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The role of color duplex sonography in the brain death diagnostics

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Summary In Russia brain death diagnostic is still under great public attention. In such environment confirmatory tests are absolutely necessary. Aim of our study is to investigate the cerebral blood flow in brain death using color-coded duplex sonography. The sonographic study of 20 patients with brain death was performed and included transcranial and extracranial color duplex sonography. All patients were untapered. The following parameters were measured – presence of reverberating flow, Vmax ranges.

Results: At baseline TCDS revealed both MCA in all patients, and the BA in 18 patients. Oscillating flow with Vmax -32 ± 12 sm/s in MCA was found. Reverberating flow in the proximal segment of ICA and in the V2 segment of VA was found in all patients. Vmax ranges were 96 ± 27 sm/s in ICA and 58 ± 17 sm/s in VA. After 6 h TCDS was successful in 16 patients. In all of 16 cases blood flow in the MCA as a systolic peak or reverberating flow was detected. Basilar system study was successful in 12 cases. In all vessels blood flow was as systolic peaks.

Extracranial ICA and VA were visualized in all cases. In the ICA and V2, V3 segments of the VA reverberating flow were detected. Vmax was 47 ± 25 sm/s in ICA and 35 ± 17 sm/s in VA. In BD color duplex scanning reveals oscillating flow or systolic spikes in distal ICA, VA, intracranial vessels. In TCDS, the most common finding is MCA with reverberating flow. The optimum combination is extracranial and intracranial scanning in the early stages of BD.

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Introduction

The brain death (BD) is defined as the irreversible loss of function of the brain, including the brainstem, developing on the assumption of pulmonary ventilation and heart

beating. The BD is diagnosed in intensive care units (ICU) as a result of severe brain damaging and causes at least 10% of mortality in ICU in developed countries. Traumatic brain injury, malignant stroke, tumor, diffuse hypoxic–ischemic brain damage are supposed to be the main causes of BD. All these factors affect the brain and lead to brain edema and swelling, intracranial pressure increase, gradual reduction of cerebral perfusion pressure, decrease and termination of intracranial blood flow and necrosis of brain parenchyma up to 2nd cervical segment [1–3].

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According to the Russian National Guidelines of BD there are Diagnostic criteria for clinical diagnosis of BD [4]:

1. Defined cause irreversible deep coma.
2. Exclusion of complicating medical conditions that may confound clinical assessment (absence of hypothermia, drug intoxication, severe electrolyte and endocrine disturbance).
3. Systolic blood pressure ≥ 90 mm Hg.
4. Absence of brainstem reflexes.
5. Mydriasis with no response to the bright light.
6. Apnea with arterial $pCO_2 \geq 60$ mm Hg.
7. The observation period of 6 and 24 h with the primary and secondary brain injury respectively.

In general, these criteria correspond to neurologic criteria for the diagnosis of brain death of American Academy of Neurology [2,5].

The following two confirmatory tests are approved for BD diagnosis in Russia:

1. Electroencephalography (EEG) – reveals no electrical activity of brain in BD patients.
2. Cerebral angiography – detects cerebral blood arrest in BD patients.

Angiography is believed to reduce the observational period only and does not substitute to any clinical criteria of BD. According to the Russian National Guidelines on Diagnostics of Brain Death, ultrasound confirmatory tests are being investigated and can not be recommended for BD diagnosis, at the same time, all over the world ultrasound tests are the 3rd in order of sensitivity and frequency for BD diagnostics [6,7]. Transcranial Doppler (TCD) is notably desirable in patients in whom specific components of clinical testing cannot be reliably performed or evaluated such as barbiturate brain protection, hypothermia or face trauma [8–10].

Our department has gained experience in ultrasonography in clinical and confirmatory tests, 438 cases of BD were diagnosed since January 1995 to December 2010 [11]. The diagnosis of BD was confirmed by TCD and EEG. Color duplex sonography (CDS) was started to be performed in 2009.

We initiated a prospective observational study of the extra- and intracranial artery CDS in BD diagnostics in 2009. 20 patients with BD have been enrolled in the study up to December 2010. The study was approved by Local Ethic Committee of Moscow State University for Medicine and Dentistry in 2008.

The aim of the study was

- to investigate whether CDS of both extra- and intracranial arteries increases sensitivity of the test in patients with BD compared with CDS of intracranial arteries alone;
- to clarify CDS criteria of circulatory blood arrest.

Materials and methods

The study was started in Moscow hospital intensive care units in 2009 and has still been going on.

20 patients with BD due to traumatic brain injury and intracranial hemorrhage were included in the study and

Table 1 Systolic velocity ranges in extra- and intracranial arteries.

Systolic velocity	ICA (sm/s)	VA (sm/s)	MCA (sm/s)	BA (sm/s)
1st exam	96 \pm 27	58 \pm 17	32 \pm 12	38 \pm 9
2nd exam	47 \pm 25	35 \pm 17	15 \pm 8	21 \pm 7

underwent a sonographic study which included color duplex sonography (CDS) of extracranial and intracranial arteries.

BD was diagnosed according to the Russian National Guidelines of BD. The average age of patients was 25 \pm 5.4 years. The average time from ICU admission to BD development was 27 \pm 6.5 h. The diagnosis of traumatic brain injury and intracranial hemorrhage was detected by computer tomography at the admission. All the patients had severe diffuse brain injury with the transverse and axial dislocation. Craniotomy was not carried on.

The sonographic study was performed according to the Rules of Task Force Group on Cerebral Death of Neurosonology Research Group of the World Federation of Neurology [12].

The following criteria of the test were mandatory:

1. The investigation of anterior and posterior circulation.
2. Bilateral visualization of intracranial internal carotid artery branches.

The study was conducted on a portable device Sonosite Micromaxx (USA) with broadband transducers L5–10 MHz, P1–5 MHz twice: at baseline after assessment of clinical criteria of BD and 6 h later. Presence of reverberating flow, Vmax ranges, presence of midline shift in B mode were also measured.

Results

At baseline CDS revealed both MCA (right and left) in all 20 patients, both ACA in 16 patients and BA in 18 patients. Oscillating flow with Vmax -32 ± 12 sm/s in MCA was found.

Data of extra- and intracranial artery and blood flow rates are presented below (Tables 1 and 2).

A midline shift 4–10 mm in B-mode was noted in 13 patients and it made artery differentiation difficult.

Reverberating flow in the proximal segment of ICA and in the V2 segment of VA was found in all patients.

Vmax ranges were 96 \pm 27 sm/s in ICA and 58 \pm 17 sm/s in VA respectively.

Reverberating and oscillating flow of intracranial and extracranial artery are presented in Figs. 1–4.

Table 2 Visualization frequency of extra- and intracranial arteries (n = 20).

N = 20	MCA	ACA	PCA	BA	VA V2	ICA prox
1st exam	20	16	15	18	20	20
2nd exam	16	11	5	12	20	20

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