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Title:
VISUALIZATION METHOD OF PRESSURE AND STRESS INSIDE THE AORTA

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Abstract:
There are many kinds of medical systems for surgical training, surgery support and preoperative plan: surgical simulators, surgery navigators, and surgical simulations. The aorta is the largest blood vessel in our body and the aortic surgery, which is called AVR (Aortic Valve Replacement) or AVP (Aortic ValvuloPlasty), is necessary when the aortic valve malfunctions. For the preoperative plans, it is necessary to investigate the pressure and the stress inside the aorta. Therefore, we have tried to visualize them with MPS (Moving Particle Semi-implicit) method that is one of particle methods and can treat incompressible fluid such as blood. There is bloodstream inside the aorta so that the simulation of the blood, which is liquid, is necessary. Particle method is usually used for fluid dynamics, while FEM (Finite Element Method) is used for elastic body that composes the aortic wall and the aortic valve. If the two different methods are used for the simulation, it is difficult to judge the collision detection between the blood and the aortic wall or valve, and also to calculate the pressure inside the aorta and the stress on the aortic valve. Then, we have modeled the both materials, which are the blood and the aortic wall or valve, with particles, and calculated the pressure and the stress with the unified method. The basic equations are Cauchy's equation of motion and equation of continuity although the different characters are presented with constitutive equations for both fluid and elastic body. As the result of the simulation with 60k, 3k and 64k particles for the aortic wall, the aortic valve and the blood, respectively, the aortic valve opens and closes repeatedly according to the change of the pressure inside the aorta, and it has been possible to visualize the pressure inside the aorta and the stress on the aortic valve. The simulation time with a PC composed of Core2Quad Q9660 (CPU) and GeForce GTX460 (GPU) was about 1 second per step.

Keywords: Visualization, Simulation, Fluid Dynamics, Particle Method, Aorta