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CARDIAC AND RESPIRATORY EFFECTS OF INTRACRANIAL PRESSURE GRADIENT PULSATILITY ON CEREBROSPINAL FLUID FLOW

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Introduction The relative importance of the cardiac and respiratory cycles on intracranial pressure and cranial CSF flow remains an open question [1]. In this study, we analyzed real-time in-vivo intracranial pressure differences and used a mathematical model to assess the influence of cardiac and respiratory components for aqueductal CSF flow.

Methods We obtained simultaneously collected real-time subdural and ventricular in-vivo pressure measurements from a group of normal-pressure hydrocephalus patients [2], and defined the intracranial pressure difference as the difference between the subdural and ventricular pressure. We considered a subset of time intervals, and computed the frequency spectrum of the pressure difference signals via FFT. We modelled an idealized aqueduct as a rigid, CSF-filled cylinder of radius 2 mm. Using the dominant frequencies of the pressure differences as input, we computed the corresponding velocity and pressure distribution of CSF in the aqueduct using the incompressible Navier-Stokes equations. From the velocity distributions, we computed the peak CSF flux and stroke volumes.

Results The in-vivo pressure measurements reveal pulsatile intracranial pressure differences, of magnitudes ranging up to 0.3 mmHg. The spectrum of these pressure differences express two main frequencies, 1.5 and 0.3 Hz, associated with the cardiac and respiratory cycle respectively, with corresponding amplitudes 0.120 and 0.038 mmHg (Figure 1a). On the other hand, in the induced CSF flux frequency spectrum, we find a contribution from the respiratory cycle of amplitude 0.28 mL/s compared to 0.24 mL/s from the cardiac cycle (Figure 1b). Finally, for the stroke volumes, we find respiratory and cardiac contributions of 297 and 52 μL, respectively.

Discussion Cardiac-induced pulsatility clearly dominates (~3x) the respiratory pulsatility in the intracranial pressure differences. However, for the aqueductal CSF flux induced by these pressure differences the cardiac and respiratory component are of comparable magnitude. The respiratory-associated stroke volume clearly dominates (~6x) the cardiac component. These findings provide a fundamental link between seemingly discrepant previous findings regarding the relative influence of respiratory and cardiac contributions, originating from different measurement modalities, on intracranial pressure and flow.

References

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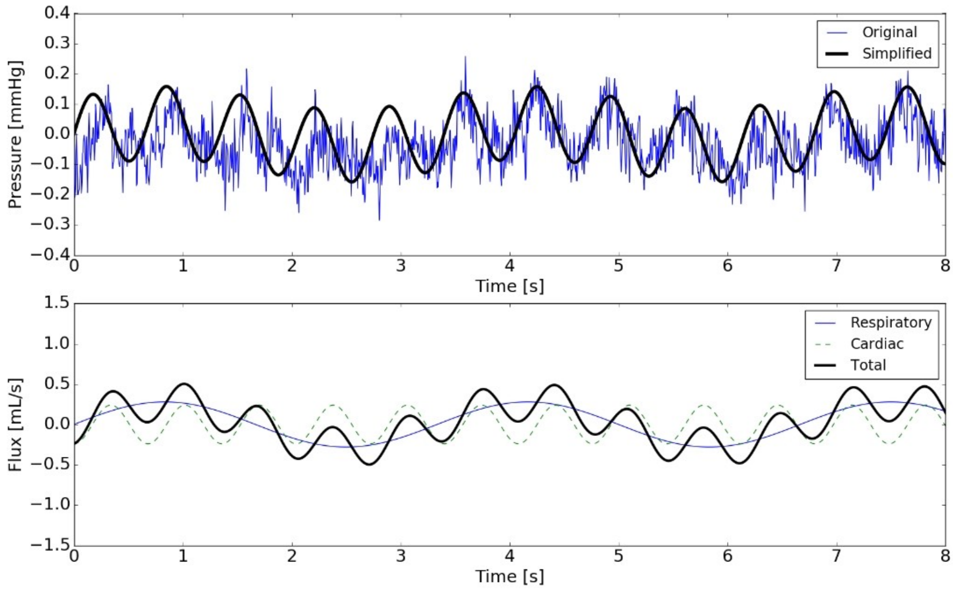

Figure 1: a) The original measurement of the pressure difference, together with the simplified sinusoidal pressure difference consisting of two frequencies. **b)** Aqueductal flux resulting from the simplified pressure difference in a). Cardiac and respiratory components also shown separately.