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NUMERICAL ANALYSES OF FOOD BOLUS VELOCITY AND FORCE ON EPIGLOTTIS DURING SWALLOWING USING 3D SWALLOWING SIMULATOR "SWALLOW VISION®"

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Recently, the mortality rate from the pneumonia has been increasing with the progress of aging society. The main cause of the pneumonia in elderly person is mis-swallowing. In order to prevent the mis-swallowing, it is important to adjust the food properties at the nursing or public welfare facilities. There were several researches of biometrical measurements for the study of appropriate food properties for persons who have swallowing difficulties. However, the previous studies were unable to obtain the physical values and visual information of the organs and food bolus, simultaneously. Therefore, we conducted the numerical analyses for the movement and configuration of food bolus, and considered the swallowing easiness with 3D swallowing action simulator "Swallow Vision®". Swallow Vision® was developed with the basis of 3-dimentional MPS (Moving Particle Simulation) method. The Organ models using Swallow Vision® shown in Fig. 1 were reconstructed from CT, VF (Video Fluorography) and MRI images [1]. The accuracy of configuration and movement (organs and food bolus) of Swallow Vision® had been validated by authors past researches [1], [2].

In Swallow Vision®, the food bolus was defined as number of particles. Each particle was the calculation point which could be moved freely. It was possible to simulate rapid and dynamic changes of the food bolus. We analyzed the water as Newtonian fluid and the thickened liquid as Non-Newtonian fluid.

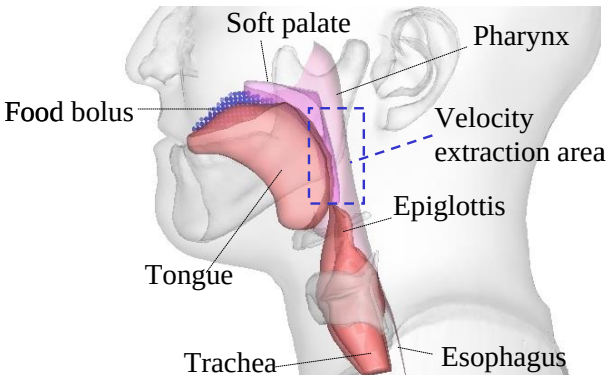

Fig.1 Organ models in 3D swallowing action simulator "Swallow Vision®"

The physical values (velocity and pressure) and the configuration of food bolus and organs were simulated with the water and the thickened liquid at the enclosed area in blue broken line in Fig. 1. The average velocity of water was about 0.6 m/s and the thickened liquid velocity was about 0.5 m/s when the food bolus passed through the pharynx. The velocity distribution of thickened liquid was narrower than that of water (Fig. 2, 3). The maximum velocity of water around the pharynx using MPS method was nearly same with the actual measurement results using ultrasonography [3]. The pressure of water changed dynamically at the time when the epiglottis was forced by water during the swallowing action (Fig. 4).

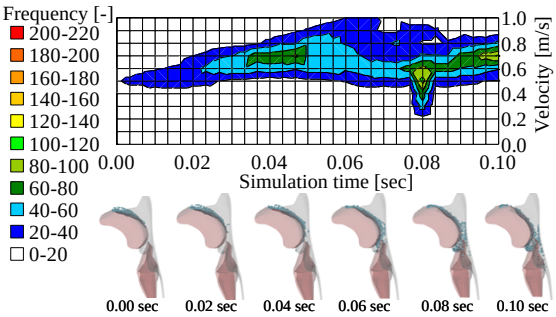

Fig. 2 Velocity distribution of water

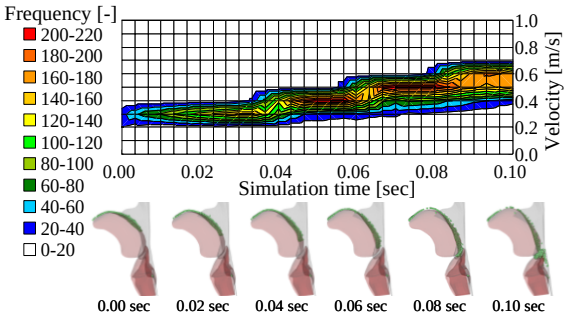

Fig. 3 Velocity distribution of thickened liquid

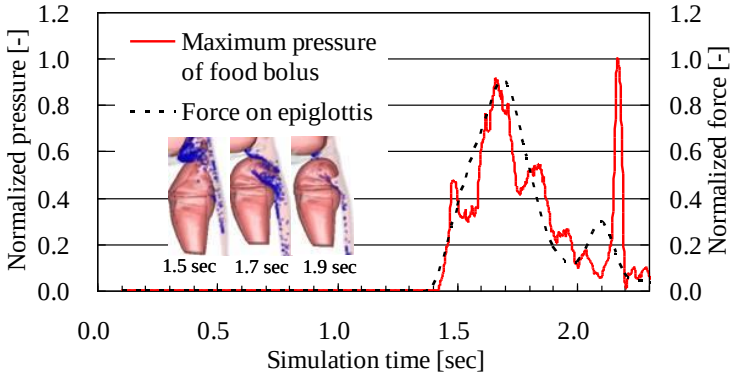

Fig. 4 Pressure of water and force on epiglottis

Swallow Vision® was able to calculate the food bolus velocity, pressure and force on epiglottis. The velocity of food bolus is concerned to the swallowing easiness and the force on epiglottis is related to the sensual feeling of swallowing. Thus, Swallow Vision® may be useful to analyze the swallowing easiness and the feeling.

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