Use of color power transcranial Doppler sonography to monitor aneurysmal coiling.

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Use of Color Power Transcranial Doppler Sonography to Monitor Aneurysmal Coiling

J. M. Wardlaw, J. C. Cannon, and R. J. Sellar

Summary: We describe the use of a recently developed technique in the field of color Doppler sonography, called *power Doppler* or *color Doppler energy*, that produces better images of the intracranial arteries than those obtained by conventional color Doppler techniques. Color Doppler energy makes it possible to identify aneurysms and their relationship to the parent artery, thus allowing one to observe how much of an aneurysm remains patent and the condition of adjacent arteries during endovascular treatment. We describe the use of this technique during the insertion of Guglielmi detachable coils into aneurysms and during subsequent follow-up examination.

Index terms: Aneurysm, ultrasound; Interventional instruments, coils; Ultrasound, Doppler

Power Doppler, or *color Doppler energy*, is a development in the field of color Doppler imaging that is considerably more sensitive than conventional Doppler imaging to any movement of red blood cells. As a result, this technique allows detection of very low-flow velocities and can show motion in situations in which the flow is multidirectional and the net flow is zero (1). Color Doppler energy does not display directional information, although a cursor can be placed on the vessel of interest to obtain a spectral waveform that does show the direction of flow. Color Doppler energy has an advantage over conventional transcranial color Doppler imaging in that more detail of the intracranial arteries is visible, including smaller branches and abnormalities, such as aneurysms or arteriovenous malformations (2).

Platinum Guglielmi detachable coils are being evaluated for the treatment of intracranial aneurysms (3). It is not yet known what the long-term benefits of insertion of these coils will be as compared with conventional neurosurgical clipping of the aneurysm. The Guglielmi detachable coils are inserted through a guiding catheter placed in the artery from which the aneurysm arises using a femoral artery approach. Repeated small injections of contrast material and the acquisition of miniangiograms allow the position of the coil to be checked and the residual aneurysmal neck to be assessed.

Having found that sonograms obtained with the use of color Doppler energy showed intracranial aneurysms considerably better than did those obtained with conventional color Doppler techniques (4), we applied the color Doppler energy technique to real-time monitoring of the placement of Guglielmi detachable coils in intracranial aneurysms during interventional neuroradiologic procedures in six patients.

Materials and Methods

An Acuson 128XP10V scanner functioning with a 2-MHz hand-held probe (S219) was used. The color Doppler energy mode had been installed to function in the transcranial Doppler environment (Acuson Corp, Mountain View, Calif).

Six patients (22 to 61 years old; mean, 42 years) were studied after informed consent was obtained. Four procedures were elective, two were emergency. Patients were imaged through the temporal bone window on the side on which the aneurysm was known to be. Usually, the patients had had prior transcranial Doppler sonography so they were known to have a good bone window. Because the probe has to be manually positioned, it was used intermittently during the actual endovascular procedure to avoid interfering with the operator.

A good magnified view of the area of the aneurysm was obtained, and this area was observed intermittently from the start to the finish of the procedure. In particular, attention was paid to the first appearance of the coil in the aneurysm, to the positioning of the coils in the aneurysm, and to the presence of any residual aneurysmal neck.

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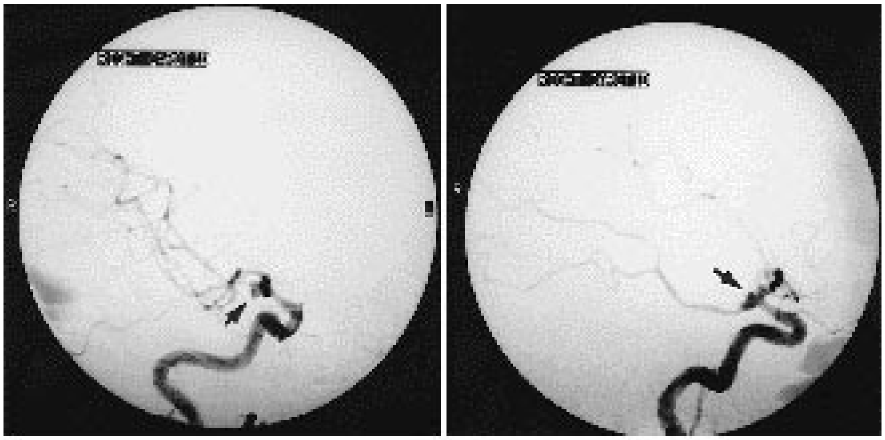
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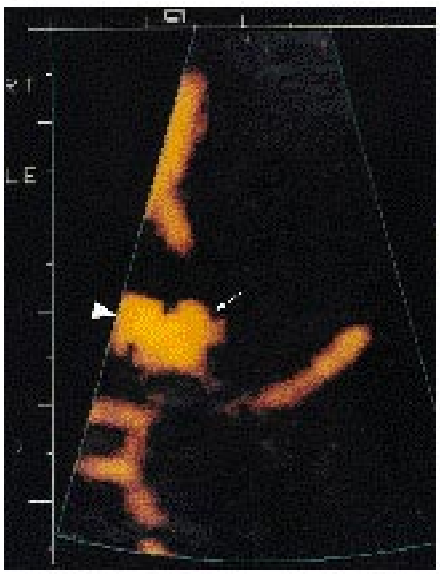
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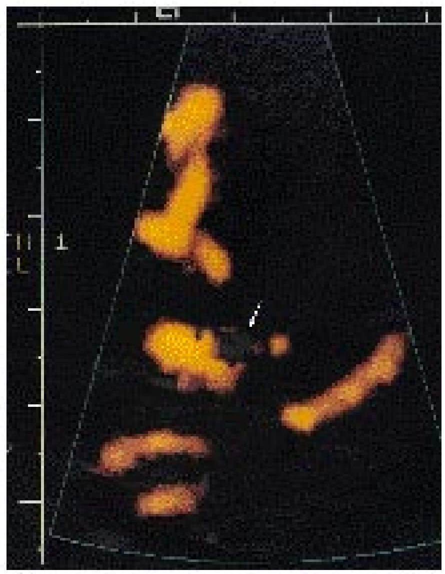
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Fig 1. *A*, Intraarterial digital subtraction angiograms of the right internal carotid artery (ICA) show a wide-necked aneurysm of the posterior communicating artery (PCoA) (*arrows*).

B, Corresponding axial transcranial Doppler sonogram (obtained with the color Doppler energy technique) taken through the right temporal bone window shows the wide-necked PCoA aneurysm (*arrow*) arising from the ICA (*arrowhead*).

C, Sonogram obtained with transcranial color Doppler energy technique after insertion of one Guglielmi detachable coil. Note the echogenic signal from the coil (*arrow*) and persistent large aneurysmal neck. *Figure continues.*

Counting emboli at the same time that the aneurysm is being imaged can be done by placing an electronic cursor over the artery of interest and observing the spectral waveform. Emboli are detected as audible "pops" corresponding with a short-duration, high-intensity signal falling within the waveform. Patients were imaged again the day after the coils were placed.

Results

The sites of the seven aneurysms in which coils were deposited in the six patients were as follows: the posterior communicating artery (PCoA) in one; the terminal internal carotid artery in two; the anterior communicating artery in one; the middle cerebral artery in two; and the basilar artery tip in one.

The aneurysms were clearly visible in five of the patients; although in the sixth patient, extremely slow flow in the aneurysm was not detectable by color Doppler sonography (nor was it seen by magnetic resonance imaging). In all patients it was possible to see the coils being placed in the aneurysm (Figs 1 and 2). During and immediately after passing the current to detach the coils, a generalized increase in color flow signal was observed in all vessels near the aneurysm (seen as flashing color), possibly caused by a hyperemic effect in response to the detaching current passed through the coil.

During coiling of one wide-necked PCoA aneurysm, it was possible to see the coil mass temporarily occlude the PCoA, which was the sole supply to the ipsilateral posterior cerebral artery. A transient hemianopia developed, which resolved when the coils moved back to the fundus.

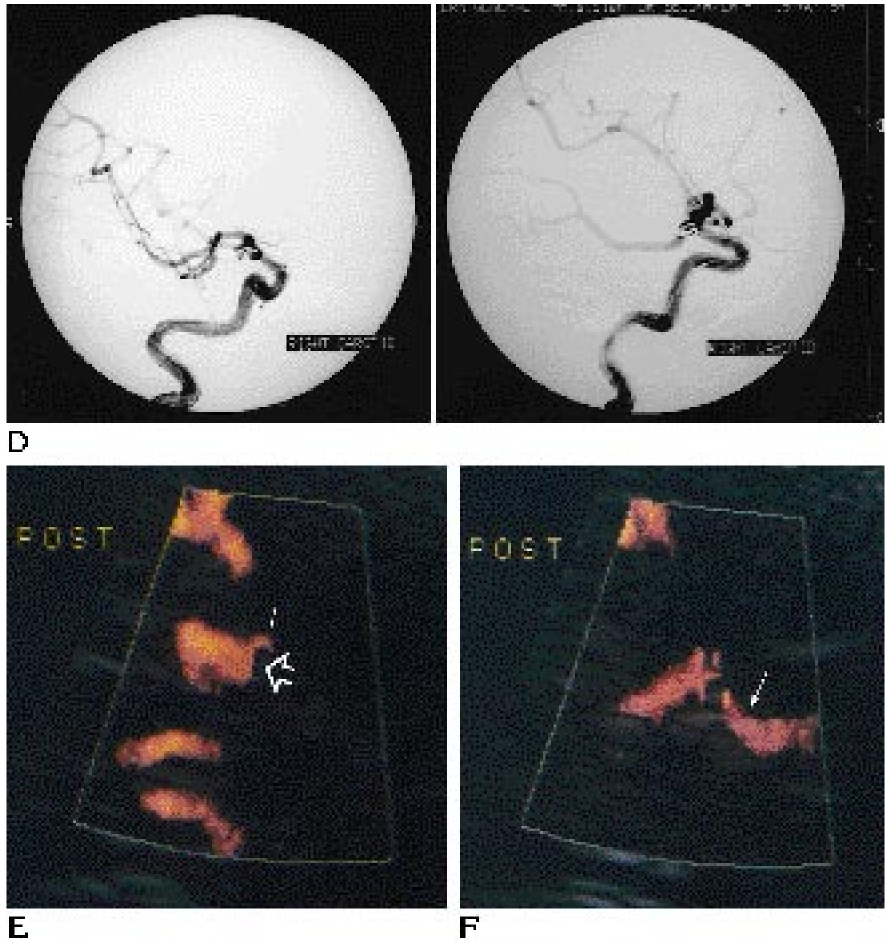


Fig 1, *continued.*

D, Angiograms obtained at the end of the coiling procedure shows a persistent neck on the PCoA aneurysm. Note that, owing to the wide neck, it was not considered safe to attempt placement of an additional coil, as some difficulty had already been experienced during placement of the first coil, which had drifted from the aneurysm fundus to occlude the posterior cerebral artery partially. This was immediately visible on sonograms, before a hemianopia occurred. The hemianopia resolved once the coil settled back into the fundus.

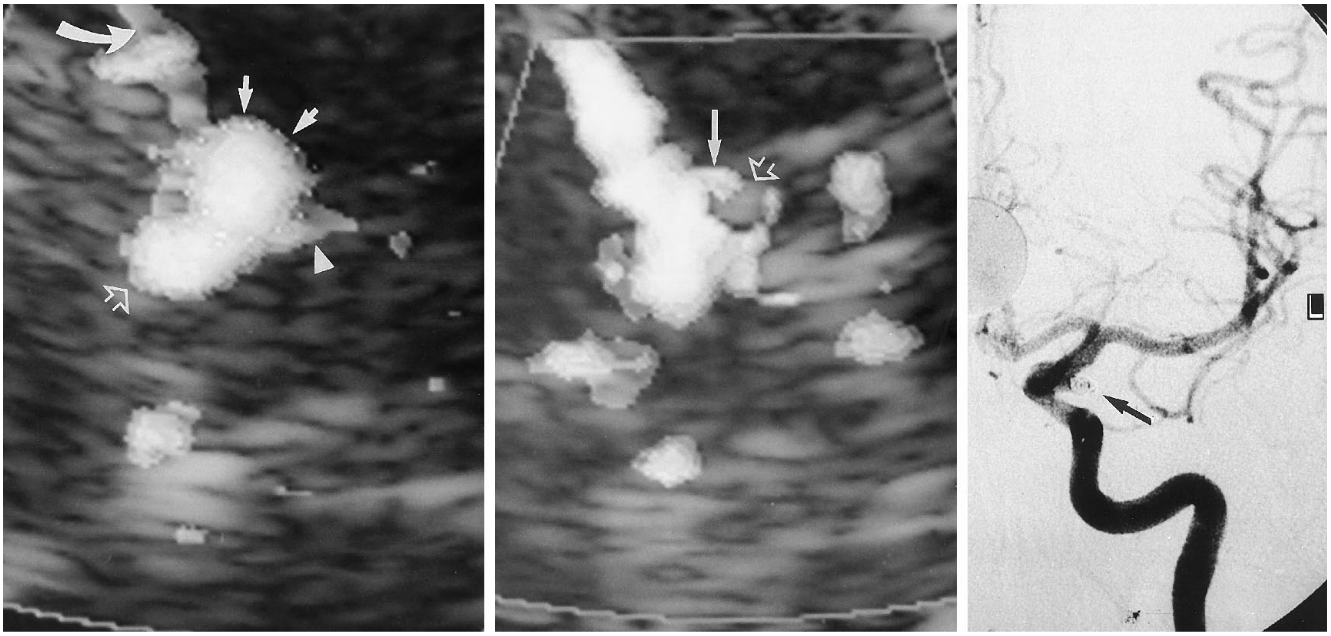
E and *F*, Transcranial power Doppler images obtained 24 hours after coil placement at slightly different probe positions show the relationship of the aneurysm to the PCoA. In *E*, note that the coils (*open arrow*) are still in the correct position and the neck (*arrow*) is still patent. In *F*, the PCoA (*arrow*) appears normal.

At the end of the procedures, five of the aneurysms were completely obliterated angiographically and no color flow was visible in them, although a high-signal reflection was visible from the coil. In two other aneurysms, only partial obliteration was achieved, and residual color flow was visible in the aneurysms as well as in the angiographically visible neck.

Discussion

Although it is not always possible to obtain useful color flow information through the skull, the color Doppler energy, or power Doppler, technique has improved the quality of images obtained with transcranial vascular sonography. We were able to visualize placement of coils during interventional procedures in all six of the patients in whom we applied this technique.

One benefit of the technique is for use with aneurysms that arise at a bifurcation. Visualization of the arteries separate from the aneurysm can be difficult angiographically. Moreover, coils can further obscure the origins of these branch arteries. In addition to providing a real-time image, color Doppler energy allows assessment of these arteries in terms of flow. Any reduction in normal arterial flow would be a contraindication to further insertion of coils. Similarly, dislodgment of thrombus from the aneurysm into an adjacent artery can be seen as diminished flow in that artery, or even as a moving filling defect if large enough. The ability to count the number of smaller emboli in arteries adjacent to the aneurysm during the procedure may also alert the physician to potential complications. Although it is not possible to resolve individual loops of the coils with this technique, it is possible to see which part of the aneurysm is occupied by the coils and how much residual neck is still present. The ultrasound probe is hand-held, but a device for fixing it to the patient's head for continuous imaging during the procedure would be feasible.



A B C

Fig 2. *A*, Axial transtemporal, transcranial color Doppler power image (reproduced in black and white) of an aneurysm of the posterior communicating artery (PCoA) (*straight solid arrows*) before embolization. The internal carotid artery in cross section (*open arrow*), the PCoA (*arrowhead*), and the middle cerebral artery (*curved arrow*) are also visible.

B, Axial transtemporal color Doppler power image (reproduced in black and white) of the PCoA aneurysm (*solid arrow*) after insertion of several Guglielmi detachable coils (*open arrow*). Note that the plane of section is slightly craniad of *A*, and the bilobate aneurysmal structure is only partially obliterated.

C, Corresponding digital subtraction angiogram of the aneurysm (*arrow*).

The sonographic demonstration of a residual aneurysmal neck may also be useful for follow-up examinations. If color Doppler energy proves to be reproducible and reliable, it may spare patients some of the risk and inconvenience of repeated conventional angiography. Further study will be required to assess the reliability of this technique before it can be used for follow-up. In the meantime, interventional neuroradiologists should be aware of the use of transcranial power Doppler sonography as a potentially useful imaging tool.

Acknowledgments

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