Manifestations of Cardiac Disease in Carotid Duplex Ultrasound Examination

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CAROTID DUPLEX ULTRASOUND (CDUS), COMBINING GRAY-SCALE (B MODE) AND COLOR
and spectral (pulsed-wave) Doppler, has become the modality of choice for the initial evaluation and
surveillance of extracranial carotid artery disease, with a reported accuracy for the detection of carotid
stenosis exceeding 90% (1).

The assessment of carotid artery stenosis severity using CDUS is largely dependent on the pattern and
velocities of blood flow within the carotid arteries, with the peak systolic velocity (PSV) in the internal
carotid artery generally serving as the primary diagnostic parameter. There are a number of cardiac
disorders that can affect flow velocities and Doppler waveforms within the cerebrovasculature. It is
important to recognize these disorders for multiple reasons, including the potential to inaccurately
diagnose carotid artery stenosis. In addition, as CDUS may be obtained for the evaluation of nonspecific
symptoms, such as dizziness or syncope, it may be possible to identify clues to the presence of a cardiac
etiology through careful assessment of the Doppler waveforms. The sonographic clues on a CDUS
examination that suggest an underlying cardiac disorder include abnormal spectral Doppler waveform
morphology, waveform abnormality in multiple vessels (e.g., common/internal carotid and vertebral
arteries), waveform abnormality bilaterally, and unusually low or high velocities in the absence of sig-
ficant vascular lesions on color and/or gray-scale imaging.

We present a series of cases demonstrating classic CDUS manifestations of common cardiac disorders
(Figs. 1 to 3) (1,2).

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Figure 1. Normal Carotid Duplex Ultrasound Examination

A normal common carotid artery (CCA) spectral Doppler waveform (A) has a sharp systolic increase with flow throughout diastole (low-resistance waveform) due to a preponderance of carotid flow entering the ICA (internal carotid artery). Transient early diastolic flow reversal may be seen in proximal to mid CCA. (B) The ICA Doppler waveform demonstrates significant continuous forward flow throughout diastole. There is normal, laminar flow without spectral broadening, and the peak systolic velocity is typically <100 cm/s. (C) In contrast, the Doppler waveform of the external carotid artery (ECA) has a sharp systolic increase, rapid decrease in flow toward baseline, and minimal (if any) sustained diastolic flow. Transient flow reversal in early diastole is common. This pattern of flow is characteristic of blood supply to high-resistance vascular beds, such as the limbs or the osseous and muscular structures of the head and neck. The temporal tap maneuver (arrow) produces ECA waveform oscillations during manual tapping of a branch of the superficial temporal artery near the temple and aids in the accurate identification of the ECA. (D) The Doppler waveform of the cervical vertebral artery typically has an appearance similar to that of the ICA with a low resistance pattern and sustained diastolic flow. There are areas of drop out in B mode due to acoustic shadowing from the cervical spine. ORG = origin.
Figure 3. Low Cardiac Output, Intra-Aortic Balloon Pump, and Left Ventricular Assist Device

(A) Low cardiac output. Doppler waveforms demonstrate unusually low peak systolic velocity, but have preserved upstroke. These findings suggest a low cardiac output state. In this particular case, the patient had dilated cardiomyopathy with a left ventricular ejection fraction <20%. In the setting of low cardiac output, caution is advised when using standard velocity criteria for the assessment of ICA stenosis. In such cases, use of the velocity ratio (i.e., the ICA/CCA peak systolic velocity ratio) is likely more accurate than absolute velocities for determination of severity of stenosis.

(B) Intra-aortic balloon pump. Doppler waveforms obtained from a patient undergoing treatment with an intra-aortic balloon pump (IABP) at a 1:1 setting. As expected, IABP-assisted waveforms have 2 systolic peaks for each pulse, the first reflecting intrinsic left ventricular contraction and the second due to balloon inflation. End-diastolic velocity cannot be determined in the setting of an IABP. Flow reversal is commonly seen after the second (augmented) peak reflecting balloon deflation. For more accurate measurement of carotid velocities, one should turn off the IABP while insonating the vessels. If this is not possible, velocity from the first (nonaugmented) peak should be used as the peak systolic velocity.

(C) Left ventricular assist device (LVAD). Doppler waveforms from a patient with advanced cardiomyopathy and a functional LVAD demonstrate low-velocity flow with delayed upstroke and loss of pulsatility. Carotid Doppler waveform morphology among patients with LVADs is variable and highly dependent on pump settings. In this particular case, continuous arterial flow likely reflects a higher pump rate. Abbreviations as in Figure 1.
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REFERENCES
