Indications for Mechanical Ventilation

- Surgical procedures requiring general anesthesia
- Apnea
- Acute ventilatory failure
- Impending ventilatory failure
- Severe oxygenation deficit
Which Ventilator?

• No ventilator is clearly better than any other

• Select machine based on spectrum of patients, financial resources, and available expertise

• Persons operating the ventilator are more important than the machine
Mode

- No mode is clearly superior
- Often guided by institutional policy or personal preference
- Best to initiate with either ACMV or high rate IMV, to produce complete respiratory muscle rest
ACMV

- Patient or time triggered
- Volume cycled
- All breaths fully ventilator supported at user-defined parameters
- In tachypneic patients
  - Poor tolerance
  - Air-trapping
ACMV

Pressure

Volume

Flow
SIMV

• Most frequently used mode
• Preset number of breaths assisted by the ventilator
• Allows unrestricted and unassisted spontaneous breathing between mechanical cycles
• Variation : near-total support to spontaneous breathing
Pressure Support Ventilation (PSV)

Patient triggered, pressure boosted, volume supplement

Uses/Advantages

• Comfortable
• Full support possible
• Better weaning
• At low levels (5-7 cm) used to overcome ETT resistance

Disadvantages

• No back up
• Volume boost is compliance dependent – problems due to secretion, spasm
PSV

Pressure

Volume

Flow
PCV

• Time triggered, time cycled, pressure limited
• Volume and inspiratory flow are dependent variables
• Useful for patients with persistently high airway pressures
• Neuromuscular paralysis and heavy sedation needed for most patients
PCV

Pressure

Volume

Flow
Other Methods of Ventilatory Support

- Why? Hazards of ventilation
  Patient-ventilator interactions

- Indications, efficacy and safety are still clinically uncertain

- Not available for widespread use
• Airway pressure release ventilation
• High frequency ventilation
• Inverse ratio ventilation
• Proportional assist ventilation
• Combination modes
• Liquid ventilation
• Best to begin with a high FiO$_2$ to ensure satisfactory oxygenation, and to replace any existing oxygen debt

• Preferably maintain at <0.5-0.6 to minimize oxygen toxicity

• But remember that hypoxia is always more deleterious than hyperoxia
Tidal Volume

- Standard recommendation has been 10-15 mL/kg
- May aggravate injuries in the already diseased lung
- Growing tendency to lower delivered volume to 5-7 mL/kg or less in those with diseased lungs
Respiratory Rate

• Most patients require mandatory rates in the 8-12/min range

• Patients with hypermetabolic states or raised intracranial pressures may need higher rates

• With assist-control support, machine rate is set slightly lower than patient’s spontaneous rate
PEEP

- Physiological PEEP (3-5 cm H₂O) to maintain normal lung volumes in supine position and correct for loss of glottic function after intubation
- Higher levels of PEEP often needed for patients with severe lung injury
- Potential beneficial and adverse effects
PEEP Trial

• 3-5 cm H₂O increments and assess physiological effects after 15-30 min
• Level causing adequate oxygenation at less toxic FiO₂ levels without any hemodynamic effects selected
• Optimal PEEP level results in tidal ventilation on the steep portion of patient’s pressure-volume curve
Complications in Ventilated Patients

- Related to airway intubation
- Cardiopulmonary effects of positive pressure ventilation
- Other noncardiopulmonary effects
- Adverse effects of sedation and paralysis
- Equipment malfunction
Complications Related to Intubation

- Cardiac arrhythmias
- Pulmonary aspiration
- Oropharyngeal injury and bleeding
- Right mainstem bronchus intubation
- Sinusitis (nasotracheal intubation)
- Tracheal injury at cuff site
- Ventilator associated pneumonia
Cuff Pressure Injury

- Edema, inflammation, ulceration
- Cuff pressures > capillary perfusion pressure (i.e. around 25-30 cm H₂O)
- Laryngeal stenosis is a serious sequel
- Regular monitoring of cuff pressure
Ventilator Associated Pneumonia

- 20-40% of ventilated patients
- Loss of upper airway defenses
- Bacterial colonization of oropharynx and gastrointestinal tract
- Secretions enter trachea through interstices of balloon cuff
Barotrauma

- Presence of extra-alveolar air
- Incidence 5-15%
- Pneumothorax - high mortality
- Risk factors
  - severe underlying lung disease
  - high airway pressures
- ‘Volutrauma’ vs. ‘Barotrauma’
AUTO PEEP

Pressure

Volume

Flow
Oxygen Toxicity

- Excessive free radical generation
- Risk increases with longer duration
- Spectrum from subclinical cellular changes to clinical manifestations of tracheobronchitis, noncardiogenic edema and pulmonary fibrosis
- Prevent - maintain $\text{FiO}_2 < 0.5$ to 0.6
Hemodynamic Consequences

- Positive airway pressure transmitted to the pleural space, heart and great vessels within the chest
- Less venous return, right ventricular preload, and left ventricular afterload
- Compression - hyperinflated lungs
- Neural and humoral mechanisms
- Diminished cardiac output and hypotension
Weaning

• Abrupt or gradual withdrawal of ventilatory support when the cause of respiratory failure is resolving
• Only when the patient reestablishes tolerable balance between ventilatory demand and ventilatory capabilities
• Easy in a majority of patients
• 20-30% patients fail initial attempts
Initiation Of Weaning

- Optimum time
  - Late: ventilator induced complications
  - Early: cardiopulmonary consequences
- Important prerequisites
  - Stable general condition
  - Satisfactory pulmonary gas exchange
  - Cardiovascular stability
  - No sedation and neuromuscular block
Weaning Techniques

• Physician preference and experience

• Methods
  T-piece trials
  IMV
  PSV
  Combination
  Others (uncommon)

• Advantages and limitations
Ventilating ARDS Patients

Traditional strategy

Volume cycled ventilation

Tidal volume preset at 10-15 mL/kg

PEEP as needed

Aim for normal ABG (Po$_2$, Pco$_2$ & pH)
Ventilating ARDS Patients

**Revised strategy**
- Prevent alveolar injury, facilitate healing
- Pressure targeted ventilation
- Tidal volume 4-8 mL/kg
- PEEP above lower inflection point and sufficient for adequate Po$_2$:FiO$_2$ ratio
- Aim at adequate ABG; normalization of Pco$_2$ and pH not important
Ventilating ARDS Patients

- Conventional volume cycled mode
- If elevated airway pressures
  Reduce delivered tidal volume
  PCV with conventional or inverse I:E
- Employ and titrate PEEP early
- Try nonstandard approaches only in refractory patients
Mechanical Ventilation in Patients with Neuromuscular Disorders

- No intrinsic lung disease
  - Large tidal volumes safe
  - Low ventilating pressures
  - Normal or minimally increased $\text{FiO}_2$
- May need mechanical ventilation for long duration
- Weaning may take weeks
Mechanical Ventilation in Patients with Obstructive Airway Diseases

Principles

• Intentional hypoventilation despite an exaggerated respiratory drive
• High flow to reduce inspiratory time
• Management and prevention of dynamic hyperinflation & auto-PEEP

sufficient expiratory time
external PEEP (COPD only)
Summary

• Mechanical ventilation is an important intervention in critically ill patients

• Need for individualization and regular adjustments

• Potential adverse consequences need to be avoided
"No one now on ever seen him is to maintain as the vitals are within "life" parameters!

staff has but our order him as long

FdR"