Adjustment of respiratory mechanicals parameters in emphysema and asthma during pressure controlled ventilation

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Abstract: **The pathophysiology of asthma and emphysema are quite different. Asthma is an inflammatory process leading to reversible endoluminal obstructive ventilatory deficit due to increased resistance into the airways, the other functional parameters (CO transfer capacity, gasometry, pulmonary compliance) as well as chest x-rays are normal in steady state. While the emphysema corresponds to a destruction of the pulmonary parenchyma beyond the terminal bronchioles, parenchymal destruction is responsible for an increase in lung compliance which results in irreversible extrinsic bronchial obstruction, as a consequence the transfer capacity of the CO is lowered, and the gasometry can be disturbed (hypoxemia initially, then possibly hypercapnia), following bronchial obstruction, a chronic distention appears, defined by a permanent elevation of CRF, VR, and VR / CPT ratio. In this work, we will study the effect of these two pathologies related to the respiratory mechanics by a simple lung simulator. The principle is to vary the respiratory resistance and compliance according to the pathologies stated above, in order to propose the best adjustments which depends on the state of the respiratory system, this adjustment is made on the mechanical parameters of the ventilators so as to provide the adequate ventilation.**

Keywords: **Electrical model. Asthma. Pulmonary emphysema.**

I. INTRODUCTION

Mechanical ventilation is a medical treatment which is used to assist or replace spontaneous breathing [1].This may involve a ventilator; the breathing may be assisted by an anesthesiologist. As continuous mandatory ventilation (CMV) is a mode of mechanical ventilation in which breaths are delivered based on set variables such as the flow or mouth pressure [2]. In our study we will evaluate the behavior of the respiratory system during pressure controlled mode in normal and pathological state of physiological parameters. Mathematical models (MM) of the respiratory system [3] plays an actual important role in developing and correcting ventilators work that supports breathing during patient's treatment [4,5].

The mean objective of this paper is to study the effect of these two pathologies related to the respiratory system by a simple lung simulator. The purpose is to vary the respiratory resistance and compliance according to the pathologies stated above, in order to propose the good adjustments which depends on the state of the respiratory system, this adjustment is made on the mechanical parameters related to the ventilators so as to provide the adequate ventilation. This paper consists of two sections and a conclusion. The first section describes the detailed process of modeling PCV signal and a subject's respiratory system in normal and pathological state, followed by a simulation process. The second section presents the results through illustration of tidal volume and airflow curves after a variety of respiratory resistance and compliance, followed by the interpretation. The conclusion provides the ideas for future work.

II. THEORETICAL OVERVIEW

A. The pressure controlled ventilation model

The pressure controlled ventilation is characterized by signals shown in Figure 1 and 2, the curve of pressure explains the setting variables in PCV device such as:

- Inspiratory pressure (IP),
- Inspiratory time (T_{in}),
- Expiratory time (T_{ex}).
- Constant time of ventilator (τ).

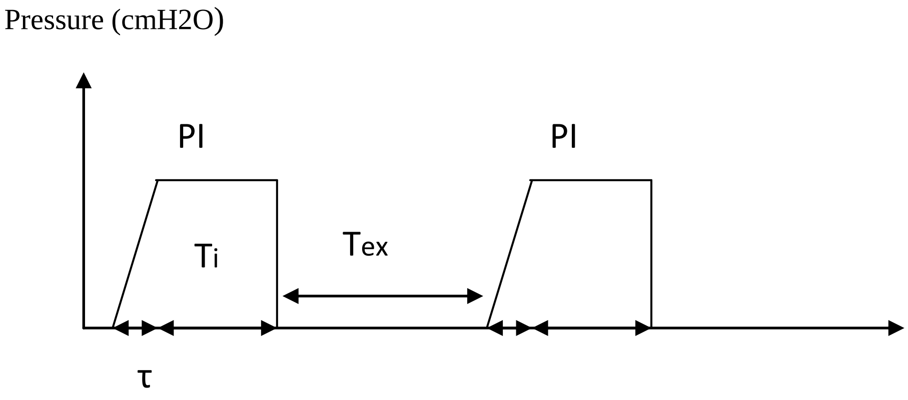

Fig 1: Typical waveform of pressure support for PCV .

The parameters values which are setting in this work are [6]:

- IP = 25 cmH_2O.
- τ = = 0.2s.
- T_{in} =1s, T_{ex}=2s.

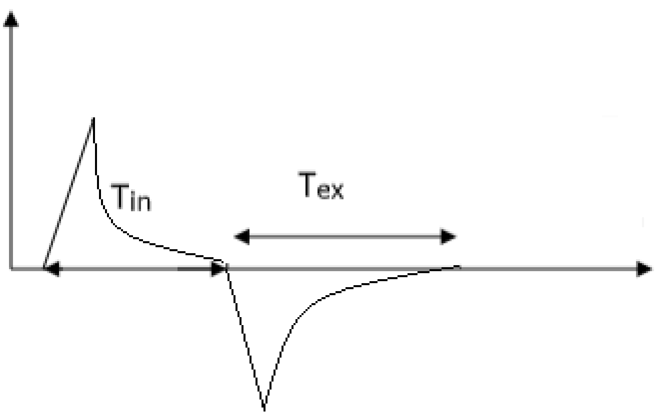

Fig 2: Typical waveform of air flow measurement

B. **Normal and pathological values of the respiratory resistances and compliance**

As mentioned above, respiratory mechanics undergo changes in the case of pathology, so this table Tab.1 [7] presents the respiratory pathologies and its linked physiological parameters

Table 1: the respiratory pathologies

	Rrs (CmH2O/l/second)	Crs (l /CmH2O)
Asthma	4	0.1
Emphysema	2	0.2

III. RESULTS

The obtained curves, seen in Fig.4, Fig. 5, demonstrate the change in behavior of the respiratory system simulated during tree complete respiratory cycle. The shown duration equals approximately 4 seconds. 0.5 second for inspiration, whereas 1.5 seconds for expiration. The airflow and tidal volume values were measured at four times, and we will find that, as the increasing of Rrs due to asthma, the values of the two physiological variables decreased, while the exponential fall had increased. While the increasing of Crs caused by emphysema, leads to the increasing of the two physiological variables.

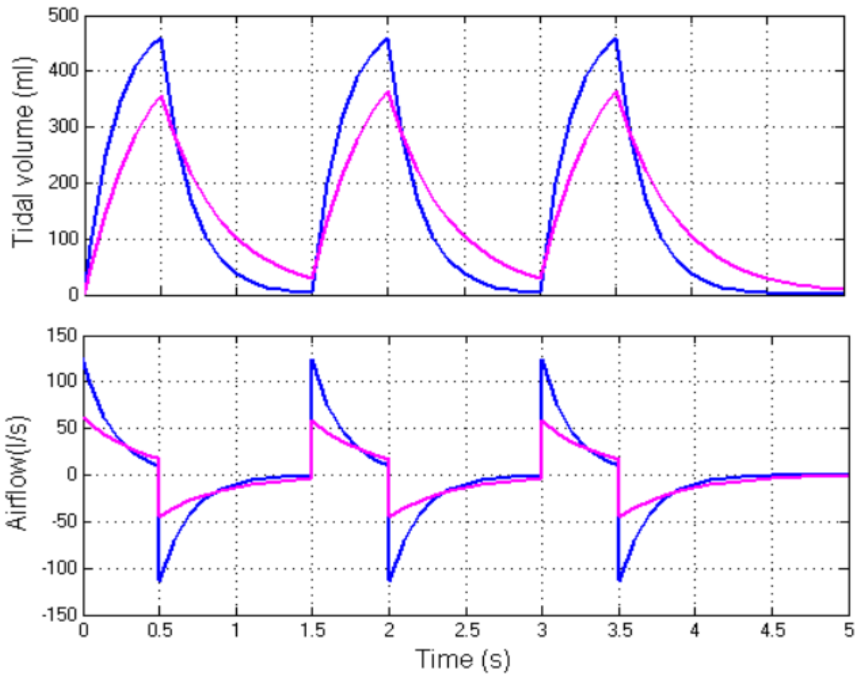

Figure 3: Waveforms of tidal volume and airflow with changing in Rrs at PEEP = 0 cmH2O and Paw = 25 cmH2O [8,9].

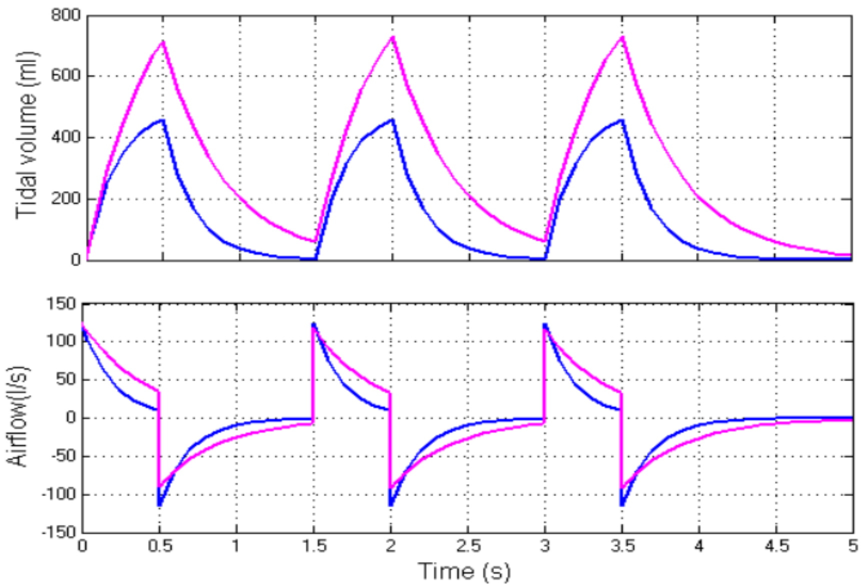

Figure 4: Waveforms of tidal volume and airflow with changing in Crs at PEEP = 0 cm H2O and Paw = 25 cmH2O [10].

IV. CONCLUSION

Due to asthma, the respiratory impedance increased, which is perfectly shown in our results, when we had changed the resistance value from 2 to 4 CmH2O/l/second into the single compartmental electrical model, model, the tidal volume and airflow slopes had decreased as a function of increasing values of Rrs, while the exponential fall was increased, wich is cause to increasing of the expiratory time. While in the emphysema, the increasing of Crs leads to the increasing of tidal volume and airflow, which is evident because there are several implications of residual functional capacity , residual volume , and total pulmonary capacity. This study will have clinical implications for adjusting the parameters of PCV in pathological conditions and to ensure about the adequate ventilation without risk of lung injury, precisely the increasing of the exponential fail at the time of expiration, due to asthma and emphysema can lead to risk of high tidal volume, during expiration, which exposes the patient to the risk of barotraumas or hyperinflamation, which directs to troubles in gas exchange at the level of the alveolocapillary such as hypoxia and hyperoxia, hypercapnia or hypocapnia, moreover the lungs can be damaged . The increasing of respiratory resistance can be reduced by the increasing of inspiratory pressure, so as to trigged the sufficient tidal volume. The anesthesiologist must be careful about the adjustment of Tex which is normally fixed at 3 Rrs.Crs or 5 Rrs.Crs, so as the expired tidal volume is about 90% or 95% of total volume. Hans to overcome the high resistance effect and to ensure the adequate expiration which respects the subject’s state, the physician must be careful about this elevation related to slops waveforms and to exponential fall and then correct the expiratory time.

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