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RESEARCH ARTICLE

Comparative Analysis of Optic Nerve Diameter Using Ultrasonography Between Normotensives and Preeclamptic Patients at University of Medical Sciences Teaching Hospital, Ondo, Nigeria

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ABSTRACT

Background: **It is an established fact that obstetric patients with preeclampsia do have increased optic nerve diameter compared with normotensives patients. Ultrasonography is increasingly advocated as a valuable screening tool for evaluating the optic nerve diameter as a surrogate marker for raised intracranial pressure due to its noninvasive nature, low cost, portability, dynamic real-time assessment and rapid performance. This study aims to compare the ultrasonographic measurement of optic nerve diameter between two groups of preeclamptic and normotensive pregnant women.**

Methodology: **This cross-sectional descriptive study was carried out at the Department of Radiology, University of Medical Sciences Teaching Hospital Complex, (UNIMEDTHC), Ondo State, Nigeria. It consisted of 90 preeclamptic (study) and 90 normotensives (control) aged-matched pregnant women. The optic nerve diameters were measured by the radiologist using a high frequency linear ultrasound probe (7.5–12 MHz).**

Results: **The optic nerve diameter as measured by ocular ultrasound scan was statistically significantly higher (p-value of <0.05) in preeclamptic patients compared to normotensives with a mean of 6.22 ± 0.83 mm versus 4.50 ± 0.69 mm, respectively.**

Conclusion: **Ocular ultrasound scan for measurement of optic nerve diameter is a reliable screening tool for assessing raised intracranial pressure in preeclamptic patients when compared to normotensive ones.**
Therefore, it is recommended that performing non-invasive ocular ultrasound scans be advocated for all pregnant women with or at risk of preeclampsia.

Keywords: Optic Nerve Diameter, Preeclampsia, Raised Intracranial Pressure, Sonography.

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1. Introduction

Despite advances in medicine and women's health, preeclampsia (PE) still remains one of the main causes of maternal and perinatal deaths globally [1], [2].

Raised intracranial pressure, a complication of PE if quickly identified and prompt action taken can improve outcome for the foetus and preserve maternal life [3], Therefore, a fast, dependable and non-invasive method of determining raised intracranial pressure (ICP) is strongly advocated.

The gold standard for monitoring ICP is an intraventricular catheter connected to external pressure transducer [4]. It is however invasive, and associated with many complications [5].

Noninvasive methods for measuring intracranial pressure includes Computed Tomography with rapid acquisition time and radiologic signs in keeping with raised

ICP are easily detected. The drawbacks are that it is costly, employs ionizing radiation and cannot be done by patient bedside [6].

MRI is also a noninvasive imaging tool with the same clinical applications like CT, its ability to detect raised ICP and also identify the etiology of the raised ICP. Its drawback is that it is costly, time consuming, cumbersome, not readily available and can't be done by the patient's bedside [7].

Prompt detection of elevated ICP is essential for better feto-maternal outcome, hence the need for a fast, reliable, cheap, non-invasive and readily accessible method of determining raised ICP that can also be done by the bedside. Ultrasonography is fast, non-invasive, reproducible and can be done by the patient bedside. It is also readily available.

Recent advances in medicine have shown that there is a relationship between the brain and the optic nerve. The optic nerve itself is a prolongation of the brain matter and its nerve sheath is continuous with that of the dura mater. The subarachnoid space within the brain contains cerebrospinal fluid (CSF) which is also seen in the subarachnoid space of the optic nerve. In cases of raised ICP, the pressure in the brain is also transmitted to the CSF around the optic nerve, thereby expanding it [8].

Studies have shown that the most distensible part of the optic nerve is at 3 mm behind the orbit where the former is only surrounded by fat and the dura sheath is most sensitive to raised ICP [9]. Hence measurement of the optic nerve diameter (OND) at this point gives a non-invasive measurement of the ICP.

It has also been established that OND is increased in cases of raised ICP; and since preeclampsia is a known cause of raised ICP, OND is also increased in the former [10], [11].

While most studies done to evaluate the usefulness of OND in detecting raised ICP has been in patients [12], [13] with head injury, a lot of studies have also been done to show its relevance in preeclampsia [8], [10]–[12].

Though a lot of physiological changes occur in pregnancy, this study aims to validate the fact that OND changes seen in preeclampsia is not due to physiological changes but as a result of raised intracranial pressure by comparing the optic nerve diameter between PE patients and normotensive pregnant women.

2. Materials and Methods

This prospective, cross-sectional study was carried out at the Department of Radiology, UNIMEDTHC, Ondo State, from September 2020 to August 2021. One hundred and eighty consenting pregnant women who presented at the obstetrics unit at estimated gestational age of 28 weeks and above were serially recruited into the study. Exclusion criteria for both groups were patients with previous history of eye surgery or brain surgery, those with intracranial pathology or glaucoma, patients with preexisting (chronic) hypertension and renal diseases. Of the 180 patients, the first group (A) were 90 healthy pregnant women with normal blood pressure less than or equal to 120/80 and no proteinuria in their urine while the second group (B) were pregnant women diagnosed with PE by the Obstetrician based on clinical and laboratory findings: blood pressure greater than or equal to 140/90 mmHg on two separate examinations and proteinuria of 1+ or higher from two different evaluation.

High frequency linear transducer of 7 MHz–12 MHz SONOSCAPE Real-time ultrasound machine Model S8 EXP® was used. All participant lay supine on the couch with their eyes closed and informed not to move the eyeballs during the procedure.

To reduce discomfort to the patient, the temporal side of the eye was the starting point and gradually extended towards the nasal part until the optic nerve was identified as a hypoechoic linearly oriented structure extending from the optic disc and surrounded by the echogenic retrobulbar fat. Both longitudinal and transverse scans were performed. An electronic caliper was used to mark the point of the widest distensibility of the optic nerve which at 3 mm behind the globe [14]–[16] (Fig. 1). The widest diameter visible (3 mm behind the optic disc) was measured three times and the mean value recorded.

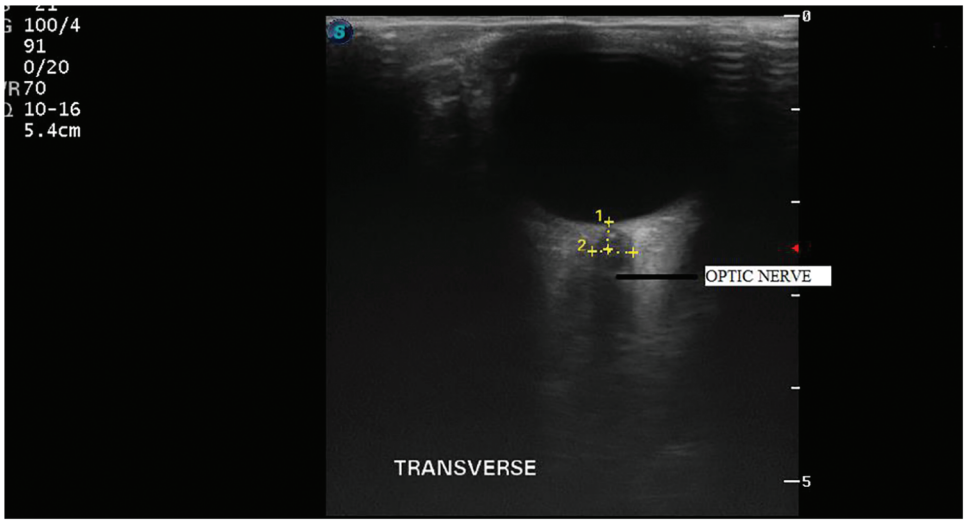

Fig. 1. Showing label 1 and 2 which are 3 mm behind the optic disc and the measured diameter of the optic nerve respectively.

All data were recorded in the patient's datasheet. These were then transferred into the computer spreadsheet using Statistical Package for Scientific Solutions (SPSS) version 23.0 for windows (SPSS Inc., Chicago, IL, USA). Independent Sample T-test was used to compare the OND on ultrasound among PE and normotensives patients.

Pearson Correlation was also used to determine the relationship between OND on ultrasound, blood pressure and proteinuria in patients with PE and normotensives.

A level of $p \leq 0.05$ was considered statistically significant for all tests.

Approval for the study was granted by the hospital ethics and research committee and written consent taken from all patients.

3. Results

The age range of the study population is between 23 through 45 years. There was no statistically significant difference in their demographics.

Both groups were comparable in terms of age, gestational age, height and weight.

This is shown in Table I.

Optic nerve diameter was measured for the right and left eyes. There were statistically significant differences in OND between the preeclamptic and the normotensive group. The range of OND on the right for preeclamptic and normotensives were 4.74–8.52 mm and 2.99–5.54 mm with a mean of 6.45 ± 0.85 mm and 4.23 ± 0.62 mm respectively ($p = 0.001$).

Similar results were noted on the left where the range of OND for preeclamptic and control groups were 4.97–8.26 mm and 2.79–5.23 mm respectively with a mean of 6.25 ± 0.63 mm and 4.1 ± 0.65 mm respectively ($p = 0.001$).

This is shown in Table II.

Of the 90 preeclamptic patients, 30 had mild, 42 moderate and 18 had severe proteinuria.

TABLE I: Demographic Data Between Study Population with Values Given as Mean

Variables	Preeclamptic n = 90	Normotensive n = 90	Statistics	p-value
*Height in m	1.62 ± 0.08	1.61 ± 0.09	0.862	0.355
*Weight in kg	88.4 ± 10.2	83.2 ± 10.9	0.963	0.328
Age (years)	32.4 ± 5.8	31.9 ± 5.6	0.267	0.606
*EGA in weeks	36.3 ± 3.3	35.9 ± 3.3	0.004	0.950

Note: * independent sample t-test was used to compare means, EGA-Estimated Gestational Age.

TABLE II: Comparing OND of Preeclamptic and Normotensive Patients

OND Mean ± SD Range	Preeclamptic n = 90	Normotensive n = 90	t*	p-value
Right	6.45 ± 0.85 (4.74–8.52)	4.23 ± 0.62 (2.99–5.54)	20.62	**0.001**
Left	6.35 ± 0.63 (4.97–8.26)	4.10 ± 0.65 (2.79–5.23)	21.27	**0.001**

Note: * independent sample t-test was used to compare means, OND-Optic nerve diameter, SD-standard deviation.

TABLE III: Relationship Between OND on Ultrasound and Laboratory Parameters

Variable's	r	p-value
Proteinuria	0.461	0.001
Blood pressure	0.419	0.001

Note: r = Pearson correlation coefficient, BMI = Body mass index, EGA = estimated gestational age.

Proteinuria was graded into mild (+) moderate (++) and severe (+++).

The OND was highest in preeclamptic with severe proteinuria with a mean value of 7.2 ± 0.8 mm while those with moderate proteinuria had a mean value of 6.5 ± 0.8 mm, and those with mild had mean values of 5.9 ± 0.6 mm.

There was a statistically significant difference between them ($p = 0.001$).

Increases in OND were positively correlated with increases in proteinuria grading and blood pressure. These are shown in Table III.

4. Discussion

Raised intracranial pressure is one of the complications of PE usually associated with significant maternal and fetal compromise if not detected promptly. Ocular ultrasonography of the optic nerve has proved to be a valuable screening tool in the prediction of raised ICP in patients with PE.

In this study, the mean OND was significantly higher in preeclamptic compared to the normotensives (6.22 ± 0.83 mm: 4.50 ± 0.69 mm $p = 0.001$). This is similar to the findings in separate studies by Singh *et al*. [10] and Blaivas *et al*. [12].

Singh *et al*. [10] study showed that there was a significant increase in OND among the preeclamptic compared to control participants (5.60 ± 0.37 mm: 4.70 ± 0.46 mm, $p = 0.001$).

Blaivas *et al*. [12] checked the OND of patients with CT findings of raised ICP and compared with normotensives, where he recorded a mean of 6.27 mm and 4.42 mm respectively. The slight difference in OND they documented and that of the present study may be due to the differences in the population. Singh *et al*. [10] studied 75 patients while Blaivas *et al*. [12] studied 35 patients as against 180 patients in this index study.

Mladen *et al*. [13] measured ICP using an intraventricular catheter in patients with brain injury and correlated it with OND measurements to determine the cut off. The ROC curve from their study showed that that the optimal cutoff value of OND for predicting ICP was 6.1 mm. Another study on Preeclampsia by Simenc *et al*. [11] gave a benchmark of >5.8 mm to detect increased ICP with a sensitivity of 90% and a specificity of 84%.

Our study also suggests that a cut off value for raised ICP would be around 6 mm (Our mean is 6.22 ± 0.83 mm).

Also, there was a moderate, positive correlation between mean OND and severity of proteinuria ($p = 0.001$). The mean OND was highest in preeclamptic with severe proteinuria, which correlates with the study done by Dong *et al*. [17] in which he reported that higher grades of

proteinuria had severe preeclampsia with higher incidence of fetal growth restriction and stillbirths.

While our study did not categorize patients into mild or severe PE, it shows that higher OND values correlated positively with increasing proteinuria and blood pressure measurement (Table III).

Also noted in this study is that there was no significant correlation between optic nerve diameter and estimated gestational age. Also, no significant correlation was found between the age, gestational age, weight and height of the PE patients and the normotensive groups. This agrees with the study by Arzpeyma *et al*. [18].

This study shows that increase in OND seen in preeclampsia can be attributed to raised ICP associated with preeclampsia and once raised ICP sets in, there's resultant increase in OND.

5. Conclusion

Sonographic measurement of the optic nerve is an important screening tool for the evaluation of raised intracranial pressure in preeclamptic patients. Also, it is readily available, reproducible and can be done by the bed side. Bedside optic nerve diameter is strongly advocated to be included in the management plan of preeclamptic patient to improve fetal and maternal outcome.

Declaration of Support

None.

Conflict of Interest

The authors declare no conflict of interest.

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