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Experimental Validation of Computational Fluid Dynamics Used for Pharyngeal Flow Patterns during Obstructive Sleep Apnea

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Abstract : Obstructive sleep apnea (OSA) is a sleep disorder where the patient suffers a disturbed airflow during sleep due to partial or complete occlusion of the pharyngeal airway. Recently, numerical simulations have been used to better understand the mechanism of pharyngeal collapse. However, to gain confidence in the solutions so obtained, an experimental validation is required. Therefore, in this study an experimental validation of computational fluid dynamics (CFD) used for the study of human pharyngeal flow patterns during OSA is performed. A stationary incompressible Navier-Stokes equation solved using the finite element method was used to numerically study the flow patterns in a computed tomography-based human pharynx model. The inlet flow rate was set to 250 ml/s and such that a flat profile was maintained at the inlet. The outlet pressure was set to 0 Pa. The experimental technique used for the validation of CFD of fluid flow patterns is phase contrast-MRI (PC-MRI). Using the same computed tomography data of the human pharynx as in the simulations, a phantom for the experiment was 3 D printed. Glycerol (55.27% weight) in water was used as a test fluid at 25°C. Inflow conditions similar to the CFD study were simulated using an MRI compatible flow pump (CardioFlow-5000MR, Shelley Medical Imaging Technologies). The entire experiment was done on a 3 T MR system (Ingenia, Philips) with 108 channel body coil using an RF-spoiled, gradient echo sequence. A comparison of the axial velocity obtained in the pharynx from the numerical simulations and PC-MRI shows good agreement. The region of jet impingement and recirculation also coincide, therefore validating the numerical simulations. Hence, the experimental validation proves the reliability and correctness of the numerical simulations.

Keywords : computational fluid dynamics, experimental validation, phase contrast-MRI, obstructive sleep apnea
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