DIAGNOSTIC VALUE OF DOPPLER ULTRASONOGRAPHY IN CAROTID ARTERY ATHEROSCLEROSIS

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Abstract

The carotid arteries are two major pairs of blood vessels in the neck, the internal and external carotids, that supply oxygen-rich blood to the brain, neck, and face. The right common carotid originates from the brachiocephalic trunk, while the left arises directly from the aortic arch. Carotid artery disease is caused by a buildup of fatty deposits, known as plaques, in the arteries that send blood to the brain. Plaques are clumps that include cholesterol, fat and blood cells that form in the artery. This process is called atherosclerosis. Carotid arteries narrow when they are clogged with plaques. A clog in carotid arteries makes it hard for oxygen and nutrients to reach the brain. The first line diagnosis of atherosclerotic plaques in carotid arteries is a Carotid Duplex Ultrasound, which uses high-frequency sound waves combined with Doppler technology to detect plaque buildup, stenosis and blockages in the carotid arteries, helping diagnose risks for stroke. It evaluates blood flow speed and vessel structure to assess carotid artery disease, blood clots and arterial damage. Duplex ultrasound (DUS) is a highly accurate, non-invasive primary screening tool, generally offering over 90% sensitivity for identifying high-grade (70-99%) stenosis and occlusion. Its diagnostic accuracy for high-grade stenosis often exceeds 85-90%, making it the preferred initial imaging test. Because of the low cost, minimal risk, and accuracy of duplex sonography, some carotid surgeons advocate endarterectomy on the basis of these results alone. A recent survey revealed that most vascular surgeons (75%) accept endarterectomy without preoperative arteriography for appropriate indications.

Keywords: Atherosclerosis, Common Carotid Artery, Plaque formation, Doppler Ultrasonography.

Introduction

The head and neck receive the majority of their arterial blood supply from the carotid and vertebral arteries. The common carotid arteries (CCAs) constitute the primary vessels delivering blood to the brain and face, with a total flow of approximately 600-700 ml/min.
There are two Common Carotid Arteries:

1. Right common carotid artery- originates from brachiocephalic trunk.
2. Left common carotid artery – arises directly from aortic arch.

Both arteries ascend in the neck within the carotid sheath, alongside the internal jugular vein and vagus nerve. They do not give off branches in the neck and typically divide at the level of the upper border of the thyroid cartilage (around the C4 vertebral level).
In the level of bifurcation these arteries divide into:

1. The internal carotid artery (ICA)
2. The external carotid artery (ECA)

ICA gives blood supply to brain and eyes and has no neck branches, whereas ECA supplies blood to face, scalp, tongue and neck structures.
Other important structures:
The carotid sinus is a widened area of the internal carotid artery that contains baroreceptors, which detect blood pressure changes and help regulate heart rate and vessel tone.
The carotid body is a small chemoreceptor cluster near the carotid bifurcation that senses oxygen, carbon dioxide, and pH levels in the blood, helping control breathing.
The most common disease of carotid artery is atherosclerosis occurring at the carotid artery bifurcation, typically involving the distal common carotid and proximal internal carotid artery, and to a lesser extent the proximal external carotid artery.
The fact that atherosclerosis develops next to branch ostia, bifurcations, and bends suggests that flow dynamics are important in this process. Low flow velocity and high shear stress are

typical environments for the development of atherosclerotic plaque· Constricted arteries and the carotid sinus, which have slower blood flow, are affected by the pulsing pattern of the cardiac cycle's blood flow, which results in fluctuating shear rates. A thrombus occlusion or embolization may occur as a consequence of the carotid artery gradually narrowing or of plaque rupture, both of which can induce transient ischemic attack (TIA) or strokes. (6,4)
Carotid artery disease account for between 10-20% of ischemic stroke.
Understanding the anatomy of carotid blood supply is crucial in diagnosing and treating these vascular conditions and diseases.

Understanding Atherosclerosis

Carotid artery plaque is a measure of atherosclerosis and is associated with future risk of atherosclerotic cardiovascular disease (ASCVD), which encompasses coronary, cerebrovascular, and peripheral arterial diseases.
Atherosclerosis is principally a lipid-driven process initiated by the accumulation of low-density lipoprotein and remnant lipoprotein particles and an active inflammatory process in focal areas of arteries particularly at regions of disturbed non-laminar flow at branch points in the arteries.
The development of these plaques lead to progressive narrowing and hardening of arteries, resulting in reduced blood flow and impaired oxygen delivery to tissues. Plaques may also become unstable and rupture, leading to thrombus formation and arterial occlusion.
The risk factors of atherosclerosis include:

- Diabetes
- Family history
- Blood pressure
- Inflammatory diseases such as rheumatoid arthritis and psoriasis
- Older age (male >45 and female > 55 years old)
- Smoking
- Unhealthy diet

After understanding the anatomy of the carotid arteries and the pathophysiological process of atherosclerotic plaque formation, the next essential step is to evaluate how these changes can be detected in clinical practice. (4.3)

Diagnosis of atherosclerotic plaques in carotid artery disease

Carotid artery atherosclerotic plaques are diagnosed primarily through non-invasive imaging:

- Carotid Duplex Ultrasound
- CT Angiography (CTA)
- MR Angiography (MRA)
- Contrast Enhanced Utrasound
- Positron Emission Tomography
- Digital Subtraction Angiography

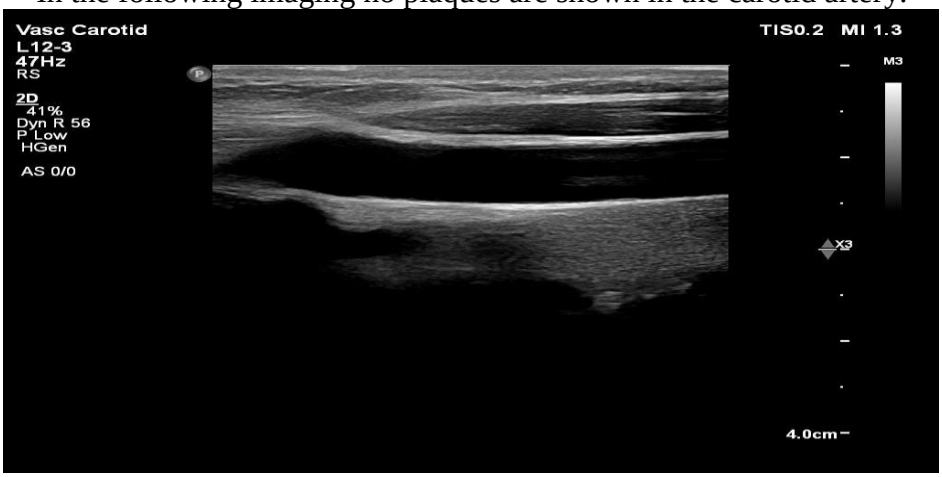
Carotid Duplex Ultrasound

One of the most widely used imaging methods for assessing carotid artery disease is duplex ultrasonography (DUS). This technique combines two complementary ultrasound modes. B-mode (grey-scale) imaging uses reflected sound waves to create real-time images of the carotid

artery, allowing evaluation of the vessel wall, lumen structure, and the presence of atherosclerotic plaque.

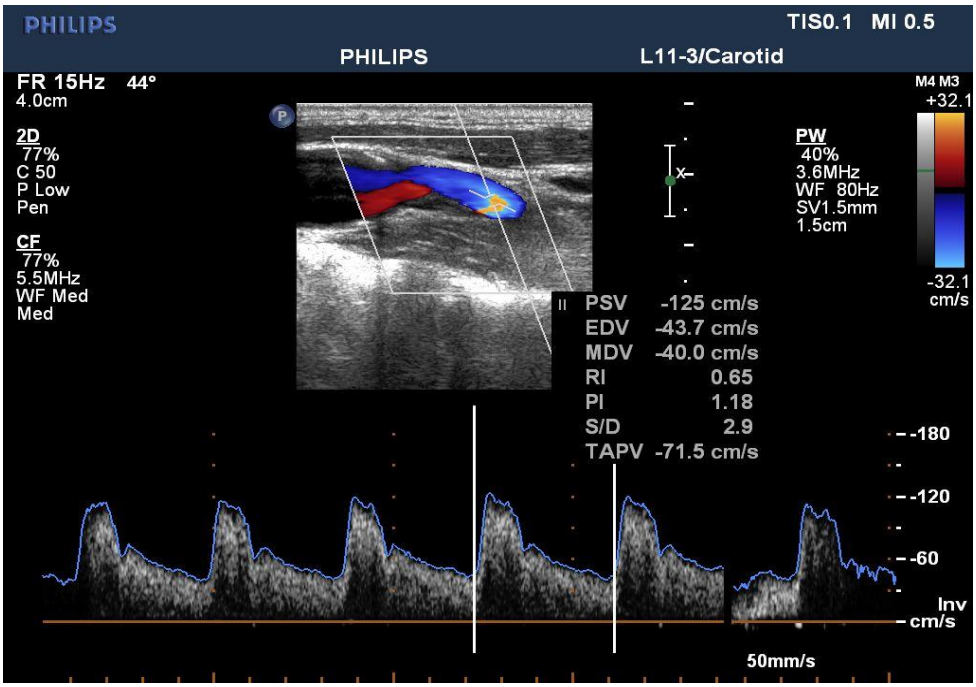
In addition, color and Doppler ultrasound assess blood flow by detecting changes in sound frequency caused by moving red blood cells. This provides both visual information about flow patterns and measurable data such as blood flow velocity, which are important for identifying and grading carotid artery stenosis. (1,2,5)

In the following imaging no plaques are shown in the carotid artery.



In the figure shown below, we have an atherosclerotic plaque of 1.77mm in bulbus caroticus.

In the picture shown above, a borderline plaque of 0.91mm is shown.



In the figure above, an approximately 75% of stenosis is shown.

Conclusion

Carotid ultrasonography is a safe, non-invasive, widely available imaging method, while still providing a real-time assessment of both structural changes and functional impact without exposing the patient to radiation. In addition, carotid ultrasound has high sensitivity and specificity for detecting moderate to severe stenosis**,** making it highly effective for identifying patients at increased risk of ischemic stroke. Color duplex ultrasound has replaced carotid arteriography as the preferred screening test for carotid artery occlusive disease. Because of the low cost, minimal risk, and accuracy of duplex sonography, some carotid surgeons advocate endarterectomy on the basis of these results alone. A recent survey revealed that most vascular

surgeons (75%) accept endarterectomy without preoperative arteriography for appropriate indications. (1,2,4)

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