Numerical Simulation of Fluid-Structure Interaction for a Simplified Model of the Soft Palate

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ABSTRACT

This paper presents a simplified 2D model of fluid-structure interaction for the soft palate in the upper airways with the potential application to study the basic biomechanical mechanisms of the Obstructive Sleep Apnea Syndrome (OSAS). The interaction between the inhaled air through nose and mouth with the soft palate is modeled as compressible flow over a rigid plate in a channel with a flexible structure attached to the plate.

Similar models have successfully been used to model the self-sustained oscillating interaction between the vocal folds and the expiratory airflow in the vocal tract [1]. The method is based on the fourth order Summation by Parts (SBP) [2] finite difference operator in space and the classical fourth order explicit Runge-Kutta method in time for the numerical solution of the compressible flow field. The coupling between the fluid and the structure is handled with an explicit, two-way staggered method where forces and deformations are exchanged between the flow and deformable structure in each time-step. The moving mesh for the fluid domain is handled in an ALE fashion.

The inhaled air flow in the pharynx is modeled with the compressible Navier-Stokes equations, and the elastic wave equation is used to model the deformation of the soft palate. The numerical method based on the high order SBP difference operator [3, 4] provides a means to get stable solutions and low dispersion errors on structured grids. A multi-block method is employed to subdivide the computational domain into topologically rectangular regions.

The drag and lift forces, the position and the velocity of the elastic part of the soft palate are examined. We plan to compare the computed results with experiments to be done in our laboratory. It is demonstrated that the model is able to reproduce the oscillating behavior of the soft palate during normal breathing conditions under the influence of gravity. Potential application to the prediction of the outcome of surgery for OSAS patients is discussed.

REFERENCES

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