Intracranial Pressure Evaluation

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Optic nerve sheath diameter (ONSD) measurement with ophthalmologic ultrasound is an adjunctive tool used by physicians in the hospital setting to evaluate patients for elevated intracranial pressure (ICP). ONSD measurement is performed using a high-frequency linear transducer applied to the patient's closed eye covered with a clear barrier dressing. The linear probe is oriented with the indicator towards the supine patient's right side and gel is applied over the barrier dressing (Fig. 1).

The optic nerve is identifiable as a hypoechoic structure posterior to the retina. A transverse measurement of the nerve is obtained 3 mm posterior to the retina (Fig. 2). Measurements are obtained on both eyes to ensure accuracy. An ONSD measurement greater than 5 mm correlates with elevated ICP [3, 6, 9] (Fig. 3).

What is the utility of ONSD by emergency medical services (EMS) providers in the prehospital setting? Altered mental status is a common reason for EMS activation. A subset of these patients will have elevated ICP as the cause of their altered mentation. The ability of prehospital providers to detect elevated ICP or the presence of a serious intracranial injury with existing prehospital resources is limited. Current practice strategies focus on obtaining a historical report of trauma to the cranium and identifying external signs of head trauma. In the absence of these factors, prehospital providers report various clinical findings and utilize both the Glasgow Coma Scale (GCS) and the Alert, Responsive to Verbal Stimuli, Responsive to Painful Stimuli, and Unresponsive (AVPU) Scale to convey the depth of coma in a patient [7, 12]. With the increased availability and use of prehospital ultrasound, ONSD measurement can provide EMS with an objective measure to identify elevated ICP in patients with poorly differentiated altered mental status and confirm ICP elevation in traumatic head injury.

With the introduction of any new technology it is necessary to question how such an addition will improve patient care or EMS workflow. Detecting elevated

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Fig. 1 Patient and transducer positioning for ONSD measurement

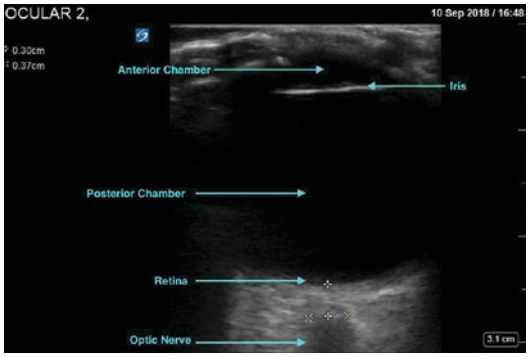

Fig. 2 Normal ophthalmic anatomy and ONSD measurement

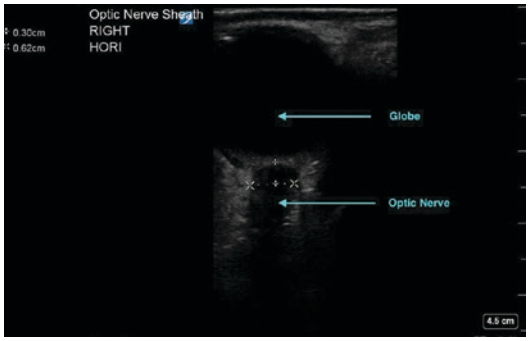

Fig. 3 Abnormal ONSD measurement

ICP in the field has the potential to change prehospital patient management, as has been previously demonstrated with the performance of prehospital FAST exams [13]. An abnormal ONSD measurement in the field may prompt crews to consider transporting the patient to a neurosurgically-equipped receiving facility, to request pre-arrival activation of the trauma team at a destination hospital with a trauma designation, or to request air medical transport from the scene in geographically isolated areas. In extremely austere settings or in clinical environments where computed topography is not possible (such as in polar research stations, high altitude base camps or disaster zones), ONSD measurement may be the only non-invasive diagnostic means of ICP evaluation. Clinical signs of impending herniation coupled with elevated ONSD can additionally lead to earlier administration of an osmotic agent.

While there exists an abundance of research confirming that paramedics and other prehospital non-physician providers can learn ultrasound exams with ease and perform them with a high degree of accuracy and proficiency [1, 11], ONSD measurement has not been studied in this manner. Additionally, most studies that report a high degree of accuracy of ONSD measurement utilize a small cohort of highly trained physicians with extensive ultrasound backgrounds [4]. Among ultrasound fellowship-trained physician sonographers, considerable inter-rater agreement exists [5, 10]. The inter-rater reliability of this exam across ultrasonographers with less training is unknown. Additionally, patients with critical head injuries are likely to have other pressing clinical needs such as airway management, intravenous access, anticonvulsant administration in the case of seizure activity, cardiac monitoring, and ventilatory support, which the EMS provider must balance with the precision skill of ONSD measurement.

The prehospital environment presents a unique set of challenges to obtaining quality ultrasound images. The noise level, varying light conditions, and the need to perform skills while an EMS transport unit is in motion together create a scanning environment that is very different from the emergency department or intensive care unit, where most research assessing the validity of ONSD measurements has been conducted [8]. While one study demonstrated the feasibility of obtaining this exam in the prehospital setting, the sonographers in this study were also physicians with robust ultrasound training backgrounds [2].

Additional challenges to the implementation of an ultrasound-based treatment guideline in the prehospital setting include the time and resources required to train providers and to maintain competency over time. Current accredited paramedic training programs require over 1000 clock hours of training, and the National Registry of Emergency Medical Technicians (NREMT) requires 60 additional hours of continuing education every 2 years for paramedics to maintain membership [14]. Locally, EMS providers at all levels are required to perform skill maintenance, training on protocol updates, and clinical measures. These requirements of practice pose a significant demand on prehospital providers. To further mandate additional training requirements for the maintenance of ultrasound skills may disproportionately strain rural EMS agencies, ironically where the ONSD measurement skill would likely be most impactful.

In summary, the evidence does not yet support broadly incorporating this exam in general EMS provider training, nor in the routine prehospital acquisition of ONSD in the evaluation of patients with altered mental status. In remote settings or areas where neurological diagnostics are not readily accessed, ONSD measurement may support clinical decision-making to sufficiently warrant its use. In these situations, a training protocol should be developed for prehospital providers, and their performance assessed by an experienced sonographer. Further research and investigation on ONSD evaluation in the prehospital setting is necessary prior to broad implementation.

References

1. Brooke M, Walton J, Scutt D, et al. Acquisition and interpretation of focused diagnostic ultrasound images by ultrasound-naïve advanced paramedics: trialing a PHUS education programme. Emerg Med J. 2012;29:322.
2. Houze-Cerfon CH, Bounes V, Guemon J, et al. Quality and feasibility of sonographic measurement of the optic nerve sheath diameter to estimate the risk of raised intracranial pressure after traumatic brain injury in the prehospital setting. Prehosp Emerg Care. 2019;23(2):277–83.
3. Kimberly HH, Shah S, Marrill K, et al. Correlation of optic nerve sheath diameter with direct measurement of intracranial pressure. Acad Emerg Med. 2008;15(2):201.
4. Lochner P, Brio F, Zedde ML, et al. Feasibility and usefulness of ultrasonography in idiopathic intracranial hypertension or secondary intracranial hypertension. BMC Neurol. 2016;16:85.
5. Oberfoell S, Murphy D, French A, et al. Inter-rater reliability of sonographic optic nerve sheath diameter measurements by emergency physicians. J Ultrasound Med. 2017;36:1579.
6. Ohle R, McIsaac S, Woo MY, et al. Sonography of the optic nerve sheath diameter for detection of raised intracranial pressure compared to computed tomography. J Ultrasound Med. 2015;34:1285.
7. Pollack AN. Emergency care and transportation of the sick and injured 10th edition. Burlington; Jones and Bartlett Learning. 2011.
8. Qayyum H, Ramlakhan S. Can ocular ultrasound predict intracranial hypertension? A pilot diagnostic accuracy evaluation in a UK emergency department. Eur J Emerg Med. 2013;20(2)
9. Rajajee V, Vanaman M, Fletcher JJ, et al. Optic nerve ultrasound for the detection of raised intracranial pressure. Neurocrit Care. 2011;15:506.
10. Robba C, Santori G, Czosnyka M, et al. Optic nerve sheath diameter measured sonographically as non-invasive estimator of intracranial pressure: a systematic review and meta-analysis. Intensive Care Med. 2018;44:1284.
11. Rooney KP, Lahham S, Lahham S, et al. Pre-hospital assessment with ultrasound emergencies: implementation in the field. World J Emerg Med. 2016;7(2):117.
12. Teasdale G, Jennett B. Assessment of coma and impaired consciousness: a practical scale. Lancet. 1974;304:81–4.
13. Walcher F, Weinlich M, Conrad G, et al. Prehospital ultrasound imaging improves management of abdominal trauma. Br J Surg. 2006;93:238.
14. National Registry of Emergency Medical Technicians. www.nremt.org. Accessed 27 Nov 2018.