Transport Ventilators
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Goals of Mechanical Ventilation

- Provide mechanical power to maintain physiologic ventilation
- Manipulate ventilatory rate, pattern and pressures
- Decrease the work of breathing
- Decrease the myocardial workload
Indications

- Apnea
- Acute respiratory failure
- Impending ventilatory failure
- Hypoxemia
Types of Ventilatory Support

- Pressure cycled
  - Inspiration ends at preset airway pressure
  - Volume per breath is variable
  - Lungs need to be relatively free of resistance and compliant
  - Patient is unconscious, sedated, or cooperative
  - Usually used for short term, but can be used for long-term ventilatory support
Types of Ventilatory Support

- Volume or time cycled ventilation
  - Most popular and easily applied
  - Preset volume limits with predictable tidal and minute volume
Modes of Ventilation

- Control
- Assist/Control
- Synchronized Intermittent Mandatory Ventilation (SIMV)
- Continuous Positive Airway Pressure (CPAP)
- Pressure Control
- Pressure Support
Control

- All parameters of the ventilator cycle (rate, tidal volume, flow rate) are controlled by the ventilator
- Patient is ‘locked out’ from triggering a breath
- Patient has no active role in the ventilatory cycle
- Not routinely used
Patient may trigger additional breaths, above what has been set, by generating inspiratory effort greater than the sensitivity setting.

Flow rate and tidal volume are controlled by the ventilator.

Benefits: controls ventilatory pattern.

Cautions: may stack breaths that may lead to air trapping (adjust sensitivity).
SIMV

- **Ventilator delivers machine breaths**
  - Base respiratory rate and tidal volume are set
  - Synchronized with patient’s spontaneous breath
  - Patient is able to breath spontaneously through the ventilator circuit
  - Spontaneous breaths do not trigger a ventilator cycle with flow rate and tidal volume patient controlled
  - Keeps respiratory muscles active/coordinated
  - Decreased barotrauma and the need for paralytics and sedation
Pressure Support

- Pressure set by the operator to enhance gas flow during spontaneous breaths
- Overcomes airway resistance
- Frequently used for ‘weaning’
CPAP

- Patient breaths spontaneously over elevated baseline pressure
- Tidal volume and flow are completely patient controlled
- User must set back up ventilation parameters
- Benefits:
  - increases compliance and decreases atelectasis
  - Increased PaO$_2$
  - Decreases work of breathing
CPAP (Continuous Positive Airway Pressure)
Pressure Control

- Pressure is regulated during inspiration so that the tidal volume is delivered within a certain pressure limit.
- Ventilator calculates flow rate so that pressure maximum is not exceeded.
- Difficult mode if patient is awake.
- Tidal volumes not assured. Patient must be closely monitored to ensure hypoventilation is avoided.
Terminology

- Fraction of Inspired Oxygen (\(\text{FiO}_2\))
- Tidal Volume (\(V_T\))
- Deadspace (\(V_D\))
- Frequency (\(f\))
- Minute Ventilation (\(V_E\))
- Flow Rate
- Inspiratory Time
Fraction of Inspired Oxygen

- Oxygen concentration expressed as a fraction (decimal)
- $50\% \ O_2 = \text{FiO}_2 \ 0.5$
Frequency

- Breaths per minute
- Respiratory rate
- Ventilation rate
Minute Ventilation

- Tidal volume x frequency
- Relates directly to PCO$_2$ (varies inversely)
- Blood gas analysis is required to determine therapeutic $V_E$
Flow Rate

- Inspiratory flow measured in LPM
- Maintain desired I:E ratio
- Flow may affect pressures
- In Time Cycled Ventilation: Flow rate x inspiratory time = tidal volume
  
  \[30 \text{ LPM} \times 1.5 \text{ seconds} = 750 \text{ ml}\]
Inspiratory Time

- Amount of time the ventilator takes to deliver a single breath, measured in seconds
- Each breath cycle is allowed 5 seconds in the adult mode. Therefore an ‘I’ time of 1.5 seconds allows for an ‘E’ time of 3.5 seconds
I:E Ratio

- Ratio of time for inspiration to expiration is normally 1:2
- There are clinical situations where it may be advantageous for this ratio to change (be controlled)
  - Inverse ratio ventilation
    - Delivers breaths with inspiration time greater than time allowed for expiration
    - Used for patients with ARDS
    - Some ventilators will not allow inverse I:E ratios
Tidal Volume

- **Amount of gas moved in one normal breath, expressed in ml**
- **Normally, about 500-600 ml for resting adults breathing spontaneously (5-7 ml/kg)**
- **Ventilator 10 – 15 ml/kg**
Deadspace

- The volume of gas of the tidal volume that remains in the upper airway that does not participate in alveolar gas exchange
- Normally about $\frac{1}{3}$ of $V_T$
- Extending ventilator circuit improperly may increase deadspace
Airway Pressure

- **Actual (Paw)**
  - Real-time airway pressure

- **Mean (MAP)**
  - Mean pressure over one complete ventilatory cycle

- **Peak (PIP)**
  - Highest pressure over single ventilatory cycle
Compliance

- **Measure of resistance of the lungs to a positive pressure breath**
  - Increased compliance = lower airway pressures
  - Decreased compliance = increased pressures
    - Patient needs suctioning
    - Lungs are influenced by restrictive or obstructive lung disease
    - Developing ARDS or pulmonary edema
PEEP/CPAP

PEEP

- Creates positive end expiratory pressure to allow alveoli to remain open, thereby enhancing gas exchange
  - Improved oxygenation
  - Improved compliance
  - Decreased work of breathing
  - Decreased atelectasis

CPAP

- PEEP on a spontaneously breathing patient
Clinical Guidelines

- Tidal volume 10-15 ml/kg
- Breathing rate 10-20/min
- FiO₂ based on SaO₂, ABG
- Flow rate 30-60 LPM, I:E ratio of 1:2
- PIP < 40 cm
- Minute ventilation? etCO₂
- Sigh 1.5-2x Vₜ stretch receptors release surfactant
- Sensitivity -2cm, adjusted as tolerated
- High pressure limit 10-15 cm above PIP
- Low pressure limit 10-15 cm below PIP
Ventilator Procedures

- Ensure ETT placement
- Provide initial support
  - Manual ventilation
  - PEEP
- Cardiovascular stabilization
  - Stress of intubation
  - Delay in successful intubation
- Drugs
- Establish baselines
Set Up Procedures

- FiO$_2$
- Select mode
- Set respiratory rate
- Set tidal volume
- Set flow rate
- Connect ventilator
- Check inspiratory pressure, set pressure limits and alarms
- Set PEEP
- Check patency of all connections
Procedures

In case of instability or mechanical difficulty, immediately disconnect the ventilator and use manual ventilation.
Tidal Volume Changes

- **Decreased tidal volume**
  - Check for leaks
    - Chest tubes
    - Circuitry, tube, cuff, etc.
    - Malfunction of transducer

- **Increased tidal volume**
  - Altered settings
Peak Airway Pressure Alarms

- Increased pressure (think obstruction)
  - Mucous plug
  - Pneumothorax (tension)
  - Bronchospasm
  - Kinked tube or circuit
  - Coughing or bucking
  - Pulmonary edema
  - Atelectasis
  - Right mainstem intubation
  - Position change
Peak Airway Pressures

- Decreased pressure (think leak)
  - ET tube displaced
  - Cuff leak / deflation
  - Leak in circuit
  - Tube to small, uncuffed tube
  - Chest tube
  - Tracheal-esophageal fistula
ALARM MESSAGE CENTER

MODE = A/C
Fmin = 5.4 L
EXHALATION

ED = OK

Paw (T=12SEC) (cmH2O)

3.8 cm 1.6SEC=1:2.1 451 ml del 21% O2
Complications of Ventilators

- Airway trauma
- Barotrauma
- Machine failure
- Hypotension
- Pneumothorax
- Tension pneumothorax
- Atelectasis
- Pulmonary infection
Transport Considerations

- Compatibility
- Power failure
- Occlusion or plug
- Bucking
- Barotrauma
- Need for sedation / paralytics
Questions?