Monitoring and Interpretation of Intracranial Pressure Waveform in Traumatic Brain Injury

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Introduction

Intracranial pressure (ICP) monitoring as an absolute number is generally used in the management of various intracranial pathologies; however ICP waveform analysis carries valuable information regarding intracranial compliance in these states. More sophisticated analysis of the intracranial pressure waveform has yielded important relationships, but those methods have not gained widespread clinical utility [1,2]. The pressure-volume compensatory reserve index (RAP) is a correlation coefficient between the ICP waveform amplitude (pulse ICP) and the mean ICP [1] and has been found to predict outcome in traumatic brain injury (TBI) [1]. The high-frequency centroid (HFC) is a power-weighted frequency spectrum of the ICP waveform that also correlates to outcome and mortality from TBI [3].
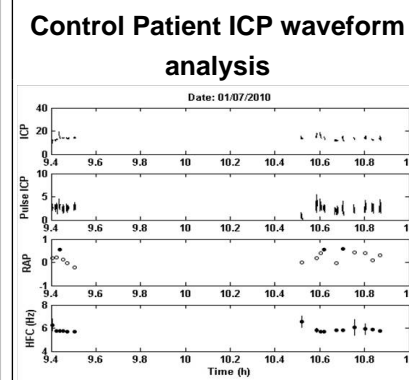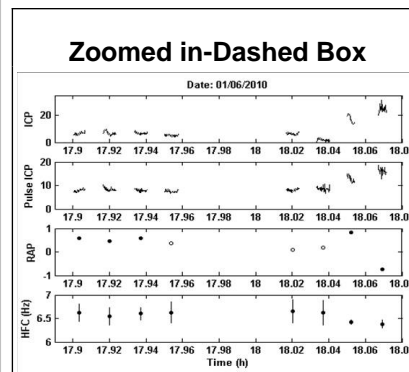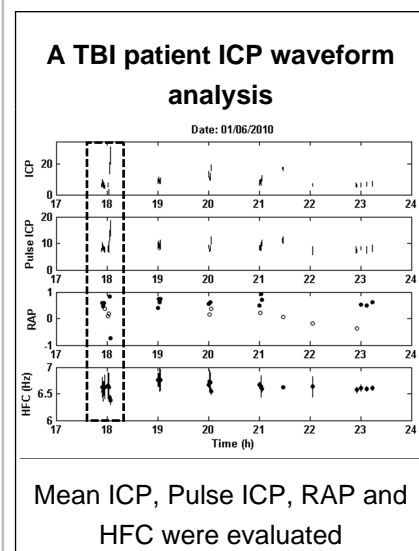
Methods

This study recorded ICP continuously in 41 TBI patients using either ventriculostomy or Camino ICP monitor device and also collected CSF pressure in 2 control patients who had lumbar CSF drainage for abdominal aortic aneurysm repair.

Data Analysis

The data was stored in Chart Software using Powerlab technology and analysis was performed using Matlab software. HFC and RAP were calculated for all patients and these results were correlated to their outcome.

Detailed ICP waveform analysis of 5 patients with acute TBI as a representative pool of 41 TBI patients and 2 control patients were analyzed. Among the 5 TBI patients whose ICP were analyzed, Glasgow outcome scale(GOS) were 1 (dead) for 2 patients , 5 (good recovery) for 2 patients and 4 (moderate disability) for the last one.

A TBI patient ICP waveform analysis

Mean ICP, Pulse ICP, RAP and HFC were evaluated

Zoomed in-Dashed Box

Control Patient ICP waveform analysis

Data analysis summary

Subject	Condition	Outcome	RAP (grand) (p-value)	Correlation coefficient between average mean ICP and average HFC (p-value)
037	TBI	Death	0.88591 (4.5225e-007)	-0.6640 (0.0019)
071	TBI	Moderate disability	0.88502 (1.9378e-009)	-0.4771 (0.0137)
060	TBI	Good recovery	0.92296 (4.8882e-008)	0.5370 (0.0216)
064	Healthy control	N/A	0.043861 (0.85026)	0.5339 (0.0127)
072	Healthy control	N/A	0.36951 (0.15896)	-0.3794 (0.1473)
026	TBI	Death	0.85507 (0.014184)	-0.89549 (0.0064064)
042	TBI	Good recovery	0.99105 (2.8113e-016)	-0.28602 (0.23518)

Results

In all 5 TBI patients, the grand RAP values as correlation coefficient between pulse ICP and mean ICP were between 0.8 to 0.9 with significant P value (P value <0.05). In 2 healthy subjects, the RAP values were between 0.8-0.9; however this correlation was not significant. Among 5 subjects with TBI, correlation coefficient between average mean ICP and average HFC were negative (-0.2 to -0.8) in 4 patients (3 significant and 1 insignificant P value) and positive (0.5) in 1 patient (significant P value). In 2 healthy subjects, ICP correlation with HFC was positive and negative in 1 patient each with 1 signficant and 1 insignificant P value respectively.

Conclusions

In pathological states, grand RAP was significantly > 0 indicating that there is a strong linear trend between average mean ICP and average pulse ICP. In healthy controls, these correlations were not significant. We also found significant (or near significant) negative correlation between the average mean ICP and average HFC may be indicative of poor outcome (death or disability).

Learning Objectives

This article will give us more insight into ICP waveform analysis in pathological states like TBI and their potential clinical use in deciphering exhaustion of intracranial compliance before rise in absolute value of intracranial pressure occurs.

References

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