

# Ultrasonographic Measurement of Optic Nerve Sheath Diameter in Normal Adults.

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## ABSTRACT

**Background:** Raised intracranial pressure (ICP) is a common manifestation of severe brain injury and measurement of optic nerve diameter using ultrasound as a non-invasive method is increasing being use as a marker to detect raised ICP. The aim of this study is to determine normal optic nerve sheath diameter in normal Nigerian adults. **Methods:** This was a cross-sectional prospective study conducted at the radiology department on 150 normal adults over a period of ten months. The optic nerve sheath diameter (ONSD) was measured 3mm behind the globe using 7.5 MHz linear probe placed over the closed eyelid with subjects in supine position. **Results:** The mean age of the studied population was 38.69±12.85 years. The mean age of males was 42.42±15.77 years and that of females was 35.92±9.33 years. This was statistically significant. The mean optic nerve sheath diameter was 4.20±0.38mm (range 3.91-5.2mm). The right and left mean optic nerve sheath diameter was 4.20±0.32mm and 4.21±0.43mm respectively. The right ONSD for males was 4.21±0.41mm while reading for the left was 4.22±0.49. Among the females the right ONSD was 4.20± 0.39mm and left was 4.21±0.48. There was no statistical significant difference between right and left ONSD. No significant difference between males and females ONSD. No significant correlation between ONSD, age, sex and side. **Conclusion:** Normal values for optic nerve sheath diameter have been established using ultrasound in normal Nigerian adult. No significant relationship between ONSD, age, sex, and side.

**Keywords:** Adults, Normal, Optic nerve sheath diameter, Ultrasound

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## INTRODUCTION

The optic nerve is a paired nerve that transmits visual information from the retina to the brain. It is the second of twelve paired cranial nerves<sup>[1]</sup>. The optic nerve is derived from optic stalks during the seventh week of development and is composed of retinal ganglion cell axons and glial cells. It is considered a part of the central nervous system being an extension of the white matter of the brain covered by pia matter and lies within the arachnoid and dura matter as far as the back of the eye<sup>[1]</sup>. The covering of the optic nerve with layers of meninges is known as the optic sheath. The optic nerve sheath is contiguous with the subarachnoid space, and cerebrospinal fluid flows freely between the cranium and orbit within the subarachnoid space.

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Hence any rise in intracranial pressure (ICP) can be transmitted to the orbit affecting the perioptic nerve sheath, changing its diameter with subsequent

swelling of the optic disc (papilloedema). However, papilloedema which can be detected by fundoscopy clinically evolves over time and may be a delayed manifestation, besides it requires a skilled observer for precise identification<sup>[2,3]</sup>. Dilatation of the optic nerve sheath has been shown to be a much earlier manifestation of ICP rise<sup>[4,5]</sup> and the increase in ONSD has been established to emerge earlier than other findings evaluated by ophthalmoscopy<sup>[4]</sup>. Study on optic nerve of cadavers and patients with raised ICP shows changes in the optic nerve diameter most especially in the anterior segment (3mm posterior to the globe)<sup>[4]</sup>. The optic nerve sheath is at its most distensible anteriorly, where it is potentially most reflective of raised ICP<sup>[4]</sup>.

Transorbital sonography is a non-invasive, safe and easy method to access the retrobulbar aspect of the optic sheath (3mm posterior to the globe) and can detect changes in the optic nerve diameter before papilloedema sets in patients with ICP. In-vitro studies suggest that the retrobulbar ONSD may undergo ultrasound-detectable distension seconds after the development of intracranial hypertension<sup>[6]</sup>. Ultrasonography is also increasing being used to study ocular anatomy and pathologies related to it and can use to follow up patient with ICP. Ultrasound is a reproducible technique in

measurement of the OPND, easily learned with low intra-observer and inter-observer variation<sup>[7]</sup>. Computed tomography (CT) and magnetic resonance imaging (MRI) are non-invasive methods which can be used to infer ICP and determine the safety or otherwise of lumbar puncture. These methods however require the patient to be moved, are frequently not available in resource-poor settings and when available it is expensive and can be normal, early in the presence of raised ICP<sup>[8,9]</sup>. Invasive intracranial devices including intra-ventricular catheters and intra-parenchymal probes are considered the gold standard for ICP measurement<sup>[10,11]</sup>. These techniques are associated with several complications and are contraindicated in some cases. They are however not readily available in developing countries.

The advantages of ultrasound allow it to be used in emergency departments and intensive care units to evaluate patients with raised ICP. However knowledge of the normal range of ONSD in a healthy population is essential to interpret this measurement as a marker of intracranial pressure in clinical practice and studies have shown there is variability in normal value of ONSD with race and ethnicity<sup>[12-14]</sup>. Therefore this study is aimed at determining optic nerve diameter in normal Nigerian adults.

## MATERIALS AND METHODS

Trans-orbital ultrasound measurement of the optic nerve sheath was performed on 300 eyes comprising of 150 consecutive normal volunteers at the radiology Department University of Abuja Teaching Hospital Gwagwalada, Abuja.

Before commencement of ultrasound examination brief history was taken. Volunteers aged 18 years and above who came for routine pre-employment, and general medical check-up were recruited into the study. Subjects with suspected raised ICP, ophthalmic disease, head or ocular trauma, intracranial tumours and ocular pathology observed during ultrasound examination were excluded from the study.

Subjects were examined in supine position with eyes closed maintaining a fixed gaze. Ultrasound gel was applied to each of the eyelid starting from the right. A 7.5 MHz linear transducer of EMP G70 China ultrasound scanner was placed over the lateral aspect of the closed upper eyelid; care was taken not to apply pressure on the globe. The probe was angled medially and caudally until the hypoechoic optic nerve could be clearly demonstrated posterior to the globe. The ONSD was measured 3mm behind the posterior scleral surface of the globe at an angle perpendicular to the eye ball using with use of electronic caliper. An average of two measurements was recorded for each eye. All scans were done by

two observers to minimise intra-observer variation. The age and sex of the subjects were recorded.

### Statistical analysis

Data were analysed using SPSS 19.0 software. Mean±SD was presented for age. Frequencies and percentages were computed for gender and age groups. Pearson's correlation coefficient (*r*) was computed to assess correlation with age and sex. *p*<0.05 was considered significant.

## RESULTS

A total of 150 consecutive subjects comprising 64 (42.7%) males and 87 (57.3%) females were recruited for this study. The mean age of the subjects was 38.69±12.85 years (range: 18–78 years). The majority (38.2%) are in the age range of 30-39 years. The mean age of males was 42.42±15.77 years and that of females was 35.92±9.33 years. This difference was statistically significant. (*p*=0.05).

Mean optic nerve sheath diameter was 4.20± 0.38 mm (range 3.91-5.20)

The mean right and left ONSD was 4.20±0.32mm (range 4.3-5.2mm) and 4.21±0.43mm (3.91-.5.0mm) respectively. The left ONSD was higher than the right. This was not statistically significant *p*=0.07 and 0.09 for right and left respectively.

The right ONSD for males was 4.21±1.2mm while reading for the left was 4.22±1.5mm. Among the females the right ONSD was 4.20± 1.0mm and left was 4.21±1.6mm. [Table 1]. Mean values were higher in males compared to females. This was not statistically significant *p*=0.440.

The highest measured OPND was seen in 18-19 age groups measuring 4.25mm and 4.27mm for right and left respectively. The lowest value was recorded in age group >70 measuring 4.21 and 4.20 for right and left side. [Table 2]

There was weak positive correlation between ONSD, age and sex but this was not statistically significant. (Pearson correlation=0.059, *p*=0.476 for age; Pearson correlation =0.063, *p*=0.440 for sex) [Table 3].

**Table 1: Sex distribution with mean right and left ONSD.**

Sex	Frequency	Percentage	ROPNS (mm)	LOPNS (mm)
Males	64	42.7	4.21 ± 1.2	4.22 ± 1.5
Females	85	57.3	4.20 ± 1.0	4.21 ± 1.6

**Table 2: Age and mean right and left ONSD**

Age group (years)	Frequency	Percentage	ROPNS (mm)	LOPNS (mm)
21 – 29	3	2.0	4.22 ± 0.46	4.23± 0.62
30 – 39	34	22.7	4.25 ± 1.8	4.27 ± 1.3
40 – 49	58	38.7	4.24 ± 0.6	4.25 ± 1.6
50 – 59	35	23.3	4.23 ± 0.56	4.22 ± 0.53
60 – 69	15	10.0	4.20± 0.51	4.21 ± 0.42
> 70	5	3.3	4.21± 0.49	4.20± 0.77
<b>Total</b>	<b>150</b>	<b>100.0</b>		

**Table 3: Pearson correlation between ONSD, age and sex.**

Parameter	Correlation	OPNS	P-value
Age	0.059		0.476
Sex	0.063		0.440



**Figure 1: Transorbital ultrasonogram showing the optic nerve sheath (OPNS) measured 3mm behind the globe (green arrow indicating 3mm from the globe while the horizontal electronic caliper represents OPNS measurement).**

### DISCUSSION

Raised intracranial pressure a neurological emergency, is a common manifestation of severe brain injury with several aetiologies such as brain tumours, obstructive hydrocephaly, posttraumatic intracranial haemorrhage, meningoencephalitis, and toxic encephalitis<sup>[10]</sup>. It is associated with poor neurological outcomes and increase mortality including brain death from brainstem herniation. There is a need for early and rapid diagnosis to prevent brain death. Monitoring and frequent evaluation of patients with raised ICP is of paramount importance especially in the Neuro-intensive Care Unit and emergency units<sup>[8,10]</sup>.

Transorbital ultrasound has been proven to be simple, reproducible method of detecting raise ICP early before papilloedema sets in by measuring the optic nerve sheath diameter<sup>[4,5]</sup>. This prompted this study to establish a base line values for normal optic nerve sheath diameter which can aid in diagnosis of raised ICP.

Several studies have shown variation in the range of optic nerve sheath diameter in normal subjects obtained using ultrasonography. Maude et al<sup>[12]</sup> obtained a range of 4.24–4.83 mm ONSD in Bangladesh among one hundred and thirty -six volunteers using 15 MHz transducer. Ali et al<sup>[15]</sup> in Pakistan found the normal range of ONSD between 4.3–5.7 mm among hundred healthy subjects using 7.5 MHz transducer. Bauerle et al<sup>[16]</sup> in German obtained mean value of 5.4 mm and normal range 4.3-7.6 mm among forty subjects. A range of 3.1-4.6 mm optic nerve diameter among eighty healthy Nepalese subjects using 13MHz linear transducer was reported by Shrestha<sup>[14]</sup>. The range of ONSD obtained in this study (3.9-5.2mm) was similar to the reported values by Ali et al<sup>[15]</sup> in Pakistan, higher than values recorded by Maude et al<sup>[12]</sup> in Bangladesh, Shrestha in Nepal<sup>[14]</sup> and Blantyre<sup>[7]</sup> in UK. Our values were however lower than obtained values in Germany.

The differences in normal range between studies may be due to differences between ethnicities and race, differences in methodology applied, differences in population size, type of ultrasound machine used (two dimensional/ three dimensional ultrasound) and differences in the frequency of probe used. The precision of measurement of ONSD increases with increasing frequency of the ultrasound probe used<sup>[17]</sup>. The relatively narrow normal range of optic nerve sheath diameter was obtained with higher frequency probe (13-15MHz) in studies by Maude et al<sup>[12]</sup> in Bangladesh and Shrestha in Nepal<sup>[14]</sup>.

There has been no consensus on the optimal cut-off value of abnormal ONSD to indicate elevated ICP, however measured ONSD of 5 mm is the critical value that is usually considered abnormal in adults, especially if bilateral, it may suggest raised ICP<sup>[18]</sup>. The measured ONSD obtained in this study was however less than 5mm.

The mean right and left optic nerve sheath obtained by Shrestha<sup>[14]</sup> in his study was 3.97 mm and 3.98 mm. These values were lower than the figures obtained in the present study; the similarity with this study was that the left value of ONSD was higher compared to right. Our values (right =4.20mm and left=4.21) mm were however close to figures obtained in by Anas<sup>[19]</sup> (right=4.18mm and left 4.16 mm) in a study to determine normal optic nerve diameter in adults and Garcias<sup>[20]</sup>. The differences in mean right and left values of OPND in these studies<sup>[14,19,20]</sup> was however not statistical significance. This finding was also obtained in the present study.

There was no statically significant difference in right and left ONSD in males and female. Similar findings was obtained in other studies<sup>[12-16,19,20]</sup>. Other studies<sup>[14-15]</sup> also showed no difference in ONSD between males and females. This was in agreement with our work.

In a study conducted by Ballantyne et al<sup>[21]</sup> to determine normal optic nerve sheath in normal children, they observed a progressive increase in optic nerve diameter with increasing age. There was a significant positive correlation between ONSD and age established from their study. Similar finding was obtained in a study by Aschkan<sup>[22]</sup> on sonographic evaluation of optic nerve sheath diameter in children with raised intracranial pressure among the controls used. This is contrary to findings in this study, no significant correlation between ONSD and age was observed. However our findings was in agreements with other studies<sup>[14,15,20]</sup>. The index study recruited only adults.

Computed tomography and Magnetic resonance imaging provides high spatial resolution and can be use to determine normal range of ONSD. Bauerle et al<sup>[16]</sup> established a good correlation between ultrasound and MRI measurement of the ONSD 3 mm behind the papilla. In their separate studies conducted on measurement of ONSD using ultrasound and MRI, 3mm behind the papilla recorded a mean ONSD of 5.4mm and 5.6mm respectively. However, it is unknown whether same can be attributed between CT and ultrasound measurement of ONSD. MRI and CT are expensive and not readily available in this environment.

Limitation of this study is that of the smaller sample size. To detect clinically important effect, the sample size must be large enough<sup>[23]</sup>. However, an overlage sample is not necessary as it seems unethical to involve unnecessary extra subjects because of cost implication.<sup>[24]</sup>

## CONCLUSION

Normative values for normal optic nerve sheath diameter for Nigerian adults using ultrasound have been established. This will play a significant role in early diagnosis of raised intracranial pressure.

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