Research Article

Comparison of Optic Nerve Sheath Diameter between both eyes: A Bedside Ultrasonography Approach

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Abstract

Context: Optic nerve sheath diameter (ONSD) has long been accepted as a reliable proxy of intracranial pressure especially in critical care and bedside settings. The present consensus is to measure ONSD in both eyes and take average value, which is cumbersome and a potential cause of discomfort to the patient. **Aim:** We aim to compare the values of ONSD of the right and left eye in a random sample as measured by bedside ocular ultrasonography (USG) in Indian adults. **Settings and Design:** This was a prospective study conducted from September 2012 to March 2013 in the Department of Internal Medicine of a tertiary care hospital situated at moderate high altitude (11,500 ft) in India. **Materials and Methods:** Patients admitted with high altitude pulmonary edema (HAPE) were recruited by convenience sampling. The ONSD of both eyes were measured 3 mm behind the globe using a 7.5 MHz linear probe on the closed eyelids of supine subjects. **Statistical Analysis:** Analysis was done using SPSS 17.0. **Results:** A total of 47 patients of HAPE were recruited to the study with daily ONSD recording of both eyes during the admission period. The mean ONSD of the left eye was 4.60 (standard deviation [SD] = 0.71) whereas the mean ONSD of right eye 4.59 (SD = 0.72). The ONSD of the right eye and left eye was strongly correlated (correlation coefficient = 0.98 with $P < 0.0001$). The mean difference in the ONSD of both eyes (right–left) was −0.0044 (SD = 0.11) which was not statistically significant ($P = 0.533$). **Conclusion:** Our results suggest that the difference in ONSD of both eyes is not statistically significant in disease or health. This study also suggests that the ONSD of either eye can be predicted by the other eye recordings. Based on these findings, it can be suggested that during ocular USG for routine bedside/research purposes it is sufficient to measure ONSD of any of the one eye to save time and avoid discomfort to the patient.

Keywords: Eye, hospital emergency service, intracranial pressure, ultrasonography

Introduction

In the present era, there is a rising interest in the role of optic nerve sheath diameter (ONSD) in the fields of critical care and neuroimaging. ONSD is used as a proxy bedside marker for raised intracranial pressure (ICP).[1,2] Given the increasing research work done in the field of ultrasonography (USG) assessment of ONSD, it is of utmost importance that protocols for the ONSD measurement during optic nerve sheath USG (ONSU) be well defined before designing further studies. There is a lot of controversy and variability in measurement of the ONSD by different investigators in their studies. There is no consensus regarding the axis of measurement and which eye (left/right/mean of both eyes) to be used. Furthermore, very little is mentioned in detail in the publications for comparison.

The present guidelines suggest ONSU in both eyes and the mean of both eyes to be used as the ONSD. However, during studies/bedside measurements, it becomes difficult to measure from both the eyes due to the paucity of time especially in the emergency setting and also discomfort to the patients/individuals. In this study, we aimed to evaluate the difference in the ONSD of the right eye and the left eye in a random sample.

Materials and Methods

This is a prospective observational study wherein single center recruitment was done by diagnosis of high altitude pulmonary

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edema (HAPE). In an ongoing study on the role of ONSD in HAPE, the right and left eye ONSD were measured in all the patients. A separate analysis to see the correlation between the recordings of ONSD for both the eyes was done independent of the status of underlying disease (i.e., HAPE).

The study population included all consecutive patients of HAPE admitted to the hospital during the study. Other inclusion criteria were (a) native lowlanders, (b) with no known comorbidities before induction, and (c) inducted to high altitude (more than 11,500 ft) either by road or air for occupational purposes. Exclusion criteria were (a) native highlanders, (b) any other illness associated with HAPE, (c) de-induction to low altitude during disease before remission of HAPE, and (d) lost to follow-up for any reason. The study was conducted from September 2012 to March 2013. The data were collected in a tertiary care hospital at an altitude of 11,500 ft. Informed consent was taken from the patients as per the revised ethical guidelines for human experimentation of Helsinki Declaration of 2000.[3]

There is no reference standard for the index test. The test was performed to compare the concordance in the results of the test when performed in the right and left the eye. All patients (n = 47) underwent ONSU of both eyes using visual axis at admission and predefined intervals till discharge of the patient. In brief, the patient was placed in a supine position and asked to look upward to a point in the ceiling. He was asked to close his left eye, with his right eye focusing on the center point at the ceiling. Ultrasound gel was put in a hand glove, and the same was placed over the closed eye. 7.5 Hz probe of Fuji Sonosite M Turbo® was used, and ONSU was done in B-scan mode. The average time for each scan was one min. ONSD was measured postultrasound using onscreen calipers at 3 mm behind the globe, as it reflects the best measure of ICP.[4] ONSD was measured within 6 h of admission and after that every 24 h till day 10 (D10) of admission or until the day of discharge, whichever was earlier. ONSU was repeated in the same individual during various stages of the disease and after remission of disease. ONSD was done by a single investigator (primary author) who was not blinded to the diagnosis of HAPE. A random sample of 10 ONSU out of every 100 ONSU conducted by the primary author was counter checked by the radiologist independently, who was blinded to the primary diagnosis and the earlier measurements.

This study allows the comparison between both eyes in 256 recordings over a period of 10 days. The analysis was done using SPSS Statistics for Windows, version 17.0 (SPSS Inc, Chicago, Ill, USA), by Pearson's correlation and Student's *t*-test.

Results

The study group was managed uniformly for HAPE with supplemental oxygen therapy. A total of 64 participants developed HAPE during the study, out of which four patients were native highlanders, two had associated high altitude cerebral edema with HAPE, eight patients were de-inducted to lower altitude, and three were lost to follow-up due to associated comorbidities of hypertension (HTN), diabetes mellitus , and coronary artery disease, respectively. The remaining 47 patients, who were prospectively evaluated from the day of admission to discharge with ONSD of both eyes, were analyzed.

The mean (standard deviation) ONSD of the left eye was 4.60 (0.71) mm whereas the mean ONSD of right eye 4.59 (0.72) mm. The ONSD of the right eye and left eye was strongly correlated (correlation coefficient of 0.98 with $P < 0.0001$). The mean difference in the ONSD of both eyes (right–left) was −0.004 (0.114) mm which was not statistically significant. On regression analysis of ONSD of the right eye with the left eye and vice-versa, the coefficient of regression (R^2) was found to be 0.975 ($P < 0.0001$) [Figures 1 and 2]. On comparison of the day-wise ONSD from the day of admission to the D10 of both eyes, ONSD from both eyes correlated well [Table 1] and the differences were not statistically different during any phase of illness [Table 2].

Discussion

The role of ONSD as a surrogate marker for raised ICP is well known. The studies have conclusively proven the role of

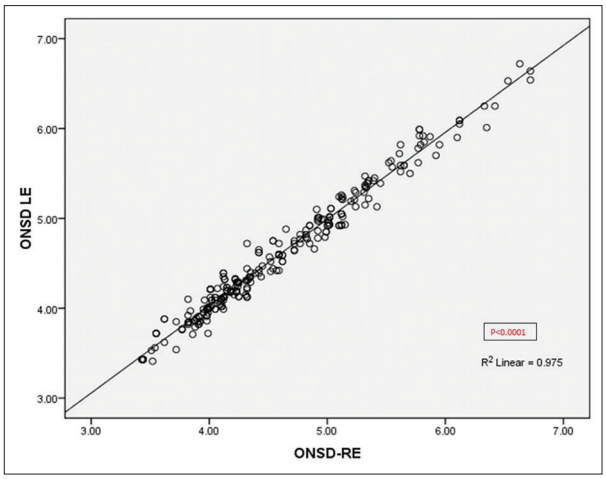

Figure 1: Correlation of the ONSD of right eye with left eye. ONSD: Optic nerve sheath diameter, LE: Left eye, RE: Right eye

Table 1: Correlations for optic nerve sheath diameter both eyes (day-wise) till day 10 of admission

	n	Correlation	*P*
ONSD-RE D1 and ONSD LE D1	47	0.982	<0.001
ONSD RE D2 and ONSD LE D2	47	0.968	<0.001
ONSD RE D3 and ONSD LE D3	46	0.958	<0.001
ONSD RE D4 and ONSD LE D4	44	0.949	<0.001
ONSD RE D5 and ONSD LE D5	33	0.971	<0.001
ONSD RE D6 and ONSD LE D6	17	0.960	<0.001
ONSD RE D7 and ONSD LE D7	10	0.937	<0.001
ONSD RE D8 and ONSD LE D8	6	0.935	0.006
ONSD RE D9 and ONSD LE D9	4	0.973	0.027
ONSD RE D10 and ONSD LE D10	2	1.000	0.000

ONSD: Optic nerve sheath diameter; LE: Left eye; RE: Right eye; D: Day

Table 2: Mean differences in day-wise optic nerve sheath diameter of both eyes till day 10 of admission

	Mean	SD	SEM	95% CI of the difference		*P*
				Lower	Upper	
ONSD-RE D1-ONSD LE D1	0.02660	0.11552	0.01685	−0.00732	0.06051	0.121
ONSD RE D2-ONSD LE D2	0.00596	0.12240	0.01785	−0.02998	0.04189	0.740
ONSD RE D3-ONSD LE D3	−0.01630	0.12763	0.01882	−0.05421	0.02160	0.391
ONSD RE D4-ONSD LE D4	−0.01705	0.12512	0.01886	−0.05508	0.02099	0.371
ONSD RE D5-ONSD LE D5	−0.01242	0.08070	0.01405	−0.04104	0.01619	0.383
ONSD RE D6-ONSD LE D6	−0.00353	0.07874	0.01910	−0.04401	0.03695	0.856
ONSD RE D7-ONSD LE D7	−0.00600	0.10047	0.03177	−0.07787	0.06587	0.854
ONSD RE D8-ONSD LE D8	−0.02500	0.10540	0.04303	−0.13561	0.08561	0.586
ONSD RE D9-ONSD LE D9	−0.07750	0.10532	0.05266	−0.24508	0.09008	0.237
ONSD RE D10-ONSD LE D10	−0.09000	0.15556	0.11000	−1.48768	1.30768	0.563

ONSD: Optic nerve sheath diameter; LE: Left eye; RE: Right eye; D: Day; SD: Standard deviation; SEM: Standard error mean; CI: Confidence interval

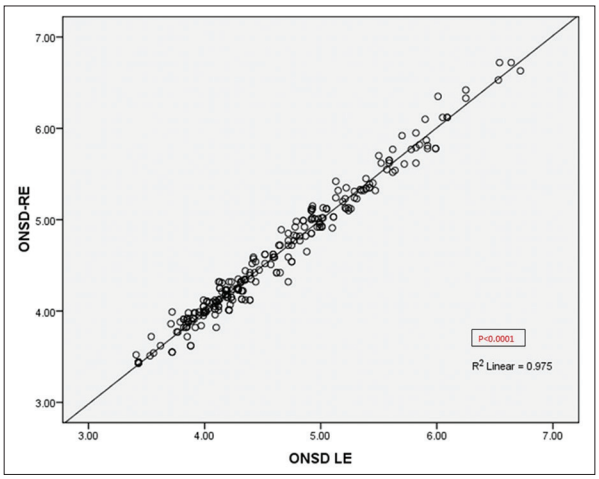

Figure 2: Correlations for ONSD – both eyes (day-wise) till day 10 of admission. ONSD: Optic nerve sheath diameter, LE: Left eye, RE: Right eye D - Day

increased ONSD in cases with intracranial HTN with reversal of ONSD on subsidence of increased ICP.[1,2,5] There are some contradicting reports of weak correlation of the ONSD in cases with increased ICP[6] which could be due to associated pitfalls when measuring ONSD during ONSU.[7]

Many studies have employed the mean recording of both the eyes for ONSD[8] whereas some studies have measured in only one eye. The research primarily aimed at studying the difference in the right eye and left eye ONSD, which has not been well studied in the past. There was no statistically significant difference in the ONSD of either eye in our study. This corroborates with the studies already published in the past wherein there was no difference in the measurement of both the eyes. In a study by Maude *et al*. in healthy volunteers from Bangladesh, there was no difference in the individual mean measurements in the right eye and left eye ($P = 0.12$).[9] In another study on healthy infants and children by Ballantyne *et al*., there was no statistical difference in the right and left eye ONSD ($P = 0.66$).[10] In another prospective case–control study by Romagnuolo *et al*. in ten healthy volunteers, there was no significant difference in the ONSD of both eyes in supine or Trendelenburg position.[11]

Our study included measurement of ONSD in both diseased patients and the same patients after the subsidence of the illness. This is a major strength as most of the previous studies were done only on healthy volunteers. In a similar study on the comparison of diseased patients with normal tension glaucoma and healthy volunteers, there was no statistically significant difference in ONSD of the right and left eyes in either group.[12]

The mean ONSD shown above should not be considered as the mean of healthy individuals as it is a combination of diseased ONSD recordings and recordings on the same set of subjects on subsidence of disease. Thus, misinterpreting these ONSD as cutoff of healthy adult males or diseased adult males should be avoided as this study was not designed for the same.

The limitations of the study include the inclusion of only males; thus, any gender differences cannot be commented based on this study. Furthermore, the lack of a gold standard such as computed tomography (CT) scan or magnetic resonance imaging (MRI) to confirm the findings is also a limitation of the study. A separate well-designed study to measure the ONSD in healthy controls and diseased patients with simultaneous neuroimaging by CT/MRI would validate the findings of our study better.

Conclusion

We can conclude based on the findings of this study that measurement of either eye is sufficient for bedside or research purposes as the differences in the ONSD in both eyes are statistically insignificant. This would help in saving the time of the examiner and discomfort to the patient.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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