MECHANICAL VENTILATION

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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

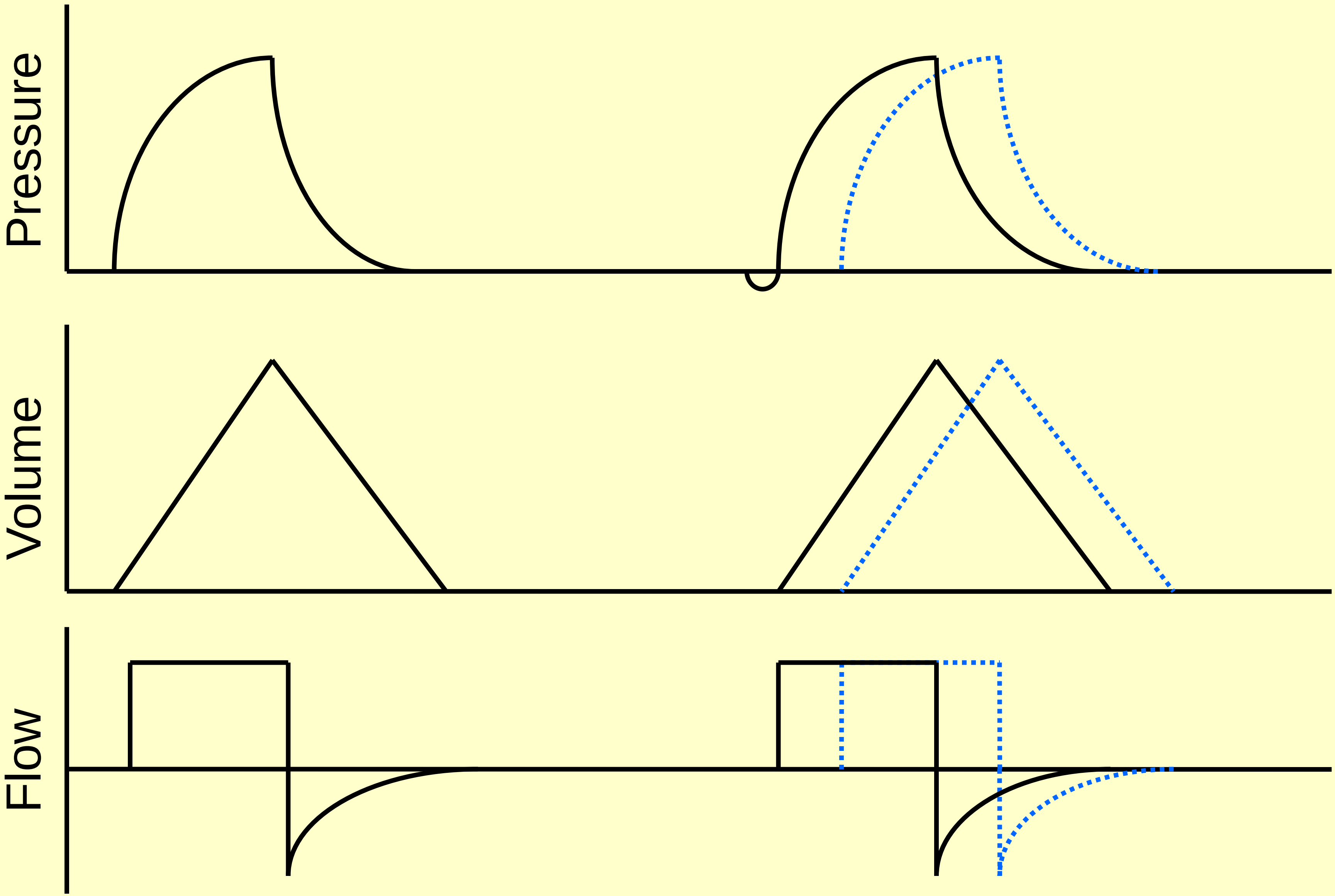
Mode

- 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

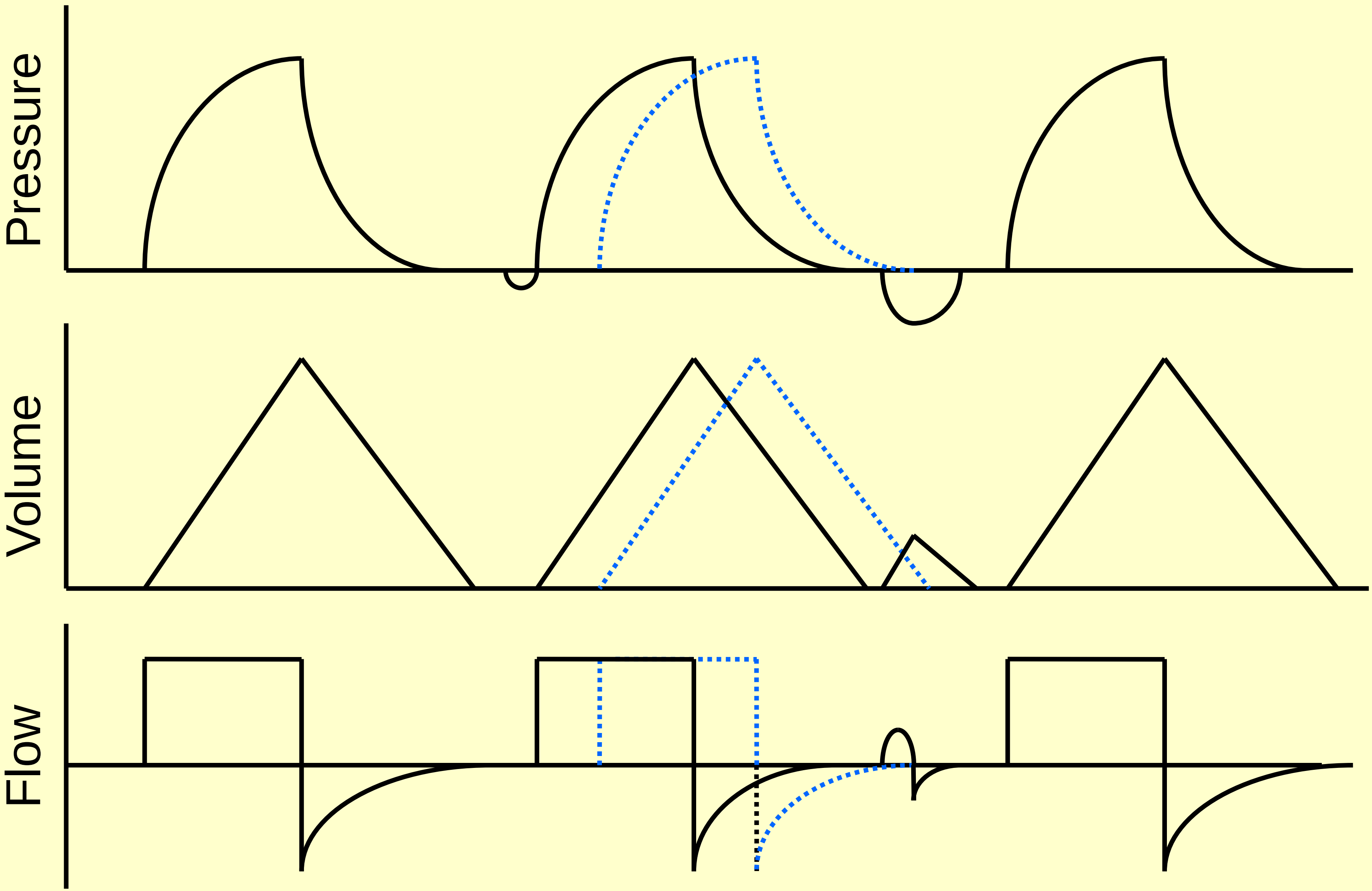
ACMV



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

SIMV



Pressure Support Ventilation (PSV)

Patient triggered, pressure boosted, volume supplement

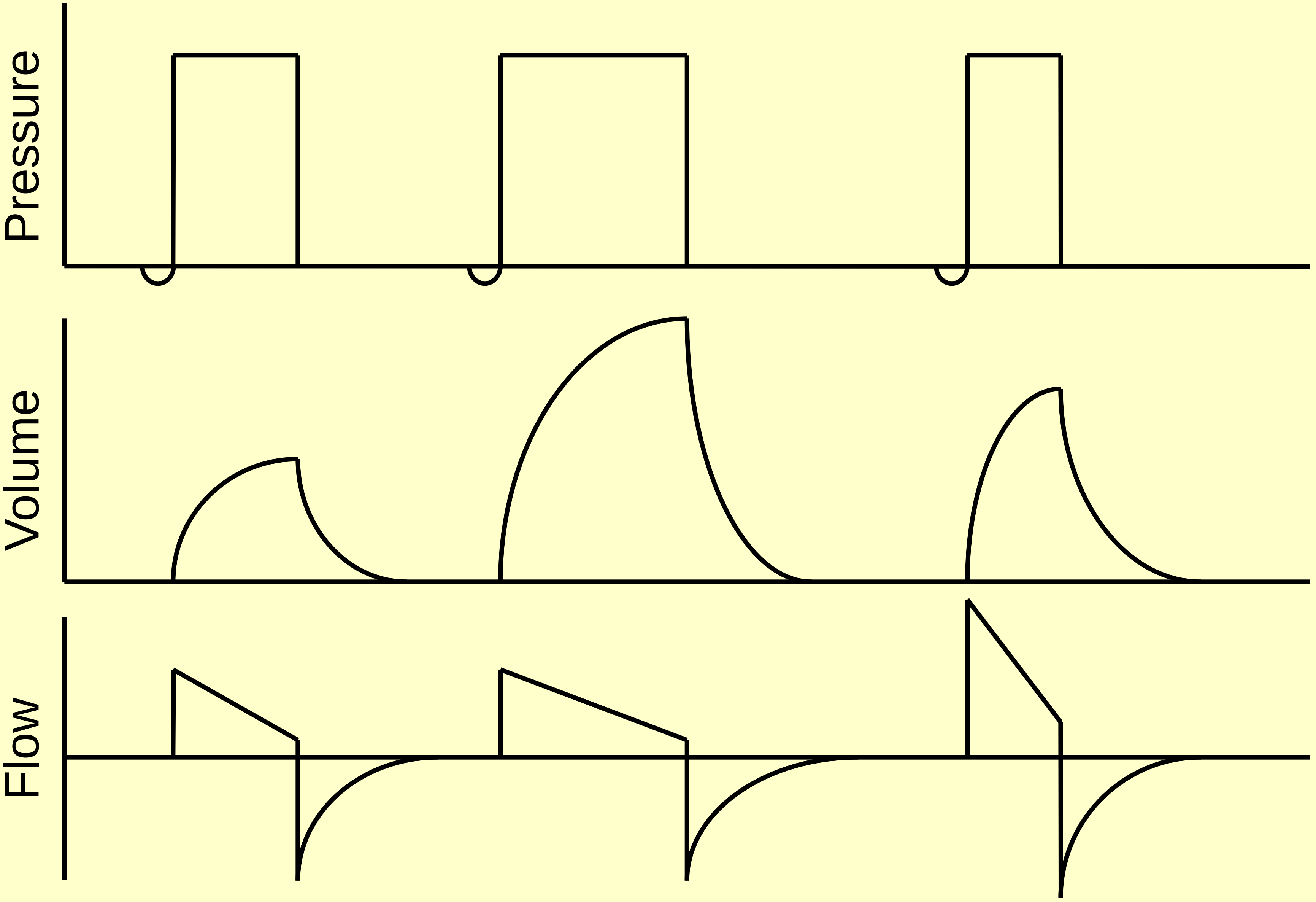
<u>Uses/Advantages</u>

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

<u>Disadvantages</u>

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

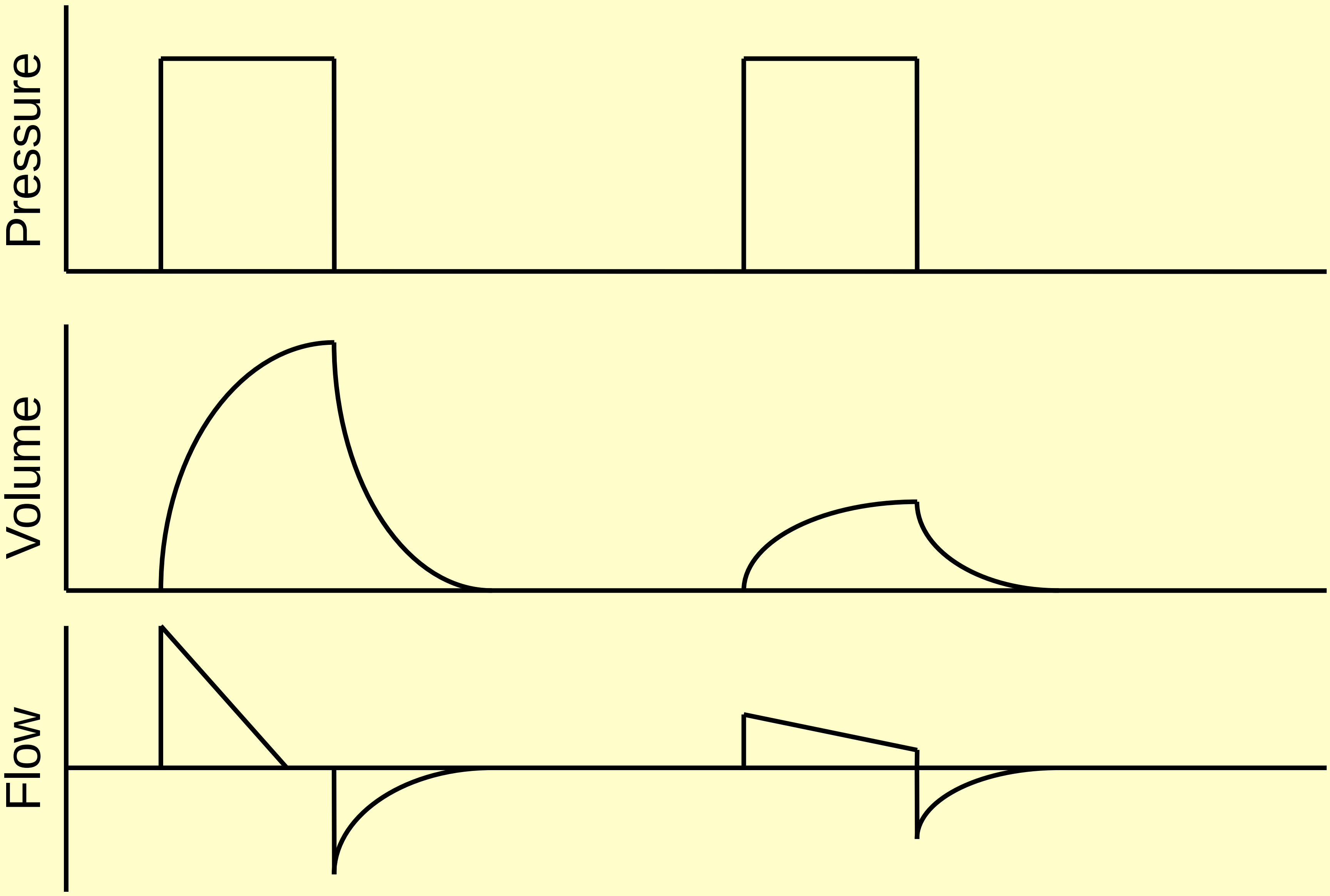
PSV



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



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

FiO_2

- 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 H_2O) 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 H_2O increments and assess physiological effects after 15-30 min
- Level causing adequate oxygenation at less toxic FiO_2 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 H_2O)
- Laryngeal stenosis is a serious sequel
- Regular monitoring of cuff pressure

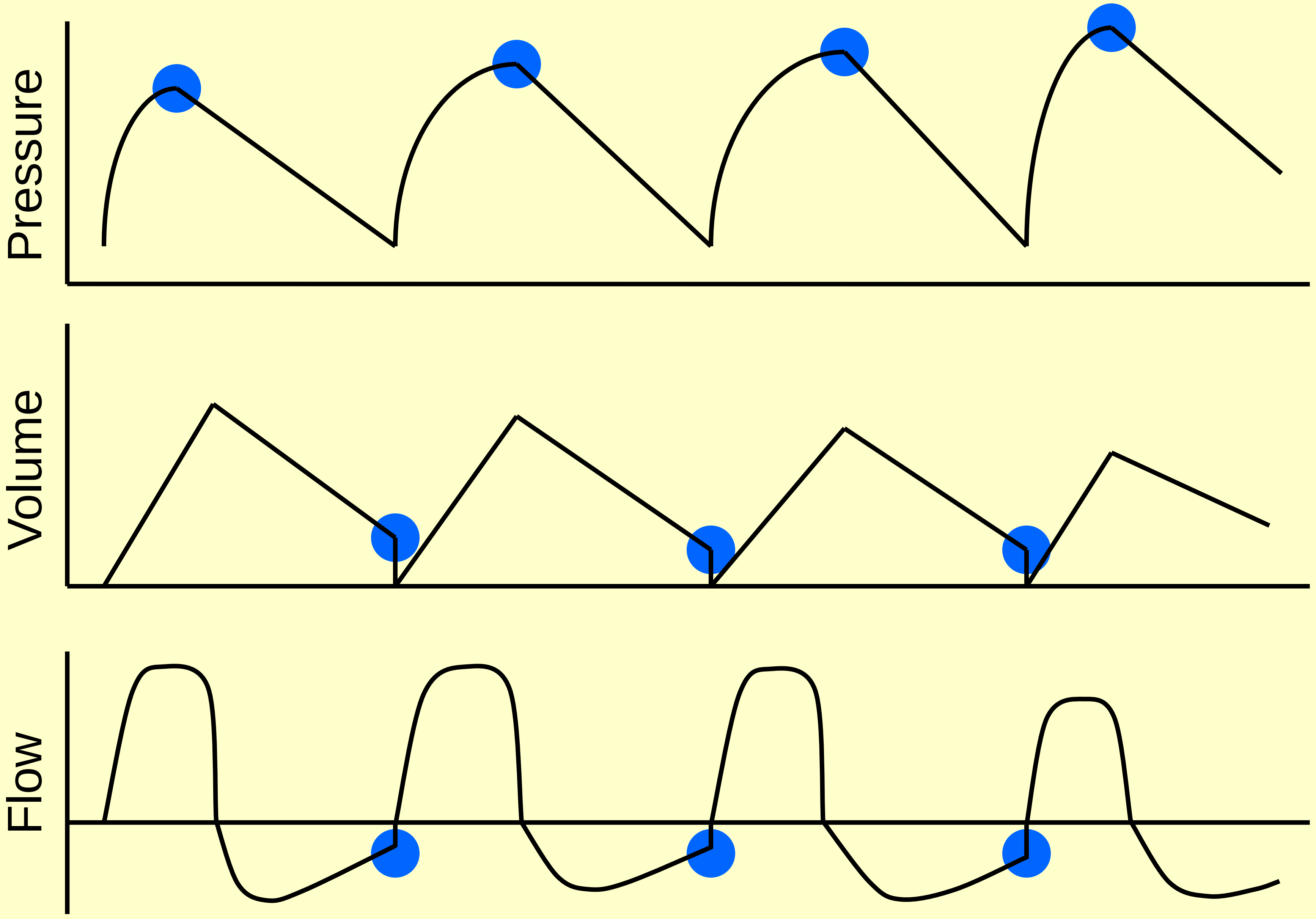
Ventilator Associated Pneumonia

- 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



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 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

<u>Traditional strategy</u>

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 FiO_2
- May need mechanical ventilation for long duration
- Weaning may take weeks

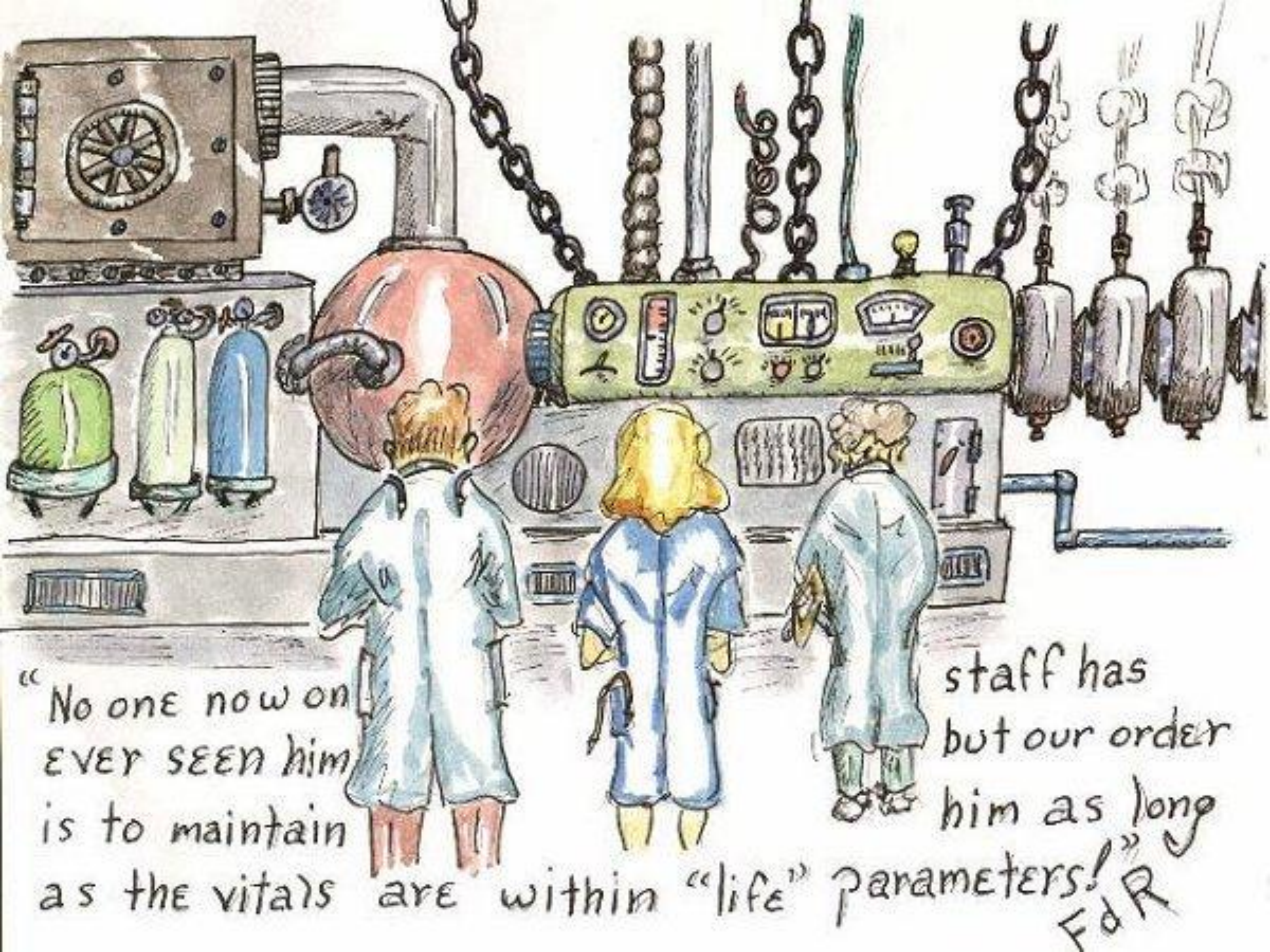
Mechanical Ventilation in Patients with Obstructive Airway Diseases

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 staff has ever seen him but our order is to maintain him as long as the vitals are within "life" parameters!"
FdR