

“Inspiratory Steady Flow Analysis in Symmetrically Bifurcating Lung Airways”

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Abstract

The aim of this project is to study the flow features of air in a human respiratory tract using open source CFD package ‘OpenFOAM v7’. These flow characteristics include velocity profile at critical sections, recirculation regions and wall shear stress analyses. Since the real respiratory tract has complicated geometries, unsymmetrical bifurcations and varying flow conditions, this study is restricted to laminar flow of air under steady state condition. The geometry is also simplified to 2D circular tube with symmetric bifurcations. The Re number of the flow is taken as 500.

Problem Statement

This study focuses on a small portion of the respiratory tract where a parent tube, diameter 1.2 cm is symmetrically bifurcated into two daughter tubes of diameter 1 cm. Each of this daughter tube is further bifurcated into two sub daughter tubes of diameter 0.75 cm. Angle of bifurcation is taken as 60 degree in both of these bifurcations. Velocity profile, recirculation region and wall shear stress at the critical sections have been analysed in this study.

The mesh is generated using ‘blockMesh’ utility with 65664 hexahedral elements and 0.125 mm cell size in the flow direction. Velocity driven model, which involve parabolic velocity at inlet and fixed zero pressure at outlet is adopted. The Re number of the flow is taken as 500. The simulation is done for 2.5 seconds to achieve steady state condition. The ideal solver for this problem is icoFoam but to calculate wall shear stress, pisoFoam/pimpleFoam solver is also used.

In this study, three different cases are analysed (with and without blockage). The blockage length taken is 1.5 cm with diameter of vena contracta as 0.4 cm.

Case 1 – Without blockage

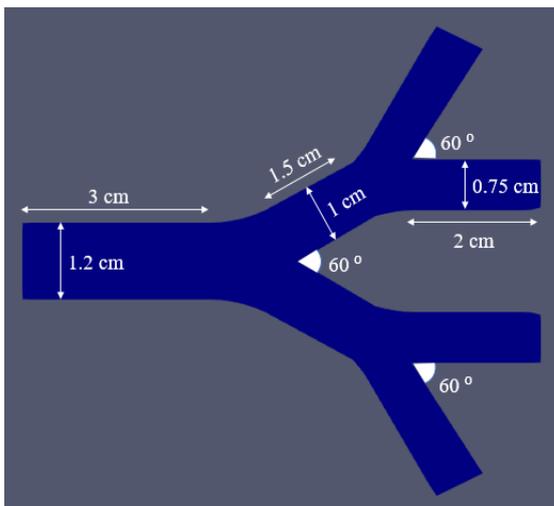
Case 2 – With blockage before first bifurcation

Case 3 – With blockage after first bifurcation in the upper daughter tube.

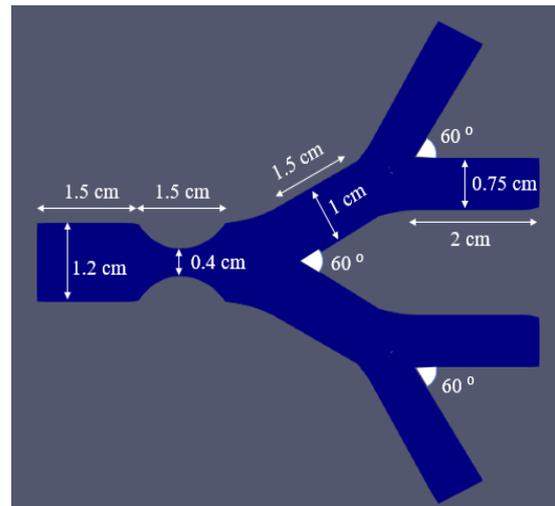
Basic Diagram

Detailed description of geometry for each of the cases is shown below:

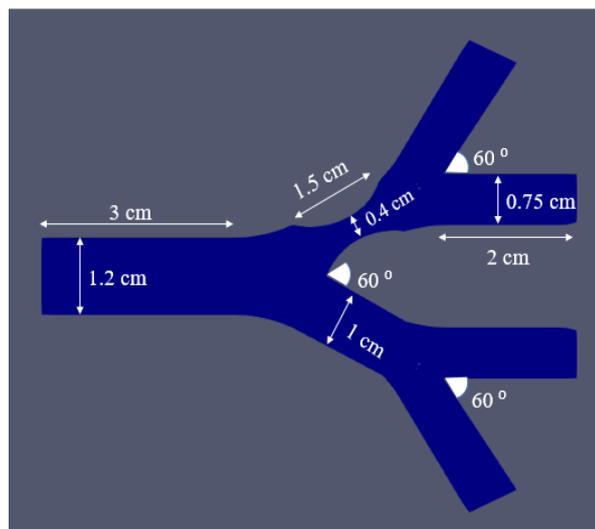
Case - 1



Case - 2



Case-3



Flow and fluid properties of air are shown below:

Fluid	Kinematic viscosity	Re	Inlet velocity
Air	0.00001654 m ² /s	500	U = 0.689 m/s