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Original Contribution

Bedside sonographic measurement of optic nerve sheath diameter as a predictor of intracranial pressure in ED☆

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ABSTRACT

Background: Ocular ultrasonography of optic nerve sheath diameter (ONSD) to determine intracranial pressure (ICP) has become favorable in recent years.
Objective: To demonstrate the efficacy of ONSD measurement in determining the ICP increase due to nontraumatic events in the emergency department.
Methods: A total of 100 patients with suspected nontraumatic intracranial event were enrolled in this prospective study. Patients were divided equally into 2 groups including 50 patients as group I with pathology on cranial computed tomography (CT) and group II with normal cranial CT. Prior to CT scans, patients underwent ONSD measurement by a radiologist using 11- and 14-MHz transducers.
Results: The ONSD values of groups I and II were 5.4 ± 1.1 and 4.1 ± 0.5 mm, respectively. Optic nerve sheath diameter was found to be larger on the side of lesion in patients with a lesion ($P < .05$). The cutoff value of the difference between ONSD values of both eyes in the presence of pathology was determined as 0.45 (sensitivity, 80%; specificity, 60%; the area under the curve, 0.794; 95% confidence interval, 0.705-0.883). The between-ONSD and midline shift size was statistically significant ($r = 0.366$, $P = .009$). The cutoff value of ONSD for the detection of midline shift was determined as 5.3 mm (sensitivity, 70%; specificity, 74%; the area under the curve, 0.728; 95% confidence interval, 0.585-0.871).
Conclusion: Optic nerve sheath diameter measurement via bedside ocular ultrasonography in patients with suspected intracranial event in the emergency department is a useful method to determine ICP increase and its severity.

1. Introduction

Intracranial pressure (ICP) is the pressure caused by the total volume of brain, cerebrospinal fluid (CSF), and blood in the skull and it is constant. The ICP will increase as a result of an increase in any of the intracranial structures due to events such as head trauma, ischemic stroke, hemorrhagic stroke, mass lesion, and infection [1]. Intracranial pressure increase is associated with poor clinical outcomes, such as increased mortality rate [2].

Cranial computed tomography (CT) is preferred in first place for detection of intracranial events in the emergency department [3]. However, in situations where CT scans cannot be performed, physical examination is unsatisfactory in determining the ICP increase, especially in unconscious, intubated, and paralyzed patients [4]. Invasive ICP monitoring is the gold standard for demonstrating ICP increase [2]. However, invasive ICP monitoring can lead to complications such as hemorrhage and bacterial colonization, and also this technique cannot be applied to all patients with increased ICP [5]. Therefore, ICP monitoring must be done via a noninvasive, simple, reproducible, and bedside method [6].

The examinations to be carried out in the emergency department must be limited due to the greater volume of patients and limited resources. At the same time, speeding up the diagnosis and treatment

☆ Ocular sonography in detecting increased intracranial pressure due to nontraumatic cerebrovascular events

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for patients with life-threatening conditions is very important. Ultrasonography (USG) has become an indispensable component of the emergency department as a result of being an easy-to-learn, bedside, fast, noninvasive, and reproducible method [7]. Today, USG is used in abdomen, thorax, heart, bone, soft tissue, and eye examinations of patients in the emergency department [8–12].

During embryogenesis, optic nerve becomes protruded from diencephalon into the orbit, with a nerve sheath consisting of 3 layers of meninges. Simultaneously, CSF passes freely into intracranial and intraorbital subarachnoid spaces. Intraorbital subarachnoid space surrounding the optic nerve shows the same pressure change with intracranial subarachnoid space [13]. Optic nerve, subarachnoid space, and sheath diameter expand with ICP increase. Measurement of optic nerve sheath diameter (ONSD) via ocular USG has been widely used recently for assessment of ICP increase [14–17]. Optic nerve sheath diameter measurement was studied in postmortem specimens, intrathecal infusion models, children with ventriculoperitoneal shunts, and patients with head trauma in the emergency setting [7,18,19]. In these studies, it has been shown that ICP increase can be detected noninvasively and ONSD is correlated with CT and magnetic resonance imaging in case of ICP increase [20–22].

In this study, it was aimed to demonstrate the efficacy of ONSD measurement in determining the ICP increase due to nontraumatic events and to compare it with increased ICP findings on cranial CT scans in the emergency department.

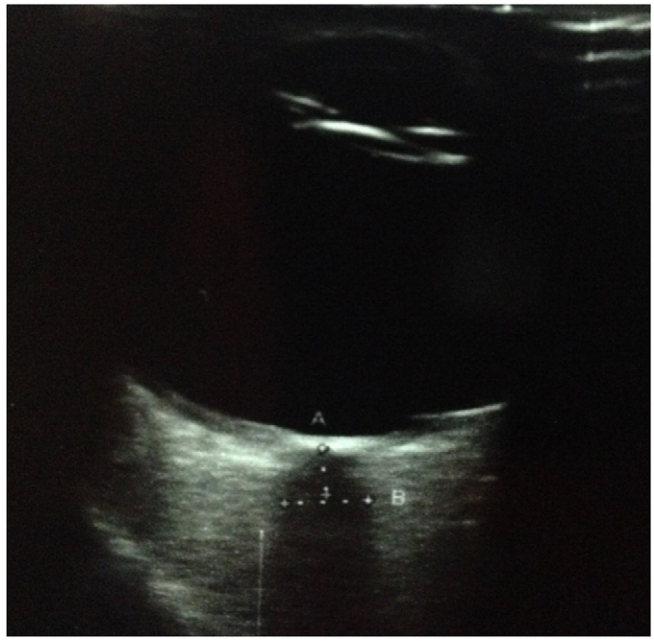

Fig. 1. Measurement technique of ONSD; transverse measurement of optic nerve 3 mm proximal from optic disk while eyelids were closed.

2. Materials and methods

This prospectively designed study was initiated following Ankara Numune Training and Research Hospital ethics committee approval and was conducted in the emergency department between January 11, 2013, and January 3, 2014. Patients with suspected nontraumatic intracranial event according to the result of physical examination were enrolled in this study. Patients were divided into 2 groups as group I including patients with pathology on cranial CT and as group II including patients with normal cranial CT. Presence of any findings of hemorrhage, mass lesion, acute infarction, edema, and shift on cranial CT was considered as pathological.

The exclusion criteria were as follows: (1) <18 years of age; (2) history of glaucoma or current medications that might have affected CSF pressure; (3) ophthalmic diseases, such as tumors or traumas; (4) poisoning by drugs or substances that cause impaired consciousness; (5) electrolyte disorders (such as hyponatremia or hypernatremia, hypocalcemia or hypercalcemia); (6) endocrine disorders (such as hypoglycemia or hyperglycemia, hypothyroidism or hyperthyroidism). Age, sex, Glasgow Coma Scale (GCS) score, cranial CT findings, and ONSD measurements of patients were noted.

2.1. Measurements

Optic nerve sheath diameter measurement was performed by a radiologist using Aplio 500 Platinum system (Toshiba America Medical Systems Inc, Tustin, CA) with 11- and 14-MHz transducers in the emergency department. Patients were examined in the supine position with a closed eyelid. First, both eyes were scanned in vertical and horizontal planes through the eyelid, and then optic disk of the eye was viewed and ONSD measurements were performed in transverse and sagittal planes by using hypoechoic lines, 3 mm proximal to the optic disk, as references (Fig. 1). Cranial CT images were obtained within 15 to 20 minutes after ONSD measurements and evaluated by another radiologist. The ICP increase was considered positive in the presence of intracranial pathology, at least 3-mm midline shift (MLS), mass effect, severe edema, sulcal effacement, ventricular collapse, or compression of the cisternae [18].

2.2. Statistical analysis

All data were analyzed using the SPSS software package (version 21.0; SPSS, Chicago, IL), and $P < .05$ (2-tailed) was set as the level of statistical significance.

Age, sex, GCS values, ONSD values, and the difference between ONSD values of both eyes of patients in 2 groups were compared. The higher ONSD value of left and right eyes was used for statistical analysis. An ONSD value less than 0.5 cm for both eyes was considered normal. Cutoff value, specificity, and sensitivity levels of ONSD and the difference of ONSD values between both eyes were determined. In group I, ONSD was compared with GCS, presence of hemorrhage, and MLS.

Kolmogorov-Smirnov test was used to determine the normality of the distribution of the continuous and discrete quantitative variables. Descriptive statistics were expressed as mean ± SD or median (minimum-maximum) for continuous and discrete quantitative variables,

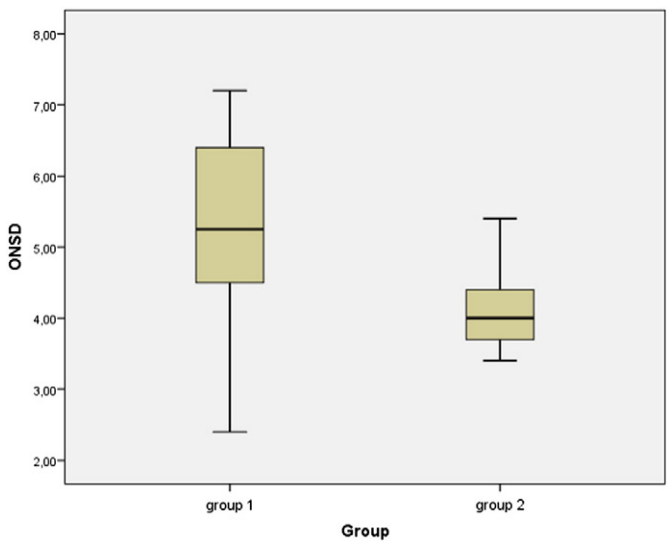

Fig. 2. Comparison of ONSD values of groups. Optic nerve sheath diameter values were measured as 5.4 ± 1.1 mm in group 1 and 4.1 ± 0.5 mm in Group 2 ($P \leq .001$).