Orbital Doppler Sonography and Documentation of Brain Death

G Litscher

Citation

Abstract
Multiparametric confirmatory tests for documentation of brain death were studied from a 24-year-old subject with clinically defined brain death after severe head injury. The importance of transorbital ultrasound Doppler sonographic measurements is discussed.

INTRODUCTION
In recent years, fewer organs have been available for explantation eventhough new biomedical devices for confirmatory testing and determination of brain death have been developed [123456789]. Brain death or cerebral death is defined as irreversible cessation of all brain functions. However, it is difficult - indeed, impossible - to provide diagnostic standards for a condition that has never been adequately defined [9]. The documentation of brain death is primarily based on clinical criteria from neurologic examinations. In addition, tests including EEG recordings, evoked potentials, cerebral angiography, cerebral scintigraphy and more recently, transcranial Doppler ultrasonography (TCD), near infrared spectroscopy (NIRS) and heart rate variability, are used to document the dynamics of cerebral circulatory arrest [101112131415161718].

The aim of this present study was to examine transorbital and transtemporal Doppler sonographic recordings during the development of brain death in a 24-year-old patient.

MATERIALS AND METHODS
SUBJECT
A 24-year-old male subject from the intensive care unit with clinically defined brain death after severe head injury was investigated using combined multiparametric biosignal recordings. The study was approved by the ethics committee of the University of Graz (10-055 ex 99/00).

MULTIDIRECTIONAL TRANSORBITAL AND TRANSCRANIAL DOPPLER SONOGRAPHY
Transorbital and transtemporal Doppler sonographic examinations were performed with a portable Multi-Dop T unit (DWL Electronic Systems GmbH, Sipplingen, Germany). A 4 MHz and a 2 MHz probe were used in a multidirectional ultrasound probe holder construction (Fig. 1). The monitoring arrangement for simultaneous recording of Doppler sonographic signals in the ophthalmic artery (OA) and the middle cerebral artery (MCA) was stationary at the circumference of the head. Blood flow profiles in the OA were measured transorbitally. Under acoustic control, the angle and position of the probes were adjusted until the greatest possible signal amplitude was reached.

Figure 1
Figure 1: Biomedical devices for confirmatory testing of brain death including multidirectional ultrasound probe holder construction.
BIOELECTRICAL BRAIN ACTIVITY

Electroencephalography remains one of the most well-validated confirmatory tests. Recordings were obtained for 30 minutes with a 12-channel instrument (Picker Internat. GmbH, Schwarzer ED14, Munich, Germany).

RESULTS

CASE REPORT

A 24-year-old man fell from a height of 4 m and hit a cement block with his head. He was found at the accident site gasping for air. The patient was intubated and respirated upon admittance to the intensive care unit. Pupils were bilaterally anisocor and not reactive to light. Brain stem areflexia was present. The first results from CT of the head revealed fractures on the occipital left, subarachnoid hemorrhage, brain edema and tentorial herniation. The patient showed clinical signs of brain death.

Instrumental tests showed the following results: Electrical activity was at lower levels than 2 µV with the instrument set shown in Figure 2. Transcranial Doppler sonography showed a bilateral oscillating flow in the middle cerebral artery (Fig. 3a). A residual flow profile was still detectable on both sides transorbitally (Fig. 3b).

Since residual flow could be detected orbitally, cerebral angiography was performed. This showed that the internal carotid artery was poorly perfused on both sides. The right internal carotid artery was occluded distal from the perfused ophthalmic artery, the left middle cerebral artery was poorly perfused. At the same time, missing perfusion of the cerebral anterior artery, the basilar artery and the right middle cerebral artery was visible (Fig. 4).

DISCUSSION

The EEG is considered a highly sensitive method for documenting brain death and evaluating cerebral cortical function. For determining brain death this method is the most commonly used confirmatory electronic test in Europe.
However, comparability and validity is influenced by different technical problems and varying evaluative criteria. We must consider, that cerebral activity may be detectable even when brain stem functions are missing, which can also be reflected in EEG activity.

Brain death is given, when irreversible loss of entire cerebral function occurs. The definite, clinical diagnosis of brain death does not require an isoelectric EEG. On the other hand, angiographically detectable, remaining circulation can be present despite isoelectric EEG and missing brain stem potentials, which indicates that presumable cerebral functions are given by cerebral blood flow [1].

New developments in the field of biomedical engineering enable us to accurately register bioelectric activity in the intensive care unit, despite massive interference, in dimensions which were not determinable thus far. Within case reports, our research group recently referred to the problems in defining an "isoelectric" EEG [7].

To our knowledge, there are only two reports dealing with transorbital Doppler sonography and brain death.

Karaali et al. [13] investigated the blood flow velocity changes in orbital arteries by using TCD in 8 patients with brain death. Because of the technical difficulty, this method does not seem to be practical for routine application [13]. Nonetheless, it may be used as an alternative non-invasive method when Doppler studies of the carotid arteries are not adequate due to limiting conditions, such as open wounds, presence of vascular catheters, or large cervical hematomas.

Lampl et al. [18] performed a prospective controlled diagnostic study using transorbital, transtemporal, and transforaminal approaches. Fifty-seven patients with clinically determined brain death were examined. In 2 patients, a positive finding was demonstrated only using the transorbital approach.

In brain death transcranial Doppler offers high sensitivity and specificity for a pattern of systolic spikes and oscillating flow. However, due to the difficulty in penetrating the temporal bone barrier with TCD, 10 - 15 % of the results have demonstrated a false finding of no flow [18]. Incorporating the transorbital approach could increase the sensitivity and specificity of TCD confirming brain death [18] or could exclude the diagnosis of brain death as shown by the present case report.

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CORRESPONDENCE TO

Gerhard Litscher, PhD Department of Biomedical Engineering and Research in Anesthesia and Critical Care University of Graz Auenbruggerplatz 29 A-8036 Graz Austria Tel.: +43 316 385-3907; -83907 Fax: +43 316 385-3908 gerhard.litscher@uni-graz.at
http://www.neuromonitoring.org

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Author Information
Gerhard Litscher, Ph.D.
Department of Biomedical Engineering and Research in Anesthesia and Critical Care, University of Graz