INTEGRATED PHANTOM ANALYSIS OF PERFUSION, DIFFUSION, AND FLUCTUATION MRI

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TARGET AUDIENCE:

Researchers interested in relations and mechanisms among blood-perfusion, water-diffusion, water-fluctuation, and biomechanics of the intracranial tissue, and noninvasive assessment of intracranial condition.

PURPOSE:

To clarify relations and mechanisms among blood-perfusion, water-diffusion, water-fluctuation, and biomechanics of the intracranial tissue, we developed an original cranial phantom for magnetic resonance imaging (MRI).

METHODS:

The new cranial phantom consisted of a high-density polypropylene filter (filtration accuracy of 0.5 µm, apparent diffusion coefficient [ADC] of 1.3×10^{-3} mm^2/s) with intra- and extra-filter spaces, and a capacitor space, which were filled with water at 17 degrees centigrade (Fig. 1). These correspond to a brain parenchyma, artery and vein, and cerebrospinal fluid space, respectively. Then, volume loading was periodically applied to the cranial phantom by a pulsation flow (simulated cerebral blood flow) pump. Under these conditions, on a 3.0-T MRI, we determined the regional phantom flow and the ADC change (water-fluctuation) in the pulsation period [1] using pseudo-continuous arterial spin labeling and ECG-triggered multi-phase single-shot diffusion echo planer imaging with multi-b (16 points), respectively. Moreover, we compared those values with trans-cranial phantom flow obtained with phase contrast cine MRI and actual pressure wave in the phantom.

RESULTS AND DISCUSSION:

The ADC change during the pulsation period in the filter was synchronized with the trans-cranial phantom flow and actual pressure wave in the phantom, indicating water-fluctuation are affected by biomechanical properties. The regional phantom flow agreed with the trans-cranial phantom flow and the ADC change. Moreover, ADC calculated with lower b-values (0 to 160 s/mm^2) depended on the regional phantom flow.

CONCLUSION:

Our original phantom makes it possible to clarify relations and mechanisms among blood-perfusion, water-diffusion, water-fluctuation, and biomechanics of intracranial tissue. Perfusion, diffusion, fluctuation, and biomechanics of the intracranial tissue interact in diverse ways.

REFERENCES:

[1] Ohno N, et al. *Radiology*, 261, 560-565, 2011.

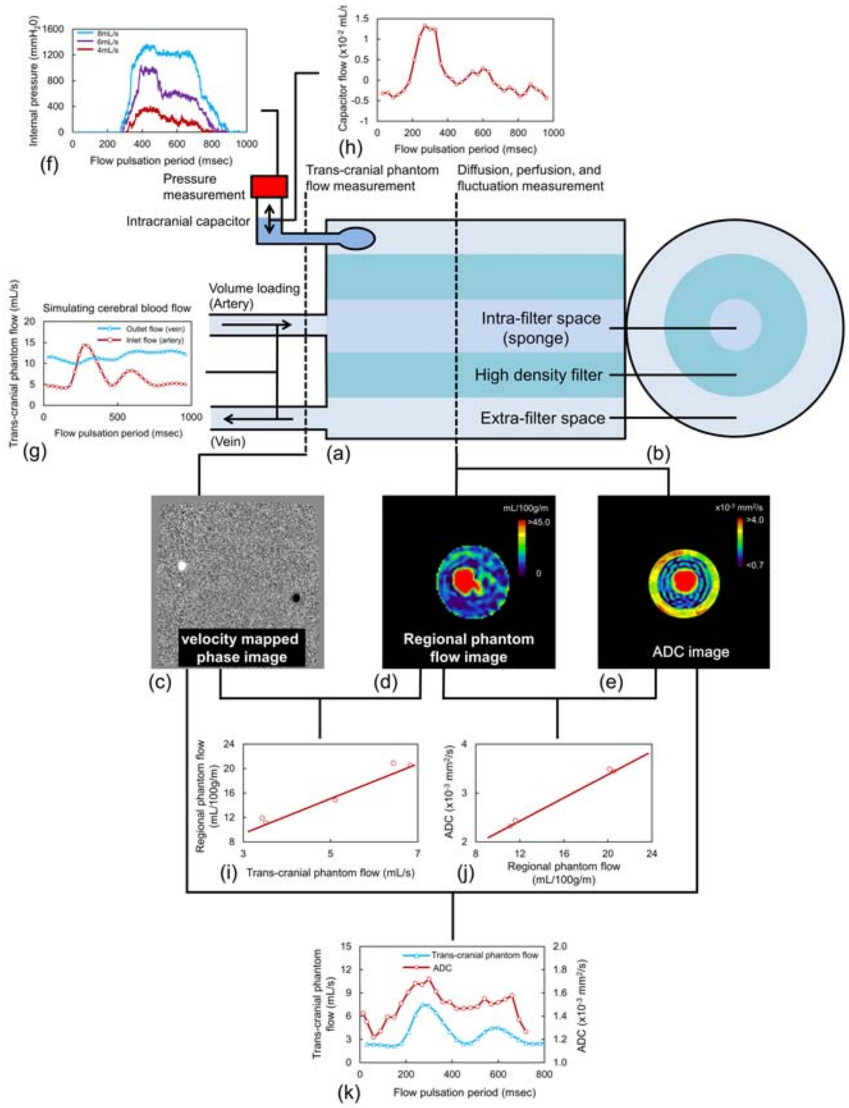

Fig. 1 (a) Lateral and (b) bottom views of the cranial MRI-phantom. Examples of (c) velocity mapped phase image, (d) regional phantom flow image, and (e) ADC image. (f) Pressure wave in the phantom obtained with digital pressure gauge. (g) Inlet (arterial) and outlet (venous) flow wave generated by a pulsation flow pump. (h) Capacitor flow (simulated cerebrospinal fluid [CSF] flow) wave. Relations between (i) trans-cranial phantom flow and regional phantom flow, and (j) regional phantom flow and ADC obtained with low b-value. (k) Change in the ADC and trans-cranial phantom flow during the pulsation period.