

Inspiration is the major regulator of human CSF flow.

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Abstract

The mechanisms behind CSF flow in humans are still not fully known. CSF circulates from its primary production sites at the choroid plexus through the brain ventricles to reach the outer surface of the brain in the subarachnoid spaces from where it drains into venous bloodstream and cervical lymphatics. According to a recent concept of brain fluid transport, established in rodents, CSF from the brain surface also enters the brain tissue along para-arterial routes and exits through paravenous spaces again into subarachnoid compartments. This unidirectional flow is mainly driven by arterial pulsation. To investigate how CSF flow is regulated in humans, we applied a novel real-time magnetic resonance imaging technique at high spatial (0.75 mm) and temporal (50 ms) resolution in healthy human subjects. We observed significant CSF flow exclusively with inspiration. In particular, during forced breathing, high CSF flow was elicited during every inspiration, whereas breath holding suppressed it. Only a minor flow component could be ascribed to cardiac pulsation. The present results unambiguously identify inspiration as the most important driving force for CSF flow in humans. Inspiratory thoracic pressure reduction is expected to directly modulate the hydrostatic pressure conditions for the low-resistance paravenous, venous, and lymphatic clearance routes of CSF. Furthermore, the experimental approach opens new clinical opportunities to study the pathophysiology of various forms of hydrocephalus and to design therapeutic strategies in relation to CSF flow alterations.

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