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Intra and Interobserver Reliability of Optic Nerve Sheath Diameter in Normal Nepalese Adults using Transorbital Ultrasound

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ABSTRACT

Introduction: Transorbital sonographic measured optic nerve sheath diameter (ONSD) has turned into a promising screening and monitoring tool lately. Nonetheless, the test qualities of this procedure require to be addressed to be feasible to use in clinical practice. This study aims to assess the intra and interobserver reliability of transorbital ultrasound.

Methods: A prospective observational study was conducted on 37 healthy adults. Three serial ONSD of both the eyes were measured using ultrasound by two investigators independently.

Results: The age of the participants ranged from 20 to 30 years with a mean age of 23.86 ± 2.35 years with 54.1% male and 45.9% female. The mean ONSD of both eyes was 4.15 ± 0.38 mm for investigator 1 and 4.11 ± 0.37 mm for investigator 2. The mean ONSD of the two investigators was 4.13 ± 0.37 mm with a mean difference of -0.036 ± 0.118 mm (at 95% confidence interval, -0.003 − 0.075 mm). For intra-observer reliability, Intraclass correlation analysis for investigator 1 showed 0.995 for the right eye and 0.995 for the left eye and investigator 2 showed 0.993 for the right eye and 0.997 for the left eye. Interobserver intraclass correlation analysis showed excellent correlation of 0.973. In addition, Bland-Altman plots were drawn to see the interobserver limit of agreement using mean ONSD (4.13 ± 0.37 mm) and mean difference (-0.036 ± 0.118) of two investigators.

Conclusion: Measurement of ONSD by transorbital ultrasound is a feasible method to assess intracranial pressure noninvasively with high intra and interobserver agreement.

Keywords: *Intracranial Pressure; Observer Variation; Optic Nerve, Transorbital Ultrasound*

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INTRODUCTION

Various methods have been utilized for measuring intracranial pressure (ICP), such as radiologic imaging or invasive techniques. The "gold standard" for confirmation of raised ICP is evaluating pressure by invasive intracranial catheters attaching to the ICP measurement transducer.[1] Nonetheless, the method is extremely invasive and may result in grave problems like infection, haemorrhage, and malfunction.

Sonographic assessment of ONSD appeared to be a rational proxy technique in the identification of increased ICP, notably in emergency room and intensive care units. There are several pieces of research promoting the usage of sonography in this area. The results were encouraging and associated with invasively detected ICP values.[2,3,4] It has the benefit of being portable, noninvasive, economical and repeatable. But Normal values quoted vary from 4.0 mm to 5.9 mm in separate studies.[5,6,7] Contrary to other cross-sectional imaging, sonography is nonetheless operator-dependent which notably influences the sensitivity and specificity in the identification of numerous conditions.[8]

With this wide range of normal cut-off values of ONSD and operator dependence, reproducibility is a crucial aspect to utilize transorbital sonography for repeated monitoring of ICPvariations.

This study aims to study the intra and interobserver reliability of ONSD in normal adults using ultrasound.

METHODS

A prospective observational study was performed in the department of neurosurgery at Kathmandu Medical College Teaching Hospital (KMCTH), Sinamangal, Kathmandu between March 2022 and April 2022. This study was approved by the institutional review committee (IRC) of KMCTH. Informed consent was taken from healthy adult volunteers. Healthy Nursing staff, interns, medical officers, lecturers, post-graduate residents and visitors of the patients, who are 18 years and above were enrolled on the study. Those with ocular diseases or any features suggestive of raised intracranial pressure were excluded from the study.

The sample size was calculated using G*Power ver. 3.1.9.6 for Mac. The statistical test was a Correlational bivariate normal model and an A priori type of power analysis was selected. With input parameters set as a hypothetical effect size of 0.5, alpha error of 0.05, and power of 0.9, the sample size of37 was derived. Non-probability sampling technique was used.

ONSD was measured using a 5-13 MHz linear array transducer of the GE healthcare ultrasound system (model: LOGIQ e, GE Healthcare Shanghai, Co., Ltd., Shanghai-201203, P.R. China) by two investigators who has experience in performing more than 100 ONSD previously. After applying ultrasound coupling gel at the temporal side on the closed eyelid in the supine position, the linear transducer was kept horizontally. The transducer was adjusted till the appearance of the hypoechoic optic nerve behind the globe. ONSD of both eyes were measured at 3 mm behind the globe taking the transverse diameter of hypoechoic shadow right angle to the optic nerve by using machine inbuilt electronic calliper. Three measurements were taken for each eye by each investigator and data obtained were recorded and also averaged to yield the mean ONSD. Measurement of both investigators was carried out within 15 minutes and obtained data were blinded to each other.

Statistical analysis was performed using IBM SPSS Statistic version 25 (IBM Corporation, USA) for Macintosh. Categorical variables were expressed in terms of frequency and percentage and continuous variables were expressed in terms of mean and standard deviation. The intraclass correlation coefficient was used to assess intra and interobserver reproducibility. To analyse the agreement between the two investigators, the Bland-

Altman plot was constructed. An Independent sample t-test was run after calculating the mean difference and mean of the two investigators. From the calculated mean and standard deviation at a 95% confidence interval, both positive and negative limits of agreement were calculated, thereafter Bland-Altman plot was constructed. Furthermore, Linear regression analysis was done to look for the variance of difference across the range of the mean of mean difference horizontal line, this should show an insignificant p-value more than 0.05 plus coefficient mean of mean difference value close to zero, this signifies the absence of proportional bias that is required for a good agreement.

RESULTS

A total of 37 healthy individual adults were included in this study. ONSD of both eyes with three measurements on each eye was performed by the two investigators independently. The age of the participants ranged from 20 to 30 years with a mean age of 23.86 ±2.35 years. There were 20 male (54.1%) and 17 female (45.9%) participants.

Mean ONSD for 3 measurements of the right eye was 4.10± 0.38 mm with a range of 3.40 − 4.90 mm and of the left eye was 4.18 ± 0.46 mm with a range of 3.23 − 5.17 mm for the investigator 1. The mean ONSD of 3 measurements of the right eye was 4.06±0.36 mm with a range of 3.47 − 4.87 mm and of the left eye was 4.15 ± 0.48 mm with a range of 3.20 − 5.03 mm for the investigator 2. Mean ONSD of both eyes was 4.15 ± 0.38 mm with a range of 3.40− 4.92 mm for investigator 1 and 4.11± 0.37 mm with a range of 3.33− 4.93 mm for investigator 2. The mean ONSD of the two investigators was 4.13 ± 0.37 mm with a mean difference of -0.036 ± 0.118 mm (at 95% confidence interval, -0.003 − 0.075 mm).

Intra-observer reliability by using Intraclass correlation analysis for investigator 1 showed excellent correlation of 0.995 (at 95% confidence interval, 0.991 − 0.997) for right eye and of 0.995 (at 95% confidence interval, 0.991 − 0.997) for left eye. Intraclass correlation for investigator 2 showed excellent correlation of 0.993 (at 95% confidence interval, 0.987− 0.996) for right eye and of 0.997 (at 95% confidence interval, 0.994− 0.998) for left eye. Inter-observer reliability by using Intraclass correlation analysis showed excellent correlation of 0.973 (at 95% confidence interval, 0.946 − 0.986).In addition, the Bland-Altman plot (Figure 1) was drawn to see the inter-observer limit of agreement using the mean ONSD (4.13 ± 0.37 mm) and mean difference (-0.036 ± 0.118) of two investigators. Further, linear regression analysis demonstrated a coefficient mean difference value of -0.003 with a p-value = 0.7 which signifies no proportional bias. A Scatter plot (Figure 2) between the mean ONSD of two investigators was also drawn.

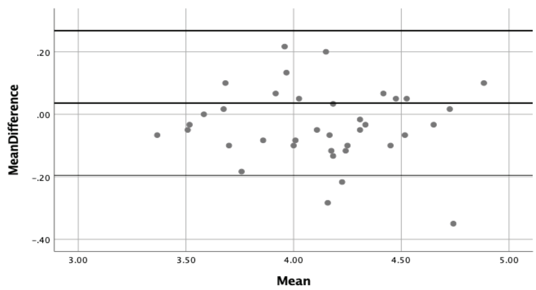

Figure 1: *Bland Altman plots for assessment of agreement between two investigators with a middle horizontal line of mean of mean difference and upper and lower horizontal line of limits of agreement (mean ± 1.96 times of standard deviation)*

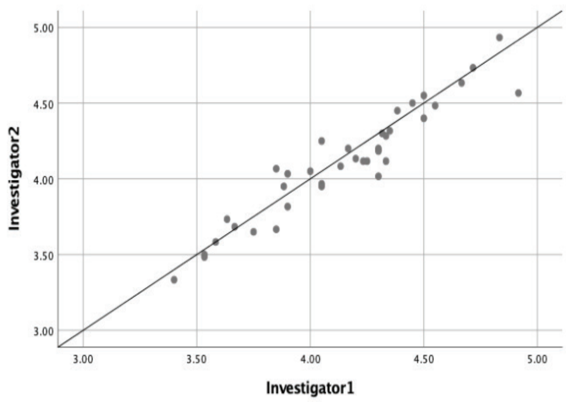

Figure 2: *Scatter plot of optic nerve sheath diameter for agreement between two investigators, line of perfect agreement is shown*

DISCUSSION

Elevated ICP is correlated with high morbidity and mortality in traumatic brain injury as a result of the risk of a secondary ischemic insult. Elevated ICP is equally unacceptable in non-traumatic conditions like meningitis, stroke, liver failure, encephalitis and post-resuscitation syndrome following cardiac arrest.[9,10,11,12,13]

Invasive measurement of ICP is the gold standard. Nonetheless, they may risk complications such as haemorrhage, infection or dislodgement. Anatomically the optic nerve is encompassed by cerebrospinal fluid (CSF) and it is wrapped in a sheath that is an elongation of the dura mater. This continuous link gives ICP transmission straight into the optic nerve sheath whenever there is no CSF circulation block. Henceforth, calculating the difference in ONSD provides vital information regarding the variations in ICP. The distension of sheath was verified to happen instantaneously in cases of raised ICP.[14] This serves as a basis for the assessment of ONSD by ocular sonography and neuroimaging studies. Neuroimaging studies in the form of computed tomography (CT)or magnetic resonance imaging (MRI) can be utilized to correctly speculate raised ICP by delivering more accurate measurements of ONSD.[13,15] Nonetheless, these procedures are costly, take a long time and call for the transport of patients hence their utilization is thus constrained. By contrast, sonography thus has earned extensive usefulness in the intensive care units in addition to emergency as well. Its disproportionate dominance among the other imaging techniques is owing to its wide availability, real-time evaluation, and portable and non-invasive technique.[16] This study also used transorbital sonography for ONSD measurement and validate these data to look for reproducibility as well as reliability as ultrasound is thought to be an operator-dependent technique.

The mean age of participants was 23.86 ± 2.3 years in this study. Similar to this study, Ghimire et al. and Bäuerle et al. observed mean age of 23.07 +/- 2.49 years and 24.5 ± 0.8 years respectively.[17,18] This study showed 54.1% male and 45.9% female participants. Comparable to this study, Ghimire et al. found 55% male and 45% female participants and Wang et al. reported 54.7% male and 45.3% female participants in their study.[17,19] Mean ONSD for the right eye was 4.10 ± 0.38 mm and left eye was 4.18 ± 0.46 mm for investigator 1 and the right eye was 4.06 ± 0.36 mm and left eye was 4.15 ± 0.48 mm for investigator 2 in this study of normal Nepalese adults. Identical to these findings, a previous study by Ghimire et al. in their study of the right eye of normal adults found mean ONSD of 4.16 +/- 0.55 mm for Observer 1 and 4.17 +/- 0.53 mm for observer 2 and the study by KC et al. in their study of normal Nepalese adults demonstrated mean ONSD value for the right eye was 4.10 ± 0.50 mm and for the left eye was 4.22 ± 0.49 mm. [17,20] In concordance with other studies of observer agreement, this study also showed intraobserver variability lesser than what was observed in interobserver variability. [17,21] Various authors have revealed high intraobserver reliability of ONSD measurement by transorbital sonogram. [17,19,22] This study also found high intraobserver reliability among both investigators. Concerning interobserver reliability, this study demonstrated an excellent correlation between ONSD measurement between two investigators. Moreover, Bland Altman plots illustrated robust agreement on the measurement of ONSD between both investigators. The mean difference value was close to zero which signifies no evidence of systemic bias. Previous studies by several authors also support similar findings concerning interobserver reliability. [17, 19,22,23] In addition, the scatter plot showed a positive linear correlation with the strong relationship of ONSD measurement between both investigators. A study by Ghimire et al. and Wang et al. also found similar findings. [17,19]

CONCLUSION

Measurement of ONSD by transorbital ultrasound is reliable and reproducible with high intra and interobserver agreement. This study serves as a basis for future application of this non-invasive, portable technique in neurosurgical patients for evaluation of ICP non-invasively.

CONFLICT OF INTEREST

None

SOURCE OF FUNDING

None

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