Introduction to Basic Waveforms

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Flight Medical

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Flight 60 - State-of-the-Art ∿ Intuitive ∿ Independent

Goal of this presentation:

•To provide an introduction ventilator waveform analysis.

• Identify and detect patient asynchrony.

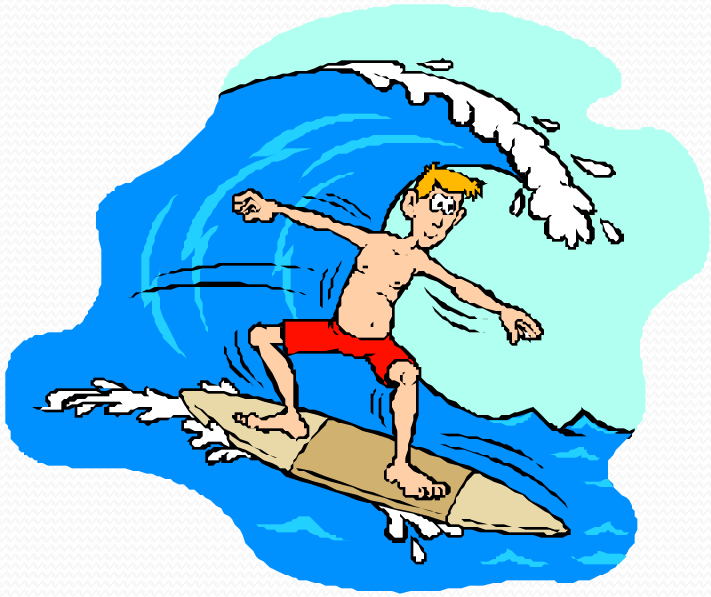
•Allow users to interpret, evaluate, and troubleshoot the ventilator and the patient's response to the ventilator.

A skilled Respiratory Therapist should use ventilator waveforms and graphics to assess the status of the patient's lungs . It's the same way a Cardiologist or a Nurse uses an **EKG** to view the condition of the heart

This is especially important for respiratory therapists to help make appropriate recommendations and have synchrony for their patients on mechanical ventilation.

There are 3 types of waveforms

- Pressure verses Time
- Flow verses Time
- Volume verses Time

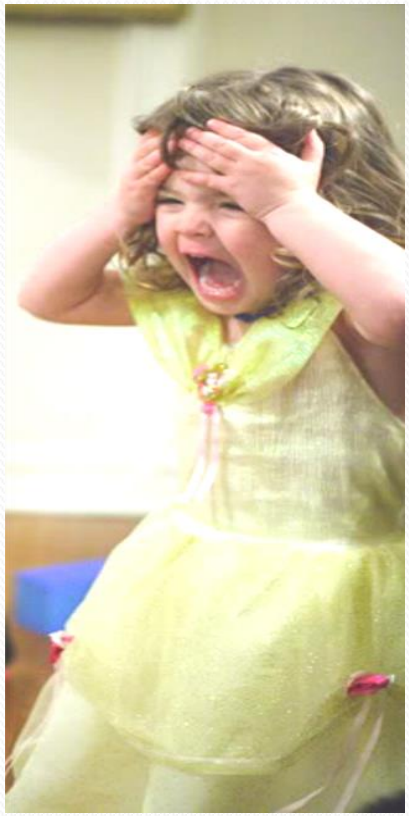


There are 2 types of Loops

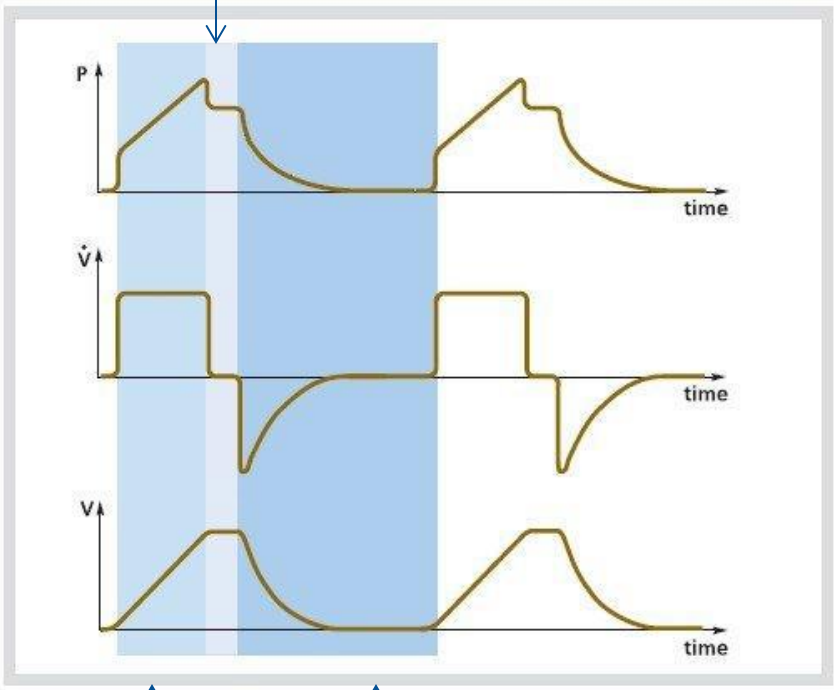
- Flow / Volume loops
- Volume / Pressure loops

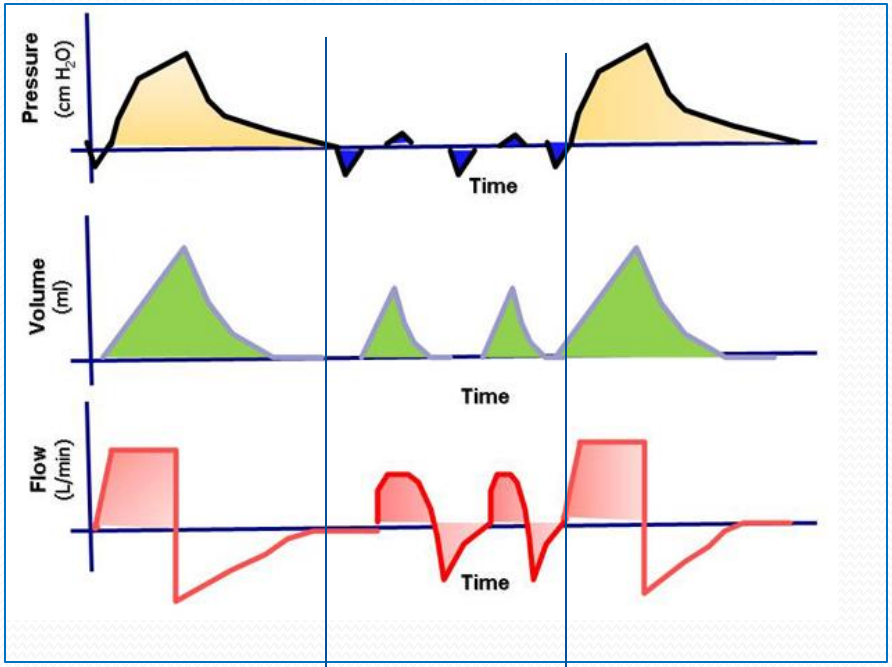
Dividing a mechanical breath into the following 4 components helps to better identify and correct asynchronies:

- Trigger Phase
- Inspiratory Phase
- Expiratory Phase
- Cycle Phase



Inspiratory Pause





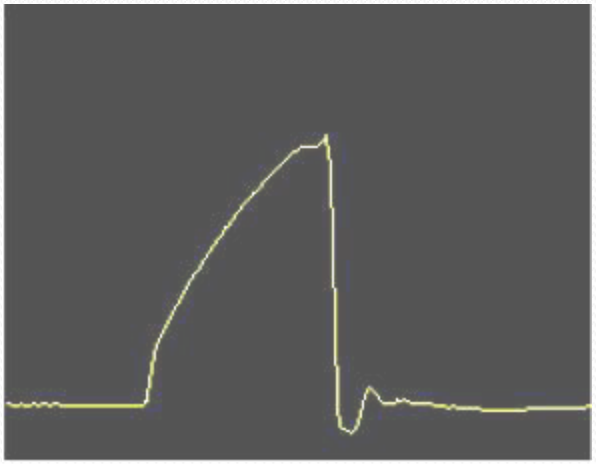
Inspiratory Phase

Expiratory Phase

Patient triggers

Pressure Waveform

- In Volume modes, the shape of the pressure wave will be a ramp for mandatory breaths.

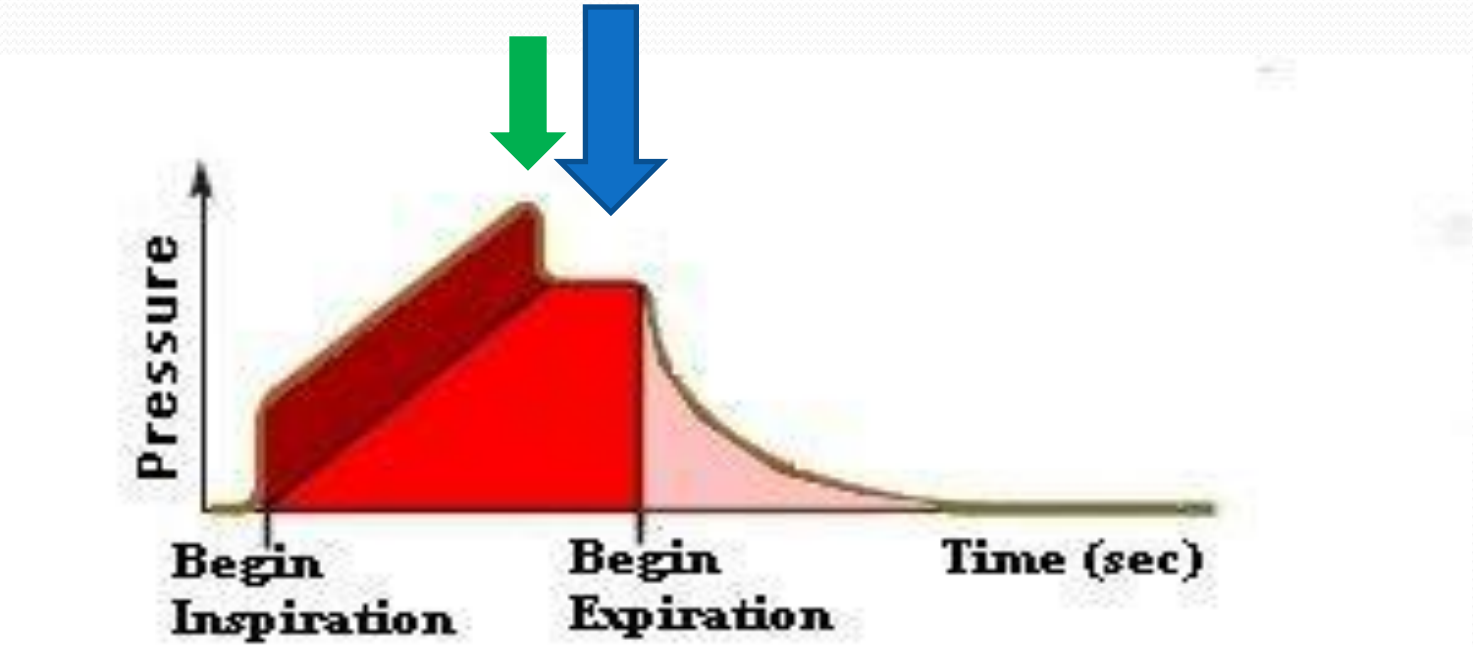


- In Pressure modes, the shape of the pressure wave will be a square shape. Indicating that pressure is constant during inspiration or pressure is a set parameter.

Pressure Waveforms can be used to assess:

- Air trapping (auto-PEEP)
- Airway Obstruction
- Bronchodilator Response
- Respiratory Mechanics (C/Raw)
- Active Exhalation
- Breath Type (Pressure vs. Volume)
- PIP, Pplat
- CPAP, PEEP
- Asynchrony
- Triggering Effort

Pressure Waveform



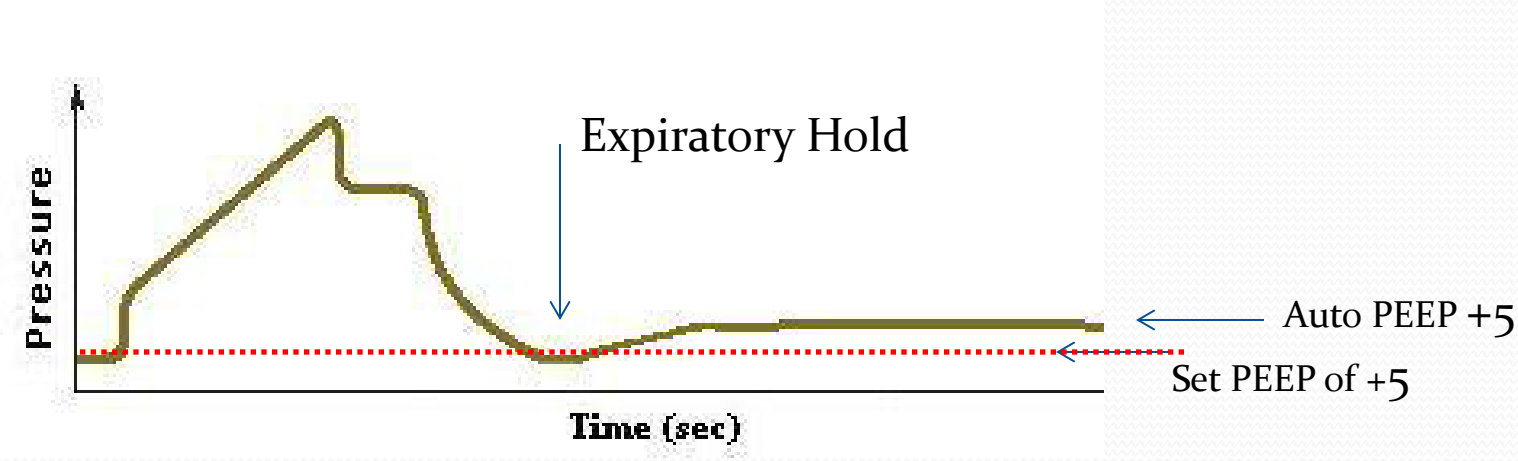
Peak Inspiratory Pressure (PIP)
Plateau Pressure (Pplat)
Airway Resistance (Raw)
Alveolar Distending Pressure

Pressure Waveform

- The baseline for the pressure waveform will be higher, when PEEP is added.
- There will be **a negative deflection just before the waveform with patient triggered breaths.**

Pressure Waveform

Air-Trapping (Auto-PEEP)

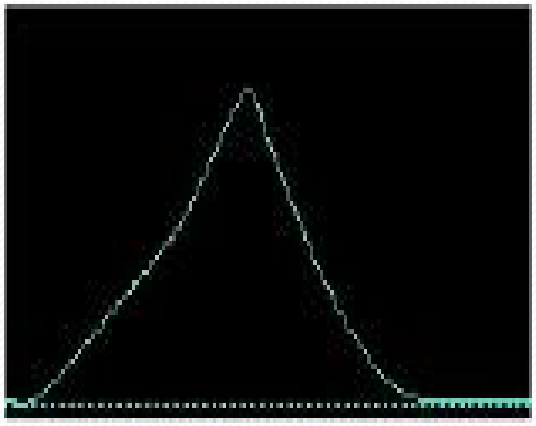


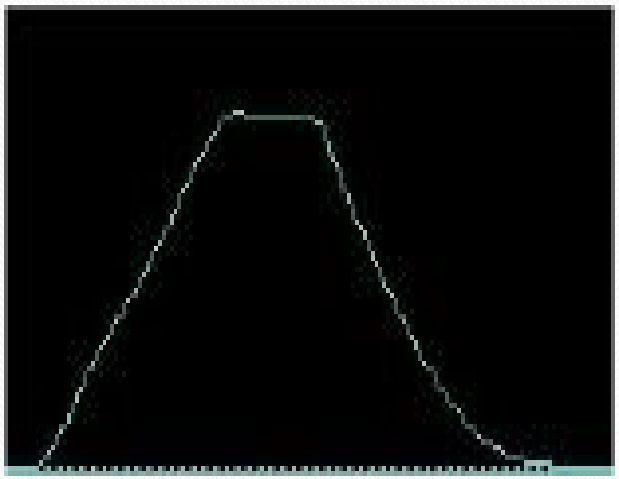
Total PEEP of +10

- While performing an expiratory hold maneuver, trapped air will cause the waveform to rise above the baseline.
- An acceptable amount of auto-PEEP should be < 5cm H_2O

Volume Waveform

- **The Volume waveform will generally have a "mountain peak" appearance at the top. It may also have a plateau, or "flattened" area at the peak of the waveform.**

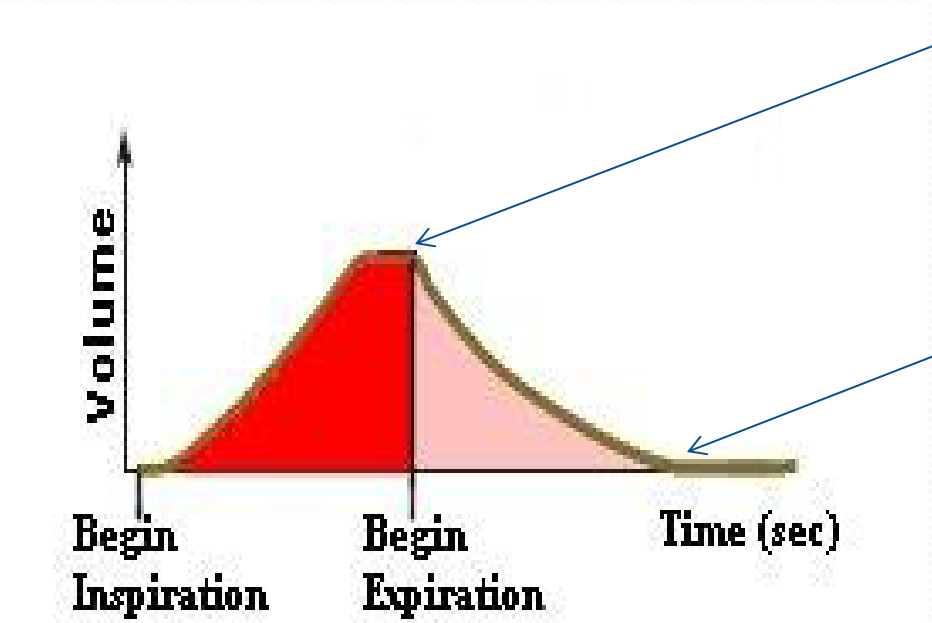




Can be used to assess:

- Air trapping (auto-PEEP)
- Leaks
- Tidal Volume
- Active Exhalation
- Asynchrony

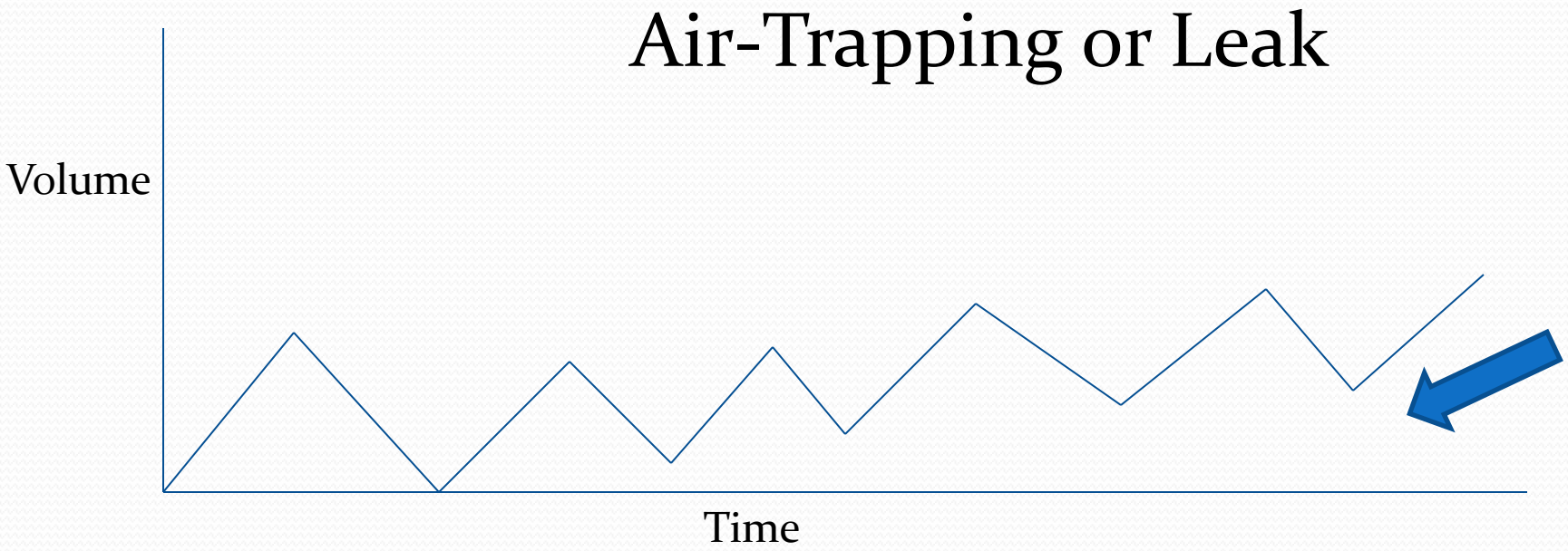
Volume Waveform



Inspiratory Tidal Volume

Exhaled volume returns to baseline

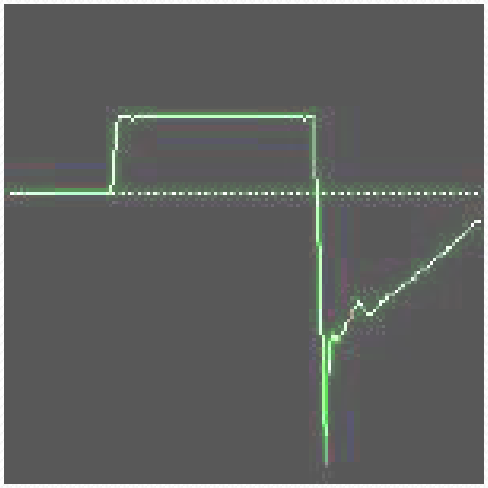
Volume Waveform



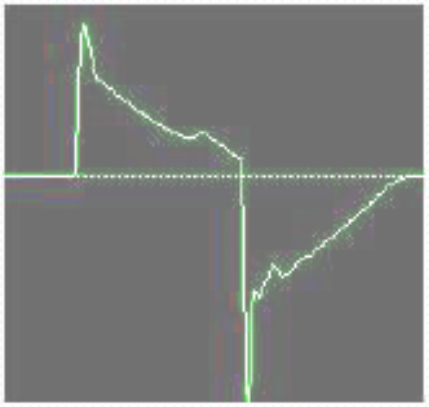
- **If the exhalation side of the waveform doesn't return to baseline, it could be from air-trapping or there could be a leak (ET tube, vent circuit, chest tube, etc.)**

Flow Waveform

- In Volume modes, the shape of the flow wave will be square.
- This means that flow remains constant or flow rate is a set parameter.



- In Pressure modes, the shape of the flow waveform will have ramp pattern.

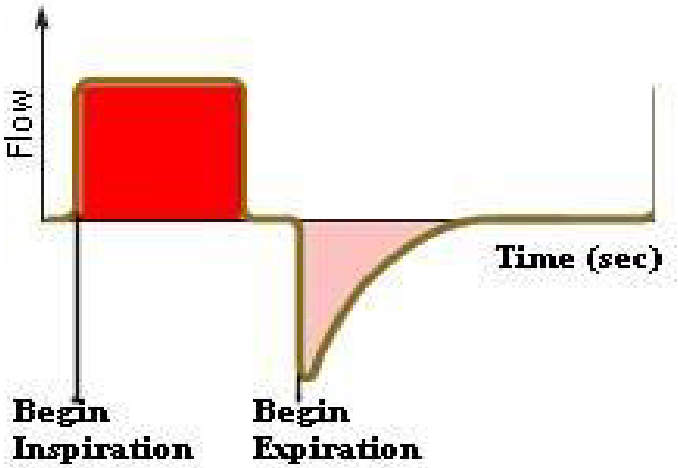


- **Most current ventilators allow you to select the desired flow pattern in Volume Control Ventilation.**

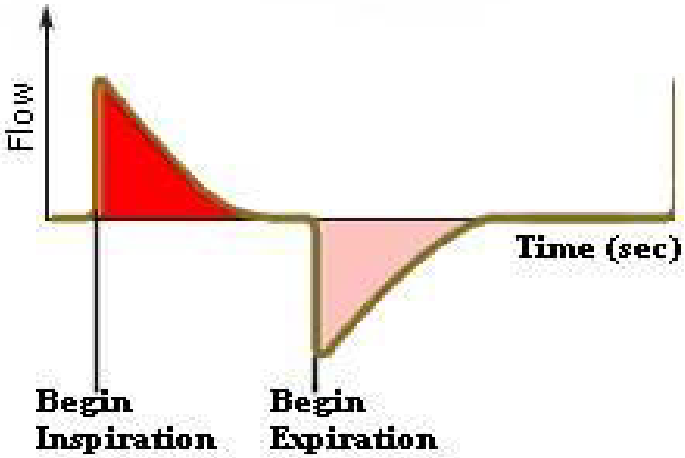
Can be used to assess:

- Air trapping (auto-PEEP)
- Airway Obstruction
- Bronchodilator Response
- Active Exhalation
- Breath Type (Pressure vs. Volume)
- Inspiratory Flow
- Asynchrony
- Triggering Effort

Flow Waveform



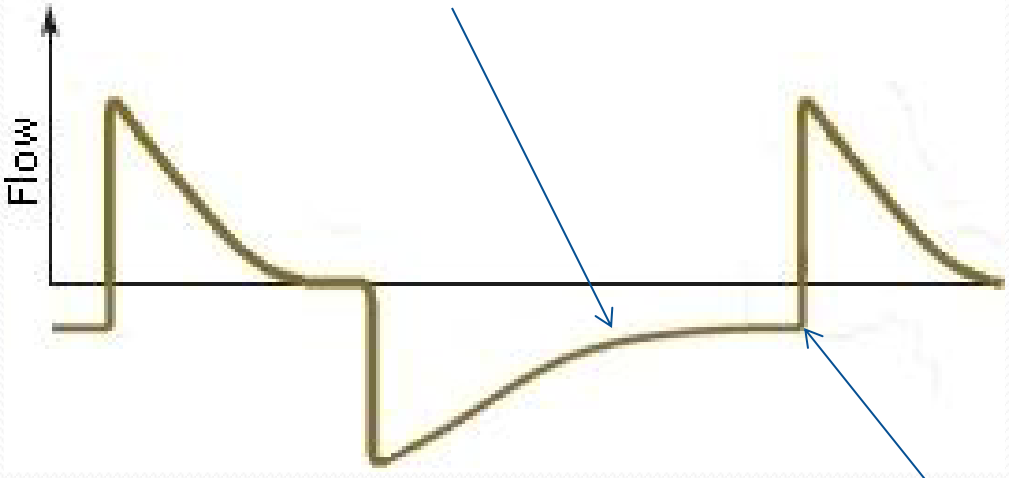
Square Waveform



Descending Waveform

Auto-Peep (air trapping)

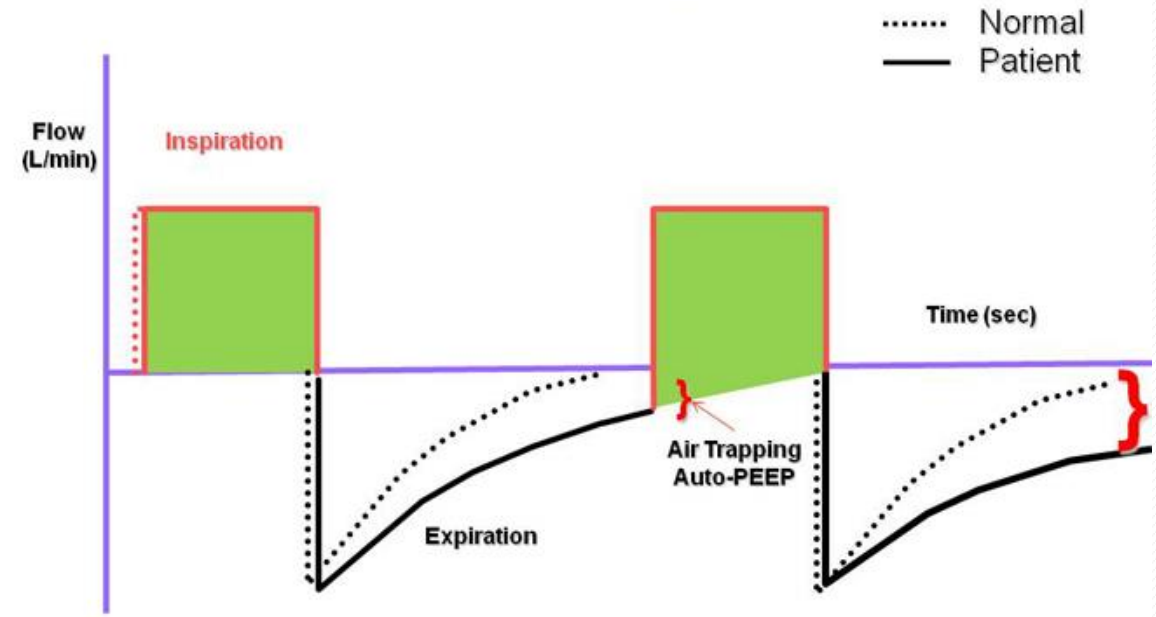
Expiratory flow doesn't return to baseline



Start of the next breath

If the expiratory portion the waveform doesn't return to baseline before the start of the next breath starts, there could be air trapping. (emphysema, improper I:E ratio)

Air Trapping



Flow Waveform

Bronchodilator Response

Notice exhalation time

Pre-Bronchodilator

Post-Bronchodilator

- To assess response to bronchodilator therapy, you should see an increase in peak expiratory flow rate.
- The expiratory portion of the curve should return to baseline sooner.

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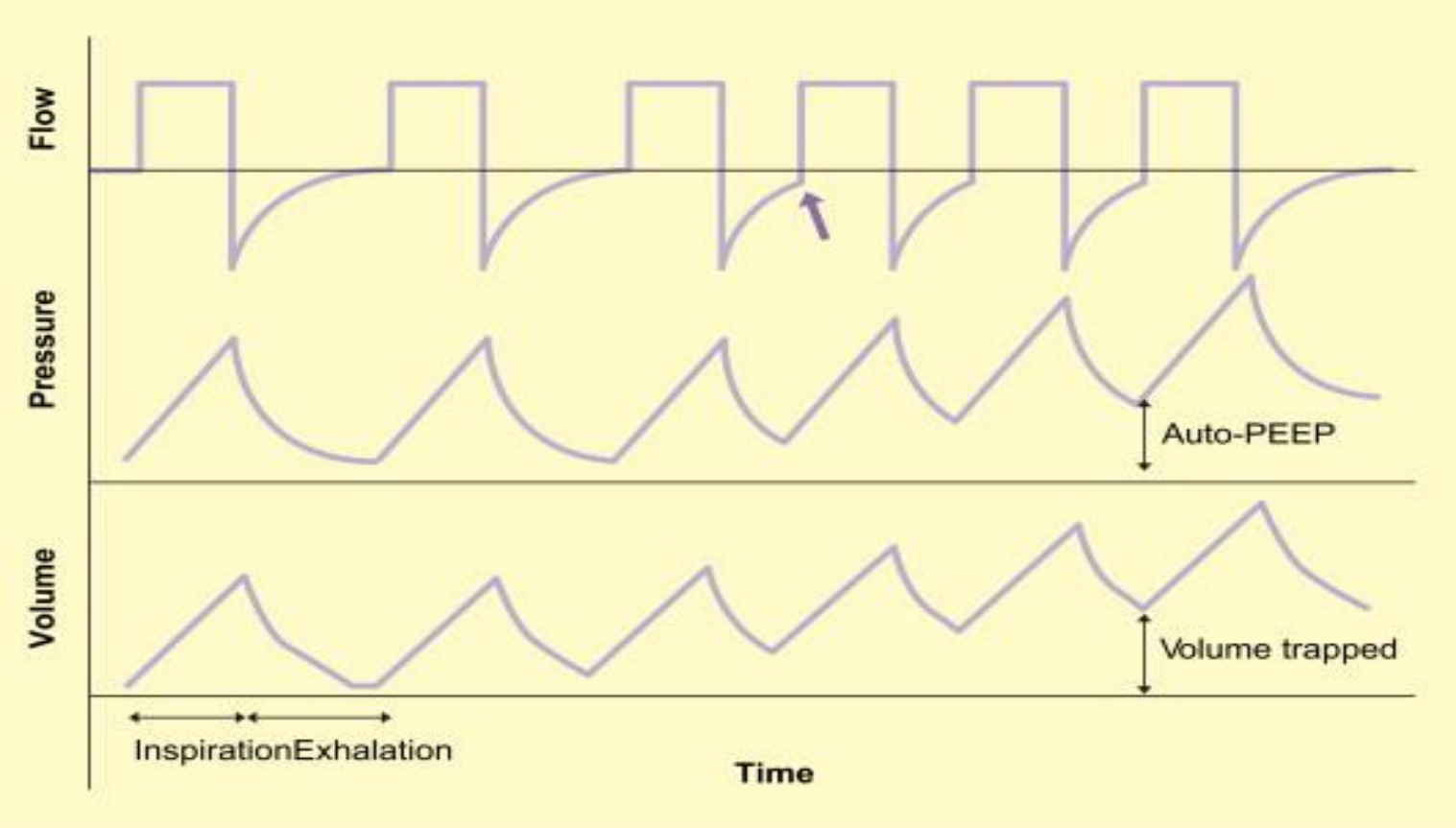
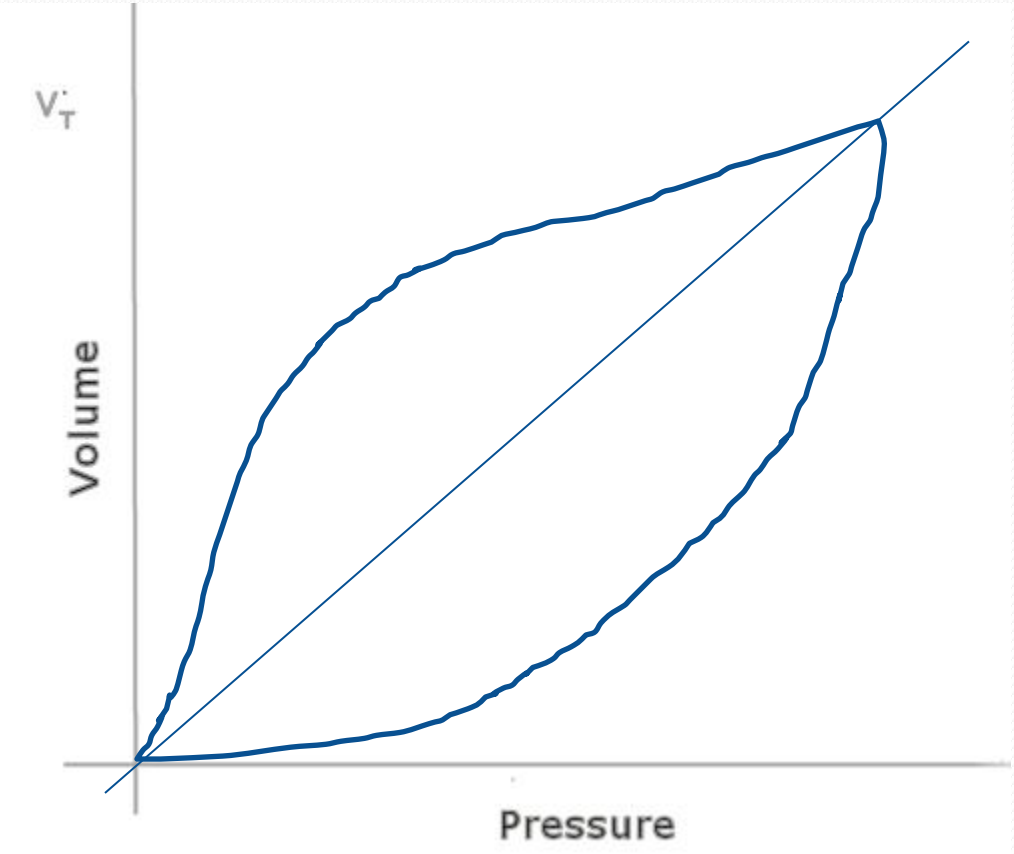
Air-Trapping or Leaks will be visible in all waveforms and loops.



Wake UP !!!

Pressure/Volume Loops



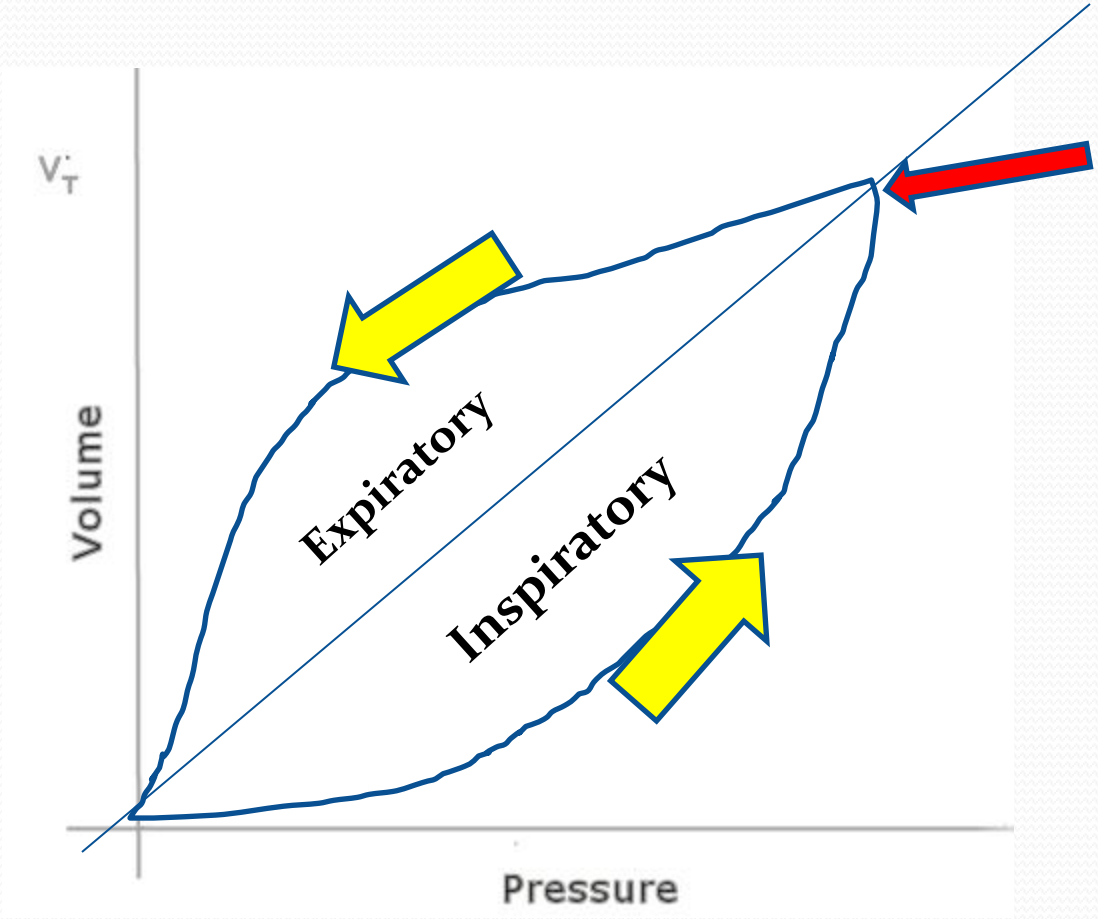
Pressure/Volume Loops

- Volume is plotted on the y-axis, Pressure on the x-axis.
- Inspiratory curve is upward, Expiratory curve is downward.
- The bottom of the loop will be at the set PEEP level. It will be at Zero (0) if there's no PEEP set.
- If an imaginary line is drawn down the middle of the loop, the area to the right represents inspiratory resistance and the area to the left represents expiratory resistance.

Can be used to assess:

- Lung Over distention
- Airway Obstruction
- Bronchodilator Response
- Respiratory Mechanics (C/Raw)
- WOB
- Flow Starvation
- Leaks
- Triggering Effort

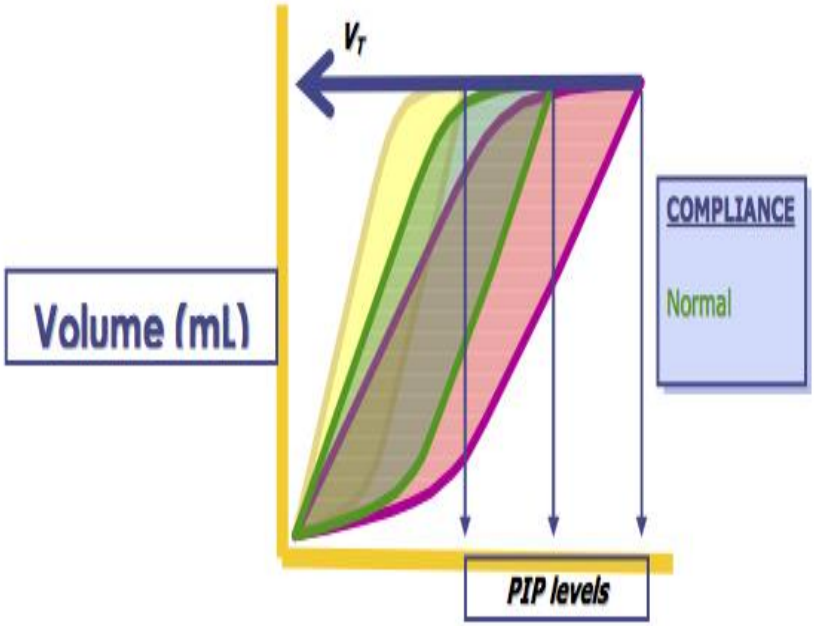
Pressure/Volume Loops

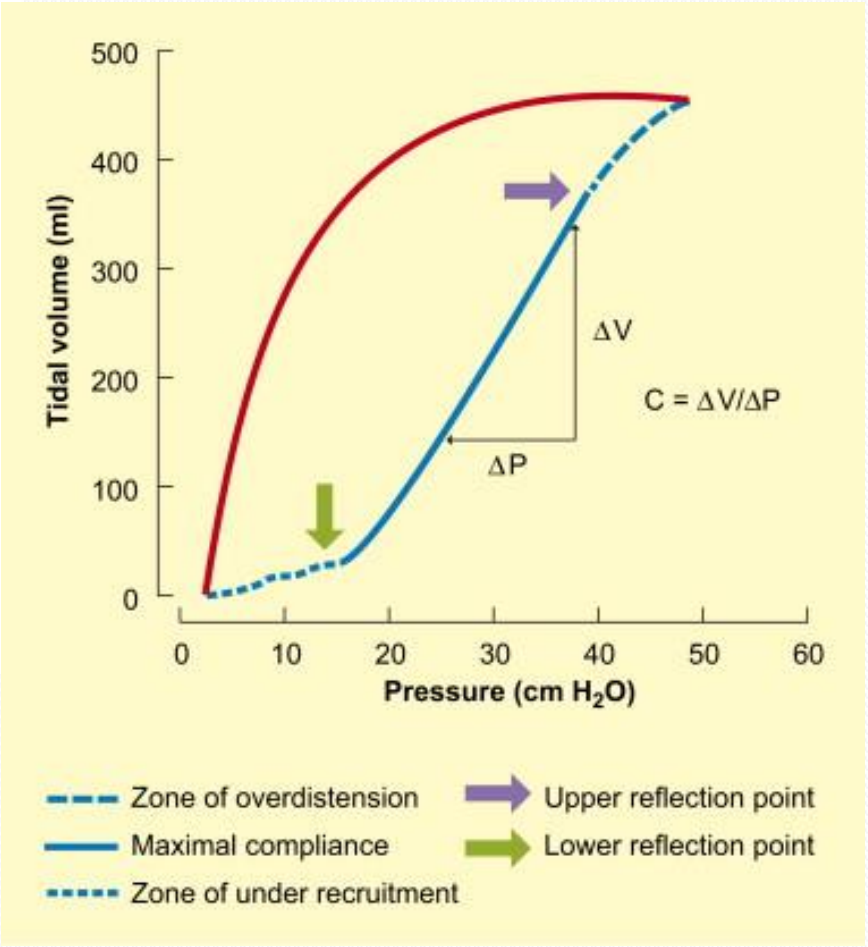


- The top part of the P/V loop represents Dynamic compliance (Cdyn).

- Cdyn = Δvolume/Δpressure

Pressure/Volume Loops



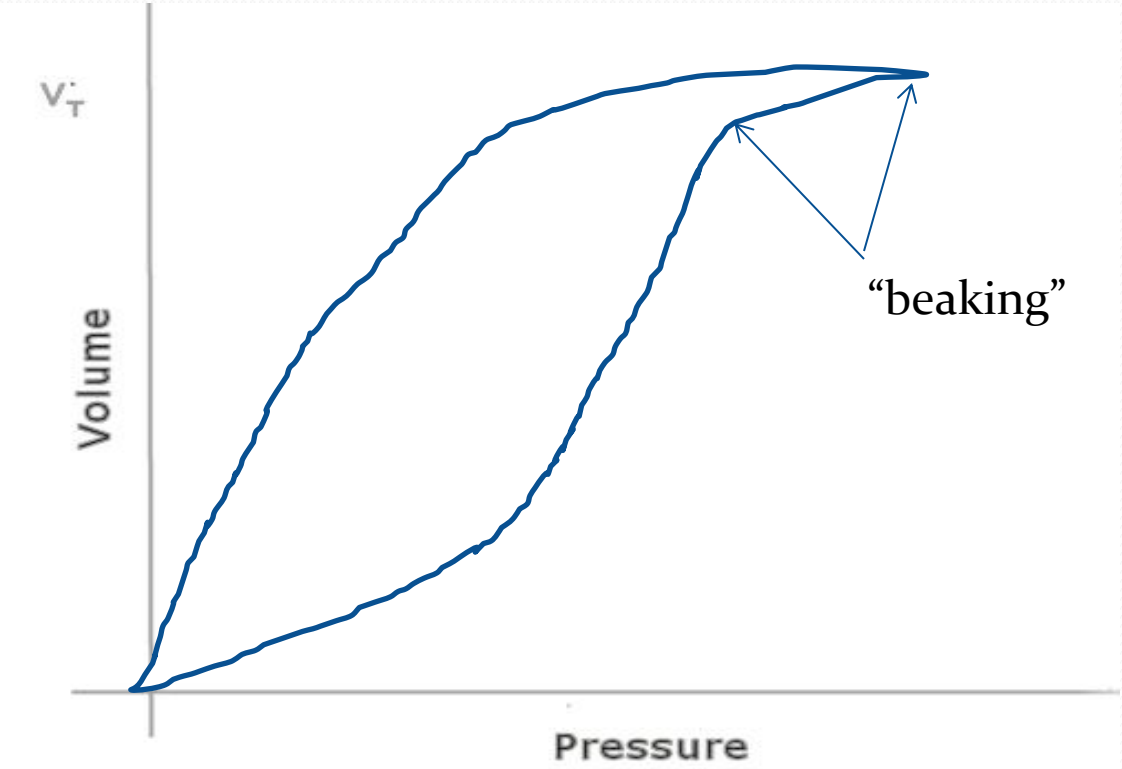


Pressure-volume loops essentially are looking at compliance (change in volume for a given change in pressure). However, they also can give information about over-inflation, prolonged inspiration, and leaks.

As Compliance decreases, so does the volume. PIP levels will increase in value with a shift to the right of the curve.

Pressure/Volume Loops

Over distention

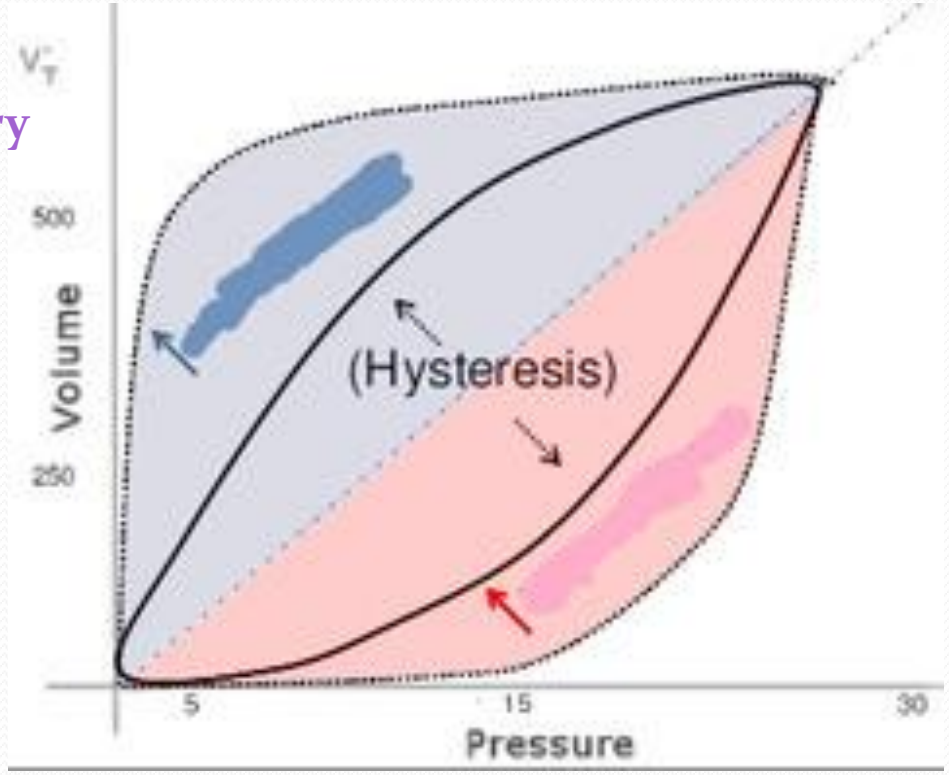


- **Pressure continues to increase with little or no change in volume, creating a "bird beak".**
- **Fix this by reducing amount of tidal volume delivered**

Pressure/Volume Loops

Airway Resistance

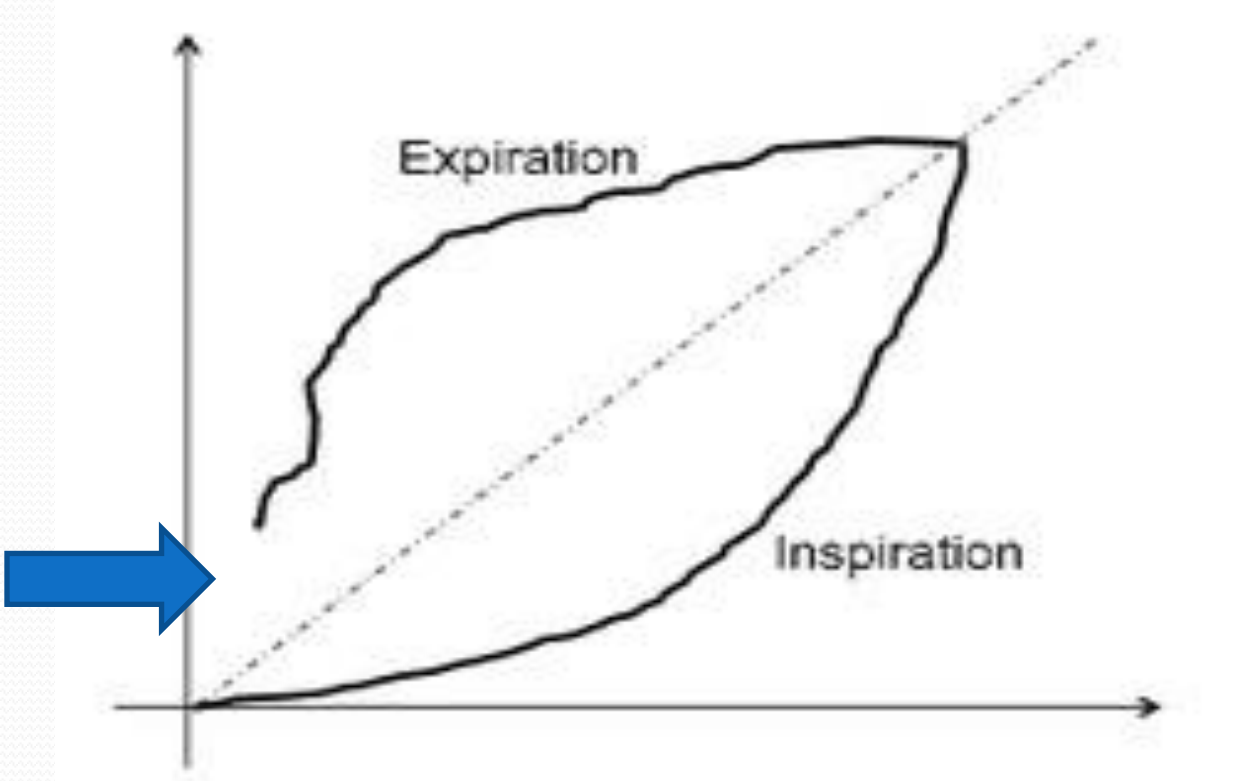
Increased expiratory resistance: secretions, bronchospasms, etc.



Increased inspiratory resistance: kinked ET tube, patient biting tube

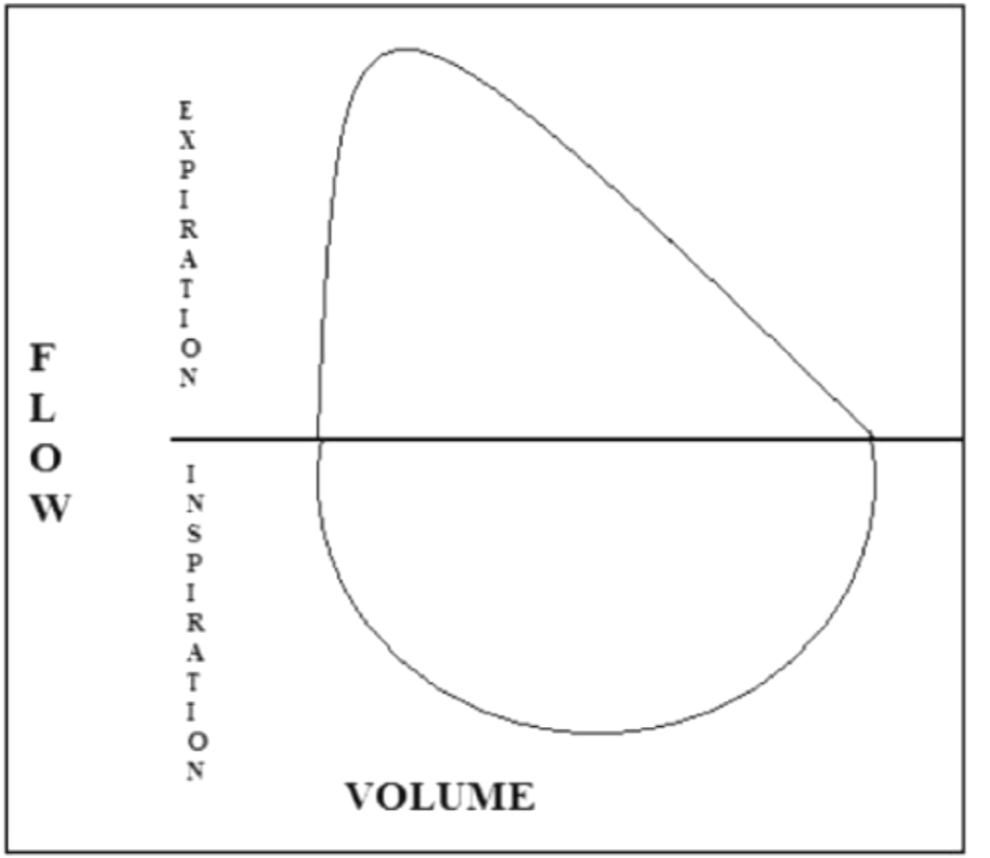
- **As airway resistance increases, the loop will become wider.**
- **An increase in expiratory resistance is more commonly seen.**

Pressure/Volume Loops



•**The expiratory portion of the loop doesn't return to baseline. This indicates a leak.**

Flow/Volume Loops



Critical Care

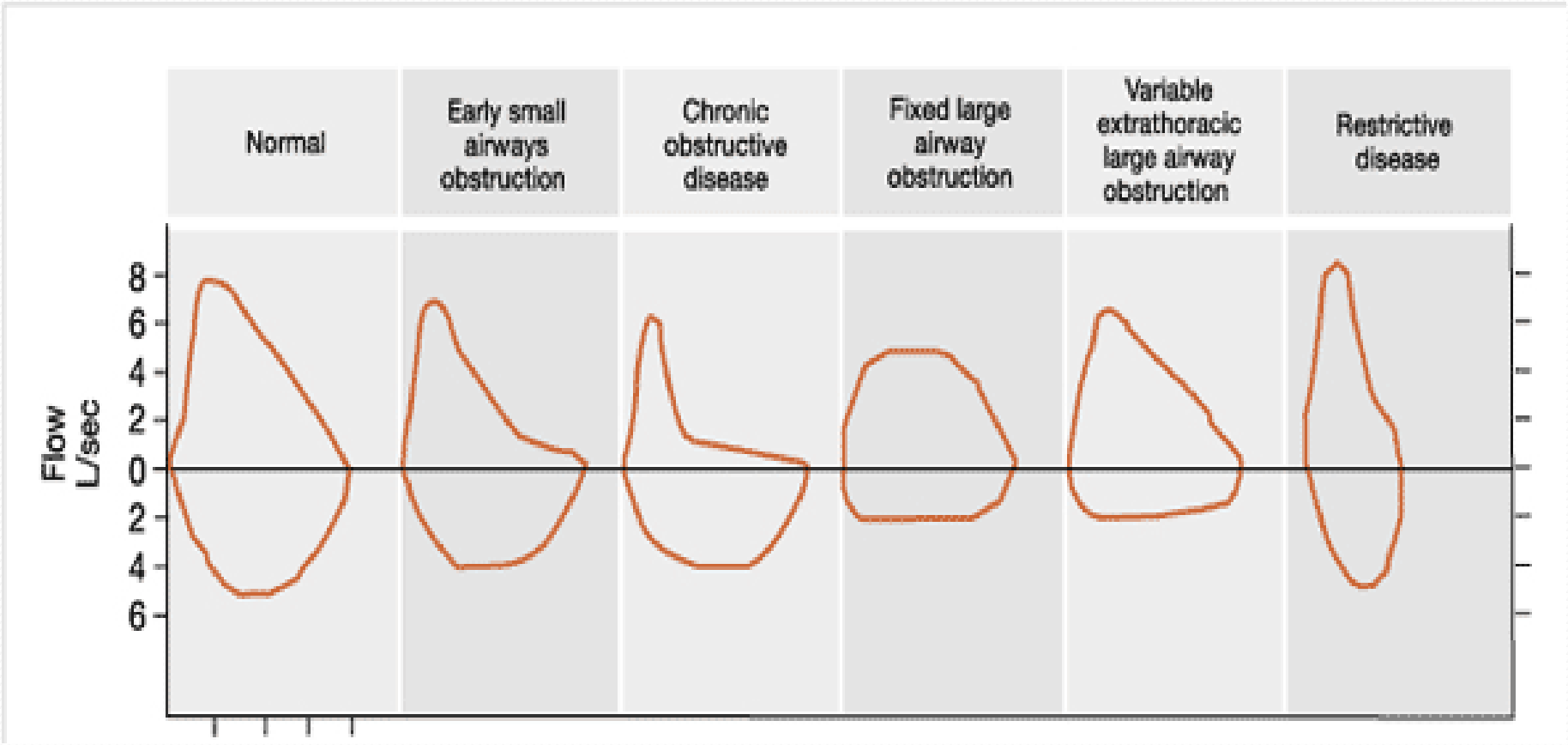
Flow/Volume Loops

- Flow is plotted on the y axis and volume on the x axis
- Flow volume loops used for ventilator graphics are the same as ones used for Pulmonary Function Testing, (usually upside down).
- Inspiration is above the horizontal line and expiration is below.
- The shape of the inspiratory portion of the curve will match the flow waveform.
- The shape of the expiratory flow curve represents passive exhalation.

Can be used to assess:

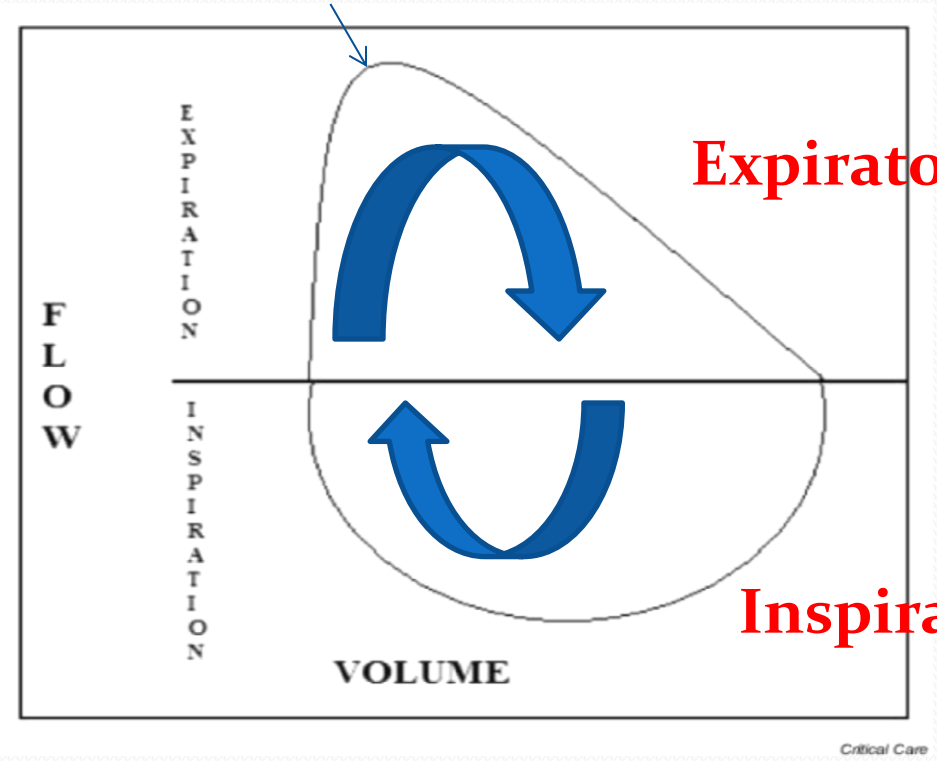
- Air trapping
- Airway Obstruction
- Airway Resistance
- Bronchodilator Response
- Insp/Exp Flow
- Flow Starvation
- Leaks
- Water or Secretion accumulation
- Asynchrony

Flow/Volume Loops



Flow/Volume Loops

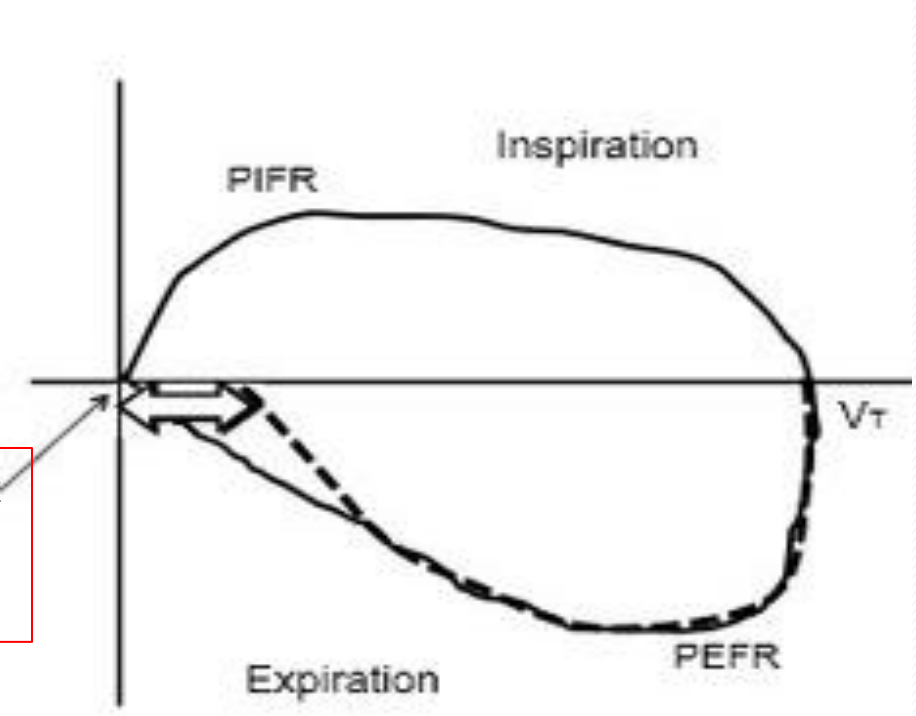
Peak flow



Expiratory Phase

Inspiratory Phase

Flow/Volume Loops

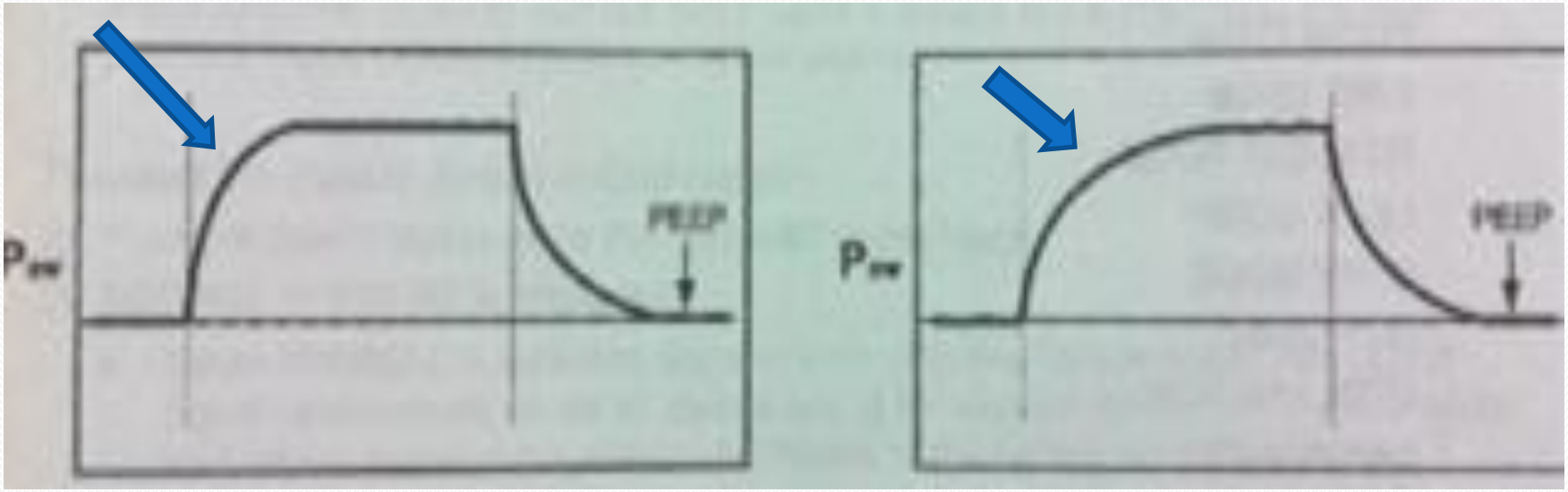


Expiratory part of loop does not return to starting point, indicating a leak.

•If there is a leak, the loop will not meet at the starting point where inhalation starts and exhalation ends. It can also occur with air-trapping.

Rise Profile

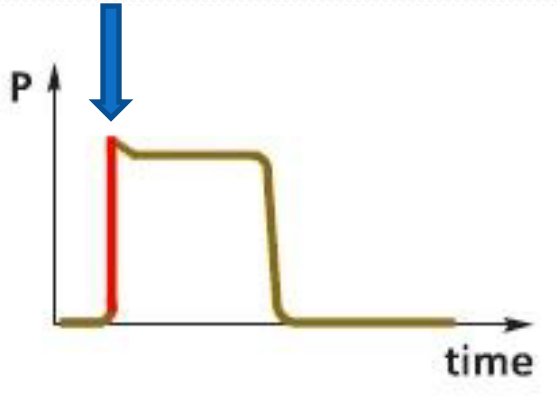
There are 5 different rise times, ranging from 1 (fastest) to 5 (slowest)

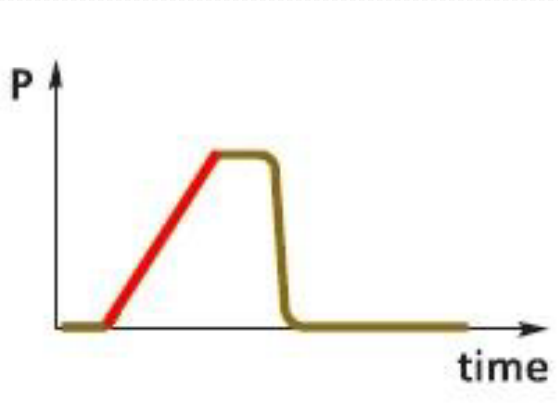


- The inspiratory rise time determines the amount of time it takes to reach the desired airway pressure or peak flow rate.

Used to assess if ventilator is meeting patient's demand in Pressure Support mode.

Rise Profile

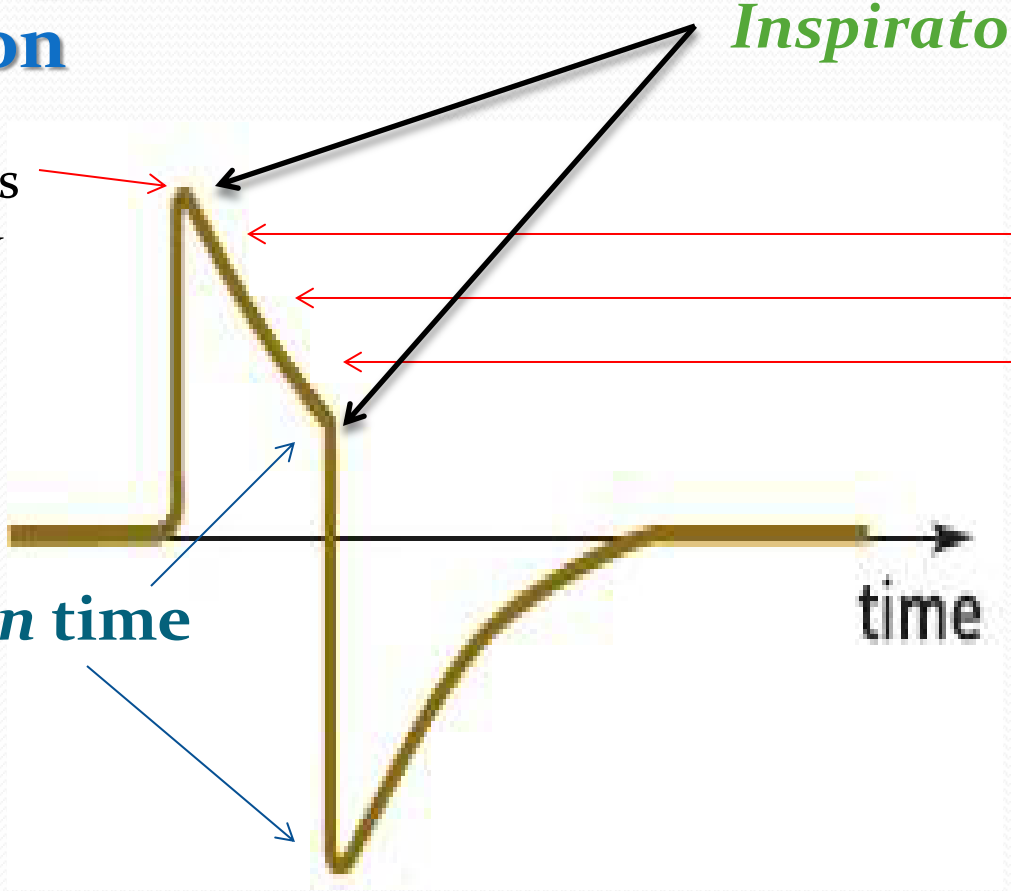




- If rise time is too fast, you can get an **overshoot** in the pressure wave, creating a pressure "spike". If this occurs, you need to decrease the rise time. This makes the flow valve open a bit more slowly.

- If rise time is too slow, the pressure wave becomes rounded or slanted, when it should be more square. This will decrease Vt delivery and may not meet the patient's inspiratory demands. If this occurs, you will need to increase the rise time to open the valve faster.

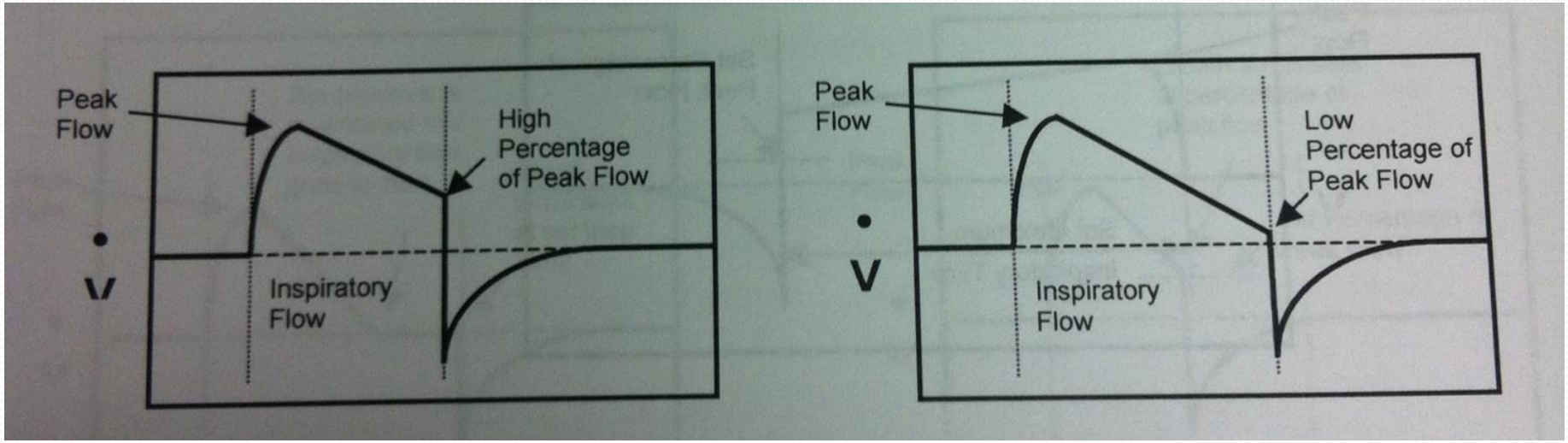
Pressure Support Flow Termination



- **The Pressure Support Flow Termination** determines when the ventilator flow cycles from inspiration to expiration, in Pressure Support mode.

- This is set from 10% to 70 % of Peak Flow.

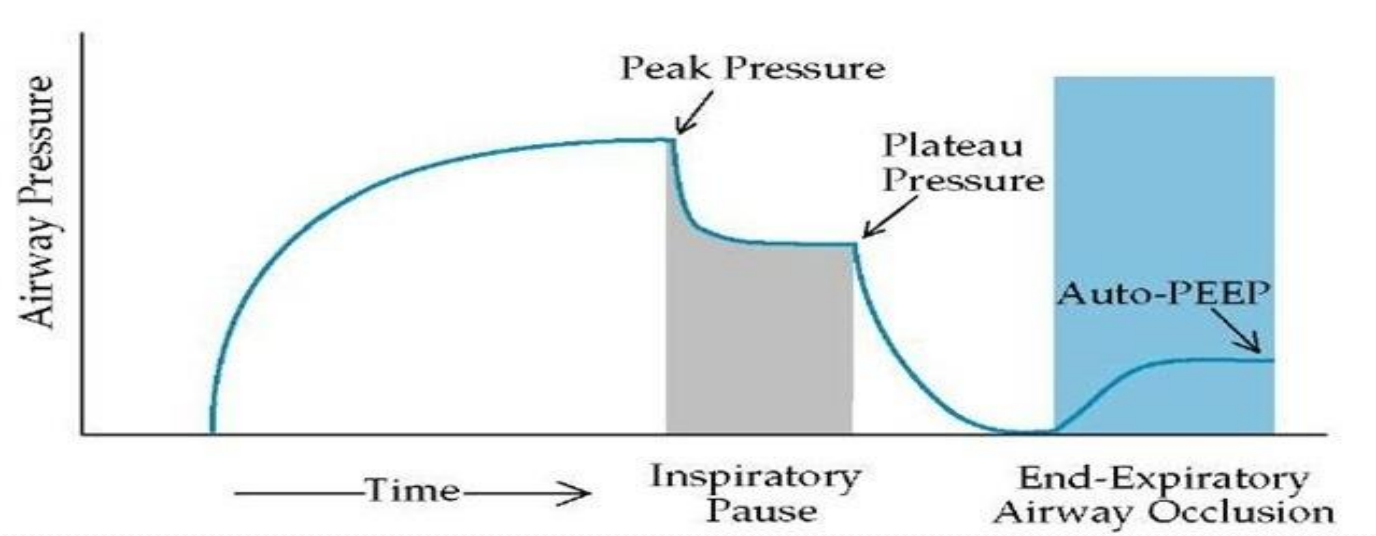
Pressure Support Flow Termination



Use **Flow Termination** to select the percentage of peak flow used to cycle pressure supported breaths. They are cycled from inspiratory to expiratory when the flow reaches the set percentage of the peak flow. When Pressure Flow Termination is enabled, it is used for flow termination for **Pressure Controlled** breaths as well.

Static Compliance

$$C_{stat} = \frac{V_T}{P_{plat} - PEEP}$$



The plateau pressure is measured by interrupting flow or pausing the ventilator at full inspiration. The static compliance of the respiratory system is computed by dividing the tidal volume delivered to the patient by the change in pressure (plateau pressure minus PEEP). A reduction in the normal static compliance is indicative of a stiffer lung or chest wall.

Normal values are 50 to 70 ml per cm H2O

The end …….

Thank you for your attention and time !