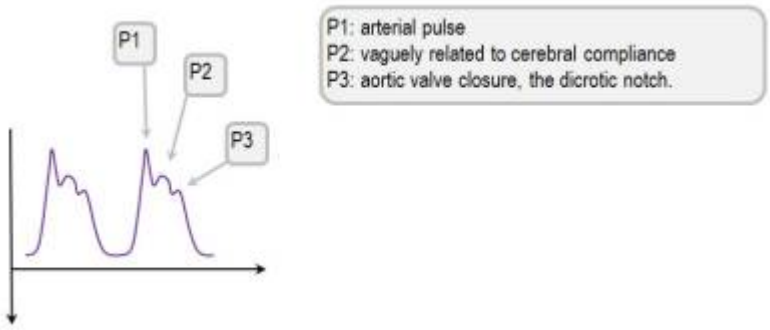
Intracranial pressure waveform

Intracranial pressure monitoring waveform has a flow of 3 upstrokes in one wave.



P1 = (Percussion wave) represents arterial pulse

P2 = (Tidal wave) represents intracranial compliance

P3 = (Dicrotic wave) represents aortic valve closure

In normal ICP waveform P1 should have highest upstroke, P2 in between and P3 should show lowest upstroke.

On eyeballing the monitor, if P2 is higher than P1 - it indicates intracranial hypertension.

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see Application of non-invasive intracranial pressure waveform analysis in acute brain injury: Intracranial Compliance Scale [1].

Analysis of intracranial pressure waveforms (ICPW) provides information on intracranial compliance. We aimed to assess the correlation between noninvasive ICPW (NICPW) and invasively measured intracranial pressure (ICP) and to assess the NICPW prognostic value in this population. In this cohort, acute brain-injured (ABI) patients were included within 5 days from admission in six Intensive Care Units. Mean ICP (mICP) values and the P2/P1 ratio derived from NICPW were analyzed and correlated with outcome, which was defined as: (a) early death (ED); survivors on spontaneous breathing (SB) or survivors on mechanical ventilation (MV) at 7 days from inclusion. Intracranial hypertension (IHT) was defined by ICP > 20 mmHg. A total of 72 patients were included (mean age 39, 68% TBI). mICP and P2/P1 values were significantly correlated ($r = 0.49$, $p < 0.001$). P2/P1 ratio was significantly higher in patients with IHT and had an area under the receiving operator curve (AUROC) to predict IHT of 0.88 (95% CI 0.78-0.98). mICP and P2/P1 ratio was also significantly higher for ED group (n = 10) than the other groups. The AUROC of P2/P1 to predict ED was 0.71 [95% CI 0.53-0.87], and the threshold P2/P1 > 1.2 showed a sensitivity of 60% [95% CI 31-83%] and a specificity of 69% [95% CI 57-79%]. Similar results were observed when decompressive craniectomy patients were excluded. In this study, P2/P1 derived from noninvasive ICPW assessment was well correlated with IHT. This information seems to be as associated with ABI patients outcomes as ICP.Trial registration: NCT03144219, Registered 01 May 2017 Retrospectively registered, https://www.clinicaltrials.gov/ct2/show/NCT03144219 [2].

Intracranial pressure (ICP) is an important and established clinical measurement that is used in the management of severe acute brain injury. ICP waveforms are usually triphasic and are susceptible to artifact because of transient catheter malfunction or routine patient care. Existing methods for artifact detection include threshold-based, stability-based, or template matching, and result in higher false positives (when there is variability in the ICP waveforms) or higher false negatives (when the ICP waveforms lack complete triphasic components but are valid).

Megjhani et al., hypothesized that artifact labeling of ICP waveforms can be optimized by an active learning approach which includes interactive querying of domain experts to identify a manageable number of informative training examples. The resulting active learning based framework identified the non-artifactual ICP pulse with a superior AU-ROC of 0.96+0.012, compared to existing methods: template matching (AUC: 0.71 + 0.04), ICP stability (AUC: 0.51+0.036) and threshold-based (AUC: 0.5 + 0.02) [3].

1)
Frigieri G, Robba C, Machado FS, Gomes JA, Brasil S. Application of non-invasive ICP waveform analysis in acute brain injury: Intracranial Compliance Scale. Intensive Care Med Exp. 2023 Jan 27;11(1):5. doi: 10.1186/s40635-023-00492-9. PMID: 36703025.
2)
Brasil S, Frigieri G, Taccone FS, Robba C, Solla DJF, de Carvalho Nogueira R, Yoshikawa MH, Teixeira MJ, Malbouisson LMS, Paiva WS. Noninvasive intracranial pressure waveforms for estimation of intracranial hypertension and outcome prediction in acute brain-injured patients. J Clin Monit Comput. 2022 Nov 18:1–8. doi: 10.1007/s10877-022-00941-y. Epub ahead of print. PMID: 36399214; PMCID: PMC9673225.
3)
Megjhani M, Alkhachroum A, Terilli K, Ford J, Rubinos C, Kromm J, Wallace BK, Connolly ES, Roh D, Agarwal S, Claassen J, Padmanabhan R, Hu X, Park S. An active learning framework for enhancing identification of non-artifactual intracranial pressure waveforms. Physiol Meas. 2018 Dec 18. doi: 10.1088/1361-6579/aaf979. [Epub ahead of print] PubMed PMID: 30562165.