The Use of Transthoracic Echocardiography in Diagnosing Brachiocephalic-Subclavian Artery Stenosis

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INTRODUCTION

Subclavian artery stenosis is commonly caused by atherosclerotic disease. Clinical manifestations include ipsilateral arm claudication, arm numbness, vertebrobasilar symptoms, and cardiac ischemia secondary to coronary steal in patients with left internal mammary artery bypass graft. Diagnosis has been traditionally made using duplex ultrasound and confirmed using computed tomography or magnetic resonance imaging (MRI). However, echocardiography can be useful in detecting ostial and proximal brachiocephalic, left subclavian, and left carotid disease, although this utility has been underappreciated. We present the case of a female patient with a history of right arm numbness and dizziness with recent unremarkable carotid arterial Doppler findings who was diagnosed with right brachiocephalic arterial stenosis incidentally found on transthoracic echocardiography.

CASE PRESENTATION

The patient was a 65-year-old woman with a medical history of diabetes mellitus, hypertension, hyperlipidemia, mild aortic valve stenosis with mean and peak gradients of 12 and 20 mm Hg, respectively, and also a history of significant peripheral vascular disease with a history of right carotid endarterectomy in June 2012, transaortic endarterectomy of the right and left renal arteries in the mesenteric artery region, and left venous-to-femoral arterial bypass in 2007. She presented to the cardiology clinic for a follow-up appointment regarding management of her hypertension and valvular heart disease and modification of her cardiovascular risk factors. It was noted that the patient’s systolic blood pressure measured in the left forearm was higher than that on the right side by a difference of 40 mm Hg. The patient at that time denied any right upper extremity claudication, dizziness, or lightheadedness. Vascular surgery consultation was obtained and conservative management was recommended due to the fact that the patient was asymptomatic and it was felt that no further testing was necessary.

Six months later, the patient was seen by the cardiologist with symptoms of right arm pain and lightheadedness. Because of the patient’s reported lightheadedness, transthoracic echocardiography was performed to assess for any progression of her aortic valve stenosis. Transthoracic echocardiography revealed normal left ventricular ejection fraction, mildly thickened left ventricular walls, grade 2 diastolic dysfunction, and mild aortic valve stenosis with mean and peak gradients of 12 and 20 mm Hg, respectively. The view of the aortic arch as seen at the suprasternal notch view on echocardiography is shown in Figures 1 and 2, and a schematic diagram is also shown in Figure 3; the first branch of the aortic arch on the left is the brachiocephalic artery, followed by the second branch, which is the left common carotid artery, followed by the third branch on the right, which is the left subclavian artery. In our patient, there was turbulent flow and severe ostial plaque and narrowing at the first branch off the aorta (brachiocephalic) when imaged from the suprasternal view (Figures 1 and 2, Videos 1 and 2).

An unexpected high gradient was also found along the beam of the continuous-wave transducer placed at the suprasternal notch. A Pedoff transducer was used to record a peak velocity of 4.6 m/sec and a peak gradient of 85 mm Hg, suggesting the presence of severe stenosis along the brachiocephalic trunk (Figures 4 and 5). Vascular reconsultation was obtained because of these findings, and computed tomography was performed for confirmation. Computed tomographic (CT) angiography showed severe calcified plaque within the origin of the brachiocephalic artery as well as additional stenosis within the subclavian artery (Figures 6–10).

Previously, the patient underwent carotid duplex ultrasound that demonstrated retrograde flow in the right vertebral artery suggestive of possible subclavian artery stenosis. On the basis of these findings and the patient’s symptoms, the decision was made to proceed with diagnostic angiography and percutaneous revascularization to treat her brachiocephalic and subclavian artery occlusive disease.

Invasive angiography was performed and showed no flow refluxing beyond the brachiocephalic artery into the thoracic aorta (Figure 11). Severe calcification was noted in this same position. This was indicative of 100% occlusion of the brachiocephalic artery. Pressure measurement was taken, and a >50 mm Hg gradient was obtained across the ostium of the brachiocephalic artery. Balloon angioplasty across the brachiocephalic artery was then performed, and an 8 × 30 mm balloon-expandable stent was deployed. The sheath was then pulled back into the subclavian artery beyond its origin, and angiography demonstrated additional 60% stenosis in the subclavian artery distal to the vertebral takeoff. The pressure gradient measured across this distal subclavian artery demonstrated a 25 mm Hg gradient. This lesion was then treated with a 6 × 40 mm self-expanding stent. Postprocedural angiography demonstrated an excellent result, with no evidence of any residual stenosis. Repeat echocardiography showed resolution of the increased gradient across the ostium.
The prevalence of brachiocephalic or subclavian artery stenosis is about 0.8%–1.9% in the general population and up to 8.5% in patients with coronary artery disease. Atherosclerotic disease of the supra-aortic trunk vessels, including the innominate artery, subclavian artery, and the common carotid artery, tends to present either as a low-flow state distal to the lesion or as embolic events. A typical of the brachiocephalic artery in the suprasternal position (Figures 12–14, Videos 3–5).

The patient was seen in the cardiology clinic 4 months after the percutaneous intervention and was doing well, with complete resolution of her right arm pain and dizziness.

**DISCUSSION**

The prevalence of brachiocephalic or subclavian artery stenosis is about 0.8%–1.9% in the general population and up to 8.5% in patients with coronary artery disease. Atherosclerotic disease of the supra-aortic trunk vessels, including the innominate artery, subclavian artery, and the common carotid artery, tends to present either as a low-flow state distal to the lesion or as embolic events. A typical
A brachial blood pressure difference of >20 mm Hg between the upper extremities raises initial suspicion of subclavian stenosis. Most cases of subclavian stenosis are asymptomatic and rarely require intervention. Indications for treatment include clinical symptoms of stroke, transient ischemic attacks, subclavian steal syndrome, vertebrobasilar insufficiency, and upper extremity ischemia. Diagnosis is usually made by duplex sonography and confirmed by CT or magnetic resonance angiography, particularly in cases in which the origin or a portion of the subclavian artery cannot be assessed because of its location when it is posterior to the clavicle. Duplex sonography has been found to have low sensitivity and low positive predictive value in diagnosing brachiocephalic disease, possibly because of a limited sonographic window, as the origin of the brachiocephalic artery arises deep in the intrathoracic cavity. Although computed tomography and magnetic resonance have better accuracy, they have limitations. Accurate imaging of the subclavian artery with magnetic resonance angiography can be limited by the very short circulation time, resulting in venous contamination. The development of multi-detector row CT scanners and the use of 64-slice CT angiography, in addition to the availability of three-dimensional workstations, have resulted in incremental increases in volume coverage and spatial and temporal resolution, as well as a reduction in acquisition time to just a few seconds. However, despite the advances in

Figure 6 Computed tomography showing significant calcification (arrow) at the ostium (arrow) of the brachiocephalic artery.

Figure 7 Computed tomography coronal view showing significant calcification (arrow) at the ostium of the brachiocephalic artery.

Figure 8 Computed tomography volume-rendered image from a posterior approach showing calcification of the aortic arch and severe calcification (arrow) of the ostial and proximal brachiocephalic trunk.

Figure 9 Computed tomography volume-rendered images showing severe calcification (arrow) of the ostial and proximal brachiocephalic trunk.
technology, dye exposure and motion-created artifacts remain significant limitations.

Conventional contrast arteriography is the gold standard in confirming the diagnosis of subclavian occlusive disease, with treatment planned at the time of diagnostic evaluation. However, it is an invasive procedure and carries risks for potential embolic complications during catheter manipulation, as well as contrast-induced nephropathy and vascular access complications. In the literature, there are many angiographic studies of innominate artery occlusion, but reports describing

Figure 10 Computed tomography three-dimensional volume-rendered image showing calcification of the brachiocephalic trunk (arrow) before the bifurcation as well as calcification of the right internal carotid. The view of the ostial brachiocephalic lesion is obstructed by the clavicle.

Figure 11 Angiogram showing deployment of a balloon self-expanding stent in the brachiocephalic artery, with residual 60% stenosis at the origin of the right subclavian artery (vertical arrow).

Figure 12 Post-intervention two-dimensional transthoracic echocardiogram suprasternal view showing no narrowing of the ostium of the brachiocephalic trunk (arrow), suggesting resolution of the stenosis in this area.

Figure 13 Post-intervention color Doppler image of the two-dimensional transthoracic suprasternal view showing laminar flow (arrow) at the ostium brachiocephalic trunk, which is suggestive of normal flow velocity across the brachiocephalic trunk and resolution of the stenosis in this area.

Figure 14 Pulsed wave Doppler in the suprasternal transthoracic echo view showing a normal gradient after surgery with resolution of the high gradient across the ostium of the brachiocephalic artery, suggesting resolution of the stenosis in this area.
Doppler sonographic findings are rare.\(^7\) In this case, we demonstrate the role of transthoracic echocardiography in diagnosing ostial brachiocephalic disease using a phased-array transducer (2–5 MHz) placed at the suprasternal notch along the long-axis view of the aorta.\(^8\) The usual anatomy of the aortic arch vessels begins from left to right, with the brachiocephalic trunk as the first branch, followed by the left common carotid artery, and then the left subclavian artery on the right (Figure 3). In our case, there was a good correlation between echocardiography, CT angiography, and arterial angiography. Unfortunately, transthoracic echocardiography is underappreciated as a potential tool in diagnosing ostial brachiocephalic disease. Combining carotid duplex ultrasound with the suprasternal transthoracic echocardiographic views increases sensitivity and specificity by increasing the depth of view.

**CONCLUSIONS**

Assessment of the great vessels in the suprasternal view on transthoracic echocardiography can be challenging. However, it is important to view the great vessels in the transthoracic suprasternal notch echocardiographic window to avoid missing the diagnosis of significant stenosis in these vessels.

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**SUPPLEMENTARY DATA**

Supplementary data related to this article can be found at https://doi.org/10.1016/j.case.2017.10.008.

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