بسم الله الرحمن الرحيم

Essential variables and Mechanical Breath types

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Time Schedule (11:00am to 12:30pm)	
Introduction	11:00 – 11:05
Hamilton Ventilators Intro	11:05 – 11:15
Essential variables.. ppt	11:15 – 11:45
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FAQ Questions	12:20 – 12:30

Introduction to Hamilton Medical

HAMILTON MEDICAL:

In 1983 Hamilton Medical was founded with a vision: to develop Intelligent Ventilation solutions that make life easier for patients in critical care and for the people who care for them.

Today, Hamilton Medical is a leading manufacturer of critical care ventilation solutions for a variety of patient populations, applications, and environments.

Special Intentions of Hamilton Ventilator:

- To keep ventilation continue with transportation
- To keep ventilation at high altitudes
- To keep ventilation in MRI room
- To keep ventilation with Heliox therapy (Oxygen and Helium therapy)
- To keep ventilation with Dynamic lungs, weaning status, volumetric capnography and protective ventilation tools.
- To keep ventilation with Esophageal pressure monitoring
- To keep ventilation with automated ETT cuff pressure management.

E-Learning & Education:

Hamilton Medical provides educational resources, workshops and training for mechanical ventilation and ventilators.

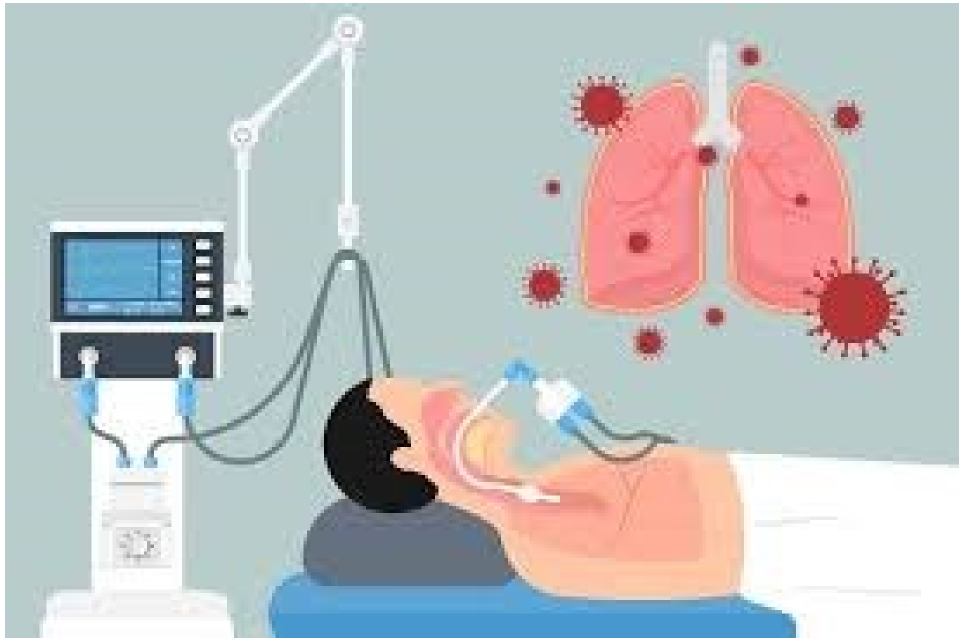
- Basic Modules (06)
- Features Modules (12)
- Products Modules (36)

Total Modules with Certificates = 50

Note

Anyone wants to attend Hamilton Medical's certified Module, should have to register him/herself on Hamilton Medical E-learning and education through Following link.
(https://www.hamilton-medical.com/en_PK/E-Learning-and-Education/College/Login/Registration.html)

Essential variables and Mechanical Breath types

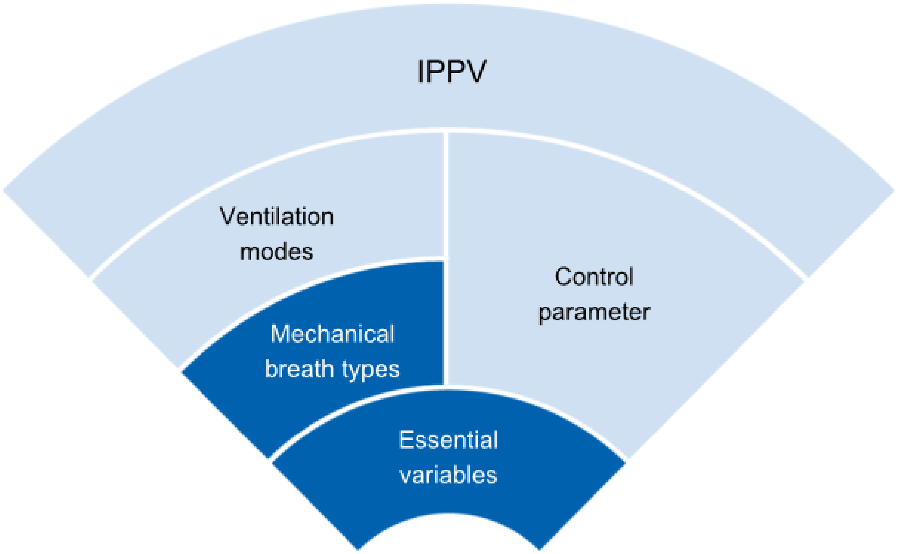


Essential Variables:

The essential variables are serve as a foundation of mechanical breaths, while mechanical breaths are the foundation of Ventilation modes.

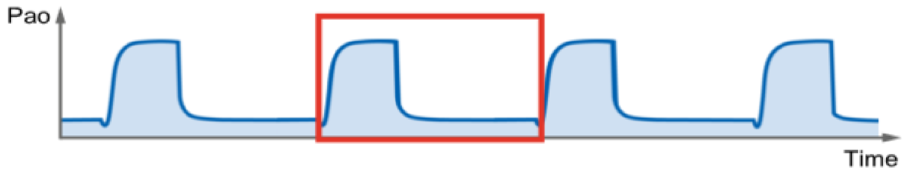
1. Triggering   2. Cycling   3. Controlling   4. Targeting   5. Base line pressure/PEEP

The essential variables are directly related to the major ventilator control parameters. They belong to the core of intermittent positive pressure ventilation (IPPV) regardless of ventilator brand and models.



Mechanical Breath

A mechanical breath is defined as any breath realized through a ventilator system.



To carry out mechanical ventilation, a ventilator must receive the commands from its operator's on:

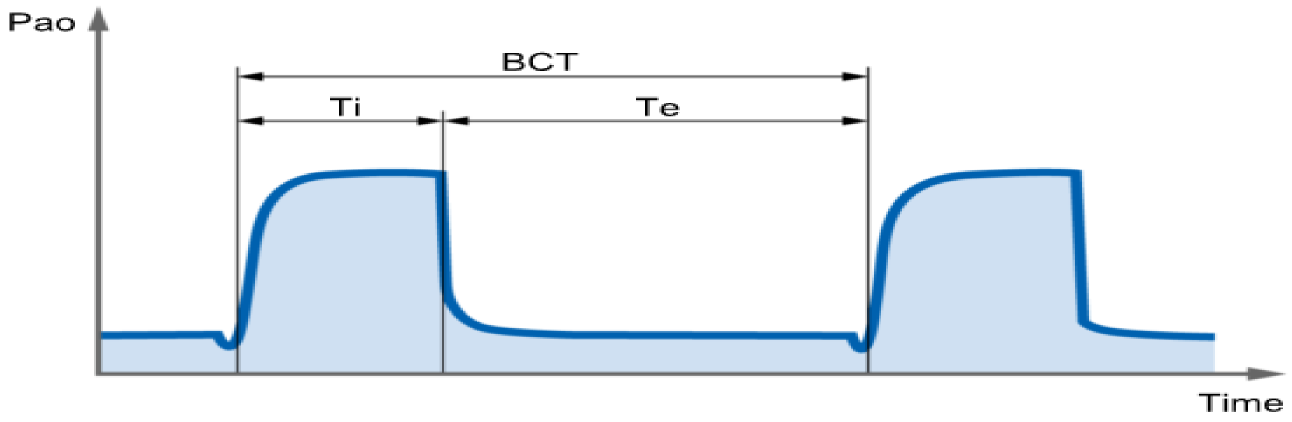
- When inspiration should start and stop
- When expiration should start and stop
- How the delivery of inspiratory gas should be controlled
- How big the mechanical breath should be
- How high the baseline pressure should be

Every mechanical breath takes a certain length of time to complete. The duration is Breath Cycle Time (BCT) Or Total Cycle Time (TCT).

BCT always contains two portions:

1. Ti (Inspiratory Time)
2. Te (Expiratory Time)

Conventionally Ti comes first.



Inspiration:

During inspiration, a ventilator delivers gas into a ventilator system, resulting in the airway pressure to rise and the lungs are inflated.

Expiration:

During inspiration, a ventilator stops gas delivery and allows the gas exit the ventilator system resulting in the airway pressure to drop and the lungs are deflated.

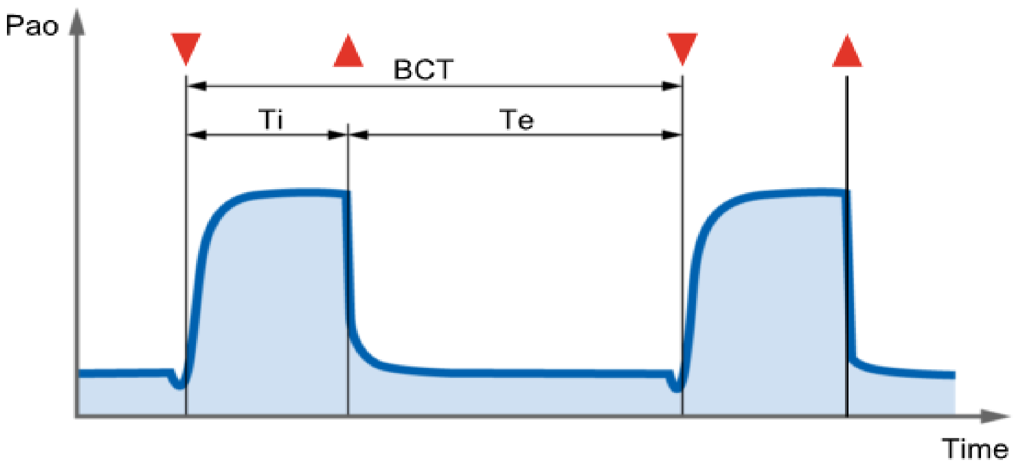
BCT, Ti and Te:

BCT, Ti and Te are specified with two time events i.e: triggering and cycling.Both are the essential variables.

1. TRIGGERING

TRIGGERING

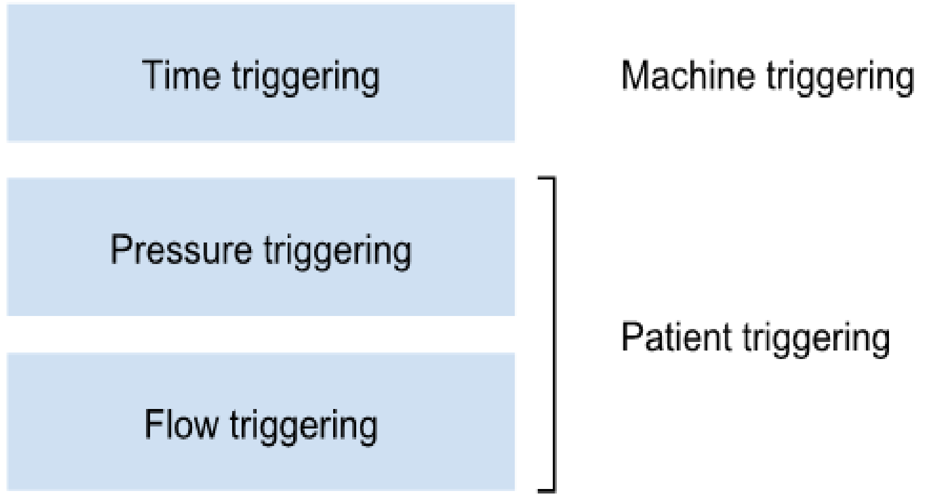
- Trigger refers to the time point when the inspiration starts.
- Cycling refers to the time point when the inspiration ends.
- "Ti" is the duration from a triggering point to the following cycling point.
- "Te" is the duration from a cycling point to the following triggering point.
- BCT is the duration from a triggering point to the next triggering point.



Triggering Mechanics

Triggering can be realized with different mechanics. The common ones are:

- Time triggering
- Pressure triggering
- Flow triggering



Both pressure and flow are regarded as patient triggering.

Time Triggering

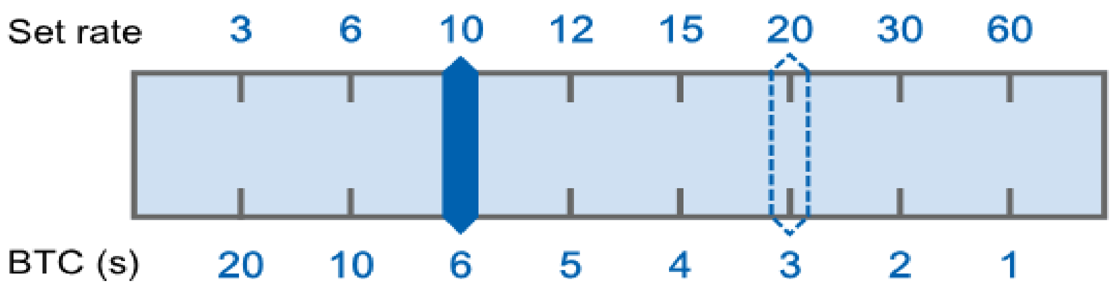
Time triggering is also known as “Machine triggering” or “Ventilator triggering” and is based on BCT which is defined with the set rate.

Once the rate is set, the ventilator automatically converts the rate to BCT with a simple equation.

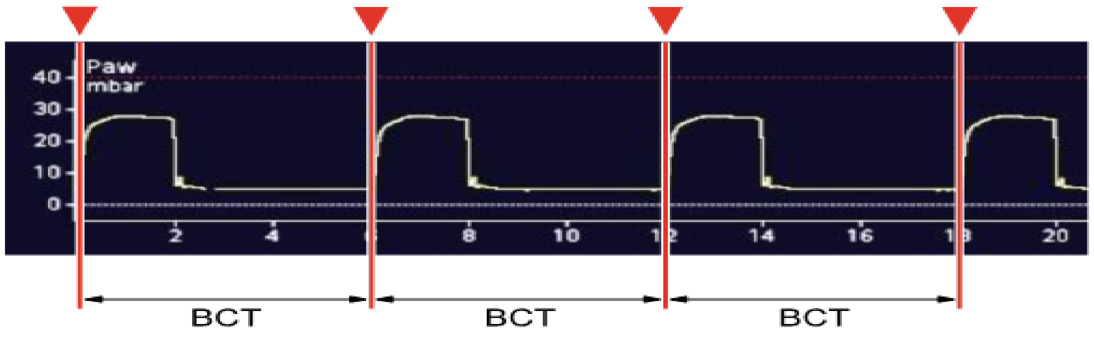
$$\text{BCT (s)} = \frac{60}{\text{Set rate (b/min)}}$$

Breath cycle time in seconds equals 60 divided by set rate in breath per minute.

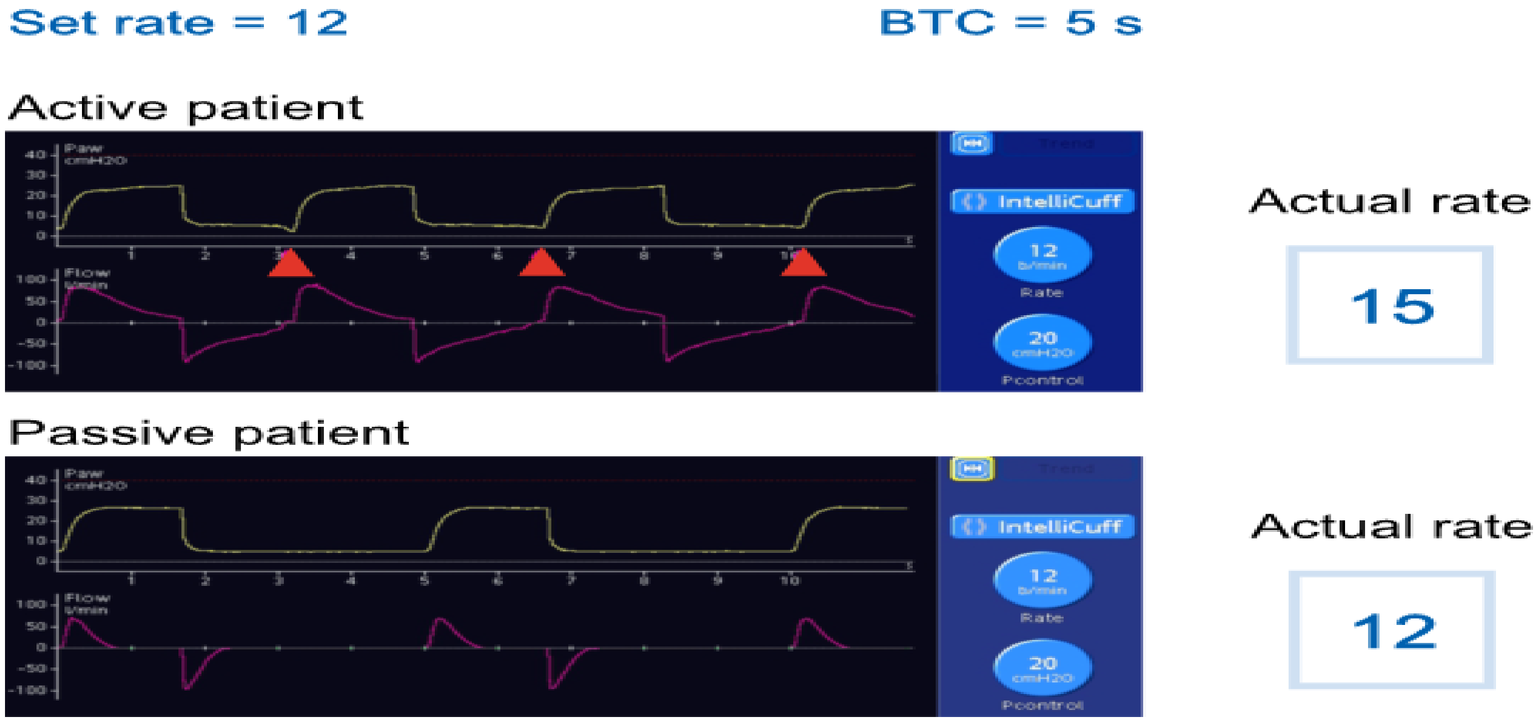
In other words, every set rate has a corresponding BCT. For instance, if you set the rate of 10 b/min, the resultant BCT is 6 seconds. If you set 20 b/min the resultant BCT is 3 seconds. The scale shows the commonly used rates and the corresponding BCTs.



A BCT is the interval between any two consecutive triggering points.Whenever the defined BCT is over, the ventilator delivers inspiratory gas.



Currently all ventilation mode in Hamilton Medical Ventilator allow the patient to trigger, unless the patient trigger is deliberately disabled.

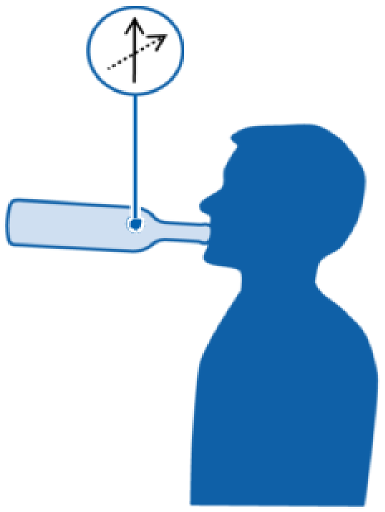


- If so an active patient can dominate the actual rate, which is often higher than the set rate.
- If the patient is passive, however the actual and the set rate are equal.
- Therefore, the actual rate usually serves as the minimum or backup rate.

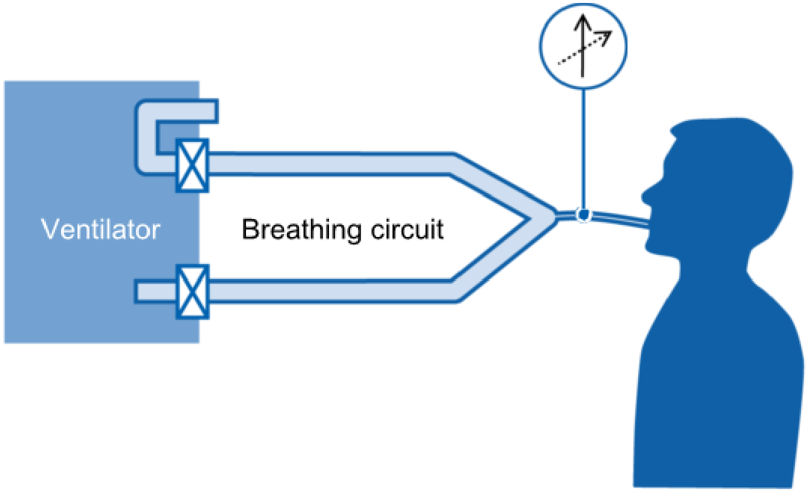
Pressure Triggering

Pressure triggering is a form of patient triggering. It relies on circuit or airway pressure monitoring.

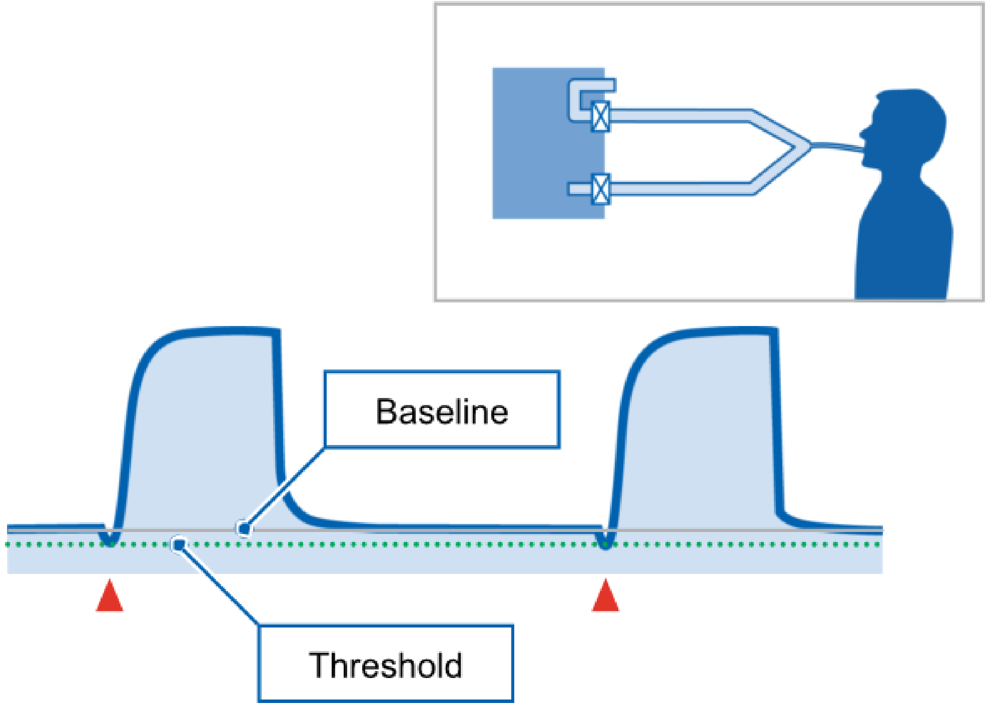
One way to understand pressure triggering may be that you suck an empty glass bottle. Your effort generates a negative pressure inside the bottle but little gas flow. The stronger you suck the more negative the pressure is.



If pressure trigger is activated, the breathing circuit serves as the “Glass bottle”. The patient’s inspiratory effort cause the airway pressure to drop from the current baseline.

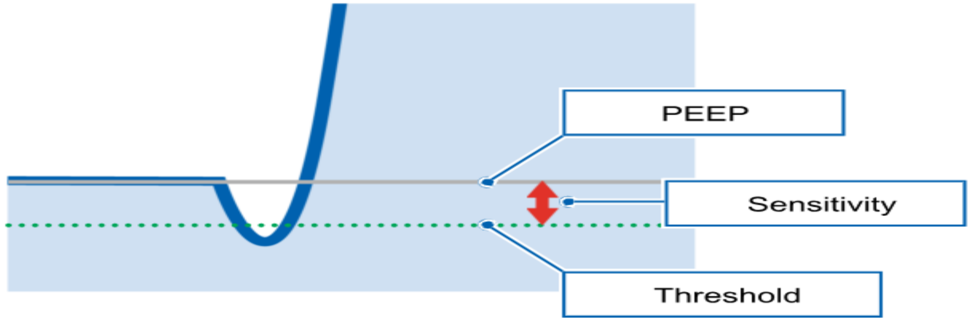


If the pressure drop reaches a set virtual threshold, the ventilator is triggered and starts delivery of inspiratory gas.

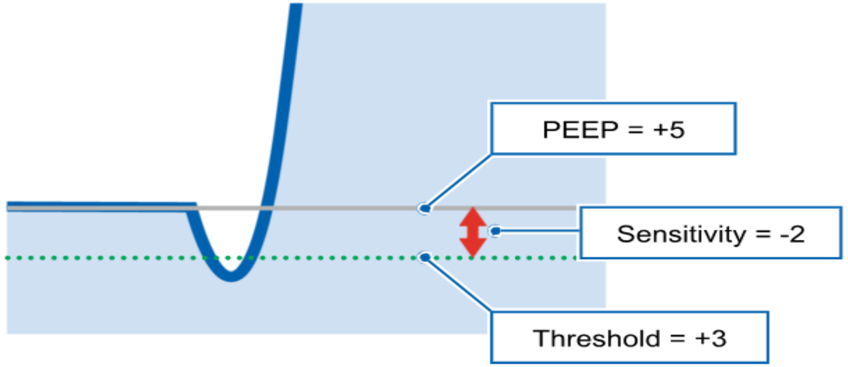


To utilize pressure triggering, you must active pressure triggering and set pressure trigger sensitivity.

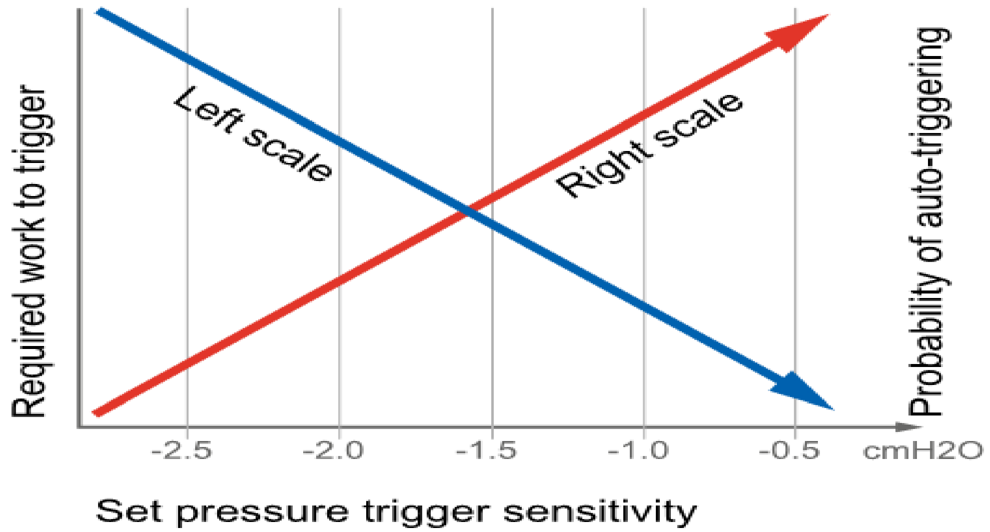
The sensitivity is a negative value of cmH2O, such as -0.5, -2 or -5cmH2O. The value represents as Pressure threshold below the current PEEP.



For instance, if the PEEP is 5 cmH2O, and the trigger sensitivity is set at -2 cmH2O, the ventilator is triggered if the actual airway pressure drops to below 3 cmH2O.



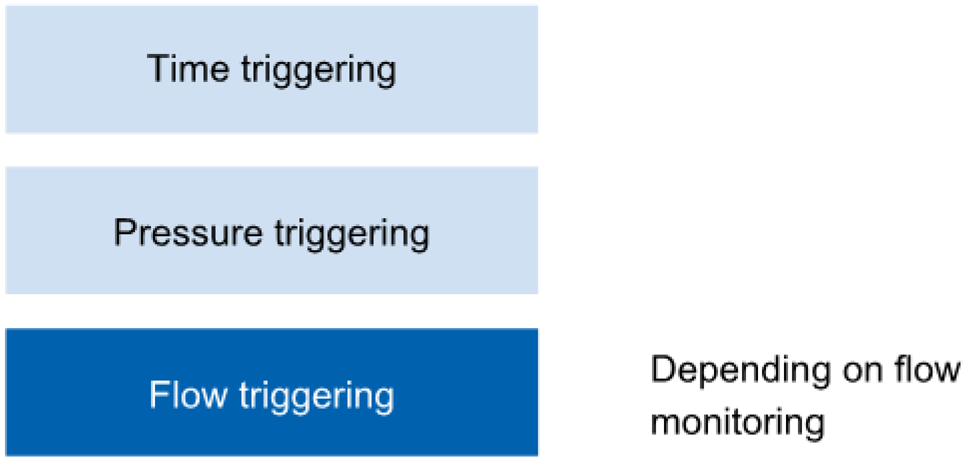
The smaller the absolute value of sensitivity, the more sensitive the triggering, and vice versa. So, pressure trigger of -0.5 cmH2O is more sensitive than that of -2.0 cmH2O.



Flow Triggering

Flow triggering is another form of patient triggering. It relies on circuit or airway. To make understanding easier, let us first specify three flow types:

> Flow A
> Flow B
> Airway flow



Flow A:

The gas flow measured at the inspiratory limb of the circuit.

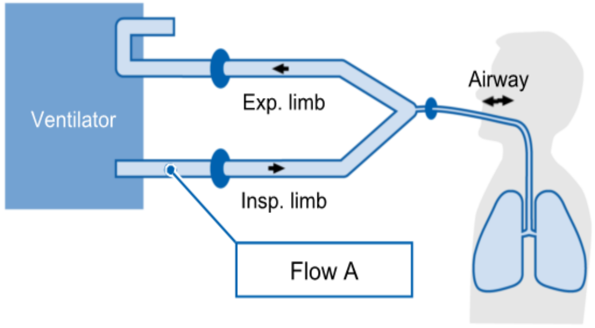
Flow B:

The gas flow measured at the expiratory limb of the circuit.

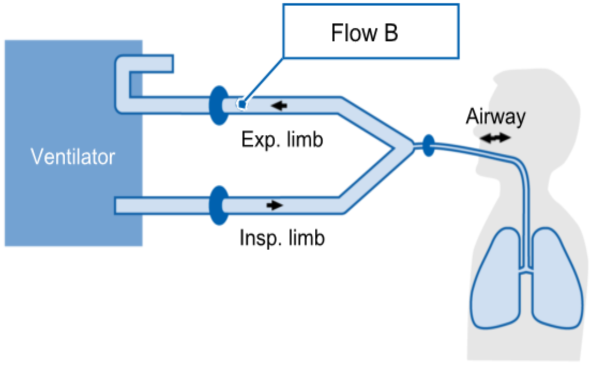
Airway Flow:

The gas flow measured at the airway. It can be either inspiratory or expiratory.

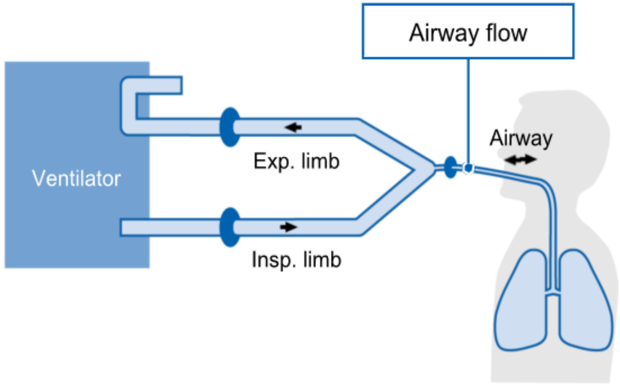
Flow A



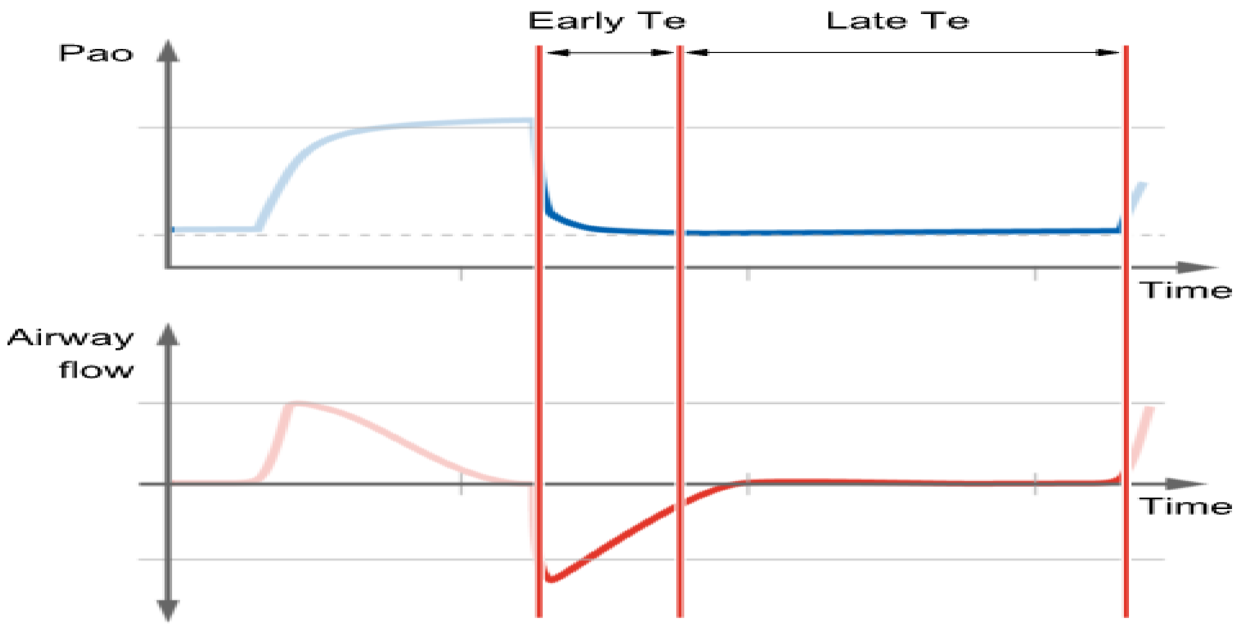
Flow B



Airway Flow



Further , let us divide expiratory time into early expiration and later expiration



Early Expiration

At early expiration, the ventilator closes it’s inspiratory valve and fully open it’s expiratory valve for a maximum expiratory flow.

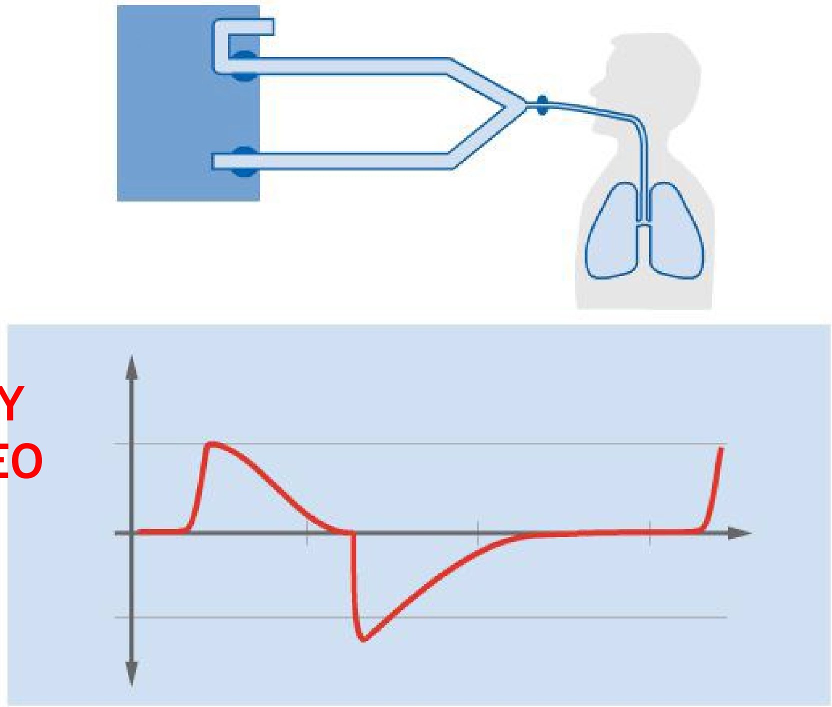
The high circuit pressure, drives the gas out, and the airway pressure drops sharply. Both the flow B and the expiratory airway flow rise out quickly to maximum and then decrease gradually as the circuit pressure drops.

Late Expiration

At late expiration, the ventilator start to rebuild and maintain the set baseline pressure by:

a) Reducing the expiratory valve opening for a high resistance against the expiratory flow
b) Slightly opening an inspiratory valve for a constant base flow, which is crucial for flow triggering

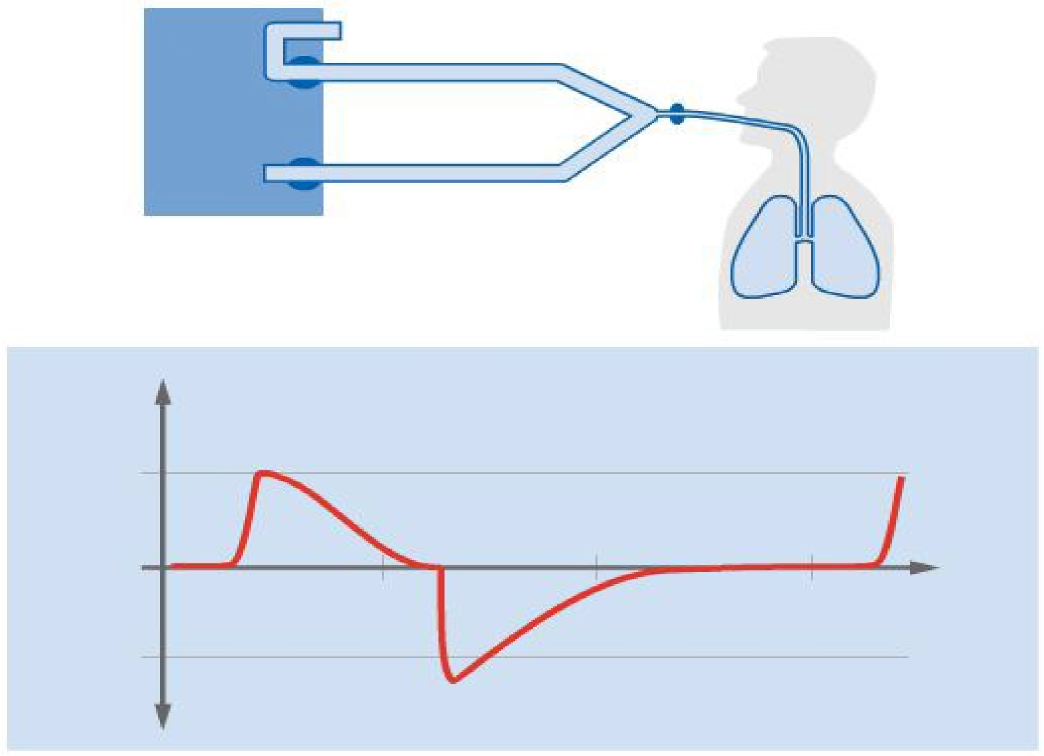
PLAY VIDEO



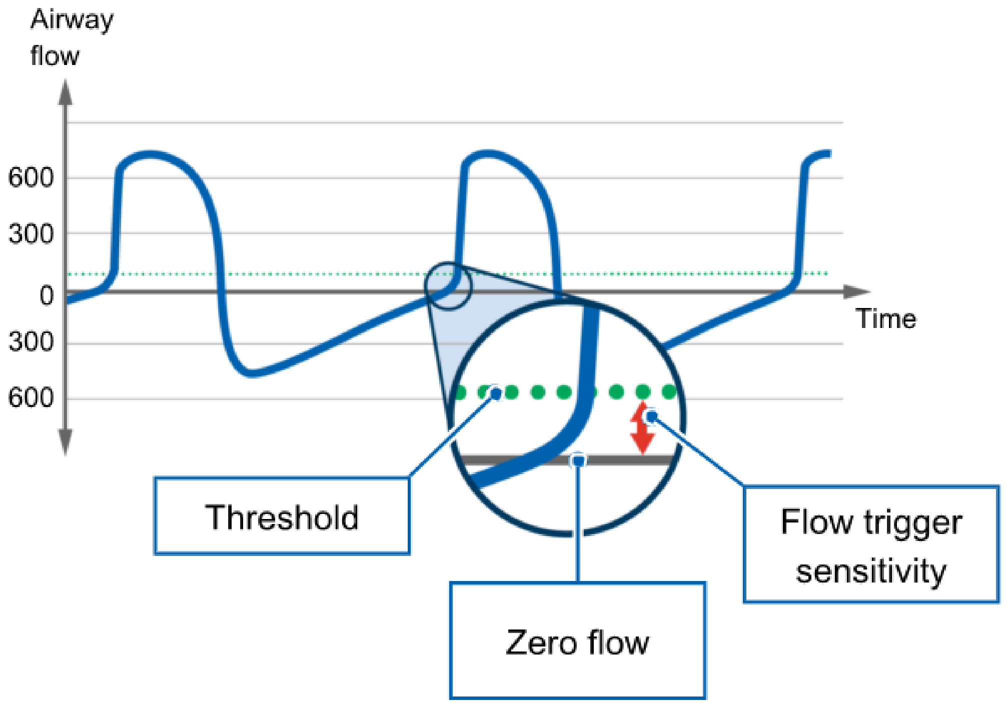
If the patient does not inhale, both the Flow A and Flow B are equal to the base flow, and the airway flow is zero.

If the patient inhales, a part of the base flow goes to the patient, resulting in an inspiratory Airway flow and a decreased Flow B.

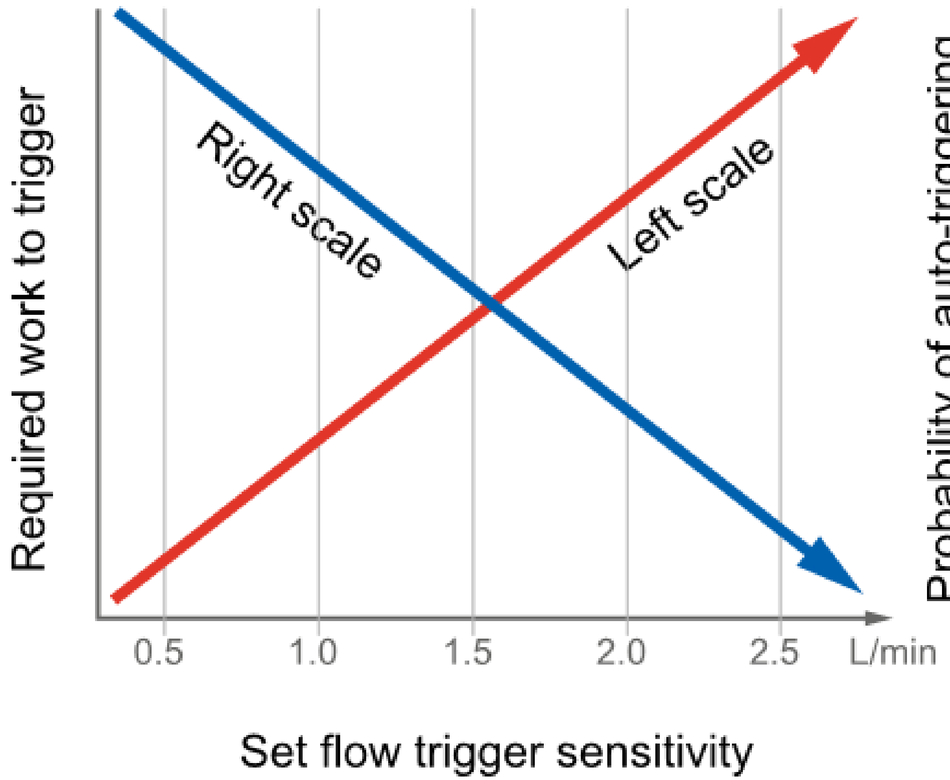
PLAY VIDEO



If the detected inspiratory airway flow or the difference between Flow A and Flow B reaches a defined Threshold, the ventilator is triggered.



To use flow triggering, you must active flow triggering and then set flow trigger sensitivity. The sensitivity is expressed in Litres/min, such as 0.5, 1, 2 or 5 Litres/min. The smaller the set value, the more sensitive the flow trigger is, and vice versa.



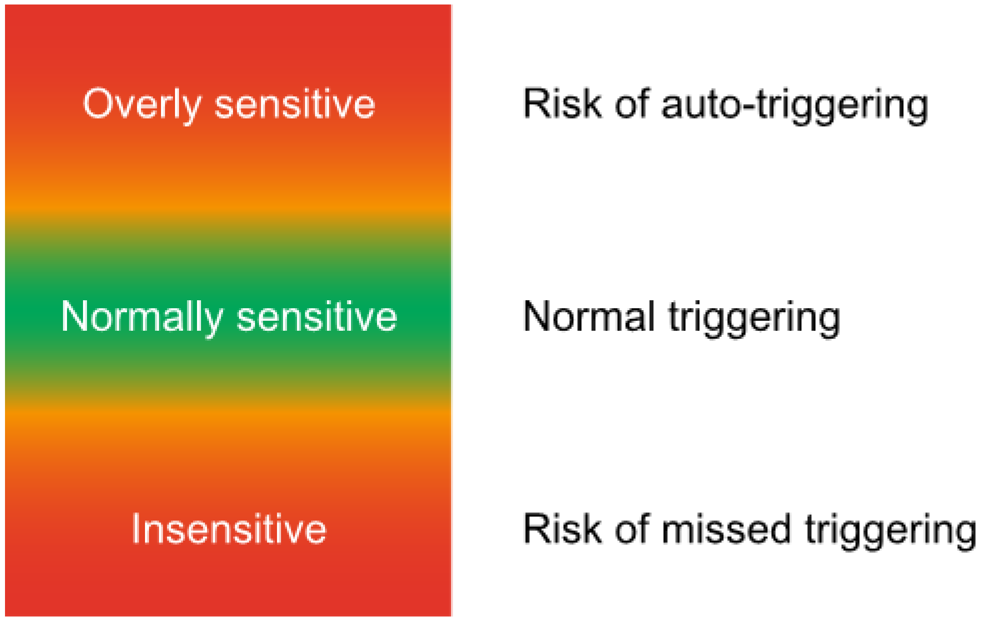
Remember

For a ventilated patient,
Flow trigger is generally easier than pressure trigger under the same condition of use.

Abnormal Patient Triggering

Unlike time triggering, patient triggering both pressure and flow can fails in two forms.

1. In-sensitive
2. Overly sensitive



In-sensitive

> The first form is that a ventilated patient has inspiratory effort, but the ventilator does not respond.

> The common causes are either the patient's effort is too weak. Or the patient triggering setting is not enough sensitive, or both.

Missed triggering:

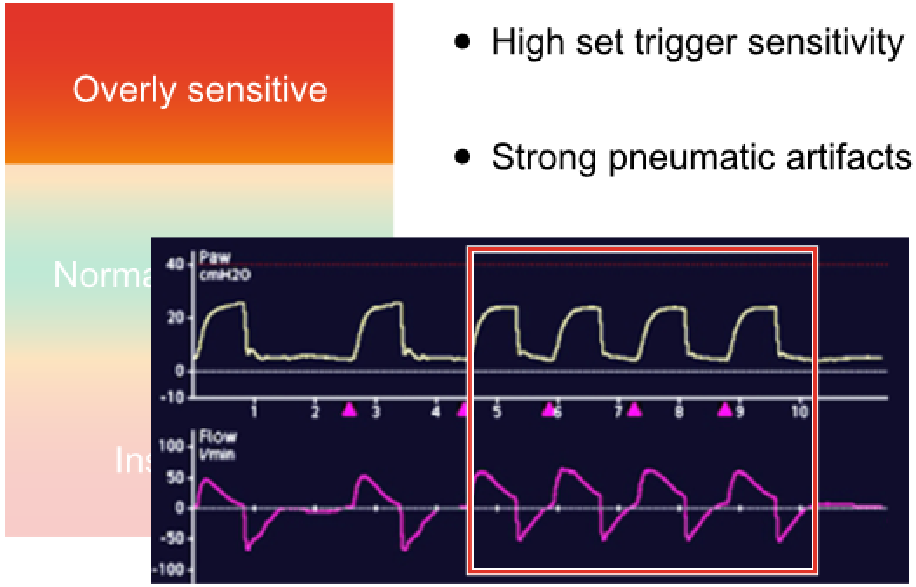
- Patient signals are too weak
- Low set trigger sensitivity

Overly sensitive

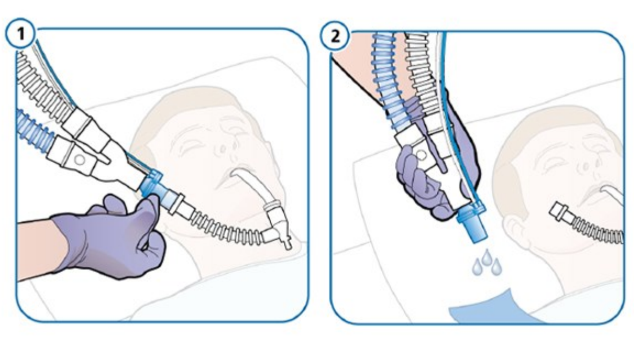
The second form is auto triggering, which means that the ventilator is triggered when the patient does not inhale. Typically auto-triggering appears as a series of quick and rhythmic mechanical breaths.

Auto-triggering:

- High set trigger sensitivity
- Strong pneumatic artifacts

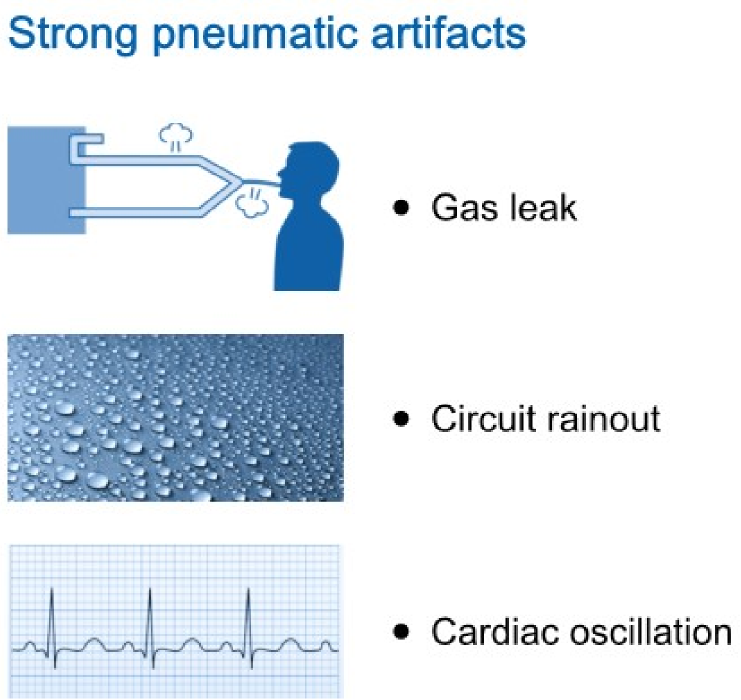


Waveform recorded in pressure A/C mode



Auto-triggering occurs when the ventilator is triggered by pneumatic artifacts but not by the expected patient's inspiratory effort. The artifacts often results from gas leak, condenced water in the circuit,or even cardiac oscillation.

Another possible cause of auto-triggering is that pressure or flow trigger is set to an overly sensitive level.



Cure of Auto-Triggering

The best remedy for auto-triggering is to remove the root cause. If this is not possible, you may carefully decrease the patient trigger sensitivity until auto-triggering disappears.

Bear in mind that this makes triggering harder for the patient.

2. Cycling

Cycling:

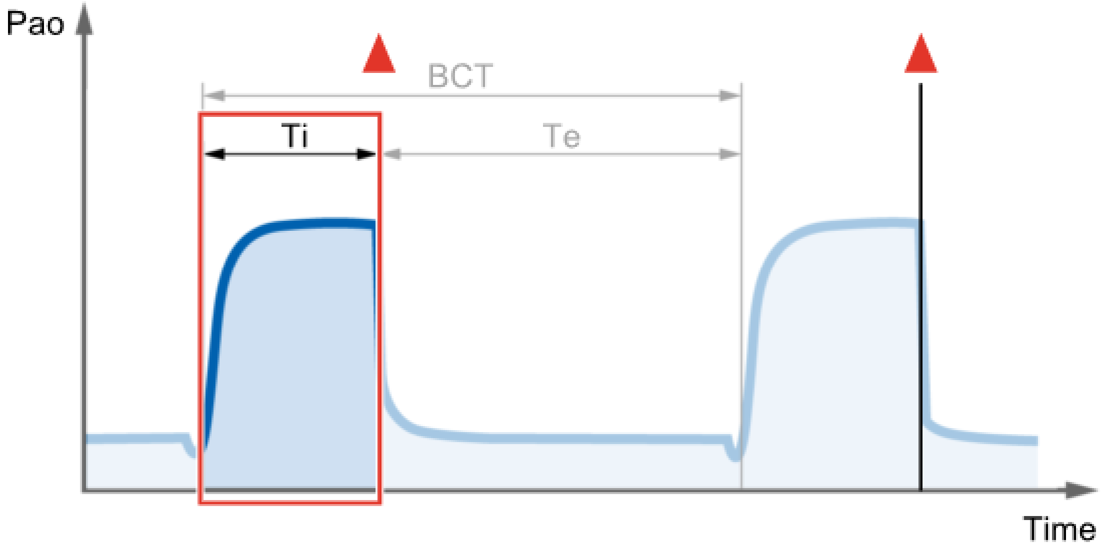
Cycling refers to the “End of Inspiration”.It determine the length of inspiration.

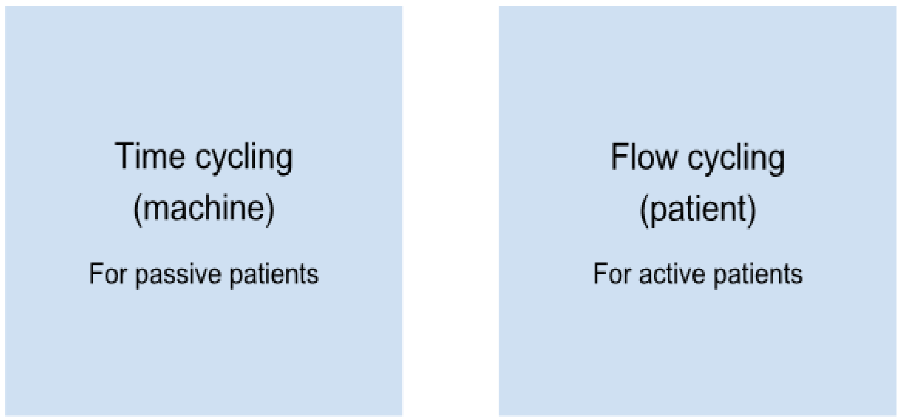
BCT:

BCT is the sum of Ti and Te, if the BCT is given, an increase in Ti causes a corresponding decrease in Te, and vice versa.

Cycling Mechanism:

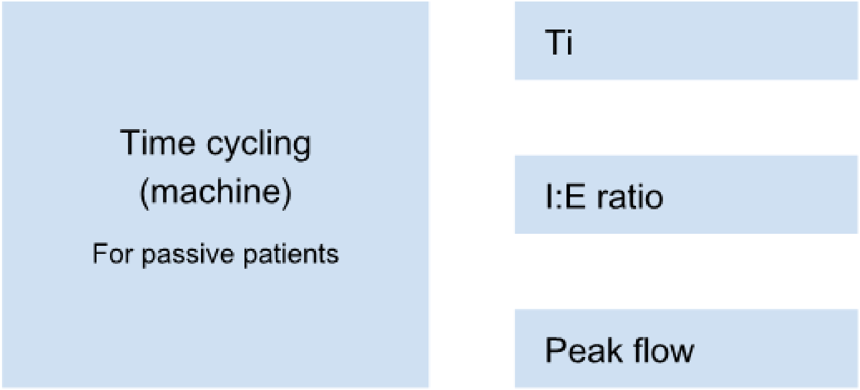
Time cycling and flow cycling are commonly used cycling mechanism.





Time Cycling:

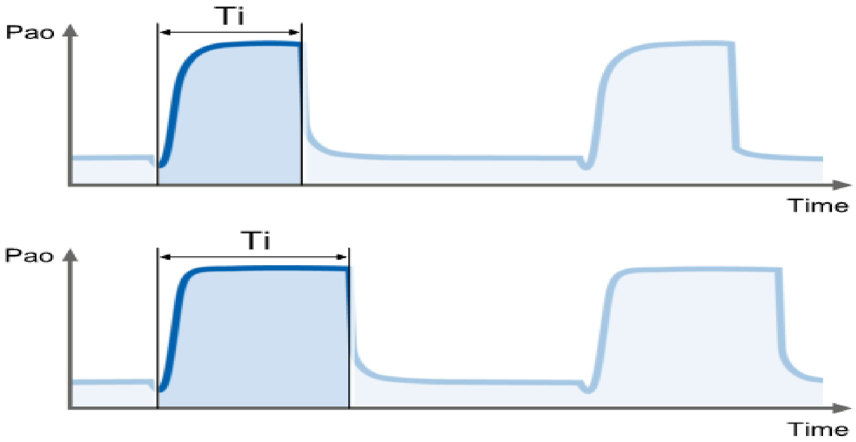
With time cycling, you can define Ti in several ways, including Ti, I:E ratio and Peak flow.



Time Cycling by setting Ti:

In this case, the operator directly sets Ti in seconds. The ventilator switches from inspiration to expiration when the set Ti is over.

This method applies on both volume and pressure breaths.



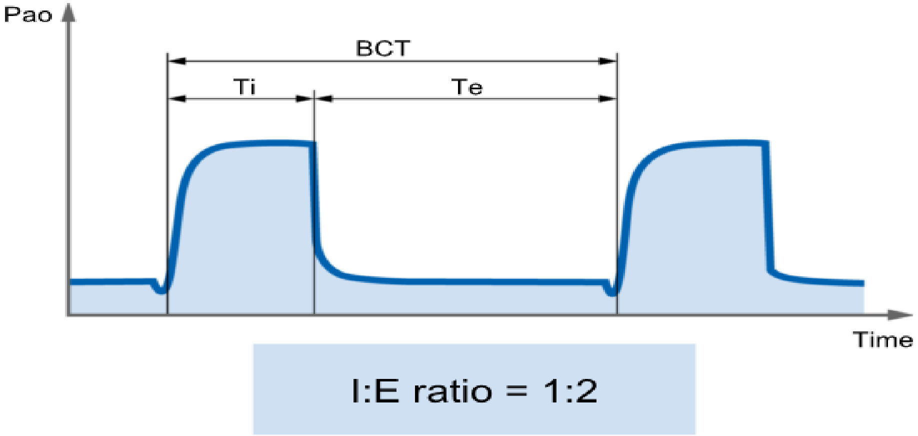
	Ti	I:E	Peak flow
Volume breath	✓	✓	✓
Pressure breath	✓	✓	X

Time Cycling by setting I:E ratio:

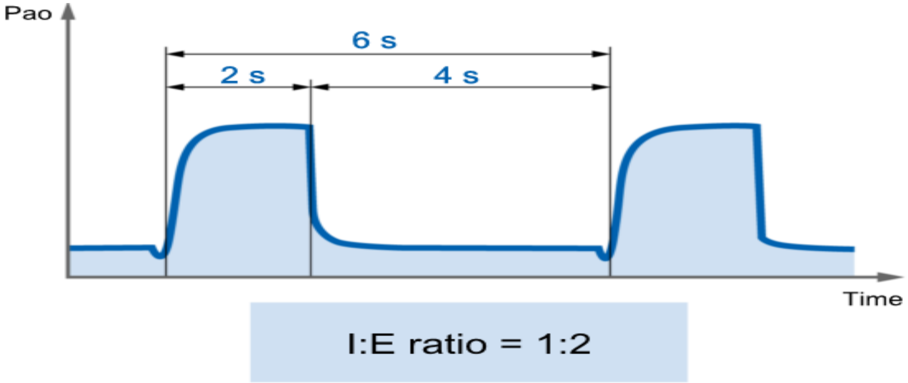
Every breath cycle time, or BCT has two portion, i.e: Ti and Te.

The ratio between Ti and Te is I:E ratio.

The number on the left of colon represents the Ti portion and the number on the right the Te portion.



Assume that we set the rate to 10 breaths per minute for a BCT of 6 seconds. If the set I:E ratio is 1:2, the resulting Ti is 2 seconds, and Te 4 seconds, respectively.

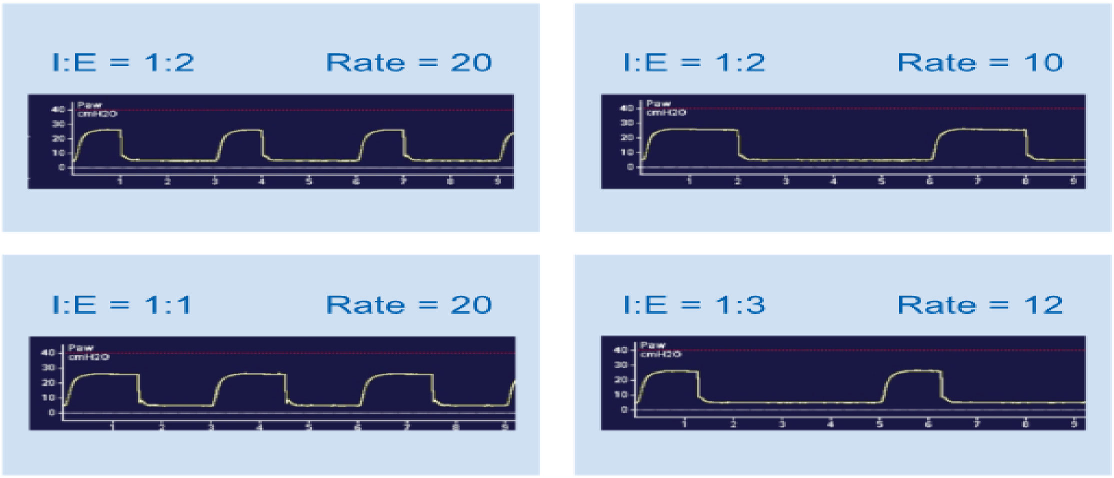


The advantages of I:E ratio are:

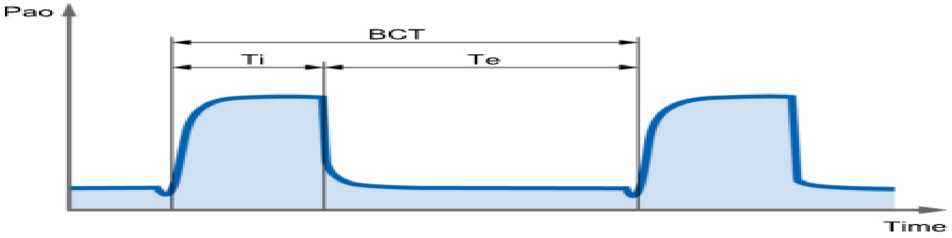
a) A change in either I:E ratio or the set rate, causes corresponding in both Ti and Te
b) The relation between Ti and Te is clearly shown.

The disadvantage is that you do not get Ti and Te in seconds without mental calculation.

Note: In an active patient, the actual breath cycle time, Ti and Te may differ from the expected values.



The I:E ratio method applies to both volume or pressure breaths.



	Ti	I:E	Peak flow
Volume breath	✓	✓	✓
Pressure breath	✓	✓	✗

Time Cycling by setting Peak flow:

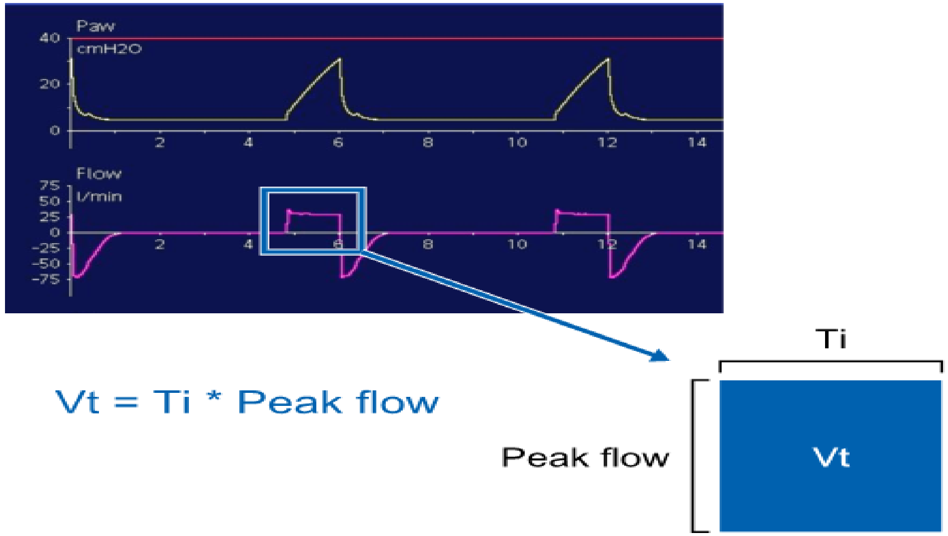
It is a bit confusing how can Ti be defined by setting Peak flow?

Time cycling (machine)

For passive patients

- Ti
- I:E ratio
- **Peak flow**

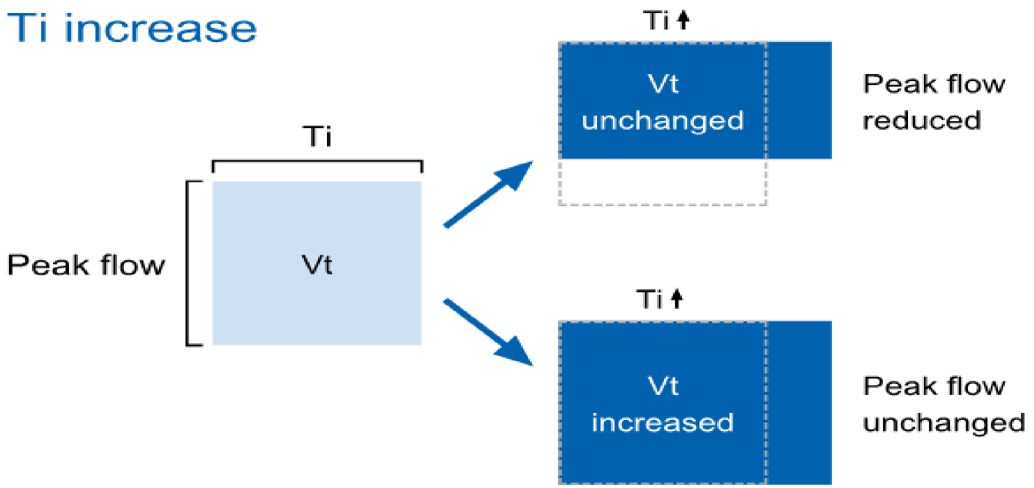
Peak flow refers to Peak Inspiratory Flow. This method applies only to volume breaths with an square flow pattern, meaning that a ventilator delivers the gas at a constant flow rate during inspiration.



Vt = Ti * Peak flow

Under this condition, VT is the product of Ti and Peak flow. Therefore Ti increases when you increase the set tidal volume or decrease the set peak flow, or both.

Ti decreases when you do the opposite.

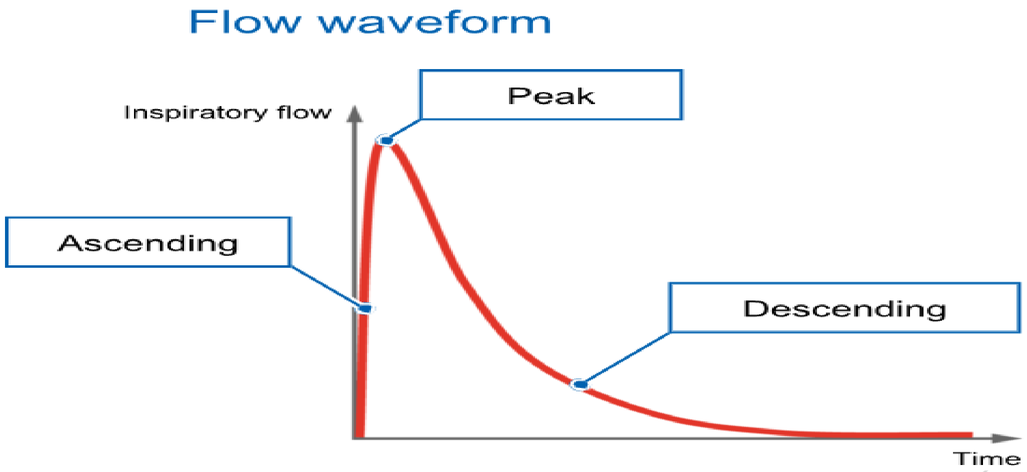


Flow Cycling:

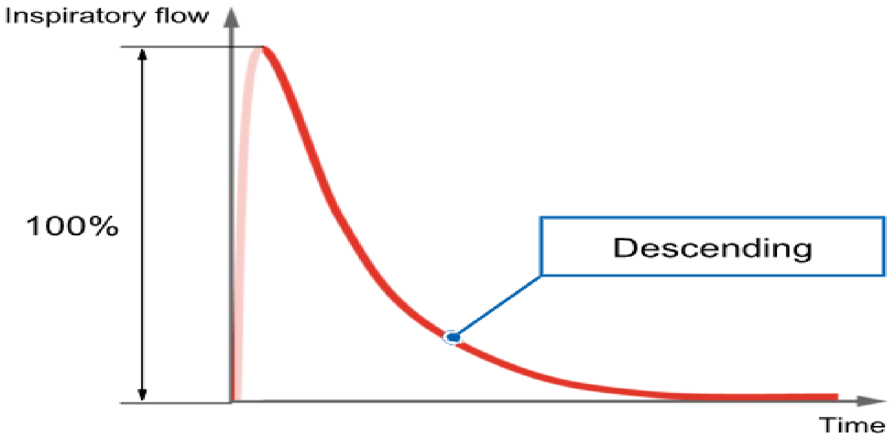
Flow cycling is another way to terminate inspiration based on the change in inspiratory flow.

It is designed for activ ths.

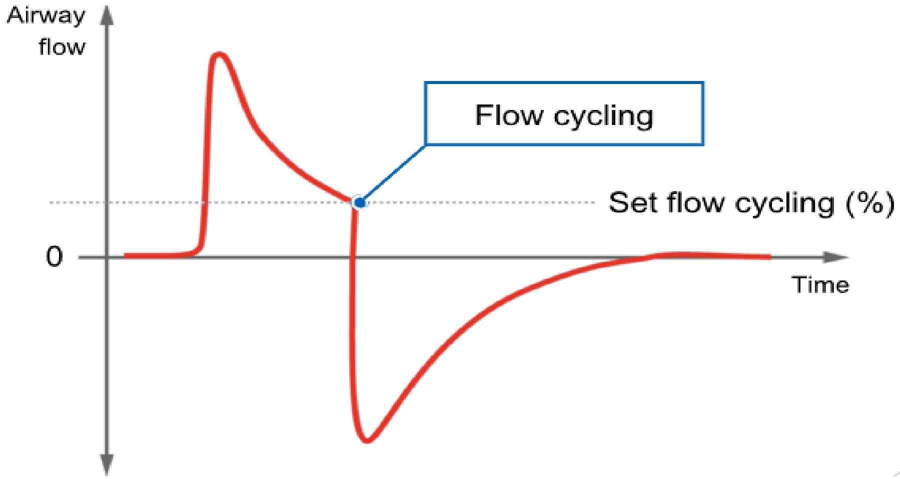
In a pressure breath, the inspiratory flow is uncontrolled. Typically the inspiratory flow rises quickly to the peak at beginning and then drops gradually back to zero.



Flow cycling works with the decending part of inspiratory flow.The peak inspiratory flow is taken as 100%
regardless of it’s absolute value.



A ventilator switches from inspiration to expiration if the inspiratory flow drops to a preset level in percent.



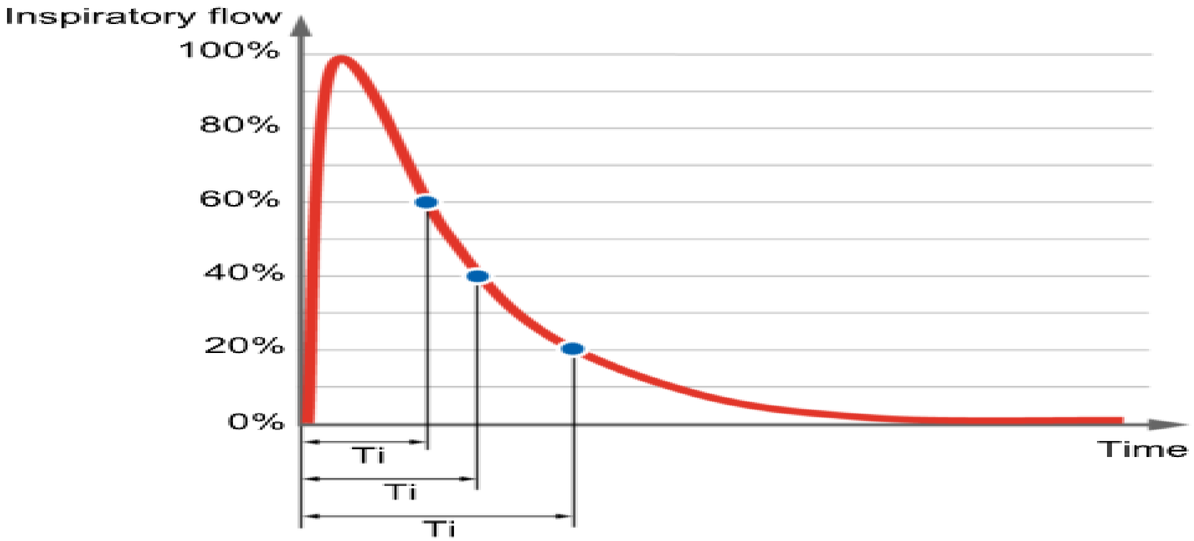
If the flow cycling is adjustable in your ventilator, you can find the control of flow cycling.

In all Hamilton medical ventilators, this control is labelled as “Expiratory trigger sensitivity”(ETS). You can set it any where between 5% to 80%.

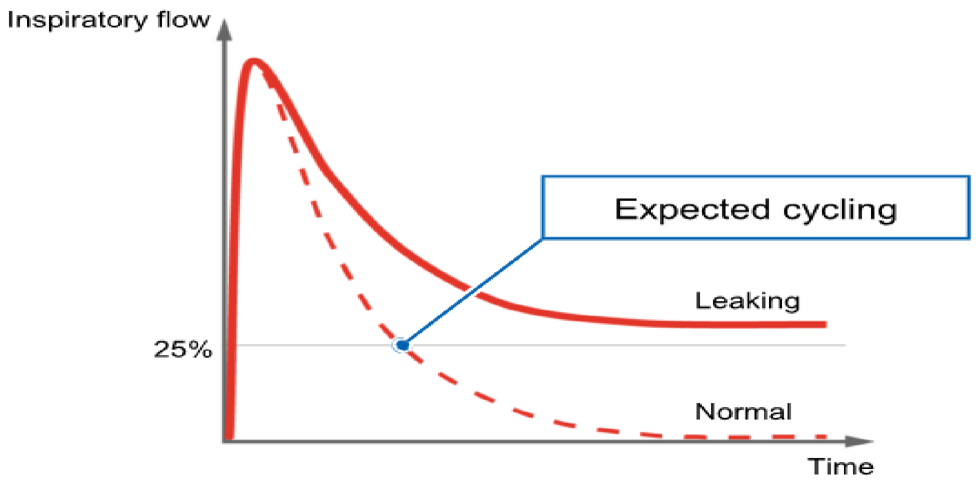
This control is unavailable if flow cycle is fixed at factory.

Flow Cycling enables you to influence the Ti of spontaneous breaths. The lower the set percent, the longer the Ti is , and vice versa.

Flow cycling is very useful to improve patients-ventilator synchrony.

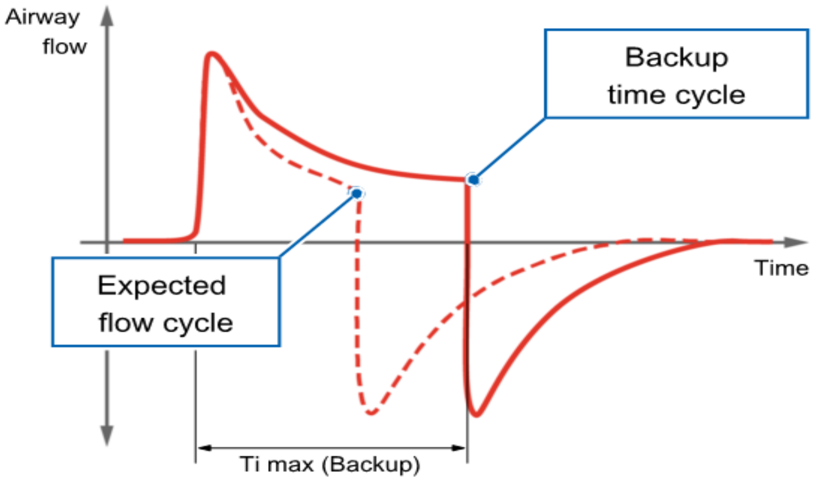


Flow cycling can fails if the system has a massive leak, and the ETS is set very low, because the inspirato not falls to the set cycling level.The consequence is endless inspiration. This is clinically unacceptable.



To avoid the possible incidence, a ventilator has a **backup time cycling** which may be adjustable. If so, you can find a control for that.

In Hamilton Medical ventilators, this control is called “Maximum Inspiratory Time” or Ti max.



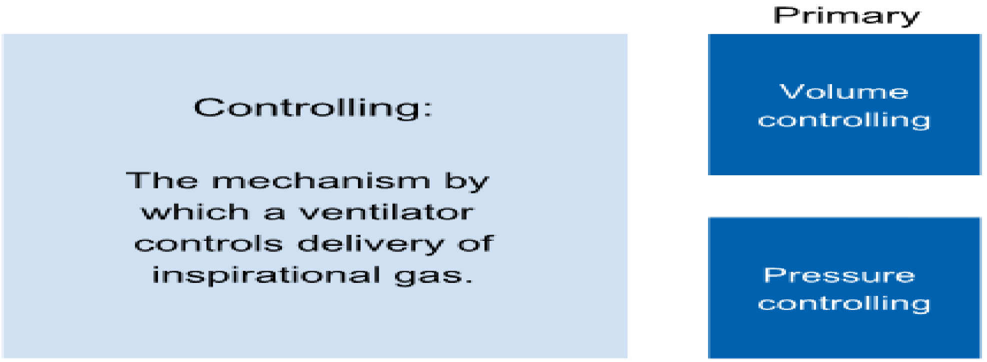
3. Controlling

Controlling:

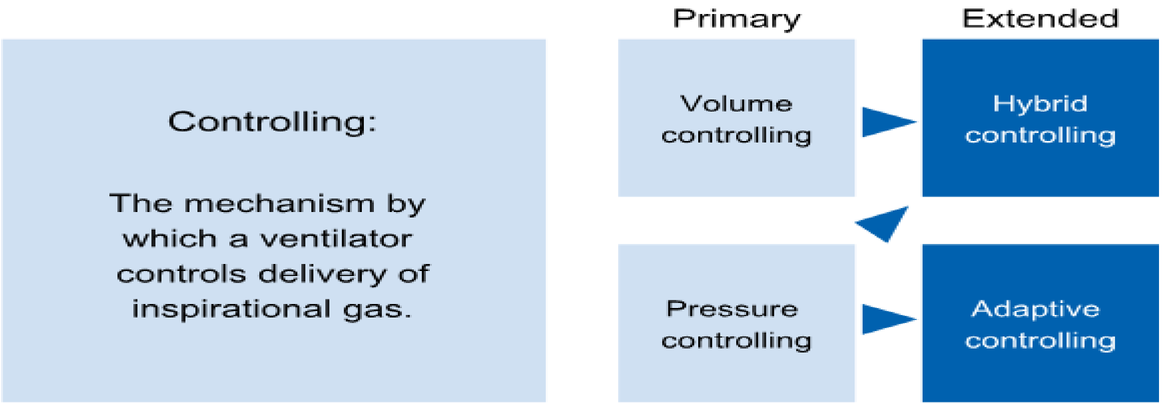
The 3rd essential variable is controlling. Controlling is defined as the mechanism on how a ventilator **Control gas delivery during inspiration.** There are only two primary controlling types:

1. Volume Controlling
2. Pressure Controlling

At any given time, a ventilator can only control either the **volume** or the **pressure**, but not both.

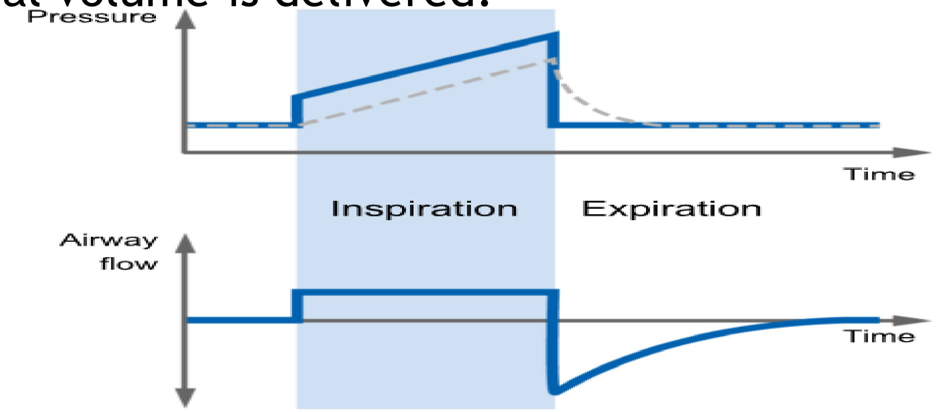


In addition, there are two extended controlling mechanism. Pressure controlling has a variant called **Adaptive Controlling.** Some ventilator have **Hybrid Controlling.**

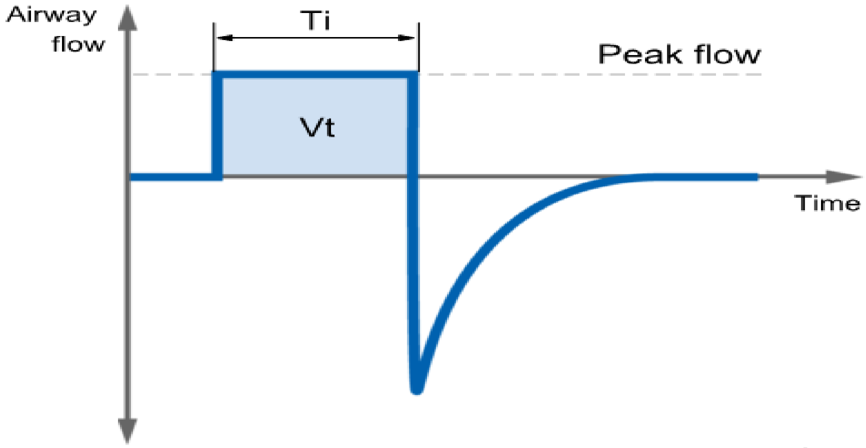


Volume Controlling (flow Controlling)

A better term for volume controlling is "flow controlling", because during inspiration a ventilator actually controls the flow of inspiratory gas delivered into the circuit. At the end of inspiration, the set tidal volume is delivered.

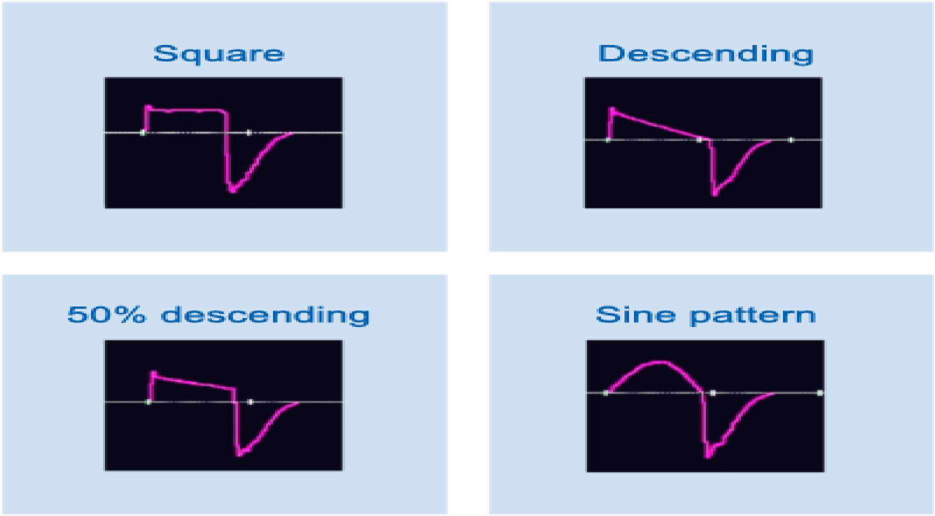


Volume controlling is shaped with three primary controls: i.e: VT, Ti and Peak flow.
Typically we set VT and Ti, or Ti and Peak flow. The ventilator calculate the third one automatically.



Volume controlling may have a secondary control: (Inspiratory) flow pattern. Square pattern is the third most common one.

However, some ventilators provide more flow pattern. For example, Hamilton G5, S1 and C6 ventilators provide square, descending and sine flow patterns.



The major perceived advantage of volume controlling is stable tidal volume as well as minute volume with which we may comfortable.

Stable Vt and possibly stable minute volume

However, volume controlling has 4 inherent disadvantages.

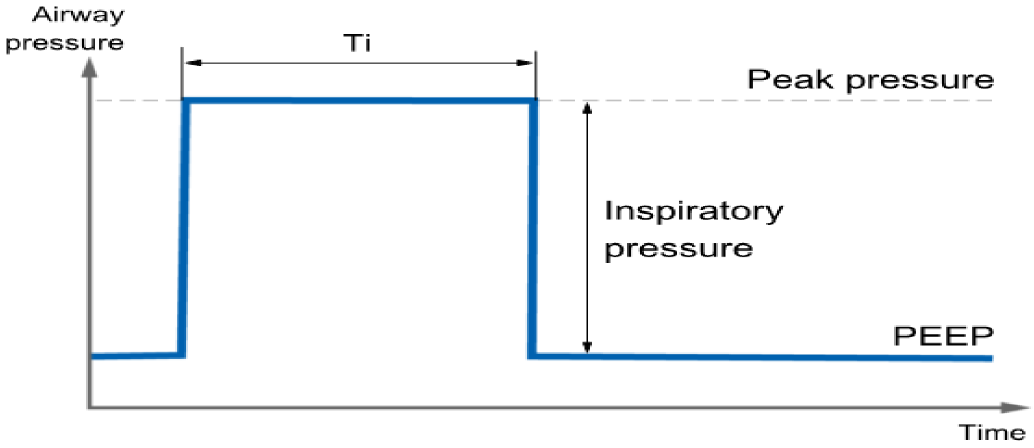
- asynchrony in active patient; with volume controlling, a ventilator dictates all important aspects of inspiratory gas delivery. This is hardly acceptable if the patient is active. This explain why patient-ventilator asynchrony often occurs in volume modes.
- Invisible volume loss in circuit; with volume controlling, the tidal volume that a ventilated patient receives is always less than that a ventilator delivers into the circuit. This is due to gas compression is an elastic breathing circuit. The tidal volume difference is invisible volume loss. For instance, if the set tidal volume is 500 ml, the patient may only get 450 ml.This invisible volume loss needs to be corrected by circuit compliance compensation.
- no leak compensation; with volume controlling, leak compensation is imposible, because a ventilator delivers exactly the same volume into the circuit.
- variable peak pressure; with volume controlling, the peak pressure is variable, dependent on the set VT, Peak flow, the patient's

respiratory resistance and compliance and breathing efforts. A constantly high peak pressure can damage the lungs.

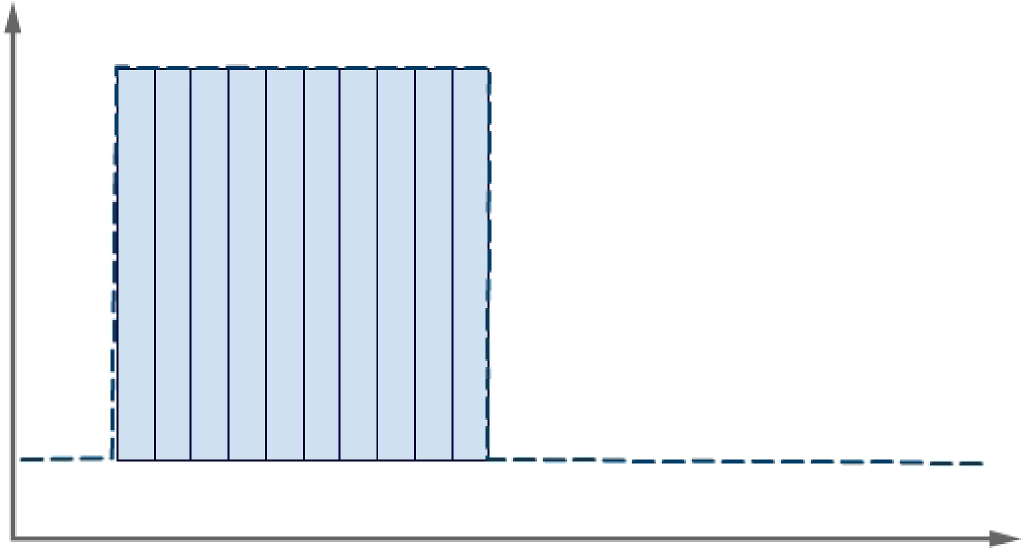
- Due to these disadvantages, volume controlling has given place slowly but steadily to pressure controlling.

Pressure Controlling

With pressure controlling a ventilator 1st draws a target airway pressure profile according to the setting of Ti and inspiratory pressure.



During inspiration, the ventilator dynamically adjusts the inspiratory gas flow to minimize the gap between the actual airway pressure and the target pressure profile.



This means that the ventilator increases the inspiratory flow if the monitored pressure is much below the target pressure.

It **decreases** the inspiratory flow, if the monitored pressure is a bit below the target pressure.

It **stops** the inspiratory flow if the monitored pressure matches the target pressure.

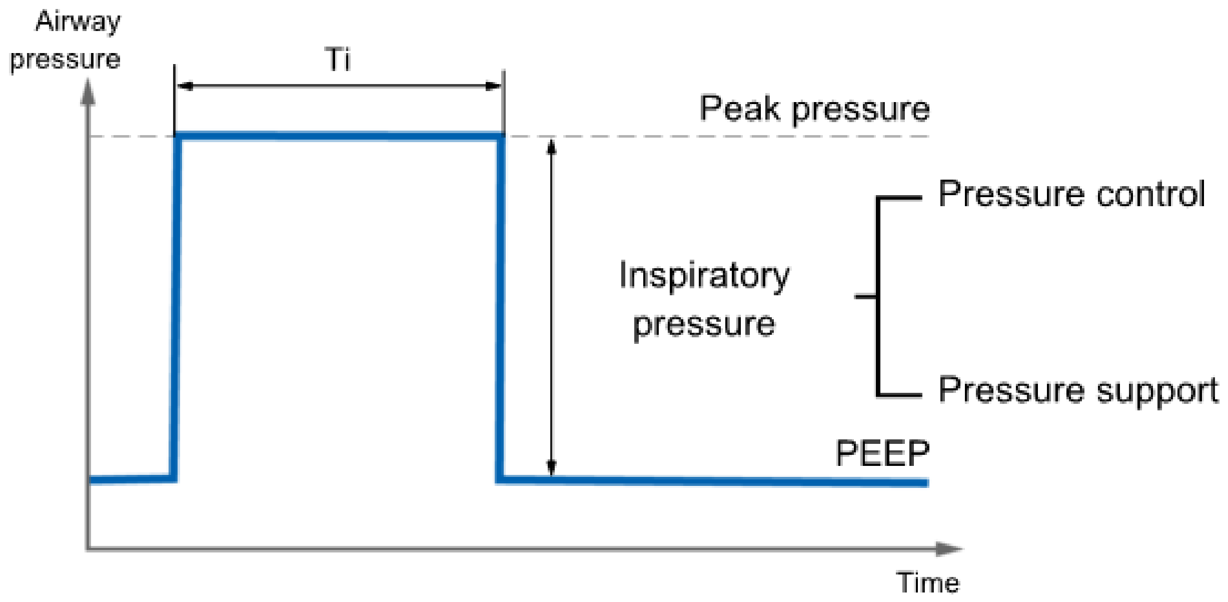
If actual p << Target p	Insp. flow ↑↑
If actual p < Target p	Insp. flow ↑
If actual p = Target p	Insp. flow -

Pressure controlling is shaped with two primary controls: Ti and inspiratory pressure.

Inspiratory pressure refers to the intended positive pressure applied above PEEP. It drives gas to move into the lungs. In Hamilton Medical ventilators, inspiratory pressure is labeled either,

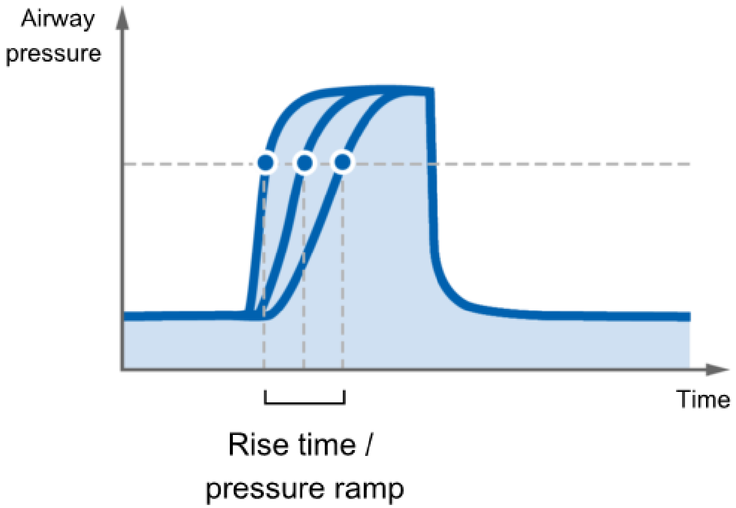
as **Pressure control** for mandatory breaths, or

as **Pressure support** for spontaneous breath.



Pressure controlling may have a secondary control: **Pressure ramp** (Pramp) or **Rise time**.

It is defined as the time required for airway pressure to rise to a target pressure at the beginning of inspiration. A short P-ramp means a fast circuit pressurization, and vice versa.



If volume controlling is compared to a dictator, pressure controlling is somewhat a liberal because VT and inspiratory flow can vary as per the patient’s demand.

Because of this important property, patient-ventilator asynchrony occurs much less frequently.

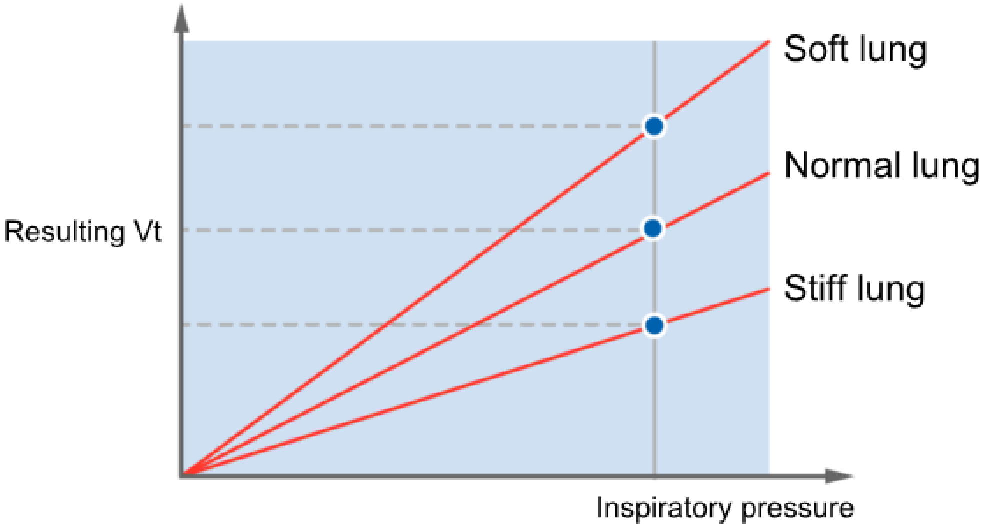
When the system has a leak, causing circuit pressure to drop, the ventilator immediately responds with increase in the inspiratory flow.

This is how leak compensation works. With pressure controlling, a ventilator can effectively compensate a moderate leak.

- Superior patient ventilator synchrony
- Leak compensation

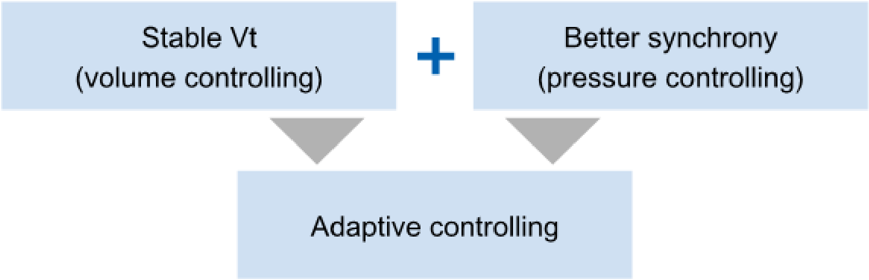
With pressure controlling, the tidal volume is variable, dependent on the set inspiratory pressure, the patient’s respiratory resistance and compliance, and the patient’s breathing efforts.

Under unfavorable conditions, the resultant tidal volume can be too large or too small. It is important to set tidal volume alarms properly to safeguard the patient.



Adaptive controlling

Adaptive controlling represents the outcome of the efforts to exploit the advantages and to minimize the disadvantages of both volume and pressure controlling.



Adaptive controlling is a variant of pressure controlling.

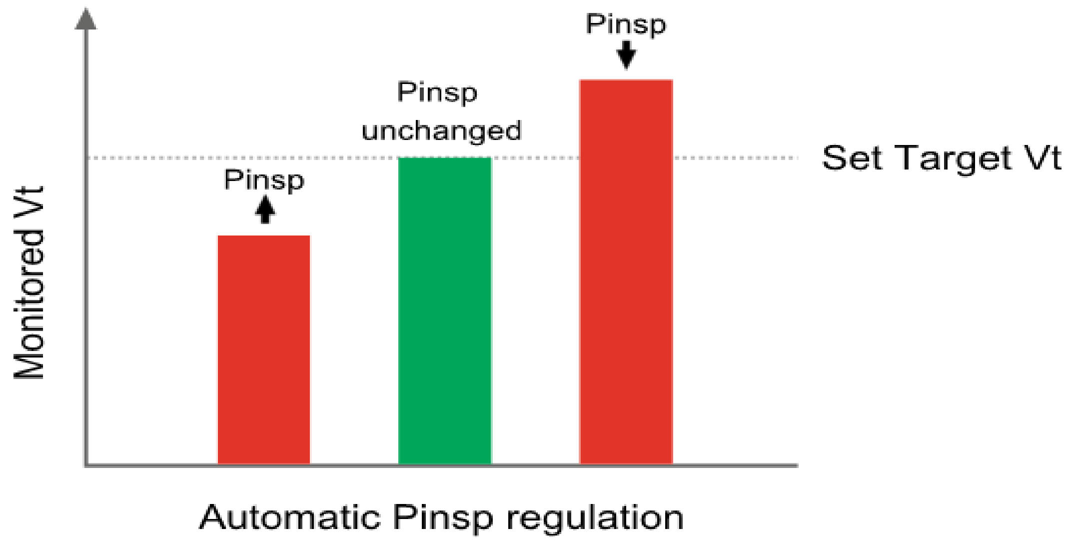
With pressure controlling, the inspiratory pressure is set, the peak pressure stays stable, and the resultant Vt may vary.

With adaptive controlling, the inspiratory pressure is automatically regulated breath-by-breath to match the monitoring Vt to the target Vt set by the operator.

	Pressure controlling	Adaptive controlling
Inspiratory pressure	Set and fixed	Automatic regulated
Resulting tidal volume	Variable	Targeted relatively stable

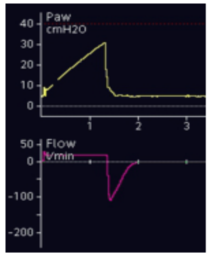
In detail, the ventilator does the following:

- Increases inspiratory pressure if the monitored Vt is below the target.
- Decreases inspiratory pressure if the monitored Vt is above the target.
- Keeps inspiratory pressure unchanged if the both tidal volume are equal.

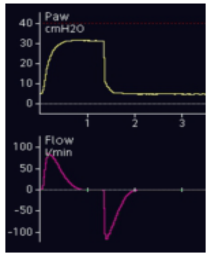


Adaptive controlling may be misperceived as volume controlling because tidal volume can be set in both cases. Other than that, they have nothing in common. Here the waveforms of volume, pressure and adaptive breaths exhibit the similarities and differences.

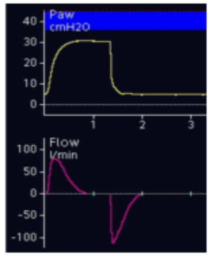
Adaptive controlling ≠ Volume controlling



Volume controlling breaths



Pressure controlling breaths



Adaptive controlling breaths

Advantages of adaptive controlling

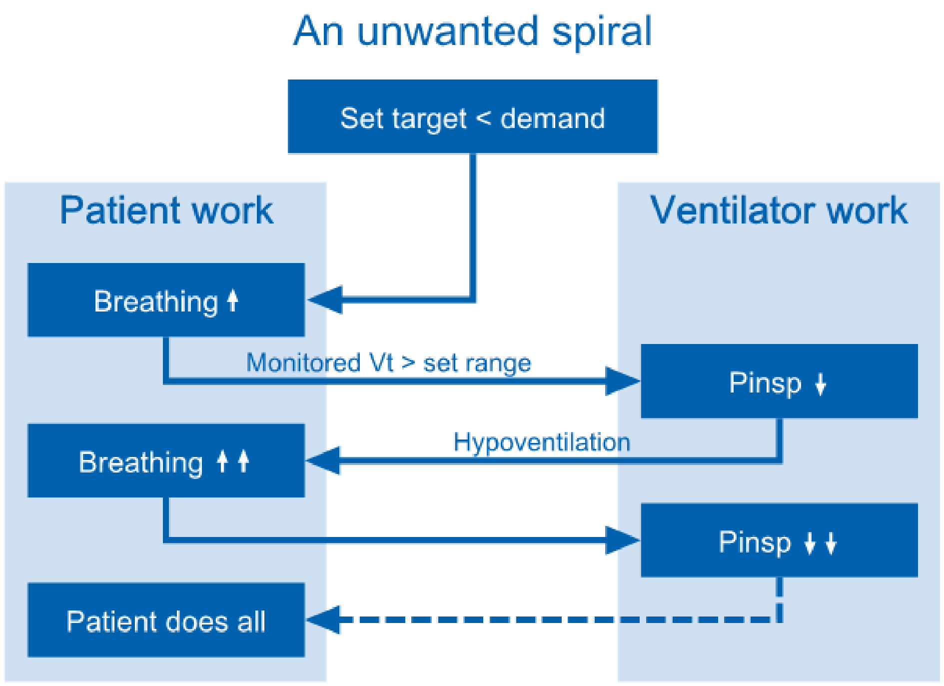
The major advantages of adaptive controlling are:

a) The actual Vt can be rather stable, especially in passive patients
b) It keeps most advantages of pressure controlling.

For optimal performance, adaptive controlling has a hard, yet rarely mentioned requirement for the operator:

The target volume must be always adapted to the patient’s current ventilatory demand, which may change over time.

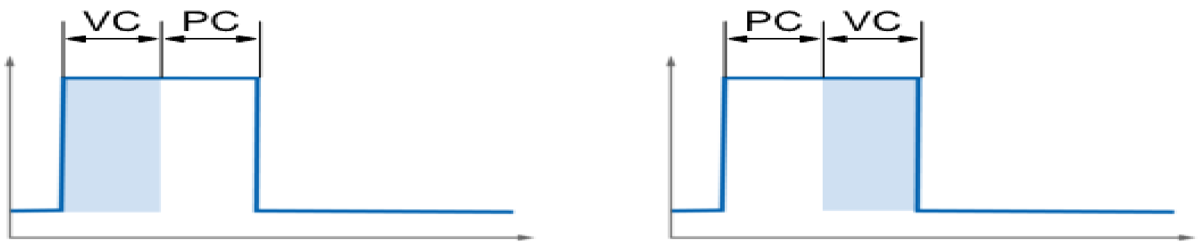
- An unfavorable scenario is that the target volume is set lower than the current demand.
- The patient has to breathe harder to satisfy the demand.
- As the monitored Vt exceeds the set target, the ventilator reduces the inspiratory pressure.
- At the end, the patient does all work of breathing, and the ventilator does little.



Hybrid Controlling

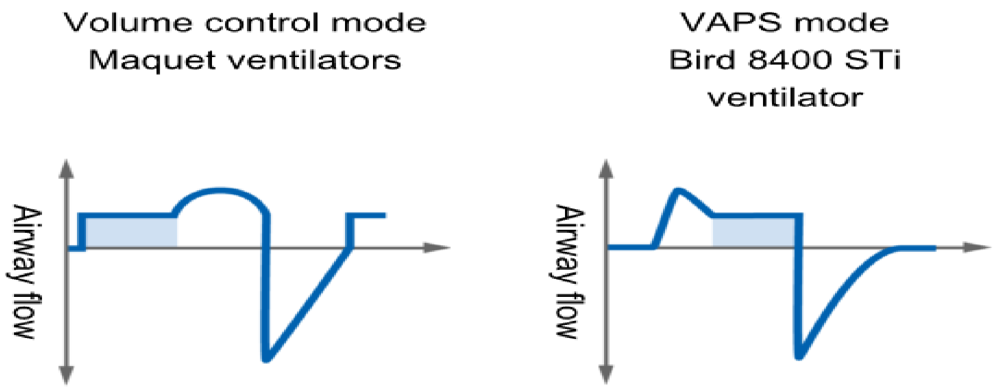
Hybrid controlling is defined as application of both pressure controlling and volume controlling within the same mechanical breath.

In Chatburn's taxonomy of mechanical ventilation, hybrid controlling is named as "dual control".



Typical examples include volume assured pressure support (VAPS) mode of Bird 8400 STi ventilator and volume control mode of Maquet ventilators.

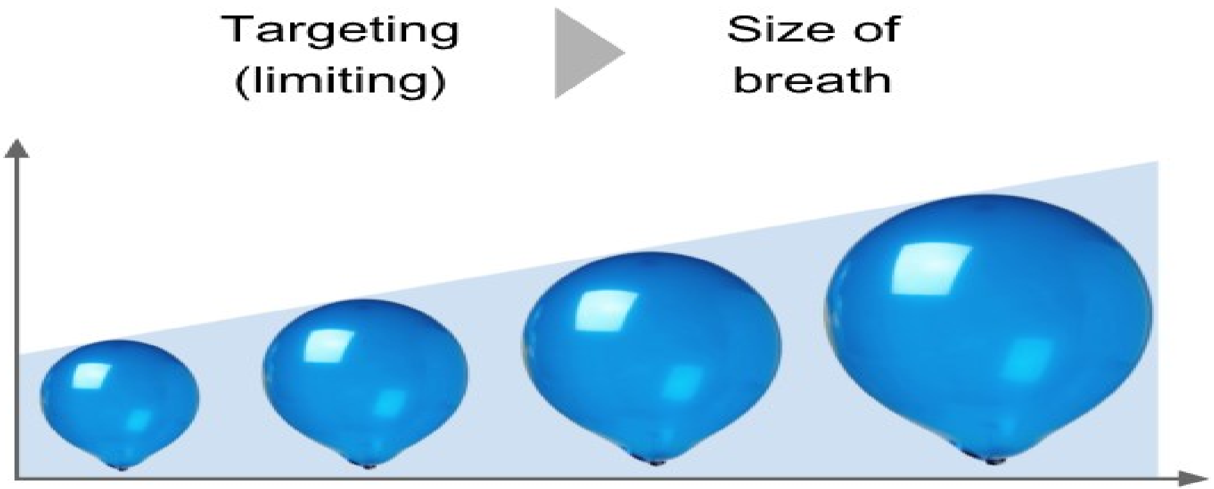
We will not go deeper with hybrid controlling because it is complicated to understand and has not been popularized thus far.



4. Targeting

Targeting:

Targeting is the fourth essential variable to define the size of a mechanical breath. Targeting is also known as "limiting" with the same meaning.



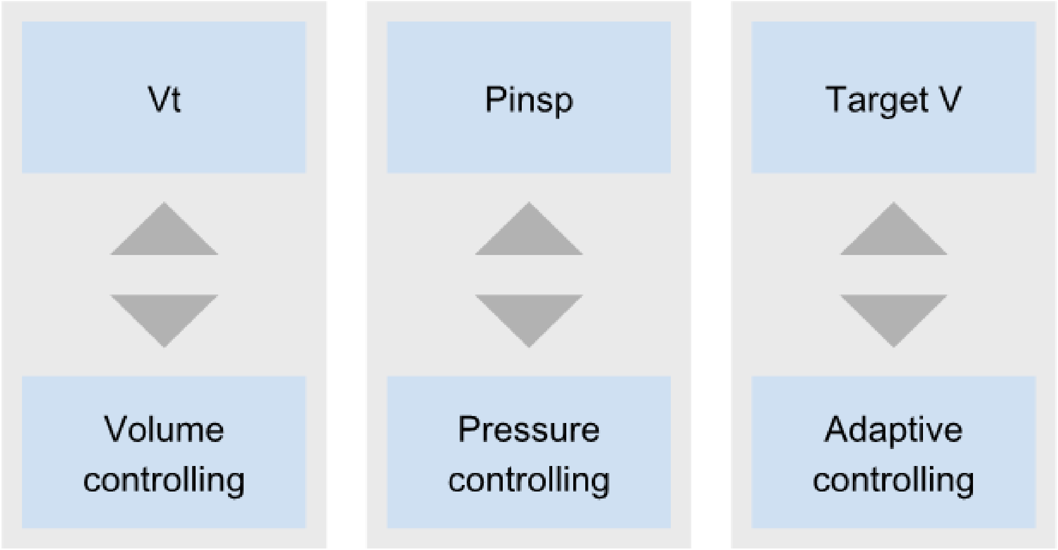
Target parameter:

Targeting is always paired with the controlling type.

The target parameter is:

- Tidal volume with volume controlling
- Inspiratory pressure with pressure controlling
- Target tidal volume with adaptive controlling.

When the set targeting is reached, a ventilator stops delivering further gas into the circuit. Reaching the target, however, does not necessarily mean immediate cycling from inspiration to expiration



5. PEEP

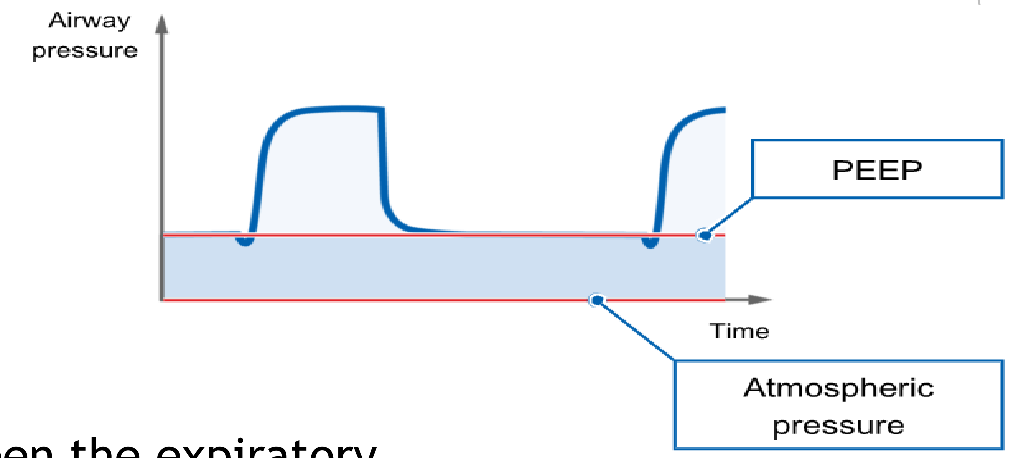
PEEP: (The baseline pressure)

PEEP stands for Positive End Expiratory Pressure and is the baseline pressure above which inspiratory pressure is applied intermittently.

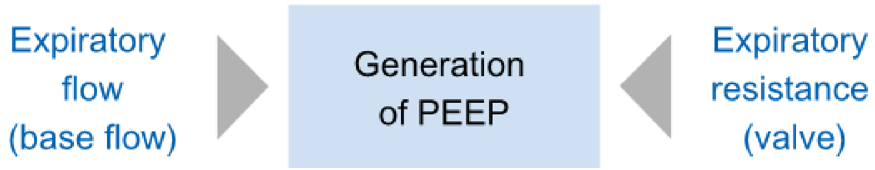
This is the fifth and the last essential variable.

PEEP is expressed in cmH2O, and counts from zero or atmospheric pressure.

PEEP is adjustable in all ventilators.



PEEP is generated by interaction between the expiratory gas flow and the resistance imposed by the expiratory valve of the ventilator.



PEEP alone is therapeutic as it can increase functional residual capacity (FRC), improve alveolar gas exchange, keep the lung units open, and even improve lung compliance.

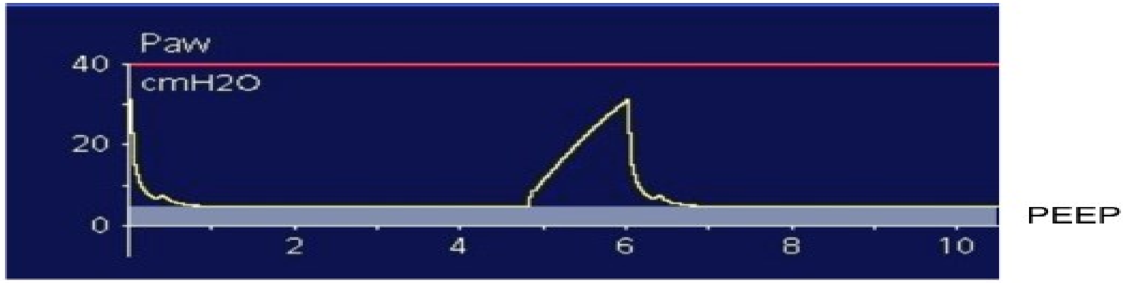
PEEP is therapeutic

- Increase FRC
- Improve oxygenation
- Keep the lung units open
- Improve lung compliance

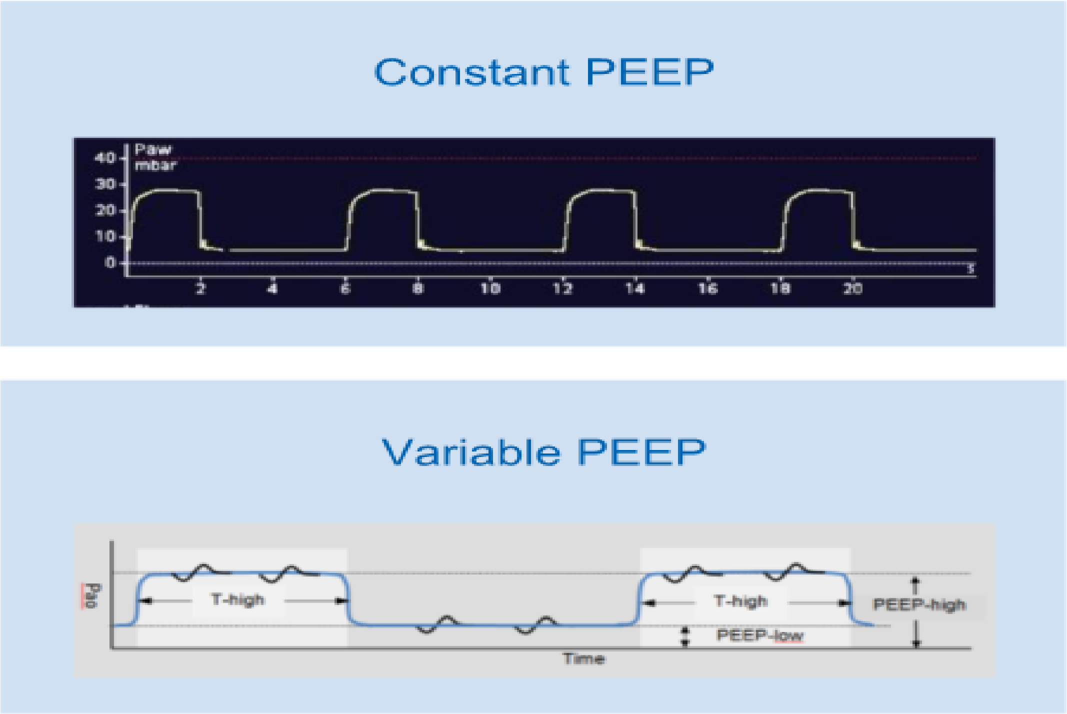
A moderate level of PEEP, 3 to 5 cmH2O, is generally recommended, and may be beneficial for all intubated and ventilated patients.

A high PEEP may be clinically necessary for patients with restrictive lung diseases, such as ARDS.

Avoid to use zero PEEP although it is possible.



PEEP is usually constant in all ventilation modes. An exception is in biphasic modes where PEEP alternates automatically between two set levels.



Breath type

From variables to mechanical breaths

So far, we have learned all five essential variables. With this knowledge, we are now ready to define mechanical breath types.

This task requires just three variables:

- Triggering
- Cycling
- Controlling

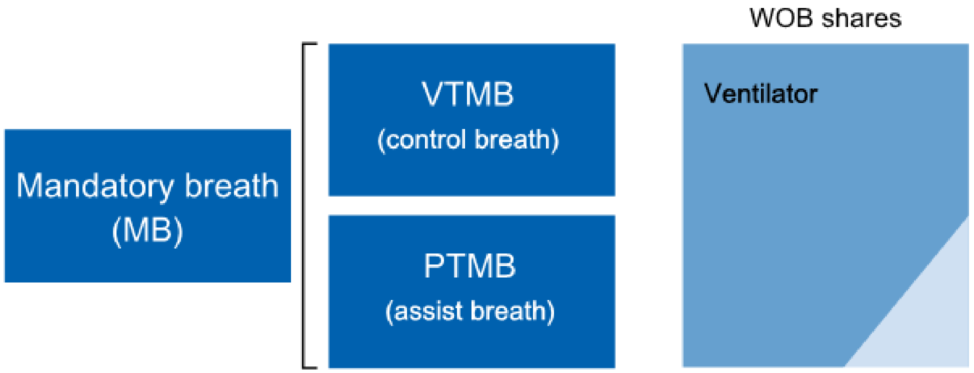
PEEP is applicable for all breath types and targeting is paired with controlling.

Mandatory Breath & Spontaneous Breath

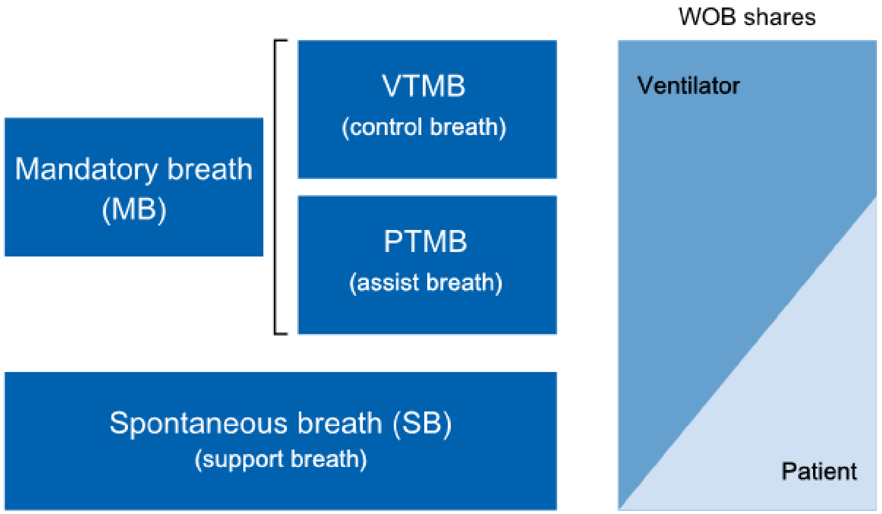
Here we need to explain two terms: mandatory breath and spontaneous breath.

If a mechanical breath is time cycled, it is a mandatory breath (MB). With MB, the ventilator does all or most of work of breathing. MB has two types:

- If a MB is time triggered, it is a ventilator-triggered mandatory breath or VTMB. It is also known as control breath.
- If a MB is patient-triggered, it is a patient-triggered mandatory breath or PTMB. It is also known as assist breath.



If a mechanical breath is patient triggered and flow cycled, it is a spontaneous breath or SB. With SB, the patient does all or most of work of breathing. A SB can be supported or unsupported by the ve



Classification of mechanical breath types:

Here is a 3 x 3 matrix for classification of mechanical breath types:

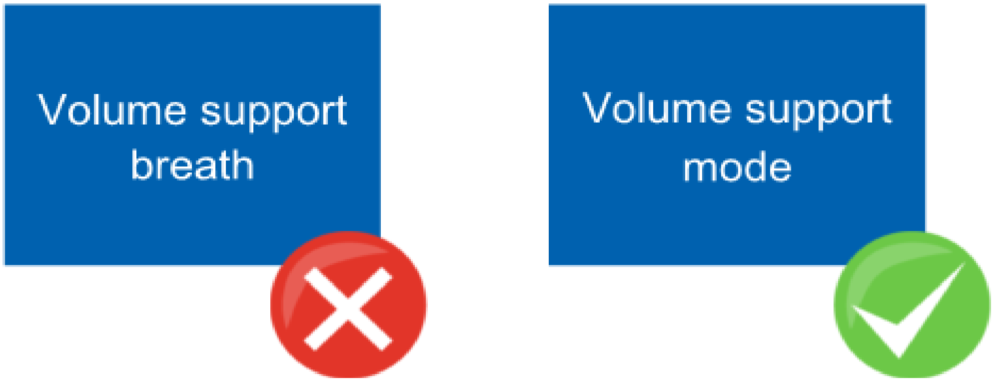
- One dimension is based on triggering and cycling. Dependent on the selection, a mechanical breath can be either a VTMB, PTMB, or a SB.
- The other dimension is based on controlling. Dependant on the selection, a mechanical breath can be either a volume, pressure, or adaptive breath.

Combining the two dimensions, we get eight breath types

	Volume controlling	Pressure controlling	Adaptive controlling
Time-triggered, time-cycled	Volume VTMB	Pressure VTMB	Adaptive VTMB
Patient-triggered, time-cycled	Volume PTMB	Pressure PTMB	Adaptive PTMB
Patient-triggered, flow-cycled	---	Pressure SB	Adaptive SB

There is no volume supported breath because flow cycling is impossible with volume controlling, however there is a mode called “Volume Support”.

Do not mix up the two.

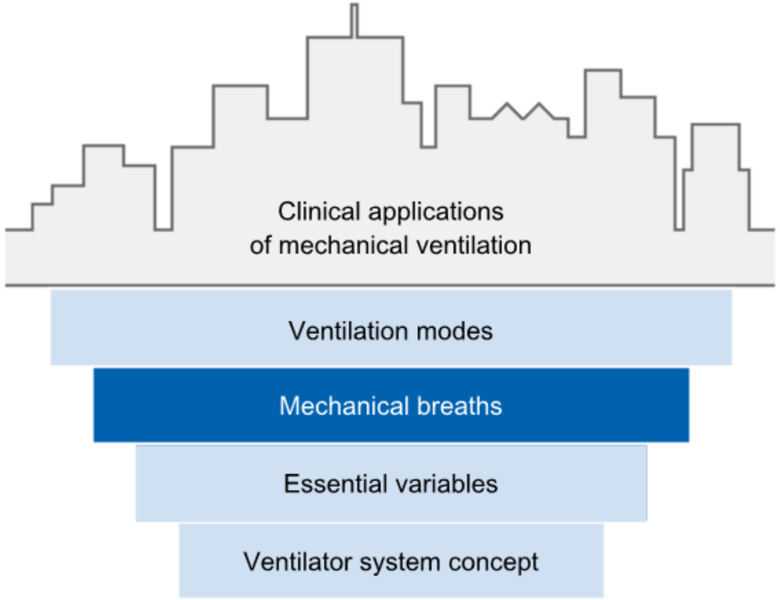


Breath types:

There is no volume support breath because flow cycling is impossible with volume controlling. However, there is a mode called “Volume support”.

Do not mix up the two.

These mechanical breath types are critically important, because they form the foundation of conventional and adaptive modes.



When facing an unknown ventilation mode, if you can identify correctly its essential variables and breath types, you can pretty much tell what it can do and where it can be used, regardless of its given name.

Conclusions:

In this learning module, we learnt five essential variables:

- Triggering
- Cycling
- Controlling
- Targeting
- PEEP

The knowledge of essential variables is very useful because the variables are directly related to ventilator control parameters.

By applying this knowledge of the essential variables, we identified eight mechanical breath types. The mechanical breath types are the foundation of ventilation modes.

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