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Influence of blood flow change by the deformation of stented parent artery in an intracranial aneurysm

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INTORODUCTION

The inflow into an aneurysm is reported to be related to the transformation of the parent artery forward the aneurysm [1]. The deformation of parent artery after stent placement has been observed with various stents for cerebral aneurysms. Mori et al. clarified the effect of expansion of the parent artery by stent placement using an idealized model [2]. Expansion of the parent artery can decrease the inflow rate into aneurysm. The effect of expansion of the parent artery may be decreased the influence on the aneurysm and contribute to effect of the stent placement. This result suggests that the deformation of the parent artery can decrease the effect of the aneurysm.

We investigate the inflow into the aneurysm and the wall shear stress (WSS) on the aneurysm at expansion of the parent artery by stent placement using a realistic model. The aim of the present study was to clarify the possibility of change in inflow to the aneurysm in the expansion of the parent artery.

METHODS

A patient-specific geometry of an internal carotid artery with an aneurysm was used in this study, as shown in Figure 1 (a). The geometry was provided by the Virtual Intracranial Stenting Challenge (VISC) [3]. The numerical data for the geometry were provided in the form of STL data. We reconstructed the artery shape using a Voronoi diagram to reproduce expansion of the parent artery by stent placement. Figure 1 (b) shows the centerline generated from the Voronoi diagram and the region of expansion of parent artery by stent placement from the points that A to D (case 3: 25 mm), B to D (case 2: 20 mm), and C to D (case 1: 15 mm). To examine the effects of expansion of parent artery after stent placement, the diameter of the stent placement region was varied. Three models with different diameters were constructed as follows: no expansion, 3% expansion, and 6% expansion. These procedures were based on methods implemented in the Vascular Modeling ToolKit (VMTK). Moreover, the position of stent placement fixed to the center of stent of length for the aneurysm neck.

RESULTS AND CONCLUSION

Figure 1 (c) shows the inflow rate with and without a stent in various cases. In the original case with the stent, the inflow rate was decreased by 8.6% compared with that without the stent. In all cases, the inflow rate was decreased by stent placement. Moreover, the expansion effect was greater than the stent effect. Expansion of the parent artery changed the inflow rate into the aneurysm by changing the flow forward the aneurysm. The most effective case was 36.9% in case2 with 6% expansion. The effects of expansion of the parent artery were 35.9% in 36.9%. In case 2 with the stent with 6% expansion, the effect of flow obstruction by stent placement was hardly observed. The inflow rate into the aneurysm in case 3 with the stent with 6% expansion was more increased at 6.6% compared with that in case2 with the stent with 6% expansion. In both cases 2 and 3, the inflow into the aneurysm was changed by expansion of the parent artery. However, in case 3, the expansion of the parent artery caused the flow to be changed excessively. Moreover, in terms of the mean WSS, the original case with the stent was decreased by 12.6% compared with that without the stent. In all cases, the mean WSS was decreased by stent placement. In case 1 with 6% expansion and both cases 2 and 3, the expansion effect was greater than the stent effect.

This study examined the inflow into the aneurysm to determine the possibility of a decrease in the inflow rate by examining the effect of expansion of the parent artery using a realistic model. The expansion of the parent artery could decrease the inflow rate and the mean WSS on the aneurysm wall compared with the original case. These data suggest that the expansion of the parent artery was effective and could promote thrombus growth in an aneurysm. However, these results owing to fixing of the stent position and we will examine the inflow rate using further stent positions in our future work.

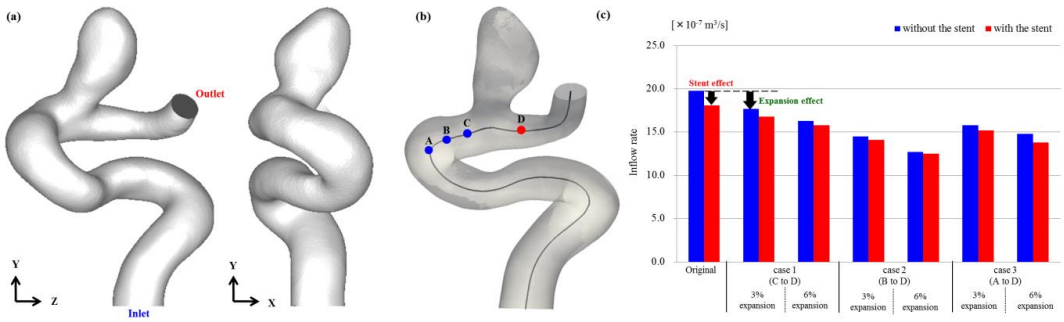

Figure 1 Reconstructed carotid artery with an aneurysm (a). The centerline and the region of expansion of the parent artery caused by stent placement (b): A to D (25 mm), B to D (20 mm), and C to D (15 mm). The inflow rate with and without the stent in a various cases(c); the blue bar indicates the results without the stent and the red bar indicates the results with the stent. The horizontal axis represents each case, and the vertical axis represents inflow rate through the aneurysm neck.

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