Transcranial Doppler for Noninvasive intracranial pressure monitoring

Flow velocity signals from transcranial Doppler (TCD) have been used to estimate ICP; however, the relative accuracy of these methods is unclear. This study aimed to compare four previously described TCD-based methods with directly measured ICP in a prospective cohort of traumatic brain-injured patients. Noninvasive ICP (nICP) was obtained using the following methods: 1) a mathematical "black-box" model based on the interaction between TCD and arterial blood pressure (nICP_BB); 2) based on diastolic flow velocity (nICP_FVd); 3) based on critical closing pressure (nICP_CrCP); and 4) based on TCD-derived pulsatility index (nICP_PI). In time domain, for recordings including spontaneous changes in ICP greater than 7 mm Hg, nICP_PI showed the best correlation with measured ICP ($R = 0.61$). Considering every TCD recording as an independent event, nICP_BB generally showed to be the best estimator of measured ICP ($R = 0.39$; $p < 0.05$; 95% confidence interval [CI] = 9.94 mm Hg; area under the curve [AUC] = 0.66; $p < 0.05$). For nICP_FVd, although it presented a similar correlation coefficient to nICP_BB and marginally better AUC (0.70; $p < 0.05$), it demonstrated a greater 95% CI for the prediction of ICP (14.62 mm Hg). nICP_CrCP presented a moderate correlation coefficient ($R = 0.35$; $p < 0.05$) and similar 95% CI to nICP_BB (9.19 mm Hg), but failed to distinguish between normal and raised ICP (AUC = 0.64; $p > 0.05$). nICP_PI was not related to measured ICP using any of the above statistical indicators. We also introduced a new estimator (nICP_Av) based on the average of three methods (nICP_BB, nICP_FVd, and nICP_CrCP), which overall presented improved statistical indicators ($R = 0.47$; $p < 0.05$; 95% CI = 9.17 mm Hg; AUC = 0.73; $p < 0.05$). nICP_PI appeared to reflect changes in ICP in time most accurately. nICP_BB was the best estimator for ICP "as a number." nICP_Av demonstrated to improve the accuracy of measured ICP estimation [1].

A technology uses Two Depth Transcranial Doppler to compare arterial pulsations in the intra- and extra-cranial segments of the ophthalmic artery for non-invasive estimation of ICP [2].

Numerous techniques have been described with several novel advances. While none of the currently available techniques appear independently accurate enough to quantify raised ICP, there is some promising work being undertaken [3].

1)
Cardim D, Robba C, Donnelly J, Bohdanowicz M, Schmidt B, Damian M, Varsos GV, Liu X, Cabeleira M, Frigieri G, Cabella B, Smielewski P, Mascarenhas S, Czosnyka M. Prospective Study on Noninvasive Assessment of Intracranial Pressure in Traumatic Brain-Injured Patients: Comparison of Four Methods. J Neurotrauma. 2016 Apr 15;33(8):792-802. doi: 10.1089/neu.2015.4134. Epub 2015 Dec 17. PubMed PMID: 26414916; PubMed Central PMCID: PMC4841086.
2)
Koskinen LD, Malm J, Zakelis R, Bartusis L, Ragauskas A, Eklund A. Can intracranial pressure be measured non-invasively bedside using a two-depth Doppler-technique? J Clin Monit Comput. 2016 Mar 14. [Epub ahead of print] PubMed PMID: 26971794.
3)
Padayachy LC. Non-invasive intracranial pressure assessment. Childs Nerv Syst. 2016 Sep;32(9):1587-97. doi: 10.1007/s00381-016-3159-2. Review. PubMed PMID: 27444289.