Mechanical ventilation
3rd Lecture

Dr. Mohammed Sami

Common Ventilator Settings parameters/ controls

- **Fraction of inspired oxygen (FIO_2) نسبة الاوكسجين في الهواء المستنشق**
- **Tidal Volume (VT) amount of airthat moves in or out of the lungs with each respiratory cycle**
- **Peak Flow/ Flow Rate**
- **Respiratory Rate/ Breath Rate / Frequency (F)**
- **Minute Volume (VE)**
- **I:E Ratio (Inspiration to Expiration Ratio)**
- **Sigh التنهد**

● Fraction of inspired oxygen (FIO_2)

- **The percent of oxygen concentration that the patient is receiving from the ventilator. (Between 21% & 100%) (room air has 21% oxygen content).**
- **Initially a patient is placed on a high level of FIO_2 (60% or higher).**
- **Subsequent changes in FIO_2 are based on ABGs and the SaO_2.**

- An FiO_2 of 100% for an extended period of time can be dangerous (oxygen toxicity) but it can protect against hypoxemia

- For infants, and especially in premature infants, high levels of FiO_2 (>60%) should be avoided.

It can cause retinopathy

- Usually the FIO_2 is adjusted to maintain an SaO_2 of greater than 90% (roughly equivalent to a PaO_2 >60 mm Hg).

- Oxygen toxicity is a concern when an FIO_2 of greater than 60% is required for more than 25 hours

● Tidal Volume (VT)

- **The volume of air delivered to a patient during a ventilator breath.**
- **The amount of air inspired and expired with each breath.**
- **Usual volume selected is between 5 to 15 ml/ kg body weight)**

- **In the volume ventilator, Tidal volumes of 10 to 15 mL/kg of body weight were traditionally used.**

- **the large tidal volumes may lead to (volutrauma) that damage the lungs**

- **For this reason, lower tidal volume targets (6 to 8 mL/kg) are now recommended.**

● Peak Flow/ Flow Rate

- **The speed of delivering air per unit of time, and is expressed in liters / minute.**

- **The higher the flow rate, the faster peak airway pressure is reached and the shorter the inspiration;**

- **The lower the flow rate, the longer the inspiration.**

● Respiratory Rate/ BreathRate / Frequency (F)

- **The number of breaths the ventilator will deliver/minute (10-16 b/m).**
- **Total respiratory rate equals patient rate plus ventilator rate.**
- **We should double-checks the functioning of the ventilator by observing the patient's respiratory rate.**

Minute Volume (VE)

- **The volume of expired air in one minute .**
- **VE = (VT x F)**
- **In special cases, hypoventilation or hyperventilation is desired**

I:E Ratio

- The I:E ratio is the ratio of inspiratory time to expiratory time.
- It is usually kept in the range between 1:2 and 1:4
- A larger I:E ratio
  - possibility of air trapping
  - auto-PEEP
- Inverse I:E ratio
  - correct refractory hypoxemia in ARDS patients

- I:E ratio may be altered by manipulating any one or a combination of the following controls:
  (1) flow rate,
  (2) inspiratory time,
  (3) inspiratory time %,
  (4) frequency, and
  (5) minute volume (tidal volume and frequency).

PEEP

- Positive end-expiratory pressure (PEEP)
  - PEEP reinflates collapsed alveoli and supports and maintains alveolar inflation during exhalation.
    - increases the functional residual capacity
    - useful to treat refractory hypoxemia.
  - The initial PEEP level may be set at 5 cm H2O
  - Auto-PEEP is present when the end-expiratory pressure does not return to baseline pressure at the end of expiration.

PEEP

↓

Decreases the pressure threshold for alveolar inflation

↓

Increases FRC

↓

Improves ventilation

↓

(1) Increases V/Q

(2) Improves oxygenation

(3) Decreases work of breathing

- Complications of PEEP

(1)decreased venous return and cardiac output,

(2)barotrauma,

(3)increased intracranial pressure, and

(4)alterations of renal functions and water metabolism.

Flow rate

- The peak flow rate is the maximum flow delivered by the ventilator during inspiration.
- The inspiratory flow needs to be sufficient to overcome pulmonary and ventilator impedance otherwise the work of breathing is increased.
- Peak flow rates of 60 L per minute may be sufficient,
- higher rates are frequently necessary in patients with bronchoconstriction.

TABLE 8-9 Effects of Flow Rate Change on I Time, E Time, and I:E Ratio

Parameter Change	I Time	E Time	I:E Ratio
Increase flow rate	Decrease	Increase	Increase
Decrease flow rate	Increase	Decrease	Decrease

TABLE 8-10 Effects of V_T Change on I Time, E Time, and I:E Ratio

Parameter Change	I Time	E Time	I:E Ratio
Increase tidal volume	Increase	Decrease	Decrease
Decrease tidal volume	Decrease	Increase	Increase

TABLE 8-11 Effects of Frequency Change on I Time, E Time, and I:E Ratio

Parameter Change	I Time	E Time	I:E Ratio
Increase f	Minimal change	Decrease	Decrease
Decrease f	Minimal change	Increase	Increase

Trigger

- The variable that causes the. **Ventilator** to begin the inspiratory phase
- patient's inspiratory effort is detected by either pressure or flow. The **sensitivity** of the **trigger** determines how much effort the patient has to exert before his inspiration is augmented by the ventilator

Trigger

There are two ways to initiate a ventilator-delivered breath:

1. pressure triggering
   - initiated if the demand valve senses a negative airway pressure deflection (generated by the patient trying to initiate a breath) greater than the trigger sensitivity.
   - A trigger sensitivity of -1 to -3 cm H_2O is typically set
2. flow-by triggering
   - initiated when the return flow is less than the delivered flow, a consequence of the patient's effort to initiate a breath
   - the trigger sensitivity is usually set at 2 L/min

Classification of positive-pressure ventilators:

- **Ventilators are classified according to how the inspiratory phase ends.**
- **They are classified as:**

1- Pressure cycled ventilator

2- Volume cycled ventilator

3- Time cycled ventilator

1- Volume-cycled ventilator

- **Inspiration is terminated after a preset tidal volume has been delivered by the ventilator.**

- **The ventilator delivers a preset tidal volume (VT), and inspiration stops when the preset tidal volume is achieved.**
- **دفع الهواء يتوقف بعد إيصال الحجم المراد ايصاله للمريض**

2- Pressure-cycled ventilator

- **In which inspiration is terminated when a specific airway pressure has been reached.**

- **The ventilator delivers a preset pressure; once this pressure is achieved, end inspiration occurs.**

3- Time-cycled ventilator

- **In which inspiration is terminated when a preset inspiratory time, has elapsed.**

- **Time cycled machines are not used in adult critical care settings. They are used in pediatric intensive care areas.**

Ventilator mode

- **The way the machine ventilates the patient**

- **How much the patient will participate in his own ventilatory pattern.**
- **هل سيساهم المريض بالتنفس او يعتمد تماما على الجهاز**
- **Each mode is different in how much work of breathing the patient has to do.**

Modes of Mechanical Ventilation

A- Volume Modes

1- Assist-control (A/C)

2- Synchronized intermittent mandatory ventilation (SIMV)

B- Pressure Modes

1- Pressure-controlled ventilation (PCV)

2- Pressure-support ventilation (PSV)

3- Continuous positive airway pressure (CPAP)

4- Positive end expiratory pressure (PEEP)

5- Noninvasive bilevel positive airway pressure ventilation (BiPAP)

Volume modes
1- Assist Control Mode A/C

- **The ventilator provides the patient with a pre-set tidal volume at a pre-set rate .**

- **The patient may initiate a breath on his own, but the ventilator assists by delivering a specified tidal volume to the patient.**
- **Patients can breathe at a higher rate than the preset number of breaths/minute**

- The total respiratory rate is determined by the number of spontaneous inspiration initiated by the patient plus the number of breaths set on the ventilator.

- In A/C mode, a mandatory (or “control”) rate is selected.

- If the patient wishes to breathe faster, he or she can trigger the ventilator and receive a full-volume breath.

- **Often used as initial mode of ventilation**

- **When the patient is too weak to perform the work of breathing (e.g., when emerging from anesthesia).**

Disadvantages:

- **Hyperventilation,**

Volume modes

2- Synchronized Intermittent Mandatory Ventilation (SIMV)

- **The ventilator provides the patient with a pre-set number of breaths/minute at a specified tidal volume and FiO_2.**
- **In between the ventilator-delivered breaths, the patient is able to breathe spontaneously at his own tidal volume and rate with no assistance from the ventilator.**
- **However, unlike the A/C mode, any breaths taken above the set rate are spontaneous breaths taken through the ventilator circuit.**

- The tidal volume of these breaths can vary from the tidal volume set on the ventilator, because the tidal volume is determined by the patient's spontaneous effort.

- Adding pressure support during spontaneous breaths can minimize the risk of increased work of breathing.

- Ventilators breaths are synchronized with the patient spontaneous breathe. (no fighting)

- **Used to wean the patient from the mechanical ventilator.**

- **Weaning is done by gradually lowering the set rate and allowing the patient to assume more work**