Lec.5

INVASIVE VENTILATION

Introduction About Mechanical Ventilation

Mechanical ventilation is typically used after an invasive intubation, a procedure wherein an endotracheal or tracheostomy tube is inserted into the airway. It is used in acute settings such as in the ICU for a period of time during a serious illness. It may be used at home or in a nursing or rehabilitation institution if patients have chronic illnesses that require long- term ventilation assistance



Meaning of Mechanical Ventilation

In medicine, mechanical ventilation is a method to mechanically assist or replace spontaneous breathing

Main goal of mechanical ventilation

Reduce the work of breathing to allow for respiratory muscle rest and recovery

Indication of mechanical ventilation

Respiratory failure: An inability of the heart and lungs to provide adequate tissue oxygenation or removal of carbon dioxide.
Hypoxemic respiratory failure - lung failure just decrease in PaO2
Hypercapnic respiratory failure - pump failure decrease in PaO2 and PaCO2
Neuromuscular diseases: Myasthenia Gravis, Guillain-Barre Syndrome
Musculoskeletal abnormalities Such as chest wall trauma.
Infectious diseases of the lung such as pneumonia, tuberculosis
Obstructive lung disease in the form of asthma, chronic bronchitis or emphysema.

Conditions such as pulmonary edema, atelectasis, pulmonary fibrosis.

Patients who have received general anesthesia as well as post cardiac arrest patients requires ventilatory support until they have recovered from the effects of the anesthesia or out from a danger

EFFECTS OF POSITIVE PRESSURE VENTILATION

System	Effect
Respiratory / Pulmonary	↑ mPaw, alveolar and pleural pressures
Cardiovascular	• ↑intrathoracic pressure -↓venous return - ↓ CO and SV • CVP is increased with PEEP • Effects are more pronounced with use of PEEP
Renal	Decreased CO – Decreased GFR – Reduced filtration and urine output
Hepatic	Reduced hepatic blood flow with PEEP (32% decrease with PEEP of 20 cm H2O
Gastrointestinal/ Abdominal	•Increase in Intra abdominal pressure – impaired circulation •Erosive oesophagitis, stress related mucosal damage

Basic information mechanical ventilation

Respiratory rate (R.R) or frequency (F): is a number of breath per minute or 60 seconds.

Tidal Volume (Vt): the volume of air that enter the lung in each breath for example 0.5 L or 500 ml.

Minute ventilation (MV) = R.R * Tv

Types or forms of mechanical ventilation

Negative pressure ventilator positive pressure ventilator



Some Important Topics

1. Airway resistance physiology:

Flow
Airway size
Airway length

2. Total cycle time (TCT):

It's the time of inspiratory phase and expiratory phase
(I time + E time = TCT).
What is the TCT if the R.R equal to 10b/min on A/C mode?
60s÷10b= 6 second and this equal to TCT.
Or if the rate is 20b/min the TCT is 3 second
But if we are in **pressure control** and the I time was 1 second and I: E ratio is 1:2 it mean the E time equal to 2 second and TCT is 3 second, in this case the rate is 20b/min.

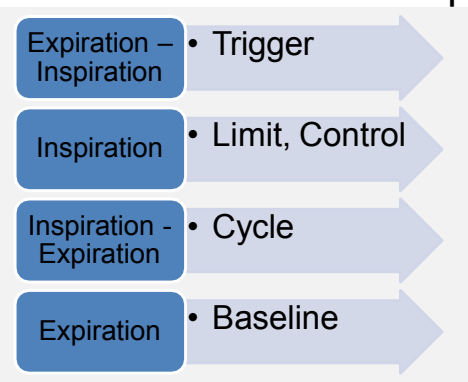
Settings of Mechanical Ventilation

Mechanical Ventilator Settings regulates the rate, depth and other characteristics of ventilation.
Settings are based on the patient's status (ABGS, Body weight, level of consciousness and muscle strength)



Phase Variables

There are four distinct phases of ventilator breath



Four parameters can be controlled or manipulated during each phase: Volume, Pressure, Flow, Time.

TRIGGER

TRIGGERING

The ventilator needs to know when to start a breath. This is known as triggering. A ventilator breath may be triggered (initiated) by the patient (when breathing spontaneously) or triggered by the ventilator (after a set time)

Ventilators use signals from various sites from within the ventilator circuit. The trigger signal can be sensed at the proximal endotracheal tube, in the inspiratory limb, and in the expiratory limb of the circuit. The trigger signal can be pressure, flow, time and neural signal.

Pressure triggering: This requires the patient to generate a small negative inspiratory pressure (generally negative 1–3 cm H2O). This negative pressure is sensed by the ventilator, causing the ventilator to start inspiration and deliver the next breath.

Flow triggering: In this a minimum of flow around 10 L/m is always present in the ventilator circuit (Bias Flow). Flow triggering occurs when a flow transducer in the patient/ventilator systems senses a change in flow i.e. flow moves in to airway opening. Usually flow trigger is kept at 2 L/m. This is the preferable triggering mode in spontaneously breathing patient.

Time triggering: A breath is time triggered when the patient does not initiate a breath and ventilator delivers a breath after a set time (depends on the set respiratory rate).This is the default setting in patient who do not have spontaneous breathing effort (e.g. on neuromuscular blocker).

Neural triggering: It is currently developed to minimise the delay interval between the generation of the signal to breathe in the brain (sensed by diaphragmatic muscle signals) and the actual delivery of flow from the ventilator.

LIMIT OR INSPIRATORY PHASE

This is the phase of the ventilator delivered breath that begins with the initiation of the breath, and ends when the ventilator stops inspiratory

flow. Inspiratory valve is open and the expiratory valve is closed. During the inspiratory phase, air flow is determined by variables called limit variables which could be either pressure or flow. The limit variable does not terminate the inspiration; it allows inspiration to continue till the cycling criterion is reached.

CYCLING: CHANGEOVER FROM INSPIRATION TO EXPIRATION

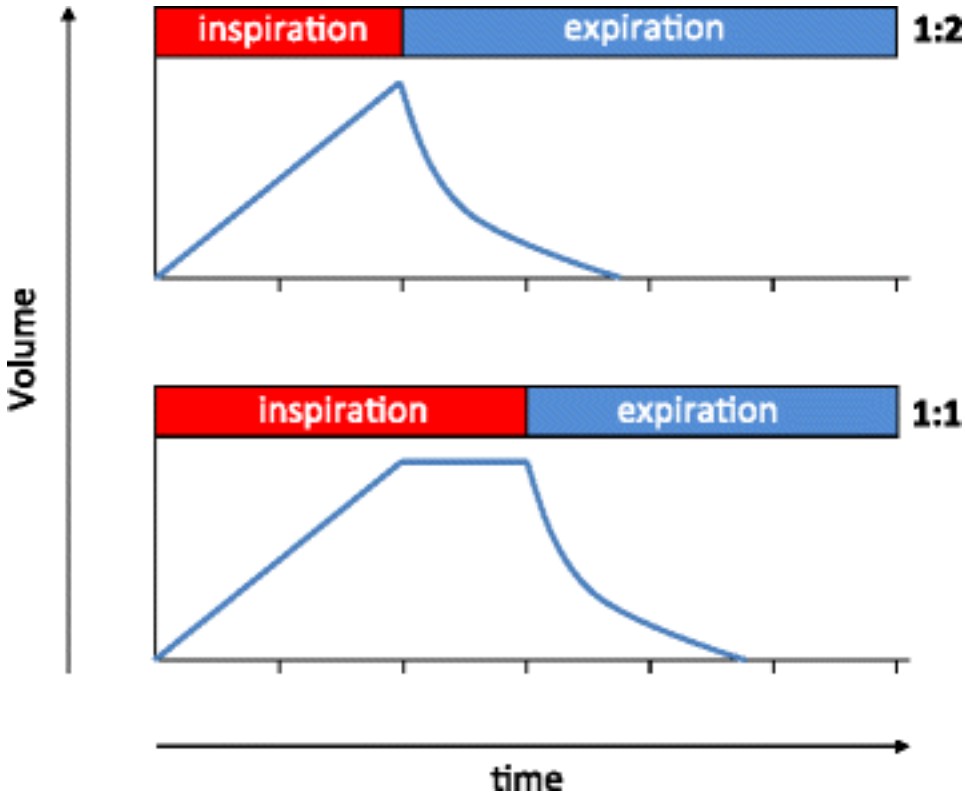
This is known as 'cycling.' Cycling defines how the ventilator recognizes that the inspiratory phase is over, and expiration starts with opening of the expiratory valve. Ventilators may cycle (changeover to expiration) when a certain tidal volume (set inspiratory tidal volume, volume cycled), inspiratory time (time cycled), flow rate (flow cycled). Pressure controlled ventilation is time cycled, volume controlled ventilation without pause is volume cycled and Pressure support mode is flow cycled.

PARAMETERS OF MECHANICAL VENTILATION

- ➤ RESPIRATORY RATE (F): NORMALLY 10-20B/M
- ➤ TIDAL VOLUME (VT): 5-15ML/KG
- ➤ OXYGEN CONCENTRATION (FIO2): 21-90%
- ➤ I:E RATIO: 1:2
- ➤ FLOW RATE: 40-100L/MIN
- ➤ SENSITIVITY/TRIGGER: Such as 0.5-1.5 CM H2O
- ➤ PRESSURE LIMIT: 10-25CM H2O
- ➤ PEEP - USUALLY, 5-10 CMH2O
- ➤ PRESSURE MAX: USUALLY 40 H2O

I:E Ratio

- The I:E ratio is the ratio of the duration of inspiratory and expiratory phases
- A normal I:E ratio at rest is about 1:2, and so the default duration of the expiratory phase in mechanical ventilation is approximately twice the duration of the inspiratory phase.
- The inspiratory rise time determines the rate at which the ventilator achieves a target pressure (in pressure control and pressure support modes) or flow rate (in volume control modes).



- Total cycle time (TCT) equals inspiratory time (T_I) plus expiratory time: TCT = T_I + T_E

- Respiratory rate (f) equals 1 min (60 seconds) divided by TCT.

$$\mathrm{f} = \frac{1\ min}{TCT} = \frac{60\ SECOND}{TCT} = breaths/min.$$

- a Calculate TCT from f. $\mathrm{TCT} = \frac{60\ SECOND}{f}$

I:time (Inspiratory Time)
E:time (Expiratory Time)

I:E Ratio= 1:2 most common
Respiratory Rate 15
60 ÷ 15 = 4 (total cycle time)
I= 1 second, E= 3 seconds, I:E Ratio 1:3
Respiratory Rate 12
60 ÷ 12 = 5 (total cycle time)
I= 1 second, E= 4 seconds, I:E Ratio 1:4

Notes

- Infant ReVel default I:Time= 0.3 seconds
- Pediatric ReVel default I:Time= 0.7 seconds
- Measured I:E ratios will have decimal points – They are actual real time measurements that change dependent on patients measured respiratory rate.
  Examples= 1:3.2, 1:4.1, 1:2.7, 0.7:2.3

$$Ti=V_T(L)/flow(L/s)$$

e.g., A time cycled ventilator is set with the following parameter:
Vt=500
f=12
I:E =1:4. If a constant flow waveform is used
What is the inspiratory gas flow?
Flow= 0.5L/1sec x 60sec/min= 30L/min

e.g., You are asked to ventilate a 63yr old female pt in severe CHF.
Her ABG on a non-rebreather: pH = 7.18, PaCO2 = 83, PaO2 = 98, HCO3 = 31.
She is orally intubated with a 7.5 ETT with VT=400ML, RR=15, I:E = 1:4
Determine the following:
Ti
Ei
TCT
flow

e.g., You are asked to ventilate a 33yr old male pt in severe ARF.
His ABG on a non-rebreather: pH = 7.18, PaCO2 = 73, PaO2 = 90, HCO3 = 31.

He is orally intubated with a 8 ETT with constant gas flow 40 L/min, RR=14, I:E = 2:3
Determine the following:
Ti(I time)
Te(E time)
TCT
VT

Adjusting I:E Ratio

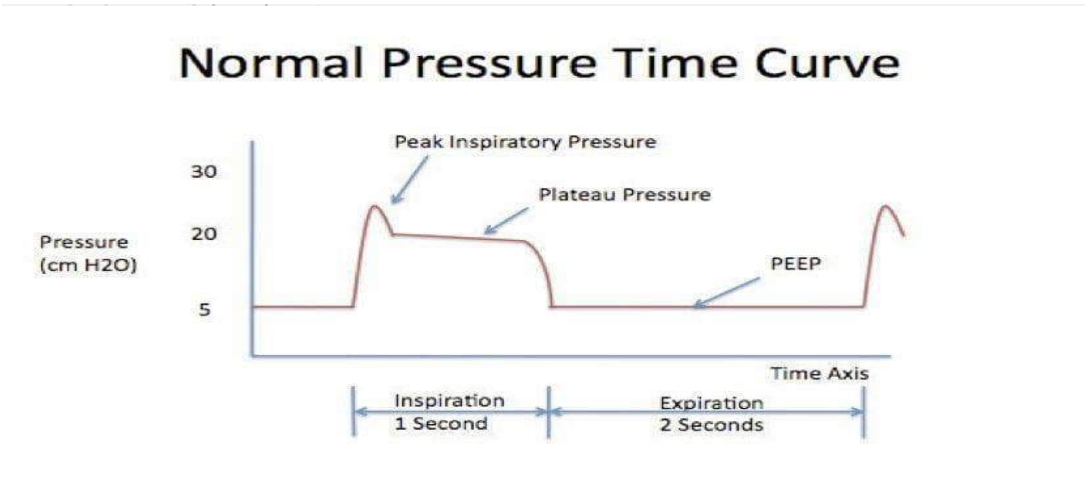
- $\dot{V}_I$: $\uparrow \dot{V}_I \rightarrow \downarrow T_I \rightarrow$ smaller I:E ratio
- $\dot{V}_I$: $\downarrow \dot{V}_I \rightarrow \uparrow T_I \rightarrow$ larger I:E ratio

- VT: $\uparrow VT \rightarrow \uparrow TI \rightarrow$ larger I:E ratio
- VT: $\downarrow VT \rightarrow \downarrow TI \rightarrow$ smaller I:E ratio

- f : $\uparrow RR \rightarrow \downarrow T_E \rightarrow$ larger I:E ratio
- f : $\downarrow RR \rightarrow \uparrow T_E \rightarrow$ smaller I:E ratio

Important definitions:

- Barotrauma: injury resulting from high airway pressure.
- Volume trauma: injury resulting from high volume inside the lungs.
- Exhaust valve: valve in a ventilator with a bellows that allows driving gas to exit the bellows housing when it is open.
- Expiratory flow time: time between the beginning and end of expiratory gas flow.
- Expiratory pause time: time from the end of expiratory gas flow to the start of inspiratory flow.
- Expiratory phase time: time between the start of expiratory flow and the start of inspiratory flow. It is the sum of the expiratory flow and expiratory pause times.
- Inspiratory phase time: time between the start of inspiratory flow and the beginning of expiratory flow. It is the sum of the inspiratory flow and inspiratory pause times.
- Inspiratory: expiratory phase time ratio (I:E ratio): ratio of the inspiratory phase time to the expiratory phase time.
- Minute volume: sum of all tidal volumes within 1 minute.
- Peak pressure: maximum pressure during the inspiratory phase time.
- Plateau pressure: resting pressure during the inspiratory pause. Airway pressure usually falls when there is an inspiratory pause. This lower pressure is called the plateau pressure.
- Positive end-expiratory pressure (PEEP): airway pressure above ambient at the end of exhalation. This term is commonly used in reference to controlled ventilation.



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