

Invasive mechanical ventilation

definition mechanical ventilation:
using an apparatus to facilitate transport of oxygen and CO₂ between the atmosphere and the alveoli for the purpose of enhancing pulmonary gas exchange

Invasive mechanical ventilation: Indications

- **Fysiological**
- **clinical**

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Fysiological indications

- *supporting cardiopulmonary gas exchange*
 - alveolar ventilation
 - arterial oxygenation
- *increasing lung volume*
- *reducing the work of breathing*

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Clinical indications

- *reversing*
 - hypoxemia
 - acute respiratory acidosis
- *relieving respiratory distress*
- *preventing or reversing*
 - atelectasis
 - respiratory muscle fatigue
- *permitting sedation and neuromuscular blockade*
- *decrease oxygen consumption*
- *reduce intracranial pressure*
- *stabilising the chest wall*

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Use of mechanical ventilators

- types of ventilators
- ventilator mechanics
- modes of ventilation
- ventilator settings

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types of mechanical ventilators

- **positive pressure**
- **negative pressure**

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ventilator mechanics

- 4 phases of ventilation
- 4 variables to begin, sustain and terminate these phases
- trigger
- limit / target
- cycle
- baseline

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4 phases of ventilation

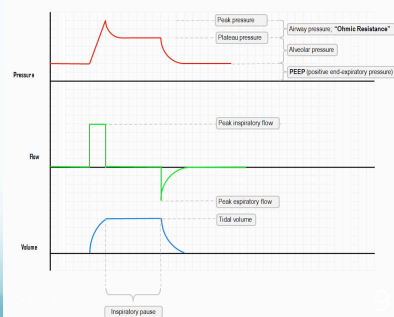
- change from exhalation to inspiration
- inspiration
- change from inspiration to exhalation
- expiration

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the 4 variables to begin, sustain and terminate these phases

- pressure
- flow
- volume
- time



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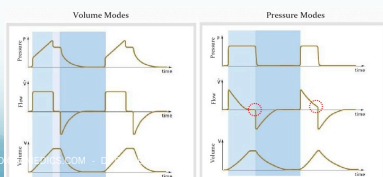
Trigger

- pressure triggered
- flow triggered
- or
 - patient triggered = patient-assisted
 - machine triggered = machine controlled
 - time triggered
- combination of triggers
 - flow triggered
 - + time triggered
 - depending on the patient's ability to interact with the ventilator and initiate a breath

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limit / target

- is a variable that maintains inspiration
- inspirations can be
 - pressure limited: a preset pressure is reached before the end of inspiration
 - flow limited: a preset flow is reached before the end of inspiration
 - volume limited: a preset volume delivered during inspiration



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cycle

- is the variable that ends inspiration
 - volume
 - pressure
 - flow
 - time

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baseline

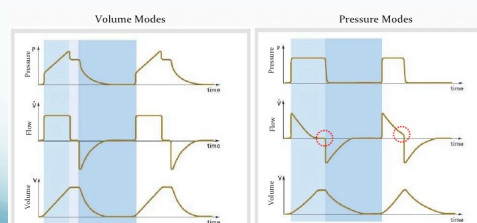
- is the variable that is controlled during exhalation
- the patient exhales to a certain baseline pressure that is set on the ventilator

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modes of ventilation: *introduction*

- ventilator modes refers to HOW the machine ventilates the patient



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modes of ventilation: *introduction*

- Selection of a particular mode determines how much the patient will participate in his or her own ventilatory pattern
- The choice depends on the patient's situation and the goal of treatment
- Because brands of ventilators vary in their ability to perform certain functions, not all modes are available on all ventilators

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ventilator settings

- *respiratory rate or frequency*
 - number of breaths per minute
 - 6-20

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ventilator settings

- *tidal volume*
 - volume of gas delivered to patient during each ventilator breath
 - 6-10mL/kg

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ventilator settings

- *oxygen concentration*
 - fraction of inspired oxygen delivered to patient
 - FiO₂: *between*
 - 21%
 - 100%

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ventilator settings

- *positive end-expiratory pressure (PEEP)*
 - positive pressure applied at the end of expiration
 - 3-5cm H₂O

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ventilator settings

- *pressure support*
 - positive pressure used to augment patient's inspiratory efforts
 - 5-10 cm H₂O

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ventilator settings

- *inspiratory flow rate and time*
 - speed with which the tidal volume is delivered
 - 40-80 L/min or time 0,8-1,2 s

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ventilator settings

- *I:E-ratio*
 - ratio of duration of inspiration to duration of expiration
 - 1:2 to 1:1,5

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ventilator settings

- *sensitivity*
 - determines the amount of effort the patient must generate to initiate the ventilator breath
 - It may be set for pressure-triggering or flow-triggering
 - *pressure trigger: 0,5 - 1,5 cm H₂O below baseline pressure*
 - *flow trigger: 1-3 L/min below baseline flow*

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ventilator settings

- *high pressure limit*
 - the maximum pressure the ventilator can generate to deliver the tidal volume
 - When the pressure limit is reached, the ventilator terminates the breath and spills the undelivered volume into the atmosphere
 - 10-20 cm H₂O above peak inspiratory pressure

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Complications

- ventilator-induced lung injury
- cardiovascular compromise
- gastrointestinal disturbances
- patient-ventilator dyssynchrony
- ventilator-associated pneumonia

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Ventilator-induced lung injury

- air leaks
- results of
 - barotrauma (pressure)
 - volutrauma
 - atelectrauma: repeated opening and closing of the alveoli
- results in
 - pneumomediastinum
 - pneumothorax
 - subcutaneous emphysema
 - pneumopericardium
 - pneumoperitoneum
 - pneumoretroperitoneum

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Ventilator-induced lung injury

- biotrauma
 - initiation of inflammatory-immune response
 - can result in ARDS

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Ventilator-induced lung injury

- prevention of lung injury
 - plateau pressure less than 32 cm H₂O
 - use PEEP to avoid end-expiratory collapse
 - tidal volume 6-10 mL/kg

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Cardiovascular compromise

- positive pressure ventilation increases intrathoracic pressure
- decreases venous return to the right side of the heart
- decrease cardiac output
- secondary consequence
 - hepatic dysfunction
 - renal dysfunction
 - impaired cerebral venous return => increased intracranial pressure

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Gastrointestinal disturbances

- when air leaks around the cuff of the ETT
 - results in
 - vomiting
 - pharyngeal stimulation
 - prevention
 - nasogastric tube
 - ensure appropriate cuff inflation
- constipation due to
 - immobility
 - medication
 - sedatives
 - analgesics
 - paralytic agents

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Patient-ventilator dyssynchrony

- *the patient should breathe in synchrony with the machine*
- *results in*
 - decreased effectiveness of mechanical ventilation
 - auto-PEEP
 - psychologic distress
- *prevention*
 - adjustment of the ventilator
 - sedation of patient
 - paralysis of the patient

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Ventilator-associated pneumonia

- *pneumonia 48 to 72 hours (2-3 days) after endotracheal intubation*

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Ventilator-associated pneumonia: causes

- **mostly due to colonization of bacteria via he tube**
- **other factors**
 - positive pressure ventilation
 - nebulizers
 - nasogastric intubation
 - gastric alkalization with
 - enteral feedings
 - medications
 - patient related factors
 - malnutrition
 - severity of the patients illness
 - presence of ARDS

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Prevention of ventilator-associated pneumonia

- Semirecumbency: *elevation of the head of the bed 30-45 degrees*
- sedation vacation: *daily interruption of sedation to evaluate the patient and their need for continued sedation and mechanical ventilation*

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Sedation vacation

- **Contraindications sedation vacation**
 - hemodynamic instability
 - increased intracranial pressure
 - ongoing agitation
 - seizures
 - alcohol withdrawal
 - the use of neuromuscular blocking agents
- *if the patient tolerates being off the sedation more than 4 hours, then the sedation is discontinued*

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Sedation vacation: signs of intolerance

- ongoing agitation
- increased respiratory rate
- decreasing oxygen saturation
- cardiac dysrhythmias
- signs of respiratory distress

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Other measures to reduce the incidence of ventilator associated pneumonia

- endotracheal tubes with a polyurethane cuff
- other shapes of the cuff
- silver coated endotracheal tubes

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Weaning

- = the gradual withdrawal of the mechanical ventilator
- after the original process for which ventilatory support was required has been corrected
- after patient stability has been achieved

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Weaning

readiness to wean: *algorithm for assessing whether a patient is ready to be extubated*

- every day patients should be screened for their readiness to be weaned
- weaning parameters
- weaning intolerance indicators

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Weaning methods

- the methods depend on
 - the pulmonary status
 - length of time on the ventilator

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Weaning methods

- T-tube trials
- synchronised intermittent mandatory ventilation (SIMV)
- pressure support ventilation (PSV)

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Weaning methods: T-tube trials

- alternating periods of ventilatory support with periods of spontaneous breathing
- the patient is disconnected from the ventilator and breathes spontaneously on a T-piece oxygen delivery system
- the duration of time spent off the ventilator is progressively increased
- the patient is observed closely for respiratory muscle fatigue
- CPAP may be added

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Weaning methods: synchronised intermittent mandatory ventilation (SIMV)

- the ventilator is placed in the SIMV mode
- the rate is slowly decreased (1-3 breathes at a time) until zero is reached
- arterial blood gas sample is obtained 30 minutes after the trial

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Weaning methods: pressure support ventilation (PSV)

- PSV augments the patients spontaneous breaths with positive pressure boost during inspiration
- the level of pressure support is gradually decreased 3-6 cm H₂O, while the tidal volume is maintained at 10-15 mL/kg
- until a level of 5cm H₂O is achieved

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Nursing management:

- patient assessment
- symptom management
- ABCDE bundle
- ventilatory assessment
- patient safety

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Nursing management: patient assessment (bedside evaluation of)

- placement of ETT
- subcutaneous emphysema
- dyssynchrony with the ventilator
- vital capacity
- minute ventilation
- arterial blood gas values
- pulse oximetry
- capnography
- compliance
 - passive
 - active

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Nursing management: symptom management

- symptoms
 - anxiety
 - pain
 - shortness of breath
 - confusion and agitation
 - sleep disturbances
- promoting a healing environment
- minimizing noise levels
- access to natural light
- establishing a method of communication
- provide explanation of what is occurring around the patient
- promoting sleep
- lessen anxiety
 - music therapy
 - guided imagery
 - nursing presence
 - animal assisted therapy

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Nursing management: ABCDE bundle

- focus on enhancing communication between team members
 - standardizing patient care processes
 - decreasing the incidence of delirium
 - decrease the incidence of prolonged weakness
- ABCDE
 - awakening
 - breathing
 - coordination
 - delirium monitoring
 - early mobility

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Nursing management: ABCDE bundle

- ABC
 - *SAT: spontaneous awakening trial*
 - *SBT: spontaneous breathing trial*

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nursing management: ABCDE bundle

- Delirium nonpharm interventions
 - Pain
 - monitoring using an objective scale
 - management
 - orientation
 - talk about
 - day
 - date
 - place
 - discuss current events
 - provide caregiver names
 - use
 - clock
 - calendar
 - Sensory: consider need for
 - hearing aids
 - eye-glasses
 - sleep
 - noise reduction
 - day/night variation
 - "time out" to minimize interruptions of sleep
 - promoting comfort & relaxation
 - massage
 - daytime bath
 - back care
 - wash face/hands

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Nursing management: ABCDE bundle

- E: Early exercise & mobility

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Nursing management: ventilatory assessment

- review of all the ventilator settings and alarms
- understand the alarms and their related problems
- monitoring of
 - *peak inspiratory pressure*
 - *exhaled tidal volume*
 - *arterial blood gas*

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Nursing management: patient safety

- bedside maintaining a functional manual resuscitation bag connected to oxygen
- ensure that the ventilator tubing is free of water
- avoid kinking of the ventilator tubing
- maintain the tubing and connections
- changing tubing
- monitoring the temperature of the inspired air
- if the ventilator malfunctions
 - *remove the patient from the ventilator*
 - *ventilate manually with a resuscitation bag*

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Patient safety: Intrahospital transport of critically ill patients

- *pretransport coordination and communication*
 - *confirm receiving unit readiness to receive patient*
 - *nurse to nurse handoff*
 - *notify other members of the health care team of timing of transport and request equipment*
 - *mechanical ventilator in receiving unit*
- *accompanying personnel*
 - *a minimum of 2 people should accompany a critically ill patient*
 - *unstable patients should be accompanied by a physician*

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Intrahospital transport of critically ill patients

- *accompanying equipment*
 - *blood pressure monitor*
 - *pulse oximeter*
 - *cardiac monitor with defibrillator*
- *medications*
 - *basic resuscitation medications*
 - *Additional: sedatives, narcotic analgetics, additional intravenous fluids*
- *oxygen delivery device*
- *oxygen source with at least 30 minute reserve*
- *manual resuscitation bag*
- *transport ventilator + back up battery*

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Intrahospital transport of critically ill patients

monitoring during transport

- *continuous electrocardiographic monitoring*
- *continuous pulse oximetry*
- *periodic*
 - *blood pressure*
 - *pulse rate*
 - *respiratory rate*

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