Duplex carotid sonography in distinguishing acute unilateral atherothrombotic from cardioembolic carotid artery occlusion.

K Kimura, K Yonemura, T Terasaki, Y Hashimoto and M Uchino

*AJNR Am J Neuroradiol* 1997, 18 (8) 1447-1452

http://www.ajnr.org/content/18/8/1447

This information is current as of October 19, 2023.
Duplex Carotid Sonography in Distinguishing Acute Unilateral Atherothrombotic from Cardioembolic Carotid Artery Occlusion

Kazumi Kimura, Kiminobu Yonemura, Tadashi Terasaki, Yoichiro Hashimoto, and Makoto Uchino

**PURPOSE:** To distinguish between acute complete unilateral cardioembolic and atherothrombotic internal carotid artery (ICA) occlusion by using duplex carotid sonography. **METHODS:** We studied 11 patients with cardioembolic ICA occlusion (CE group), 32 patients with atherothrombotic ICA occlusion (AT group), and 25 patients with normal angiographic findings (control group). We obtained B-mode scans and measured the end-diastolic flow velocity (EDV) in both common carotid arteries within 3 days of the onset of symptoms. Side-to-side ratios of EDV (ED ratio) were calculated by dividing the flow velocity on the unaffected side by that on the affected side. **RESULTS:** In the AT group, the proximal ICA was full, with a large area of heterogeneous and partially calcified plaque, and the EDV (10.9 ± 6.1 cm/s) was significantly lower than that in the control group (20.3 ± 6.0 cm/s). The ED ratio was greater than 1.4 in all but one patient. In three patients in the CE group, B-mode scans showed a mobile, echogenic intravascular structure in the proximal ICA. The EDV (1.8 ± 3.4 cm/s) was significantly lower than that in the control and AT groups. The ED ratio was greater than 1.4 in all cases. **CONCLUSION:** We conclude that B-mode scans and the EDV in the common carotid artery can help to distinguish between acute cardioembolic and atherothrombotic ICA occlusion.

**Index terms:** Arteries, carotid, internal; Arteries, stenosis and occlusion; Arteries, ultrasound

ICA origin occlusion (AT group). The clinical diagnosis of CE occlusion was made when a patient met at least two of the following three criteria (8–10): sudden onset of clinical symptoms; demonstration of a cardiac source of emboli, such as atrial fibrillation or flutter, recent myocardial infarction, congestive heart failure, and mitral or aortic valve disease; and evidence of embolization to other parts of the body. In all patients in the CE group, onset of symptoms was sudden; 10 patients had atrial fibrillation and one patient had acute inferior myocardial infarction. Two patients had embolization of the iliac artery. Angiographic findings showed distal occlusion without stenosis at the origin of the ICA. The clinical diagnosis of AT occlusion was made in patients who did not meet the above criteria but who had extracranial ICA occlusion that was thought to be due to atherosclerosis. Angiographic findings of all these patients showed rounded or pointed stump occlusion at the origin of the ICA. In the AT group, 23 patients had acute carotid territory stroke, seven had an acute occlusion of the central retinal artery, and two had transient ischemic attacks. For this study, ICA siphon occlusion without a cardiac source of emboli was excluded because it was difficult to distinguish an AT from a CE pathogenesis.

We obtained B-mode scans and measured the flow velocity by pulsed Doppler sonography in both common carotid arteries (CCAs). The transducer was operated at 5 to 10 MHz for B-mode imaging and Doppler functions. The pulse repetition frequency was mainly 5000 Hz, and the low-pass filter was 50 Hz.

B-Mode and Color Doppler Flow Imaging

Both carotid arteries were examined in all patients. Imaging was performed while the subjects were lying in the supine position with the head turned away from the side being scanned and the neck extended. The transducer was placed on the neck using the anterior oblique and posterior longitudinal approach. The CCA and ICA were first visualized with B-mode scans in the longitudinal and transverse planes and were then scanned using color Doppler flow imaging. The proximal ICA was investigated for morphologic abnormalities.

Blood Flow Velocity in the CCA

On longitudinal scans, the sample volume was set in the CCA, which was displayed as linearly as possible. A range-gate pulsed Doppler sample volume, 5 to 7 mm in size, was used to measure the blood flow velocity of the CCA. Special care was taken to keep the incident angle between the CCA and the beam at 30° to 60°. First, we measured the end-diastolic flow velocity of both CCAs and determined the mean value of five consecutive cardiac cycles.
These velocities were then corrected with the incident angle. Then, the side-to-side ratio of the end-diastolic flow velocity (ED ratio) was calculated by dividing the velocity on the unaffected side by that on the affected side in the CE and AT groups. In the control group, the ED ratio was obtained by dividing the velocity on the faster side by the slower velocity.

The age and flow velocity data for each group were expressed as the mean plus or minus the standard deviation (SD). For the analysis of velocity data, we used the unpaired t test. A P value of less than .05 was accepted as indicating a significant difference.

### Results

**B-Mode and Color Doppler Flow Imaging**

In the control group, B-mode scans showed no morphologic abnormalities at the bifurcation or in the proximal ICA in any of the patients.

In all patients in the AT group, the proximal ICA was full, with a large heterogeneous and partially calcified area of plaque (Fig 1). Color flow Doppler imaging showed the anterograde...
flow in systole and retrograde flow in diastole proximal to the stump in the affected ICA. It indicated a hemodynamically significant ICA occlusion and suggested that these patients had suffered an atherothrombotic ICA occlusion.

In the CE group, eight patients had no morphologic abnormalities at the bifurcation or in the proximal ICA. But in three cases, B-mode scans showed a mobile, echogenic intravascular structure in the proximal ICA, which probably represented a thrombus (Fig 2 and Table). The movement of the echogenic intravascular structure was synchronous with the cardiac cycle. The intravascular structure moved quickly from the proximal to the distal ICA during the systole of the cardiac cycle, whereas, during the diastole of the cardiac cycle, the intravascular structure moved slowly from the distal to the proximal ICA. This finding is characteristic of cardioembolic ICA occlusion. In eight patients with no morphologic abnormalities, color Doppler flow imaging showed absent color Doppler signals or anterograde flow in systole and retrograde flow in diastole in the affected ICA. It indicated a hemodynamically significant ICA occlusion.

Blood Flow Velocity in the CCA

The end-diastolic flow velocities in both CCAs were measured in the 68 patients. The typical waveforms in the AT, CE, and control groups are shown in Figures 1, 2, and 3. The end-diastolic flow velocities and the ED ratio in each group are shown in Figures 4 and 5 and in the Table.

In the control group, the end-diastolic flow velocity in 50 CCAs was $20.3 \pm 6.0$ cm/s, and the ED ratio was $1.2 \pm 0.1$; all values were less than 1.4 (mean ED ratio value $+2$ SD).

In the AT group, the end-diastolic flow velocity ($10.9 \pm 6.1$ cm/s) on the affected side was significantly lower than that in the control group ($P < .01$). Only in three of 32 patients could the end-diastolic flow velocity on the affected side not be detected. The ED ratio was greater than 1.4 in all but one patient.

In the CE group, the end-diastolic flow velocity ($1.8 \pm 3.4$ cm/s) on the affected side, which
was zero in eight patients, was significantly lower than that in the control and AT groups (P < .01). In the remaining three patients it was 3.0, 6.0, and 10.3 cm/s, respectively. The ED ratio was greater than 1.4 in all patients.

The CE and AT groups could easily be distinguished from the control group on the basis of the ED ratio (>1.4).

Discussion

Duplex carotid sonography is a useful tool for diagnosing ICA occlusion (1–3). On the basis of the B-mode scan findings, our results indicated that 32 patients suffered an atherothrombotic ICA occlusion. In three patients in the CE group, B-mode scans showed a mobile, echogenic intravascular structure in the origin of the ICA. In patients with acute cardioembolic ICA occlusion, the embolus was usually lodged at the top of the bifurcation of the ICA (10). We suspect that mobile, echogenic intravascular structures are fresh thrombi that extend from the ICA bifurcation to the origin of the ICA. It is also possible that these patients had an embolus lodged in the proximal ICA that subsequently lysed and then lodged more distally in the ICA. Steinke et al (11) reported that mobile, thin, echogenic intravascular structures were visible on B-mode scans in 15% of their patients with a dissected ICA. We believe, therefore, that ICA occlusion caused by dissection would not be different from cardioembolism on the basis of carotid sonographic findings alone.

Recently, Yasaka et al (3) reported that the side-to-side ratio of end-diastolic velocity in the CCA can serve to identify the site of occlusion in the ICA in patients with acute cardioembolic stroke. In our study, the ED ratio in the CCA of all patients in the control group was less than 1.4, while in 42 of 43 patients in the group with ICA occlusion it was greater than 1.4. An ED ratio of more than 1.4 may also occur with atherothrombotic siphon occlusion or aortogenic embolic ICA occlusion or with extracranial ICA dissection. Therefore, the finding of a CCA ED ratio of more than 1.4 in the absence of plaque of ICA origin or a mobile intravascular structure is a likely indication of a distal obstructive lesion of diverse causes.

The end-diastolic flow velocity in the CE group was lower than that in the AT group. In eight of these 11 patients the end-diastolic flow velocity was zero. The end-diastolic flow velocity was zero in eight patients, was significantly lower than that in the control and AT groups (P < .01). In the remaining three patients it was 3.0, 6.0, and 10.3 cm/s, respectively. The ED ratio was greater than 1.4 in all patients.

The CE and AT groups could easily be distinguished from the control group on the basis of the ED ratio (>1.4).
phy, it is more likely to represent a CE occlusion than an AT occlusion.

We conclude that B-mode scans and the end-diastolic flow velocity in the CCA may help to distinguish differences between acute cardioembolic and atherothrombotic ICA occlusion.

References