Cerebrospinal Fluid Research

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Oral presentation

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Induced canine hydrocephalus alters pulsation absorber characteristics

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from 52nd Annual Meeting of the Society for Research into Hydrocephalus and Spina Bifida
Providence, RI, USA. 11–14 June 2008

Published: 3 February 2009

Cerebrospinal Fluid Research 2009, **6**(Suppl 1):S29 doi:10.1186/1743-8454-6-S1-S29

This abstract is available from: http://www.cerebrospinalfluidresearch.com/content/6/S1/S29

Background

Systems analysis performed with normal canines has revealed an important role of pulsatile intracranial cerebrospinal fluid (CSF) movement in absorbing strong arterial pulsations transmitted to the brain. The role is analogous to a *notch filter* centered at the cardiac frequency. Performance efficiency of the notch filter depends on how well the center frequency of the notch filter (or notch frequency) remains tuned at the target frequency (i.e. cardiac frequency). In our previous analysis with intracranial pressure (ICP) and arterial blood pressure (ABP) data obtained from normal canines, a sharp attenuation of the gain around the cardiac frequency during normal ICP has been observed, suggesting that notch filter manifested in the intracranial system performs more effectively under normal ICP levels than under elevated ICP levels. How the notch filter responds to the pathophysiology of hydrocephalus is yet to be investigated.

Materials and methods

We hypothesize that the mismatch of notch frequency relative to the cardiac frequency increases, and the efficacious performance of the notch filter (i.e. pulsation absorber) decreases in hydrocephalic animals. To test the hypothesis we have applied time-varying transfer function (TVTF) technique derived from autoregressive moving average model (ARMA) identified using optimal parameter search (OPS) algorithm to ABP input and ICP output data recorded from six canines with *normal*, *hydrocephalic*, and *shunt treated* conditions.

Results

The preliminary results have shown that 1) on the average, frequency mismatch between the notch frequency and the cardiac frequency is lower in normal dogs (0.49 ± 0.4 Hz) than in both hydrocephalic (0.66 ± 0.5 Hz) and shunt treated (1.0 ± 0.6 Hz) dogs; and 2) on the average, the performance of the pulsation absorber characterized by the value of the gain at the cardiac frequency decreases more than 50% in both hydrocephalic and shunt treated conditions with respect to the normal physiological condition.

Conclusion

The results suggest that 1) under normal conditions, the notch filter mechanism buffers arterial pulsation input by tuning close to the cardiac rhythm; 2) the notch frequency in hydrocephalus appears to be tuned to frequencies other than the cardiac frequency or fluctuates around the cardiac frequency; 3) the hydrocephalic condition decreases normal efficacious absorption by increasing the frequency mismatch between notch frequency and cardiac frequency; and 4) treatment of hydrocephalus with CSF diversion through a shunt does not seem to restore efficacy of the pulsation absorber.