DEPARTMENT OF ELECTRONIC AND TELECOMMUNICATION ENGINEERING

UNIVERSITY OF MORATUWA

BM2101 - Modelling and Analysis of Physiological Systems

Simulation of Respiratory Mechanics

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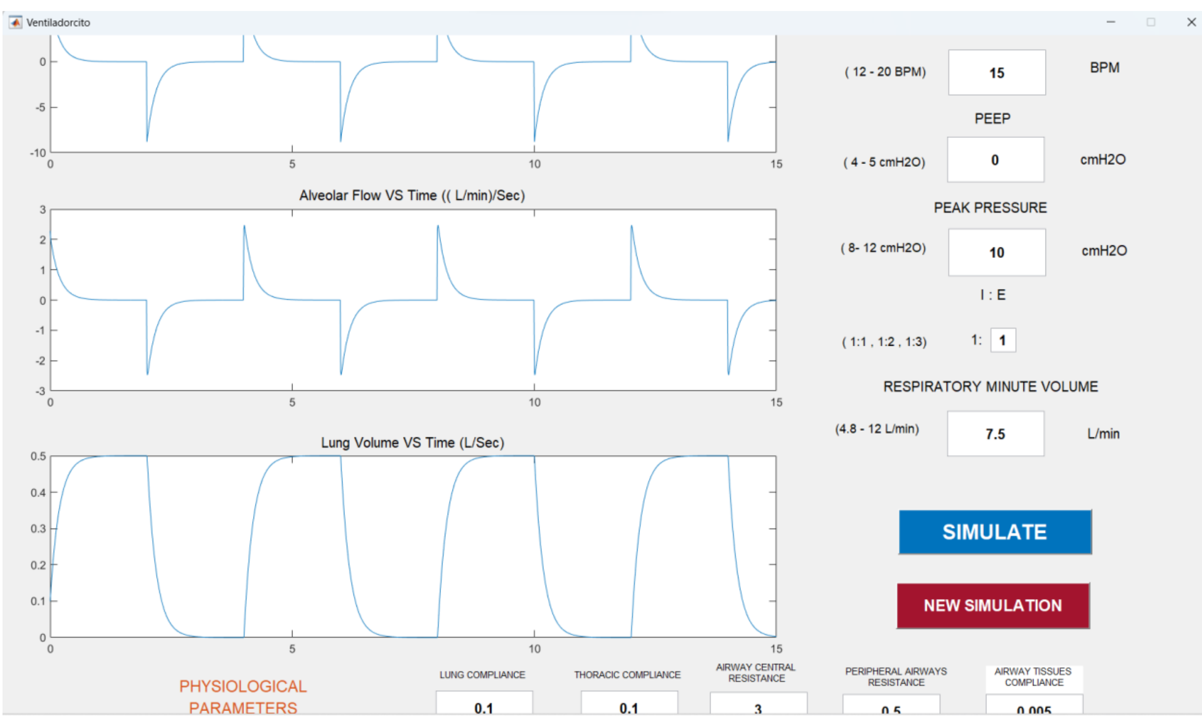
1. Normal person

These are the values for a normal person under normal conditions.

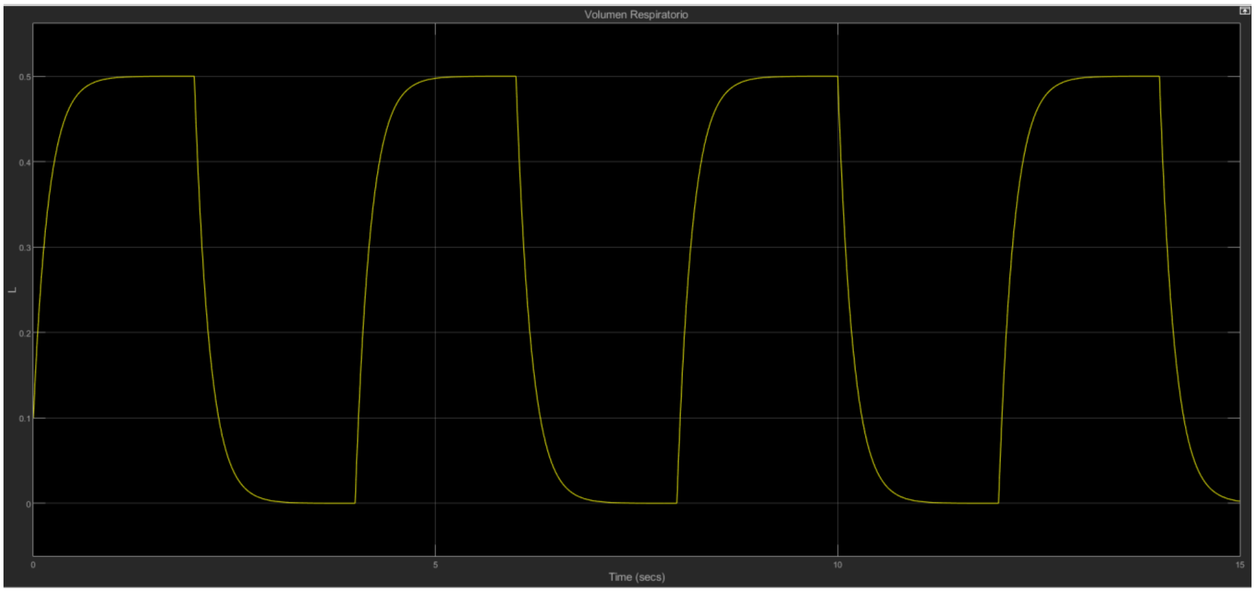
- Lung compliance = 0.1 L/cmH_2O
- Thoracic compliance = 0.1 L/cmH_2O
- Airway central resistance = 3 cmH_2O/(L/s)
- Peripheral airway resistance = 0.5 cmH_2O/(L/s)
- Airway tissue compliance = 0.005 L/cmH_2O

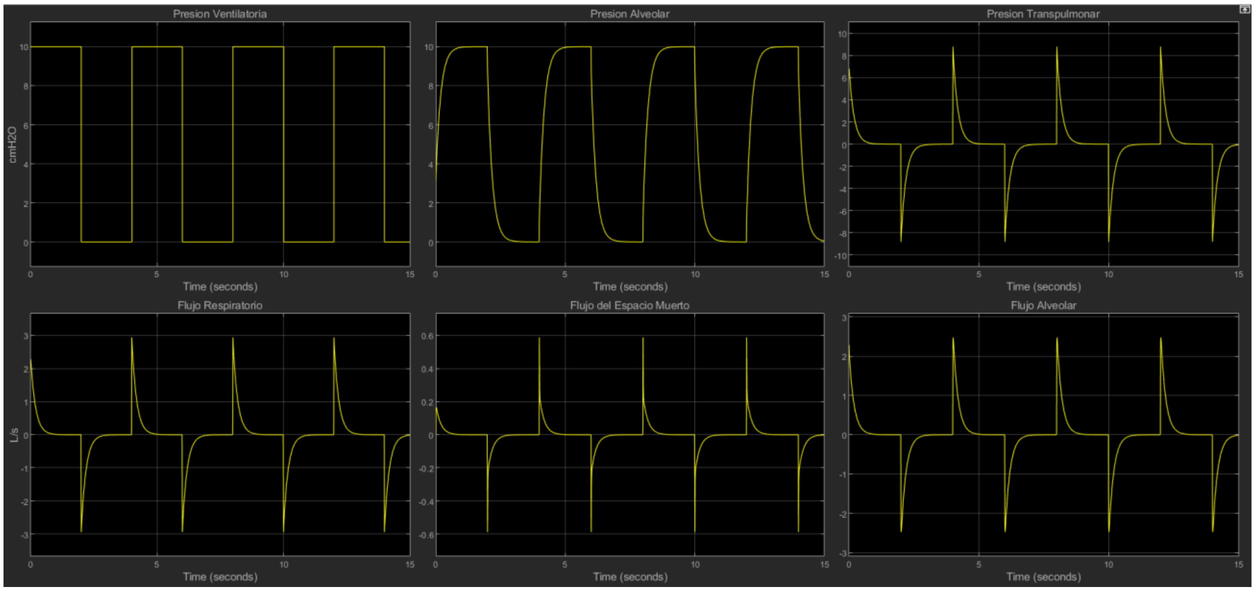
This is the results for the normal person who has connected to a ventilator under

- Breathing frequency = 15
- PEEP = 0
- Peak pressure = 10



The following graphs explain this more.





2. Restrictive pulmonary disease

In restrictive pulmonary disease, lung compliance is decreased. This means that it takes more pressure to inflate the lungs, which can lead to shortness of breath and other symptoms.

Therefore, the lung compliance and thoracic compliance both should be decreased in restrictive pulmonary disease. This would mean that it would take more pressure to inflate the lungs, which would reduce the tidal volume and minute ventilation.

Airway central resistance, peripheral airway resistance, and airway tissue compliance are not affected by restrictive pulmonary disease.

The ventilator settings also need to be adjusted in restrictive pulmonary disease. The peak pressure would need to be increased to ensure that the lungs are adequately inflated. The PEEP (positive end-expiratory pressure) would also need to be increased to help keep the alveoli open at the end of expiration.

The breathing frequency would likely need to be increased as well to ensure that the patient is receiving enough ventilation. However, it is important to be careful not to increase the breathing frequency too much.

Therefore, Let's select following values for restrictive pulmonary disease.

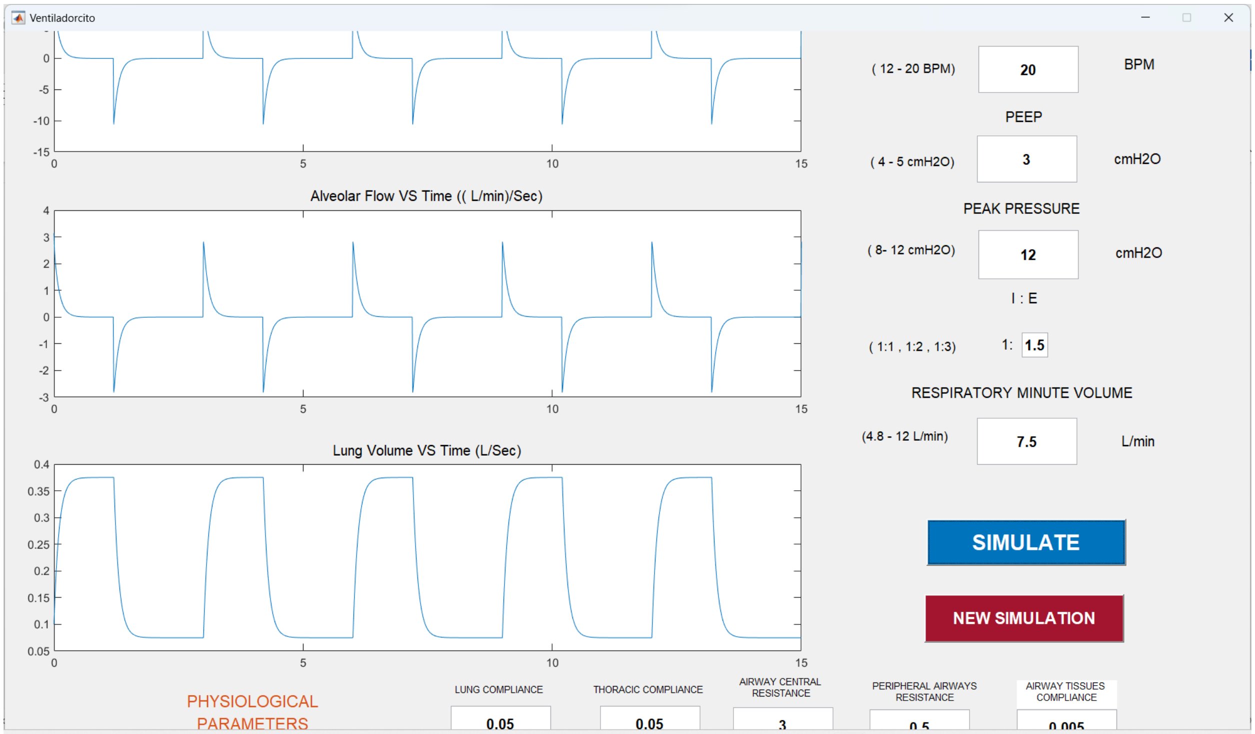
- Lung compliance = 0.05 L/cmH_2O
- Thoracic compliance = 0.05 L/cmH_2O
- Airway central resistance = 3 cmH_2O/(L/s)
- Peripheral airway resistance = 0.5 cmH_2O/(L/s)
- Airway tissue compliance = 0.005 L/cmH_2O

This is the result for this person

It shows that the respiratory minute volume has been reduced.

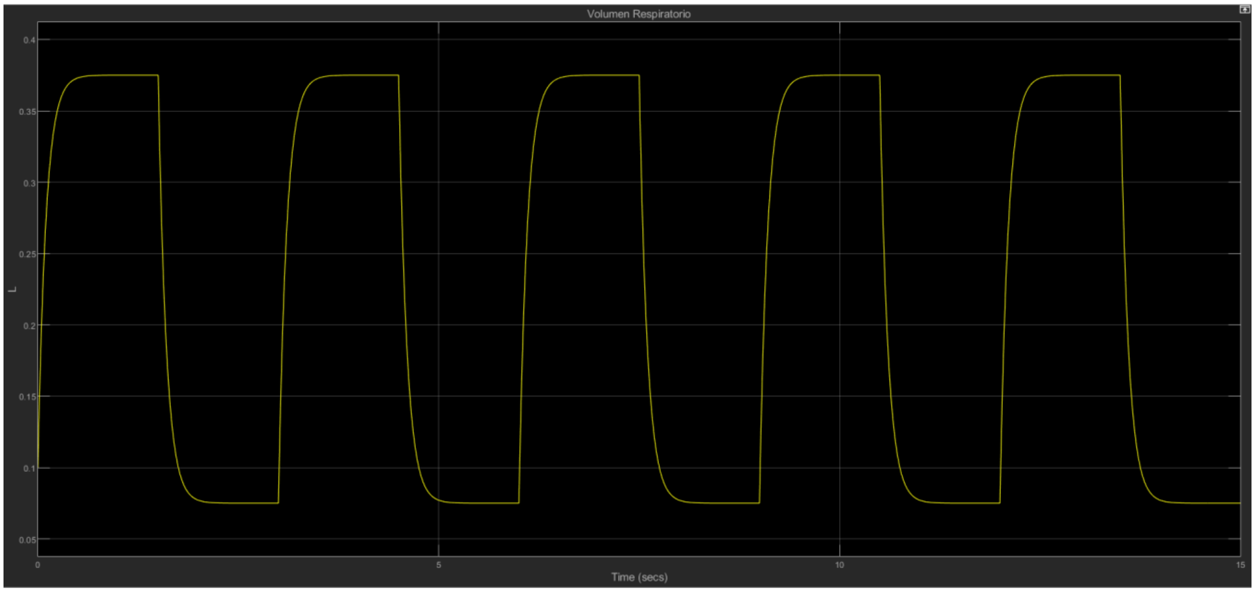
Therefore, let's adjust the ventilator settings such that,

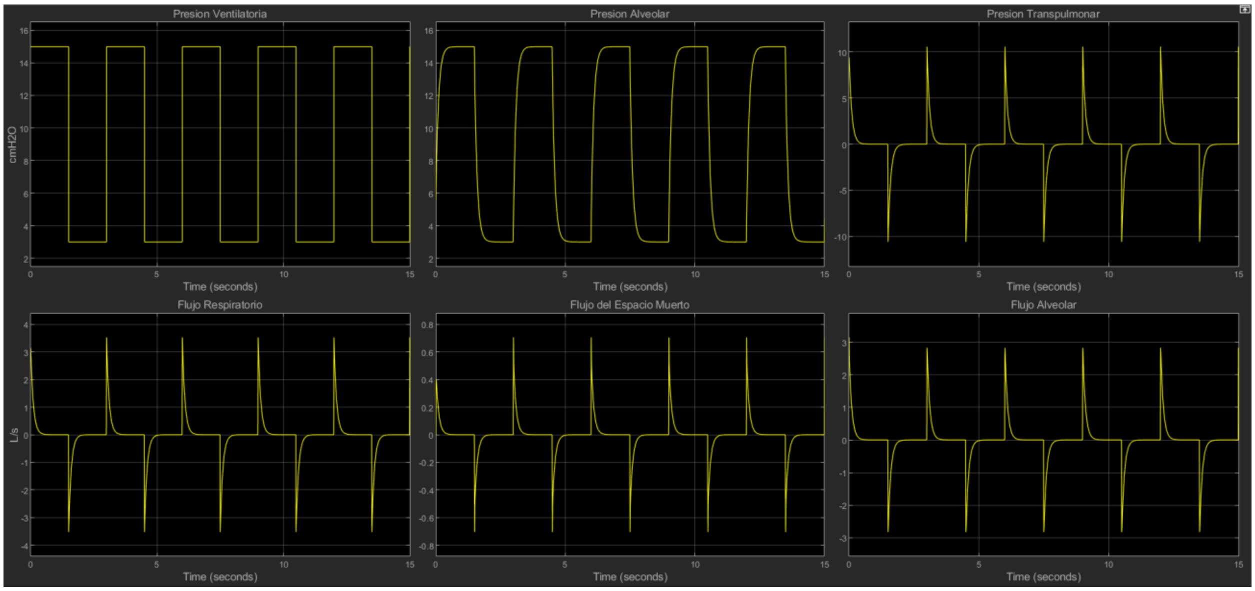
- Breathing frequency = 20
- PEEP = 3
- Peak pressure = 12
- I:E ratio = 1:1.5



Now we can see the respiratory minute volume seems to be fine for this person.

The following graphs explain this more.





3. Obstructive pulmonary disease

In obstructive pulmonary disease, the lung compliance is increased. This means that it takes less pressure to inflate the lungs, but the airways are narrowed, which makes it difficult to exhale. This can lead to shortness of breath, wheezing, and other symptoms.

The values of lung compliance and thoracic compliance would be increased. This would mean that it would take less pressure to inflate the lungs, but the airways would be narrower, which would make it difficult to exhale.

The values for airway central resistance, peripheral airway resistance, and airway tissue compliance would be affected by obstructive pulmonary disease. The airway central resistance and peripheral airway resistance would be increased, which would make it more difficult to exhale. The airway tissue compliance would be decreased, which would make the lungs more rigid and difficult to inflate.

The ventilator settings need to be adjusted in obstructive pulmonary disease. The peak pressure would need to be decreased to prevent barotrauma. The PEEP (positive end-expiratory pressure) would also need to be increased to help keep the alveoli open at the end of expiration.

The breathing frequency would likely need to be increased as well to ensure that the patient is receiving enough ventilation. However, it is important to be careful not to increase the breathing frequency too much, as this can lead to auto-PEEP.

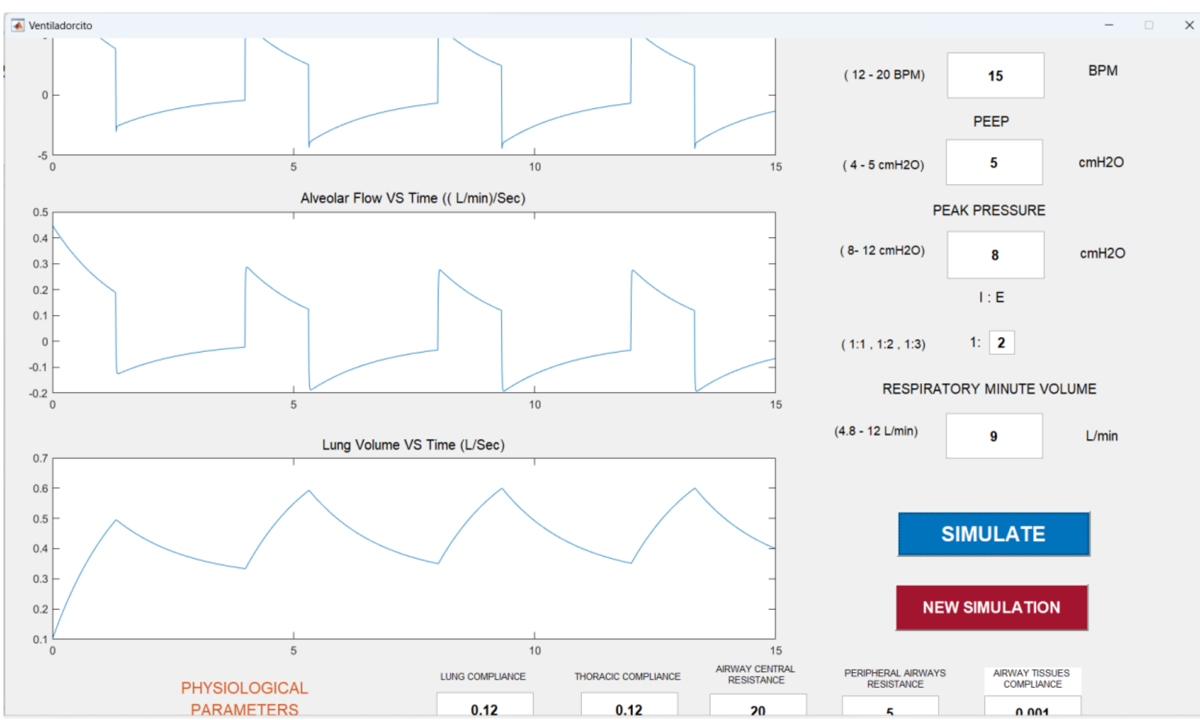
Therefore, Let's select following values for restrictive pulmonary disease.

- Lung compliance = 0.12 L/cmH_2O
- Thoracic compliance = 0.12 L/cmH_2O
- Airway central resistance = 20 cmH_2O/(L/s)
- Peripheral airway resistance = 5 cmH_2O/(L/s)
- Airway tissue compliance = 0.001 L/cmH_2O

And also let's adjust the ventilator settings as follows

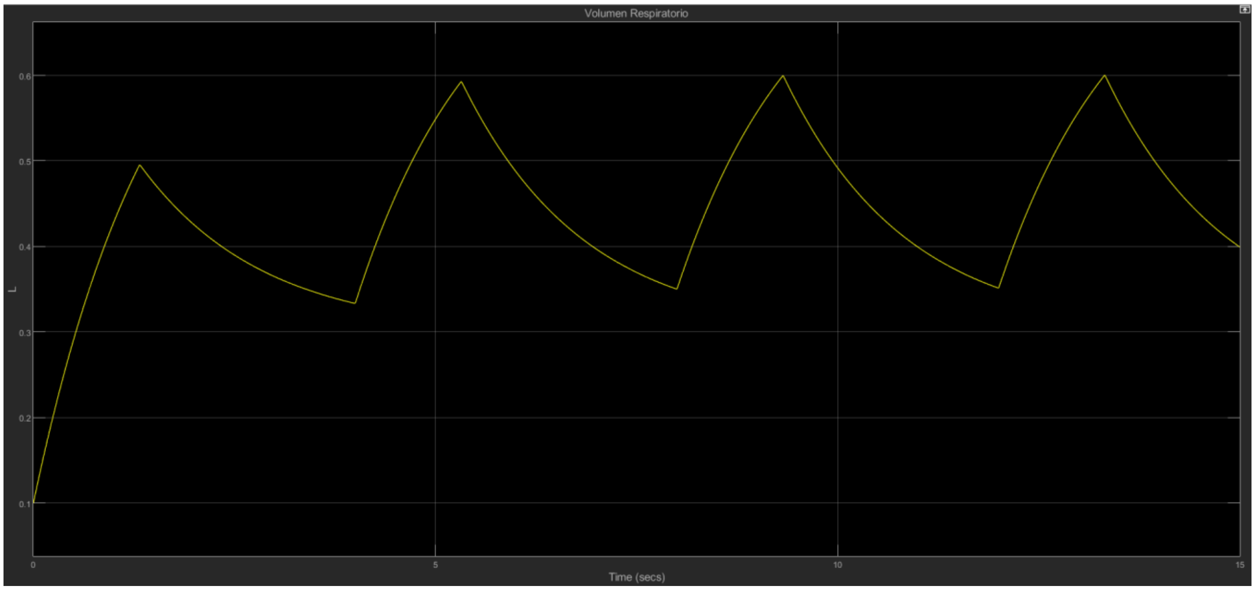
- Breathing frequency = 15
- PEEP = 5
- Peak pressure = 8
- I:E ratio = 1:2

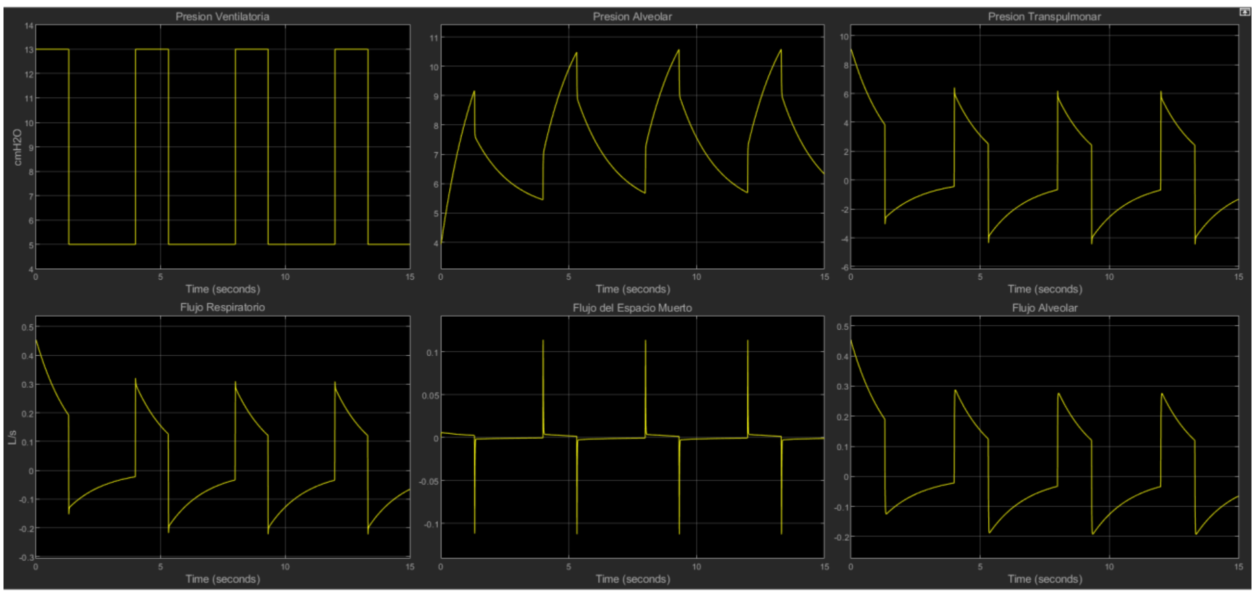
This is the result.



Here we can see, by using the ventilator, the patient is having enough respiratory minute volume.

These are the graphs for more explanation.





Differences in minute ventilation for the same setting of the ventilator

Minute ventilation (MV) is the volume of air that enters the lungs per minute. It is calculated as the product of respiratory rate (RR) and tidal volume (VT).

The same setting of the ventilator can result in different MVs for several reasons, including:

- **The patient's underlying condition:** Patients with different underlying conditions may have different respiratory rates and tidal volumes, even if they are on the same ventilator settings. For example, a patient with pneumonia may have a higher respiratory rate than a patient with asthma.
- **The patient's size:** Larger patients have larger lungs and therefore have a higher MV than smaller patients.
- **The ventilator's settings:** Even if the ventilator is set to the same settings, different ventilator models may have different MVs. This is because different ventilators may have different algorithms for calculating MV.
- **The patient's effort:** Patients who are actively breathing will have a higher MV than patients who are not actively breathing.

It is important to monitor MV in patients who are on ventilators to ensure that they are receiving the appropriate amount of ventilation. If MV is too low, the patient may not be getting enough oxygen. If MV is too high, the patient may be at risk of barotrauma, which is a lung injury that can be caused by excessive pressure.

Examples of how the same setting of the ventilator can result in different MVs:

- A patient with pneumonia may have a respiratory rate of 20 breaths per minute and a tidal volume of 500 mL. This would give them an MV of 10,000 mL per minute.
- A patient with asthma may have a respiratory rate of 15 breaths per minute and a tidal volume of 300 mL. This would give them an MV of 4500 mL per minute.
- A larger patient may have a respiratory rate of 18 breaths per minute and a tidal volume of 600 mL. This would give them an MV of 10,800 mL per minute.