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Validation of subclavian duplex velocity criteria to grade severity of subclavian artery stenosis

Albeir Y. Mousa, MD,[a] Ramez Morkous, MD,[b] Mike Broce, BA,[b] Michael Yacoub, MD,[a] Andrew Sticco, MD,[a] Ravi Viradia, MD,[a] Mark C. Bates, MD,[a] *and* Ali F. AbuRahma, MD,[a] *Charleston, WVa*

ABSTRACT

Background: Validation of subclavian duplex ultrasound velocity criteria (SDUS VC) to grade the severity of subclavian artery stenosis has not been established or systematically studied. Currently, there is a paucity of published literature and lack of practitioner consensus for how subclavian duplex velocity findings should be interpreted in patients with subclavian artery stenosis.

Objective: The objective of the present study was to validate SDUS measurements using subclavian conventional or computed tomography angiogram (subclavian angiogram [SA])-derived measurements. Secondary objectives included measuring the correlation between SDUS peak systolic velocities and SA measurements, and to determine the optimal cutoff value for predicting significant stenosis (>70%).

Methods: This is a retrospective review of all patients with suspected subclavian artery stenosis and a convenience sample of carotid artery patients who underwent SDUS and SA from May 1999 to July 2013. SA reference vessel and intralesion minimal lumen diameters were measured and compared with SDUS velocities obtained within 3 months of the imaging study. Percent stenosis was calculated using the North American Symptomatic Carotid Endarterectomy Trial method for detecting stenosis in a sufficiently large cohort. Receiver operating characteristic curves was generated for SDUS VC to predict >70% stenosis. Velocity cutoff points were determined with equal weighting of sensitivity and specificity.

Results: We examined 268 arteries for 177 patients. The majority of the arteries were for female patients (52.5%) with a mean age of 66.7 ± 11.1 years. Twenty-three arteries had retrograde vertebral artery flow and excluded from further analysis. For the remaining 245 arteries, the average peak systolic velocity was 212.6 ± 110.7 cm/s, with a range of 45-626 cm/s. Average stenosis was 25.8% ± 28.2%, with a range of 0% to 100%. Following receiver operating characteristic analysis, we found a cutoff value of >240 cm/s to be most predictive of >70%. Area under the curve was 0.94 with 95% confidence intervals of 0.91 to 0.97. The sensitivity and specificity for predicting >70% stenosis was 90.9 and 82.5%, respectively.

Conclusions: In patients with known or suspected disease involving the great vessels, a subclavian artery flow velocity exceeding 240 cm/s seems to be predictive of significant subclavian stenosis. Thus, we propose new SDUS VC, for predicting subclavian artery stenosis. However, because of the use of a convenience sample, it is possible that the current proposed cutoff point might need to be adjusted for other populations. (J Vasc Surg 2017;■:1-7.)

Left subclavian and brachiocephalic arteries are the critical sources of blood flow for arm circulation.[1] Atherosclerotic subclavian occlusive disease is mainly asymptomatic secondary to significant collateral circulation, but in subset group of patients, symptoms may occur. Symptoms are mainly related to posterior cerebral circulation arterial insufficiency (subclavian steal syndrome [SSS]),[2] arm claudication, inadequate flow reserve for arteriovenous dialysis conduits, or coronary angina inpatient with internal mammary coronary bypass graft (coronary-subclavian steal).[3] In the case of subclavian disease it is often direct or indirect reduction of flow to the target organ that causes symptoms, unlike symptomatic carotid occlusive disease, which is mainly secondary to atheroembolic disease.

Atherosclerosis is the main etiology for subclavian stenosis; however, other nonatherosclerotic causes such as large cell arteritis, thoracic outlet syndrome, and radiation arteritis do occur.[4]

One study reported a prevalence of subclavian stenosis of 1.5% in patients with no underlying peripheral arterial disease, 4.3% in hypertensive patients, 4.3% in patients with a history of smoking, 6.8% in patients with diabetes mellitus, 7.6% in patients with cerebrovascular disease,

From the Department of Surgery, Robert C. Byrd Health Sciences Center, West Virginia University, Charleston Area Medical Center, Vascular Center of Excellence[a]; and the Center for Health Services and Outcomes Research, Charleston Area Medical Center Health Education and Research Institute.[b]

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Correspondence: Albeir Y. Mousa, MD, Robert C. Byrd Health Sciences Center, West Virginia University, Charleston Area Medical Center, Vascular Center of Excellence, 3110 MacCorkle Ave, SE, Charleston, WV (e-mail: amousa@hsc.wvu.edu).

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and 11.5% in patients with peripheral arterial disease.[5] Another report indicated subclavian stenosis of ≥50% stenosis may occur up to 19% in patients with peripheral vascular disease.[6] However, higher high-density lipoprotein has been inversely correlated with incidence of subclavian stenosis.[7]

Clinicians rely mainly on blood pressure difference between the two arms, with significant subclavian stenosis defined as ≥15 mm Hg inter-arm pressure difference.[7] The same study reported that significant subclavian stenosis is present in approximately 2% of the free-living population and 7% of the clinical vascular patient population.[7]

Presently, there is no current consensus to validate subclavian duplex ultrasound velocity criteria (SDUS VC) for the grade or severity of subclavian artery stenosis. The paucity of published literature and lack of consensus among practitioners for what SDUS VC should be considered when evaluating subclavian artery stenosis motivated the authors to address this question.

METHODS

This was a retrospective review of subclavian arteries of patients with suspected/treated subclavian artery stenosis, contralateral arteries of patients with suspected/treated subclavian artery stenosis, and a convenience sample of subclavian arteries from carotid artery patients who underwent SDUS and subclavian angiogram (SA) (conventional or computed tomography angiogram) from May 1999 to July 2013 (Fig 1). Indications for subclavian interventions included vertebrobasilar insufficiency secondary to subclavian steal, upper extremity discomfort that limits daily activity, angina pectoris associated with coronary steal syndrome, and compromised inflow in patient with arteriovenous fistulae. The study was approved by our governing Institutional Review Board and conducted in accordance with the Health Insurance Portability and Accountability Act requirements and the prevailing ethical principles governing research. The Institutional Review Board waived informed consent because of the retrospective study design. Vessel diameters were measured by SA, and corresponding SDUS velocities were recorded. Percent stenosis was calculated using the North American Symptomatic Carotid Endarterectomy Trial (NASCET) method for detecting stenosis in a sufficiently large cohort. Multiple respected radiologic studies[8,9] have used NASCET criteria to evaluate arch vessels stenosis. In the current study, all vertebral arteries originated from subclavian arteries. All subclavian arteries with both measurements (peak systolic velocity [PSV] measured by duplex ultrasound and percent stenosis measured by angiogram) were included. However, subclavian arteries with retrograde vertebral flow, where the PSVs were often unmeasurable or nonexistent were excluded from further analysis.

ARTICLE HIGHLIGHTS

- **Significance:** This article reports ultrasound criteria to detect subclavian artery obstruction.
- **Type of Research:** Retrospective cohort study
- **Take Home Message:** Peak systolic velocity of >240 cm/s in the subclavian artery had a good sensitivity to detect >70% stenosis
- **Recommendation:** It is suggested that ultrasound has high sensitivity for detecting subclavian artery stenosis compared with angiography.
- **Strength of Recommendation:** 2. Weak
- **Level of Evidence:** C. Low or very low

Definitions. Hypertension is defined as >140 mm Hg systolic blood pressure and >90 mm Hg diastolic blood pressure. Patients with peripheral vascular disease are patients with leg claudication (ankle brachial index <0.9 in patients without diabetes) or compromised flow on the arterial Doppler waveforms (in patients with diabetes).

Subclavian stenosis is the severity of area reduction as determined by NACSET criteria. SSS is severe subclavian stenosis with retrograde flow through vertebral artery. SSS is categorized as either complete (ie, retrograde vertebral artery flow throughout cardiac cycle) or partial (ie, retrograde vertebral artery flow during systole and cephalad flow during diastole).[10] Symptomatic SSS includes posterior cerebral insufficiency, arm ischemia, and possible coronary artery symptoms if patient has a history of coronary artery bypass graft.

SDUS. All studies were done in an Intersocietal Accreditation Commission laboratory, by a registered vascular technologist. All studies were part of our formal carotid duplex and extracranial carotid artery imaging protocol. PSV measurements were obtained for our entire cohort following a standard protocol. Examinations were performed using Philips (Koninkijke Philips N.V., Amsterdam, The Netherlands). The angle between the ultrasound beam and the direction of blood flow was maintained at ≤60°. A linear-array transducer of 5 MHz was used. Three essential components were reported for each subclavian artery (PSV, direction of vertebral blood flow, and change in wave form from triphasic to biphasic or monophasic). In SDUS three waveforms may be encountered. In normal arteries, there is a triphasic wave: rapid systolic anterograde flux, short retrograde flux in early diastole, and slow anterograde flux in late diastole. When stenosis is encountered, the wave becomes biphasic, losing its diastolic components and systolic anterograde flow is followed by Doppler-silence during diastole. In severe stenosis, the wave becomes monophasic: rapid anterograde flow during systole and slow anterograde flow during diastole, usually with low velocities, turbulence, and rounded peaks.