

# Measuring the optic nerve sheath diameter in a head-injured man

Measuring optic nerve sheath diameter does not involve radiation exposure and can be done quickly at the bedside during the evaluation of a patient with head injuries.

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## CASE

Emergency medical services (EMS) was activated for an assault at a private residence. A basic life support ambulance was promptly dispatched to the scene, where the crew found a 44-year-old male lying supine in bed. Bystanders stated that after drinking all day, the patient had been involved in an altercation and had subsequently fallen down a staircase face first. His Glasgow Coma Scale (GCS) score at the scene was 6. Full cervical spine precautions were taken before transport, with a cervical collar and a long backboard. Because of the patient's decreased level of consciousness, insertion of an oral airway was attempted; but it was later withdrawn because of an intact gag reflex. High-flow oxygen was applied via a nonbreathing mask. A fingerstick blood glucose test was performed en route to the emergency department (ED); the result was 103 mg/dL.

At the ED, the EMS crew was able to provide only a limited history. On examination, the patient's GCS score was now 10, and his vital signs remained stable. High-flow oxygen was continued, IV access was obtained, and the patient was given a trial of naloxone, which produced no change in his mental status. His airway was patent, and breathing was unlabored. Breath sounds were equal bilaterally. Bruising was noted over the right anterior chest. There was no jugular venous distention, and the trachea was midline. The remainder of the primary examination findings were negative.

On the secondary examination, there were no battle signs or raccoon eyes. However, blood was noted coming out of the patient's right ear. His speech was incomprehensible, but his pupils were equal, round, and reacted to light. The remainder of the secondary examination findings were negative. Laboratory results were as follows: blood alcohol level, 0.39%; urinalysis, 3+ blood; urine toxicology screen, positive for barbiturates. The results of a chemistry panel, CBC, and coagulation studies were all normal. A supine chest film demonstrated multiple rib fractures but no pneumothorax was seen.

Given the mechanism of injury and the mental status changes, a focused assessment using sonography in trauma examination was performed. The results were negative for any intraperitoneal free fluid or pericardial effusion. The optic nerve sheath diameter (ONSD) was then measured using bedside ultrasonography; the average of two measurements was 6.9 mm (normal, less than 5 mm) (see Figure 1). CT of the patient's head was subsequently performed and demonstrated a left subarachnoid hemorrhage and left subdural hematoma (see Figure 2, page 28). CT of the cervical spine was negative for any injury.

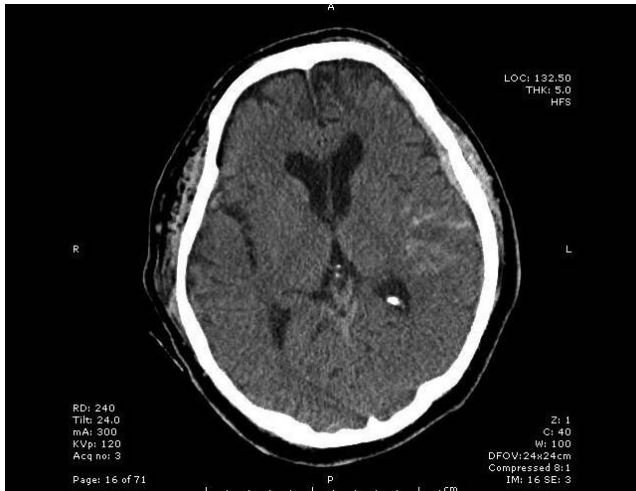
A medical helicopter was summoned to transfer the patient to a tertiary facility 90 miles away for definitive care. Before transfer, he underwent rapid sequence intubation with in-line stabilization to secure the airway for transfer. The patient was managed nonoperatively during a 12-day hospitalization that was complicated by a CSF leak and temporal bone fracture lacerating the facial nerve. At the end of this period, he was discharged to a rehabilitation facility.

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**FIGURE 1.** Sonographic measurement of the left optic nerve sheath is shown; the + measurement is 3 mm behind the optic disk, and the × measurement is the optic nerve sheath diameter.

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**FIGURE 2.** CT demonstrates a left subdural hematoma and subarachnoid hemorrhage.

### DISCUSSION

The optic nerve sheath is a direct extension of the dura and contains CSF. Any intracranial process that elevates intracranial pressure (ICP)—tumor, intracranial hemorrhage, pseudotumor cerebri, hydrocephalus—will cause the optic nerve sheath to dilate.

**The evidence** One of the best studies demonstrating the relationship of ONSD to ICP was published by a group of researchers who performed two intrathecal infusions, one to infuse and remove Ringer's solution and another to monitor CSF pressure. Serial sonographic measurements of the ONSD were taken during the infusion. The researchers found that an ONSD greater than 5 mm correlated with a mean CSF pressure of 30 mm Hg—that is, an elevated ICP; during the infusion phase, changes in the ONSD closely followed the lumbar CSF pressure.<sup>1</sup>

While ONSD varies somewhat among individuals, cutoff values have been established. Values considered normal for ONSD are less than 5 mm in adults, less than 4.5 mm in children aged 1 to 15 years, and less than 4 mm in infants.<sup>2</sup> Diameters that are greater than these cutoff values indicate an elevated ICP.



**FIGURE 3.** Measuring optic nerve sheath diameter using ultrasonography at the bedside

One of the first studies comparing the ONSD measurement taken by emergency physicians experienced in sonography with CT findings of elevated ICP found that the sensitivity and specificity of ONSD compared with CT were 100% and 95%.<sup>3</sup> The positive predictive value was 93%, and the negative predictive value (NPV) was 100%.<sup>3</sup> In a more recent study again involving adults and using the standard 5 mm as the cutoff, the sensitivity of ONSD for elevated ICP was 100% and the specificity was 63%, with an NPV of 100%.<sup>4</sup> When correlated with CT of any traumatic intracranial injury, the sensitivity of ultrasonography was 84% and the specificity was 73%.<sup>4</sup> The value of measuring ONSD lies not in quantifying the ICP but rather in the procedure's NPV.

**The technique** The ONSD measurement is easily and rapidly obtained at the patient's bedside by using any commercially available ultrasound machine. For this application, the B-mode setting is used. Copious amounts of transducer gel are placed over the patient's closed eyelid, and a high-frequency (7.5-10 MHz) linear probe is lightly placed over the gel. The operator's hand is typically braced on a facial bony prominence for safety and patient comfort. The probe is placed in a transverse orientation, with the indicator to the

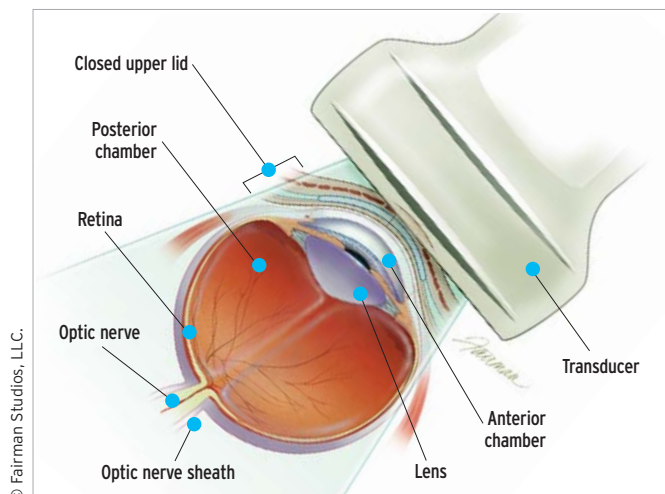
### TEACHING POINTS

- Ultrasonography of the optic nerve sheath gives the clinician an objective measurement to assess for elevated intracranial pressure (ICP).
- In rural or other austere environments in which CT or neurosurgery are absent or limited and rapid transfer to a tertiary facility within the "golden hour" is key to reducing patient morbidity and mortality, the optic nerve sheath diameter (ONSD) can serve as a surrogate marker of elevated ICP.
- This procedure is strongly supported by anatomy and physiology, and studies are beginning to confirm its clinical utility as a screening method for patients with suspected elevated ICP.
- Measuring ONSD does not involve radiation exposure, can be performed within minutes, and does not involve transferring the patient to a radiology suite for imaging.
- Skill in performing the procedure is relatively easy to acquire.

### COMPETENCIES

- Medical knowledge
- Interpersonal & communication skills
- Patient care
- Professionalism
- Practice-based learning and improvement
- Systems-based practice

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**FIGURE 4.** Diagram of sonographic measurement of optic nerve sheath diameter

convention of the patient's right side (see Figure 3, page 28). The optic nerve sheath is then identified and measured 3 mm distal to the optic disk, and the ONSD measurement is taken within the visualized sheath (see Figure 4). Data suggest that consistent optic nerve sheath measurements can be made after as few as 20 practice studies.<sup>5</sup>

The technique can be learned through any number of emergency medicine or critical care sonography courses. Examinations should be proctored by a clinician experienced in sonography before use in a clinical setting. The American College of Emergency Physicians' policy statement detailing initial training, proficiency, and credentialing serves as a good practice resource.<sup>6</sup>

**Comments** Just as the fundoscopic examination has allowed clinicians to assess ICP by evaluating the optic disk for papilledema, ultrasonography of the optic nerve sheath

goes one step further and gives the clinician an objective measurement to assess for elevated ICP. In rural or other austere environments in which CT or neurosurgery are absent or limited and rapid transfer to a tertiary facility within the "golden hour" is key to reducing patient morbidity and mortality, the ONSD can serve as a surrogate marker of elevated ICP. This procedure is strongly supported by anatomy and physiology, and studies are beginning to confirm its clinical utility as a screening method for patients with suspected elevated ICP.

Measuring ONSD has a high NPV, does not involve radiation exposure, can be performed within minutes, and does not involve transferring the patient to a radiology suite for imaging. This allows for ongoing resuscitation and stabilization of the patient while obtaining vital information that can change treatment decisions. In addition, skill in performing the procedure is relatively easy to acquire. Measurement of the ONSD using bedside ultrasound in the rural ED is a promising tool that may expedite patient treatment and/or transfer to a trauma center. **JAAPA**

**Peter Lindbloom** practices in the emergency department at Mille Lacs Health System, Onamia, Minnesota. He has indicated no relationships to disclose relating to the content of this article.

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