

## Peri-operative Optic Nerve Sheath Diameter estimation: Non-invasive eye examination as a useful tool in the Anaesthesiologist's Armamentarium

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Point-of-care ultrasound (POCUS) also known as stethoscope of 21st century has revolutionized the way we evaluate, assess fluid status, insert invasive lines or administer regional/ peripheral blocks to the patients of all age groups. Life threatening conditions like pneumothorax/ haemothorax, cardiac tamponade and abdominal emergencies can be readily diagnosed and promptly managed.<sup>1</sup> This is desirable that an ophthalmic anaesthesiologists can pickup comorbidities or post- traumatic sequelae in high risk patients. Accordingly, written informed consent can be taken before proceeding with any kind of anaesthesia.

Though, invasive intracranial device (IID) insertion is the gold standard for intracranial pressure (ICP) monitoring these modalities need to be judiciously used because of associated risks of infection and haemorrhage.<sup>2</sup> There is a layer of subarachnoid space between the optic nerve and its sheath where cerebrospinal fluid percolates leading to increase in its diameter. Hence, Optic Nerve Sheath Diameter (ONSD) has come up as a validated, non-invasive ICP estimation technique.

### **Technique of POCUS-ONSD Measurement.**

- Take written informed consent from the patient/legal guardians.
- Familiarize yourself with USG machine, its knobology, ocular anatomy and Sono-anatomy. Choose the correct examination preset. For example ocular setting to get high quality images.
- Get the ergonomics right, USG monitor should be facing the observer. Select high-frequency linear or hockey-stick probe(9-13 Hz).

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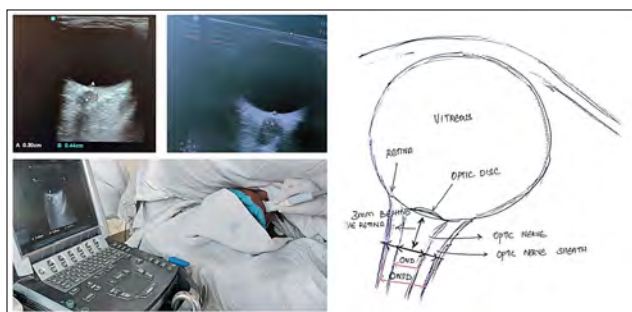
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- Take all aseptic precautions. Apply a thin coating of KY Jelly over footplate of the probe and then cover it with tegaderm or a sterile glove. Make sure there are no wrinkles. Alternatively, saline soaked gauze piece can be used as a safe liquid medium for USG image visualization without any harm to the eyes of the patient.
- This is important to pay attention to hand positioning and avoid undue pressure on the eyeball during examination. USG probe should be resting on bony/cartilaginous structures ie supraorbital area and side of nose (Figure 1).



*Figure 1. Optic nerve sheath diameter (ONSD) measurement using USG probe, actual Image obtained and line diagram to explain the sono-anatomy. Optic Nerve Diameter (OND)*

- The ocular lens can be seen anteriorly, followed by the anechoic vitreous fluid. At the bottom of the screen, the retina is seen as a bright structure due to posterior acoustic enhancement. At the posterior margin of globe, optic nerve is seen as a dark, well-demarcated tubular structure. Around this is the dark shadow of the optic nerve sheath, see Figure 1

- Using the freeze frame and calliper functions on the USG machine, precise measurements of the optic nerve sheath diameter can be done. ONSD is most often taken at a distance of 3 mm from the posterior globe margin. Measurement is done transversely from inner-edge to inner-edge of Optic Nerve Sheath. This is believed to be the site of maximum pressure changes along the long axis of the optic nerve.
- Take at least 3 readings for each eye to avoid subjective bias and then calculate mean value for right and left eye.
- To further improve accuracy of ICP assessment, ratio of ONSD to Eyeball Transverse Diameter (ETD) can be calculated. It has been described as a better predictor with good sensitivity and specificity than ONSD alone.
- Influence of wakefulness, technique of ICP measurement, intraindividual correlations and dynamic changes of ONSD and ICP after ICP decreasing therapy are being further evaluated.

## ONSD Values

Pocket Sized Ultrasound Devices has been observed to have similar validity and reliability as standard ultrasound devices. When measuring 3 mm from the globe margin, ONSD measurements up to 4 mm in infants, 4.5 mm in children and up to 5 mm in adults are considered normal.

Normal threshold for the optic nerve sheath diameter ranges between 4.8 to 6.2 mm in adults depending upon the technique used. ONSD values above 5 mm (bilaterally) correspond with elevations in intracranial pressure above 20 mmHg & values above this predict further increase in ICP.<sup>3</sup>

### Literature Review

**Traumatic brain injury :** Correlations between invasive ICP and ultrasound-ONSD/ETD ratio, ultrasound-ONSD, CT-ONSD/ETD ratio, and CT-ONSD has been observed. The ratio of ONSD to ETD tested by ultrasound was found to be a reliable predictor of intracranial hypertension.<sup>4</sup> Accuracy can be further improved using CLOSED protocol.<sup>5</sup>

**Fetal Assessment:** For fetuses with intracranial lesions, orbital ONSD has been used as an early tool to diagnose raised ICP using transabdominal or transvaginal high-resolution transducers.

**Perioperative applications :** The ONSD estimation has been found to be useful in obstetrics, pediatrics,, various laparoscopic and robotic surgeries for optimizing position for surgery, administration of volume of regional anaesthetic agents and speed of infection. Also, effect of various drugs on ICP can be non invasively estimated.<sup>6,7</sup>

**Resuscitation / Hypoxic Brain Injury / Brain Death:** A comparison of non-invasive versus invasive measures of ICP in hypoxic ischaemic brain injury (HIBI) after cardiac arrest has been done.

ONSD and TCD methods demonstrated agreement with invasively-monitored ICP, suggesting their potential roles in the detection of intracranial hypertension in HIBI after cardiac arrest. Bedside USG of the Optic Nerve Sheath might have an important role in determining potential brain death in critically ill ICU patients. Intermittent transorbital ONSD measurements can be useful for prognostication purposes. Thus counselling can be done for the cadaveric organ donation.<sup>8</sup>

**Future Perspectives :** AUTomatic Optic Nerve MeAsurement (AUTONoMA) system for OND and ONSD assessment in ultrasound B-mode images based on deformable models has been developed. Measurements thus recorded has been compared with manual readings obtained by two operators. There were no significant differences. AUTONoMA could accurately segment the ON and its sheath in 71 out of 75 images with good and a positive correlation with manual operators. Hence system may allow for standardization of Optic Nerve Diameter (OND) and ONSD measurements, reducing manual evaluation variability.<sup>9</sup>

Astronauts spend extended periods in microgravity and may develop ophthalmic abnormalities. Understanding factors contributing to visual impairment and intracranial pressure (VIIP) syndrome, has become a high priority for National Aeronautics and Space Administration (NASA) because this medical obstacle

obstacle can impact the success of future missions, including Mars missions. If confirmed, ONSD biomarker can be used for preflight identification of astronauts at risk for developing VIIP.<sup>10</sup>

To conclude, ONSD is a safe, non-invasive, radiation free, easy to perform, repeatable tool to predict changes in ICP with the potential of screening patients who need neuroimaging/ invasive measurement of ICP. ONSD/ETD ratio might be more sensitive and specific for ICP assessment. Accuracy can be further improved using CLOSED protocol.

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