



Bedside Ultrasonography of the Optic Nerve Sheath in Brain Death

Mehmet Akif Yazar*

Anesthesiology and Reanimation, Ministry of Health, Nevşehir Public Hospital, Nevşehir, Turkey

ABSTRACT

Increased intracranial pressure has successfully been detected by using bedside optic nerve sheath diameter (ONSD) ultrasonography. ONSD ultrasonography has become one of the current methods used to detect potential brain death in recent years. In this study, we carried out ONSD ultrasonography for patients who were diagnosed with brain death and in comatose state. Mean ONSD values obtained from the patients with brain death were compared with ONSD values of patients in a comatose state. There was no significant difference between the mean ONSD values of the right and left eye and no significant difference in transverse and sagittal plane measurements in all groups. Mean ONSD values of Group BD were significantly higher than both Group CT ($P < .05$) and Group CM values ($P < .05$). Some of the patients with a history of intracranial hemorrhage, subdural hematoma, or traumatic brain injuries who remain in a comatose state in intensive care units may ultimately result in brain death. Therefore, it may be kept in mind that intermittent ONSD measurements of patients in deep comas might have an important role for diagnosing brain death early for purposes of cadaveric organ donation. In conclusion, transorbital ONSD measurement using bedside ultrasonography, an inexpensive, comfortable, and noninvasive test for patients in deep comas, may be helpful in determining potential brain death.

BRAIN death is defined as the irreversible cessation of all functions of the entire brain, including the brain stem [1]. The diagnosis of brain death can usually be made based on the physical examination. Brain stem reflexes, such as pupillary light, corneal, oculocephalic, oculovestibular, oropharyngeal, and respiratory reflexes are absent [2]. Brain death involves different pathologic processes that cause brain edema and increase intracranial pressure, which ultimately lead to brain incarceration. As a result of extreme increased intracranial pressure, brain perfusion will cease; this is typically visualized as a halting of the flow of contrast medium at the skull base on angiography. Several tests showing the cessation of brain perfusion are available like angiography, computed tomography angiography, and magnetic resonance imaging angiography [3]. Other confirmatory methods are based on the evaluation of cerebral blood flow alterations. Doppler sonography is one of these methods that reveals blood flow velocity changes of the carotid arteries and internal cerebral circulation [4].

Increased intracranial pressure has successfully been detected by using optic nerve sheath diameter (ONSD) ultrasonography [5]. Its use in screening for and ruling out

intracranial pressure elevations has widely been studied and promoted. Hence, ONSD ultrasonography has become one of the current methods used to detect potential brain death in recent years. In this study, the aim was to evaluate the usefulness of ONSD measurement by bedside ultrasonography in cases of brain death diagnosis in the intensive care unit (ICU).

PATIENTS AND METHODS

We divided patients into 3 groups. Fifteen patients who were declared brain death (Group BD), 15 deeply comatose patients with a Glasgow Coma Scale score of 3 (Group CM), and 15 patients for the control group (Group CT) were included in the study. The patients in Group CM have been monitored in the ICU because of intracranial hemorrhage, ischemic stroke, or brain injury but did not yet have any findings of brain death. The patients in Group CT were

*Address correspondence to Mehmet Akif Yazar, MD, Ministry of Health, Nevşehir Public Hospital, Nevşehir, Turkey. Tel.: +90 384 228 505; Fax: +90 384 228 5151. E-mail: makifyazar@hotmail.com

Table 1. Demographic Data of Groups

Patient No.	Control Group (n = 15)			Comatose Group (n = 15)			Brain Death Group (n = 15)		
	Sex	Age, (y)	Cause of ICU Admission	Sex	Age, (y)	Cause of ICU Admission	Sex	Age, (y)	Cause of ICU Admission
1	M	65	Limb trauma	M	65	Stroke	M	48	Subarachnoid hemorrhage
2	M	70	Postoperative ileus surgery	M	70	Subarachnoid hemorrhage	M	74	Stroke
3	F	76	COPD	F	55	Intracranial hemorrhage	M	25	Drug intoxication
4	M	42	Renal Failure	M	51	Intracranial malignancy	F	51	Stroke
5	F	67	COPD	F	53	Stroke	M	53	Subarachnoid hemorrhage
6	M	61	Postoperative Intestine surgery	M	61	Subarachnoid hemorrhage	M	41	Subarachnoid hemorrhage
7	F	71	Postoperative ileus surgery	F	71	Stroke	M	43	Pneumonia
8	M	56	Renal Failure	M	26	Diffuse axonal injury	M	56	Subdural Hematoma
9	M	36	Limb trauma	M	36	Intracranial hemorrhage	F	60	Stroke
10	M	86	Postoperative hip surgery	M	58	Stroke	M	63	Stroke
11	F	72	Postoperative hip surgery	F	69	Stroke	F	72	Stroke
12	F	59	Cirrhosis	F	59	Stroke	M	18	Subarachnoid hemorrhage
13	F	68	COPD	F	57	Subarachnoid hemorrhage	M	19	Subarachnoid hemorrhage
14	F	62	COPD	F	53	Intracranial hemorrhage	F	30	Subarachnoid hemorrhage
15	M	80	Postoperative hip surgery	M	80	Stroke	M	17	Subarachnoid hemorrhage

Abbreviations: COPD, chronic obstructive pulmonary disease; F, female; ICU, intensive care unit; M, male; No., number.

undergoing a cure to the ICU for another disease such as renal failure or postoperative surgery aside from an intracranial event.

ONSD was measured with a 12-MHz IOT332 linear ultrasound probe (Esaote SpA, Via di Caciolle, Italy). Measurements were performed by both an intensive care physician and a radiologist, and the average values were recorded. The probe was placed on the eye surface at an appropriate angle in order to display the optic nerve entering into the globe. Both transverse and sagittal plane ONSDs were recorded for both eyes. Mean ONSD values obtained from patients with brain death were compared with ONSD values of patients in comas.

SPSS 13.0 statistical package (IBM, Armonk, New York, United States) was used for analysis of data. The data were given as mean and SD at 95% confidence interval. Student *t* test and Mann-Whitney *U* tests were used accordingly to compare groups in terms of normal distribution and nonparametric measurements, respectively.

RESULTS

Mean age in years \pm standard deviation (SD) of 15 patients with brain death (8 men) was 44.67 ± 18.59 . The most common cause of brain death was subarachnoid hemorrhage (53.3%) in this group. Mean age in years \pm SD of Group CM (8 men) was 57.60 ± 13.14 . The most common cause of deep coma was a stroke (46.6%). Mean age in years \pm SD of Group CT (8 men) was 64.73 ± 12.70 . Demographic data and indications for admission to ICU in each group are presented in Table 1. In all groups, there was no significant difference between the mean ONSD values of the right and left eyes and

there was no difference in the mean ONSD values when measured in the transverse and sagittal planes. Mean ONSD values of Group BD were significantly higher than Group CT ($P < .05$). Mean ONSD values of Group BD were significantly higher than Group CM values ($P < .05$). Mean ONSD values are presented in Table 2.

DISCUSSION

Traumatic brain injury or anoxia can cause significant brain edema [6]. Hence, brain death is a condition of significantly increased intracranial pressure. Also, when the increase in intracranial pressure exceeds the mean arterial pressure, there is no longer cerebral perfusion pressure and cerebral perfusion stops. This condition causes infarction in the brain and brainstem in the short term [7]. Therefore, in cases of brain death, which is the complete infarction of the brain and brainstem, the increase of ONSD is not surprising. One study showed this increase by comparing brain death cases with healthy subjects [8]. Topcuoglu et al reported the relationship between ultrasonographic ONSD measurements of patients in comas and patients with brain death [9]. In our study, ONSD values in brain death cases were higher in comparison with patients in deep comas.

ONSD is approximately 5 mm in healthy individuals [10]. Unlike other studies, our control group has patients thought to have no increased intracranial pressure, and ONSD values of the control group were consistent with those of

Table 2. Comparison of ONSD Among the Control Group, Coma Group, and Brain Death Group

	Control Group (N = 15)		Comatose Group (N = 15)		Brain Death Group (N = 15)	
	Left	Right	Left	Right	Left	Right
Mean ONSD (cm) in the transversal plane \pm SD	5.07 \pm .32	5.03 \pm .34	6.98 \pm .38	6.98 \pm .36	7.53 \pm .29	7.56 \pm .29
Mean ONSD (cm) in the sagittal plane \pm SD	5.13 \pm .33	5.06 \pm .33	7.01 \pm .49	7.00 \pm .46	7.55 \pm .30	7.58 \pm .32
Mean ONSD (cm) \pm SD	5.07 \pm .32		6.99 \pm .42		7.55 \pm .29	

Abbreviation: ONSD, optic nerve sheath diameter.

healthy individuals in the literature. In patients in a comatose state, these values may be high due to an intracranial event [11]. The ONSD values of the patients in comas in our study were significantly higher than in the patients in the control group.

Some of the patients in comas with intracranial hemorrhage, subdural hematoma, or traumatic brain injuries in ICUs may result in brain death. In our study, the ONSD values of brain death cases were significantly higher than those of patients in a comatose state. Therefore, intermittent ONSD measurements of patients in deep comas might have an important role for diagnosing early brain death for cadaveric organ donation.

The main limitation of this study was that there were 2 patients with facial trauma including orbital fracture. Transorbital ONSD measurements were carried out in these patients, but ONSD values might have been affected by facial trauma.

In conclusion, transorbital ONSD measurement using bedside ultrasonography, which is an inexpensive, easy, and noninvasive test for use on patients in deep, comatose states, may be helpful in determining potential brain death.

REFERENCES

- [1] President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research. Defining death: a report on the medical, legal, and ethical issues in the determination of death. Washington: US Government Printing Office; 1981.
- [2] Guidelines for the determination of death: report of the medical consultants on the diagnosis of death to the President's Commission for the Study of Ethical Problems in Medicine and Biomedical and Behavioral Research. *JAMA* 1981;246:2184–6.
- [3] Lovrenčić-Huzjan A, Vuković V, Jergović K, Demarin V. Transcranial doppler as a confirmatory test in brain death. *Acta Clinica Croatica* 2006;45:365–73.
- [4] Payen DM, Lamer C, Pilorget A, Moreau T, Beloucif S, Echter E. Evaluation of pulsed Doppler common carotid blood flow as a noninvasive method for brain death diagnosis: a prospective study. *Anesthesiology* 1990;72:222–9.
- [5] Blaivas M, Theodoro D, Sierzewski PR. Elevated intracranial pressure detected by bedside emergency ultrasonography of the optic nerve sheath. *Acad Emerg Med* 2003;10:376–81.
- [6] Sekhon MS, McBeth P, Zou J, Qiao L, Kolmodin L, Henderson WR, et al. Association between optic nerve sheath diameter and mortality in patients with severe traumatic brain injury. *Neurocritical Care* 2014;21:245–52.
- [7] Sullivan J, Seem DL, Chabalewski F. Determining brain death. *Critical Care Nurse* 1999;19:37.
- [8] Lovrencic-Huzjan A, Simicevic DS, Popovic IM, Puretic MB, Cvetkovic VV, Gopcevic A, et al. Ultrasonography of the optic nerve sheath in brain death. *Perspectives in Medicine* 2012;1:414–6.
- [9] Topcuoglu MA, Arsava EM, Bas DF, Kozak HH. Transorbital ultrasonographic measurement of optic nerve sheath diameter in brain death. *J Neuroimaging* 2015;25:906–9.
- [10] Maude RR, Hossain MA, Hassan MU, Osbourne S, Sayeed KLA, Karim MR, et al. Transorbital sonographic evaluation of normal optic nerve sheath diameter in healthy volunteers in Bangladesh. *PloS One* 2013;8:e81013.
- [11] Geeraerts T, Merceron S, Benhamou D, et al. Non-invasive assessment of intracranial pressure using ocular sonography in neurocritical care patients. *Intensive Care Med* 2008;34:2062–7.