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Original article

Role of serial ultrasonic optic nerve sheath diameter monitoring in head injury

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ABSTRACT

Objectives. – To compare optic nerve sheath diameter (ONSD) measurements in head injury patients with a group of normal subjects and investigate the significance of serial ONSD monitoring in head injury patients.
Methods. – All patients with a head injury admitted to our hospital with a program of conservative management at the time of admission were included in this prospective study. On admission, the patient was assessed using the Glasgow Coma Scale (GCS), orbital ultrasound for optic nerve sheath diameter (ONSD), and CT brain scan. CT scan findings were tabulated with Marshall and Rotterdam scores. The patient was serially assessed with ONSD every 24 to 48 hours. If the patient deteriorated, repeat CT and ONSD measurements were performed. A control group consisting of normal subjects was used for comparison.
Results. – The case group consisted of 40 patients and the control group included 16 volunteers. The mean age of the case group was 38.9 years and the control group 36.3 years. The mean ONSD was 4.8 mm in the case group as compared to 3.4 mm in control group ($P < 0.0001$). In the case group, we found a significant correlation between GCS and ONSD, GCS and radiological scores and ONSD and radiological scores. The change in serial recordings of ONSD measurements were termed ascending, descending or static. All the patients with descending trend in serial ONSD values had good outcome and required no surgical intervention.
Conclusions. – Ultrasound ONSD measurement is a useful investigation tool in a setting where invasive ICP monitoring is not available. Serial recording of ONSD is valuable and provides valuable information regarding decision making.

1. Introduction

Orbital ultrasound to measure optic nerve sheath diameter (ONSD) is an innovative procedure which is useful to detect increased intracranial pressure (ICP) [1–5]. It is also a non-invasive method and a very useful technique to monitor the ICP in head injury patients. As this technique is not as accurate as invasive ICP monitoring, serial recordings might be more useful than depending only on a single value. The ONSD measurements of head injury patients were in fact, compared to healthy subjects. We also investigated the significance of serial ONSD monitoring in head injury patients.

2. Methods

This prospective study was carried out in Department of Neurosurgery over a period of 21 months from September 2013 to May 2015. All patients with a head injury admitted in our hospital with a program of conservative management at the time of admission were included in the study. Head injury patients with no parenchymal injury, ocular trauma or requiring polytrauma management were excluded from the study. On admission the patient was assessed based on a Glasgow Coma Scale (GCS), ultrasound study of the optic nerve sheath and whole brain CT scan. CT scan findings were recorded using Marshall [6] and Rotterdam scores [7].

Abbreviations: CT, computed tomography; ICP, intracranial pressure; ONSD, optic nerve sheath diameter; GCS, Glasgow Coma Scale; GOS, Glasgow Outcome Scale.

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The Marshall system places patients into one of six categories (I to VI) of increasing severity on the basis of findings on non-contrast CT scan of the brain.

The Rotterdam CT classification uses an individual score for predictors like basal cisterns, midline shift, intraventricular or subarachnoid hemorrhage and epidural mass lesion and uses a score classification of up to a maximum of 6. Both these scores are used to assess the severity of brain injury and to predict the outcome. The patient was serially assessed with ocular sonography every 24 to 48 hours. ONSD measurements were performed (by a single radiologist) using a 7.5 MHz linear probe (PHILIPS HD 7XE); the optic nerve sheath being measured 3 mm behind the point of entry into the globe. The measurements were taken from each eye separately after applying jelly on the closed eyes. The average of both eyes was taken for comparison. If patient had deteriorated neurologically (GCS decreased by 2 points), they were evaluated using a plain brain CT scan and ONSD measurements. The decision regarding surgery was made depending on clinical condition and CT scan findings.

The change in serial recordings of ONSD measurements (trend) was termed ascending, descending or static. Only variations (increase or decrease) of average R-L ONSD above 5% were considered in order to note it as ascending or descending. The outcome of the patient was assessed with Glasgow Outcome Scale (GOS), scores of 4 and 5 being a good outcome and 1 to 3 being a poor outcome.

Institutional Ethics Committee approval was given to conduct the study. Descriptive statistics of patient variables were calculated. The correlation between radiological scores (Marshall and Rotterdam) and ONSD was evaluated using the Pearson coefficient of correlation formula. The difference of mean ONSD in the case group and control group was compared by using the Student's *t*-test. The accepted risk of error for statistical tests was 5%.

The patients were included into a case group. A control group consisting of normal population with no intracranial pathology was taken for comparison of ONSD measurements. The case group consisted of 40 patients and control group consisted of 16 patients. The control group and the patients were not paired. The mean age of the case group was 38.9 years (range 18–80 years) and the control group was 36.31 years (24–62 years). There were only 2 female patients in the case group whereas, the M:F ratio of the control group was 1:1.

3. Results

The mean right-left ONSD of patients and healthy subjects, 4.8 mm and 3.4 mm respectively, were different ($P < 0.0001$) (Table 1). Out of 40 patients, there were 18 mild, 17 moderate and 5 severe head injury patients. The mean ONSD values of the mild, moderate and severe head injury patients were 4.4, 4.9 and 5.7 mm, respectively (Table 1).

The statistical correlation between GCS, ONSD and radiological scores in the case group are shown in Table 2. Average right-left ONSD was higher for lower GCS ($P = 0.0005$). Low GCS scores were observed in patients with higher Marshall and Rotterdam scores ($P = 0.003$ and 0.001 respectively). Average right-left ONSD was higher for higher Marshall and Rotterdam scores ($P = 0.000004$ and 0.001, respectively).

Ten out of the 40 patients (25%) were operated on. Four of the 10 patients had a severe head injury and the remaining 6 patients had a moderate head injury. The surgical group and the conservatively managed patients in the case group were compared and shown in Table 3. The trend in serial ONSD recordings of the patients are shown in Table 4.

The range of ONSD in the normal population studied (control group) was 2.9 to 4.1 mm. In our study, the significant ONSD value considered to suggest raised ICP was > 4.5 mm.

The average follow-up was 9 months (range 3–18 months). Mortality occurred in four patients (10%). They were two operated patients with severe head injury and two conservatively treated patients with moderate head injury. GOS was found in 36 patients at 3 months, in 27 patients at 6 months and 15 patients at 12 months. At 3 months, GOS was 5 in 34 patients and, 4 in 2 patients. GOS 4 was observed in one operated patient of severe head injury and, one conservatively treated patient of moderate head injury.

Table 1
The mean and range of ONSD values of control group, case group and subgroups.

Group	Number	Mean ONSD (mm)	Range of ONSD (mm)
Control group	16	3.4	2.9 to 4.1
Case group	40	4.8	3.4 to 7.5
Mild head injury	18	4.4	3.4 to 5.7
Moderate head injury	17	4.9	4.2 to 6
Severe head injury	5	5.7	4.9 to 7.5

ONSD: optical nerve sheath diameter.

Table 2
Statistical analysis (Pearson's correlation) of parameters of the case group ($n = 40$).

Parameter	*r*-value	*P*-value
GCS & ONSD	−0.5224	0.0005
GCS & Marshall score	−0.4576	0.003
GCS & Rotterdam score	−0.4901	0.001
ONSD & Marshall score	0.6003	0.000004
ONSD & Rotterdam score	0.4917	0.001

GCS: Glasgow Coma Scale; ONSD: optical nerve sheath diameter.

Table 3
Comparison between the surgical and conservative management groups.

	Surgical group	Conservative	*P*-value
Number	10	30	
Mean GCS	9 ± 1.93	12.26 ± 2.13	0.0003
Mean ONSD	5.45 ± 0.86	4.57 ± 0.569	0.001
Mean Marshall score	4.2 ± 0.91	2.866 ± 0.681	0.001
Mean Rotterdam score	4.4 ± 0.516	3.43 ± 0.85	0.002

GCS: Glasgow Coma Scale; ONSD: optical nerve sheath diameter; values are expressed as mean ± SEM.

Table 4
Trend in serial ONSD recordings of severe, moderate and mild head injury patients.

Trend	Severe		Moderate		Mild	Total
	Surgery	Conservative	Surgery	Conservative	Conservative	
Ascending	2	0	3	1	2	8
Descending	0	1	0	6	10	17
Static	2	0	3	4	6	15

ONSD: optical nerve sheath diameter.

4. Discussion

Orbital ultrasound to detect ONSD is becoming increasingly popular as an adjuvant modality of neuro-imaging tools in the neurology ICU. Although it has some limitations, it is non-invasive, safe, easily reproducible, repetitive, and a cost-effective examination when compared to invasive intracranial pressure monitoring. It is efficient and the examination takes approximately 5 minutes per patient [8]. In head injury patients, associated orbital trauma with optic nerve injury the application of ONSD should be avoided. In some systemic and local diseases, optic nerve sheath becomes enlarged and it is suggested that clinician should treat these cases with caution [9].