Perioperative Noninvasive Assessment of Intracranial Tension by Ultrasonographic Monitoring of Optic Nerve Sheath Diameter: Our Experience

Sangeeta Khanna, Jyotirmoy Das, Sudhir Kumar, Yatin Mehta

ABSTRACT

Intracranial hypertension occurs with significant regularity during general anaesthesia. Although majority of times it goes unrecognised and does not cause significant perioperative morbidity, its importance cannot be ignored especially in patients with intracranial pathologies. The intracranial tension can rise significantly during prolonged extreme positioning like steep trendelenburg position for pelvic surgeries. This might have serious impact on the recovery characteristics and can cause reduced cerebral perfusion pressure, delayed awakening, need for post operative ventilatory support, etc. We started using sonoimaging guided estimation of the optic nerve sheath diameter to get an estimate of the intracranial tension. Although limited by observer variations and subjectivity, in the hands of a single trained personal, it provides a reproducible yet non invasive, simple real time assessment of intracranial tension. This brief communication is based on our experience over the last 6 months in 60 patients. Although reports of monitoring optic nerve sheath diameter with ultrasound in ICU patients are plenty in the literature, no report is available stating its utility in monitoring intraoperative intracranial tension to the best of our knowledge and search results using the keywords ‘ultrasonography’, ‘optic nerve sheath diameter’, ‘intraoperative’, ‘intracranial tension’, and ‘anaesthesia’.

Keywords: Optic nerve, Optic nerve sheath diameter, Intracranial tension, Ultrasonography, Steep trendelenburg position, Anaesthesia.

INTRODUCTION

Normal intracranial tension (ICT) varies between 7 and 15 mmHg in a supine adult. Pressure above 15 mmHg is considered abnormal and over 20 mmHg pathological. Perioperative events where the greatest change in ICT is encountered are laryngoscopy, nonphysiological positioning like steep trendelenburg position for robotic or laparoscopic pelvic surgeries and during emergence from anaesthesia.

A raised ICT can also affect the recovery of patients from anaesthesia and emergence characteristics despite using short acting anaesthetics. These patients might require prolonged post operative ventilation and/or recovery unit/ICU length of stay. This can be a serious concern for the patient and family members.

DESCRIPTION OF THE TECHNIQUE

After clearances from Institutional review board and Ethics committee, we monitored optic nerve sheath diameter (ONSD) in 60 patients posted for robot assisted laparoscopic radical prostatectomy in the last 6 months using a portable ultrasound (Fig. 1). These patients did not have any clinically significant ocular problems or symptoms apart from age related visual impairment. Patients were counselled about the use of ultrasound on their eyes and explained about the mild pressure and discomfort they may encounter. They were also reassured about the benign nature of the intervention. A 10 to 5 MHz linear probe was used using the axial technique. Measurements were done at the preoperative ward (baseline reading), 30 minutes after final patient positioning at steep trendelenburg position and pneumoperitoneum of 15 mmHg, 90 minutes after the 2nd reading and at 1 hour after extubation when the patient was in the postoperative ward.

We selected a point 3 mm behind the globe as the reference point for measurement. The horizontal diameter of the sheath was measured at the level of the reference point (Fig. 2). A position of 3 mm behind the globe is recommended because the ultrasound contrast is greatest and the results are more reproducible at that point. This reference point was also shown to exhibit maximum diameter fluctuations induced by gelatinous injections in the cadeveric model. This landmark point has already been used by various researchers in correlating the elevated ICT with the ONSD. The mean of three readings was taken on each eye and the value was recorded in the anaesthesia record chart.

For us, the aim behind monitoring the ONSD was to analyse its trend and get an idea of ICT at that particular point of time.

RESULTS

Table 1 shows the demographic characteristic of the study population. We analysed the mean and standard deviation...
values of both the eyes at all the measured time points (Table 2) and observed the trend in change in ONSD while keeping the degree of trendelenburg, ventilation, end tidal CO₂ and anaesthetic conduct standardised.

Significant variation in ONSD was observed intraoperatively which increased with duration of trendelenburg and pneumoperitoneum. It was interesting to observe that the readings did not touch the baseline values even after 1 hour postextubation.

DISCUSSION

Optic nerve sheath is a continuation of the dura mater surrounding the optic nerve and the area within the sheath outside the optic nerve contains CSF which freely communicates with the CSF of the craniospinal subarachnoid space via communicating channels. On ultrasound, a normal optic nerve sheath measures up to 5.0 mm in diameter. Any rise in ICT leads to dilatation of the optic nerve sheath due to high CSF pressure. It has been shown that the ONSD of > 5 mm predicts an ICT of ≥ 20 cm H₂O with sensitivity and specificity nearing 100%. Hansen and Helmke demonstrated a linear relationship between the ONSD and CSF pressure. Hamilton et al found that ONSD increases by 0.0034 ± 0.0003 mm/mmHg of ICT. So a rise in ICT from 10 to 30 mmHg will cause the ONSD to increase by at least 0.08 to 0.1 mm. This is a very delicate measurement and needs practice to decipher. Going by the measurements of Hamilton et al as described above, the ICT in our patients must have fluctuated even up to 3 times the baseline. This is a significant finding as with the rise in ICT, the cerebral perfusion goes down even if the mean arterial pressure is adequate. The question might arise on the reliability of ONSD in trendelenburg position. Trendelenburg position along with pneumoperitoneum is known to increase all the downstream pressures like central venous pressure,

Table 1: Demographic data

<table>
<thead>
<tr>
<th>Preoperative parameters</th>
<th>values</th>
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<tbody>
<tr>
<td>Patients, n</td>
<td>60</td>
</tr>
<tr>
<td>Demographic details</td>
<td></td>
</tr>
<tr>
<td>Age (years), mean (SD)</td>
<td>58.2 (6.7)</td>
</tr>
<tr>
<td>Sex (male:female)</td>
<td>48:12</td>
</tr>
<tr>
<td>BMI (kg/m²), mean (SD) (range)</td>
<td>26.2 (4.8) (17.4-41.6)</td>
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intraocular pressure (IOP) and intracranial pressures. The two most important predictors of the rise in IOP and ICT are the duration of surgery and end tidal CO$_2$. It has been observed that ONSD does not change appreciably with change in patient’s position (supine to 30° trendelenburg or reverse trendelenburg). So, we can safely say that whatever rise in ONSD we observed in our trendelenburg positioned patients were not actually a false interpretation due to positional effects like the central venous pressure reading. Subsequently in the future we are planning to maintain the ONSD within 10% of the baseline value or 5 mm whichever is higher and initiate a couple of interventions if it increases alarmingly. Although, not a part of discussion in this article, for the benefit of the reader, a few interventions in the event of significantly raised ICT is mentioned:

- **Adjusting ventilation**: Ventilation can be adjusted to keep the end tidal CO$_2$ concentration at less than 35 mmHg, if it is high. Hypercarbia increases the cerebral blood flow and consequently increases the ICT as per the Monro-Kellie hypothesis.
- Avoiding excessive rotation of the head so that venous outflow from the head and neck is not compromised.
- Propofol infusion in a titrating dose to decrease the ICT
- Increase the MAP to above 80 mmHg at least to have a CPP of >50 mmHg.

Effective CPP (eCPP) needs to be taken into consideration. Excessive fluid administration in order to maintain MAP at the reference range along with positional reduction in venous drainage from the head and neck region can lead to perivascular edema which can compromise the cerebral blood flow even in the presence of a near normal MAP.

Limitations of our report are as follows:
- Our experience is not a randomised controlled trial. It was an observation in 60 consecutive patients without ocular pathology apart from age related visual impairment.
- Observer bias can be a major setback during the initial learning phase.
- When compared to invasive monitoring of ICT, ultrasound is probably less accurate.
- Availability of a portable ultrasound machine can be a logistical problem in certain set ups.

### CONCLUSION

Early detection and intervention of a raised ICT is very crucial in certain patient populations. In spite of the limitations, the technique can be a very exciting noninvasive modality of assessing, controlling and real time reconfirmation of ICT variation. It may not be very accurate as per present literary evidence, but serves as a good guide to manipulate a multitude of interventions to keep ICT at check if ONSD increases alarmingly. This will probably help in smoother and quicker emergence from anaesthesia, reduction in perioperative morbidity and possible shorter length of stay in the post anaesthesia care unit/hospital.

Through this article our aim is to generate enough interest in this unique modality of intraoperative monitoring at least in those surgeries where we anticipate a rise in ICT. Our observation showed a significant rise in ONSD and therefore ICT during trendelenburg position with pneumoperitoneum. It will be exciting if multicentric randomised controlled trials are undertaken and results are analysed and its effectiveness, prognostic significance and reproducibility verified.

### REFERENCES

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