Commentary

Using MRI of the optic nerve sheath to detect elevated intracranial pressure

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Abstract

The current gold standard for the diagnosis of elevated intracranial pressure (ICP) remains invasive monitoring. Given that invasive monitoring is not always available or clinically feasible, there is growing interest in non-invasive methods of assessing ICP using diagnostic modalities such as ultrasound or magnetic resonance imaging (MRI). Increased ICP is transmitted through the cerebrospinal fluid surrounding the optic nerve, causing distention of the optic nerve sheath diameter (ONSD). In this issue of *Critical Care*, Geeraerts and colleagues describe a non-invasive method of diagnosing elevated ICP using MRI to measure the ONSD. They report a positive correlation between measurements of the ONSD on MRI and invasive ICP measurements. If the findings of this study can be replicated in larger populations, this technique may be a useful non-invasive screening test for elevated ICP in select populations.

The recognition that elevated intracranial pressure (ICP) is transmitted through the optic nerve and its sheath has been known for many years. This physiological process is the basis for the physical exam finding of papilledema on fundoscopic examination. Recently, interest has turned to measurement of the optic nerve sheath diameter (ONSD) through non-invasive imaging technologies to provide surrogate markers for early elevated ICP. In this issue of *Critical Care*, Geeraerts and colleagues [1] present their research correlating magnetic resonance imaging (MRI) measurements of ONSD with ICP. In a retrospective review of 38 patients with traumatic brain injury requiring both invasive ICP monitoring and MRI, they found a significant positive relationship between ONSD measured by MRI and ICP ($r = 0.71$). The best cut-off value to detect an ICP >20 cmH_2O based on a receiver operating characteristic curve was found to be ONSD = 5.82 mm with a sensitivity of 90% and a specificity of 92%. A cut-off value of 5.30 mm yielded a sensitivity of 100%.

The optic nerve is surrounded by cerebrospinal fluid (CSF), which is contiguous with intracranial CSF. Increased ICP is transmitted through this subarachnoid space causing distention of the dural optic nerve sheath, especially the retrobulbar segment [2]. The optic nerve and its surrounding sheath can be imaged and measured on MRI using a fat-suppressed T2-weighted sequence [3,4].

MRI has been used to demonstrate increased ONSD in idiopathic intracranial hypertension [5], and interestingly, decreased ONSD in CSF hypotension [6]. The ONSD has also been shown on MRI to decrease after drainage of subdural hematomas [7]. The research presented by Geeraerts and colleagues is unique in its comparison of ONSD with simultaneous direct measurements of ICP through invasive monitoring.

Their findings generally correlate with a growing body of research using bedside ultrasound measurements of ONSD to detected elevated ICP. Original research with lumbar intrathecal infusions performed by Hansen and Helmke [8] demonstrated rapid changes in the ONSD with alteration of CSF pressures. In emergency department patients with traumatic brain injury, the ONSD correlates with signs of elevated ICP on computed tomography scans [9,10]. More recently, researches have compared bedside ultrasound measurements of ONSD to invasive ICP [11-13]. While there is some variation in the optimal cut-off value, the correlation between ONSD and ICP remains consistent.

In their current article, Geeraets and colleagues provide further evidence of this physiological relationship and an intriguing possibility for non-invasive assessment of ICP using MRI. The obvious drawbacks to MRI include its expense, long

CSF = cerebrospinal fluid; ICP = intracranial pressure; MRI = magnetic resonance imaging; ONSD = optic nerve sheath diameter.

acquisition times, need for patient transport, and limited availability. However, some research has shown that MRI may provide more precise measurements then ultrasound [14]. Geeraerts and colleagues used a conventional T2 sequence with relatively large slice thickness and interslice spacing, resulting in an overall feasibility of measuring the ONSD in 95% of patients. Greater accuracy and reliability would be expected in coronal T2 slices with thinner slices. As MRI becomes more accessible and faster, non-invasive MRI measurements may prove to be useful in certain clinical settings and as a potential reference standard for further research.

Continued research with larger studies is required to confirm the precision and accuracy of MRI measurements of ONSD, as well as the optimal measurement technique [15]. Additionally, the time course of ONSD distention and reduction needs to be further delineated.

Currently, non-invasive assessments of ICP do not obviate the need for invasive ICP monitoring. Invasive monitoring detects minute to minute variations in ICP and, in the case of intraventricular drains, can also be therapeutic. However, non-invasive screening tests may be useful in select populations who would not otherwise require invasive monitoring and could undergo MRI scans, such as patients with liver failure, meningitis, stroke, and moderate traumatic brain injury.

In summary, the study by Geeraerts and colleagues adds to a growing body of research demonstrating a correlation between increased ONSD and elevated ICP. By demonstrating the correlation of MRI measurements of the ONSD with invasive ICP monitoring, they illustrate the potential of yet another non-invasive method to screen for elevated ICP. While this technique will not replace invasive ICP monitoring, it may be useful in select patient populations that would not otherwise have invasive monitoring but are at high risk for elevated ICP. Further research is required before we can use measurements of the ONSD to predict exact values of ICP, but it may be useful as a screening test to estimate the probability of elevated ICP.

Competing interests

The authors declare that they have no competing interests.

References

1. Geeraerts T, Newcombe VFJ, Coles JP, Abate MG, Perkes IE, Hutchinson PJA, Outtrim JG, Chatfield DA, Menon DK: **Use of T2-weighted magnetic resonance imaging of the optic nerve sheath to detect raised intracranial pressure.** *Crit Care* 2008, **12:**R114.
2. Hansen HC, Helmke K: **The subarachnoid space surrounding the optic nerves. An ultrasound study of the optic nerve sheath.** *Surg Radiol Anat* 1996, **18:**323-328.
3. Weigel M, Lagreze WA, Lazzaro A, Hennig J, Bley TA: **Fast and quantitative high-resolution magnetic resonance imaging of the optic nerve at 3.0 tesla.** *Invest Radiol* 2006, **41:**83-86.
4. Seitz J, Held P, Strotzer M, Muller M, Volk M, Lenhart M, Djavidani B, Feuerbach S: **Magnetic resonance imaging in patients diagnosed with papilledema: a comparison of 6 different high-resolution T1- and T2(*)-weighted 3-dimensional and 2-dimensional sequences.** *J Neuroimaging* 2002, **12:**164-171.
5. Gass A, Barker GJ, Riordan-Eva P, MacManus D, Sanders M, Tofts PS, McDonald WI, Moseley IF, Miller DH: **MRI of the optic nerve in benign intracranial hypertension.** *Neuroradiology* 1996, **38:**769-773.
6. Watanabe A, Horikoshi T, Uchida M, Ishigame K, Kinouchi H: **Decreased diameter of the optic nerve sheath associated with CSF hypovolemia.** *AJNR Am J Neuroradiol* 2008, **29:**863-864.
7. Watanabe A, Kinouchi H, Horikoshi T, Uchida M, Ishigame K: **Effect of intracranial pressure on the diameter of the optic nerve sheath.** *J Neurosurg* 2008, **109:**255-258.
8. Hansen HC, Helmke K: **Validation of the optic nerve sheath response to changing cerebrospinal fluid pressure: ultrasound findings during intrathecal infusion tests.** *J Neurosurg* 1997, **87:**34-40.
9. Blaivas M, Theodoro D, Sierzenski PR: **Elevated intracranial pressure detected by bedside emergency ultrasonography of the optic nerve sheath.** *Acad Emerg Med* 2003, **10:**376-381.
10. Tayal VS, Neulander M, Norton HJ, Foster T, Saunders T, Blaivas M: **Emergency department sonographic measurement of optic nerve sheath diameter to detect findings of increased intracranial pressure in adult head injury patients.** *Ann Emerg Med* 2007, **49:**508-514.
11. Soldatos T, Karakitsos D, Chatzimichail K, Papathanasiou M, Gouliamos A, Karabinis A: **Optic nerve sonography in the diagnostic evaluation of adult brain injury.** *Crit Care* 2008, **12:**R67.
12. Geeraerts T, Merceron S, Benhamou D, Vigue B, Duranteau J: **Non-invasive assessment of intracranial pressure using ocular sonography in neurocritical care patients.** *Intensive Care Med* 2008 [Epub ahead of print].
13. Kimberly HH, Shah S, Marill K, Noble V: **Correlation of optic nerve sheath diameter with direct measurement of intracranial pressure.** *Acad Emerg Med* 2008, **15:**201-204.
14. Lagreze WA, Lazzaro A, Weigel M, Hansen HC, Hennig J, Bley TA: **Morphometry of the retrobulbar human optic nerve: comparison between conventional sonography and ultrafast magnetic resonance sequences.** *Invest Ophthalmol Vis Sci* 2007, **48:**1913-1917.
15. Blehar DJ, Gaspari RJ, Montoya A, Calderon R: **Correlation of visual axis and coronal axis measurements of the optic nerve sheath diameter.** *J Ultrasound Med* 2008, **27:**407-411.