruits found that 9% of patients (45/500) had severe subclavian stenosis, and 64% of these (32/45) had a positive subclavian steal test [4]. No patients had symptoms as a result

Table 1
Doppler measurements and plethysmographic measurements of blood pressure.

Doppler measurements	Common carotid artery		Internal carotid artery		Vertebral artery	
	Right	Left	Right	Left	Right	Left
Systole (cm/sec)	63	64	40	49	32	−37
Diastole (cm/sec)	12	11	13	17	8	−6
mean (cm/sec)	21	24	22	24	16	−11

Plethysmographic measurements of blood pressure	Brachial blood pressure		Ankle blood pressure	
	Right	Left	Right	Left
Systolic/Diastolic (mmHg)	160/87	137/85	47/19	111/27
Mean (mmHg)	115	99	31	59

Note that a negative number indicates reversal flow in Doppler measurements. ICA, internal carotid artery; CCA, common carotid artery.