

**Current Topics in
Mechanical Ventilation
For Adults**

Arthur Jones, EdD, RRT

<http://www.geocities.com/jonesapjr/index.html>

Learning Objectives

- ◆ Describe and compare ventilation modes and innovations available on recently-introduced mechanical ventilators.
- ◆ Explain the purpose of newer ventilator controls.
- ◆ Explain the rationale and function of selected lung protective strategies.

Ventilation Modes

Volume Control

^ **Advantages**

- ◆ constant TV, despite changes in patients' lung 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:

- ◆guaranteed tidal volume
- ◆minimized plateau pressure

Dual Control Modes

△Breaths are pressure controlled with a guaranteed minimum volume, 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

Dual Control Breath-to-Breath

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

Dual Control Breath-to-Breath

- △ Modes- assist-control substitutes
 - ◆ Pressure-Regulated Volume Control- PRVC (Maquet)
 - ◆ Volume Targeted Pressure Control- VTPC (Newport e500)
 - ◆ Volume Control Plus (VC+) (PB 840)
 - ◆ Autoflow (Drager)
 - ◆ P-CMV (Hamilton Galileo, Raphael, G-5)

Dual Control Breath-to-Breath

- △ Volume guaranteed PSV
 - ◆ Maquet Servo-i
 - ◆ Newport e500
 - ◆ Puritan Bennett 840
 - ◆ Drager
 - ◆ Hamilton Galileo, Raphael, G-5

Pressure control with volume guarantee

- △ Deliver minimum set TV, VE, with automatic reduction in pressure as mechanics improve

Pressure control with volume guarantee

- △ Breath attributes
 - ◆ patient or time-triggered
 - ◆ pressure limited
 - ◆ time-cycled
 - ◆ flow variable

Pressure control with volume guarantee

^Precautions

- ◆ not for all patients
- ◆ erratic patient effort prevents ventilator logic from making appropriate adjustments.

Pressure support with volume guarantee

^Pressure support breaths with minimum tidal volume

^Breath attributes

- ◆ patient-triggered
- ◆ pressure-limited
- ◆ flow-cycled
- ◆ flow variable
- ◆ volume guarantee (minimum)

Pressure support with volume guarantee

^Precautions

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

Pressure support with volume guarantee

^Precautions

- ◆ During hyperpnea, as due to increased demand, the ventilator will reduce its support when it is most needed

Pressure support with volume guarantee

^Precautions

- ◆ Inappropriate expiratory trigger prolongs inspiration & may cause:

f auto-PEEP

f patient discomfort

Patient-tailored modes

^Proportional assist ventilation (PAV)^(TM) Puritan Bennett 840

^Adaptive support ventilation (ASV)^(TM) Hamilton ventilators

Patient-tailored modes

^Commonalties

- ◆ IBW entered
- ◆ respond to changes in mechanics
- ◆ % support adjusted
- ◆ TV determined by ventilator

PAV

- ^Support level is based on patient demand
- ^Ventilator adapts to changes in resistance and compliance
- ^Graphics display of WOB
- ^Weaning proceeds by decreasing % support by ventilator

Adaptive Support Ventilation

- ^ASV algorithm determines optimal breathing pattern (TV, f) for patient, based on:
 - ◆ estimated anatomic deadspace
 - ◆ expiratory time constant (R^*C)

Link to online presentations on ASV
<http://www.hamilton-medical.com/Clinical-resources.149.0.html>

Adaptive Support Ventilation

- ^Ventilator volume guarantees both mandatory and spontaneous breaths
- ^Weaning proceeds by decreasing % support by ventilator

Spontaneous breath tube compensation

- ^Provides PSV level based on tube size and inspiratory flow
 - ◆ availability
 - f* Drager ventilators
 - f* Hamilton ventilators
 - f* Puritan-Bennett 840

Spontaneous breath tube compensation

- ^Provides PSV level based on tube size
 - ◆ theoretically, WOB same as if patient is extubated.
 - ◆ "electronic extubation"

Links to articles on tube compensation
<http://www.chestjournal.org/cgi/reprint/122/3/980>
<http://ccforum.com/content/7/5/347>

Adjustable Expiratory Trigger

^Purposes

- ◆ increase synchrony for expiration
- ◆ increase patient comfort
- ◆ prevent auto-PEEP

Adjustable Expiratory Trigger

^Adjusted by observing:

- ◆ patient effort
- ◆ I:E ratio
- ◆ ventilator graphics

Adjustable Expiratory Trigger

^Ventilators with adjustable expiratory triggers:

- ◆ Hamilton ventilators
- ◆ Puritan Bennett 840
- ◆ Newport e500
- ◆ Siemens Servoi

Adjustable rise time

^Rise time- time required to reach PIP

^Purposes:

- ◆ improve patient comfort
- ◆ decrease inspiratory WOB

^Adjusted by observing:

- ◆ patient effort
- ◆ ventilator graphics

Lung Protective Strategies

Rationale- To decrease mortality while minimizing lung injury

- maximize mean airway pressure- oxygenation
- minimize plateau pressure- volutrauma

Low TV with PEEP

- optimal TV
 - ◆ TV = 6mL/kg IBW
 - ◆ Ppt remains an issue
 - ◆ VP curve is useful here

Link to article on low TV ventilation
<http://content.nejm.org/cgi/content/full/342/18/1301>

Low TV with PEEP

- optimal PEEP
 - ◆ minimizes phasic stretch
 - ◆ determine by graphics, serial measurement
- recruitment maneuver- 40 cm H₂O CPAP for 40-90 sec.

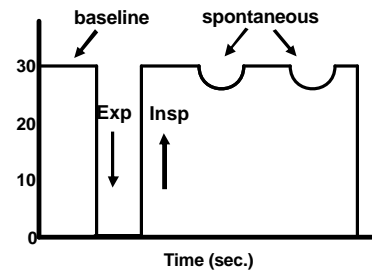
Link to article on recruitment maneuver
<http://ajrcm.atsjournals.org/cgi/content/full/167/12/1620>

Dual level CPAP

- Not a new mode- studied by Downes, (1987)
- Two levels of CPAP, with time-triggered, time-cycled pressure release and spontaneous breathing.

Link to tutorial on APRV
<http://www.ccmtutorials.com/rs/mv/strategy/page14.htm>

Dual level CPAP



Dual level CPAP

- △ Indication- acute lung injury
- △ Advantages
 - ◆ lower peak, plateau pressures
 - ◆ spontaneous breathing
 - ◆ recruitment, with limited opportunity for de-recruitment
 - ◆ improved VA/Q matching
 - ◆ limited adverse circulatory effects

Dual level CPAP

- △ Disadvantages
 - ◆ asynchrony with spontaneous breaths
 - ◆ unfamiliarity of staff with technique
 - ◆ limited research

Dual level CPAP

- ^Availability
 - ◆ Draeger Evita, Evita 4
 - ◆ Hamilton Galileo, Raphael, G-5
 - ◆ Puritan-Bennett 840
 - ◆ Siemens Servo

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

- ^Noninvasive PPV
- ^Lung protective strategies
- ^Combined pressure-volume targeted modes
- ^Prone positioning
- ^Tracheal gas insufflation

Summary & Review

- Volume and pressure-targeted ventilation each have advantages and disadvantages
- Dual control modes developed to combine volume and pressure modes

Summary & Review

- Dual control- within breath, or breath- to-breath
 - pressure control with volume guarantee
 - pressure support with volume guarantee
- Bilevel CPAP

Summary & Review

- Modes tailored to patient
 - ideal body weight
 - changing lung mechanics
 - adjusted to % of desired support

Summary & Review

- Additional ventilator adjustments
 - expiratory trigger
 - inspiratory rise time
 - compensation for tube resistance
- Lung protective strategies
- Kacmarek's ventilation strategies through the next decade

END

References

- Frawly PM. Airway pressure release ventilation: theory and practice. AACN clinical issues 2001;12:234.
- Iotti G (Ed). Closed-loop control mechanical ventilation. Respiratory Clinics of North America 2001;7(3).
- Branson RD. Techniques for automated feedback control of mechanical ventilation. The clinical and management quarterly newsletter NAMDRC 2001;25(3).
- Woodgate PG, Davies MW. Permissive hypercapnia for the prevention of morbidity and mortality in mechanically ventilated newborn infants (Cochrane Review). In: The Cochrane Library, 4, 2001. Oxford: Update Software.
- Kacmarek RM. Which developments in mechanical ventilation will outlast the next decade? <http://www.chestnet.org/education/pccu/vol14/lesson1.html>