Original Article

Effect on the size of optic nerve sheath diameter in patients undergoing surgeries under spinal anaesthesia versus peripheral nerve blocks – A randomised controlled study

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ABSTRACT

Background and Aims: Post-dural puncture headache is a complication of spinal anaesthesia, theorised to be triggered by a lowering in intracranial pressure due to the cerebrospinal fluid leak through the dural puncture. Our objective was to evaluate whether there is a decrease in optic nerve sheath diameter (ONSD) with a reduction in intracranial pressure after spinal anaesthesia. **Methods:** Patients were randomised by a computer-generated randomisation table to receive spinal anaesthesia (Group S) or peripheral nerve block (Group P) after assessing their eligibility for the anaesthesia procedure as per the protocol. The ONSD was measured in the preoperative period and again at 4 h and 24 h after the anaesthetic, both in the supine and sitting positions, along with haemodynamic parameters. Continuous variables such as age, height, weight, mean arterial pressures, and ONSD were expressed as mean [standard deviation (SD)] [95% confidence interval (CI)] and compared using the student's *t*-test. Repeated measure ANOVA and Bonferroni were used to compare intra-group parameters. **Results:** The mean decrease in the ONSD from a baseline mean of 3.95 (SD: 0.17) (95%CI: 3.87, 4.02) to 3.89 (SD: 0.26) (95%CI: 3.78, 4.007) mm at 4 h and 3.94 (SD: 0.12) (95%CI: 3.89, 4.0) mm at 24 h after spinal anaesthesia was statistically significant. The changes in the ONSD measurements in Group P were not statistically significant. Headache was not reported at 24 h or in the follow-up at postoperative day 5. **Conclusion:** Measurement of ONSD is an easy, economical method for identifying decreased intracranial pressure after spinal anaesthesia. Further research could identify cut-off values to prognosticate PDPH in high-risk individuals.

Keywords: Anaesthesia, intracranial hypotension, optic nerve, point-of-care-systems, post-dural puncture headache, spinal

INTRODUCTION

Post-dural puncture headache (PDPH) is an infrequent complication encountered with neuraxial anaesthesia caused by intracranial hypotension. Severe neurological complications, including cerebral venous thrombosis and subdural hematoma, have been linked with PDPH.[1] Diagnosis of intracranial hypertension using optic nerve sheath diameter (ONSD) with ultrasound has been validated. It is used as a point-of-care device in critical care units for adult and paediatric populations.[2] Using ONSD to diagnose low pressure after dural puncture and having a cut-off to predict the PDPH would be an additional step in identifying PDPH.

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The incidence of PDPH varies and is reported to be approximately 36% or more following lumbar puncture, 0%–10% following spinal anaesthesia, and 81% following accidental dural puncture during epidural insertion.[3] Low intracranial pressure has been posited with few imaging techniques providing diagnostic features, and the diagnosis of PDPH is mainly based on history and clinical features. Magnetic resonance imaging (MRI) in 54 patients with PDPH revealed venous distension of the lateral sinus in 39.1%.[4]

The study's primary objective was to assess the change in ONSD after spinal anaesthesia in the postoperative period. The hypothesis was that the size of the ONSD would decrease after spinal anaesthesia. The secondary objective was to assess any variations in diameter based on position and document the occurrence of headache, nausea, vomiting, or tinnitus.

METHODS

The study commenced after approval of the institutional ethics committee (IEC Ref No: AIIMS/BBN/IEC/JULY/2022/202, dated 17th October 2022), and the study was registered at Clinical Trials Registry - India (vide registration number: CTRI/2022/12/047823). The research was performed according to the principles of the Declaration of Helsinki (2013) and Good Clinical Practice guidelines. Patients provided written and informed consent to participate in the study and allowed the use of their data for research and educational purposes.

This is a randomised study in 46 patients of either gender above 18 years, American Society of Anesthesiologists (ASA) physical status I–II posted for surgeries that were feasible under spinal anaesthesia or peripheral nerve blocks with surgical duration under 3 h (hernia repairs, circumcision, toe amputations, and debridements). Pregnant patients, patients with known raised intracranial tension, bleeding disorders, large hernias, obese patients, and emergency surgeries were excluded. Failure of spinal or peripheral nerve block, need to change the anaesthetic plan, or patients with eye pathologies were also excluded.

In patients who fulfilled the inclusion criteria, two anaesthesiologists (Dr A and Dr B) performed ONSD at baseline T(0) (preoperatively) with the portable ultrasound machine (USG) in the preoperative area. The patients were subsequently randomised into group S (spinal anaesthesia) and group P (peripheral nerve block) by using a computer-generated randomisation table, generated by RAND(01) (Microsoft 2010) (Microsoft Excel computer software, Redmond, Washington). The randomised group allocation, which was sealed in an opaque envelope by the incharge (I), was handed over to the anaesthesiologists (Dr S or Dr R), who performed anaesthesia (spinal or peripheral nerve block) as per the group allotted. The incharge was not involved in any part of the study process or data collection. After the surgery, ONSD was performed at 4 h T(4) and 24 h T(24) by Dr A and Dr B. The anaesthesiologists performing ONSD were blinded to the allocation.

Preoperatively, two anaesthesiologists (Dr A and Dr B) measured the ONSD, and two measurements of each eye were taken in the transverse and sagittal planes at 3-mm depth to the optic nerve head at T(0), T(4), and T(24) by using the 13-MHz linear USG probe (Edge II, Fujifilm Sonosite. Inc, Worldwide Headquarters, Bothell, WA, USA) in the supine position and 5 min after attaining the sitting position [Figures 1 and 2]. The power output of the linear ultrasound probe was reduced to a thermal index of 0 and a mechanical index of 0.2 to minimise any thermal injury. A total of 16 measurements (two observers, two eyes, four measurements, two sagittal, and two coronal: 2 × 2 × 4) of ONSD were made at each time point.

Patients were monitored using standard ASA monitors, including pulse oximetry, electrocardiograph, and non-invasive blood pressure continuously, perioperatively and during ONSD measurement. After 18-G intravenous cannula placement and connection

Figure 1: Optic nerve sheath diameter measurement with a linear ultrasound probe. (transverse: (a) and sagittal: (b))

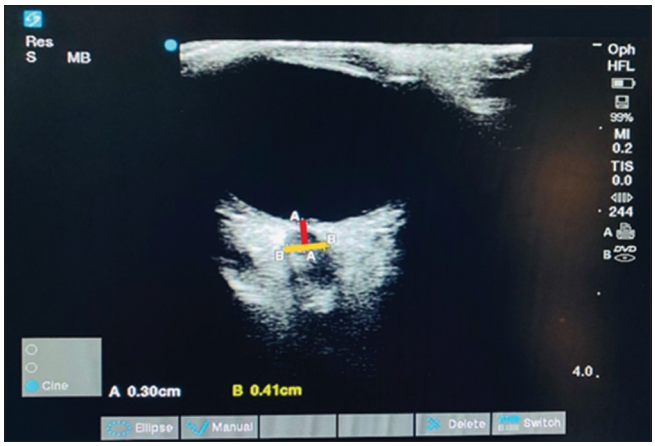

Figure 2: Ultrasound image of optic nerve sheath diameter measurement (B-B: 0.41 cm) is the diameter at a depth of 3 mm A-A)

to the monitors, the patients received a USG block or spinal anaesthesia as per the randomisation. Group S received spinal anaesthesia in sitting posture with a 25-G Quincke needle, and 3 mL of 0.5% hyperbaric bupivacaine was administered in the subarachnoid space. The number of spinal attempts was recorded. After confirming an adequate level, surgery was started. Group P received the appropriate peripheral nerve block under ultrasound guidance, and surgery commenced after the effective block at the surgical site had been confirmed. Patients were monitored in the postoperative period for any new onset of PDPH.

PDPH was characterised as any headache occurring within 24 h of spinal anaesthesia that intensifies within 15 min of sitting or standing and subsides within 15 min of lying down. It may be accompanied by symptoms such as neck stiffness, tinnitus, hyperacusis, photophobia, or nausea.

The primary outcome was the change in ONSD observed at 4 h and 24 h after introducing local anaesthetic in the subarachnoid space. Secondary outcomes were the presence of headache (whether orthostatic or not), nausea, vomiting, or tinnitus.

Statulator, the online free software for sample size calculation, was used (http://statulator.com/). A previous research paper demonstrated that a difference in ONSD greater than 0.5 mm (10% of mean ONSD in asymptomatic normal adults [mean ONSD: 4.9 mm]) would be clinically relevant.[5] Twenty patients were required in each group, considering a significance level of 5%, a power of 95%, and a dropout rate of 15% (~23 in each group).

Statistical analysis was performed using Statistical Package for the Social Sciences Version 23 (SPSS Inc, Chicago, IL, USA). Continuous variables such as age, height, weight, mean arterial pressures and ONSD were expressed as mean [standard deviation (SD)] (95% confidence interval (CI) and compared using the student's *t*-test. Categorical variables such as gender, number of attempts, and incidence of PDPH have been expressed as numbers and analysed using the Chi-square test. Repeated measure ANOVA and Bonferroni were used to compare intra-group parameters. The results were evaluated within the 95% CI, and $P < 0.05$ was accepted as statistically significant.

RESULTS

Of the 61 patients assessed for eligibility, 13 were excluded as they did not meet the inclusion criteria, and two declined to participate (consolidated standards of reporting trials (CONSORT) flow diagram of the study participants [Figure 3]). The 46 participants were randomised into Group S and Group P. All patients had successful blocks, both spinal and ultrasound-guided peripheral nerve blocks. Two patients with ankle blocks had inadequate blocks after surgery was started, but surgery could be completed with local infiltration.

The two groups had no statistical difference regarding age, height, weight, or surgeries performed [Table 1]. However, a significant difference in mean arterial pressure was observed at 4 h between the two groups ($P = 0.001$).

The mean value of the 16 measurements of ONSD was considered. ONSD between the two groups in the preoperative period in the supine and sitting positions were comparable. There was a decrease in optic nerve sheath diameter (ONSD) observed in Group S from the preoperative reading of 3.95 (SD: 0.17) (95%CI: 3.87, 4.02) to 3.89 (SD: 0.26) (95%CI: 3.78, 4.007) at 4 h and 3.94 (SD: 0.12) (95%CI: 3.89, 4) mm at 24 h after spinal anaesthesia was statistically significant, and no change was observed in group P at all points. Within the group, the *P*- values were not significantly different (Group S: $P = 0.31$; Group P: $P = 0.23$).

Table 2 shows a significant difference in ONSD observed 4 h after spinal anaesthesia ($P = 0.03$) and 24 h after spinal anaesthesia ($P = 0.015$) in the supine position between Group S and Group P. It also shows

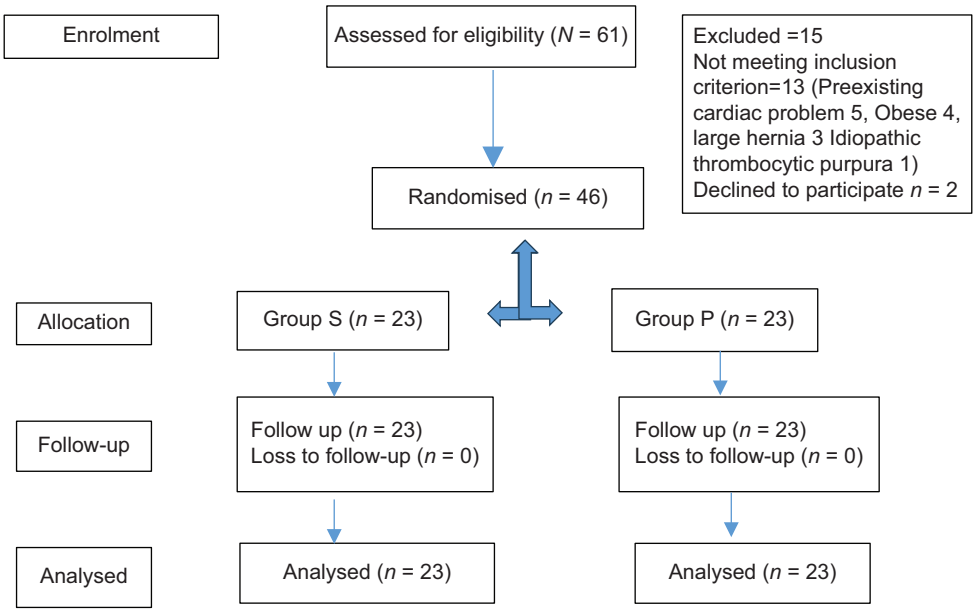

Figure 3: Consolidated standards of reporting trials (CONSORT) flow diagram of the study participants

Table 1: Comparative demographic and surgical data of the study participants

Parameters	Group S (*n*=23)	Group P (*n*=23)
Age (years), mean (SD)	35.6 (14.2)	40.36 (14.5)
Gender (Female/Male) (*n*)	16/9	17/8
Height (centimetres), mean (SD)	160.4 (6.75)	163.8 (4.19)
Weight (kg), mean (SD)	54.76 (11.5)	55.88 (5.64)
Baseline MAP, mean (SD)	92.08 (8.5)	95 (6.7)
MAP (mmHg) at 4 h (sitting), mean (SD)	87.65 (5.85)	94.9 (6.33)
MAP (mmHg) at 4 h (sitting), mean (SD)	90.16 (7.27)	94.5 (5.34)
PDPH (*n*)	0	0
Surgeries (*n*) (type of anaesthesia)		
a. Inguinal hernia	2 (SA)	3 (Ilioinguinal, Iliohypogastric nerve block)
b. Debridement	4 (SA)	3 (Ankle & femoral nerve block)
c. Amputation of toes	3 (SA)	1 (Digital block)
d. Below knee amputation	3 (SA)	4 (Femoral & Sciatic nerve blocks)
e. Implant removal	4 (SA)	3 (Femoral & sciatic nerve blocks)
f. K wire medial malleolus fracture	3 (SA)	4 (Ankle block)
g. Circumcision	4 (SA)	5 (Penile block)

Data expressed as mean (SD) or number of patients. *n*=Number of patients, MAP=Mean Arterial Pressure, PDPH=Post-Dural Puncture Headache, SD=Standard Deviation, SA=Spinal Anaesthesia

a significant difference in ONSD observed 4 h after spinal anaesthesia ($P = 0.014$) and 24 h after spinal anaesthesia ($P = 0.05$) in a sitting position between Group S and Group P.

Table 2 shows there was no significant difference observed between the supine and sitting position at baseline ($P = 0.696$), 4 h after spinal anaesthesia ($P = 0.708$), and 24 h after spinal anaesthesia ($P = 0.543$) in Group S, and no significant difference was observed between supine and sitting position at baseline ($P = 0.970$), 4 h after spinal anaesthesia ($P = 0.151$), and 24 h after spinal anaesthesia ($P = 0.420$) in Group P.

DISCUSSION

In our study, the primary outcome measure was the reduction in the size of ONSD in the postoperative period, which was significant at 4 h and 24 h after spinal anaesthesia. Changes in ONSD with posture, evaluated as a secondary outcome, showed no statistical significance.

Scant literature is available on changes in ONSD after spinal anaesthesia or any correlation with PDPH. The causal factor for the pathophysiology of PDPH is assumed to be intracranial hypotension (ICH) caused by the cerebrospinal fluid (CSF) leak from the dural

Table 2: Comparison of optic nerve sheath diameter in group S (spinal) and group P (peripheral nerve block) in millimetres

Time of measurement	Group-S (*n*=23)	Group-P (*n*=23)	*P*
Preoperative sitting	3.95 (0.17) (3.87, 4.02)	4 (0.061) (3.98, 4.03)	0.133
Preoperative supine	3.96 (0.21) (3.86, 4.05)	4.01 (0.054) (3.99, 4.03)	0.227
4 h after anaesthesia- Sitting	3.89 (0.26) (3.78, 4)	4.01 (0.054) (3.99, 4.03)	0.03
4 h after anaesthesia- Supine	3.88 (0.33) (3.77, 3.99)	4.02 (0.068) (4, 4.04)	0.014
24 h after anaesthesia- Sitting	3.94 (0.12) (3.89, 4)	4.01 (0.06) (3.99, 4.04)	0.015
24 h after anaesthesia- Supine	3.92 (0.24) (3.82, 4.02)	4.02 (0.058) (3.99, 4.04)	0.05

Data expressed as mean (SD) (95%CI). SD=Standard Deviation, CI=Confidence Interval)

puncture. The diagnosis has mostly been made based on history and clinical features, and no diagnostic tests have been performed to confirm the diagnosis. Orthostatic headache is a key feature of PDPH and is also seen in headaches due to intracranial hypotension. It can be inferred that ICH could be reflected in the ONSD as a decrease in size, which can be measured and is the basis for our hypothesis.

Ultrasound measurement of ONSD is a point-of-care test for assessing intracranial pressure (ICP), which is easy, inexpensive, and does not take much time. With the availability of ultrasound as a point-of-care investigative device in operation theatres, real-time evidence has been generated regarding the effect of general anaesthetic agents on ONSD.[6-9] The addition of injectate into the epidural space and caudal has also been assessed with the simultaneous rapid increase in ONSD.[10,11]

Spontaneous intracranial hypotension is caused by a CSF leak from a dural tear, and nearly 92% of patients have an orthostatic headache.[12] Several adult studies have shown that ONSD changes within minutes of pressure change and that the change in ONSD is strongly correlated with changes in ICP reflecting real-time changes.[13] Based on this, the measurements of ONSD were done 5 min after assuming the sitting position.

In our study, there was a change in ONSD between positions with a mean change of 0.01 mm, which could be because there was no removal of CSF and the small size of the needle used. Similarly, in another study in patients with ICH, the ONSD of 2.96 (SD: 0.15) was associated with low ICP (≤60 mmH2O), further corroborating the use of ONSD to detect ICH.[14]

Fichtner *et al.*[15] measured ONSD in patients with orthostatic headaches typical of ICH, and the mean ONSD was significantly lower in that group. In our findings, the mean ONSD at 4 h in the sitting position was 3.9 (SD: 0.26) and 3.91 (SD: 0.33) in the supine position in the study group. The postural difference in mean was not significant but was significantly different from that of the patients in the control group.

Most PDPH develops within 24–48 h, with 90% developing within 3 days.[16] In the postoperative period, patients were followed up over the telephone for 5 days regarding headache, degree of headache, and any postural change or associated symptoms. No patients complained of headaches even in the follow-up, which the small sample size could explain.

Beşir *et al.*,[17] in their evaluation, concluded that the lowest ONSD after spinal occurred at 24 h. Mean ONSD in two separate researches in patients with PDPH was significantly less at 24 h, though the mean varied from 3.6 to 3.9 mm.[18,19] Based on this, we have also taken measurements at 24 h in the postoperative period.

Though Mowafy *et al.* reported an incidence of 18.8% incidence of PDPH in the obstetric population, a large study in Japan reported an incidence of 1.16% in obstetric patients and 0.16% in non-obstetric patients, agreeing with our findings.[20,21]

A bibliographic study on ONSD revealed a sustained interest in raised ONSD; however, only one study on reduced ONSD after spinal anaesthesia appeared in their search string, showing the enormous scope for further investigation.[22]

Though the decrease in ONSD was marginal after spinal anaesthesia and a 10% decrease would be relevant statistically, a larger sample size may be needed to reflect the clinically significant decrease. The limitations of our study are that the sample size is small and the ONSD measurements were done only for 24 h postoperatively. The change in ONSD could also vary with the pressure exerted by the anaesthesiologists, which could also be a limiting factor.

CONCLUSION

Spinal anaesthesia reduces ONSD marginally compared to peripheral nerve block at T4 and T24. However, the postural change in ONSD was not significantly different within the groups. Measuring ONSD in the perioperative period after spinal anaesthesia could be a simple, inexpensive, repeatable measure to gather insight into the mechanism of PDPH, especially in patients presenting with headaches.

Study data availability

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' Institution policy.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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