Influence of mild-moderate hypocapnia on slow waves activity in TBI

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Background.In Traumatic brain injury (TBI) the pathological processes leading to unfavourable outcome are reflected in the patterns of intracranial pressure (ICP) waveforms. In particular, magnitudes of ICP slow waves (0.05 – 0.005 Hz) and complexity demonstrated positive association with outcome. Mild to moderate hypocapnia is used to treat critical ICP elevations.

Objectives. To assess changes in ICP slow waves activity (time and frequency domain), and their relationship with other physiological variables, following sudden onset mild hypocapnia.

Material and Methods. We present a retrospective analysis of ICP, arterial blood pressure (ABP) and bilateral middle cerebral artery blood flow velocity (FV) waveforms prospectively collected during CO2-reactivity studies in 29 adult severe TBI patients requiring ICP monitoring and mechanical ventilation. An FFT filter was applied (pass-band set to 0.05 – 0.005 Hz), followed by Power spectral density analysis (Periodogram method using Hanning window) (fig.1). For both baseline and hypocapnia periods, mean value, standard deviation, variance, coefficient of variation and entropy were extracted in the time domain, total power and frequency centroid were extracted in the frequency domain, and were compared statistically. RAP (compensatory reserve index - moving correlation coefficient between slow changes in ICP pulse amplitude and mean ICP) was also calculated.

Results. Hypocapnia led to a decrease in power and increase in frequency centroid and entropy of slow waves in ICP and FV (not ABP). In a multiple linear regression model RAP at the baseline was the strongest predictor for the decrease in the power of ICP slow waves ($p<0.001$) (fig.2).

Conclusion. In severe TBI patients mild to moderate hypocapnia induces a decrease in ICP and FV slow waves power, but increases their higher frequency content and their morphological complexity. The difference in power of the ICP slow waves between the baseline and the hypocapnia period depends on the baseline cerebrospinal compensatory reserve.

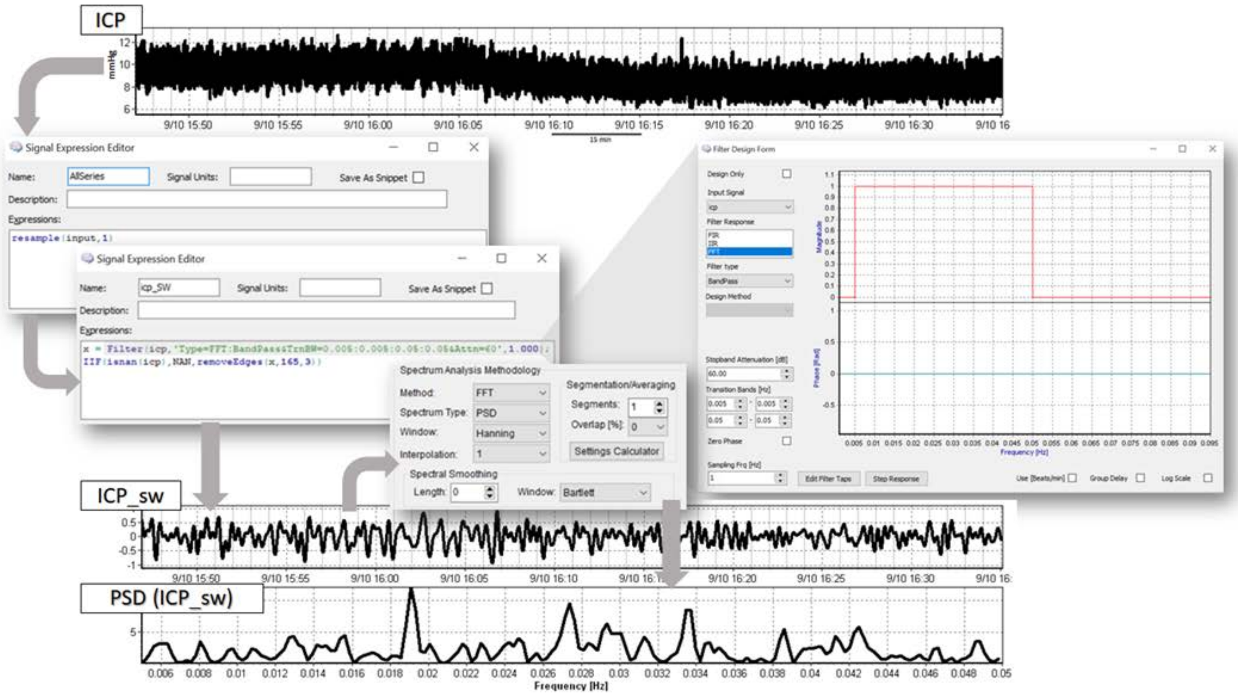

Fig 1. Signal processing methodology applied to obtain the slow wave component of the recorded signals. The whole pipeline is shown here for ICP. The raw waveform signals (time trend at the top) were first decimated to sampling frequency 1Hz (in the first signal expression editor the function 'resample' is used) and subsequently processed with a FFT band-pass filter in order to isolate the slow wave component (0.005 – 0.05 Hz) of the four waveforms (in the second signal expression editor the filter is described). The filter design form correspondent to the filer expression shows the filter type and transition bands. In the picture the so obtained ICP slow wave component is rapresented in a time trend chart (ICP_sw). A Power spectral density (PSD) analysis of the slow wave component was then performed (Periodogram method with the settings as shown in spectrum analysis methodology).