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CFD analysis in coil embolized aneurysm Porous Media vs. Real Coil Geometry: Basic Model Study

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Introduction: To clear the mechanism of aneurysmal recanalization, it is necessary to identify the blood flow characteristics in coil embolized aneurysms. In the studies using CFD, one of the main focuses is how to model the embolized coils, which are entangled in complication. There were mainly two options to solve the problem; modeling the coils as porous media or modeling the real coil geometries (e.g., using finite element method (FEM) based structural analysis). The porous media method has been popularly used since the solver setting is easy and calculation cost is less than that of FEM analysis. On the other hand, the real coil geometry method is suitable to simulate the precise blood flow in coiled aneurysms though it takes large calculation cost. In this study, we compared the flow between the two coil modeling methods, porous media coil model and real coil geometry model.

Materials and Methods: A basic aneurysm model was generated with a dome diameter of 6 mm and neck diameter of 4 mm. FEM analysis was performed to create real coil geometry. Three types of single 200 mm coil was inserted with changing coil diameter. As a result, VER was 7.8%, 9.5%, and 15.3 %. In addition, 4 x 50 mm, 2 x 100 mm, 1 x 200 mm length coil insertion were performed (i.e., these VER were 15.3%). On the other hand, porous media coil model was described by Darcy"s law. According to Ergun"s equation, the values of permeability and loss coefficient were given. We compared each pressure drop passing through the coiled region in CFD with changing the inlet velocity every 0.1 m/s from 0.1 m/s to 1.0 m/s.

Results: Comparing the pressure drop in the same VER between porous media and real coil geometry modeling, the values were larger in porous modeling in all the combinations. This result indicate that the porous media model may produce larger pressure drop. In addition, the pressure drop value was also changed due to coil length in the real coil geometry model though the VER values were all 15.3%. This result may be obtained from the difference of coil distribution in the aneurysm (i.e., in case of the most pressure dropped case, more coils were distributed at the main flow region).

Conclusions: There are clear difference between porous media and real coil geometry model (i.e., porous model using Ergun"s equation may produce larger pressure drop than real coil geometry model). Coil distribution will also affect the flow reduction in aneurysms.