

# Measurement of Optic Nerve Sheath Diameter Using Ultrasound as an Indicator of Raised Intracranial Pressure in Patients with Pre-Eclampsia

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## ABSTRACT

**Introduction:** Preeclampsia is one of the common complications of pregnancy which may have life-threatening complications. One of the main neurological consequences of preeclampsia includes increased intracranial pressure (ICP), which can be demonstrated by an increase in optic nerve sheath diameter (ONSD). The usefulness of transorbital ultrasound (USG) to assess ONSD has seldom been sought in our practice. This study aims to measure ONSD in individuals with preeclampsia and compare it with that of healthy pregnant females.

**Methods:** This prospective, randomized comparative study was performed on 60 patients and the individuals were categorized into three groups; Group I- normal pregnancy (N=20), Group II -mild preeclampsia (N=20), and Group III- severe preeclampsia group (N=20). Using a high-resolution linear ultrasound probe ONSD was measured 3mm behind the globe, and the values were compared with normal pregnant females as controls.

**Results:** The three groups were comparable in terms of age, gestational age, gravidity, and weight. The ONSD was notably elevated in patients with preeclampsia in comparison to the control group ( $p < 0.001$ ). The mean ONSD of group I was  $4.58 \pm 0.44$  mm, versus  $5.82 \pm 0.25$  mm in group II, versus,  $6.11 \pm 0.46$  mm in group III. However, the mean ONSD in the two groups of mild and severe preeclampsia were not significantly different.

**Conclusions:** The ONSD demonstrated a notable increase in preeclamptic patients compared to normal individuals, suggesting its potential as a marker for elevated ICP. The advantages of ultrasound, including availability, cost-efficiency, and speed, make it a favorable tool for monitoring increased ICP and facilitating subsequent management.

**Keywords:** Gravidity; Intracranial Pressure; Pre-Eclampsia; Pregnancy

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## INTRODUCTION

Preeclampsia is a pregnancy-related disorder that affects multiple systems and is recognized as a significant contributor to maternal mortality on a global scale. Preeclampsia occurs in 7% to 8% of pregnancies and eclampsia in up to 0.9%. Typically, it is identified by new-onset hypertension and either proteinuria or end-organ dysfunction in the second half of pregnancy. Pregnancy-induced hypertension (PIH) is ranked as the second leading cause of maternal mortality worldwide. It can be associated with various pulmonary, cardiac, renal, hepatic, and neurological complications. Elevated intracranial pressure (ICP) is one of the neurological complications of preeclampsia.<sup>1,2,3,4,5</sup>

Numerous studies have highlighted a notable correlation between elevated ICP and an augmentation in the diameter of the optic nerve sheath. Additionally, from a physiological standpoint, the optic nerve is enveloped by both a dural sheath and a subarachnoid space filled with cerebrospinal fluid. Consequently, it can be asserted that the increased ICP exerts pressure on the subarachnoid space surrounding the optic nerve, leading to the expansion of the nerve sheath. Although symptoms of raised ICP include headache, blurring of vision, and vomiting among others they usually are not specific and often present late.<sup>6,7</sup>

The gold standard method for ICP measurement is based on the use of invasive devices. However, such invasive procedures can result in complications such as infection and hemorrhage. Changes in the Optic Nerve Sheath Diameter (ONSD) is an important clinical and radiographic demonstration of increased ICP.<sup>8,9,10</sup>

Various non-invasive examinations can be used to measure ONSD such as computed tomography (CT), Magnetic Resonance Imaging (MRI), and ultrasound (USG) however due to the cost, limited accessibility, and challenges in conducting CT scans and MRIs, especially in critically ill patients, and considering the additional drawback of radiation exposure associated with CT scans, ultrasounds are often preferred imaging method in these conditions. In normal adults, ONSD is 4-4.5

mm, and levels above 5 or 5.5 mm denote raised ICP. The objective of this study is to assess the elevated intracranial pressure in preeclampsia by measuring the optic nerve sheath diameter using ocular ultrasonography.<sup>11</sup>

## METHODS

This prospective, randomized comparative study was performed on pregnant patients sent for ultrasound examination from June 2023 to December 2023 in the Department of Radiology, Nepalgunj Medical College. Institutional review committee approval and written informed consent were obtained. Inclusion criteria included consecutive, healthy women with a singleton, non-anomalous pregnancy of > 20 weeks gestation, and 18 years old or older at the time of recruitment. The exclusion criteria were:

1. Past H/O optic neuritis, severe myopia, and history of ocular or intracranial surgeries.
2. Patients with known intracranial SOL.
3. Patients with altered sensorium and/ or having multiple episodes of seizure.
4. Moderate-to-severe renal, hepatic, cardiovascular, or endocrinal dysfunction.

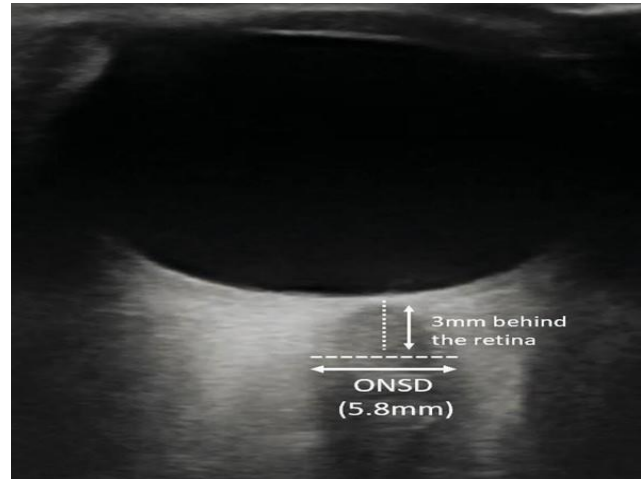
The study consisted of 60 patients who were categorized into three different groups. The sample size was determined using a Type I error rate of 0.05 and a power of 90%, based on an estimated upper limit optic nerve sheath diameter (ONSD) of 4.6 mm in a control group of healthy Nepalese adults.<sup>12</sup> To detect a 20% difference, a minimum of 18 participants per group was required; however, 20 were included to account for potential exclusions. It was assumed the severe PE group would have higher ONSD than the non-severe group.

Group I consisted of normal pregnancy (n=20), Group II- mild preeclampsia (n=20), and Group III-severe preeclampsia (n=20). Preeclampsia was defined according to the criteria established by the National High Blood Pressure Education Program.<sup>13</sup> This definition involved the association of new-onset elevated blood pressure (systolic pressure exceeding 140 mmHg or diastolic pressure exceeding 90 mmHg) and proteinuria

exceeding 0.3 g per day in a pregnant woman after 20 weeks of gestation. The determination of severe preeclampsia was based on the presence of one or more of the following indicators: blood pressure surpassing 160/110 mmHg, proteinuria exceeding 2 g per day, an elevated serum creatinine level exceeding 1.2 mg/dL, a platelet count below 100,000 cells/mm<sup>3</sup>, increased liver enzyme activities, epigastric pain, persistent headache, or other cerebral or visual disturbances. Preeclamptic patients lacking the aforementioned severe parameters were categorized as having mild preeclampsia. A checklist was prepared and information such as the age of the patient, gestational age, gravidity, weight, and previous history of preeclampsia was noted.

All patients were evaluated by Logiq P6 ultrasound machine (GE Healthcare, Waukesha, Washington) using a 7.5 MHz linear transducer for the measurement of ONSD. ONSD measurements were taken for each optic nerve in two axes of the transverse and oblique sagittal plane. The reported ONSD represents the mean of the four measurements obtained for each patient, including the transverse and sagittal planes of both eyes. Using two-dimensional mode, the depth of the optic nerve was localized and was marked at 3 mm behind the retinal and optic nerve junction with the help of a machine caliper as 3 mm behind the ocular globe, the optic nerve is only surrounded by fat and the dural sheath is distensible within its fatty environment, particularly in case of raised pressure in the cerebrospinal fluid. From this point, a transverse line is drawn from the inner to the inner edge of the optic nerve sheath (vertical hypoechoic lines) surrounding the optic nerve.

Gentle pressure was applied to the eyeball, and a thick layer of water-soluble gel was applied to the orbital fossa with the eyes closed. ONSD measurement technique is shown in Figure 1.



**Figure 1:** Optic nerve sheath diameter (ONSD) measurement using transorbital ultrasound

The results were tabulated in Microsoft Excel. Continuous variables were depicted as mean and standard deviation, and their comparison was conducted using one-way ANOVA and student t-test. Categorical data were expressed as frequency and percentage, with comparisons facilitated through the use of Chi-square or Fisher's exact test. The statistical analysis was executed using SPSS software version 26, and a p-value less than 0.05 was considered significant.

**RESULTS**

A total of 60 patients were enrolled in this study and were categorized into three distinct groups consisting of 20 patients each. Demographic profiles of all three groups are demonstrated in Table 1.

**Table 1: Demographic profile of patients in three groups (data expressed as mean ± SD)**

	Group I (N=20)	Group II (N=20)	Group III (N=20)	p Value
Age (Years)	26.4 ± 5.06	26.6 ± 4.5	27.8 ± 4.1	0.58
Gestational Age (Weeks)	35.5 ± .76	35.4 ± 1.95	36.2 ± 1.76	0.37
Gravidity	2.25 ± 0.78	1.8 ± 0.83	2.25 ± 0.85	0.14
Weight (KG)	62.4 ± 4.6	64.6 ± 4.9	68.5 ± 7.41	0.24

Each of the three groups showed similarities in terms of age, gestational age, gravidity, and

weight within their respective categories (p>0.05). Despite the commonly observed association of

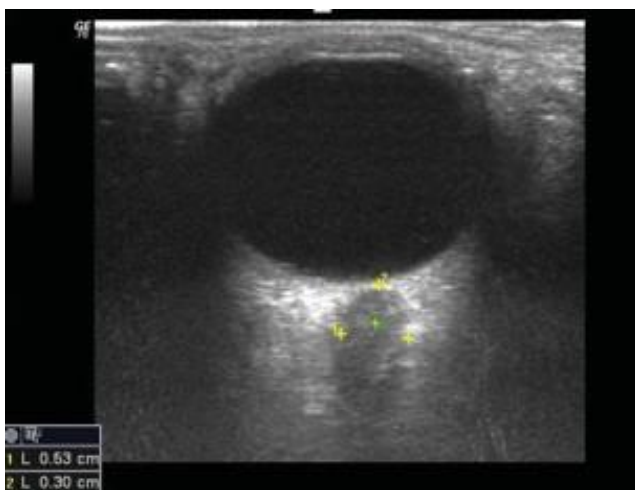
PIH with primigravida, our study revealed an insignificant difference in the incidence of PIH among the three groups.

Optic nerve sheath diameter along with systolic and diastolic arterial blood pressure were measured and compared. The comparison is illustrated in Table 2. There was a significant difference in systolic BP and diastolic BP ( $p < 0.001$ ) as both were significantly higher in Groups II and III,

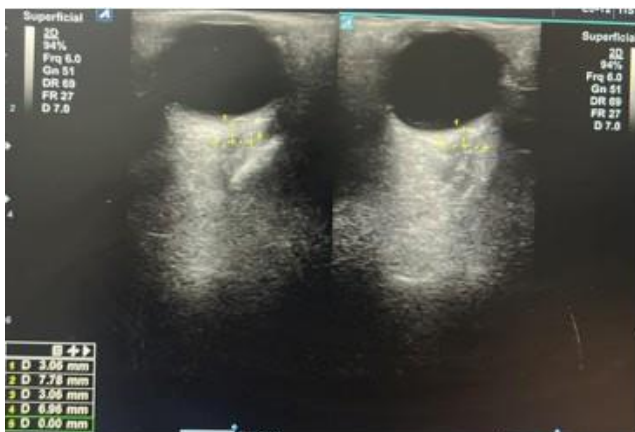
however among Groups II and III the differences were comparable. Similarly, The ONSD values were comparable for Group II and Group III, but there was a highly significant difference ( $p < 0.001$ ) when compared to the normal pregnancy group. The mean ONSD for group I was 4.58mm, while it was 5.8 and 6.1mm for groups II and III respectively.

**Table 2: Hemodynamic parameters and ONSD values**

	Group I (N=20)	Group II (N=20)	Group III (N=20)	P Value
SBP (mmHg)	107.75 ± 11.29	154.5 ± 7.93	172.75 ± 8.18	<0.001
DBP (mmHg)	73.25 ± 6.93	92.25 ± 3.79	114.75 ± 6.58	<0.001
ONSD (mm)	4.58 ± 0.44	5.82 ± 0.25	6.11 ± 0.46	<0.001



**Figure 2: Increased ONSD in the patient with mild preeclampsia**



**Figure 3: ONSD measurement in the patient with severe preeclampsia in the right and left orbit**

## DISCUSSION

Medical complications related to high blood pressure are commonly encountered during both pregnancy and the postpartum period. These hypertensive disorders represent a major contributor to premature births and pose significant risks to the health and well-being of both mothers and infants. It impacts 5 to 10 percent of expectant mothers and contributes to approximately 12 percent of maternal fatalities. Preeclampsia/eclampsia stands as the second most prevalent cause of maternal mortality in Nepal. One of the neurological complications of preeclampsia includes elevated ICP. The accuracy of the optic nerve sheath diameter (ONSD) as a screening tool for identifying increased intracranial pressure has been validated in patients with idiopathic intracranial hypertension, traumatic brain injury, and spontaneous intracranial hemorrhage. Monitoring of ICP is crucial in individuals with preeclampsia/ eclampsia as studies have demonstrated that monitoring ICP can enhance the effectiveness of clinical pharmacological interventions for intracranial hypertension in an increasing number of scenarios. Among the non-invasive techniques, USG measurement of the optic nerve sheath diameter (ONSD) has demonstrated its value in numerous clinical scenarios. In a study conducted by Jochen Bäuerle et al., they observed

that sonographic assessment, performed 3mm behind the retina, exhibits notable accuracy and reproducibility when compared to MRI findings. The cost-effectiveness, widespread availability, and capability to conduct examinations in both ICU and ward settings render ultrasound highly advantageous.<sup>14,15,16,17,18,19</sup>

In our study, demographic variables such as age, gestational age, gravidity, and age were comparable and showed no significant difference between the three groups which was in line with the study done by Davaryari et al., Nikpour et al. and Sabhia Jan et al., However, in a study by Samierad et al. they found a significant difference between the ages of two groups of patients and control women. Consistent with recent research findings, there was a significant difference in the mean optic nerve sheath diameter (ONSD) between two groups of patients with preeclampsia and those with normal blood pressure. The average ONSD for the normal blood pressure group, mild preeclampsia, and severe preeclampsia were  $4.58 \pm 0.44$ ,  $5.82 \pm 0.25$ , and  $6.11 \pm 0.46$  millimeters, respectively. These results align closely with the findings of Singh et al. 24 (4.7, 5.6, and 5.8 millimeters, respectively).<sup>20,21,22,23,24</sup>

Various prominent studies in the past have shown that ONSD above 5.8 mm was considered equivalent to ICP above 20mmHg and used as a cutoff value. The probability of having high ICP when the ONSD is below 5.8 mm is very low. In our study, in the control group diameter of all patients was below this value.<sup>25,26</sup>

## CONCLUSION

Our study illustrates the association between preeclampsia and ONSD, indicating that ONSD tends to be higher in patients with preeclampsia compared to normal individuals. However, no significant difference in ONSD was observed between the two groups of mild and severe preeclampsia. USG offers a rapid, noninvasive, and readily available means to measure ONSD and categorize patients at risk of severe neurological complications from eclampsia. This, in turn, can

facilitate timely medical intervention. Therefore, incorporating transorbital ONSD measurement as a point-of-care test for evaluating the severity of pre-eclampsia should be considered.

## CONFLICT OF INTEREST

None

## SOURCES OF FUNDING

None

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