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Effect of wall elasticity on flow structures inside cerebral aneurysms

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Introduction: We investigated how elastic deformation of the wall of a cerebral aneurysm affects the flow structure inside the aneurysm. Flow field measurement in idealized cerebral aneurysm models were conducted, using both an elastic and rigid wall model. We obtained the pressure difference between the inlet and top of the aneurysm and discuss the relationship between deformation and pressure differences.

Materials & methods: We prepared six types of T-shaped cerebral aneurysm models, with aneurysm tilt angles of 0, 10, 18, 30, 40, and 50 degrees. For each model, we fabricated both elastic and rigid wall silicone models. In this study, velocity distribution inside the aneurysm was measured by scanning stereoscopic particle image velocimetry (SSPIV) and the wall of the model was reconstructed using the SSPIV particle images. The pressure differences (□P) over time were acquired using a pressure transducer, between upstream and the top of the aneurysm. Both SSPIV and □P measurement was conducted under a pulsatile-flow condition which imitates the average flow rate waveform of healthy men.

Results: SSPIV analyses indicated that the average flow velocity within the elastic wall models was smaller than that observed within the rigid wall models. Flow structures also varied between the elastic and rigid wall models, with the exception of the 50 degree tilt model. In the elastic wall models, secondary flow was observed inside the aneurysm. We did not observe secondary flow within the rigid models with the same tilt angle, and the flow was circulated inside the aneurysms. The maximum □P during one pulsation cycle was different for each tilt angle. For the elastic models, the deformation increased as the maximum □P increased. However, for the rigid wall model, we observed no correlation between the maximum □P of the rigid wall model and deformation within the elastic wall model.

Conclusion: Comparing elastic and rigid aneurysm models, we observed a slowing of flow velocity in the elastic wall model and different flow structures. This result implies that elastic deformation might affect blood velocity and flow, and consequently pressure inside the aneurysm. The influence of elastic deformation on the entire flow field in the aneurysm should be taken into account during flow analyses.