Commentary

During which phase of cardiac cycle is freshly actively formatted (FAF) cerebrospinal fluid (CSF) released into the brain ventricles (BV): systole or diastole?

Darko D. Lavrencic

MED zasebna splošna ambulanta, Cesta 6. maja 11, 1360 Vrhnika, Slovenia, EU

Web site: http://www.med-lavrencic.si, Email address: DDL@med-lavrencic.si

Uploaded to http://med-lavrencic.si/raziskava.htm **30 April 2013**

Abstract

FAF CSF is released into BV during the diastolic phase of the cardiac cycle when net caudal CSF flow exists.

Introduction

There are numerous studies and experiments describing CSF behavior during cardiac cycle but we still do not know when exactly the new FAF CSF is released into the BV.

Discussion

During cardiac cycle in its systolic phase, the volumes of BV decrease by compression of brain and expansion of plexus choroideus (PC) (Zhu, Xenos et al. 2006). In diastole, the volumes of BV are restored.

During systole, the CSF is expelled caudally due to additional pressure on BV and returns rostrally during diastole due to negative pressure in BV – the process known as to-and fro movement of CSF. Because the caudal CSF flow is greater than rostral, there is net caudal CSF flow (Nilsson, Stahlberg et al. 1992). Theoretically, FAF CSF could release into the BV either during systole or during diastole. If it was released during systole, the PC cells would have to produce extra pressure for FAF CSF transport into BV, which would require extra energy. If, on the other hand, FAF CSF was released during diastole, this, as a passive process (sucking), would require no extra energy.

An experiment on cats was published (Oreskovic, Klarica et al. 2002) in which we may find an answer to this question. Authors describe experiment with plastic cannula introduced into the aqueduct of Sylvius during which they observed no CSF circulation at physiological CSF pressure. They also observed no FAF CSF release into BV. If there would be FAF CSF released into BV during systole, they would have had inevitably observed net caudal CSF flow. During diastole there was no negative pressure, because open plastic cannula, according to Pascal law, had not provided negative pressure in BV, that could have enabled passive process of FAF CSF release (sucking) from PC cells. Consequently, there was no caudal CSF flow either, as they observed solely CSF pulsations of positive pressure at the open end of plastic cannula. It can be conluded therefore that when net caudal CSF flow exists, the FAF CSF is released into BV during diastole.

Conclusions:

FAF CSF is released into the BV during the diastole of the cardiac cycle when net caudal CSF flow exists.

Competing interests: The author declares that no conflict of interest exists.

References

Nilsson, C., et al. (1992). "Circadian variation in human cerebrospinal fluid production measured by magnetic resonance imaging." Am J Physiol **262**(1 Pt 2): R20-24.

Recent advances in magnetic resonance imaging have made it possible to visualize and quantify flow of cerebrospinal fluid (CSF) in the brain. The net flow of CSF through the cerebral aqueduct was used to measure CSF production in six normal volunteers at different times during a 24-h period. CSF production varied greatly both intra- and interindividually. The average CSF production in each time interval showed a clear tendency to circadian variation, with a minimum production 30% of maximum values (12 +/- 7 ml/h) approximately 1800 h and a nightly peak production approximately 0200 h of 42 +/- 2 ml/h. The total CSF production during the whole 24-h period, calculated as an average of all measurements, was 650 ml for the whole group and 630 ml for repeated measurements in each time interval in one of the volunteers.

Oreskovic, D., et al. (2002). "The formation and circulation of cerebrospinal fluid inside the cat brain ventricles: a fact or an illusion?" Neurosci Lett **327**(2): 103-106.

Formation and circulation of cerebrospinal fluid (CSF) have been studied in the isolated brain ventricles of anesthetized cats by a new approach and under direct observation. A plastic cannula was introduced into the aqueduct of Sylvius through the vermis cerebelli and the outflow of CSF from the cannula was used as the CSF formation and circulation index. During the 60 min of observation at a physiological CSF pressure not a single drop of CSF escaped out of the end of the cannula. This indicates that CSF net formation and circulation inside the brain ventricles, proposed by classical hypothesis regarding CSF dynamics, should be at least re-evaluated.

Zhu, D. C., et al. (2006). "Dynamics of lateral ventricle and cerebrospinal fluid in normal and hydrocephalic brains." J Magn Reson Imaging **24**(4): 756-770.

PURPOSE: To develop quantitative MRI techniques to measure, model, and visualize cerebrospinal fluid (CSF) hydrodynamics in normal subjects and hydrocephalic patients. MATERIALS AND METHODS: Velocity information was obtained using time-resolved (CINE) phase-contrast imaging of different brain regions. A technique was developed to measure the change of lateral ventricle (LV) size. The temporal relationships between the LV size change, CSF movement, and blood flow could then be established. The data were incorporated into a first-principle CSF hydrodynamic model. The model was then used to generate specific predictions about CSF pressure relationships. To better-visualize the CSF flow, a color-coding technique based on linear transformations was developed that represents the magnitude and direction of the velocity in a single cinematic view. RESULTS: The LV volume change of the eight normal subjects was 0.901+/-0.406%. Counterintuitively, the LV decreases as the choroid plexus expands, so that they act together to produce the CSF oscillatory flow. The amount of oscillatory flow volume is 21.7+/-10.6% of the volume change of the LV from its maximum to its minimum. CONCLUSION: The quantification and visualization techniques, together with the mathematical model, provide a unique approach to understanding CSF flow dynamics.