Department of Electronic and Telecommunications Engineering

BM2012 Modelling and Analysis of Physiological Systems

Assignment1

Simulation of Respiratory Mechanics

Kavishan G. T. 210285M

Contents

1 Introduction

Respiratory system is the most important part of our body which is responsible for moving air to and from the gas exchange surface in body.So there are two zones like conduction zone and respiratory zone. Conduction zone responsible to warm, humidify, filter and clean the air entering the body and respiratory zone is responsible to exchange the gas between air and blood.Usually the effect of airways are caused for the resistant of respiratory system. They are two types as central airways and peripheral airways.Sometimes these resistance can be increased by reducing airway diameters.This is called by Obstructive Pulmonary Diseases.Compliance of lungs is the lungs capacity which can expand under the pressure.Sometimes this can be decreased by reducing total lung capacity.This is called as Restrictive Pulmonary Diseases.

Ventilator settings

Breathing frequency - Number of breathes taken in minute. Normal = 15 bpm
PEEP - Positive End-Expiratory Pressure Peak pressure: Maximum pressure reached during inhalation in mechanical ventilation.

2 Normal Ventilation

These are some approximate values for the parameters for linear model respiratory system.

1. Resistivity of central airways(Rc) = 1 cm H_2O /L/s
2. Resistivity of peripheral airways(Rp) = 0.5 cm H_2O /L/s
3. Compliance of lungs and chest wall(Cl and Cw) = 0.2L/cmH_2O
4. Shunt compliance = 0.005L/cmH_2O

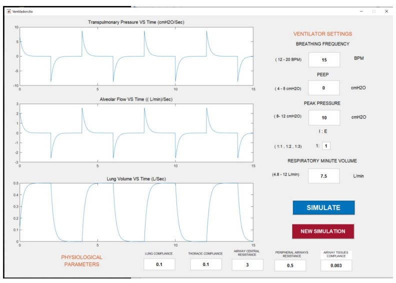

Figure 1: Normal

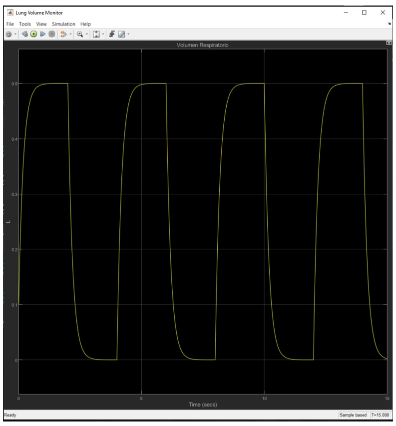

Figure 2: normal lung volume

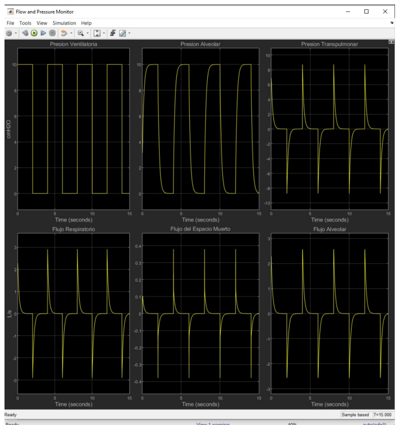

Figure 3: normal physiological parameters

3 Obstructive Pulmonary Diseases

Obstructive Pulmonary Diseases can be affect when the resistivity of airways is increased. It will be happened when airways diameters are reduced.Asthma, Bronchitis,emphysema are examples for this type.

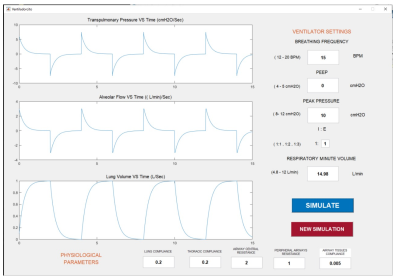

Figure 4: Obstructive

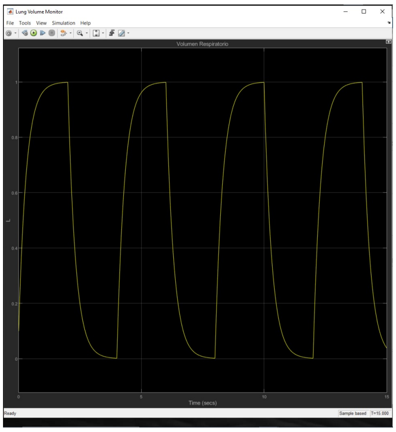

Figure 5: Obstructive lung volume

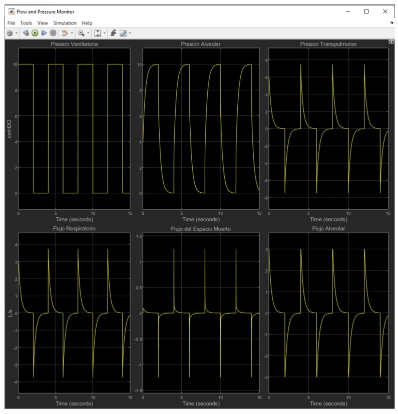

Figure 6: Obstructive physiological parameters

4 Restrictive Pulmonary Diseases

Restrictive Pulmonary Diseases can be affect when the compliance of pulmonary system is decreased.This can be happened when total lung capacity is reduced.Mesothelioma,cancer and fibrosis are some example for this.

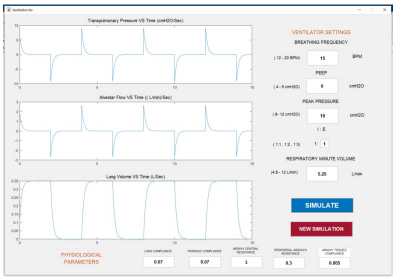

Figure 7: Restrictive

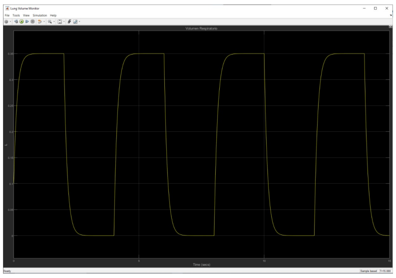

Figure 8: Restrictive lung volume

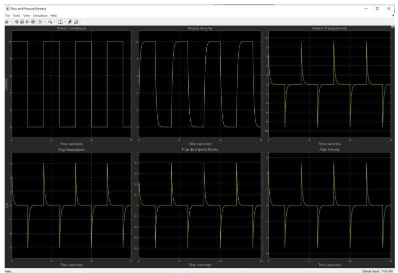

Figure 9: Restrictive physiological parameters

5 Compare physical parameters

5.1 Total Lung Volume

We can identify the total lung volume has been decreased in Restrictive diseases. Lungs can't expand usually in this type. But resistivity of airways didn't affect for the lung volume.

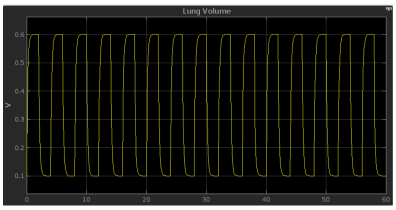

Figure 10: Normal

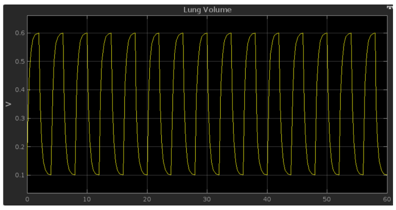

Figure 11: Obstructive

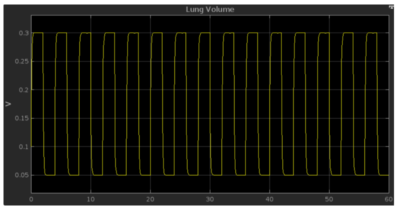

Figure 12: Restrictive

5.2 Respiratory Flow

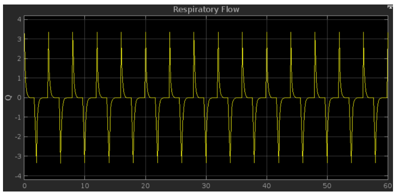

Figure 13: Normal

Figure 14: Obstructive

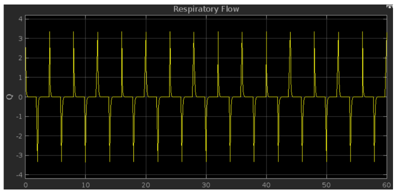

Figure 15: Restrictive

Resistivity of central and peripheral airways are increased at obstructive pulmonary diseases.This is caused to reduced the respiratory air flow which move across the central airway.But this reason is not affected for restrictive diseases.

5.3 Alveolar Pressure

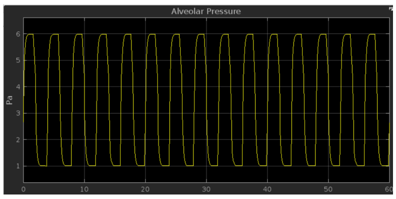

Figure 16: Normal

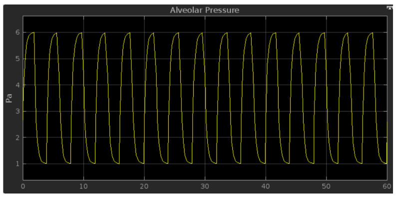

Figure 17: Obstructive

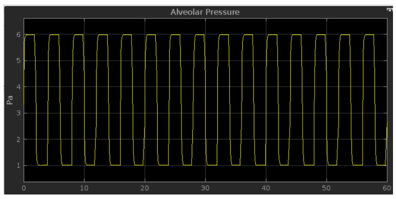

Figure 18: Restrictive

Considering restrictive and normal alveolar pressure there are no any difference but considering about obstructive diseases the increased resistance can cause a steep drop in alveolar pressure during forced expiration, leading to airway collapse.

5.4 Dead Space Flow

Dead space is the portion of each breath that does not participate in gas exchange. It's often referred to as "wasted ventilation" because the inhaled air is not involved in the exchange of oxygen and carbon dioxide.In obstructive diseases we can see an increase in dead space ventilation, as the ventilation-perfusion ratio (V/Q) becomes mismatched. It will be happened because peripheral resistivity is increased in this diseases.

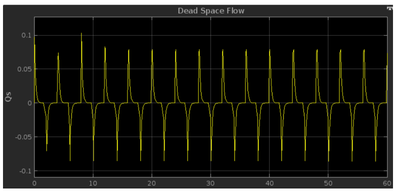

Figure 19: Normal

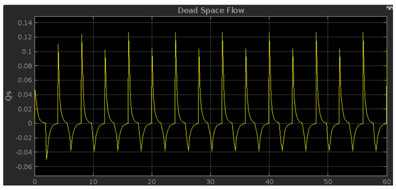

Figure 20: Obstructive

Figure 21: Restrictive

5.5 Trans pulmonary Pressure

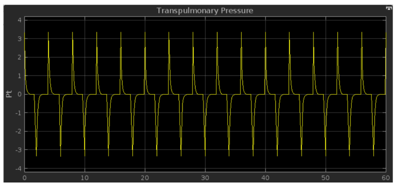

Figure 22: Normal

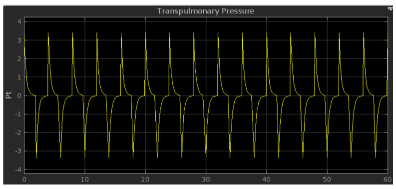

Figure 23: Obstructive

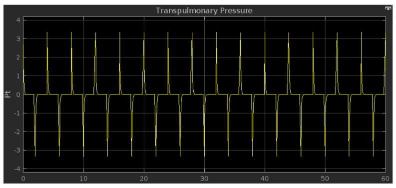

Figure 24: Restrictive

Trans pulmonary pressure (TPP) is the net distending pressure applied to the lung. It's the difference between the alveolar pressure (Palv) and the pleural pressure (Ppl); i.e., TPP = Palv – Ppl. So there is no changes among these diseases about trans pulmonary pressure.

5.6 Alveolar Flow

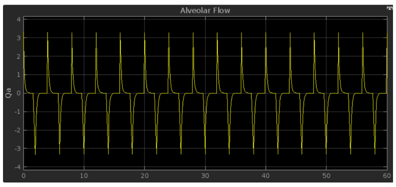

Figure 25: Normal

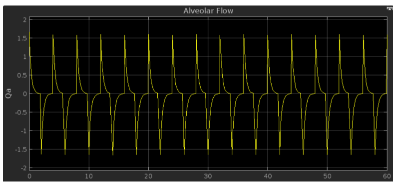

Figure 26: Obstructive

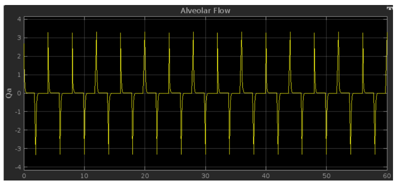

Figure 27: Restrictive

Air flow moves through alveoli is called as alveolar flow. So in obstructive pulmonary diseases this can be reduced because the resistance is increased the airways.That mean total air flow is reduced. Because this reason concentration of oxygen which moves to the blood can be reduced.So ventilation can be so fast(asthma).

5.7 Difference in minute ventilation

Minute Ventilation = Tidal Volume * Respiratory Rate

Now we compare the values we get

1. Normal - 7.5 L/min - ideal

2. Obstructive diseases - 14.98 L/min - High
3. Restrictive diseases - 5.25 L/min - Low

We can identify the minute ventilation has been decreased in Restrictive diseases. Lungs can't expand usually in this type. But minute ventilation is increased in obstructive diseases.

6 References

https://en.wikipedia.org/wiki/Minute$_{v}$*entilation*