بسم الله الرحمن الرحيم

BASICS OF MECHANICAL VENTILATION

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WNH

VENTILATORY MODES

Untriggered Modes

- CMV (IPPV)
- IMV

Triggered Modes

- A/C (SIPPV,PTV)
- SIMV
- PSV
- PSV-VG

I. Untriggered Modes

A ventilatory cycle occurs periodically at fixed intervals (strictly time-cycled).

1. **CMV = IPPV**: the ventilator rate is set *faster* than the spontaneous respiratory rate (usually 50-80/min).

2. **IMV**: the ventilator rate is *lower* (<30/min), thus the patient can breath spontaneously between two controlled ventilator cycles.

CONSEQUENCES OF ASYNCHRONY

Active expiration against ventilator inflation may lead to:

- ↓ **Tidal volume and minute volume.**
- ↑ **O_2 consumption.**
- ↑ **Intrathoracic pressure.**
- ↓ **Cardiac output.**
- ↑ **Venous pressure.**
- **Inadequate gas exchange.**
- ↑ **Risk pneumothorax and IVH.**

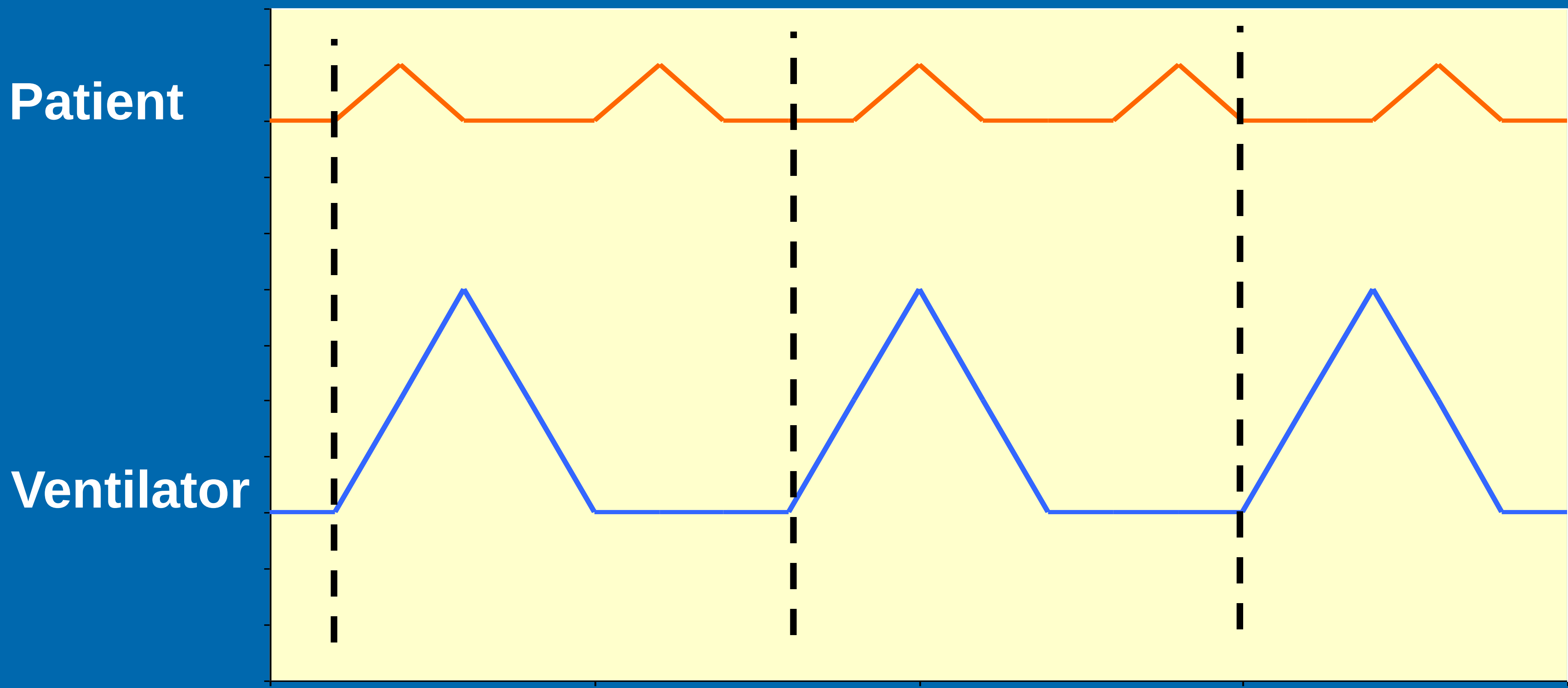
So, synchrony is extremely important and can be achieved by detecting infant's inspiratory effort and using it to trigger positive pressure inflation (triggered-ventilation).

Intermittent Mandatory Ventilation (*IMV*)

- Even if the infant initiates a breath simultaneously with mechanical inspiration, differing inspiratory times may result in the development of asynchrony during the expiratory phase.

- **After only a few breaths, the infant may be exhaling against the full pressure of a mechanical inspiration.**

- **When synchrony occurs, it is merely a random event.**



IMV:

Note the random occurrence of synchrony, since patient and ventilator essentially function independently of one another.

II. Triggered modes

1. SIMV.
2. A/C = PTV = SIPPV.
3. PSV.
4. PSV + VG.

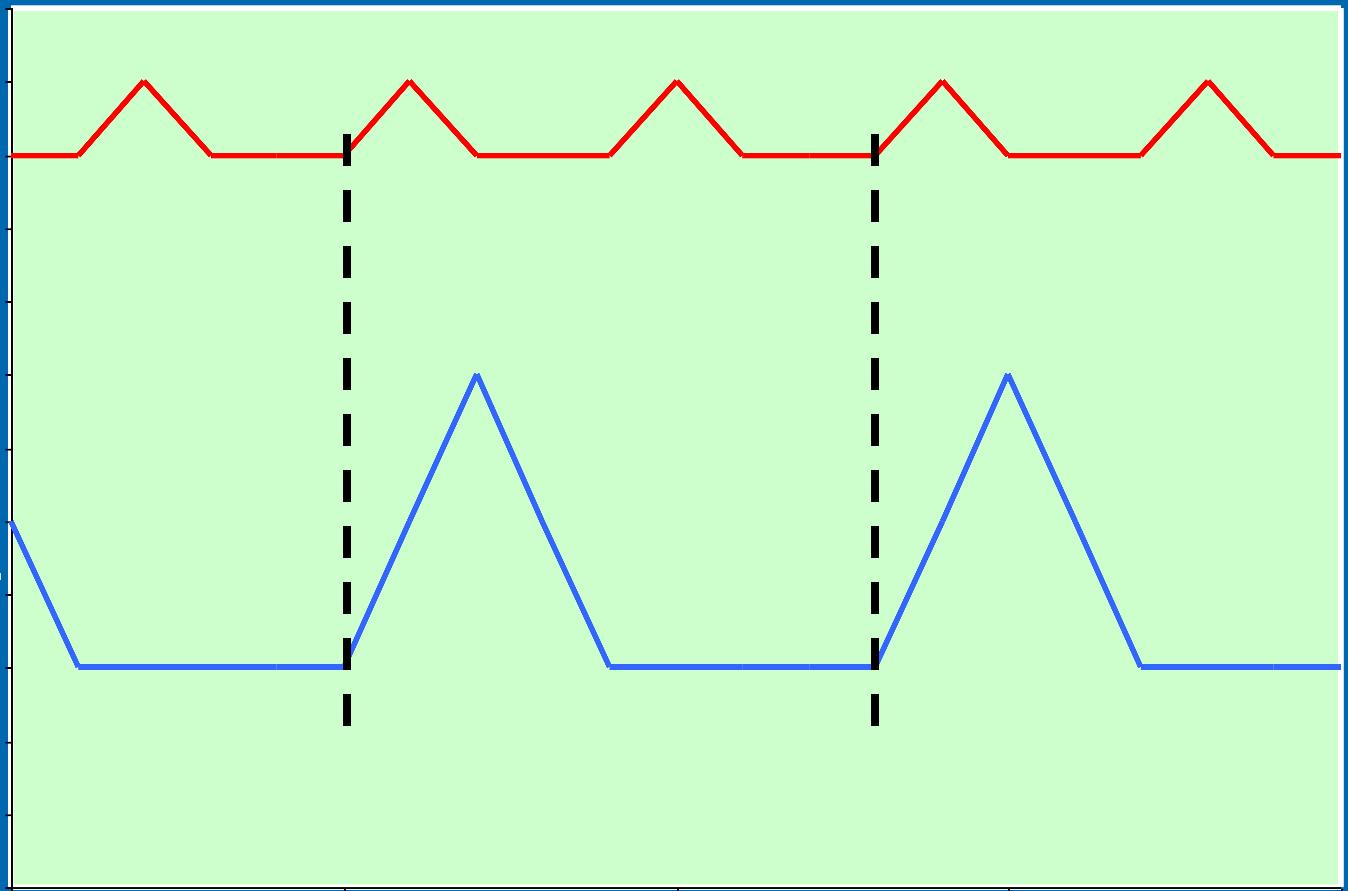
Synchronized Intermittent Mandatory Ventilation (SIMV)

- SIMV is a ventilatory mode in which the mechanically delivered breaths are synchronized to the onset of spontaneous patient breaths.

- The patient may breathe spontaneously between mechanical breaths from the continuous bias flow in the ventilatory circuit.

- Each mechanical breath is initiated in response to the onset of the patient's own respiratory effort; this results in full inspiratory synchrony.

- However, unless the inspiratory times are identical, the patient may terminate his effort and begin exhalation while the ventilator is still in the inspiratory phase, this again results in partial asynchrony.



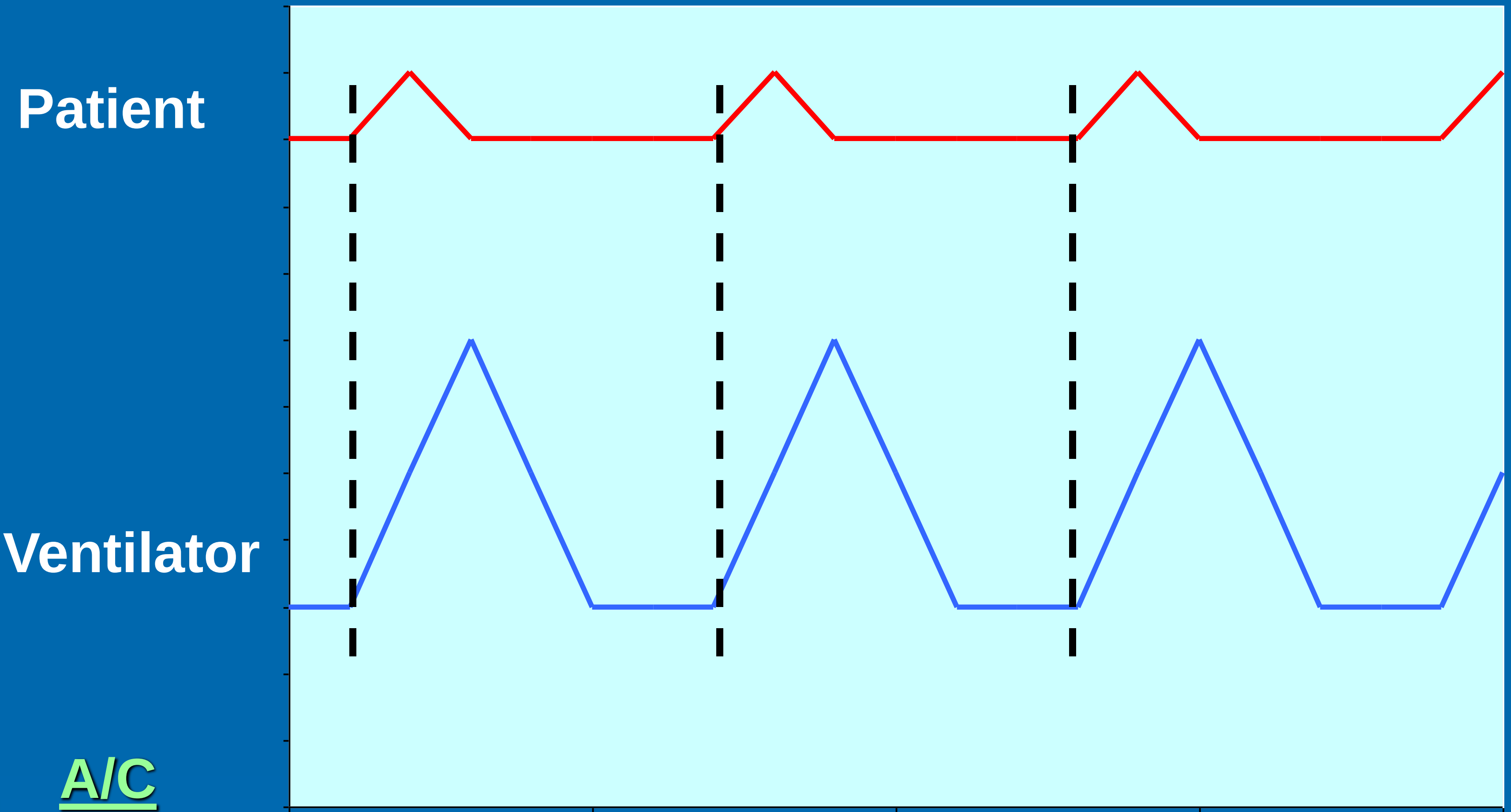
SIMV:

The onset of mechanical inspiration is synchronized to the onset of patient inspiration; the patient breathes spontaneously between mechanical breaths.

Note that dyssynchrony can develop during the expiratory phase because the inspiratory times of the patient and ventilator are different.

Assist/Control Mode Ventilation (A/C mode ventilation) (SIPPV)

- **This modality involves either the delivery of a synchronized mechanical breath each time a spontaneous patient breath meeting threshold criteria is detected *(ASSIST)***
- **Or the delivery of a mechanical breath at a regular rate in the event that the patient fails to exhibit spontaneous effort *(CONTROL).***



A/C

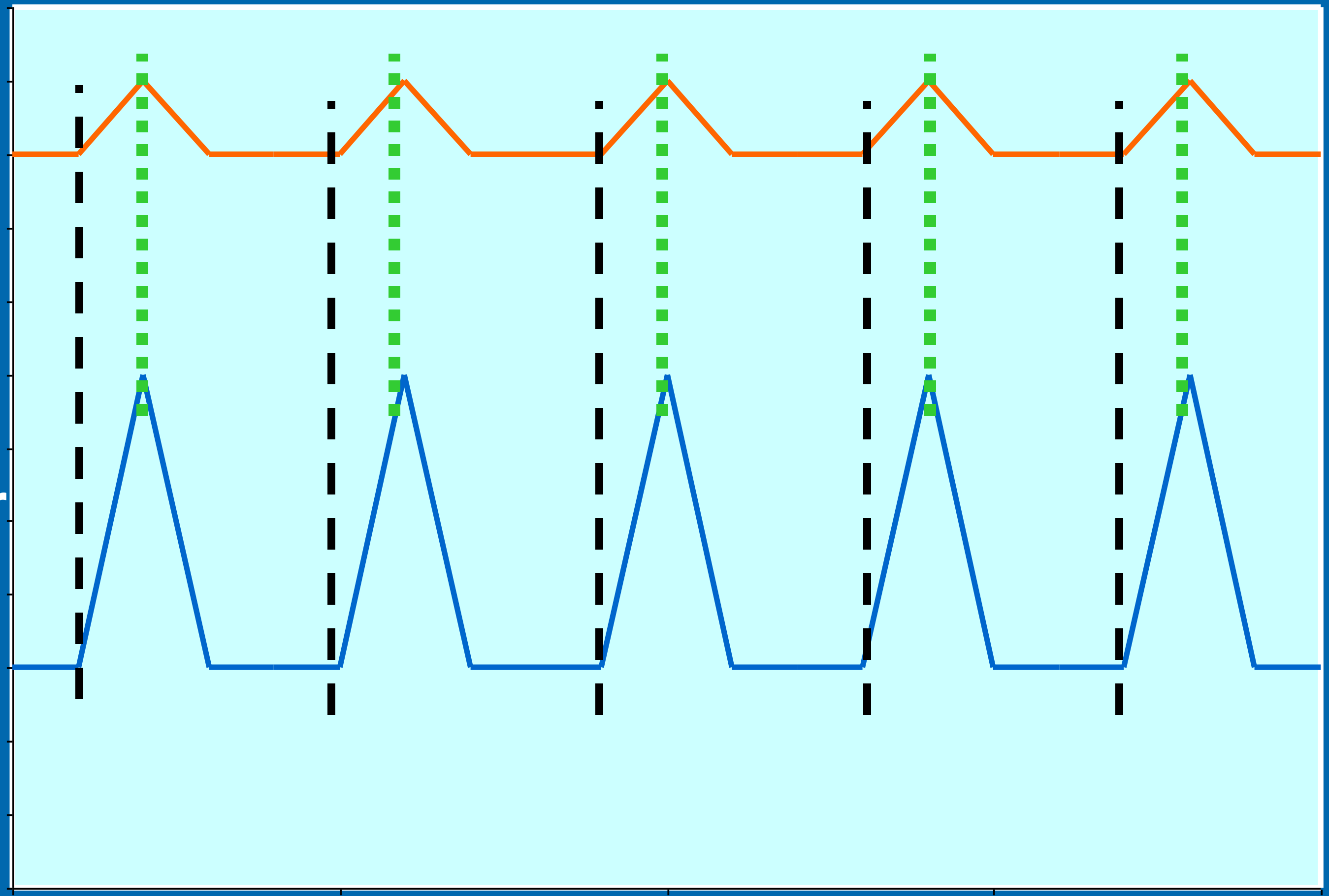
Each spontaneous breath that meets threshold criteria results in the delivery of a nearly simultaneous mechanical breath; however expiratory asynchrony occurs when inspiratory times of the patient and the ventilator are not identical.

- **However, once again, the possibility exists that expiratory dyssynchrony will occur.**

- **This problem has been overcome with the introduction of a *second signal detection system* that determines when patient inspiratory effort is about to cease, and that synchronizes the termination of the mechanical breath to this event.**

PRESSURE-SUPPORT VENTILATION [PSV]

- **A flow-derived signal to terminate inspiration permits the total synchronization of spontaneous and mechanical breaths throughout the entire respiratory cycle.**
- **Patient and ventilator are completely in phase for each and every breath.**



- **PSV :**

This system synchronizes *inspiration* by sensing patient effort: it also synchronizes *expiration* by terminating inspiration in response to a decline in airway flow. This results in complete synchronization of the functioning of the baby and the ventilator throughout the entire respiratory cycle.

Introduction

Pressure Support Ventilation (PSV), a well known and widely accepted mode of respiratory support in adults, was seldom used in neonates due to technical limitations.

PSV, specifically adapted for neonates, is now available in many neonatal/ paediatric ventilators

Definition

PSV is a pressure limited ventilatory mode in which each breath is ***patient-triggered and supported.***

It provides breath-to-breath ventilatory support by means of a positive pressure wave synchronized with the patient inspiratory effort, both ***patient-initiated and patient-terminated.***

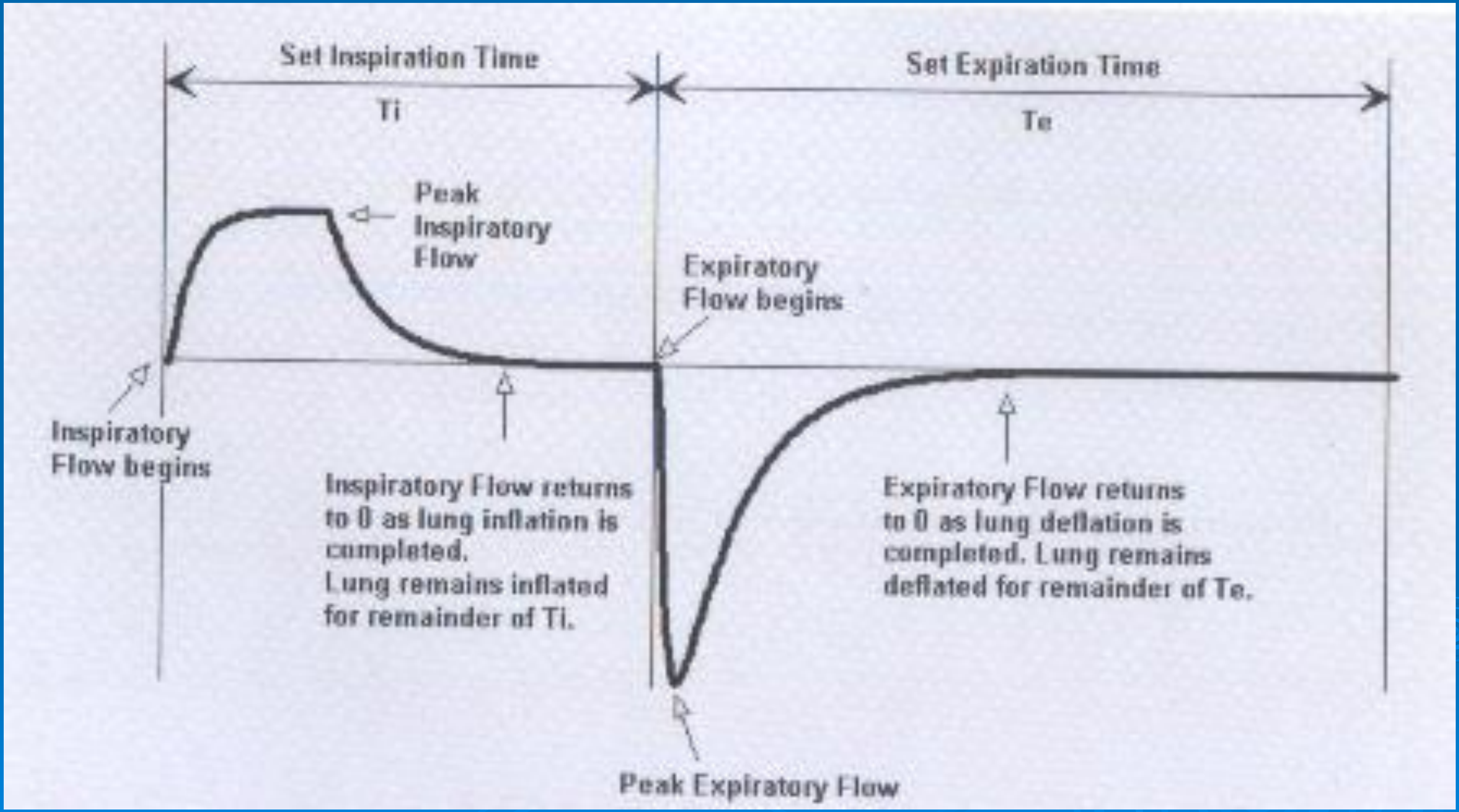
So, during a cycle of PSV four phases are distinguished:

1. **Recognition of the beginning of inspiration (Trigger).**
2. **Pressurization for the time of spontaneous inspiration.**
3. **Recognition of the end of inspiration (expiratory trigger or termination) and start of expiration.**
4. **Expiration.**

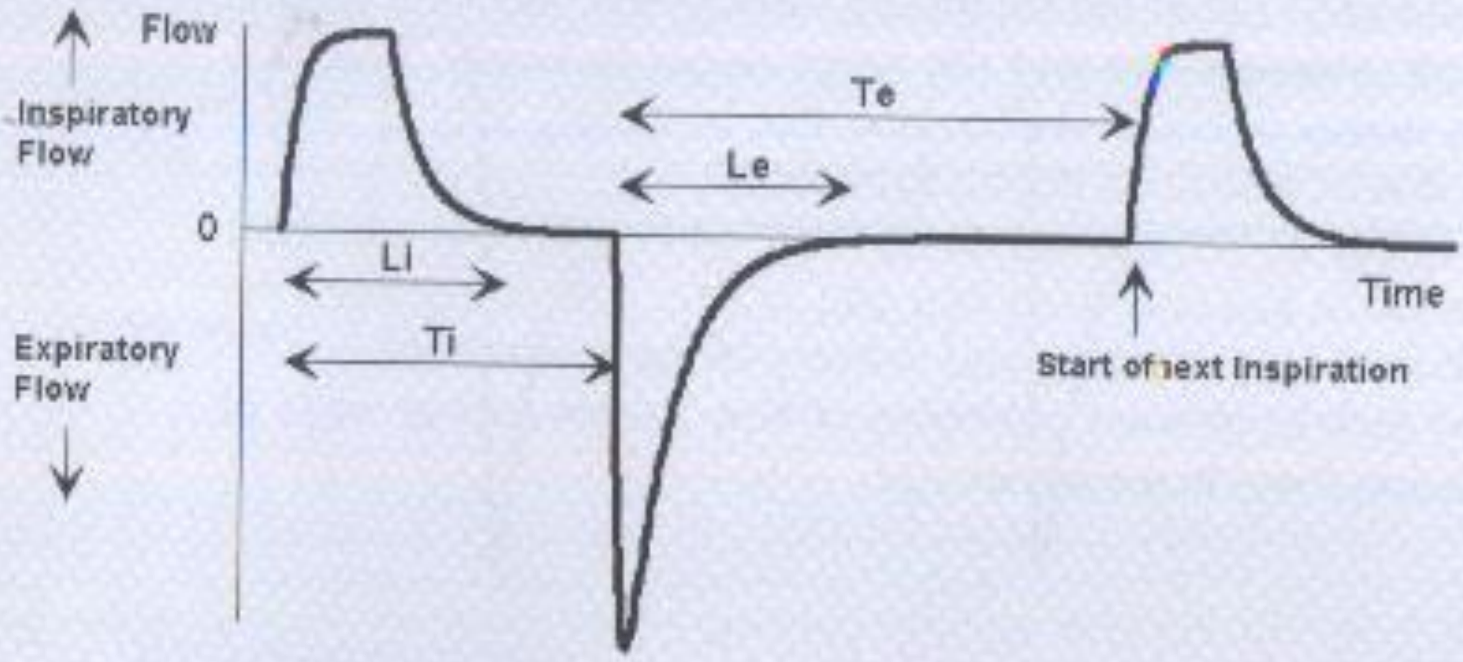
The end of inspiration is usually determined by the diminution of inspiratory flow below 15% of the peak inspiratory flow of the same cycle.

Therefore, respiratory rate and duration of inspiration are controlled by the patient.

Graph 1


Set Inspiration Time
Ti
Set Expiration Time
Te
Peak Inspiratory Flow
Expiratory Flow begins
Inspiratory Flow begins
Inspiratory Flow returns to 0 as lung inflation is completed. Lung remains inflated for remainder of Ti.
Expiratory Flow returns to 0 as lung deflation is completed. Lung remains deflated for remainder of Te.
Peak Expiratory Flow

Graph 2



Li = Time lung takes to inflate.
Inspiratory Flow occurs during this time.

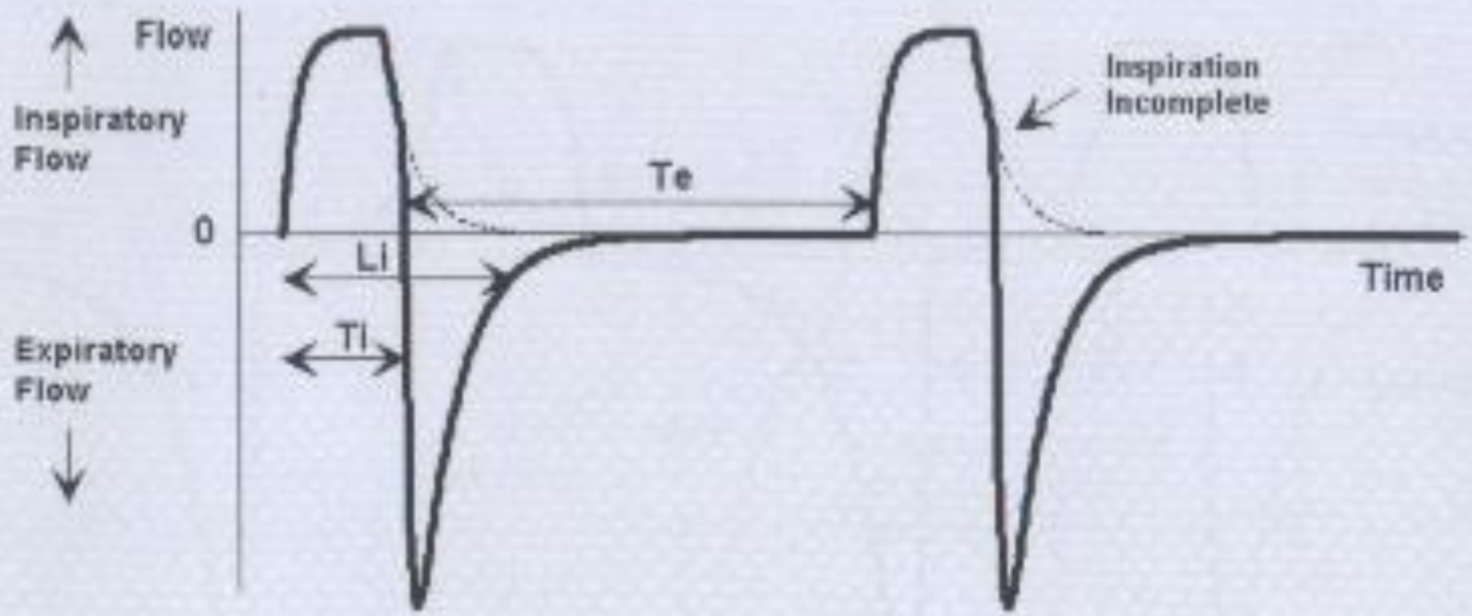
Ti = Inspiratory time set on ventilator.

Le = Time lung takes to deflate.
Expiratory flow occurs during this time

Te = Expiratory time set on ventilator.

To avoid gas tapping Te should be set longer than Le.

Graph 3



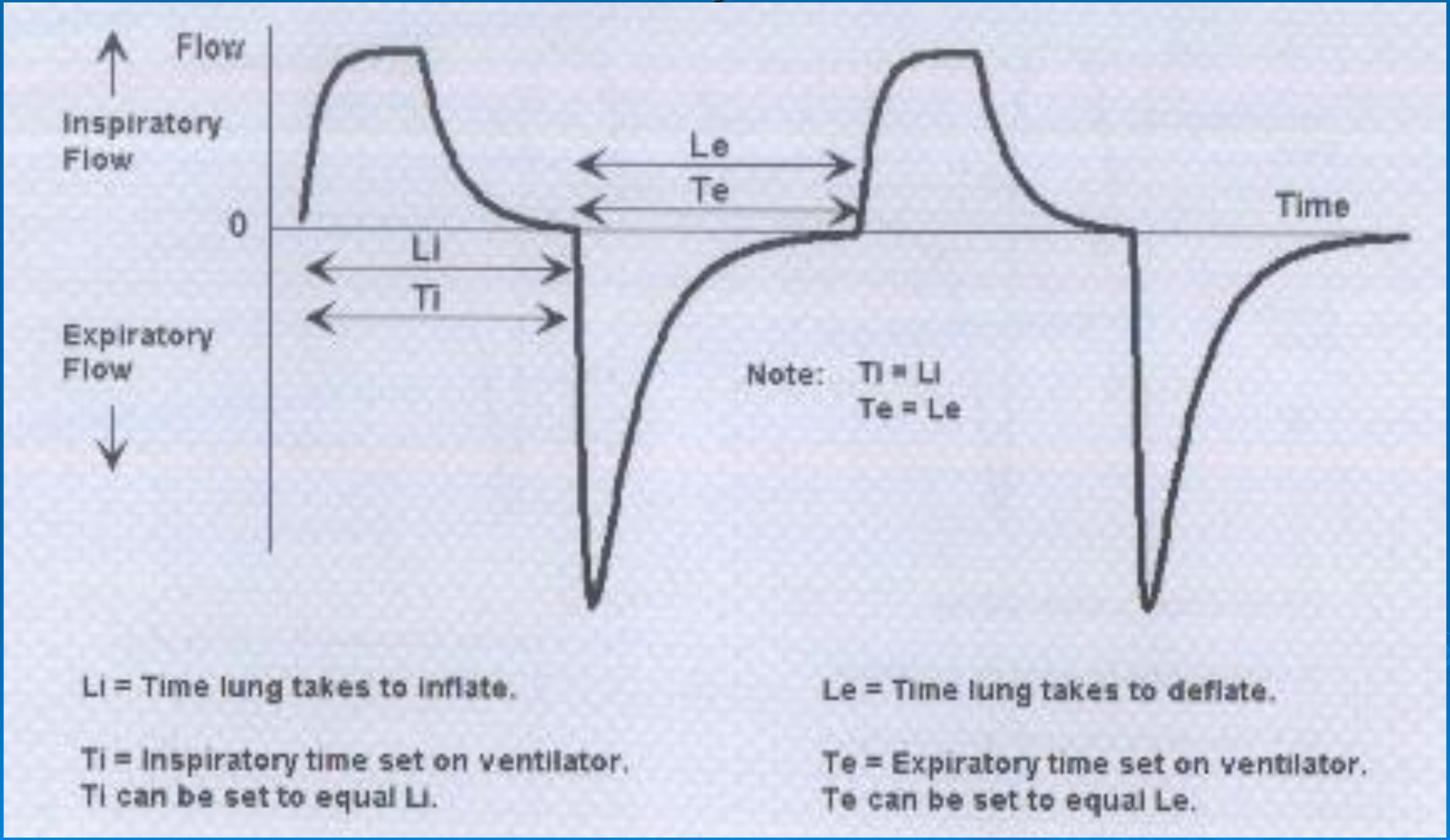
Li = Time lung takes to inflate.

Ti = Inspiratory time set on ventilator.

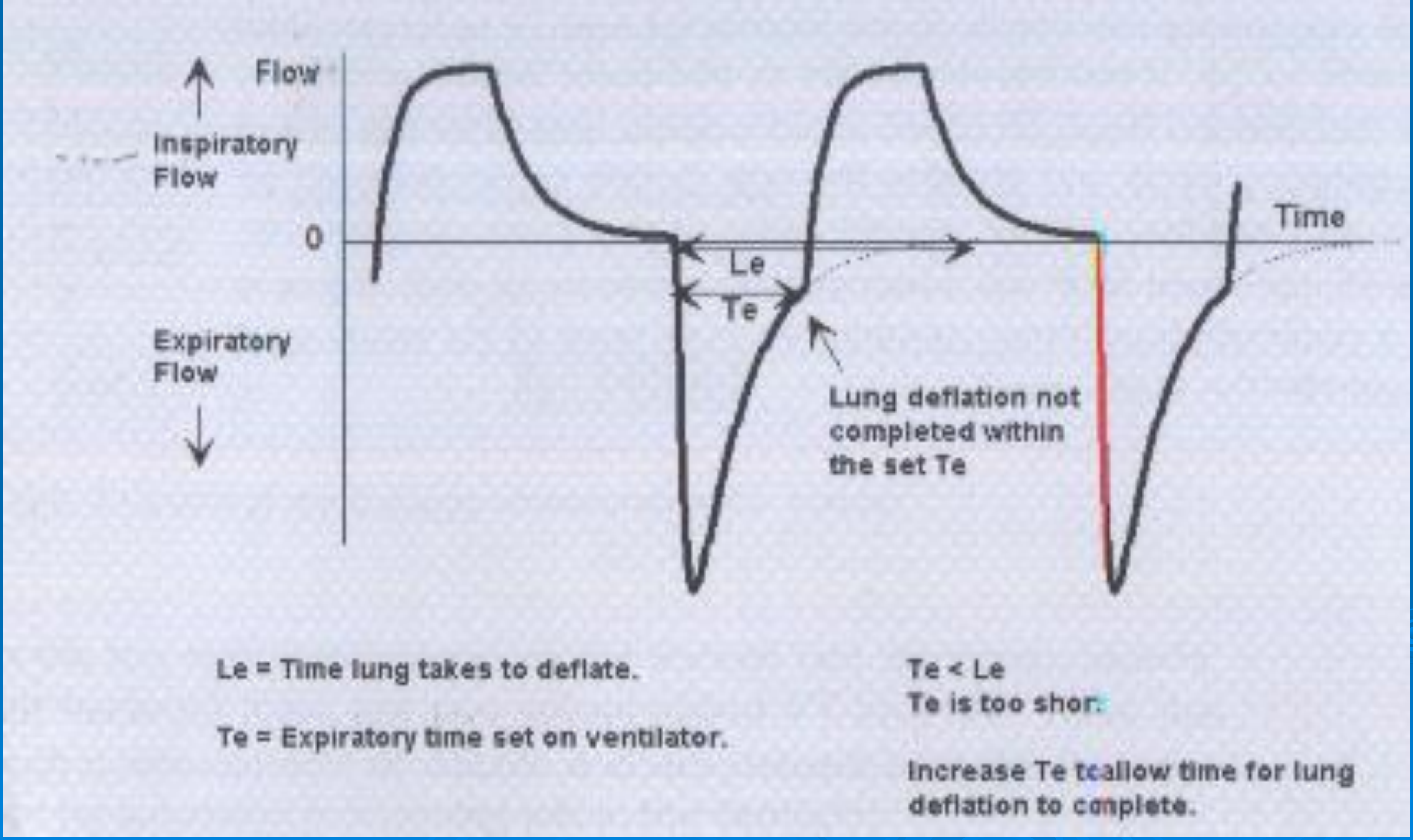
Te = Expiratory time set on ventilator.

Ti < Li
Ti is too short. Increase Ti to allow time for lung inflation to complete.

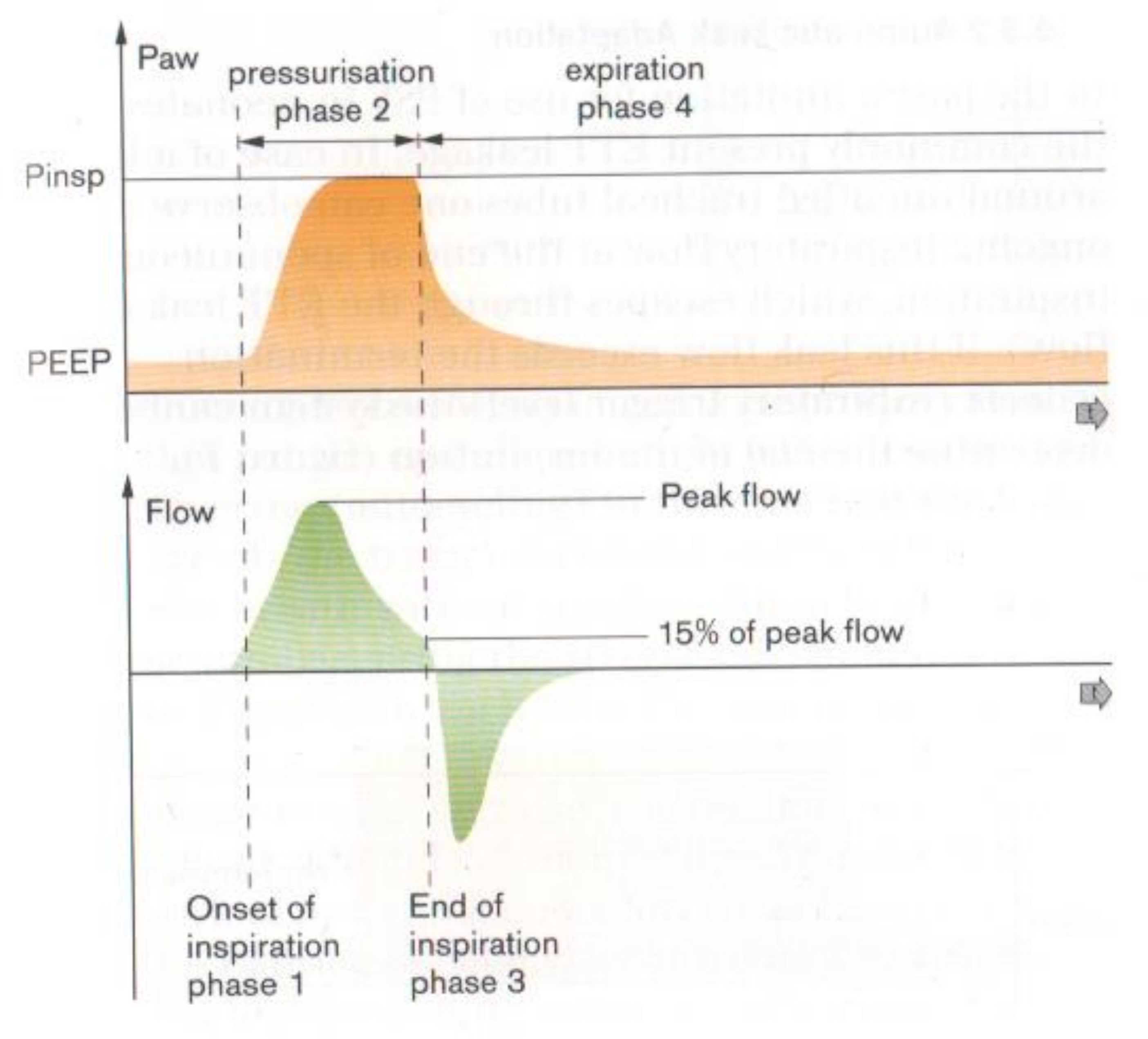
Graph 4


Flow
Inspiratory
Flow
0
Expiratory
Flow
Le
Te
Li
Ti
Time
Note: Ti = Li
Te = Le
Li = Time lung takes to inflate.
Ti = Inspiratory time set on ventilator.
Ti can be set to equal Li.
Le = Time lung takes to deflate.
Te = Expiratory time set on ventilator.
Te can be set to equal Le.

Graph 5


Flow
Inspiratory Flow
0
Time
Le
Te
Expiratory Flow
Lung deflation not completed within the set Te
Le = Time lung takes to deflate.
Te = Expiratory time set on ventilator.
Te < Le
Te is too shor.
Increase Te tcallow time for lung deflation to complete.

Pressure and airway **Flow** signals during a PSV breath, showing the 4 phases



As an additional safety feature, an upper limit of inspiratory time (Backup Ti) can be set by the user, preventing excessively long inspiratory times in case of failure of breath termination.

BACKUP VENTILATION

In case of apnea, a backup ventilation can be set in PSV.

If the patient stops triggering, the ventilator will revert to CMV delivering cycles at the set rate, Te and PiP.

Limitations and contraindications

Bronchospasm and lack of spontaneous respiratory drive are two contraindications for PSV.

Volume guarantee is a useful option for cases of bronchospasm.

It will automatically increase the pressure support level in order to deliver the set target tidal volume.

Thus peak flow is not decreased, and pressure support level is maintained during the whole spontaneous inspiration.

BENEFITS OF PSV

- Better synchrony between patient and ventilator.
- Increased patient comfort.
- Reduced need for sedation.
- Decreased work of breathing and oxygen cost of breathing.
- Endurance-oriented training of respiratory muscles.
- Deepening of weak shallow spontaneous breathing.

WEANING

During PSV

- **Start of inspiration**
- **Start of expiration**
- **Inspiratory time**
- **Breathing frequency (RR)**
- **Minute volume**

All are controlled by *the* *patient* and not by the ventilator.

Therefore PSV is predestined to become the best ventilatory mode suited to weaning off the ventilator using only the *inspiratory pressure*.

PSV AND A/C

- A/C is not a PSV.
- During A/C, pressure is controlled, and each respiratory effort is assisted as in PSV. However, during **A/C inspiratory time is FIXED** by ventilator setting.
- During PSV, inspiratory time is adapted to the patient spontaneous inspiration.
- This prevents air trapping and inversion of I:E ratio when the infant is breathing rapidly.

Some Important Reminders about Volume Guarantee

- **Volume Guarantee is a new ventilatory modality that combines the advantages of pressure-limited, time-cycled continuous-flow ventilation with those of Volume-controlled ventilation.**

- **VG can best be described as pressure-limited ventilation with tidal volume guidance or tidal volume targeting.**

- **The maximum peak pressure used during the inspiratory phase continues to remain directly under the control of the clinician but the ventilator will use a variable peak inspiratory pressure, between set Pinsp and PEEP to deliver $V_{T\ set}$.**

- **VG aims to stabilize the mean delivered tidal volume.**

Potential Advantages of using Volume Guarantee Ventilation

1. VG may lead to a more stable tidal volume in the face of changing compliance, resistance and changing endotracheal tube leak. This in turn should produce a more stable $PaCO_2$, with reduced frequency of hypercarbia or hypocarbia.

2. Reduction in lung injury from overdistension, i.e. less volume trauma.

3. **Reduced peak inspiratory pressures where the patient is making a significant contribution to the tidal volume, thereby reducing barotrauma as well.**

4. **Autoweaning: as the patient's lungs improve and compliance increases, e.g. following exogenous surfactant therapy, VG should automatically use progressively lower peak inspiratory pressures to deliver $V_{T\ set}$.**

5. **Automatic adjustment of peak airway pressure should PEEP be changed.**

6. **In combination with Pressure Support Ventilation, other benefits may also become apparent, particularly with respect to a reduction in the frequency of active infant expiration against peak inflation pressures from the ventilator.**

Overview of Different Ventilation Modes and their Characteristics

Ventilatory Mode	Inspiratory Trigger	Assistance of each breath	Ventilator Respiration Rate	Inspiratory Time	PIP
IMV	No	No	Fixed	Fixed	Fixed
SIMV	Yes	No	Fixed	Fixed	Fixed
A/C	Yes	Yes	Variable	Fixed	Fixed
PSV	Yes	Yes	Variable	Variable	Fixed
PSV + VG	Yes	Yes	Variable	Variable	Variable

Thank You