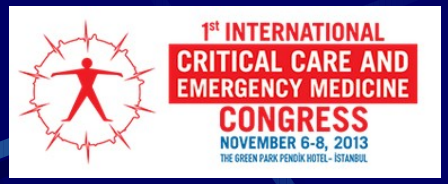

Invasive Ventilation Treatment

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07 November 2013

Ventilation

- Ventilate is derived from Latin word “ventus” meaning wind

Key Points to Understand:

- Indications for Invasive Mechanical Ventilation.
- Settings for Invasive Ventilation and How to Adjust:
  - FiO_2
  - Modes
  - Rate
  - Tidal volume
  - Airway pressures
  - PEEP
- Complications of Invasive Mechanical Ventilation.
- Weaning From Invasive Mechanical Ventilation.

Indications for IMV

- Respiratory Failure
- Cardiopulmonary arrest
- Trauma (head, neck, and chest)
- Cardiovascular impairment (tumors, infection, emboli)
- Neurological impairment (strokes, drugs, poisons, myasthenia gravis)
- Pulmonary impairment (infections, tumors, COPD, pneumonia)

Common indications for ventilation

- Hypoxemic respiratory failure – 66%
- Acute exacerbation of COPD – 13%
- Neuromuscular disorders - 10%
- Coma - 10%

Data from Americas and Europe

Am. J. Respir. Crit. Care Med., Volume 161, Number 5, May 2000, 1450-1458

Key concepts

- Determinants of Oxygenation
  - Ventilator factors:
    - * FiO_2 (fraction of oxygen in inspired air)
    - * Mean airway pressure
    - * PEEP (positive end expiratory pressure)
  - Patient factors
    - * V/Q (ventilation/ perfusion) mismatch
    - * Shunt
    - * Diffusion defect
    - * Reduced mixed venous oxygen

Key concepts

- Determinants of CO_2 clearance
  - Ventilator factors
    - * Rate
    - * Tidal volume
    - * Anatomical dead space
  - Patient factors
    - * Physiological dead space
    - * CO_2 production

Alveolar minute ventilation

- Adjust FiO_2 and PEEP according to PaO_2 and SpO_2
- Adjust TV and rate according to PCO_2 and pH

Respiratory Failure:

Hypoxemic Failure:

V/Q Mismatch vs. Shunt vs. Hypoventilation

PaO2<60mmHg on 100% NRB

Pneumonia
ARDS
Congestive Heart Failure
Pulmonary Embolism

Ventilatory Failure:

Altered Respiratory Mechanics

Acute ↑ pCO2 with Resp. Acidosis

COPD/Asthma
Acute Intoxication
Neuromuscular Disease
Sepsis
Obesity Hypoventilation

Modes of ventilation
Volume controlled

- Machine delivers a set volume irrespective of the pressure generated within the system
- Advantages

  - predefined minute volume is guaranteed
- Disadvantages

  - changes in mechanical properties of lung (resistance or compliance) can lead to high pressures

  - Patient is unable to adjust breathing pattern to changes in ventilatory demand

Modes of ventilation Pressure controlled

- Ventilator applies a predefined target pressure to the airway during inspiration
- Advantages

  - decreased risk of barotrauma
- Disadvantages

  - with decreasing compliance or increasing resistance, tidal volume and minute ventilation fall

	Volume control	Pressure control
Settings	TV, inspiratory flow, I:E ratio	Peak inspiratory pressure, inspiratory time,
Constant	Tidal volume	Maximum inspiratory pressure
Variable	Airway pressure	Tidal volume

- Continuous mandatory ventilation (CMV)
- Intermittent mandatory ventilation (IMV)
- Assist control (A/C)
- Synchronized intermittent mandatory ventilation (SIMV)
- Pressure support

Continuous mandatory ventilation (CMV)

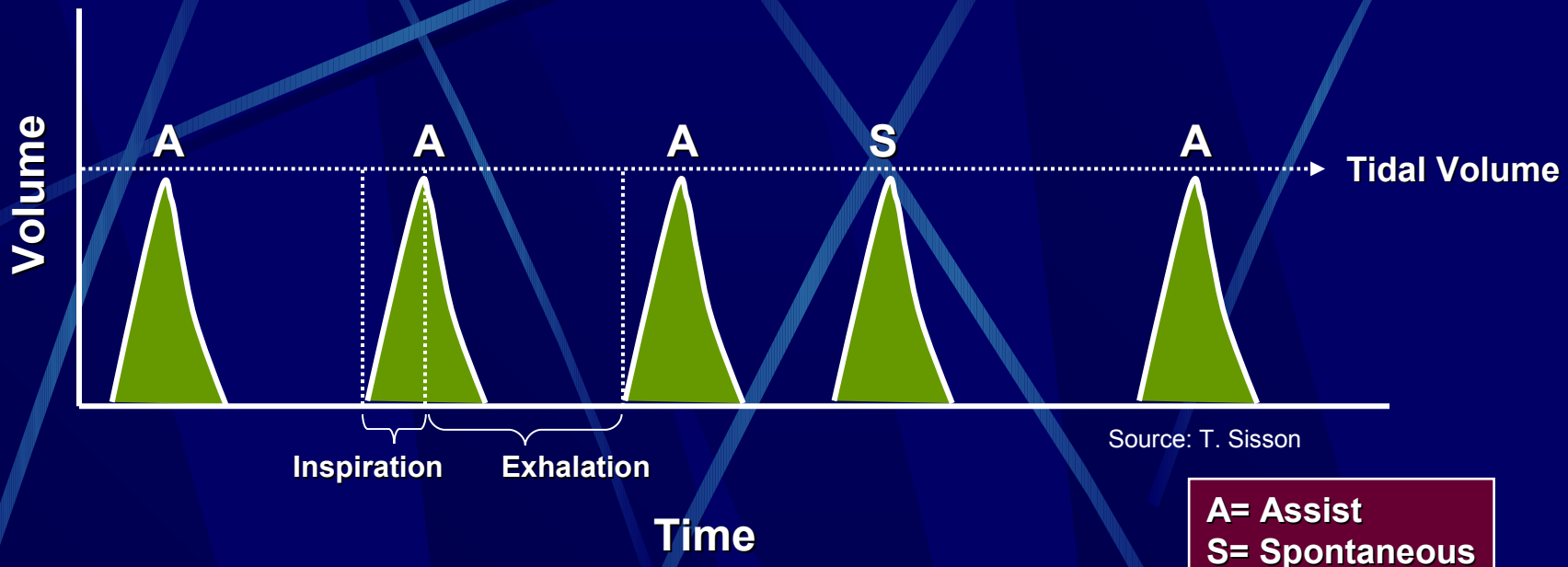
- Also known as controlled mechanical ventilation
- Rate, I:E ratio, volume determined entirely by machine and cannot be altered by patient effort
- Used only in paralyzed patients

Assist control (A/C)

- In addition to a preset number of mandatory breaths, the ventilator delivers additional full breaths whenever the patient has a spontaneous respiratory effort

- Sensitivity of trigger important

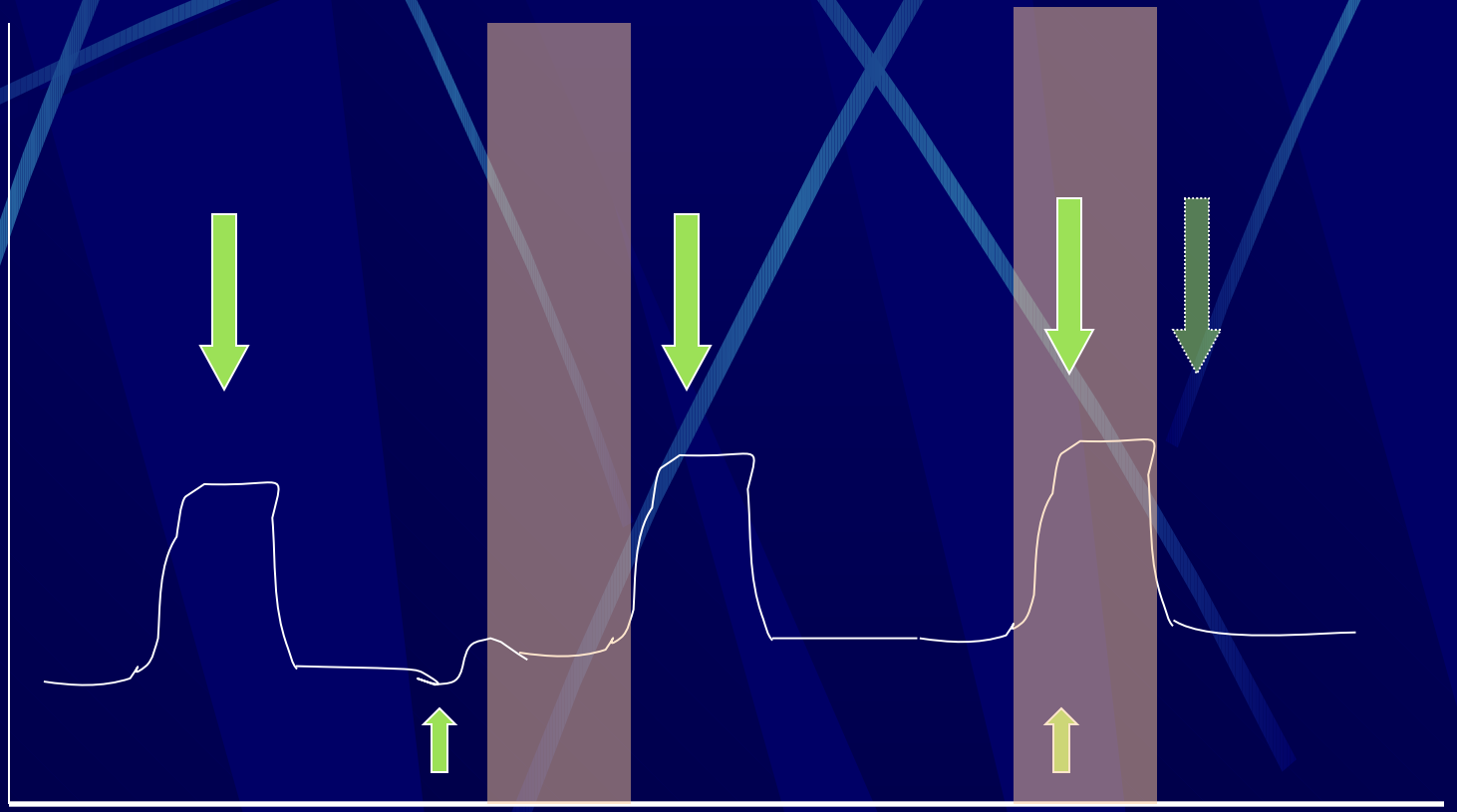
Assist/Control



- I:E- Ratio of Time Spent in Each Phase
- Tidal Volume for Each Breath is Constant at Set TV
- Minute Ventilation: Rate (breaths/min) x Tidal Volume
- Additional Breaths Above Set Rate Are at Set TV.

Synchronized intermittent mandatory ventilation (SIMV)

- The ventilator attempts to synchronize the set number of mandatory breaths with the patients respiratory efforts
- The ventilator waits for a patient effort during a sensitive period before every breath. In its absence, it gives a controlled breath
- Spontaneous breaths outside of this sensitive period are unsupported
- Commonly used mode



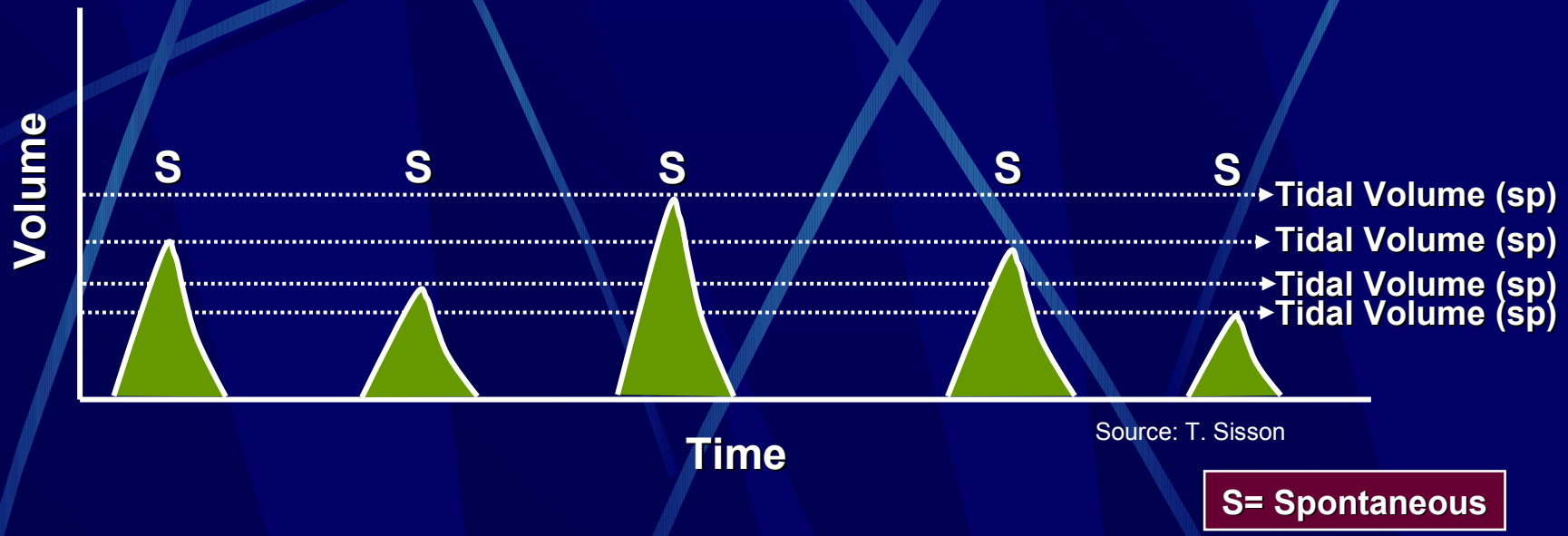
Disadvantages of SIMV

- Mandatory support can be set inappropriately low when SIMV is used as the vehicle for VCV or PCV.

Pressure support

- Delivers a breath to a preset airway pressure when the patient makes an inspiratory effort
- Cycles into expiration when inspiratory flow falls toward end of inspiration
- Used along with SIMV
- Useful for weaning

Pressure Support Ventilation



- Tidal Volume: Varies with Each Breath. No Set Volume.
- Minute Ventilation: Rate (breaths/min) x Tidal Volume.
- No Set Rate with Pressure Support.

Disadvantages of PSV

- Potential for increased work of breathing at lower levels of PSV
- Reduction in mean airway pressure with decreased patient oxygenation

Newer modes

- Hype
- Add to cost
- No reliable evidence for better outcomes in terms of mortality, duration of ventilation

- Adaptive support ventilation (ASV)
- Proportional assist ventilation (PAV)

Others

- Airway pressure release ventilation (APRV)
- Pressure controlled inverse ratio ventilation

- One of the key goals of mechanical ventilation is to decrease work of breathing

- Improper ventilator settings can however increase work of breathing, increasing patient distress and worsening hemodynamics and metabolic parameters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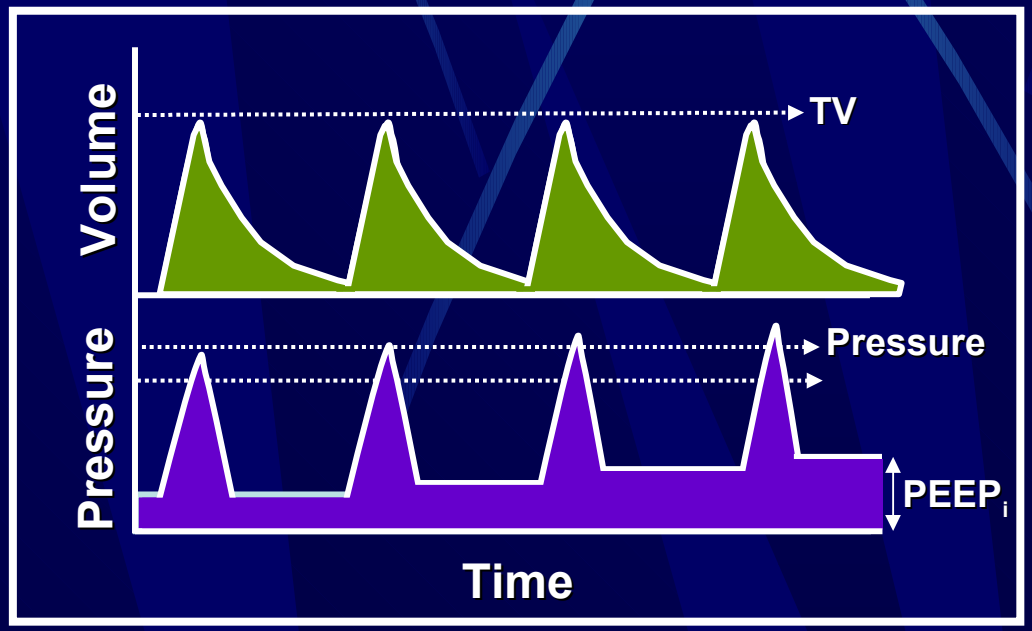
FOTOSEARCH

Complications of Invasive Mechanical Ventilation

Auto-PEEP (Intrinsic PEEP)

- End Expiratory Pressure Does Not Return to Zero (or Set PEEP):
  - Typically a Complication of Obstructive Lung Disease.
  - Results From an Inadequate Expiratory Time.
  - Patients with Asthma and COPD Need Prolonged Expiratory Phase to Empty Previous Breath.



Complications of Invasive Mechanical Ventilation

Auto-PEEP (Intrinsic PEEP)

- Problem: If Thoracic Pressure > Central Venous Pressure then Impairment in Venous Return Resulting in Hypotension.

- Management: Prolong Exhalation (Change I:E Ratio)
  -Fewer Breaths/Minute (Increase Tidal Volume)
  -Shorter Inspiratory Time (Increase Inspiratory Flow Rate)

Complications of Invasive Mechanical Ventilation

High Pressures:

- Problem: Barotrauma vs. Volutrauma
  - Large Tidal Volumes ± High Lung Pressures Lead to Lung Injury.
  - Improved Outcome in Acute Respiratory Distress Syndrome by Limiting Tidal Volumes.
  - Barotrauma Can also Manifest as Pneumothorax.

- Causes:

High Peak/Normal Plateau

↓

Increase in Airways Resistance

↓

Worsening Airway Obstruction (Asthma/COPD)
Endotracheal Tube Obstruction

↙ ↘

Biting Tube Mucus Plugging

High Peak/High Plateau

↓

Decrease in Lung Compliance

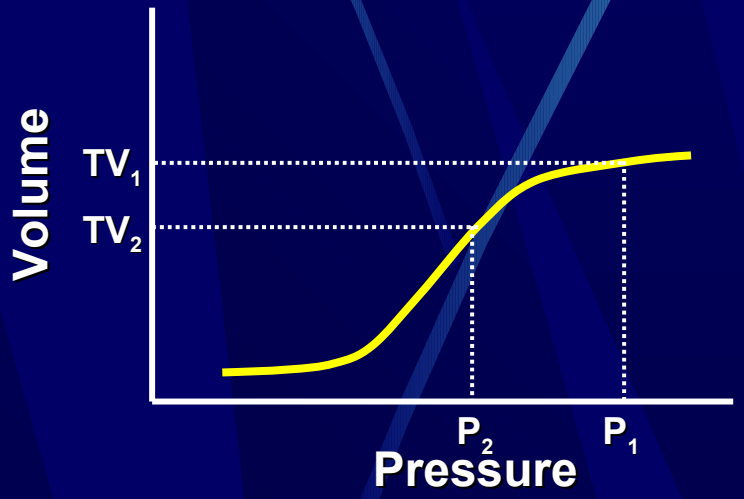
↓

Worsening Disease (ARDS/CHF)
Pneumothorax
Right Mainstem Intubation

Complications of Invasive Mechanical Ventilation

High Pressures:

- **Management:**
  - Dependent on Cause, So Try to Determine Etiology.
  - If Due to Low Lung Compliance, Decrease Tidal Volume
  - Can Consider Pressure Cycled Ventilation.



  - If Due to Increased Airway Resistance, Less of a Problem: Suctioning Bronchodilators, etc.

Complications of Invasive Mechanical Ventilation

Over-Ventilation:

- When Minute Ventilation Is Greater Than Patient Needs:
  - Patient Will Make No Spontaneous Efforts.
  - Suspect Over-ventilation When Patient Sits on Back-up Rate.
  - Also Can Be Detected with an Arterial Blood Gas.

- Management:
  - Decrease Minute Ventilation (↓ TV or ↓ Respiratory Rate).
  - For A/C, Set Back-up Rate ~4 Breaths Below Total Respiratory Rate.

Complications of Invasive Mechanical Ventilation

High FiO2:

- Problem: High Levels of Oxygen Are Toxic to Patient's Lung.
  - Exact Level of safety Has Not Been Determined.
  - ≤ 50% FIO2 Is Goal.
  - However, FIO2 Is not Decreased if it Results in Inadequate Oxygenation (Sat > 90% or pO2 > 60 mmHg).

- Management:
  - PEEP.
  - Prone Positioning.
  - Inhaled Nitric Oxide.

Complications of Invasive Mechanical Ventilation

Patient-Ventilator Dysynchrony:

- Problem: Patient Discomfort and Anxiety, Impaired Oxygenation/Ventilation.

- Management:
  - Sedation: Benzodiazepines and Narcotic Analgesics
  - Change Ventilator Mode.
  - Paralysis: Increases Risk for ICU Myopathy.

Ventilator Associated Pneumonia:

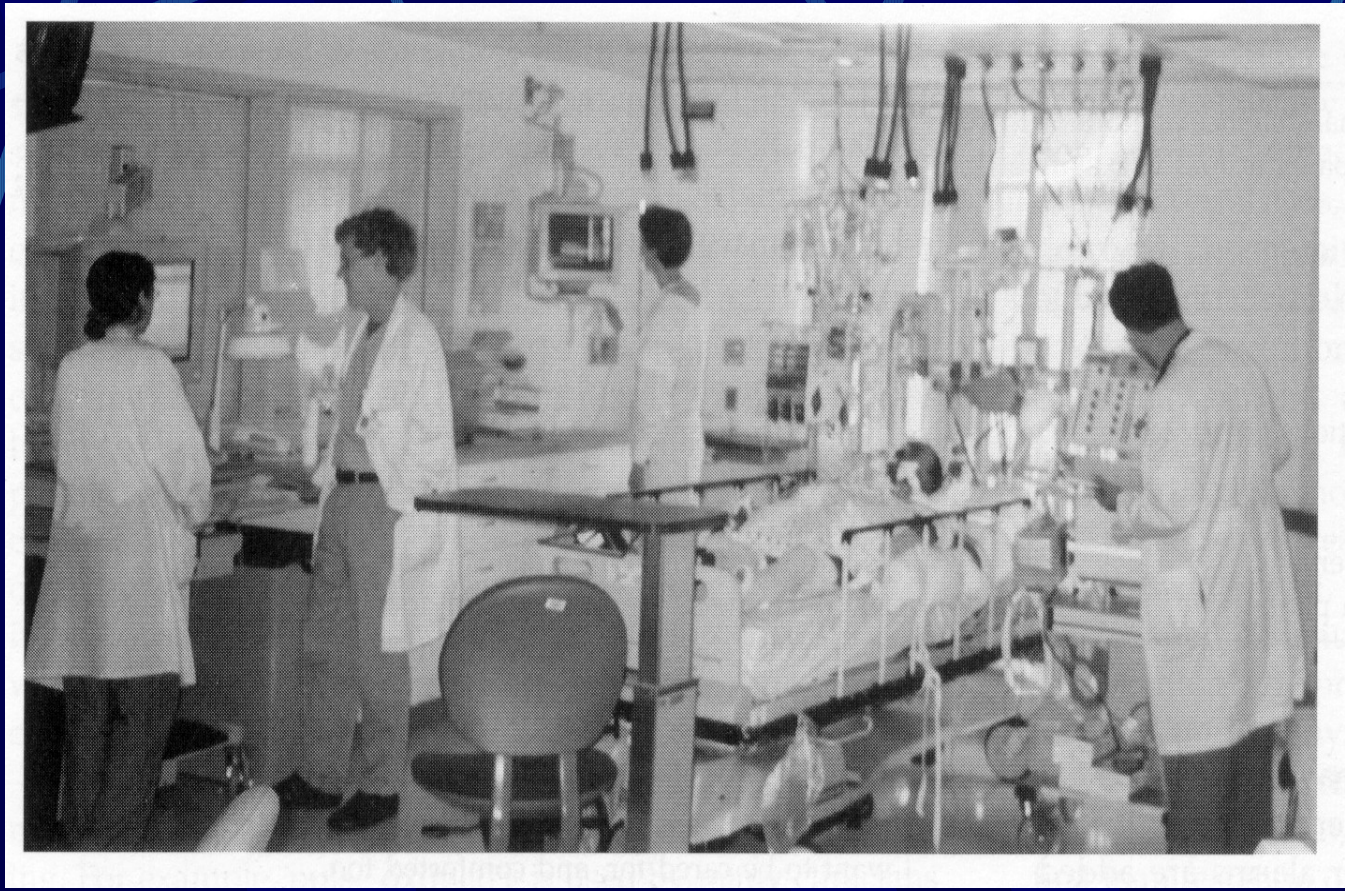
- Problem: Interruption of Upper Airway Defenses.
  - Cough, Gag, Mucus Clearance.
  - Colonization of the Airway/Upper GI Track with Pathogenic Bacteria.

- Management:
  - No Fool Proof Method to Prevent Vent-associated Pneumonia.
  - Elevate Head of Bed to 30-45 degrees.

Remember

- Ventilation is not an end in itself, it is only a form of organ support
- The nuances of ventilation should not take away from the primary goal of treating the underlying condition

Who's Watching the Patient?



Pierson, IN: Tobin, Principles and Practice of Critical Care Monitoring

Default settings

- TV-6-8ml/kg
- Rate – 15/min
- FiO2 – 100%
- PEEP – 5cmH2O
- Pressure support – 15cmH2O
- Ti – 1.0 sec
- Pramp – 50msec

How to Begin Invasive Mechanical Ventilation: Settings

- **Options** (for invasive ventilation):
  - Mode: Assist-Control (A/C), Intermittent Mandatory Ventilation (IMV), Pressure Support Ventilation (PS), Others.
  - FiO2: 21%-100%
  - Rate: 0-35
  - Tidal Volume: 4cc/kg to 10cc/kg
  - Inspiratory Flow Rate: 60L/mim to 120L/min

Monitor and re-adjust

- FiO2-
  - based on PaO2 and SpO2. maintain PaO2 60-90mmHg
  - Aim to reduce FiO2 below 60%
- PEEP-
  - based on PaO2 and SpO2.
  - Aim to reduce FiO2 below 60%.
  - Can increase rapidly but can be reduced very gradually

Monitor and re-adjust

- Rate –
  - To keep CO_2 in normal range-30 to 50 mmHg
  - Exceptions: ↑ICP, acute phase of MACD
- Pressure support –
  - Spontaneous breaths should have at least 80% of set - TV
- Tidal volume –
  - Adjust so that peak pressure < 30cm H_2O
- Ti –
  - clinical and graphical synchrony
- Pramp –
  - increase only in obstructed airways

Daily Assessments of Invasive Mechanical Ventilation

Pressures: (Peak and Plateau).

Arterial Blood Gas: (Ventilation, Oxygenation)

Chest X-ray: Position of Endotracheal Tube

Auto-PEEP: Especially in Patient with Obstruction.

Patient Comfort and Position of Head.

Weaning Candidacy.

Weaning From Invasive Mechanical Ventilation

- When?
  - Underlying Condition Has Improved:
    - $FIO_2 \leq 40\%$
    - Minute Ventilation ≤ 10 L
    - Mental Status Allows Patient to Follow Commands.

- Pre-Weaning Assessment: Parameters
  - Patient is Taken Off Support Briefly
  - Several Parameters are Assessed: MV, TV, RR, Negative Inspiratory Force, Vital Capacity

  No Perfect Predictor for Success in Coming Off Ventilator.

  Rapid Shallow Breathing Index Commonly Used: RR/TV (Liters). < 105 Suggests Likely Success.

Weaning From Invasive Mechanical Ventilation

- How?

- If Parameters Suggest that Patient is Ready, Begin Weaning Trial:

  Spontaneous Trial: Patient Breaths on Own.

Duration of Spontaneous Trial: Depends on Circumstance

~ 2 Hours.

- If Spontaneous Trial is Successful, Endotracheal Tube is Removed.

Adjuncts

- Tracheobronchial hygiene
- Sedation and analgesia
- Stress ulcer prophylaxis
- DVT prophylaxis
- Eye care

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Thanks for attention...

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