CFD CHARACTERIZATION OF TRACHEAL STENOSIS UNDER STEADY AND FORCED SPIROMETRY CONDITIONS

Concepción Paz[1], Eduardo Suárez[1], Miguel Concheiro[1], Roberto Valdés[2]

[1] Escuela de Ingeniería Industrial, University of Vigo, Spain; [2] Otorhinolaryngol. Service, Povisa Hospital, C/Salamanca, Vigo, Spain

Introduction

The study of air flow dynamics through the respiratory system is one of the most-researched areas in biofluid field. The flow through a severe tracheal stenosis has been analysed in this study. The patient was a healthy man who suffered serious damage as a result of hot smoke inhalation. The stenosis was a structural fourth type, [Freitag, 2007]. The extent of the lesion was evaluated with a CT scan, see Figure 1, and the gravity of the damage suffered determined the need to operate for recovering the affected region. During the surgery operation the stenosis area was removed and the healthy ends were spliced together.

The spirometry is the most widely used technique for evaluate success in this type of operation [Miller, 2005]. Although this technique is not considered as totally reliable, it is very difficult to obtain other quantitative results. In the last few years the computational fluid dynamics (CFD) programs have been established as a powerful tool to study and quantify a lot of biofluid flow problems [Brouns, 2007].

Figure 1: 3D image reconstruction of tracheal stenosis, previous to surgery.

Methods

To perform the simulation, previous and post-surgery tracheal geometries were reconstructed from the CT images data, with the help of the free medical reconstruction software InVesalius. Thus, both models were discretized and simulated with Ansys-Fluent platform in order to analyse the flow behaviour and the breathing effort. Every step of the entire process, from image processing to numerical simulation, has been developed in this research.

Results

Pre- and post- operation cases were evaluated under steady-state inhalation and exhalation conditions and the air flow-pressure drop curves were compared. The unsteady conditions of a typical forced spirometry were obtained as well. The results were compared with an idealized without stenosis trachea [Paz, 2012] and with the tracheotomy done, showing a three times stronger breathing effort than at normal healthy conditions. Hence the simulation results show the benefits of the surgery; as the respiratory effort after the surgery was decreased by a 40%.

Discussion

The proposed methodology is a step forward in the quantifying of patient satisfaction and comfort improvement and is a reliable measure to estimate the success or failure of an operation.

Furthermore this study has provided some bases about the process; although it is not yet possible, in the near future this tool could be used as a virtual surgery tool.

References

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