Diagnosing Brain Death Using the Transcranial Doppler With a Transorbital Approach

Yair Lampl, MD; Ronit Gilad, MD; Yehiel Eschel, MD; Mona Boaz, PhD; Abraham Rapoport, MD; Menachem Sadeh, MD

**Background:** Transcranial Doppler is a sensitive instrument for the diagnosis of brain death. The guidelines for the determination of brain death include the demonstration of specific blood flow patterns in the anterior and posterior circulation systems. A limitation of this method is the frequent false finding of no flow, especially when using the transtemporal approach in older women.

**Objective:** To evaluate the efficacy of the transorbital approach in the diagnosis of brain death using transcranial Doppler.

**Methods:** A prospective controlled, diagnostic test study was performed. Transorbital, transtemporal, and transfornaminal approaches were used. Fifty-seven patients (29 men and 28 women; mean±SD age, 68.2±12.1 years) with clinically determined brain death were examined.

**Results:** In 45 patients, oscillatory flow or systolic spikes were found in all approaches. In 4 patients, no flow was detected. In 6 patients, oscillatory flow or systolic spikes were found in 2 approaches, including the transorbital one. In 2 patients, a positive finding was demonstrated only using the transorbital approach. Using the transorbital approach, the percentage of positive findings with definitive diagnoses of brain death rose from 79% to 88%.

**Conclusion:** The transorbital approach is a useful addition for the diagnosis of brain death, using the transcranial Doppler technique.

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**IN MODERN SOCIETY, brain death is accepted as an objective indicator of the end of life and is defined as the absence of all brain functions. Since 1994, the standards committees of various neurological societies have agreed that the burden of brain status determination is a clinical decision and have defined the use of laboratory examinations as confirmatory tests.** The specific patterns of blood flow found in brain death using transcranial Doppler (TCD) are a useful aid in the diagnosis of brain death. Nevertheless, the high percentage (10%-15%) of technical errors, in which no blood flow was observed, has limited the use of this test. No flow of the middle cerebral arteries may indicate total cessation of blood flow, or the blood flow may be indiscernible because of temporal bone thickness. According to the Task Force Group on cerebral death of the Neuroradiology Research Group of the World Federation of Neurology, the absence of signal represents a limitation of the method in most cases. The task force amended the defining criteria of brain death to include: “Systolic spikes or oscillating flow in any cerebral artery which can be recorded by bilateral transcranial in-sonation of ICA [internal carotid artery] and MCA [middle cerebral artery], respectively, and any branch or other artery which can be recorded (anterior and posterior circulation).” Nevertheless, the transorbital approach, which may be used for demonstrating a positive pattern flow in the anterior circulation arteries, is only sporadically adopted for the purpose of defining brain death.

The aim of the study was to evaluate whether routine additional use of the transorbital approach in all patients suspected of brain death after undergoing TCD might increase the efficacy of the examination and decrease the frequency of inconclusive results.

**RESULTS**

Fifty-seven patients (29 men and 28 women) were examined. Their mean±SD age was 68.2±12.1 years (range, 38-91 years): men, 66.2±11.9 years (range, 38-91 years) and women, 71.1±10.3 years (range, 42-90 years). The interobserver reliability κ was 0.91.
PATIENTS AND METHODS

All patients with clinically determined brain death at The E. Wolfson Medical Center, Holon, Israel, between January 1994 and December 1999 were examined. The examinations were performed according to the guidelines for determining brain death, and all patients met the criteria for the definition of brain death. The TCD examination was performed according to the policy set forth by the medical center's brain death committee for use in these situations. A determination of death was required in cases of organ donor use or other similar purposes. The cause of deep coma had been established and was sufficient to account for a permanent loss of brain function. Patients with intoxication, hypothermia, or hypotension (systolic blood pressure <60 mm Hg) were excluded.5 Using the TCD, each patient was examined separately for 30 minutes and then at 5-minute intervals by 2 staff members (1 technician and 1 physician [Y.L.]) familiar with the method for evaluating brain death. Blood flow velocities were measured by transcranial (middle cerebral artery at a depth of 50-55 mm laterally), transforaminal (vertebral and basilar arteries at a depth of 60-100 mm), and transorbital (at a depth of 55-70 mm laterally) approaches. Abnormal flow patterns were an oscillating flow and systolic spike pattern (positive pattern) or no flow. Insonation was accomplished using a 2-MHz transducer with 100% power (Intra-View; Rimed, Raanana, Israel). Because transorbital insonation was used with 100% power, signed consent was obtained from the patients' family members.

Data were stored on a spreadsheet with Hebrew language support (Excel 97; Microsoft, Seattle, Wash). Analysis of data was carried out using commercially available software (STATISTIX, version 4.0; Analytical Software Co, La Jolla, Calif). Age is reported as mean ± SD. Frequency counts for all other data were obtained. The transorbital approach was compared independently with every other approach using the χ² test for homogeneity. In cases with expected low frequencies, the Fisher exact test was used. For each test, total observed agreement and κ were calculated. All differences were considered significant at P<.05.

In 45 patients (25 men and 20 women), oscillating flow or systolic spikes were found in all approaches. In 4 patients (2 men and 2 women), no flow was detected in all of the tests. In 3 patients (all women), oscillating flow or systolic spikes were found only in the transorbital and transforaminal approaches; in 1 man, only in the transorbital and transtemporal approaches; and in 2 patients (1 man and 1 woman), only in the transorbital approach (Table). In all subjects, the diagnosis was confirmed by the recording of extracranial bilateral signals of anterior and posterior circulation. The observed agreement between the transorbital and transtemporal approaches was 0.96 (P=.008, κ=0.78). The observed agreement between the transorbital and the transforaminal approaches was 0.92 (P=.02, κ=0.63).

<table>
<thead>
<tr>
<th>Patients</th>
<th>Transtemporal</th>
<th>Transforaminal</th>
<th>Transorbital</th>
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<tbody>
<tr>
<td>Men (n=29)</td>
<td>+</td>
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<td>+</td>
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<tr>
<td>25 (86)</td>
<td>+</td>
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<td>1 (3)</td>
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<td>1 (3)</td>
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<td>2 (7)</td>
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<tr>
<td>Women (n=28)</td>
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<tr>
<td>20 (71)</td>
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<td>5 (18)</td>
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<tr>
<td>1 (4)</td>
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<tr>
<td>2 (7)</td>
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</table>

*Data are given as number (percentage) unless otherwise indicated. Percentages of men do not sum to 100 because of rounding. + indicates presence of oscillatory flow or systolic spikes; −, no flow.

Transcranial Doppler is an additional method to evaluate brain death. In its consensus statement, the American Academy of Neurology stated the limitations of its efficacy. Researchers have noted the necessity of finding a suitable blood vessel in the anterior circulation for diagnosing brain death but have not developed the appropriate technical approach. The efficacy of TCD for diagnosing brain death is uncertain, and the results are controversial. Some authors have reported a sensitivity in the range of 100%, and others between 90% and 95%. Still, other researchers conclude that use of TCD in determining brain death has only questionable efficacy and that other methods are superior in the final diagnosis of brain death.

Transcranial Doppler offers high sensitivity and specificity for a positive pattern of systolic spikes and oscillating flow. However, because of the difficulty in penetrating the temporal bone barrier with TCD, 10% to 15% of results have demonstrated a false finding of no flow. To resolve this, an extracranial (internal carotid artery) examination was included for diagnosing brain death. The aim of this study was to determine whether incorporating the transorbital approach increased the sensitivity and specificity of TCD in confirming brain death.

The results of the study demonstrated a positive pattern in all approaches, with the transorbital approach showing 79%. The high percentage of no flow in our study (5.5% in all approaches and 15% in the transtemporal approach) can be explained by the inclusion of patients older than 90. Our patients were 2 decades older compared with the mean age in studies reporting high sensitivity. Previous investigations that included an older age sample demonstrated a higher percentage of no-flow results, especially using the transtemporal approach. In our study, we also found a greater percentage of brain death patterns in the anterior and posterior circulation systems using the transorbital approach, increasing from 79% (45/57) to 88% (50/57), consistent with the definition of brain death. Comparing the percentage of positive patterns in at least one system, the percentage rose from 89% (51/57) to 93% (53/57).

The significant differences among women with the transorbital approach compared with the other ap-
proaches is consistent with the common finding of a higher percentage of women with no-flow findings on the transtemporal approach, reaching up to 10% to 15%, depending on age- and control-matched ethnicity. This may suggest a greater importance in using the transorbital approach in women. In addition, the inclusion of older patients in our study renders its findings relevant to the question of organ donation for transplantation. Modern medicine is increasingly unsure about its role at the end of life. Determination of brain death will become more relevant as the population ages.

In conclusion, the results of our study indicate that the transorbital approach may increase the efficacy of TCD in diagnosing brain death. The interobserver coefficient correlation was high, indicating that examination by only 2 observers can confirm brain death in the case of generally decreased blood flow.

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Author contributions: Study concept and design (Dr Lampl); acquisition of data (Drs Lampl, Gilad, Eschel, Rapoport, and Sadeh); analysis and interpretation of data (Drs Lampl, Boaz, and Sadeh); drafting of the manuscript (Drs Lampl, Eschel, and Rapoport); critical revision of the manuscript for important intellectual content (Drs Lampl, Boaz, and Sadeh); statistical expertise (Drs Lampl and Boaz); obtained funding (Drs Lampl, Gilad, and Sadeh); Administrative, technical, and material support (Drs Lampl, Eschel, Gilad, and Rapoport); study supervision (Dr Lampl).

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REFERENCES