Transcranial Doppler: Applications in Neonates and Children

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KEYWORDS

- Transcranial Doppler • Neurosonology • Pediatric brain
- Neonatal brain • Cranial Doppler sonography
- Resistive index

Duplex Doppler with color flow imaging through the anterior fontanelle is simple and has proved useful in evaluating abnormalities of cerebral blood flow in the neonate.[1–4] Once the fontanelle closes, transcranial Doppler sonography can be performed using a 2- to 2.5-MHz pulsed wave Doppler transducer via the thin temporal bone. First introduced by Aeslid in 1982, this technique can be used to measure the velocity and pulsatility of blood flow within the intracranial arteries of the circle of Willis and the vertebrobasilar system.[5] Transcranial Doppler has become important in the management of children with sickle cell anemia and has proved to be a useful tool in the evaluation of various intracranial pathologies such as asphyxia, hydrocephalus, vascular malformations, vasospasm, and brain death in infants, children, and adults.

There are 2 types of transcranial Doppler equipment: nonimaging (TCD) and imaging (TCDI). Continuous wave and nonimaging pulsed wave Doppler techniques insonate specific vessels using strict criteria for vessel identification based on depth and direction of flow for intracranial vessels via the temporal bone.[6,7] Advantages of this technique include using small, inexpensive, portable units designed specifically for transcranial Doppler, and superior window maneuverability because of small transducer size. Limitations of the nonimaging technique include the need for intensive training, difficulty in finding vessels, and lack of unit availability in many hospitals. Color Doppler imaging via the anterior fontanelle or transtemporal approach allows for quick vessel identification, resulting in a shorter learning curve, and it is widely available in most radiology departments.[8–10] With training and experience, both techniques have been shown to be reliable with good reproducibility (in the remainder of this article, TCD refers to imaging and nonimaging techniques).[11]

TECHNIQUE

Neonate

In the neonate, the open anterior fontanelle provides an easy approach to insonate the anterior cerebral, middle cerebral, distal internal carotid, and basilar arteries, and the internal cerebral veins, vein of Galen, and superior sagittal sinus. Midline sagittal imaging provides direct insonation of the anterior cerebral artery (ACA) (**Fig. 1**A). The smaller thalamostriate arteries of the middle cerebral artery (MCA) may be visualized on angled sagittal images. On the coronal plane angled anteriorly via the anterior fontanelle, the supraclinoid internal carotid, middle cerebral, thalamostriate, and A1 segment of the anterior cerebral arteries can be visualized (**Fig. 1**B). Angled posteriorly, the internal cerebral veins, thalamostriate arteries, basilar artery, and transverse sinuses can be visualized. As the angle between the middle cerebral arteries and ultrasound beam is often

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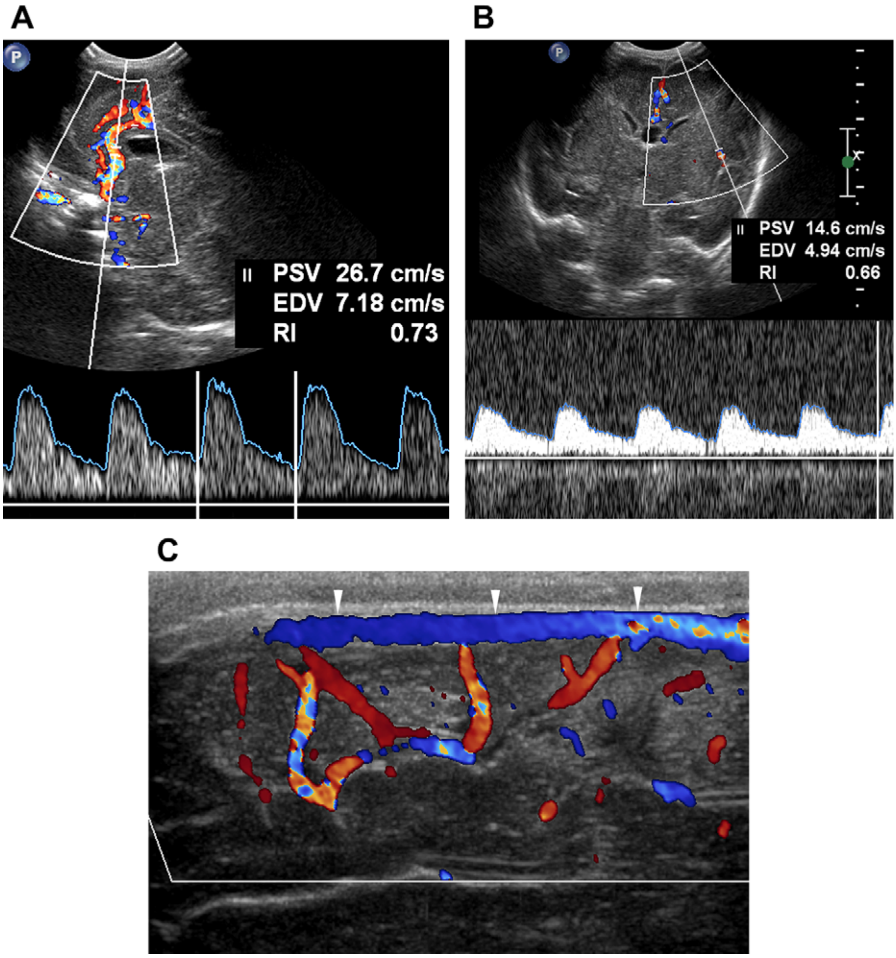

Fig. 1. Normal color flow Doppler sonogram via the anterior fontanelle in a term neonate. (*A*) Sagittal midline view with infant facing the left demonstrates the ACA coursing over the corpus callosum. Cursor is placed on the pericallosal artery demonstrating a normal RI for a term infant measuring 0.73. (*B*) Coronal view with cursor placed on the peripheral left MCA demonstrating a normal RI of 0.66. (*C*) Sagittal view using a linear transducer demonstrates flow in small cortical veins draining into the superior sagittal sinus (*arrowheads*).

perpendicular in this plane, frequency shifts can approach zero and Doppler signal is thus poor.

Proper technique includes adjusting color gain to maximize vascular signal and minimize tissue motion artifacts. The lowest band pass filter should be used to maximize low flow sensitivity when evaluating venous structures. Linear 7- to 15-MHz transducers are particularly useful in evaluating the sagittal sinus and vessels crossing the subarachnoid space (**Fig. 1**C).

Child

Once the anterior fontanelle closes, 3 cranial windows are available to insonate the intracranial circulation: the temporal bone, the orbit, and the foramen magnum.[12] The transtemporal approach is via the thin suprazygomatic portion of the temporal bone using a 2- to 3-MHz transducer cephalad to the zygomatic arch, anterior to the ear. On gray-scale imaging the heart-shaped cerebral peduncles are a useful landmark for identification. Anterior to the peduncles is the echogenic suprasellar cistern, where the circle of Willis lies. The MCA is seen as a vessel coursing toward the transducer (**Fig. 2**A). Deeper toward the midline, the bifurcation of the A1 ACA and the MCA can be identified with bidirectional flow (flow toward the transducer in the MCA and flow in the ACA away from the transducer [**Fig. 2**B]). As the transducer is angled anteriorly, flow from the ACA courses away from the transducer. The distal internal cerebral artery is inferior to the bifurcation with lower flow velocities than the MCA because of the larger angle of insonation. The posterior cerebral artery (PCA) is visualized as it circles around