

## Current Topics in Mechanical Ventilation For Adults

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### Learning Objectives

- ◆ Describe and compare ventilation modes available on recently-introduced mechanical ventilators.
- ◆ Explain the rationale and techniques for lung protective strategy.
- ◆ Discuss ventilator innovations related to triggering mechanisms and inspiratory flow control.

## Ventilation Modes

### Volume Control

#### △ Advantages

- ◆ constant TV, despite changes in mechanics
- ◆ less atelectasis

### Volume Control

#### △ Disadvantages

- ◆ limited flow- may not meet patients' needs
- ◆ patient may exert effort to inspire, after TV is delivered
- ◆ possibility of volutrauma

### Pressure Control

#### △ Advantages

- ◆ increased mean airway pressure- improved oxygenation
- ◆ limits excessive airway pressure
- ◆ improves gas distribution
- ◆ decreases WOB

### Pressure Control

#### △ Disadvantages

- ◆ TV varies with mechanics
- ◆ TV may become excessive, causing overdistension, volutrauma
- ◆ inconsistent changes in TV with PEEP, PIP

### Pressure Support

#### △ Attributes

- ◆ pressure-limited
- ◆ flow-cycled
- ◆ high, variable inspiratory flow
- ◆ decreases WOB

### Pressure Support

- △ Purpose- overcome WOB imposed by ETT
- △ Problem- correct level of PS is hard to identify, because imposed WOB varies with flow rates, impedance

### Dual Control Modes

- △ Combine volume and pressure control to achieve advantages of each type

### Dual Control Modes

- △ Breaths are pressure or volume controlled, based on feedback on patient ventilation to ventilator logic
- △ Types:
  - ◆ within breath
  - ◆ breath-to-breath

### Within Breath Dual Control

- △ Availability:
  - ◆ volume-assured pressure support- VAPS (Bird 8400sti, TBird)
  - ◆ pressure augmentation PA (Bear 1000)

### Within Breath Dual Control

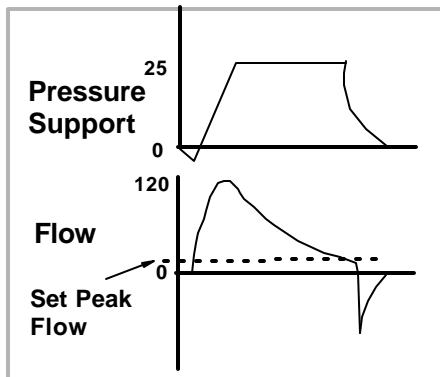
- △ Pressure support with volume guarantee for every breath
- △ Breath initiated, ventilator compares output with target, changing to volume support, if needed
- △ Initial high flow of pressure-control with constant volume delivery

### Within Breath Dual Control

- △ Breath types
  - ◆ pressure support- set TV = delivered TV
  - ◆ pressure support with partial volume assurance- delivered TV would be less than set TV
  - ◆ delivered TV > set TV

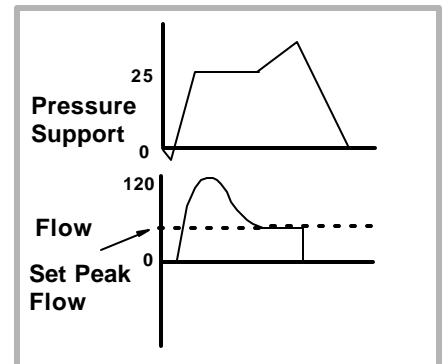
### Within Breath Dual Control

- △ set TV = delivered TV



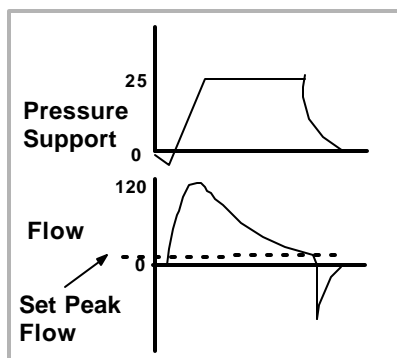
### Within Breath Dual Control

- △ delivered TV would be less than set TV



### Within Breath Dual Control

- △ delivered TV > set TV



### Dual Control- within Breath

- △ Advantages
  - ◆ allows patient to take breath larger than set TV
  - ◆ effective match between ventilator output and patient demand
  - ◆ reduction in WOB
  - ◆ reduced airway resistance
  - ◆ reduced intrinsic PEEP

### VAPS and PA

#### △ Problems

- ◆ if pressure is too high, all breaths are pressure limited
- ◆ if peak flow too low, then the switch from pressure to volume is too late, leading to excessive inspiratory time

### VAPS and PA

#### △ settings:

- ◆ TV
- ◆ PS
- ◆ PIF

### VAPS and PA

- △ if patient effort is weak, the breath converts to volume control
- △ if impedance changes, the breath converts to volume control

### Dual Control Breath-to-Breath

- △ Volume guarantee over several breaths
- △ Ventilator delivers test breaths, then adjusts pressure and flow to deliver preset tidal volume

### Dual Control Breath-to-Breath

#### △ Modes

- ◆ Pressure-Regulated Volume Control- PRVC (Siemens)- operates in volume control mode, only
- ◆ Volume Support (Siemens)
- ◆ Automode (Siemens)

### Dual Control Breath-to-Breath

#### △ Modes

- ◆ Adaptive Pressure Ventilation- APV (Hamilton)
- ◆ Autoflow (Draeger)

## Dual Control Breath-to-Breath

### △ Modes

- ◆ Variable Pressure Support- VPS (Cardiopulmonary Corporation)
- ◆ Variable Pressure Control- VPC (Cardiopulmonary Corporation)

## PRVC, Autoflow, VPC

### △ Attributes

- ◆ Patient or time-triggered
  - ◆ pressure limited
  - ◆ time-cycled
- △ Deliver constant TV, VE, with automatic reduction in pressure as mechanics improve

## VS, VPS

### △ Attributes

- ◆ patient-triggered
  - ◆ pressure-limited
  - ◆ flow-cycled
- △ Pressure support with volume guarantee

## VS, VPS

### △ Problems (VS)

- ◆ pressure level increases to maintain TV for a patient with obstruction, auto-PEEP may result from patient actively attempting to exhale

## VS, VPS

### △ Problems (VS)

- ◆ pressure level increases to maintain TV for a patient with obstruction, auto-PEEP may result from patient actively attempting to exhale
- ◆ During hyperpnea, as due to increased demand, the ventilator will reduce its support when it is most needed

## Automode, VPS/VPC

### △ Combine VS and PRVC (Servo 300)

- ◆ Patient effort present- VS occurs
- ◆ Patient effort absent- PRVC occurs

### Adaptive Support Ventilation

- △ Available on Hamilton Galileo & Raphael Silver
- △ Not just a weaning method
- △ Pressure limit of mandatory and spontaneous breaths adjusted by ventilator

### Adaptive Support Ventilation

- △ Clinician enters
  - ◆ pt's IBW
  - ◆ high pressure alarm
  - ◆ FiO<sub>2</sub>
  - ◆ flow cycle variable (10-40%)
  - ◆ initial peak flow
  - ◆ % volume control (20-200%)

### Adaptive Support Ventilation

- △ ASV algorithm determines optimal breathing pattern (TV, f, flow) for patient, based on estimated anatomic deadspace and expiratory time constant (R\*C)

### Adaptive Support Ventilation

- △ At 100% volume control, ventilator delivers:
  - ◆ 100 ml/kg/min- adults
  - ◆ 200 ml/kg/min- pediatrics

### Adaptive Support Ventilation

- △ No patient effort- mandatory breaths are pressure-limited, volume targeted, time-cycled
- △ With patient effort- dual-controlled (volume-guaranteed) pressure support

### Adaptive Support Ventilation

- △ No patient effort- mandatory breaths are pressure-limited, volume targeted, time-cycled
- △ With patient effort- dual-controlled (volume-guaranteed) pressure support
- △ As patient contribution to VE increases, mandatory breaths are decreased

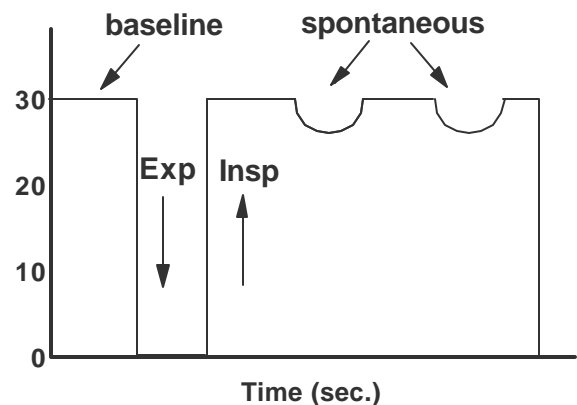
# Lung Protective Strategies

Rationale- To decrease mortality while minimizing lung injury

## Airway Pressure Release Ventilation (APRV)

- Not a new mode- studied by Downes, in 1987
- CPAP, with time-triggered, time-cycled pressure release and spontaneous breathing.

## APRV



## APRV

- ▲ Indication- acute lung injury, with decreased compliance
- ▲ Advantages
  - ◆ lower peak, plateau pressures
  - ◆ spontaneous breathing
  - ◆ recruitment, with limited opportunity for de-recruitment
  - ◆ improved V:Q matching
  - ◆ limited adverse circulatory effects

## APRV

- ▲ Disadvantages
  - ◆ asynchrony with spontaneous breaths
  - ◆ ventilator may not be transportable
  - ◆ unfamiliarity of staff with technique
  - ◆ limited research

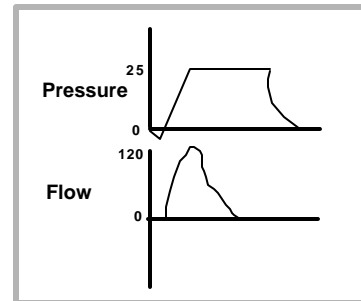
## APRV

### △ Availability

- ◆ Draeger Evita, Evita 4
- ◆ Hamilton Galileo, Raphael
- ◆ Puritan-Bennett 840

## Pressure controlled inverse ratio ventilation (PCIRV)

- square pressure wave form
- decelerating flow wave



## Low TV with PEEP

- open lung concept
- recruitment strategy- 40 cm H<sub>2</sub>O CPAP for 40-90 sec.

## Permissive hypercapnea

- Precautions/contraindications:
  - ◆ superimposed metabolic acidemia
  - ◆ cerebral edema
  - ◆ hypovolemia
  - ◆ beta blockade

## Tracheal Gas Insufflation (TGI)

- continuous flow of gas in trachea to wash out CO<sub>2</sub>
- safety issues are concerns
- equipment issues (circuits) are concerns
- see Respiratory Care 2001;46(2) Feb. for 8 articles on TGI

## Prone positioning

- research found short-term improvement
- research does not find improved outcomes
- physically difficult to achieve with many patients
- additional research needed

### High frequency ventilation

- appropriate conditions?
- appropriate patient population?
- appropriate method- jet, oscillator?

### Techniques

- Partial liquid ventilation
  - ◆ expensive
  - ◆ additional research required

### Techniques

- Nitric oxide
  - ◆ expensive
  - ◆ FDA approved only for persistent pulmonary hypertension in newborns
  - ◆ use for other conditions requires more study

### Techniques

- ECMO
  - ◆ expensive
  - ◆ research strongly supports use with neonates
  - ◆ greater mortality with adults, children

## Other Innovations

### Automatic Tube Compensation

- △ Adjust pressure support for:
  - ◆ ETT size
  - ◆ inspiratory flow
- △ Also known as 'Electronic Extubation'- test of weanability

## Automated Expiratory Trigger

- ▲ Purpose- to overcome asynchrony for expiration
- ▲ Ventilators with selectable expiratory triggers:
  - ◆ Hamilton Galileo
  - ◆ PB 840
  - ◆ Cardiopulmonary Venturi

## **Developments In Mechanical Ventilation That Will Outlast The Next Decade (Kacmarek)**

- ▲ Non-invasive PPV
- ▲ Lung protective strategies
- ▲ Combined pressure-volume targeted modes
- ▲ Prone positioning
- ▲ Tracheal gas insufflation

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