

Non-invasive estimation of intracranial hypertension: A multimodal approach.

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Introduction: Elevated intracranial pressure (ICP) is a well-known cause of secondary brain injury. The gold standard method of measuring ICP is using an intra-cerebral catheter, but several non-invasive techniques can be used to estimate it, with controversial results about their accuracy. The aim of this study was to compare different non-invasive methods of ICP assessment.

Methods: This prospective, observational study included ICU patients in whom invasive ICP monitoring was initiated. The following non-invasive methods were simultaneously used to estimate ICP: ocular ultrasound to measure the optic nerve sheath diameter (ONSD); transcranial Doppler to measure the pulsatility index (PI) and the estimated ICP (nICP) according to standard formulas; automated pupillometry (NeuroOptics, Irvine, USA) to measure the neurological pupil index (NPI). The mean value from both eyes was calculated for all measurements and correlations assessed using a Pearson's or Spearman's test, as appropriate.

Results: We studied 80 patients (traumatic brain injury = 25, subarachnoid hemorrhage = 38; others =17) with a median age of 52 years. Median Glasgow Coma Scale score on admission was 8 [5-12] and ICP assessment was performed 2 [2-3] days after ICU admission. Median ICP values were 17 [11-23] mmHg. Median values from the different non-invasive techniques were: ONSD 5.2 [4.8-5.8] mm; PI 1.1 [0.9-1.4]; nICP 21 [14-29] mmHg; NPI 4.2 [3.8-4.6]. There was a significant correlation between all the different techniques and ICP (ONSD, $r^2=0.30$; $p<0.001$ – PI, $r^2=0.55$; $p<0.001$ - nICP, $r^2=0.69$; $p<0.001$ - NPI, $r^2=0.45$; $p<0.001$). The area under the curve to predict elevated ICP (i.e. > 20 mmHg) was 0.79 [0.67-0.89] for ONSD, 0.79 [0.68-0.90] for PI, 0.85 [0.76-0.94] for nICP and 0.69 [0.55-0.81] for NPI.

Conclusions: Non-invasive techniques were well correlated with ICP and have an acceptable predictive value of intracranial hypertension.

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