DOI: https://dx.doi.org/10.4314/gjpas.v27i3.9

GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES VOL. 27, 2021: 335- 339
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TRANS-ORBITAL SONOGRAPHIC ASSESSMENT OF OPTIC NERVE DIAMETER IN A SAMPLED NIGERIAN POPULATION

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(Received 26 April 2021; Revision Accepted 24 May 2021)

ABSTRACT

Background: Studies have reported variants in the dimensions of optic nerve diameter among different ethnic groups, just as other body anatomy differs from regions to regions.
Aim: To establish normal range of optic nerve diameter in a sampled Nigerian population, sonographically.
Materials and Method: A total of 725 apparently healthy adult subjects (362 males aged 32 to 65 years and 363 females aged 30 to 68 years) were recruited from the South South and South Eastern parts of Nigeria for this prospective descriptive study. The optic nerve diameter (OND) was measured using a high-resolution digital dedicated small-parts real time ultrasound machine (Sonoace 5500; Medicol, Medison, Miami, FL, USA) with a high frequency (10-MHz) linear array transducer. Subjects were in supine position and were asked to keep their eyes closed and still. Coupling gel was placed on the closed eye lid with the transducer softly placed over the upper temporal eyelid in an axial plane. The OND was measured perpendicular to the vertical axis of the scanning plane as a horizontal distance between the two walls of the nerve sheath. The height and weight of the subjects were determined using a meter rule and a weighing scale.
Results: The mean optic nerve sheath diameter of males and females was 4.2 ± 0.13 mm. It ranged from 4.0 to 4.45 mm. The optic nerve sheath diameter of males was not significantly different from that of females ($p = 0.345$). No significant difference between the mean OND of both eyes ($p = 0.345$). Body mass index and age did not have any association with OND ($r = 0.017, 0.034$), the data were normally distributed.
Conclusion: Optic nerve diameter of apparently normal Nigerian adults ranges from 4.0 to 4.5 mm. Values outside this range may demand further evaluation in the study population.

KEYWORDS: Optic nerve diameter, Trans-orbital, Ultrasonography.

INTRODUCTION

The optic nerve, although classified as cranial nerve, is actually an extension of the forebrain and conveys afferent fibres from the ganglion cells of the retina (Estomih and Gregory, 2006; Crossman, 2008; Snell, 2010; Singh, 2014). It passes out of the orbit through the optic canal to the chiasm, where part of the fibres cross to the opposite side and pass through the optic tract to the geniculate bodies, superior colliculus, and the pretectum (Estomih and Gregory, 2006; Crossman, 2008; Snell, 2010; Singh, 2014). The optic nerve is also called cranial nerve 2 and transmits visual information from the retina to the brain.
It is derived from the embroynic retinal ganglion cell and originates from an out pouching of the diencephalon during embryonic development (Estomih and Gregory, 2006; Crossman, 2008; Snell, 2010; Singh, 2014). Fibres of the optic nerve are covered with myelin produced by oligodrendrocytes and not Schwann cells, which are found in the peripheral nervous system (Estomih and Gregory, 2006; Crossman, 2008; Snell, 2010; Singh, 2014).
Measurement of intracranial pressure is very useful in clinical practice and provides vital information on certain systemic pathology. Direct measurement of intraventricular or subdural pressure is invasive and cannot be practically carried out in the accident and

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emergency department. Raised intracranial pressure usually indicates pathologies or clinical conditions that require urgent medical attention and management. In patients with elevated intracranial pressure, dilation of the optic nerve and optic disc which may sometimes be observed during ophthalmoscopic evaluation had been reported (Newman *et al*., 2002). Elevated intracranial pressure (EICP) may be present in emergency department in patients with head trauma, hypoxia and intracranial haemorrhage including tumour complications, all of which require rapid intervention (Munch, 2001). Early diagnosis of acute intracranial hypertension is essential to enable prompt and optimal treatment.

Intracranial transducer is the gold standard for monitoring intracranial pressure, but this is an invasive procedure and the facilities are only available in well-resourced specialist units. Intracranial pressure can also be measured by lumbar puncture, but this procedure is also invasive and cannot be repeated frequently and in some cases, contraindicated. Raised intracranial pressures can also be inferred from computed tomography scan, but this facility is not available in a good number of African hospitals and has the risk of radiation exposure. Measurement of the optic nerve diameter has been shown to be a reliable method of detecting raised intracranial pressure (Beare *et al*., 2008). It has the advantage of being noninvasive, no risk of radiation exposure, is readily available and can be used at bed site without the risk of moving critically ill patients. It can also be easily repeated to re-evaluate a patient.

It is therefore, important to note that the optic nerve sheath diameter (ONSD) is increased in EICP, and its measurement can be used to directly monitor increased intracranial pressure (Blavias *et al*., 2002) in adult patients in the emergency department with suspected elevated intracranial pressure, noted that patients with altered level of consciousness may be suffering from increased intracranial pressure from a variety of causes including head injury and spontaneous intracranial bleeds. However, in most of these patients, the ophthalmoscopic evaluation is impossible or extremely difficult (Newman, 2002) and as a result, optic nerve ultrasonography (ONUS) has been recommended more often in emergency services (Blavias *et al*., 2002).

MATERIALS AND METHODS

A total of 725 apparently healthy adult subjects (made up of 362 males aged 32 to 65 years and 363 females aged 30 to 68 years) who were informed of the study, were recruited from the South South and South Eastern parts of Nigeria for this prospective descriptive study. On arrival to the imaging room, the procedure and aim of the research were explained to the volunteers. Only volunteers who gave their informed consents were recruited for the study. The optic nerve diameter (OND) was measured using a high-resolution digital dedicated small-parts real time ultrasound machine (Sonoace 5500; Medicol, Medison, Miami, FL, USA) with a high-frequency (10-MHz) linear array transducer. The ultrasound equipment produced a 3 cm x 4 cm field of view with an axial resolution of 0.5 mm and a lateral resolution of 1 to 2 mm. During measurement of the OND, subjects were in supine position and were asked to keep their eyes closed and still. Coupling gel was placed on the closed eye lid and the 10MHz transducer was softly placed over the upper temporal eyelid in an axial plane (figure 1) as described by Chan and Mork (2008). This section provided a transverse view of the globe and the postbulbar area. Thereafter, the output intensity and ultrasound gain was adjusted to achieve an optimum level of contrast between the echogenic postbulbar fat and the hypoechoic optic nerve complex. Known diabetic and hypertensive subjects, subjects with other ocular pathologies, pregnant mothers and chronic alcoholic subjects were excluded from the study. Apparently normal subjects without the above exclusion criteria and within the age range of 30 to 68 years were recruited for the study. All measurements were performed by a single well experienced sonographer (work experience > 20 years). Four measurements (two measurements for each eye) were taken and the average recorded. The OND was measured perpendicular to the vertical axis of the scanning plane as a horizontal distance between the two walls of the nerve sheath as shown by the cursor (figure 2). The height and weight of the subjects were determined using a meter rule and a weighing scale. Normality of the data obtained was tested using Shapiro Wisky test. Ethical approval for the study was obtained from the Ethical Research Committee of the Department of Radiography & Radiological Science, Faculty of Allied Medical Sciences, College of Medical Sciences, University of Calabar, Calabar, Nigeria (UC/ECRA/20/002).

Figure 1: Technique for measuring the optic nerve sheath diameter

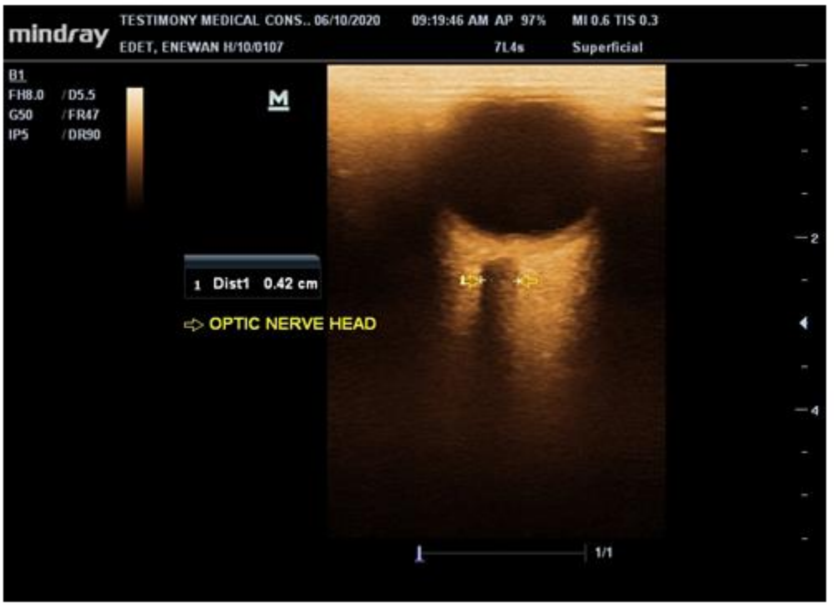

Figure 2: Ultrasound image of the optic nerve sheath diameter

RESULTS

The mean optic nerve sheath diameter of males and females was 4.2 ± 0.13 mm. It ranged from 4.0 to 4.45 mm. The optic nerve sheath diameter of males was not significantly different from that of females (p = 0.345). There was no significant difference between the mean OND of both eyes (p = 0.345). Body mass index and age did not have any association with optic nerve diameter (r = 0.017, 0.034). The data were normally distributed.

Table 1: Age and gender distribution of optic nerve sheath diameter (OND)

Age group	Males OND(mm) mean±SD	N	Females OND(mm) mean±SD	N	p-value
30-39	4.2±0.13	22	4.2±0.13	20	0.41
41-49	4.3±0.19	43	4.3±0.17	51	0.09
50-59	4.2±0.14	105	4.2±0.14	107	0.11
60-69	4.2±0.18	162	4.2±0.15	159	0.07
70-79	4.3±0.17	30	4.3±0.17	26	0.63

DISCUSSION

The superficial location of the eye, its cystic composition and the advent of high-frequency ultrasound make sonography ideal for imaging the eye among other imaging techniques (Byrae and Green, 2002). The mean optic nerve sheath diameter of males and females in the studied population was 4.2 ± 0.13 mm. It ranged from 4.0 to 4.5 mm. The optic nerve sheath diameter of males was not significantly different from that of females (p = 0.345). There was no significant difference between the mean OND of both eyes (p = 0.345). The similarity between OND of males and females and between the right and left eyes in the present study is in agreement with similar works (Ballantyne *et al*., 1999; Ballantyne *et al*., 2002; Chan and Mork, 2008). The dimension of a number of organs in the body such as plantar aponeurosis, heel pad, liver, kidney and other structures or tissues differ between males and females (Udoh *et al*., 2009; Udoh *et al*., 2010), but the optic nerve diameter is one organ that does not differ in dimension between both gender and between both eyes. However, there is a wide variation of the normal dimension of OND in other studies (Soldatos *et al*., 2008; Soldatos *et al*., 2009). Genetic and geographical factors are thought to be the most probable reason for the variation noticed. Body mass index and age did not have any association with optic nerve diameter (r = 0.017, 0.034) in this study.

The optic nerve sheath diameter (ONSD) has been reported to be useful in the assessment of intracranial pressure and direct measurement of the OND has been applied in brain-injured patient to detect elevated ICP (Gecraets *et al*., 2007). Raised ICP is usually established as an acute situation which may reduce blood perfusion and oxygen delivery to the brain, leading to ischemia and progression towards brain tamponade (Soldatos *et al*., 2009). Enlargements of the optic nerve sheath has been shown not to be a static indicator of intracranial hypertension but a dynamic phenomenon which varies with changes in the ICP (Soldatos *et al*., 2009). This property makes the optic nerve a useful tool in the monitoring of patient's ICP. Studies on brain-injured patients have shown that rapid diagnosis and treatment of intracranial hypertension are invariably associated with a better outcome (Gecraets *et al*., 2007; Tayal *et al*., 2007). Similarly, evaluation of the optic nerve sheath diameter (which has been shown to be a simple non-invasive procedure), is said to be a potentially useful tool in the assessment and monitoring of children with hydrocephalus suspected of having raised intracranial pressure (Newman, 2002).

Early diagnosis of patients with known or suspected intracranial haemorrhage can be achieved with bedside ultrasonographic measurement of the optic nerve sheath diameter to detect raised intracranial pressure (Moretti and Pizzi, 2009). Vivek *et al* (2007) on adult emergency department in-patients with suspected intracranial injury with possible elevated intracranial pressure; stated that bedside emergency department optic nerve sheath diameter ultrasound has the potential as a sensitive test for elevated intracranial pressure in adult head injury. Damage to the optic nerve typically causes permanent and potentially severe loss of vision, as well as an abnormal papillary reflex, which is diagnostically important. Injury to the optic nerve can be the result of congenital or inheritable problems like Leber's hereditary, optic neuropathy, glaucoma, trauma, toxicity, inflammation, ischemia, infection (very rarely) or compression from tumours or aneurysms. As a result of the variations in the dimensions of OND among different genetic groups, there is therefore need for normal values among different ethnic groups.

CONCLUSION

Optic nerve diameter of apparently healthy Nigerian adults ranged from 4.0 to 4.5 mm. Values of the optic nerve diameter outside this normal range may demand further evaluation in the study population.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the voluntary participation of all the subjects. The staff and management of Assurance Medical Diagnostic Centre Calabar, is also acknowledged for the approval granted to use their facilities for the study.

CONFLICTS OF INTEREST

None declared

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