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Subclavian Steal Syndrome Detected with Duplex Pulsed Doppler Sonography

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In the evaluation of the extracranial carotid circulation for occlusive disease, duplex sonography was used routinely to determine the direction of flow in the vertebral arteries. Of 600 patients examined, 15 were found to have reversed flow in a vertebral artery—the subclavian steal syndrome. This was confirmed in the seven patients who underwent angiography. Duplex sonography was found to be a rapid, safe, accurate method for recognizing unsuspected or confirming clinically suspected subclavian steal syndrome.

Duplex sonography recently has become increasingly popular as a noninvasive method for evaluating carotid occlusive disease. Duplex sonography combines high-resolution real-time imaging and pulsed Doppler flow measurements in one system. Since symptoms from carotid artery insufficiency and subclavian steal syndrome (vertebrobasilar insufficiency) may be similar [1, 2], we have included both vertebral arteries and carotid arteries in our sonographic examinations. To our knowledge, there has been no previous report of subclavian steal using duplex sonography, although Doppler ultrasound as a single method has been described [3, 4]. Observations in three patients are presented.

Subjects

Over a 5 month period, we studied about 600 patients for suspected carotid occlusive disease; 15 patients were diagnosed as having subclavian steal syndrome. Duplex sonography was performed using a Diasonics small-parts Doppler system which contains a 7.5 MHz real-time imaging transducer and a 3.0 MHz pulsed Doppler transducer.

With the duplex scanner the vertebral arteries are easily identified and a Doppler signal readily obtained. When there is normal antegrade flow through the vertebral artery, the analogue display graph will show a velocity waveform that lies above the baseline and peaks upward during systole (fig. 1). If flow is reversed as in subclavian steal syndrome, the velocity waveform will peak downward below the horizontal axis of the graph (fig. 2A).

Results

Of the 15 patients shown to have reversal of vertebral artery flow characteristic of the subclavian steal syndrome, seven had angiographic confirmation. The other eight patients have not had angiograms since they were not surgical candidates, either because of coexisting severe medical problems or being relatively asymptomatic. In eight of the 15 patients, the diagnosis was unsuspected; in the other seven, it was clinically suspected.

Case Reports

Case 1

A 38-year-old woman had a 6 month history of intermittent visual problems and occasional syncope. The only abnormal physical finding was a nonpalpable left

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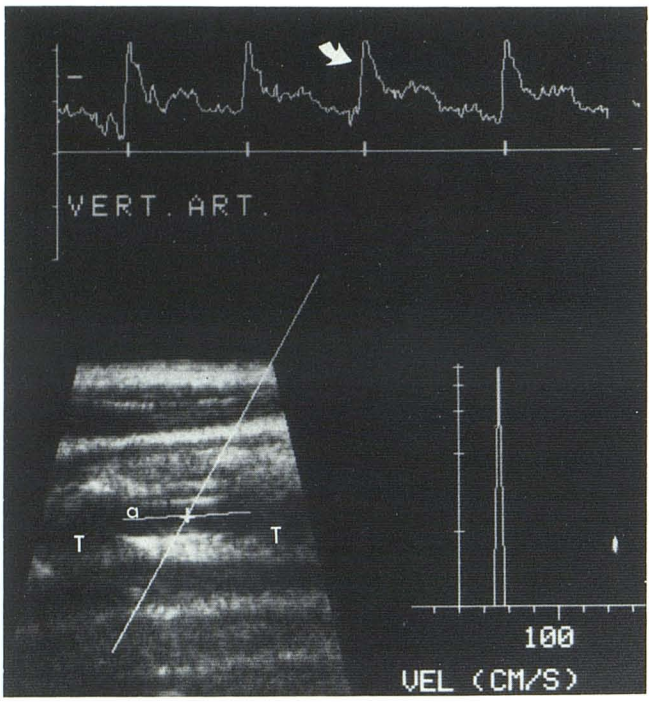

Fig. 1.—Duplex pulsed Doppler ultrasound display. Sagittal image through normal vertebral artery (a) with site of Doppler sampling indicated by cross lines (*lower left*). Waveform (*top line*) demonstrates upward deflection (*arrow*) indicating normal antegrade flow. Graph (*lower right*) shows peak velocity flow of 40 cm/sec through vertebral artery. T = shadowing produced by transverse processes of cervical vertebra through which artery courses (patient's head always to left).

radial pulse. Subclavian steal syndrome was considered. The Doppler signal from the left vertebral artery showed reversal of a normal waveform indicating retrograde flow. Angiography revealed a high-grade stenosis of the proximal left subclavian artery with reversal of flow through the left vertebral filling the distal subclavian artery (fig. 2).

Case 2

A 57-year-old woman was admitted with acute onset of epigastric and midthoracic pain and a 4 month history of postprandial abdominal pain. She denied any neurologic complaints or other symptoms. The only physical finding was a possible bruit in the upper midabdomen. Aortography showed complete occlusion of the left subclavian artery with an associated subclavian steal and a high-grade stenosis of the superior mesenteric artery. Subsequent duplex sonography also demonstrated retrograde flow through the left vertebral artery (fig. 3).

Case 3

A 58-year-old man with a 1 year history of dizziness and progressive angina was thought to have a right carotid bruit. The patient denied other significant symptomatology and no other abnormal physical findings were recorded. To evaluate the possibility of carotid occlusive disease, he was initially referred for duplex carotid sonography. The study revealed a hemodynamically significant stenosis of the left internal carotid artery at the bifurcation. Additional evaluation of the vertebral arteries showed reversal of flow through the right vertebral artery (fig. 4). Angiography verified the left internal carotid stenosis and demonstrated a severe stenosis at the origin of the right subclavian artery with subclavian steal.

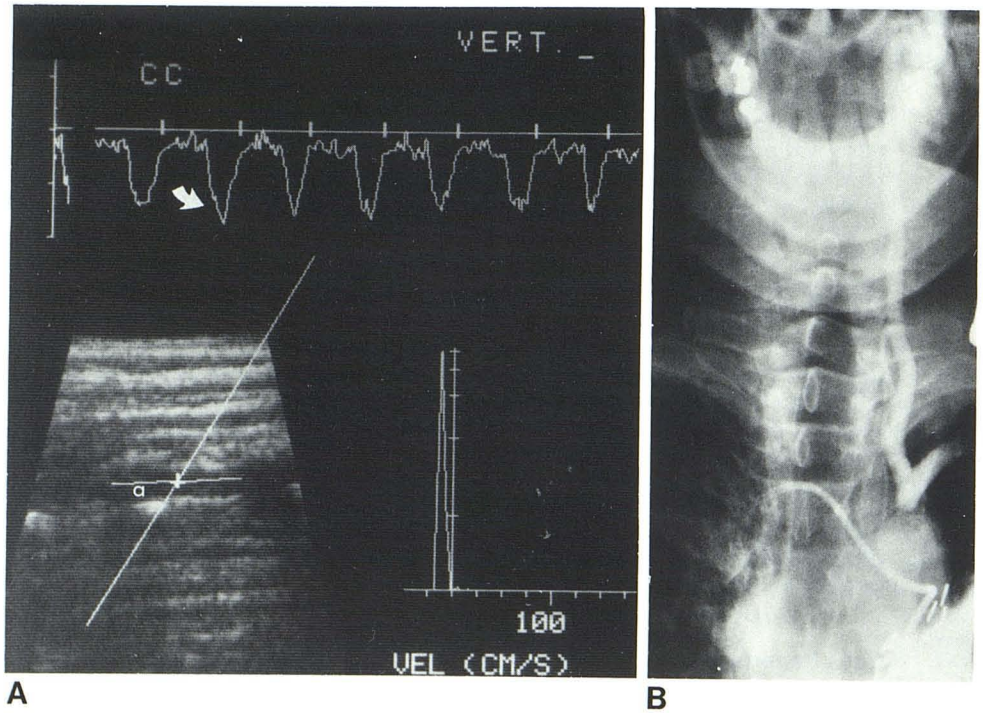

Fig. 2.—Case 1. **A**, Velocity curve (*top line*) demonstrates downward deflection (*arrow*) during systole indicating reversal of flow through vertebral artery (a). Graph (*lower right*) shows peak velocity of 15 cm/sec and reversal of flow as peak lies on negative X-axis. **B**, After selective injection into innominate artery there is retrograde flow down left vertebral artery during late venous phase, filling left subclavian artery.

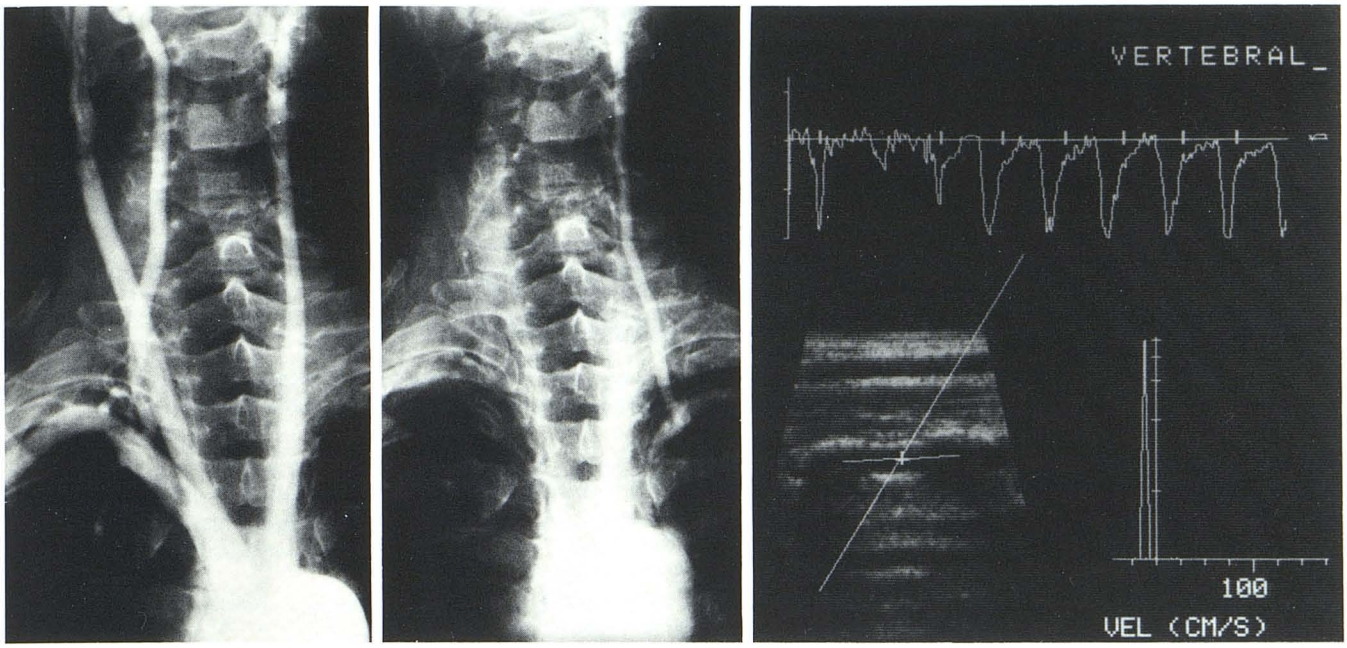

Fig. 3.—Case 2. **A**, Arch aortogram. Complete occlusion at origin of left subclavian artery. **B**, Later phase. Filling of left subclavian artery via left vertebral artery. **C**, Duplex display. Downward peak of velocity curve (*top line*) characteristic of subclavian steal.

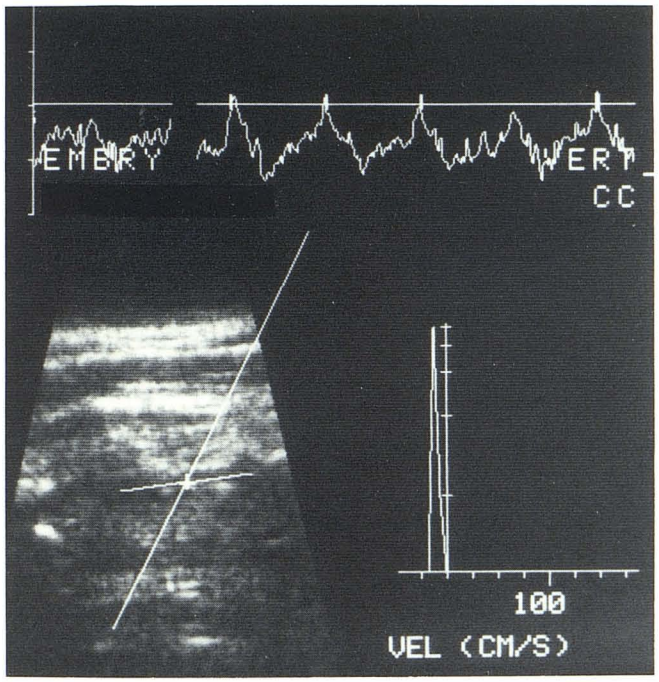

Fig. 4.—Case 3. Duplex display of right vertebral artery. Reversal of normal waveform indicating subclavian steal.

Discussion

The subclavian steal syndrome may occur after occlusion of the innominate or proximal subclavian artery from any cause, most commonly by atherosclerotic plaque. Other causes include Takayasu arteritis, posttraumatic, congenital as with interruption of the aortic arch proximal to the subclavian artery, tumor thrombus or encasement, or after surgical procedures such as the Blalock-Taussig anastomosis [5–7].

Previous investigators have shown that subclavian steal syndrome accounts for about 4% of all cerebral vascular disease and about 17% of all extracranial cerebrovascular disease. Men are affected twice as often as women. The mean age is 52 years, and left-sided occlusions predominate (2:1) [8–10].

Generally this condition is characterized by neurologic symptoms of vertebrobasilar insufficiency (vertigo, syncope, ataxia, diplopia, hemiparesis) as blood is siphoned from the cerebral circulation in a retrograde direction down the vertebral artery to the ipsilateral subclavian artery. Physical findings are diminished or absent radial pulse, and a blood pressure differential of at least 20 mm Hg between both arms. Symptoms involving the affected arm consist of claudication, fatigability, and paresthesias [11].

Patients can have a variety of symptoms varying in severity and not always conforming to the conventional description of the syndrome. One reason is that often there is coexisting carotid occlusive disease. One series found that of patients with subclavian steal syndrome, 80% had other associated extracranial arterial disease; 61% were internal carotid stenoses [12]. Also the ischemic effects from the subclavian steal may not only affect the posterior fossa circulation but also the carotid arterial territories from a siphonage effect via the Circle of Willis. It is possible that patients with hemodynamically significant carotid stenosis are at greater risk for stroke if coexisting subclavian steal is present.

Because of the varied symptomatology in patients with cerebrovascular disease, we believe routine examination of both vertebral arteries using duplex sonography is justified when evaluating the carotid arteries for occlusive disease. This usually adds only 5–10 min to the examination.

The diagnosis of subclavian steal syndrome using duplex sonography is generally rapid and easily determined. The vertebral artery is readily identified in most individuals unless it is congenitally very small or occluded. A potential pitfall is to mistake a vertebral vein signal for a retrograde artery signal since the normal venous flow is toward the heart. This distinction is usually easily made, as the arterial signal is pulsatile while the venous signal is phasic or varies with respiration (fig. 5). The vetebral vein is often imaged lying just anterior to the vertebral artery and is usually the smaller of the two vessels. Rarely a vertebral venous Doppler signal will show pulsatile features which can be differentiated from a retrograde arterial signal by comparison with the internal jugular vein. If the waveform and sound are similar to the internal jugular vein, the signal is venous. In addition, the venous signal can be altered by having the patient peform the Valsalva maneuver.

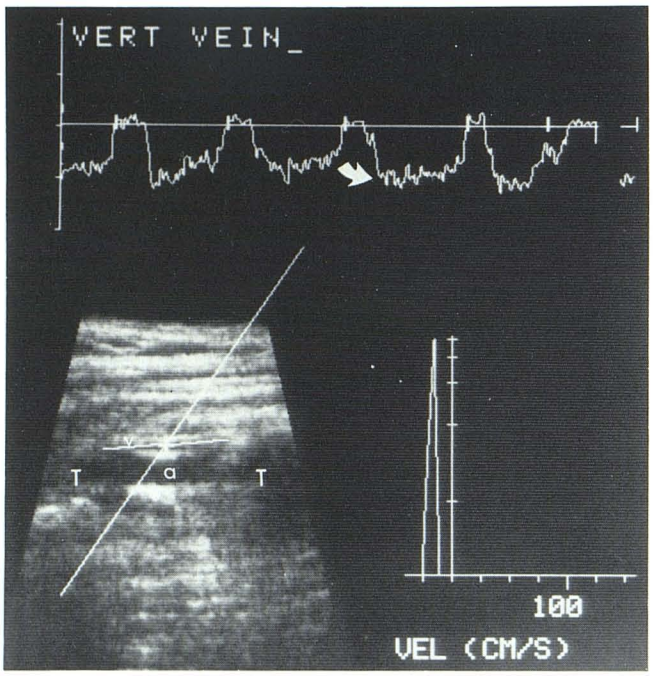

Fig. 5.—Sagittal image through vertebral artery (a) and vertebral vein (v) coursing through cervical transverse processes (T). Doppler signal (*crossed lines*) in vein shows normal reversal of flow but phasic waveform (*arrow*).

Using this technique for identifying subclavian steal, we have not had any false positive studies in the patients studied angiographically. Angiography is required, of course, to precisely localize and characterize the site of obstruction, especially if surgical therapy is indicated.

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