Guidelines for Mechanical Ventilation of Newborn Infants

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Objectives

- Definitions of different modes of ventilation
- Pressure Limited, Time-Cycled, Continuous Flow mode of Ventilation
- Volume Guarantee mode of ventilation
- High Frequency Oscillatory Ventilation (HFOV)

Definitions

- CMV
- A/C
- SIMV
- PSV
- CPAP
- VG

CMV

It is a Continuous Mandatory Ventilation :

- Time controlled
- Time cycled
- Pressure limited

flow ventilation

A/C

Assist Control:

- Time-controlled
- Volume triggered
- Time cycled
- Pressure limited
- Continuous flow

ventilation that is synchronized with each spontaneous patient breath.

SIMV

Synchronized Intermittent Mandatory Ventilation:

- Time controlled
- Volume triggered
- Time cycled
- Pressure limited
- Continuous flow

ventilation that is synchronized with patient's spontaneous breathing at a the set ventilation rate.

PSV

- It is a Pressure Support Ventilation:
  - Time controlled
  - Volume triggered
  - Flow cycled
  - Pressure limited

  Ventilation that is synchronized with each spontaneous patient breath

CPAP

Continuous Positive Airway Pressure

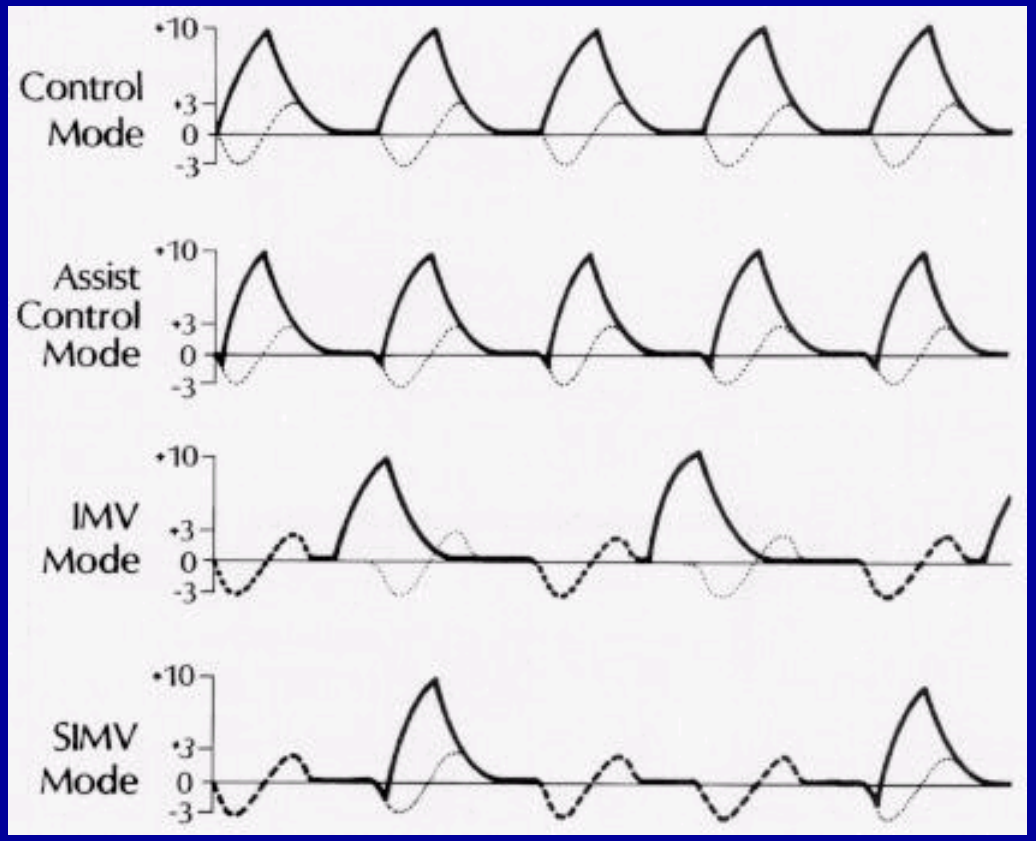
- Spontaneous breathing with positive airway pressure

VG

- Volume Guarantee
  - Volume controlled ventilation

- The ventilator controls inspiratory pressure in order to deliver the preset tidal volume .

- It may be combined with A/C, SIMV and PSV



Airway pressure tracings of the four standard volume preset modes. Thick solid lines represent ventilator breaths and thick dotted lines represent spontaneous breaths. The thin dotted lines refer to what the spontaneous pattern would have been without the ventilator breaths. IMV, intermittent mandatory ventilation; SIMV, synchronized IMV.

Pressure Limited, Time-Cycled, Continuous Flow mode of Ventilation

Pressure Limited, Time-Cycled, Continuous Flow mode of Ventilation

- SIMV: is the most commonly used mode of ventilation.
- SIMV: Synchronized Intermittent Mandatory Ventilation:
  - the ventilator breaths are triggered by patient's inspiratory efforts.
  - Patient can breathe between ventilator breaths (but not all breaths are assisted).

Pressure Limited, Time-Cycled, Continuous Flow mode of Ventilation

- Ventilator settings:
  - PIP (Peak Inspiratory Pressure): 15-25 cm of H2O
  - PEEP (Positive End Expiratory Pressure): 3-5 cm of H2O
  - Inspiratory Time: 0.35-0.45 sec
  - Ventilator Rate: 30-40 / min
- Monitoring:
  - the generated Tidal Volume (3-5 ml)

Pressure Limited, Time-Cycled, Continuous Flow mode of Ventilation

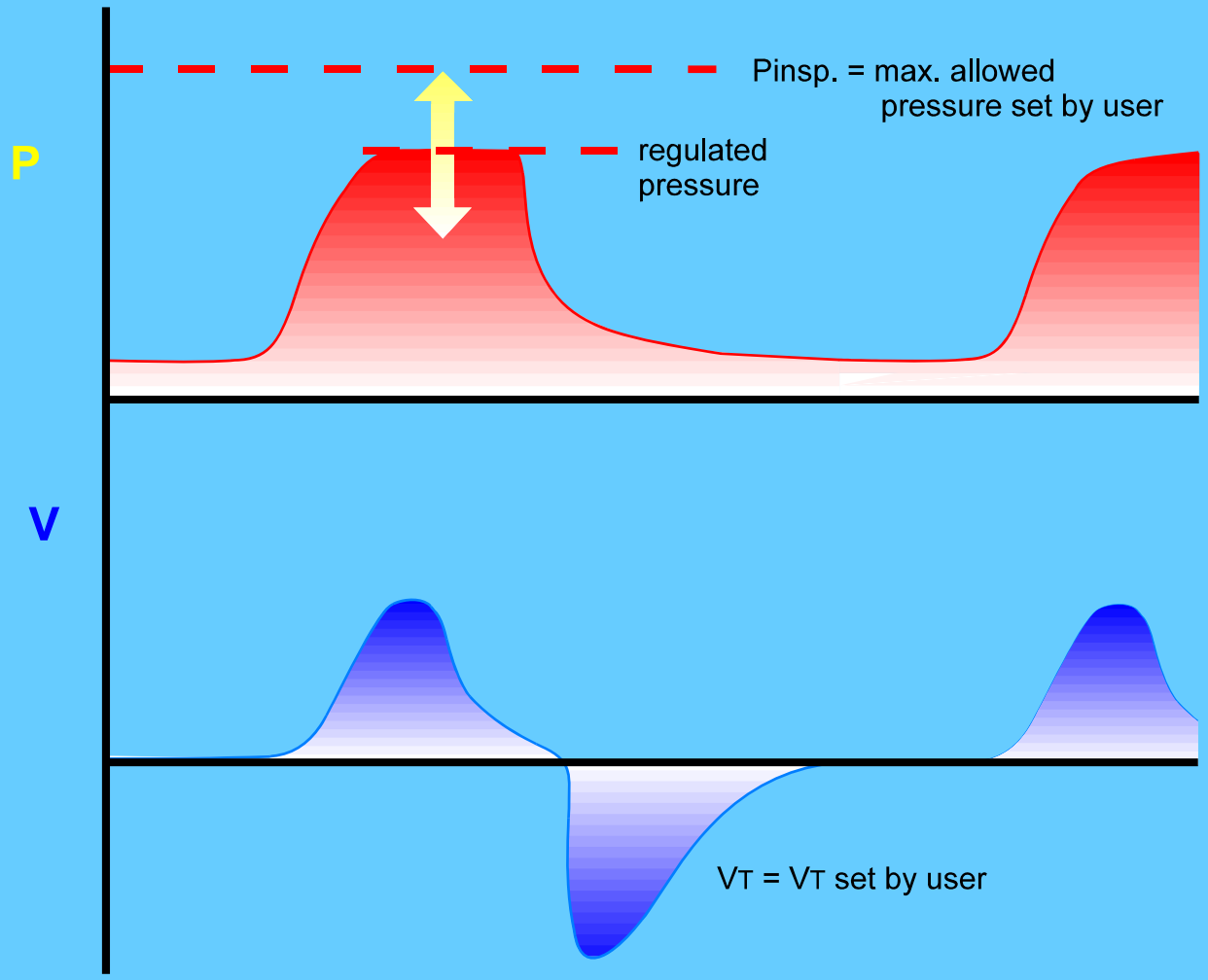
	PCO2	pH	PO2
PiP Increase	Decrease	Increase	Increase
PiP Decrease	Increase	Decrease	Decrease
PEEP Increase	± Increase	Varies	Increase
PEEP Decrease	± Decrease	Varies	Decrease
Rate Increase	Decrease	Increase	Varies
Rate Decrease	Increase	Decrease	Varies
I/E Increase	Increase	Decrease	Increase
I/E Decrease	Decrease	Increase	Decrease

Volume Guarantee mode of ventilation

Volume Guarantee
How does it work ?

The ventilator automatically adjusts the inspiratory pressure according to changes of compliance, resistance or respiratory drive to achieve a set tidal volume.

Volume Guarantee
How does it work ?



Volume Guarantee Advantage

Volume Guarantee combines the advantages of pressure limited, time cycled, continuous flow ventilation and volume controlled ventilation !

Volume Guarantee is an option and is available for all triggered ventilation modes of the Babylog 8000 :

- SIMV
- SIPPV (A/C)
- PSV

SIMV-VG

VG: Volume Guarantee

- It is a time-cycled, pressure limited mode of ventilation with automatic adjustment of the PiP to achieve a target TV
- It can be used in conjunction with Pressure Support (PS), Assist Control (AC) or Synchronized Intermittent Mandatory Ventilation (SIMV)

Advantages of VG

- VG: automatically compensates for acute changes in Compliance, resistance and spontaneous respiratory effort.
- Ventilator alarms when worsening lung compliance (pneumothorax, atelectasis) or resistance (secretions)
- PiP is weaned automatically with the improvement of the compliance.

Indications of VG

patient with respiratory failure especially when lung mechanics are likely to change rapidly.

Contraindications of VG mode of ventilation

If endotracheal tube leak > 30%

Initial Vent settings of VG

- FiO2: 0.21 – 0.6
- TV: 4-5 ml / Kg
- PEEP: 4-5 cm (based on BW & GA)
- Rate: 30-40/min (Based on BW &GA. Higher rate for Low BW & GA)

Initial Vent settings of VG

- Set Ti at 0.35 sec (0.3-4)

- Set PiP 1-2 cm above the average PIP needed to generate the target TV (if PIP > 25-30 cm: look for a reason)

Subsequent Changes

- PiP: needs to be adjusted (increments of 1-2 cm) in response to changing lung mechanics
- If the flow sensor is removed: the delivered pressure will default to the PiP limit.
- If infant is persistently tachypneic (> 80 breaths/min):
  - If PCO2 is low: consider sedation
  - If PCO2 is normal: consider increasing TV (to decrease the work of breathing related to the ET tube)

Subsequent Changes

- If “low TV” alarms repeatedly:
  - Increase the PiP limits (by 1-2 cm increments)
  - And investigate the cause of the acute change in lung mechanics (secretions, pulmonary edema, PDA, CHF, atelectasis…)
  - Consider a blood gas and a chest X-Ray
  - Consider to increase PEEP **temporarily** with an acute change in compliance (pulmonary edema, atelectasis, pulmonary hemorrhage…)

PS-VG

PSV: Pressure Support **Ventilation**

- This is a time-cycled, pressure limited synchronized mode
- Each spontaneous breath is supported
- A back up rate is set to maintain adequate support in case of apnea (40/min in term infants and 40-50/min in preterm infants).
- Inspiration is ended when inspiratory flow declines to 15% of peak flow.
- Inspiratory hold is eliminated and the chance of active expiration against positive pressure is minimized

Advantages of PSV

- The infant has more control over his respiratory pattern
- PSV maintains optimal Ti

Indication of PSV

Any patient with respiratory failure

Contraindications of PSV

Atelectasis, and the need for a prolonged Ti (>0.2 sec).

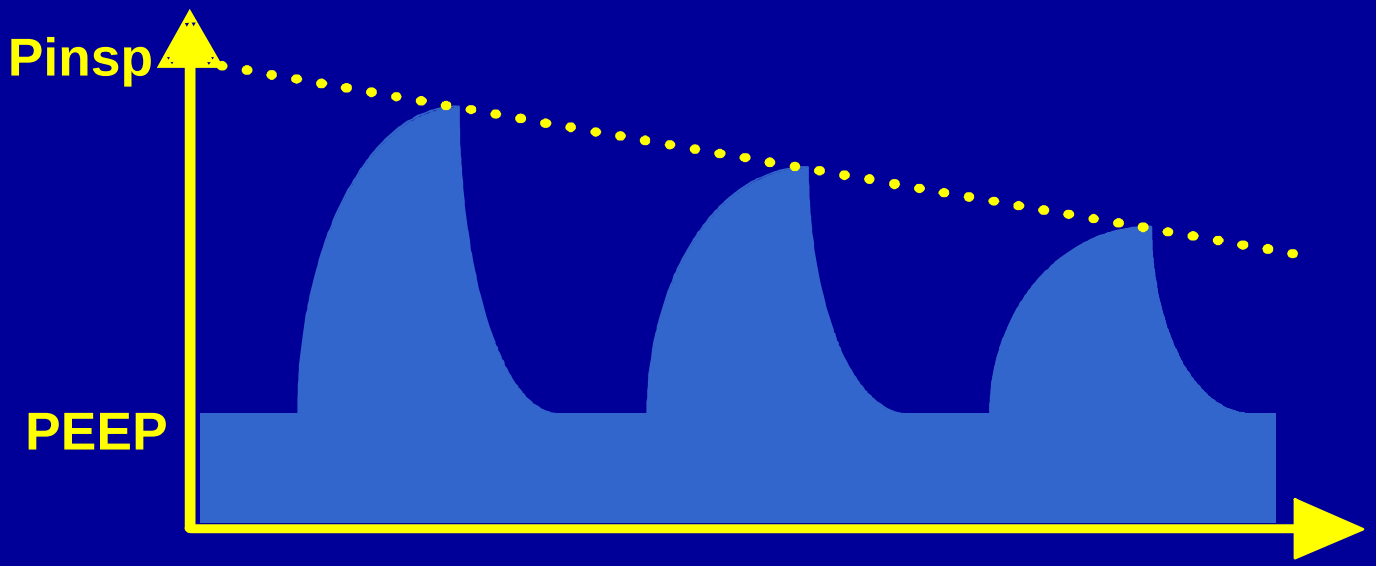
Initial Vent settings for PSVG

- FiO2: 0.21 – 0.6
- TV: 4-5 ml / Kg
- PEEP: 3-6 cm
- Rate: 30-50/min
- Set Ti at 0.4 sec for infants < 1000 g
- Set PiP 1-2 cm above the PIP needed to generate the target TV.

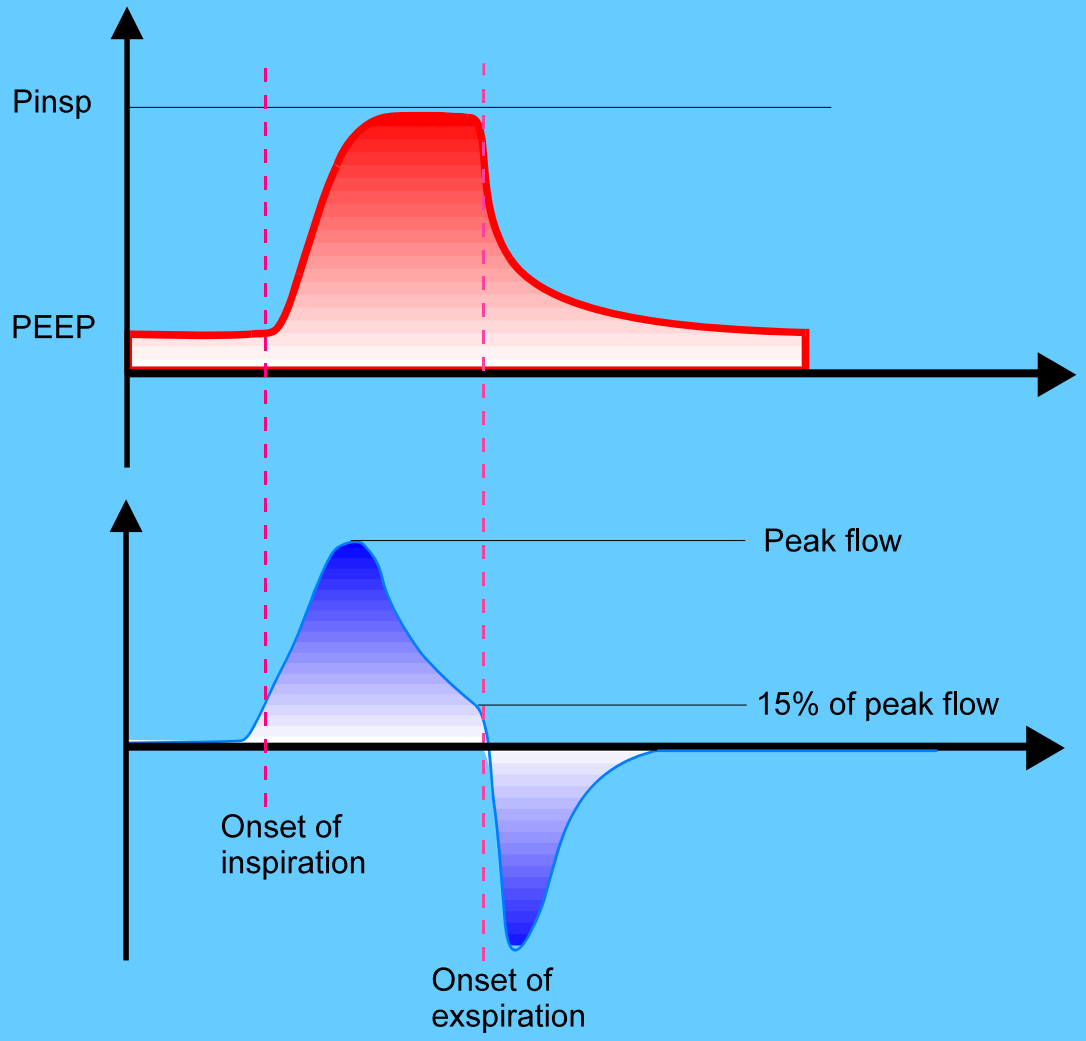
Working Principle of PSV

- The ventilator supports each breath of the patient
- The inspiratory pressure support determines the amount WOB supplied by the ventilator
- T_I is automatically adjusted to the patient's inspiratory time

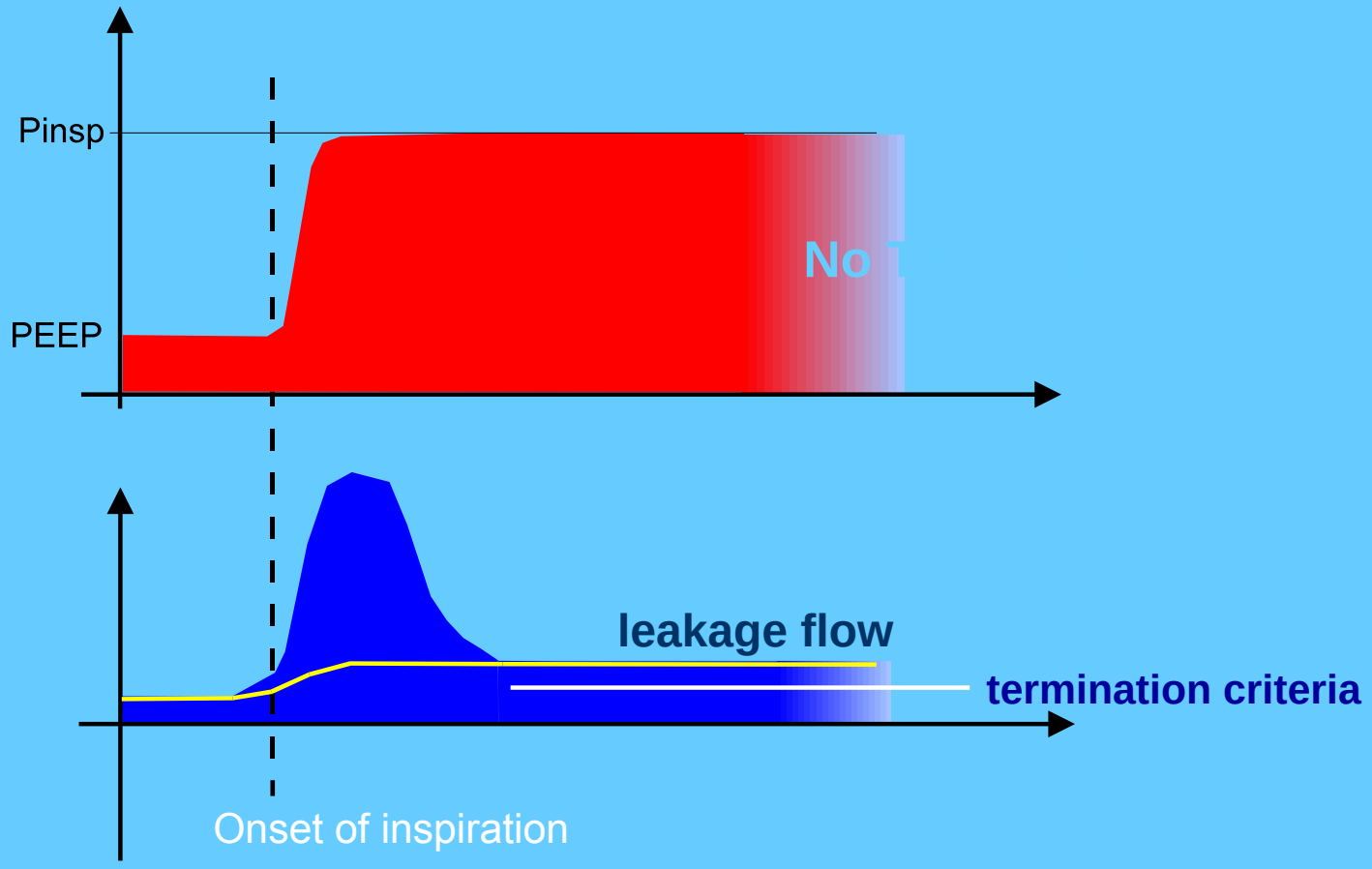
Pressure Support Ventilation
Progress of Weaning by PSV



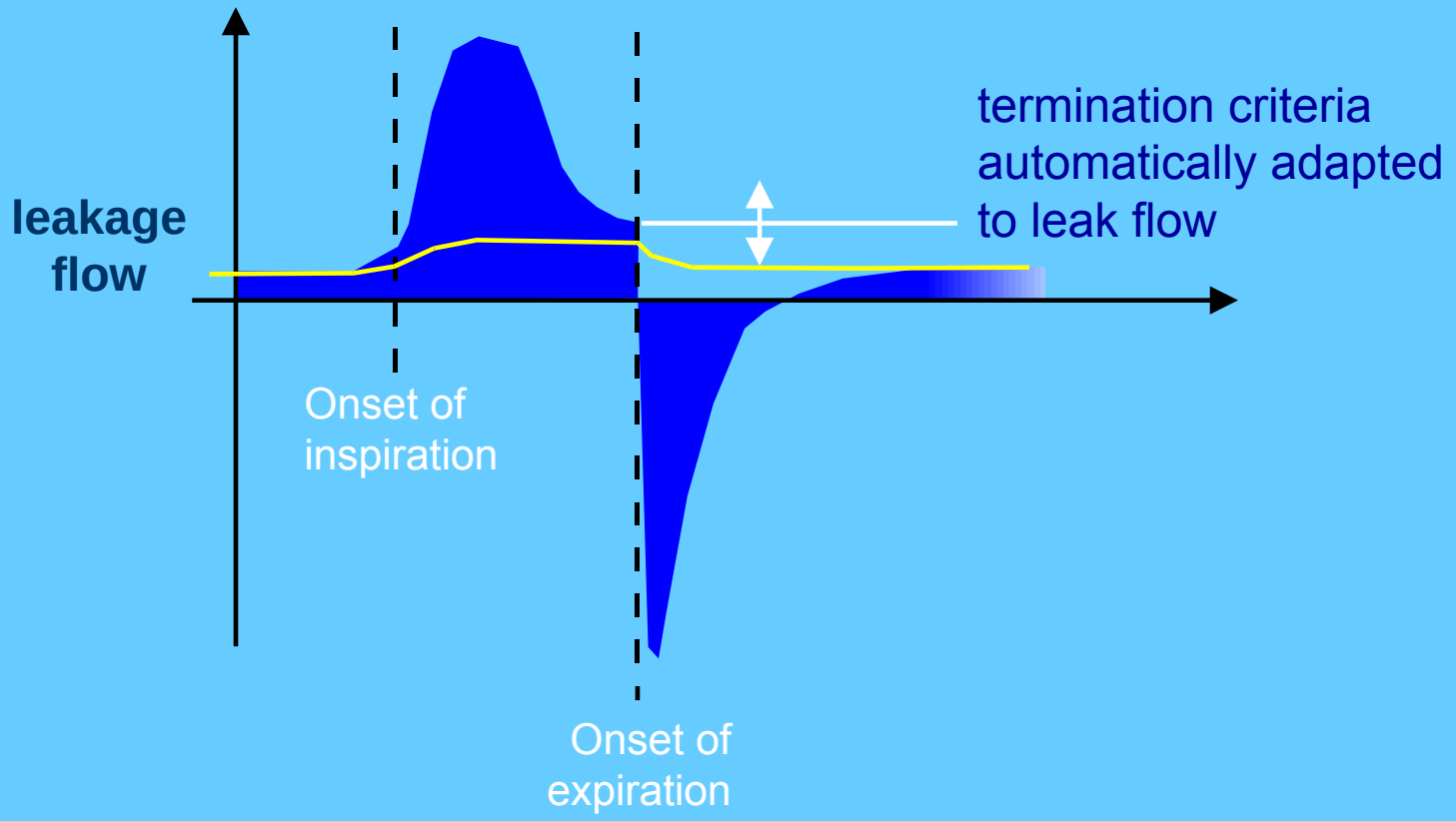
PSV: Working Principle of Breath Termination



PSV: "ETT-Leakage can be a problem



LAPS
Leak Adapted Pressure Support



Pressure Support Ventilation
"Let the patient decide !"

Let your patient decide over

- Start of Inspiration
- Depth of Inspiration
- Duration of Inspiration
- Frequency / Pattern of Respiration
- Minute Volume

Pressure Support Ventilation
"Let the patient decide !"

This leads to

- total synchrony
- less fighting the ventilator
- less need for sedation
- slower rates
- larger volumes
- lower MAP at same MV
- adequate training for respiratory muscles
- ability to sigh

Pressure Support Ventilation
Clinical Benefits

- Lower / more effective WOB
  Lower Oxygen Cost of Breathing
- Endurance training of the diaphragm

  ⇨Shorter time of weaning
- Compensation of added WOB due to
  Resistance of ET-tube and Patient Circuit

Pressure Support Ventilation
Clinical Benefits

- Reduction of active expiration
  - ⇨More natural pattern of breathing
  - ⇨Lower incidence of Pneumothoraces
- Improved patient comfort
- Stimulation of spontaneous breathing

AC-VG

AC-VG

- Assist Control Volume Guarantee
- The ventilator supports each breath of the patient with a preset volume and inspiratory time
- Risk of hyperventilation and hypocapnea

Modes associated with VG

- SIMV-VG:
  - Decreases PIP (auto-wean)
  - Abnormal PCO2 (in 4-8%)
  - Increased WOB in comparison to AC-VG
- PS-VG:
  - Decreases PIP
  - Infants with a strong resp. drive are liable to hyperventilation
  - Reduces acute inflammatory responses in RDS

Modes associated with VG

- AC-VG:
  - Assist Control Volume Guarantee
  - Decreases PiP
  - Increases the risk of hyperventilation (low PCO2 in 20%)

VG ventilation
Subsequent Adjustments

- Tidal Volume: may need to be adjusted by 0.5 ml/kg:
  - **If the PaCO2 is high**: increase the TV
  - **If the PaCO2 is low**: decrease the TV (DO NOT decrease the TV < 3 ml/kg (risk of atelectasis)
  - **If the PaO2 or Pulse oxymetry is low**: increasing the TV may increase the min ventilation and improve oxygenation.

VG ventilation
Subsequent Adjustments

- PIP limit: may need to be adjusted by 1-2 cm of H2O:
  - **The targeted TV is not met**: the ventilator alarm will display LOW TV: increase the PIP limit.
  - **If the Flow sensor is removed**: (such as during administration of surfactant or a nebulized medication, the working pressure defaults to the PIP limits): decrease PIP limit to match the average working pressure (that was needed to generate the targeted TV).

VG ventilation
Subsequent Adjustments

- If persistent tachypnea (RR> 80/min):
  - **If PaCO2 is normal**: Consider increasing TV target (even if PaCO2 and pH are normal, in this situation the infant usually generates a TV larger then the targeted TV). Tachypnea suggests increased work of breathing.
  - **If PaCO2 is low**: Consider sedation

VG ventilation
Subsequent Adjustments

- If PIP has to be increased substantially and repeatedly:
  - **Verify that the TV measurement is accurate**: assess patient's chest rise, obtain a blood gas
  - **Determine the cause of the acute change in lung mechanics**: examine the patient, obtain a chest X-Ray.

High Frequency Oscillatory Ventilation (HFVO)

High Frequency Oscillatory Ventilation (HFVO)

- Provides Vt less than the anatomic dead space
- Commonly used frequencies of 10 to 15 Hz.
- Active expiration is an intrinsic part of their design

HFVO (Indications)

- Pulmonary air leaks, including PIE (Pulmonary Interstitial Emphysema)

- Respiratory failure and/or hypoxemia on conventional ventilators

HFVO (Initial Settings)
Mean Airway Pressure (MAP)

- MAP : controls oxygenation
- Preterm Infants:
  - In diffuse alveolar disease: Conventional ventilator (CV) MAP plus 1-2 cm H2O.
  - In PIE/air leak: Same CV MAP (or less)
- Term Infants:
  - In diffuse alveolar disease CV MAP plus 2 to 4 cm H2O
  - In PIE/ air leak: Same CV MAP

HFVO (Initial Settings)
Amplitude

- Amplitude: controls ventilation
- It should be set at 10-30 cm H2O
- Adjust upward in 2-4 cm H2O
- Increments until chest wall vibrates visually

HFVO (Initial Settings)
Frequency

- 1 Hz = 60 breaths / min
- Increasing frequency: increased PCO2
- Decreasing frequency: decreased PCO2 and increased oxygenation
- BW < 1000 grams: start at 15 Hz.
- BW 1000-2000 grams: start at 12 Hz.
- BW > 2000 grams: start at 10 Hz.
- Term Infant with Meconium Aspiration Pneumonia: start at 6-10 Hz.

HFVO (Management)

- Obtain a chest X-Ray within 1 hour of initiation of HFVO to ascertain degree of lung expansion (≥ 8-9 posterior ribs)

- Consider chest X-Ray after changing MAP by ≥ 4 cm of H2O or FiO2 by > 10-20%.

HFVO
(Management: To change PCO2)

- To change PCO2: Adjust Amplitude
  - Increasing amplitude: will decrease PCO2.
  - Decreasing amplitude: will increase PCO2.
- If PCO2 too high check for:
  - Pneumothorax
  - Mechanical obstruction , ET placement
  - Atelectasis
  - Need for sedation / paralysis.

HFVO
(Management: To change PO2)

- To change PO2: adjust
  - FiO2
  - MAP (increasing MAP will increase PO2 unless lungs are over-expanded).
  - Suction
- If PO2 too low: check for
- Pneumothorax
- Mechanical obstruction, ET placement
- Atelectasis / hypotension
- Need for sedation / paralysis

HFVO
(Weaning: if adequate PO2)

- Start weaning FiO2
- If FiO2 < 60%: decrease MAP by 1 cm every 6-12 hours (correlate with chest X-Ray to evaluate lung expansion).
- If MAP 7-9 cm of H2O: consider switching to a conventional mode of ventilation or extubation.

HFVO
(Weaning: if adequate PCO2)

- Wean amplitude by 2-5 cm of H2O till
  - Desired PCO2 is reached
  - Or patient is ready to be switched to a conventional mode of ventilation
  - Or ready for extubation

Conclusions

- Definitions of different modes of ventilation
- Pressure Limited, Time-Cycled, Continuous Flow mode of Ventilation
- Volume Guarantee mode of ventilation
- High Frequency Oscillatory Ventilation (HFOV)