INDIAN SOCIETY OF ANAESTHESIOLOGISTS (ISA)
MECHANICAL VENTILATION MODULE (BASIC)

Orientation Course for Clinical Specialists &
Refresher Course for Anaesthesiologists

Basic Modes of Mechanical Ventilation

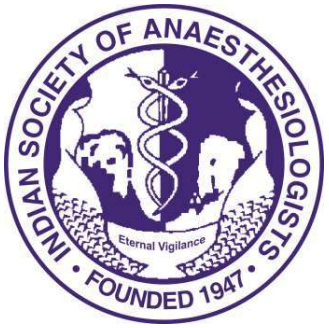
Basics

- All ventilators do only one thing: Push in air in inspiration
- Compressor +Two valves
- Inspiration
  - I. valve =Open
  - E. valve = Closed
- Insp Pause = both valves closed
- Expiration
  - I. valve = Closed
  - E. valve = Open
- Exp Pause (PEEP) = both valves closed

Volume vs. Pressure Control

Variable	Volume Control	Pressure Control
TV	Set, constant	variable
PIP	Variable	Set, constant
Inspiratory time	Set	Set
Inspiratory flow	Set	Variable
Inspiratory flow waveform	Set, constant	Decelerating type, variable

Volume vs. Pressure Control



Volume Preset

- Set parameter is the tidal volume; airway pressure is variable
- Constant tidal volume in the face of changing lung characteristics
- Patient-ventilator asynchrony due to fixed flow rate
- No leak compensation

Pressure Preset

- Set parameter is airway pressure; tidal volume delivered is variable
- Tidal volume varies with changes in lung characteristics
- Flow will vary according to patient's demands
- Compensates for leaks

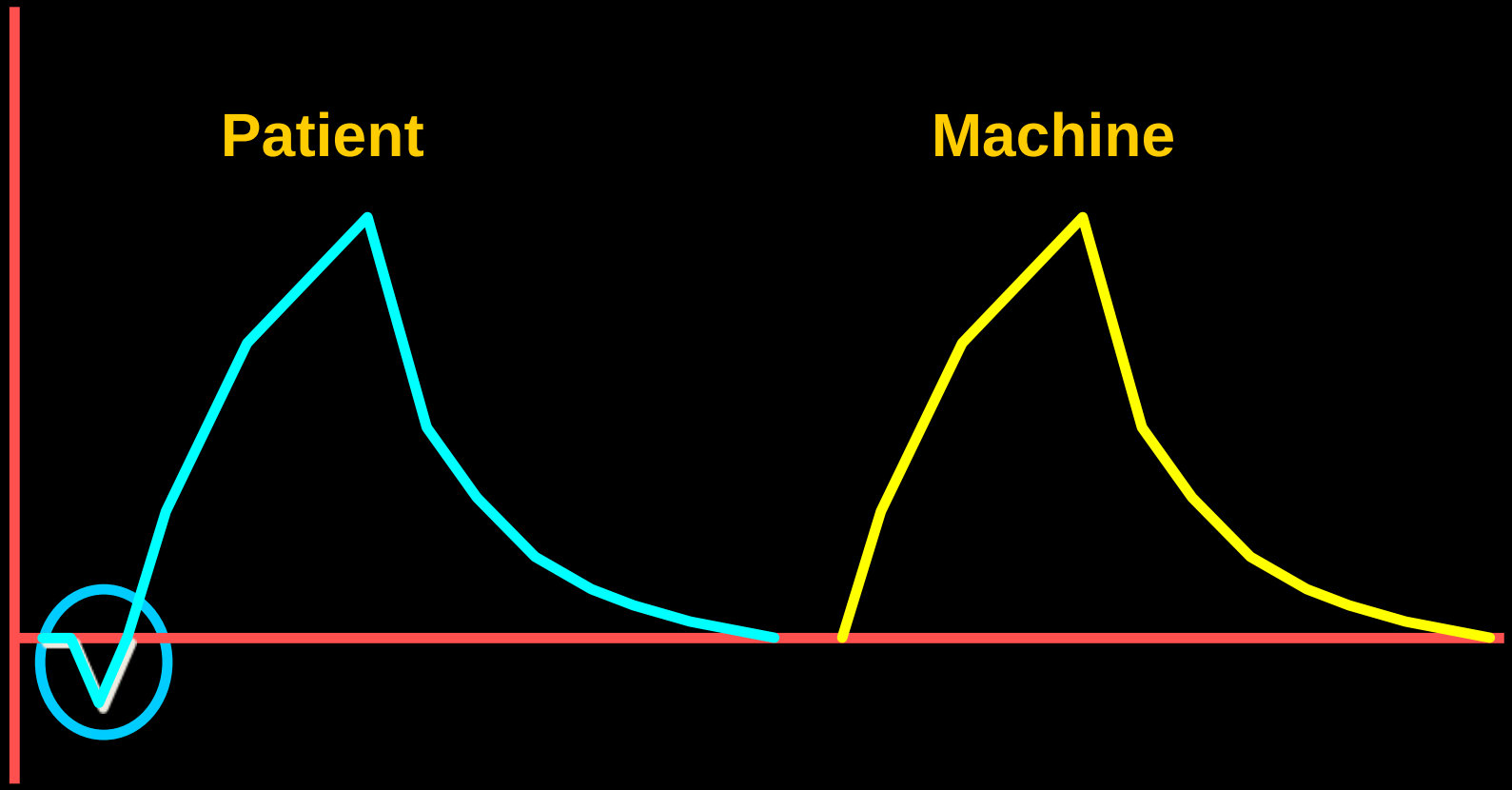
What to monitor: VCV & PCV

- During Volume Controlled Ventilation
  - Peak airway pressure
  - Plateau Airway Pressure
  - Low Pressure alarms
- During Pressure Controlled Ventilation
  - Expired Tidal volume
  - Expired minute volume

Trigger

- Time
  - Ventilator initiates the breath according to a set frequency, independent of patient effort
- Pressure
  - Patient's breathing produces a decrease in baseline circuit pressure which starts inspiration
- Flow
  - Ventilator senses inspiratory flow by the patient and initiates inspiration

Triggering



Essentials of Ventilator Graphics. 2000 RespiMedu, Inc. Deshpande and Restrepo

Inspiration - Limit

- Either flow rate or pressure
- Inspiration continues at the limit for the duration of inspiration
- It remains at that level till changeover to expiration occurs

Cycling

- Changeover from inspiration to expiration
- Inspiration ends when some variable has reached a preset value
- Time / Volume
  - Most ventilators measure flow rather than volume; with a set flow rate, adjust inspiratory time. Hence time cycled
- Flow
  - When expiratory flow reaches a preset value. PSV
- Pressure
  - When pressure reaches a preset value. E.g. Bird Mark 8

Expiration - Baseline

- From start of expiratory flow to beginning of inspiratory flow
- Most commonly baseline pressure is controlled – PEEP or CPAP

Types of Breaths

- **Mandatory**
  - Ventilator determines either start of inspiration or end of inspiration or both
  - Assisted breath if patient triggered
- **Spontaneous**
  - Start and end of inspiration are determined by patient
  - Supported breath if inspiratory pressure is greater than baseline

Modes of Ventilation

- **Control variables**
  - Are the breaths Pressure Controlled or Volume controlled?
- **Type of Breath**
  - Mandatory or Spontaneous, or a Combination
- **Conditional Variables**
  - Any variables which may determine a change in ventilator function

CMV

- **All breaths are mandatory**
- **Preset frequency, inspiratory time**
- **Pressure or volume control**
- **Time triggered**
- **Volume, flow or pressure limited**
- **Time cycled**

Set TV/ Pressure, Resp. Rate, PEE, FiO2, Ti / Flow rate / I:E ratio.

Assist Control

Like CMV

- **Each <u>additional</u> assisted breath at prefixed tidal volume or pressure**
- **Trigger: ventilator or patient**
- **Limit: Flow / volume or Pressure**
- **Cycling: volume or time**

Set TV/ Pressure, f, PEEP, FiO2,
Ti/ I:E ratio

SIMV

- **IMV**
  - Machine triggered breaths with spontaneous breaths allowed in between
- **SIMV**
  - Synchronised mandatory breaths with spontaneous breaths allowed in between
  - Ventilator creates a time window around the scheduled delivery of mandatory breath
  - If a patient effort is detected, it synchronises the machine breath with the patient's inspiration
  - If no patient effort is detected, it delivers a breath at the scheduled time

Pressure Support

- Completely spontaneous mode in which patient triggers each breath
- On inspiration patient exposed to a preset pressure
- Inspiration is terminated when the flow rate reaches a minimum level or % of peak flow
  - Trigger: Patient
  - Limit: Pressure
  - Cycling: flow

Pressure Support Ventilation (PSV)

- Spontaneous mode
- Pt initiates breath and vent delivers pre-set inspiratory pressure to help overcome airway resistance
- Pt controls the rate, tidal volume and minute ventilation
- TV is variable
- Can be used in conjunction with SIMV or CPAP
- ALWAYS set low TV / MV alarm and apnea backup

Set Pressure support, peep, Fio2, Apnea settings

Three Golden Rules

- Never silence alarm unless
  - Problem identified and sorted out
  - Chest is clearly moving
  - Patient is put on AMBU bag
- When in doubt AMBU the patient
  - Doubt about airway pressures
  - Fall in SO2
  - Patient not coordinating with ventilator
  - Unexplained alarm
- AMBU bag behind each bed

Ventilatory Strategy in ARDS

Berlin Definition of ARDS

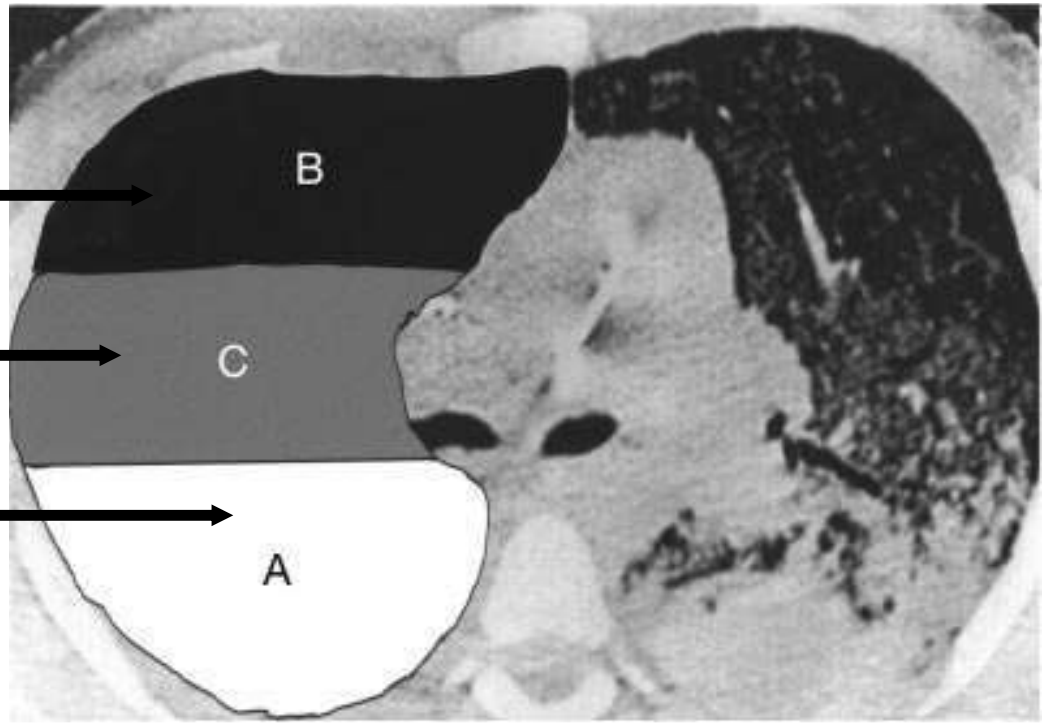
	Acute Respiratory Distress Syndrome
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms
Chest imaging	Bilateral opacities—not fully explained by effusions, lobar / lung collapse, or nodules
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (eg,ECHO) to exclude hydrostatic edema if no risk factor present
Oxygenation Mild	200 mm Hg < PaO2/FIO2 ≤ 300 mm Hg with PEEP or CPAP ≥ 5 cm H2O
Moderate	100 mm Hg PaO2/FIO2 ≤ 200 mm Hg with PEEP ≥ 5 cm H2O
Severe	PaO2/FIO2 ≤ 100 mm Hg with PEEP ≥ 5 cm H2O

Lung Injury in ARDS

Aerated

Partially aerated

Non-aerated



Lung Injury in ARDS

- In ARDS there is “non-homogeneous” affectation of the parenchyma.

- In an ARDS patient, the lungs have several distinct areas:
  - areas of normal aeration (which over distend with ventilation)
  - poorly aerated (but potentially recruitable areas)
  - non-ventilated zones.

- Thus in an adult patient, the volume of aerated lung is the size of lung in a 5-6 year old healthy boy, the so called “baby lung.”
- The small areas of normal aeration will receive the bulk of volume and over distend, resulting in volutrauma.

ARDS
Volutrauma & Atelectrauma

In ARDS, following mechanisms of lung injury have been described:

- Atelectrauma
- Oxygen toxicity
- Volutrauma
- Cyclical shear stress injury
- Biotrauma
- Barotrauma

Ventilator Induced Lung Injury

- Barotrauma
- Over distension of ventilated alveoli
  - volutrauma
- Cyclical opening and closing of lung units with IPPV
  - shear stress with alveolar injury
- Release of inflammatory mediators
- Oxygen toxicity

Initial Ventilator Setup and Adjustments

- **Calculate Ideal Body Weight (IBW):**
  - For Males, IBW (kg) = 50 + 0.91 (height [cm] – 152.4)
  - For Females, IBW(kg) = IBW (kg) = 45.5 + 0.91 (height [cm] – 152.4)
- **Select Volume Assist-Control as the ventilator mode**
- Set Initial Tidal Volume to 8 mL/kg IBW
- Reduce tidal volume by 1 ml/kg IBW at intervals =2 hours until the tidal volume = 6ml/kg IBW.

Subsequent adjustments

- Plateau Pressure Goal: Pplat $\leq$ 30 cm H2O
  - Check Pplat every 4 hours and after each change in PEEP or tidal volume.
- If Pplat >30 cm H2O
  - decreaseTV by 1 mL/kg IBW steps (minimum tidal volume = 4 ml/kg IBW).
- Arterial pH goal: pH = 7.30-7.45
- Arterial Oxygenation Goal: PaO_2=55-80 mmHg or SpO_2=88-95%

CO2 management

- Contraindications to permissive hypercapnia
  - raised intracranial pressure
  - severe circulatory instability
  - pregnancy
- Initial RR of 24-30 and adjusted to pH
- RR may be increased upto 35
- Deep sedation
  - Muscle relaxants once adequate sedation
- Oral / iv $NaHCO_3$ to maintain pH >7.25
  - Increase serum HCO_3 to the 30-35 range

Adjusting PEEP and FiO2 ARDS Network study

- Fixed combinations of FiO2 and PEEP
  Arterial Oxygenation Goal: PaO_2=55-80 mmHg or SpO_2=88-95%

FiO2	**PEEP**	**FiO2**	**PEEP**
0.3	5	0.7	12
0.4	5	0.7	14
0.4	8	0.8	14
0.5	8	0.9	14
0.5	10	0.9	16
0.6	10	0.9	18
0.7	10	1.0	20-24

MV in ARDS

- Low tidal volumes (4-6 ml/kg IBW)
- Limiting the Plateau pressures (<30 cmH2O)
- Appropriate PEEP
- Prone position if P/F < 150
- Consider muscle relaxants in P/F ratio < 150 and difficult to ventilate
- Monitor right ventricular function
- Extracorporeal support

- The Ventilatory Strategy and prevention of ventilator induced lung injury is more important than any mode of ventilation

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