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Validation of Transcranial Doppler Ultrasound with an In Vivo Stereotactic Technique

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Summary: Using an MR-guided stereotactic technique, we demonstrated that the points of insonation during transcranial Doppler examinations are the midpoints of the M1 and A1 segments of the middle and anterior cerebral arteries, respectively.

Index terms: Ultrasound, Doppler; Ultrasound, comparative studies; Brain, ultrasound; Magnetic resonance; Efficacy studies

Magnetic resonance (MR)-guided stereotactic techniques that allow precise in vivo anatomic location have recently been developed (1). Using such a system, we tested the hypothesis that we are insonating from the midpoints of the M1 segment of the middle cerebral artery and A1 segment of the anterior cerebral artery during clinical hand-held transcranial Doppler examinations. We also compared our routine maximum mean linear blood flow velocity (peak velocity) measurements with those obtained using the MR-guided stereotactic technique.

Methods

Transcranial Doppler studies were carried out on five healthy volunteers (mean age, 34.7 ± 6.7 years) with a hand-held 2-MHz pulsed-wave Doppler probe (Transpect, Medasonics, Fremont, Calif) using criteria for vessel identification detailed previously (2). The depth of insonation and peak velocity were recorded for each vessel.

Each subject was then fitted with a thermoplastic face mask. Transcranial Doppler studies were again performed using conventional MR-guided stereotactic technique with a Brown-Roberts-Wells (Radionics, Burlington, Mass) stereotactic head ring, a Cosman-Roberts-Wells (Radionics) arc frame, and a specially fabricated probe adapter. A 1.5-T MR instrument (General Electric Medical Systems, Milwaukee, Wis) was used to obtain contiguous 3- to 4-mm-thick gradient-echo images (34–51/13–15/2–4 [repetition time/echo time/excitations], 30° flip angle).

Results

All 20 vessels sought were found with both techniques. The mean difference between the hand-held and MR-guided stereotactic peak velocity of individual vessels ranged from 4.2 to 7.4 cm/s, whereas the mean difference in depth of insonation ranged from –0.8 to 1.2 mm.

There was no significant difference between the hand-held and MR-guided stereotactic depth of insonation for either the individual vessels or the aggregate. However, peak velocity aggregate data indicated that hand-held measurements were significantly yet systematically greater (5.6 cm/s) than MR-guided stereotactic measurements ($P = .0022$, Wilcoxon Signed-Rank Test).

In aggregate, the correlations between MR-guided stereotactic and hand-held depth of insonation and peak velocity were excellent ($r = .96$ and $r = .88$, respectively). Our aggregate data ($n = 20$) demonstrated a power of 80% to detect a difference in depth of 0.75 mm between the hand-held and MR-guided stereotactic techniques ($\Sigma = 4.22$ mm; $r = .96$).

Discussion

To identify a cerebral vessel confidently with conventional transcranial Doppler, one must know the cranial window used, the angle of insonation, the depth of the sample volume, the direction of flow in relation to the transducer, the spatial relationship of the vessel in reference to the bifurcation of the internal carotid artery, and the response to common carotid artery compression and/or oscillation maneuvers. These criteria seem to be adequate for experienced operators as evidenced by minimal intraob-

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server and interobserver variabilities (3). Anatomic studies in cadavers have been used to validate the transcranial Doppler examination (4, 5). There have been limited attempts to validate these criteria in vivo (6, 7). Recently, direct imaging of the basilar vessels with transcranial color duplex sonography has become possible (8).

The systematically greater peak velocity acquired with the hand-held technique in our study is probably secondary to small inaccuracies in location of coordinates with resultant sampling from off-center regions of vessel flow that have lower velocities.

In conclusion, we have confirmed that using traditional hand-held transcranial Doppler criteria, the midpoints of the M1 segment of the middle cerebral artery and the A1 segment of the anterior cerebral artery are reliably located.

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