Optic nerve sheath diameter ultrasonography case series

Agrawal et al. objective was to evaluate the accuracy of optic nerve sheath diameter as a noninvasive screening test for the detection of elevated intracranial pressure and prediction of intracranial pressure treatment intensity.

Optic nerve ultrasound was performed daily and optic nerve ultrasound measured at the point-of-care as well as remotely by an expert blinded to all patient details. Optic disc elevation was also measured. The index test was the highest remote-expert optic nerve ultrasound for the admission. The reference standard was the concurrent invasive intracranial pressure, with test-positivity set at intracranial pressure greater than 22 mm Hg. A priori the minimally acceptable sensitivity threshold was 90% with corresponding specificity 60%. They also evaluated the ability of optic nerve ultrasound to predict a therapeutic intensity level greater than 10.

One hundred twenty patients were enrolled. The intraclass correlation coefficient between point of care and expert optic nerve sheath diameter after enrollment of 50 subjects was poor at 0.16 (-0.08 to 0.41) but improved to 0.87 (0.81-0.92) for the remaining subjects after remedial training. The area under the curve of the receiver operating characteristic curve of the highest expert-measured optic nerve sheath diameter to detect intracranial pressure greater than 22 mm Hg was 0.81 (0.73-0.87); area under the curve for prediction of therapeutic intensity level greater than 10 was 0.51 (0.42-0.60). Optic nerve sheath diameter greater than 0.72 demonstrated sensitivity 82% (48-98%) and specificity 79% (70-86%) for intracranial pressure greater than 22 mm Hg. The area under the curve of highest measured optic disc elevation to detect intracranial pressure greater than 22 mm Hg was 0.84 (0.76-0.90). Optic disc elevation greater than 0.04 cm attained sensitivity 90% (56-100%) and specificity 71% (61-79%).

While optic nerve sheath diameter demonstrated a modest, statistically significant correlation with intracranial pressure, a predetermined level of diagnostic accuracy to justify routine clinical use as a screening test was not achieved. Measurement of optic disc elevation appears promising for the detection of elevated intracranial pressure, however, verification from larger studies is necessary [1].

Optic nerve sheath diameter (ONSDs) were measured by ocular ultrasonography in 40 healthy control adults. ICPs were monitored invasively with a microsensor at 6 hours and 24 hours after decompressive craniectomy (DC) operation in 35 TBI patients. ONSDs were measured at the same time in these patients. Patients were assigned to 3 groups according to ICP levels, including normal (ICP ≤ 13 mm Hg), mildly elevated (ICP = 14-22 mm Hg), and severely elevated (ICP > 22 mm Hg) groups. ONSDs were compared between healthy control adults and TBI cases with DC. Then, the association of ONSD with ICP was analyzed using Pearson's correlation coefficient, linear regression analysis, and receiver operating characteristic curves.

Seventy ICP measurements were obtained among 35 TBI patients after DC, including 25, 27, and 18 measurements in the normal, mildly elevated, and severely elevated ICP groups, respectively. Mean ONSDs were 4.09 ± 0.38 mm in the control group and 4.92 ± 0.37, 5.77 ± 0.41, and 6.52 ± 0.44 mm in the normal, mildly elevated, and severely elevated ICP groups, respectively ($p < 0.001$). A significant linear correlation was found between ONSD and ICP ($r = 0.771$, $p < 0.0001$). Enlarged ONSD was a robust predictor of elevated ICP. With an ONSD cutoff of 5.48 mm (ICP > 13 mm Hg),

sensitivity and specificity were 91.1% and 88.0%, respectively; a cutoff of 5.83 mm (ICP > 22 mm Hg) yielded sensitivity and specificity of 94.4% and 81.0%, respectively.

Ultrasonographic ONSD is strongly correlated with invasive ICP measurements and may serve as a sensitive and noninvasive method for detecting elevated ICP in TBI patients after DC [2].

In eleven patients (median age of 47 [range 20-71], 8 male and 3 female). There was a linear relationship between ICP and non-invasive estimators of ICP (nICP) with optic nerve sheath diameter ultrasonography (ONSD) ($R = 0.53$ [$p < 0.0001$]), JVP ($R = 0.38$ [$p < 0.001$]) and transcranial Doppler ultrasonography (TCD) ($R = 0.30$ [$p < 0.01$]). The ability to predict intracranial hypertension was highest for ONSD and TCD (AUC = 0.96 [95% CI: 0.90-1.00] and AUC = 0.91 [95% CI: 0.83-1.00], respectively). Jugular venous bulb pressure (JVP). presented the weakest prediction ability (AUC = 0.75 [95% CI: 0.56-0.94]).

ONSD and TCD methods demonstrated agreement with invasively-monitored ICP, suggesting their potential roles in the detection of intracranial hypertension in hypoxic ischaemic brain injury (HIBI) after cardiac arrest [3].

A prospective observational study was performed using convenience sample of 41 adult neurosurgical patients treated in neurosurgical intensive care unit with invasive intracranial pressure monitoring placed in-situ as part of their clinical care. Portable SonoSite ultrasound machine with 7 MHz linear probe were used to measure optic nerve sheath diameter using the standard technique. Simultaneous ICP readings were obtained directly from the invasive monitoring.

Seventy-five measurements were performed on 41 patients. The non-parametric Spearman correlation test revealed a significant correlation at the 0.01 level between the ICP and ONSD value, with correlation coefficient of 0.820. The receiver operating characteristic curve generated an area under the curve with the value of 0.964, and with standard error of 0.22. From the receiver operating characteristic curve, we found that the ONSD value of 5.205 mm is 95.8% sensitive and 80.4% specific in detecting raised ICP.

ONSD value of 5.205 is sensitive and specific in detecting raised ICP. Bedside ultrasound measurement of ONSD is readily learned, and is reproducible and reliable in predicting raised ICP. This non-invasive technique can be a useful adjunct to the current invasive intracranial catheter monitoring, and has wide potential clinical applications in district hospitals, emergency departments and intensive care units [4].

References

1)
Agrawal D, Raghavendran K, Zhao L, Rajajee V. A Prospective Study of Optic Nerve Ultrasound for the Detection of Elevated Intracranial Pressure in Severe Traumatic Brain Injury. Crit Care Med. 2020 Oct 13. doi: 10.1097/CCM.0000000000004689. Epub ahead of print. PMID: 33048902.
2)
Wang J, Li K, Li H, Ji C, Wu Z, Chen H, Chen B. Ultrasonographic optic nerve sheath diameter correlation with ICP and accuracy as a tool for noninvasive surrogate ICP measurement in patients

with decompressive craniotomy. J Neurosurg. 2019 Jul 19:1-7. doi: 10.3171/2019.4.JNS183297. [Epub ahead of print] PubMed PMID: 31323632.

3)

Cardim D, Griesdale DE, Ainslie PN, Robba C, Calviello L, Czosnyka M, Smielewski P, Sekhon MS. A comparison of non-invasive versus invasive measures of intracranial pressure in hypoxic ischaemic brain injury after cardiac arrest. Resuscitation. 2019 Jan 7. pii: S0300-9572(18)30912-2. doi: 10.1016/j.resuscitation.2019.01.002. [Epub ahead of print] PubMed PMID: 30629992.

4)

Raffiz M, Abdullah JM. Optic nerve sheath diameter measurement: a means of detecting raised intracranial pressure in adult traumatic and non-traumatic neurosurgical patients. Am J Emerg Med. 2016 Sep 23. pii: S0735-6757(16)30622-2. doi: 10.1016/j.ajem.2016.09.044. [Epub ahead of print] PubMed PMID: 27852525.