Ultrasonography of the optic nerve sheath in brain death

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Summary Evaluation of optic nerve sheath by means of optic nerve ultrasonography (ONUS) is a reliable tool for assessment of patients with increased intracranial pressure. The aim of this study was to present the usefulness of optic nerve sheath ultrasonography in patients with brain death.

Ten patients with brain death as a result of traumatic or non-traumatic causes were evaluated by ONUS. Optic nerve sheath diameter (ONSD) was measured with a 12 MHz linear ultrasound probe (Terason T3000, Teratech Corporation, USA). The probe was adjusted to give a suitable angle for displaying the entry of the optic nerve into the globe, at the depth of 3 mm behind the globe. For each optic nerve four measurements were made, twice in transversal and twice in sagittal plane, by rotating the probe clockwise. Mean ONSD for brain death patients were compared with mean ONSD of 17 healthy controls.

Ten individuals (7 males) with confirmed brain death (5 due to neurotrauma, 2 due to subarachnoid hemorrhage, 2 as a result of ischemic strokes and one of parenchymal hemorrhage), were evaluated. On the left side mean ONSD was 0.71 ± 0.06 cm on transversal plane and 0.72 ± 0.04 cm on sagittal plane. On the right side mean ONSD was 0.73 ± 0.05 cm on transversal plane and 0.73 ± 0.06 on sagittal plane. In controls left mean ONSD was 0.51 ± 0.05 cm on transversal plane and 0.55 ± 0.06 cm on sagittal plane. On the side right mean ONSD was 0.52 ± 0.05 cm on transversal plane and 0.54 ± 0.07 on sagittal plane. Mean ONSD in brain death was 0.72 ± 0.05 cm and 0.53 ± 0.06 cm in controls (p < 0.01).

Measurements of ONSD may be useful in distinguishing brain death persons from healthy controls.
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Introduction

Detection of increased intracranial pressure (ICP) is associated with poor outcome and therefore important in neurocritical care. Although invasive ventricular devices are the gold standard for continuous and reliable measurement of ICP, its placement could be challenging due to lack of immediate surgical availability, and their malfunction or obstruction has been reported. Transcranial Doppler sonography (TCD) is a suitable bedside method for daily assessment of the changes of ICP by continuous monitoring of the changes of blood flow velocities and pulsatility index, reflecting decreases in cerebral perfusion pressure due to increases in ICP [1]. However, its usage is restricted in patients with insufficient temporal bone windows. Non-invasive ocular ultrasonography has recently been proposed to detect elevated ICP, since the retrobulbar segment of the optic nerve is surrounded by a distensible subarachnoid space which can inflate during increase in cerebrospinal fluid pressure. Clinical studies have suggested that sonographic measurements of optic nerve sheath diameter correlate with clinical signs of increased intracranial pressure, and this technique could serve as a screening test in patients at risk for increased ICP, when invasive monitoring is not possible or is not clearly recommended [2–6].

Brain death is a clinical diagnosis developing after different pathological processes causing brain edema and raised ICP that finally lead to brain incarceration. As a result of extreme increased ICP, brain perfusion will cease, that is typically visualized as a stop of the contrast medium at the skull base on angiography. Several tests showing the cessation of brain perfusion are available like angiography, CT angiography, MR angiography and TCD [7,8].

The aim of this study was to present the usefulness of optic nerve sheath ultrasonography in patients with brain death.

Patients and methods

Ten patients with brain death as a result of traumatic or non-traumatic causes were evaluated by ONUS. Optic nerve sheath diameter (ONSD) was measured with a 12 MHz linear ultrasound probe (Terason T3000, Teratech Corporation, USA). The probe was adjusted to give a suitable angle for displaying the entry of the optic nerve into the globe, at the depth of 3 mm behind the globe (Fig. 1). For each optic nerve four measurements were made, twice in transversal and twice in the sagittal plane, by rotating the probe clock-wise. Mean ONSD for brain death patients were compared with mean ONSD of 17 healthy controls (Fig. 2).

Data are presented as means and SD. Intergroup comparison was performed by Student’s t-test.

Results

There were 10 patients (7 males) with confirmed brain death (5 due to neurotrauma, 2 due to subarachnoid hemorrhage, 2 as a result of ischemic stroke and one of parenchymal hemorrhage). Mean height was 163 ± 7 cm for females, and 179 ± 7 cm for males. Mean weight was 75 ± 13 kg in females and 86 ± 8 kg for males. Mean body mass index (BMI) was 26.7 ± 23.3.

There was no difference of measurements of mean ONSD between left and right eye in brain death persons or between measurements of mean ONSD between left and right eye in controls (Table 1). There was no difference of measurements...
of mean ONSD either in left or right eye between measurement in transversal and sagittal plane in brain death persons or in between these two types of measurement of controls respectively (Table 1). Brain death persons have statistically significant wider mean ONSD measurements compared to measurements in controls with no overlapping of results (0.72 ± 0.05 vs 0.53 ± 0.06, p < 0.01) (Table 1).

### Discussion

Brain death is a condition of extreme increase of intracranial pressure. Therefore we found statistically significant wider mean ONSD compared to controls. Up to now there was no report of ONSD in patients with brain death. Increased mean ONSD measurements were found in patients with increased ICP due to severe neurotrauma, or patients with spontaneous subarachnoid hemorrhage, intracranial hematoma or stroke. These patients had a mean ONSD of 5.99 ± 0.4 mm [6] and 6.3 ± 0.6 mm [4]. At the same time healthy controls had a mean ONSD of 5.1 ± 0.7 mm [4]. In our group of patients the same disease were the one leading to brain incarceration and finally to brain death. In our group we found a mean ONSD of 0.72 ± 0.05 cm. There was no difference if the measurement was performed in longitudinal or sagittal plane. Such measurements showed even wider ONSD compared to previously published results of patients with increased ICP [4–6]. At the same time, we found mean ONSD in controls 0.53 ± 0.05 cm, similar to previous published results of control subjects [4].

The optic nerve is a part of the central nervous system, surrounded by a subarachnoid space. The intraorbital part of the subarachnoid space is distensible and can therefore inflate if pressure in cerebrospinal fluid increases. Although there are limited reports on the values of ONSD and ONSD measurement by ultrasonography and no standardized values for healthy subjects, they usually have mean ONSD about 0.5 cm. In previous published results values of ONSD less than 5.8 mm were not likely to be associated with ICP increase above 20 mm Hg. Changes in ONSD are also strongly related to ICP changes. In patients with increased ICP mean ONSD were above 5.8 mm, and we found mean ONSD in brain death even higher, about 7.2 ± 0.5 mm. Such results are the consequence of extreme further increase of ICP in these persons due to brain incarceration.

The main limitation of this study was that all patients did not have invasive ICP monitoring to compare it with the results of ONSD. Also, some patients with neurotrauma had also ocular injury, disabling distinct demarcation of the optic nerve and optic nerve sheath, leading to some dispersion of results.

### Conclusion

ONSD may be useful in distinguishing brain death persons from healthy controls.

### References