PHILIPS

Ultrasound

Clinical case study

Diagnosis and management of carotid atherosclerosis with 3D duplex ultrasonography

Background

Carotid artery atherosclerosis or stenosis is frequently present at the carotid bifurcation or the internal carotid artery, accounting for at least 20% of all ischemic strokes.[1] Plaque formation can develop from a relatively benign collection of activated macrophages, to atheroma – an abnormal mass of fatty or lipid material with a fibrous covering. This progresses to a fibroatheroma with a defined lipid necrotic core and a fibrous cap. Such a complicated lesion is the perfect setting for initiation of thrombosis[2] and possible subsequent stroke.

While the percentage of strokes attributed to carotid disease is relatively low, the overall social and economic burden is high. It is therefore important to identify and manage carotid atherosclerosis with the aim of stroke prevention.

Role of ultrasound role in diagnosis and management

For decades diagnostic imaging has played a central role in the clinical management of patients with carotid atherosclerosis. With the advent of vascular ultrasound in the 1980s, it became possible to identify atheroma in the carotid bifurcation noninvasively. In 1999 the North American Symptomatic Carotid Endarterectomy Trial (NASCET) reported a clear surgical benefit in patients with ≥70% stenosis. As a result of the trial, it was determined that the utility of carotid duplex ultrasonography (CDU) could be increased by redefining thresholds to identify patients (asymptomatic or symptomatic) with ≥70% stenosis.

In 2003, the Society of Radiologists in Ultrasound (SRU) consensus developed recommendations for the diagnosis and stratification of internal carotid artery stenosis. These formal recommendations identify criteria from normal to total occlusion, with "≥70% ICA stenosis but less than near occlusion" as the point at which intervention may be required. This identified more specifically as:

- ICA PSV is >230 cm/sec and visible plaque and luminal narrowing are seen at gray-scale and color Doppler ultrasound (the higher the Doppler parameters lie above the threshold of 230 cm/sec, the greater the likelihood of severe disease)
- Additional criteria include ICA/CCA PSV ratio >4 and ICA EDV >100 cm/sec[3]

Today, ultrasound assessment of carotid arterial atherosclerotic disease has become the first choice for carotid artery stenosis screening, permitting the evaluation of both the macroscopic appearance of plaques as well as flow characteristics in the carotid artery.[3] Traditionally, patients are selected for intervention based on their clinical presentation and the degree of luminal narrowing in the internal carotid artery. Modern management also includes an individualized assessment of risk and takes into account intracerebral perfusion and plaque morphology.

CDU in the ED and beyond

In general, the diagnostic studies performed when a patient presents to the ED with TIA or stroke include magnetic resonance imaging (MRI) with diffusion weighted imaging or MR angiography of the head and neck to identify areas of ischemia that confirm stroke. A non-enhanced CT, perfusion CT, and/or CT angiography examination can also play a key role in diagnosis.

Duplex ultrasound is an excellent correlative imaging modality in the ED because it is relatively inexpensive compared with MRA or CT and can be conducted quickly and easily. Carotid artery duplex sonography and/or transcranial Doppler may be used to determine whether a carotid lesion or extracranial source is responsible for symptoms.[4]

Different degrees of carotid stenosis progress at different rates and therefore patients should be followed at different intervals and examined regularly. Whether a patient has been treated for TIA, acute stroke or is simply being observed over time for stenosis <70%, carotid duplex ultrasonography is considered the management modality of choice.

Patient presentation

Asymptomatic Carotid Atherosclerosis	Symptomatic Carotid Atherosclerosis
Nonqualified (Nonspecific) Symptoms: • Dizziness • Generalized subjective weakness • Syncope or near-syncope episodes • "Blurry vision," or transient positive visual phenomena (such as "floaters" or "stars")	Qualified (Specific) Symptoms: • Ipsilateral amaurosis fugax • Contralateral weakness or numbness of an arm, a leg, or the face • Visual field defect, dysarthria, and, in the case of dominant (usually left) hemisphere involvement, aphasia

Following are two case studies for patients admitted to the ED at Miami Cardiac & Vascular Institute at Baptist Hospital of Miami. Ultrasonography studies were conducted using the Philips XL14-3 xMATRIX linear array transducer on a Philips EPIQ Elite premium ultrasound system.

Case study #1

Patient history:

Presented as asymptomatic for carotid atherosclerosis:

- 63 year-old male
- Controlled diabetes and hypertension
- Two episodes of syncope and near-syncope
- No cervical bruit on physical examination

Recommendation:

3D Carotid duplex ultrasonography was ordered.
No other diagnostic testing was performed.

Findings:

Conventional imaging findings:

- No hemodynamically significant internal carotid artery stenosis by conventional Duplex Ultrasonography

	Right	Left	Unit
Prox ICA PSV	50.8	43.6	cm/sec
Prox ICA EDV	11.3	7.9	cm/sec
Mid ICA PSV	89.5	78	cm/sec
Mid ICA EDV	20.5	17.2	cm/sec
Dist ICA PSV	65.5	79.5	cm/sec
Dist ICA EDV	13.4	17.6	cm/sec
Dist CCA PSV	70.5	54.1	cm/sec
Prox ECA PSV	55.6	38.4	cm/sec
Vertebral A PSV	42.3	35.0	cm/sec
ICA/CCA ratio	0.72	0.81	

Doppler results: no hemodynamically significant findings.

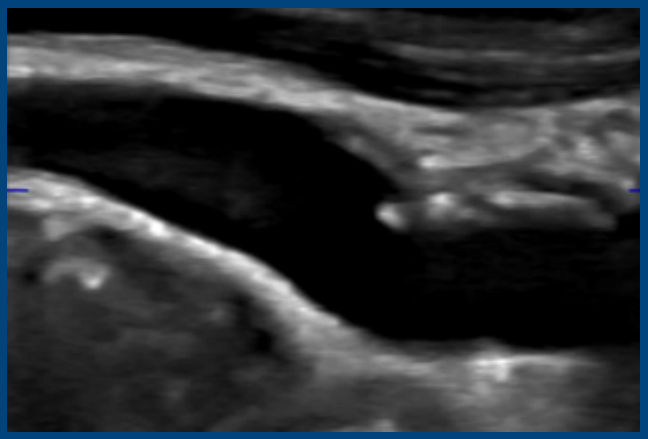
3D imaging findings:

- 3D imaging demonstrated more morphologically significant internal carotid artery atherosclerosis, and due to this, more aggressive medical therapy was suggested

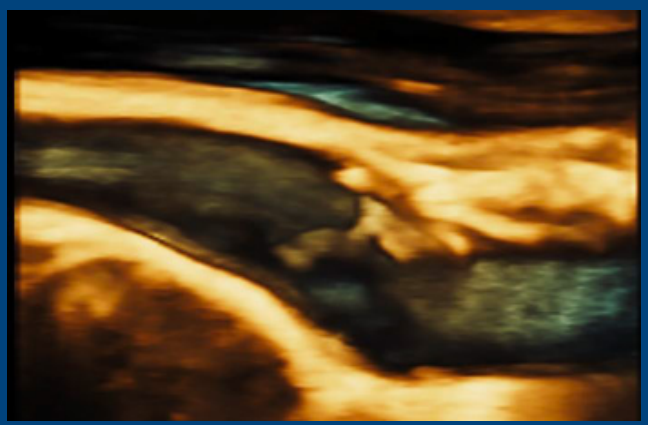
Patient disease management:

The patient was instructed to maintain the following regimen:

- Maintain BP below 130/80 mmHg
- Statin -maintain LDL to less than 70 mg/dL
- Aspirin combined with clopidogrel (Plavix)
- Diabetes –A1C below 7.0%



2D image of plaque using XL14-3 xMATRIX transducer.



3D half-volume image of plaque using XL14-3 xMATRIX transducer.

Case study #2

Patient history:

Presented as symptomatic for carotid atherosclerosis:

- 67 year-old female
- Uncontrolled hypertension
- Left eye amaurosis fugax
- Transient right arm and leg weakness and numbness

Recommendation:

A non-contrast CT and 3D Carotid Duplex Ultrasonography were ordered.

Findings:

Conventional imaging findings:

- The CT results were negative

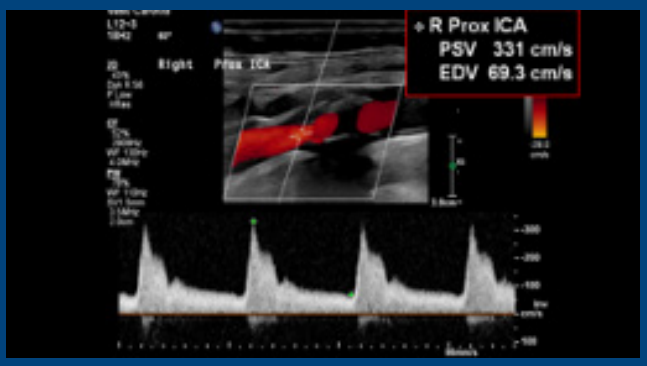
3D Carotid duplex ultrasound findings:

- 3D/4D and iSlice imaging (transforming 3D data into multiple slices) as well as vessel cast demonstrated right ICA morphologically and hemodynamically significant internal carotid artery atherosclerosis

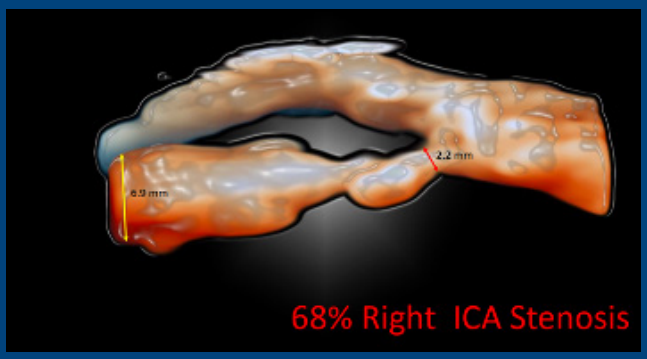
Patient disease management:

The patient was treated in the following manner:

- Patient was immediately placed on statin and aspirin
- Blood pressure was gradually adjusted
- Transcranial Doppler Imaging was performed to assess cerebral perfusion
- Patient received left internal carotid artery endarterectomy 9 days after the incident of symptoms



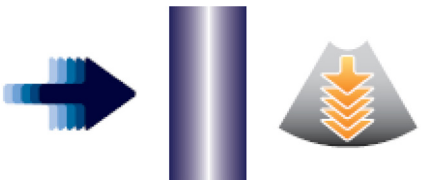
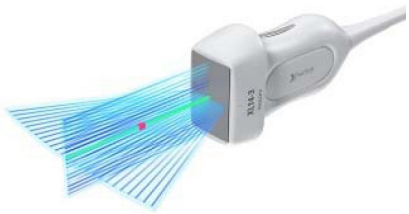
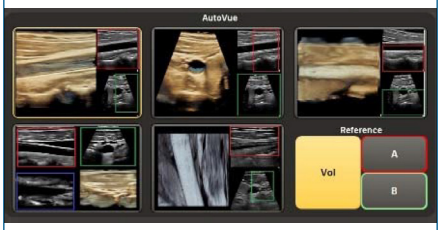
Duplex results of Right ICA showing increased PSV.



3D Vessel Cast of Right Bifurcation, ICA, and ECA with measurements of stenosis.

The technology perspective

Carotid ultrasound is utilized by clinicians to diagnose carotid artery stenosis and can assess atherosclerotic plaque morphology and characteristics. 2D imaging and Doppler ultrasound is part of this exam. The Philips ultimate solution for vascular assessment with the XL14-3 transducer on EPIQ Elite is our biggest advancement in vascular ultrasound in 20 years. This transducer enables ultra-thin slice imaging, proprietary xPlane Imaging with real time images of both longitudinal and transverse planes simultaneously, xPlane pulse Doppler and ability to visualize anatomy in amazing 3D/4D with an easy-to-use ICON-driven workflow. This solution offers a novel approach to elevate diagnostic accuracy and confidence, and in turn help clinicians to improve disease management and outcomes.

nSIGHT image architecture	**XL14-3 xMATRIX transducer**	**Advanced workflow**
		
Multi-stage precision beamformer with massive parallel processing enables • Better penetration with resolution at depth • Improved focusing throughout the image to visualize superficial vessels as well as deeper veins • Improved frame rates in all imaging modes	xMATRIX technology enables quick and easy volume acquisition, supports multiple interrogation capabilities, and provides views not possible with 2D imaging • Ultra-thin slice imaging • Live xPlane imaging • xPlane PW Doppler • 3D/4D, Vessel Cast	Visualize 3D/4D anatomy with easy to use workflow solutions • Intuitive icon-driven 3D/4D workflow reduces a 10 step conventional interface to just 1 • Instantly select rendered options with a single touch of an AutoVue icon • TouchVue interface allows finger manipulation of the volume from the touchscreen

These advancements in vascular ultrasound can enable faster scans, superb pathology details, diagnostic confidence with accurate and reproducible measurements.

About the author:

Muhammad Hasan, MBBCh, RPVI, RVT, RDCS, RDMS is the Department Manager of Echocardiography and Noninvasive Vascular Testing, Miami Cardiac & Vascular Institute at Baptist Hospital of Miami, FL. He is responsible for the fiscal, clinical, and resources management of the Non-Invasive Vascular Testing Department. This includes development, operational performance, and continuous improvement of the daily operation. Muhammad supervises a team of 50 physicians, nurses, technologists, and ancillary members to ensure compliance with Baptist Health South Florida's service standards and JCAHO and IAC performance standards among other regulatory agencies.

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