

ANALYSIS ON THE FLOW AND PRESSURE DISTRIBUTION FOR ACTUAL
STENOSIS IN TRACHEA

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*Sincerely dedicated to Abah, Mama, my fiancée, family members and friends;
My all times beloved.*

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ABSTRACT

Knowledge of flow inside the human airway is very important for medical practitioner to make accurate diagnosis. With the presence stenosis inside the airway, the flow will be changed significantly and will directly affect the input to the main bronchi. In this study, patient-specific image is used and remodelled using computational fluid dynamic software to simulate the flow within the trachea. The image contains one stenosis which was then reconstructed to other locations. This procedure will enable the study of flow behaviour in the trachea with different stenosis locations. Emphasis of analysis is focused on the flow and pressure distribution along the main airway. For each model, computations were carried out in three different flow rates which are 15 l/min, 60 l/min and 100 l/min corresponding to regular human activity which are resting, normal and heavy exercise breathing, respectively. The results show as stenosis located at the upper third of the trachea, the pressure drop along the trachea are insignificant in every breathing condition but differ to the velocity where the maximum velocity is increase as the flow rate increase. For stenosis located at the lower third of the trachea, both pressure drop and velocity did effect clearly as the flow rate increase. The effect of different location of the stenosis on the velocity distribution along the centerline shows similar increment in every flow rate and the risk in breathing difficulties if the patient having a stenosis at the third location is three times higher compare to the first location if the patient in resting condition. It increases to five times higher when doing the regular activity and eight times higher if the patient doing heavy exercise. The comparison is based on the same size of the stenosis.

ABSTRAK

Pengetahuan berkaitan dengan aliran udara di dalam ruang penafasan manusia adalah amat penting bagi kumpulan perubatan dalam membuat rawatan dan keputusan yang tepat. Stenosis dalam trakea memberi kesan besar terhadap pembahagian input ke bahagian utama bronkus. Dalam kajian ini, imej geometri yang spesifik dari pesakit yang mengalami stenosis digunakan untuk dijadikan model dan dengan menggunakan perisian perkomputeran bendalir dinamik, simulasi aliran udara sepanjang trakea dijalankan. Imej stenosis tersebut kemudiannya di struktur semula ke lokasi-lokasi yang berbeza untuk mengkaji kesan kedudukan lokasi stenosis terhadap sifat-sifat aliran di dalam trakea. Kajian ini tertumpu kepada taburan aliran dan juga tekanan sepanjang ruang utama pernafasan manusia. Simulasi di jalankan dengan menggunakan tiga kadar aliran yang berbeza iaitu 15 l/min, 60 l/min dan juga 100 l/min. yang mewakili aktiviti harian manusia: keadaan rehat, normal dan juga ketika melakukan senaman berat. Hasil daripada kajian menunjukkan sekiranya stenosis berada di bahagian atas trakea, perubahan tekanan sepanjang trakea mengalami perubahan yang kecil bagi setiap kondisi pernafasan tetapi kelajuan maksimum aliran meningkat sekiranya kadar aliran input meningkat. Bagi stenosis di bahagian bawah trakea, peningkatan kadar aliran menunjukkan efek yang ketara ke atas perubahan tekanan dan juga halaju aliran. tetapi bagi taburan halaju sepanjang trachea, ianya memberikan paten yang hampir sama bagi setiap kedudukan stenosis. Akhir sekali, risiko dalam mengalami kesukaran bernafas adalah tiga kali lebih tinggi bagi pesakit yang mengalami stenosis di bahagian bawah berbanding atas jika pesakit dalam keadaan rehat, lima kali lebih berisiko dalam keadaan normal dan lapan kali lebih berisiko sekiranya melakukan senaman berat.

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LIST OF SYMBOLS**SYMBOLS**

A	area
C	velocity of sound
E	total energy
g	local acceleration of gravity
L	length
Re	Reynolds number
Q	volume flow rate
U	mean velocity
D	diameter
ρ	density

ν	kinematic viscosity
P	pressure
P_0	stagnation pressure
μ	viscosity
V	velocity
V_0	stagnation velocity
l	liter
min	minute

CHAPTER 1

INTRODUCTION

1.0 Overview

The flow in the bifurcating lung airway is one of the most basic and revealing problems in the general case of the breathing physiology. It influence drug particle delivery patterns, pollution dispersion and so on that related to respiration system. These days, the flow inside the human airways is gaining attraction to the researchers to choose as a subject of study either doing by experimental or numerical method. In fact, human airways flow studies have been carried out by many researchers previously to provide the solution especially for breathing problems.

Due to the advanced development in the computational capability and computerized tomography (CT-scan), it offers an alternative to study a physically realistic model for the human airways. Basically, human anatomy and the respiration process are converted into simulation to understand its behaviour in the airway flow. However, knowledge of the airflow mechanism within the airways is the first thing that

needs to take into account before proceed the study. This is where the CFD tools were come as the handy tools where the characteristic and the condition that happen inside the human airways can be simulate and presented.

The airways networks has quite small dimension and it is difficult to retain dynamic similarity to the physical model. Therefore, most of the studies were limited up to third generations. But the most crucial part that needs to be considered is the main trachea where it plays as a main vessel for the air to reach the lung in respiration process. If happen any obstruction in this area, it can lead to problems in breathing compared to if the obstruction happens in one of the airways networks (right or left side) since human still can survive if one side of the network is blocked.

In this study, the actual model of the trachea diseases patients will be used to obtain the flow characteristic inside the human lung. The result then not only can aid the medical team by providing the solution for treatment but also can initiate to the new technology for medical instruments.

1.2 Objectives

The objective of the study is to determine the effect of stenosis in different locations in trachea to the flow and pressure distribution.

1.3 Scope

- a) Actual image will be used
- b) Numerical modeling will be use for analysis
- c) Effect of the stenosis location will be considered