Doppler Color Flow Imaging of Carotid Body Tumors

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Doppler color flow imaging is a new ultrasound method for the simultaneous spatial display of tissue and vessel morphology (B-mode echotomograms) and of color-coded blood flow velocity information (Doppler-mode analysis). This new method is particularly useful in the neck, not only for the assessment of brain arteries but also for the safe and valid identification of carotid paragangliomas compared with other neck tumors. Early clinical detection of carotid paragangliomas is difficult since these lesions often occur sporadically and the patients remain symptom-free until the tumor becomes noticeable. Doppler color flow imaging allows the diagnosis of even small paragangliomas, which may improve management because of existing complications of surgical therapy. (Stroke 1989;20:1574–1577)

Although carotid body tumors are thought to be the most common type of paragangliomas, their prevalence and natural history are unknown because of the difficulties of early diagnosis and noninvasive follow-up. Meyer et al recently reviewed more than 600 cases reported in the literature. Sporadic forms of carotid body tumors are more frequent than autosomal dominant ones, which may present with a 32% incidence of bilateral tumors. Concepts for treatment of carotid body tumors are impeded by the generally limited number of patients reported in individual series. However, in a 50-year retrospective study of 153 tumors from the Mayo Clinic, Hallett et al confirmed a persistent 40% risk of cranial nerve lesions after surgery even if modern surgical techniques were used. This high risk is size dependent; the larger the tumor, the higher the post-operative complication rate.

Although examination of the unaffected members of a family with a known history of carotid body tumors may result in the early diagnosis of small tumors, early diagnosis is unlikely for the majority of patients who present sporadically with or without minor complaints (e.g., discomfort, dysphagia, hoarseness, stridor) only after discovering a large palpable mass in the neck.

Noninvasive methods, and ultrasound in particular, have only occasionally been used to assess carotid body tumors. Hemodynamic Doppler-mode analysis and B-mode echotomograms, either alone or combined in conventional duplex systems, have often failed to definitely differentiate such lesions from other neck masses. The development of the Doppler color flow imaging (DCFI) technique facilitates the detection of blood flow in small tumor vessels, even in the absence of sonographically identifiable wall structures, and therefore may increase the diagnosis of carotid body tumors at a very early stage. We present the characteristic features of DCFI in two patients with carotid body tumors confirmed by subsequent arteriography.

Case Reports

DCFI examination was performed on an angiodynograph (HQAD PV, Philips Medical System, Hamburg, FRG). The system uses a 7.5-MHz linear transducer for the simultaneous display of a grayscale (B-mode) tissue echotomograph and the Doppler information, which is color-coded with regard to the intravascular blood flow direction. Cell motion toward the transducer is coded red, motion away from the transducer is coded blue. Color saturation indicates signal amplitude, depending on the velocity of the moving targets. In addition, a high-resolution conventional duplex scanner (DRF 400, Disonics, Milpitas, California), combining a 4.5-MHz single-gate pulsed Doppler system with a 10-MHz B-mode system, was used. The examination procedure and results from normal subjects are reported elsewhere. Both patients underwent subsequent selected intra-arterial digital subtraction angiography (DSA).

Case 1

A 38-year-old man was admitted with familial hypercholesterolemia and coronary heart disease.
His major complaint was exercise-dependent dyspnea. For 2 years he had noted a small mass, which had increased in size without any associated symptoms, in his right neck. Results of physical and neurologic examinations, including examination of the cranial nerves, were normal.

High-resolution B-mode analysis showed a 1.5×3.2 cm heterogeneous mass of poor echogenicity widening the right carotid bifurcation (Figure 1a). Irregularly distributed, bidirectional Doppler signals in this area between the branching external (ECA) and internal (ICA) carotid arteries as revealed by DCFI supported the diagnosis of a hypervascularized tumor (Figure 1b). Location and configuration of the carotid bifurcation and the state of vascularization were considered typical for a carotid body tumor. Intra-arterial DSA (Figure 1c) confirmed the diagnosis. Thoracic and abdominal computed tomograms gave no evidence of other paragangliomas. Concentrations of catecholamine metabolites in the blood and urine were normal.

This tumor was surgically removed without complications, and the diagnosis was histopathologically confirmed.

Case 2

A 69-year-old woman was admitted for the diagnosis of a pulsating mass at the left side of her neck below the mandible; the mass had slowly increased in size over 3 years and was initially considered to be a carotid aneurysm. Results of physical and neurologic examinations were normal except for a moderate arterial hypertension and minimal postural tremor. Results of routine laboratory investigations and concentrations of thyroid hormones and tumor markers were all within normal limits.

High-resolution B-mode analysis demonstrated a 2.6×2.8 cm circumscribed heterogeneous echo-poor tumor at the left carotid bifurcation stretching the ICA (Figure 2a). The ECA could hardly be seen, and the typical configuration of a widened carotid bifurcation was missed. However, DCFI showed a
diffuse vascularity near the carotid bifurcation (Figure 2b). Intra-arterial DSA confirmed the diagnosis and demonstrated blood supply from branches of the ECA (Figure 2, c and d.)

The patient refused surgical treatment.

Discussion

DCFI is a recently developed ultrasound technique. In addition to conventional duplex-system analysis, DCFI provides a simultaneous spatial display from the Doppler shift data of blood flow in vessels and organs, which is superimposed on the B-mode image. DCFI is particularly useful for the display of small-caliber vessels, including tumor vessels, which are regularly missed during conventional duplex-system examination because of wall structure interference.

These case reports show the impressive appearance of carotid body tumors on DCFI. Diagnosis is based on the widened contour of the bifurcation and on the easily recognized hypervascularity of the tumor. The latter is particularly necessary to differentiate tumors of the carotid body from avascular or hypovascularized cervical masses (e.g., lymph node metastases, salivary gland tumors, or brachial cysts). Thyroid tumors, which in some cases are hypervascular, are usually located medial to the carotid bifurcation and differ from carotid body tumors in their low peripheral resistance Doppler profile. Previous attempts to diagnose carotid body tumors noninvasively by ultrasound are consistent with our experience, indicating that it is not possible to differentiate reliably between solid and cystic neck masses, which may both consist of heterogeneous echo signals. Even if single-gate pulsed-wave Dopplersonography is added and an abnormal blood flow spectrum is assessed in selected areas, the lack of a two-dimensional blood flow display may result in considerable difficulty in combining anatomic and hemodynamic information. Thus, although it is often possible with conventional duplex ultrasound to differentiate carotid aneurysms from tortuous vessels, demonstration of sonolucent areas in the absence of flow signals by means of DCFI suggests

**Figure 2.** Case 2. a: Duplex sonogram of left carotid bifurcation showing circumscribed hypodense tumor stretching internal carotid artery (ICA). b: Doppler color flow image of left carotid body tumor below ICA, with pathologic vascularity. c and d: Intra-arterial digital subtraction angiograms of left carotid artery, lateral (c) and anteroposterior views (d). Hypervascular tumor in area of bifurcation, stretching both carotid artery branches.
thrombotic material in an aneurysm and hence improves the validity of noninvasive investigation.

The management of carotid body tumors is still a matter of discussion because the perioperative complication rate is high.\(^1,2,9\) In a recent review of 153 cases operated on during 50 years up to 1985, Hallett et al\(^2\) found no perioperative deaths and a stroke morbidity of 2.7% during the last 10 years. However, the major operative morbidity, consisting of injury to the lower cranial nerves, remained unchanged over 50 years (40% during the last 10 years of the study). Therefore, observation is preferred for patients with small asymptomatic tumors who could be easily followed by examination with DCFI. Resection of these tumors is suggested only if growth is observed.\(^1\) Since noninvasive diagnosis of carotid body tumors is now possible with DCFI, angiography should be restricted to patients who are to be operated on. In our two cases, the blood-supplying arteries were difficult to identify by DCFI so that high-quality angiograms still appear to be necessary before surgery. The ability to detect and follow these tumors more effectively should alert those using DCFI to establish the diagnosis more frequently in patients having routine studies of the carotid system.

References

KEY WORDS • carotid artery diseases • ultrasonics
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Stroke. 1989;20:1574-1577
doi: 10.1161/01.STR.20.11.1574

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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