Accuracy of Transcutaneous Doppler Ultrasonics in Evaluating Extracranial Vascular Disease*

RONALD BRISMAN, M.D., B. LEWIS GROSSMAN, M.D., AND JAMES W. CORRELL, M.D.
Department of Neurological Surgery and Neuroradiology, Columbia-Presbyterian Medical Center, Neurological Institute, New York, New York

The ultrasonic transcutaneous Doppler technique has been suggested as a safe method for determining extracranial carotid blood flow.4-7,9,11-13 Application of this technique to occlusive extracranial carotid disease has been reported.1,5 Arteriography has been the most helpful method used so far to verify the Doppler's effectiveness in diagnosing carotid artery disease. Since the Doppler primarily measures blood velocity, more direct determinations of blood flow would be valuable to check the Doppler's performance. The present study uses intraoperative electromagnetic flow determinations, direct carotid pressure recordings, occlusive carotid clamps (Selverstone), and arch arteriography in an effort to evaluate the effectiveness of the transcutaneous Doppler technique in determining carotid blood flow.

Clinical Material and Methods

This study is based on observations made on 21 patients. Seventeen had arch arteriography for investigation of symptoms suggesting occlusive extracranial vascular disease. Four patients who had subarachnoid hemorrhages were studied with bilateral common carotid arteriography. Dopplergrams were performed on each common carotid artery (42 arteries in 21 patients) usually prior to arteriography. An operation was performed on 14 of the internal carotid arteries in 10 patients. Pre- and postoperative Dopplergrams were obtained in all except one case where only a postoperative study could be done. In seven of the operations an endarterectomy was performed for arteriosclerotic occlusive disease. Another patient was explored for a kinked internal carotid artery. Two patients with intracranial aneurysms had a complete occlusion of the common carotid artery effected by a Selverstone clamp. It was assumed that the common carotid artery was completely occluded at the time of the transcutaneous Dopplergram. Electromagnetic flowmeter determinations were performed intraoperatively before and after endarterectomy on nine carotid arteries and on a tenth, kinked internal carotid artery in head positions of flexion, extension, and lateral rotation. Direct pressure recordings were obtained of the common and internal carotid arteries in five cases. At the conclusion of the entire study, all Dopplergrams were reviewed by two independent observers who had no knowledge of the specific arteriographic flow or pressure measurements.

The transcutaneous ultrasound blood velocity meter used was the "Dopstone."7 Two signals are displayed on a dual trace oscilloscope and are photographed with a Polaroid camera (Fig. 1 left). One trace (amplitude) is related to the total amount of erythrocytes moving, and the other trace (frequency) relates to the velocity of the fastest moving red blood cells. The instrumentation fits on a small mobile cart to facilitate bedside testing.

The transducer probe is placed as low as possible in the neck over the common carotid artery. The position of the probe tip and the angulation are adjusted to give the highest frequency and amplitude readings. Dopplergraphic criteria for reduced carotid blood flow have been described.7,8 They consist of absent flow during mid and late diastole as seen on the amplitude curve, and plateauing on the frequency curve during at least 50% of the cardiac cycle (Figs. 1 right and 2 right).

An electromagnetic flowmeter was used (Medicon K-2000), with a Statham flow
probe (Q-2080). The flow probe was placed around the common carotid artery a few centimeters proximal to the bifurcation. Zero flow was calibrated by occluding the common carotid distal to the flow probe. Care was taken to control the superior thyroid artery. Internal carotid flow was determined by occluding the external carotid (and superior thyroid artery) and measuring flow through the common carotid. When it was feasible, blood pressure readings were taken with a 25-gauge needle in the common and internal carotid arteries.

Results

Twenty-seven internal carotid arteries were studied exclusively by arteriography. Eight of these demonstrated stenosis of more than 50% of the vessel diameter. The Doppler predicted a decreased flow in six of these eight stenotic vessels, but had predicted normal flow in two cases. In the other 19 vessels, stenosis was less than 50% in lumen diameter, and the Doppler predicted normal flow in each case (Table 1).

Twelve vessels were examined by direct measurement of flow during operation, using the electromagnetic flowmeter and/or direct arterial pressure recordings (Table 2). Internal carotid artery flow was significantly decreased in six cases. The preoperative Dopplergram had correctly predicted this decreased flow in two cases, and had suggested it in another two cases, but had incorrectly predicted a normal flow in two other cases. The six vessels with normal flow had been correctly assessed by preoperative Dopplergrams. Endarterectomy, which had been