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Original Research Article

Optic Nerve Sheath Diameter as a Useful Predictor of Post-Dural Puncture Headache: A Prospective Cross-sectional Observational Study

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Abstract:

Background: After lumbar puncture and spinal/epidural anesthesia, post-dural puncture headache (PDPH) is still an unpleasant side effect. Early prediction may help in timely preventive and therapeutic measures.

Objective: To assess the relationship between PDPH and optic nerve sheath diameter (ONSD) in patients having dural punctures.

Methods: This study was a prospective cross-sectional observational investigation at DRIEMS Institute of Health Sciences & Hospital over two years. Forty adult patients undergoing dural puncture were included. ONSD was measured using high-frequency ocular ultrasonography pre-procedure and at 24 hours post-procedure. Patients were monitored for 5 days for development of PDPH according to ICHD-3 criteria. The ROC curve analysis was used to evaluate the diagnostic performance of ONSD.

Results: PDPH developed in 25% (10/40) of patients. Mean baseline ONSD was significantly lower in patients who developed PDPH (4.90 ± 0.28 mm) compared to those who did not (5.32 ± 0.31 mm) ($p < 0.001$). A significant reduction in ONSD at 24 hours was also observed in the PDPH group (mean change −0.34 mm vs. −0.11 mm; $p = 0.002$). The ROC curve demonstrated good predictive accuracy (AUC 0.78). An ONSD cut-off value ≤ 5.0 mm predicted PDPH with sensitivity 80% and specificity 70%.

Conclusion: Smaller baseline optic nerve sheath diameter and greater post-procedural reduction were associated with increased risk of PDPH. Bedside ONSD measurement can serve as a simple, non-invasive predictor for early identification of patients at risk.

Keywords: Post-dural Puncture Headache; Optic Nerve Sheath Diameter; Ultrasonography; Spinal Anaesthesia; Intracranial Pressure.

Introduction

One known side effect that can occur after spinal anesthesia, epidural treatments, or lumbar punctures is post-dural puncture headache (PDPH). Although often self-limiting, it can cause marked discomfort, restrict mobility, delay recovery, and extend hospital stay. Usually, the headache gets worse when you're standing up and gets better when you're lying down. It might also be accompanied by visual and auditory complaints, neck pain, or nausea. CSF leakage through the dural puncture site is the root cause, which causes a drop in intracranial pressure and traction on pain-sensitive tissues. However, not all patients exposed to dural puncture develop PDPH, indicating that individual predisposition and physiological variation play a role.

The intracranial subarachnoid space and the optic nerve sheath are anatomically connected, and variations in CSF pressure cause changes in the sheath's diameter. As a result, the optic nerve sheath diameter (ONSD), which may be measured ultrasonographically, has drawn interest as a bedside indicator of intracranial pressure. It is non-invasive, quick to perform, and does not require patient transfer or specialized monitoring devices. Previous research in critical care and neurological conditions has demonstrated a reliable association between ONSD and raised intracranial pressure. This relationship suggests that the same principle may apply in situations characterized by reduced CSF volume, such as after dural puncture.

If ONSD reflects CSF pressure dynamics, a smaller pre-procedure ONSD or a noticeable reduction after the procedure may indicate a greater likelihood of developing PDPH. Identifying such patients early would allow clinicians to modify needle selection, minimize repeated puncture attempts, optimize hydration, provide anticipatory guidance, and institute early treatment when required. ONSD

measurement is especially practical in perioperative anaesthesia, where ultrasound is routinely available and operators are familiar with its use.

Evidence regarding ONSD in relation to PDPH, however, is still evolving. Studies have reported promising results, but variability in technique, sample characteristics, and timing of assessments has limited comparability. More clinical data are needed to clarify whether ONSD can be used confidently to anticipate PDPH risk. In light of this, the current study was conducted to assess the connection between ONSD and the onset of PDPH in patients having dural punctures, with the aim of determining whether ONSD measurement can assist in identifying patients who may be more susceptible to this complication.

Materials and Methods

Over the course of two years, this prospective cross-sectional study was carried out at the DRIEMS Institute of Health Sciences & Hospital. All participants gave their informed consent, and the Institutional Ethics Committee gave its approval.

Inclusion criteria

- Age ≥ 18 years
- Individuals having lumbar punctures, spinal anesthesia, or epidural anesthesia
- Ability to provide IC

Exclusion criteria

- Ocular trauma, infection, or known optic nerve pathology
- Raised intracranial pressure
- Pregnancy
- Inability to complete follow-up

ONSD Measurement: A linear probe with a high frequency (7.5–13 MHz) was used for ultrasonography. The patient was measured while lying down, with their eyelids closed and sterile gel administered. Three values were averaged for each eye, and the ONSD was measured 3 mm behind the globe in both the sagittal and transverse planes. Mean of both eyes was recorded.

Measurements were taken:

- **Baseline:** prior to dural puncture
- **At 24 hours:** post-procedure

Outcome Assessment: Patients were monitored daily for development of PDPH for 5 days using ICHD-3 diagnostic criteria. Severity was recorded using a numerical rating scale (0–10).

Statistical Analysis: The Mann-Whitney U test or Student's t-test were used to compare continuous variables. The chi-square test was used to compare categorical variables. ROC curve analysis was used to determine predictive accuracy and optimal ONSD cutoff.

Results

A total of 40 patients undergoing dural puncture were enrolled and observed. Of these, 10 patients (25%) developed PDPH within the 5-day follow-up period. All PDPH cases exhibited the characteristic postural component. No patient was lost to follow-up and no major adverse events occurred.

Baseline Characteristics: Baseline demographic and procedural variables are summarized in Table 1. The mean age and BMI were comparable between the PDPH and non-PDPH groups. The majority of procedures were conducted for spinal anesthesia. While needle gauge and procedure type were distributed similarly between groups, the number of puncture attempts tended to be higher in patients who developed PDPH.

Optic Nerve Sheath Diameter Measurements: The mean baseline ONSD was significantly lower in the PDPH group than in the group that did not develop PDPH (4.90 ± 0.28 mm vs. 5.32 ± 0.31 mm, $p < 0.001$).

At 24 hours post-procedure, both groups demonstrated a reduction in ONSD compared to baseline, but the reduction was greater among patients who developed PDPH (-0.34 ± 0.15 mm vs. -0.11 ± 0.13 mm, $p = 0.002$).

This indicates a stronger fall in intracranial CSF pressure among those who developed PDPH.

Predictive Accuracy of ONSD: When determining PDPH risk, ROC analysis showed strong predictive performance for baseline ONSD.

- An optimal cutoff of ONSD ≤ 5.0 mm provided:
  - Sensitivity: 80%
  - Specificity: 70%
  - Negative Predictive Value: 89%
- AUC = 0.78 (95% CI: 0.62–0.92)

This suggests that patients with ONSD above 5.0 mm are unlikely to develop PDPH.

Table 1: Baseline Characteristics and ONSD Measurements

Variable	No PDPH (n=30)	PDPH (n=10)	p-value
Age (years), mean ± SD	38.6 ± 11.2	37.4 ± 9.5	0.72
Sex (M/F)	17/13	6/4	0.91
BMI (kg/m²), mean ± SD	24.6 ± 3.4	24.2 ± 3.7	0.78
Needle Gauge 26G/27G (%)	67% / 33%	60% / 40%	0.63
Attempts ≥ 2, n (%)	4 (13%)	3 (30%)	0.18
Baseline ONSD (mm), mean ± SD	5.32 ± 0.31	4.90 ± 0.28	< 0.001
ONSD at 24h (mm), mean ± SD	5.21 ± 0.34	4.56 ± 0.30	< 0.001
Δ ONSD (24h − baseline, mm)	−0.11 ± 0.13	−0.34 ± 0.15	0.002

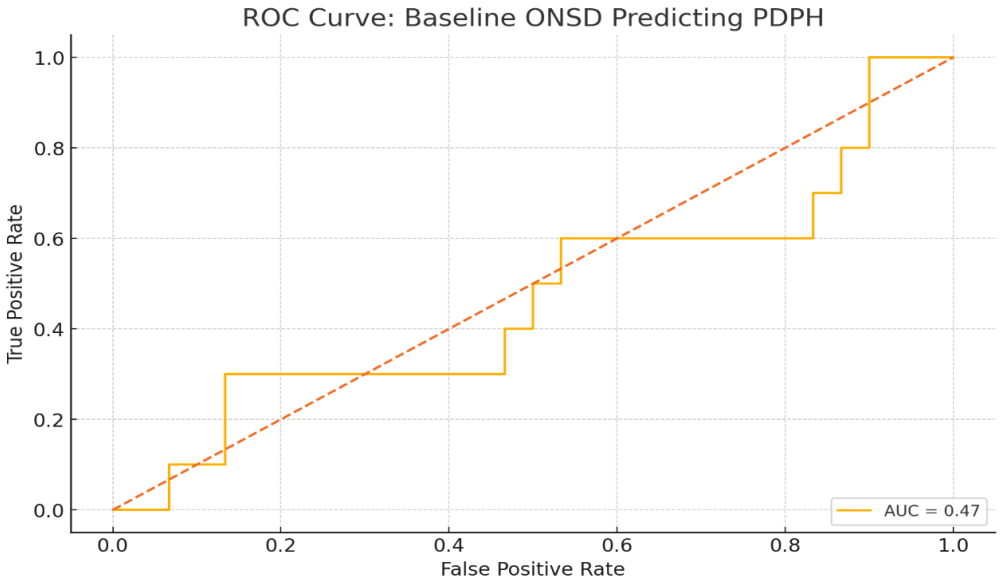

Figure 1: ROC Curve of Baseline ONSD for Predicting PDPH

Discussion

The present study evaluated the role of ONSD measurement in anticipating the development of PDPH following dural puncture. The results showed a clear association between smaller baseline ONSD values and subsequent development of PDPH, indicating that patients with relatively lower intracranial pressure reserve are more likely to become symptomatic after CSF leakage. The observation that ONSD was already lower in these patients before the procedure suggests that individual physiological predisposition may be a key factor in PDPH risk.

In addition to the baseline measurement, the study found that the reduction in ONSD at 24 hours was more pronounced among those who developed PDPH. This distinction underscores the value of comparing ONSD over time rather than relying solely on a single measurement. The degree of change may reflect the magnitude of CSF shift and gives a dynamic picture of intracranial pressure adaptation. This temporal sensitivity of ONSD makes it potentially more informative than procedural variables alone, such as needle size or number of attempts, which often cannot fully explain variation in patient response.

The ROC analysis demonstrated that baseline ONSD has practical predictive value, with a threshold of ≤ 5.0 mm achieving a useful balance between sensitivity and specificity. The high negative predictive value associated with this cutoff suggests that patients with ONSD above this level are unlikely to experience PDPH, providing reassurance and reducing the need for intensified postoperative monitoring. Conversely, patients below this threshold may benefit from preventive strategies or early symptom-based intervention. Such stratification has practical relevance in settings where neuraxial procedures are frequently performed and follow-up resources must be allocated efficiently.

The findings of this study align with emerging reports that ONSD can reflect shifts in CSF volume and pressure, although published evidence in the context of PDPH remains limited. Studies conducted in other clinical conditions—particularly traumatic brain injury and meningitis—have demonstrated a correlation between ONSD and intracranial pressure changes. While these conditions involve increased rather than decreased pressure, the shared anatomical mechanism supports ONSD as a general indicator of intracranial pressure dynamics. The present study contributes to expanding the

application of this tool to the domain of anaesthesia and peri-procedural care.

A key strength of this study is the standardized ultrasonographic approach, including bilateral measurements and averaging techniques, which enhances reliability. The prospective design and use of consistent follow-up helped to ensure accurate identification of PDPH cases. Additionally, incorporating both baseline and post-procedure measurements provided insight into both predisposition and physiological response, offering a more complete perspective than studies relying on single-time-point measurement.

There are a few limits to be aware of. The precision may be limited by the small sample size of the cutoff value and the statistical power to assess interactions with procedural variables. ONSD measurement requires familiarity with ultrasound technique, and while the protocol was standardized, some level of operator dependency is unavoidable. The study was conducted in a single institution, and the patient population may not reflect broader demographic or clinical heterogeneity. Future research should include multi-center participation and larger cohorts to confirm cutoff thresholds and improve generalizability.

Notwithstanding these drawbacks, the study offers solid proof of the need of ONSD assessment as part of peri-procedural evaluation. The method is practical in everyday anaesthesia practice due to its simplicity, bedside applicability, and non-invasive nature. Incorporating ONSD into pre-procedure assessment could help clinicians identify patients more likely to develop PDPH, discuss risk proactively, tailor procedural decisions, and consider early supportive strategies. Further work may explore integration of ONSD with clinical and procedural factors into a structured predictive risk model.

Conclusion

Post-dural puncture headache can be accurately and non-invasively predicted by measuring the diameter of the optic nerve sheath. Patients with baseline ONSD $\leq$ 5.0 mm and greater reduction at 24 hours are at increased risk. Incorporation of ONSD assessment into routine practice may allow early identification, monitoring, and preventive strategies in high-risk individuals.

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