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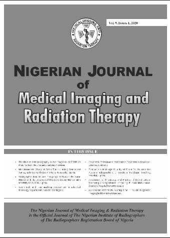

OPTIC NERVE SHEATH DIAMETER: DEFINING NORMAL VALUES IN A NIGERIAN POPULATION

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ABSTRACT

Introduction: Ultrasonographic measurement of the optic nerve sheath diameter has been identified as a non-invasive modality for the assessment of intracranial pressure but there are inconsistencies regarding the optimal cut-off value for the diagnosis of elevated intracranial pressure.
Aim: The aim of this study is to determine the normal optic nerve sheath diameter of healthy adults in Southeast Nigeria with the aim of establishing a baseline data and optimal cut-off value for ONSD for the region.
Materials and Methods: A prospective cross-sectional study conducted on 408 apparently healthy adults aged between 18-89years in Aba, Southeast Nigeria. Transocular ultrasonographic measurement of the optic nerve sheath diameter was performed using a 7.5MHz transducer.
Results: The subjects mean age was 42.7±17.09years. The ONSD mean diameter was 4.58±0.64mm and the cut-off value was 5.83mm. There was no statistically significant difference between the mean ONSD for males and that of females.
Conclusion: The study defined 5.83mm as cut-off value for the optic nerve sheath diameter for the Southeast region of Nigeria.

INTRODUCTION

Elevated intracranial pressure (EICP) is a life threatening medical condition that occurs as a result of a number of neurologic and non-neurologic pathologies. The most common cause is traumatic brain injury (TBI) and its prevalence is increasing globally even in developing countries like Nigeria [1].

Intracranial pressure (ICP) of >20mmHg is associated with poor neurological prognosis especially high risk of secondary ischaemic brain damage and poor outcome following TBI [2,3]. Prompt and timely diagnosis and management of EICP is therefore important in other to achieve positive outcome, optimize cerebral perfusion pressure and forestall secondary damage to the brain tissues [3].

The gold standard for assessment of intracranial pressure involves procedures that require the use of intracranial devices which are grossly invasive probes. These procedures require optimal coagulation, sterile condition and expertise of a neurosurgeon but these requirements are often not easily available.

Computed tomography (CT) and Magnetic Resonance Imaging (MRI) which have revolutionised neuroimaging and neurology practice were found useful in the investigation of EICP. Unfortunately, these modalities are expensive, time-consuming, and not easily available and are not suitable for critically ill patients on life support [1].

Transcranial Doppler, pulsatility index and transocular ultrasound have recently sparked interest among clinicians and researchers, and have been suggested for the timely, rapid and noninvasive assessment of ICP. Transcranial Doppler is however difficult to perform even when the operator is experienced [3,5]. Transocular ultrasonography of the optic nerve sheath diameter (ONSD) on the other hand is easy to perform and has been shown to be an accurate surrogate measure of ICP and was observed to correlate with ICP [3-8].

Previous studies by researchers have shown that changes in ONSD are directly caused by ICP changes in adult and paediatric patients who suffered TBI and that ONSD correlated accurately with direct measurement of ICP [7-14]. A rise in the ICP leads to increase in the subarachnoid space surrounding the nerve and this causes an increase in its diameter [15].

Despite the advantages in the use of sonographic measurement of ONSD as a surrogate measure of EICP, discrepancies and inconsistencies regarding optimal cut-offs and the normal values for ONSD exist [2,16,17]. These discrepancies may be due to racial differences in organ sizes or as a result of variations in measurement techniques. This work aims to determine the normal optic nerve sheath diameter of healthy adults in Southeast Nigeria with the aim of establishing a baseline data for ONSD for the region. The study also sought to know whether any statistical difference existed between the contralateral ONSD and any correlation between anthropometric parameters and ONSD

MATERIALS AND METHODS

This cross-sectional prospective study was done in Aba, a commercial, densely populated city in Southeast Nigeria. Four hundred and eight apparently healthy subjects aged 18 years and above and had no history of ophthalmic disease or neurological diseases and who consented to the study were recruited. These were strictly of Southeast Nigerian origin. Ethical approval was obtained from the Health research Ethics Committee of Abia State University Teaching Hospital and written informed consent was given by all the participants.

A semi-structured questionnaire which sought to collect data on demographics and health status was administered. The height, weight and head circumference of the participants were obtained using a stadiometer, digital scale and measuring tape respectively.

The body mass index (BMI) was also calculated as the weight divided by the height squared (kg/m^2). The head circumference was measured using a non-stretchable tape around the widest possible occipitofrontal circumference.

With patient in the supine position and eyelids shut while maintaining gaze at the ceiling, ultrasound gel was applied over the closed eyelids. A 7.5MHz transducer was placed over the close eyelid and scanning was done in the transverse and longitudinal planes of each eye according to the standard described by Mercerons and Geererts [18]. When visualization of the lens or iris was suboptimal, the transducer was adjusted to bring the best angle for displaying the exit of the optic nerve from the globe, while ensuring that the lens or iris or both is visible on the image as prescribed by [18]. This was strictly adhered to because if the lens or iris is not seen in the image, the imaging plane is likely off-axis and may result in underestimation of ONSD [19]. Images were obtained according to standard techniques using the anterior transbulbar approach to image the ONSD in an axial plane [20, 21]. The widest visible retrobulbar optic nerve sheath diameter (ONSD) was measured at a point 3mm posterior to the posterior sclera surface of the globe using an in-built electronic calliper at an angle perpendicular to the eye ball. Three measurements were obtained bilaterally and the mean of each recorded.

All data were analyzed using the SPSS software (Windows Version 20.0; IBM Corp. Armonk, NY: USA). Means and standard deviations (SD) were used for descriptive purposes for quantitative variables while frequency and percentage (%) were calculated for qualitative variables. Pearson correlation coefficient (r) was used to assess strength of correlation. Means were compared using t-tests. $p < 0.05$ was considered statistically significant.

RESULTS

The sample for this study was 408 (M=172, 42.2%; F =236, 57.8%). Their mean age was 42.7±17.09years (range 18-89 years). The mean weight and height were 67.63kg (SD 6.3) and 1.66mm (SD 0.07) respectively. The mean BMI was 24.48±4.8kg/m^2 while the mean HC was 56.69±1.11cm.

The mean ONSD obtained in this study was 4.58mm± 0.64mm (range 3.22-5.98mm). The mean ONSD obtained for the RT was 4.52 while that for the Lt was 4.64mm. The value for the Lt was higher than the Rt but the difference was not statistically significant (p=0.47). Table 2 also presents the mean ONSD values for the different age ranges. The highest mean value of ONSD was recorded among the >80yrs participants, with their ONSD measuring 4.48mm±0.49mm in males and 5.10±0.31mm in females. The lowest mean value was noted among the <20yrs subjects with the mean ONSD for the males and females corresponding to 4.34±0.41mm and 4.20±0.43mm respectively.

The mean ONSD in males was 4.64mm±0.65mm, value ranged from 4.34-4.89mm. The ONSD for females ranged from 4.20-5.10mm and the mean was 4.53mm±0.63mm. The mean ONSD for the right and left in the males were 4.63mm±0.71mm and 4.64mm±0.48mm respectively and 4.53mm±0.73mm and 4.56mm±0.41mm respectively for the females (Table 3). The values for the RT and LT ONSD were higher in males than in females though not statistically significant (p=0.116 and 0.868) respectively.

Comparison between age, height, weight, BMI and HC of the participants with ONSD showed a weak positive correlation between age and ONSD only.

Table 1: Demographic and anthropometric characteristics

Variables	Mean (SD)	N (%)
Demographic Variables		
Age(years)	42.07(17.0)	
Sex	172(42.)	
Male	236(57.)	
Female		
Anthropometric Variables		
Weight(kg)	67.63(63)	
Height(m)	1.66(0.07)	
BMI(kg/m^2)	24.48(4.80)	
HC(cm)	56.69(1.11)	

Table 2: Showing Mean ONSD among the different age groups and gender

Age (yrs)	N (%)	Male (mean ± SD)			Female (mean ± SD)			
		ONSD Right	ONSD Left	ONSD	ONSD Right	ONSD Left	ONSD	P-value [a]
≤20	34(8.3)	4.35± 0.44	4.34±0.39	4.34± 0.41	4.18± 0.422	4.22± 0.44	4.20±0.43	0.334
21-30	92(22.5)	4.34± 0.54	4.37± 0.57	4.36± 0.55	4.40± 0.62	4.42± 0.61	4.41± 0.61	0.662
31-40	86(21.1)	4.79± 0.54	4.80± 0.55	4.79± 0.54	4.55± 0.65	4.55± 0.65	4.55± 0.65	0.107
41-50	74(18.1)	4.72± 0.87	4.71± 0.88	4.71± 0.88	4.68± 0.58	4.69± 0.59	4.69± 0.59	0.878

Age (yrs)	N (%)	Male (mean + SD)			Female (mean + SD)			
		ONSD Right	ONSD Left	ONSD	ONSD Right	ONSD Left	ONSD	P-value [a]
51-60	50(12.3)	4.87+0.68	4.87+ 0.65	4.87+ 0.67	4.61+ 0.75	4.63+ 0.74	4.62+ 0.74	0.215
61-70	48(11.8)	4.61+ 0.57	4.65+ 0.55	4.63+ 0.56	4.75+ 0.53	4.74+0.53	4.74+ 0.53	0.507
71-80	16(3.9)	4.60+ 0.47	4.60+ 0.48	4.60+ 0.47	4.50+ 0.71	4.52+ 0.72	4.51+ 0.71	0.786
>80	8(2.0)	4.88+ 0.50	4.89+ 0.48	4.89+ 0.49	5.10+ 0.32	5.10+ 0.31	5.10+ 0.31	0.540

Table 3: Mean ONSD in males and females

SEX	FREQ	MEAN AGE (YEARS)	MEAN ONSD (mm)	MEAN RONSD (mm)	MEAN LONSD (mm)
MALES	172 (42.2%)	45.31 (18.12)	4.64 (0.64)	4.63	4.64
FEMALES	236 (57.8%)	39.71 (16.93)	4.53 (0.63)	4.53	4.54
TOTAL	408 (100%)	42.7 (17.09	4.58 (0.64)	4.52	4.64

Table 4 : Correlation of ONSD with anthropometric parameters

		Age	Height	Weight	BMI	HC
ONSD	R	0.199	0.010	-0.018	-0.023	-0.009
	P	0.001*	0.801	0.715	0.636	0.861

DISCUSSION

Intracranial pressure monitoring had depended on invasive intracranial devices. The invasiveness of these procedures, their consequent complications and the lack of neurologists have called for more available, easy and safer methods. Monitoring using Transocular sonographic measurement of the ONSD has gained popularity among clinicians as a noninvasive tool in the evaluation of patients who suffered trauma to the head. This method offers a cheap, safe, readily available and easy to accomplish technique for the workup of these patients. It can rapidly give information regarding ICP of these patients at bedside [3]. This technique is also easily repeatable and is not affected by change in position [22]. The aim of this study was to establish a baseline value for normal optic nerve sheath diameter beyond which diagnosis of elevated intracranial pressure can be made.

Several works have attempted to define the diameter of the optic nerve sheath among healthy individuals in different populations. Unfortunately, there are inconsistencies regarding the optimal cut-off values even among works that adopted similar measurement techniques. Chen et al [22] studied healthy Chinese adults and obtained a normal range of 3.5-6.4mm with a median ONSD value of 5.1mm and 95 percentile of ONSD was 5.9mm. Their data suggested that 95% of Chinese adults have ONSD value ≤5.9mm. From their study, it was in order to speculate that an ONSD value of >5.9mm could be considered abnormal.

Bauerle et al [23] reported a normal ONSD range of 4.3-7.6mm with a mean value of 5.4mm in the German population they studied whereas Maude et al., [17] obtained a median ONSD of 4.41mm, their values ranging from 4.25 to 4.75mm among Bangladesh volunteers. Bauerle *et al.,* [23] reported a cut -off value of 5.8mm for identifying raised ICP. Strapazzon *et al*., [24] also in their work reported 5.94mm as the cut-off value in their study.

In our study, the mean ONSD obtained among the 408 apparently healthy volunteers was 4.58mm with 95% CI of 3.32mm – 5.83mm. The upper confidence limit at 95% CI 5.83mm as reported in this work is close to that of Chen *et al*. [22], who also found 5.9mm as the upper confidence limit of 95% CI in their study among Chinese adults. Interestingly, the result of this study is at variance with reports of other works done in other regions in Nigeria. Kolade et al., [25] in Abuja Northcentral Nigeria, reported a range of 3.9-5.2mm and Aduayi [26] in Ile-Ife, Western Nigeria also reported a cut-off of 5.2mm. Ismail [27] in North western Nigeria reported a cut-off of 5.1mm. The value obtained from this work may have varied from the results of these researchers possibly as a result of varying characteristics among the different ethnicities as suggested by Ismail [27]. Wang *et al.,* [28] *also* identified differences in ONSD among different ethnicities. The similarities in the values obtained by other researchers in Nigeria may be because their researches were conducted among Nigerian nationalities possibly including volunteers from the different ethnicities in the country while our study strictly restricted inclusion to only volunteers from South eastern Nigeria. This implies that ethnicity should be put into consideration when using ONSD as marker for increased ICP in Nigeria.

There was no statistically significant difference between the mean ONSD of the Right eye and that of the Left eye. This finding is similar to the findings of other researchers [22,23,26,27]. There was also no statistically significant difference between the Right and Left ONSD in males and females. Other researchers reported similar findings. Whereas other researchers in Nigeria observed no correlation between ONSD and age, this work observed a progressive increase in the ONSD with age and there was a significant weak positive correlation between ONSD and age. The difference may be attributed to sample size and method adopted. For instance, the mean age of participants in our study was 42.2years whereas the mean age in the work done by Ismail [27] was 36.94years and more than half of the subjects he studied were under 34years.

Transocular sonographic measurement of ONSD as shown by our data and the works of other researchers proves to be a useful tool for the evaluation of intracranial pressure but should not replace other sophisticated modalities like CT and MRI especially as these modalities provide additional information about aetiology of the raised intracranial pressure [26]. This study depended on history taking to presume normal intracranial pressure as direct measure of intracranial pressure was not within the scope of study. This was the major limitation of the study.

CONCLUSION

The present study has established the normal range of ONSD in Southeast Nigeria and defined a cut-off value which can serve as a safe and reliable promising surrogate of invasive intracranial diagnostic probes in the management of elevated intracranial pressure.

Conflict of Interest: Nil

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