INFLUENCE OF BLOOD FLOW ON INTRACRANIAL WATER FLUCTUATION: A PHANTOM STUDY

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TARGET AUDIENCE:
Researchers interested in mechanism of diffusion change in cardiac cycle and the diffusion phantom study.

PURPOSE:
We have reported that the apparent diffusion coefficient (ADC) in brain tissue significantly changed during the cardiac cycle because of the water-molecule fluctuation, and this information could assist in the diagnosis of idiopathic normal pressure hydrocephalus.[1] Moreover, cerebral blood flow has direct and indirect effects on these changes (delta-ADC), ie., perfusion itself and fluctuation.[2] To clarify these relations and mechanisms, we assessed the influence of blood flow on delta-ADC using the original cranial magnetic resonance imaging (MRI)-phantom consisting of a high-density polypropylene filter (brain parenchyma) with intra- and extra-filter spaces (artery and vein), and a capacitor space (cerebrospinal fluid)[3] (Fig. 1).

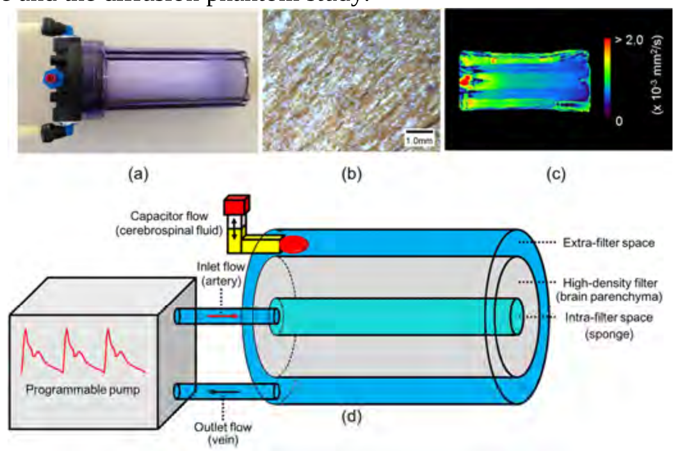

Fig. 1 (a) Frontal view of the phantom, (b) microscopic image of filter, (c) sagittal ADC image of the phantom, and (d) overview of the phantom.

METHODS:
Simulated total cerebral blood flow (StCBF) (500, 750, 1000, 1250, 1500 mL/min) was periodically applied to the cranial phantom by a programmable pulsation flow pump. Under these conditions, on a 3.0-T MRI, we obtained the sagittal diffusion weighted-images with multiple b-values of the phantom using ECG-triggered single-shot diffusion echo-planar imaging with sensitivity encoding and half-scan techniques to minimize the effect of bulk motion. Next, ADC images of 29 phases in the pulsation period were calculated in combination with b-values. Then, we evaluated maximum ADC, minimum ADC, and delta-ADC in the filter (brain parenchyma) of the phantom.

RESULTS AND DISCUSSION:
With use of low b-values (b=0-200 s/mm^2), both maximum ADC and minimum ADC during the pulsation period increased with the StCBF due to the direct and indirect effect of blood flow[4] (Figs. 2 and 3). However, with high b-values (b=0-1000 and 200-1000 s/mm^2), minimum ADC did not increase with the StCBF because of the decrease in the direct effect of blood flow (Fig. 3). Moreover ADC with b=200-1000 became smaller than with b=0-1000 because of eliminating the direct effect of blood flow. Therefore, the indirect effect of blood flow, ie., water fluctuation, was predominant with b=200-1000 (Fig. 4).

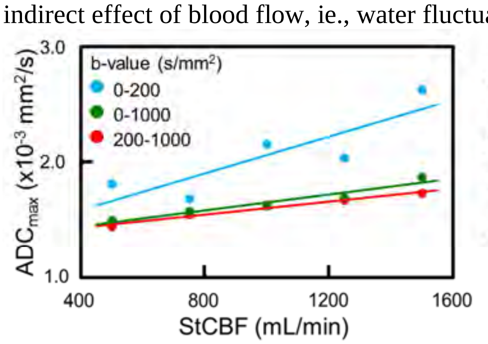

Fig. 2 Maximum ADC with each b-value.

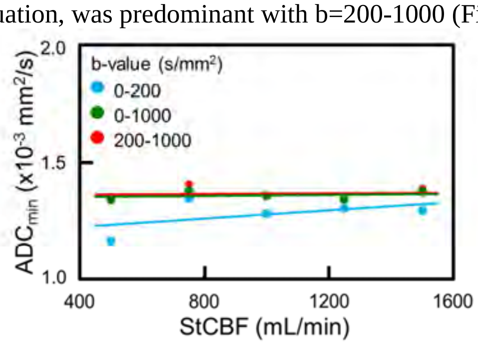

Fig. 3 Minimum ADC with each b-value.

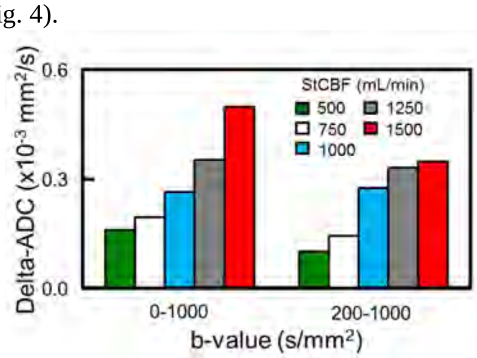

Fig. 4 Delta-ADC with each b-value.

CONCLUSION:
Our original phantom enabled us to clarify the influence of blood flow on intracranial water fluctuation, and delta-ADC in combination with b=200-1000 makes it possible to minimize the direct effect of blood flow.

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