Optic Nerve Sheath Diameter Ultrasound and the Diagnosis of Increased Intracranial Pressure

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KEYWORDS

• Ultrasound • ICP • Optic nerve sheath diameter

KEY POINTS

- Optic nerve sheath diameter ultrasound is a safe, valid, and noninvasive method of measuring intracranial pressure (ICP) with high sensitivity and specificity.
- The procedure is simple and easily learned by experienced and nonexperienced clinicians.
- Implications for providers include rapid diagnosis of elevated ICP and early medical and surgical intervention.
- Optic nerve sheath diameter ultrasound has a possible role as a screening tool for increased ICP in the patient with neurologic compromise.

Increased intracranial pressure (ICP) is a common phenomenon in the neurocritically ill patient with traumatic brain injury. The sequelae of increased ICP can cause severe disability or death if not recognized and managed immediately.[1–4] In the United States alone, more than 53,000 individuals succumb to traumatic brain injury–related deaths.[5] This amount accounts for 30.5% of all injury-related deaths and is estimated to cost the health care system approximately 76.5 billion dollars a year.[5] After an initial insult, such as blunt or penetrating trauma to the head, an increase in blood volume or edema may cause a rising pressure in the rigid inflexible vault that is the skull. These patients and their presentations are noted to be highly time-sensitive and present to emergency rooms with poor examination, limited history, or other clinical information.[5] Earlier diagnosis of elevated ICP after a traumatic event can allow for faster temporizing measures and definitive treatment in the neurologically compromised patient and improved outcomes.[5]

Although direct ventriculostomy is considered to be the gold standard of measuring ICP, the procedure is invasive, poses risks to the patient, and often is traditionally only

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performed by trained neurosurgeons. Lumbar punctures can also be used to diagnose elevated ICP. However, lumbar punctures carry risks as well, such as infection or bleeding, and can be time and resource intensive if performed on a critically ill patient. Their success can be hindered by many factors, such as body habitus, spinal hardware, or user skill. In addition, if there is obstructive hydrocephalus or concern for a compressing intracranial lesion, the lumbar puncture may not be the procedure of choice.

Other modalities such as computed tomography (CT) imaging can be done rapidly and relatively inexpensively. However, repeated CT scans expose patients to large doses of radiation and frequently require the nurse to travel with the patient, even with the increasing prevalence of portable CT scanners. In addition, traditional markers of increased ICP on CT scan, such as midline shift, basal cistern, and sulcal effacement, may not reliably confirm increased ICP.[6] MRI provides high-quality images, but is labor intensive, time intensive on the part of the nursing staff, or is not appropriate for routine assessment of increased ICPs, and many patients cannot be put in the MRI machine or are too hemodynamically unstable for MRI.

An ideal neuromonitoring tool in the neurocritically ill would be readily available, easily performed by nonradiologists, is rapid, and is noninvasive. Such technology exists today and is available in almost every intensive care unit (ICU) and emergency department in the United States—the portable ultrasound. Ultrasound can be used to measure ICP through a transorbital evaluation.

Ultrasound has been used since the early 1980s to assist clinicians in the diagnosis and clinical decision-making of critically ill patients.[7] Although ultrasound is now considered to be a standard of care in emergency and critical care medicine, machine cost and size and training have historically limited their utility. The advent of smaller, lighter, and more durable ultrasound machines has heralded the use of sonography in many emergency departments, ICUs, and even the prehospital environment with great success.[7]

This article discusses the optic nerve sheath diameter (ONSD) ultrasound procedure and highlights current literature that supports its validity and its implications to advanced practice providers.

SUMMARY OF PROCEDURE

In patients with increased ICP, physical examination findings can often be limited due to decreased responsiveness, being intubated, or being paralyzed. It is well documented that examination findings in the eye can reflect conditions elsewhere in the body. In the setting of increased ICP, papilledema, or swelling of the optic nerve disc, can take hours before it is clinically appreciated.[8] ONSD ultrasound, however, can be performed and can detect these changes in ICP before they are appreciated on physical examination. The optic nerve sheath attaches to the globe on the posterior aspect. The optic nerve sheath is contiguous with the dura mater and has an arachnoid space in which cerebrospinal fluid percolates.[8] As ICP increases, this optic nerve sheath space swells and can be appreciated on ultrasound. A typical optic nerve sheath is less than 5 mm. A finding greater than this may correlate with an ICP greater than 20 mm Hg.[8]

To perform the study, one needs an ultrasound machine with a high-frequency linear probe. The probe is placed on the patient's closed eye. Many clinicians may use a tegaderm to prevent ultrasound gel from getting in the eye. A view of the globe can be obtained. The optic nerve sheath appears as a darkened, vertical, linear pattern