

# Intracranial pressure-volume compensatory reserve index (RAP) in traumatic brain injury.

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## Introduction

Intracranial pressure (ICP) monitoring is a common practice in the management of various neurological disorders. Sophisticated analyses of the ICP waveform have yielded important information regarding intracranial compliance in these states, but have not gained widespread clinical utility(1). The pressure-volume compensatory reserve index (RAP) is a correlation coefficient between the ICP waveform amplitude (pulse ICP) and the mean ICP and has been found to predict the outcome in traumatic brain injury (TBI)(2).

## Methods

This study recorded ICP continuously in 19 TBI patients using either ventriculostomy or Camino device. It also recorded CSF pressure in 2 control patients undergoing lumbar CSF drainage for abdominal aortic aneurysm repair. RAP was calculated for 7 patients stratified based on their Glasgow outcome Scale (GOS) into good outcome group (GOS of 5, n=3) and bad outcome group (GOS of 1, n=4).

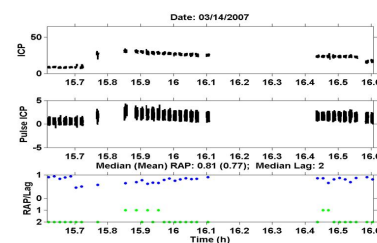
## Data Analysis

The data was recorded with Chart Software using Powerlab technology. A detailed ICP waveform analysis was performed using Matlab software. RAP was calculated for the 7 subjects with acute TBI and the 2 controls as mentioned in the Methods section. The results of the ICP waveform analysis were correlated to each subject's GOS.

## Results

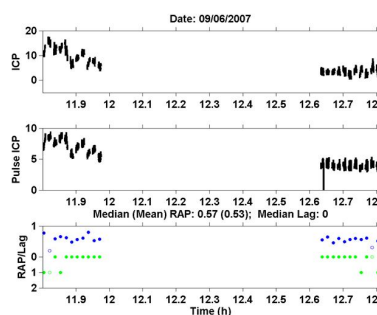
In general, a lag phase of 1-2 heart beats was noticed between pulse ICP and mean ICP in the bad outcome group as compared to lag phase of 0 -1 in the good outcome group. The mean RAP values were 0.5-0.7 and 0.3-0.9 in good and bad outcome groups, respectively. The results showed significant p-values( $p < 0.05$ ) within all subjects. In subjects who went on to die from uncontrolled increased ICP, RAP ranged from 0.63 to 0.89 during the active phase of uncontrollable ICP. In 2 healthy individuals, the RAP values were between 0.04-0.3; however this correlation was not significant.

### A TBI patient with bad outcome (Glasgow Coma Scale (GCS): 9, GOS: 1)



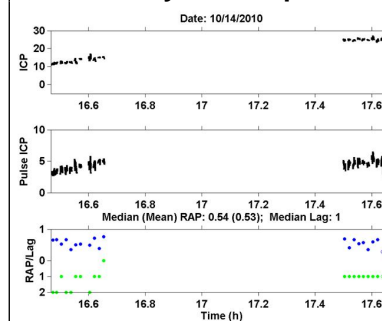
Mean RAP (blue dots) was  $>0.8$ . Higher RAPs were observed at average lag phase (green dots)=2

### A TBI patient with good outcome (GCS: 14, GOS: 5)



Mean RAP was  $>0.5$  with average lag phase=1

### A healthy control patient



Mean RAP was 0.5 with average lag phase=1

## Conclusions

In our detailed analysis of 7/19 TBI subjects, mean RAP was significantly  $>0$ , indicating that there is a strong linear correlation between average mean ICP and average pulse ICP. In healthy controls, these correlations were not significant. There seems to be a trend toward higher mean RAP in patients with a poor outcome compared to those with a good recovery. Analysis of additional subjects is ongoing.

## Learning Objectives

This study gives us valuable insights into ICP waveform analysis in pathological states like TBI and their potential clinical use in deciphering current state of intracranial compliance independent of absolute value of ICP.

## References

- 1) Westhout FD, Pare LS, Delfino RJ, Cramer SC. Slope of the intracranial pressure waveform after traumatic brain injury. *Surg Neurol* 2008; 70(1):70-74.
- 2) Balestreri M, Czonyka M, Steiner LA. Intracranial hypertension: what additional information can be derived from ICP waveform after head injury? *Acta Neurochir (Wien)* 2004; 146:131-141.