Overview Of Ventilator Graphics  
Terry L. Forrette, M.H.S., RRT

Presentation Overview
- Wave Forms and Curves
- Ventilator Management
- BiLevel/APRV
- Applications

Pressure Wave Forms
- What mode are we in?
- Differentiating sensitivity from synchrony issues
- Adjusting PC level, I:E ratio, PSV, Esen

Waveforms

Recognizing Mode of Ventilation

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**Sensitivity versus Synchrony**

- **Sensitivity** - trigger effort  
  - Demand valve design and trigger type
- **Synchrony** - matching flow to demand  
  - Selection of mode and flow pattern

**Work to Trigger (Sensitivity)**

![Graph showing work to trigger sensitivity](image)

**Patient / Ventilator Synchrony**

The Patient Is Out-breathing the Set Flow

![Graph showing air starvation](image)

What options do we have?

**Flow Patterns**

Flow-Time Curve

![Flow-time curve graph](image)

Flow-Time Curve

![Flow-time curve graph](image)

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Typical Flow Curve

Flow-Time Curve

Using Flow Patterns
- Assessing Synchrony
- Selecting “best” mode of ventilation
- Identifying AutoPEEP

AutoPEEP
- Measures trapped air not reflected by Paw
- Influences WOB, hemodynamics and lung mechanics
- Essential during PCIRV

Detecting Auto-PEEP
Zero flow at end exhalation indicates equilibration of lung and circuit pressure

Note: There can still be pressure in the lung behind airways that are completely obstructed

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Mrs. KT suffered a CHI following an automobile accident. While being ventilated in VC, using AC, she showed erratic exhaled volumes, changes in BP, and required frequent sedation. ABG’s showed moderated hypoxemia, with mild hypercapnia. Pulse oximetry was unstable and periods of desaturation were noted when the patient’s exhaled Vₜ’s became erratic. The following represents a typical flow-time tracing during a desaturation episode.

This patient was generating AutoPEEP leading to decreased \( S_pO_2 \) and erratic exhaled \( V_T \).

**Pressure - Volume Curves**

A Two Dimensional View

Using Pressure - Volume Curves

- Assessing lung mechanics
  - Compliance, airways resistance, & WOB
- Titrating ventilator settings
  - PSV, Rise time, Ese, TC
- Trouble shooting
  - Detecting AutoPEEP, circuit leaks

**Pressure - Volume Curves to Assess Lung Mechanics**
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Inspiration
Expiration
Pressure
Volume

Angle is relative to compliance

C = volume + pressure

Normal Compliance

C = volume ÷ pressure
= 600 ÷ 20
= 30 mL/cmH₂O

Decreased Compliance

C = volume ÷ pressure
= 400 ÷ 40
= 10 mL/cmH₂O

What Happened To Compliance?

600
15

C = volume ÷ pressure
=?

Compliance Changes

Assessing Airways Resistance

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Airways Resistance

Increased Inspiratory Resistance

Increased Expiratory Resistance

Changes In Raw

What Do We Have Here?

Lung Overdistension

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Maximizing PIP Levels

A = 400/20 = 20 mL/CWP
B = 600/40 = 15 mL/CWP

Upper And Lower Inflection Points

Low PEEP set point
High PEEP set point

Trigger Effort

Increased Trigger Effort

What About New Modes?

Assisted Ventilation Breath Types

Pressure Constant
- PC
- PS
- BiPAP
- BiLevel/ APRV

Volume Constant
- Volume using CMV or SIMV
- Dual Modes
- VT/IMV/VSV

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What is BiLevel?

- Cycling between the two pressure levels can be synchronized to patient breathing
  - predetermined time or triggered by patient effort
- The two pressure levels are called PEEP_h and PEEP_L
- The two timing levels are T_H and T_L

What Is BiLevel?

- Similar to PCV if there is no spontaneous breathing

What Is BiLevel?

- Similar to PCV with no spontaneous ventilation
- Substantial improvements for spontaneous breathing
  - Allows spontaneous breathing at both levels

What Is BiLevel?

- Substantial improvements for spontaneous breathing
  - Allows spontaneous breathing at both levels
  - Better synchronization
  - Tidal volume monitoring of upper spontaneous breathing
  - More options for supporting ventilation at upper level

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BiLevel or APRV?

- Is the “real” difference one of terminology?
- Original mode called APRV
- Terminology is based on length of $T_e$ and resulting I:E ratio

Clinical Guidelines

- Starting frequency commonly 10 - 15
- Set high and low times to establish release rate and I:E ratio
- Set high and low PEEP levels to establish gradient for $V_t$ exchange
  - maintain PEEP of 5 cm H₂O & keep $MAP < 35$ cm H₂O, $P_{plat} < 30$ cm H₂O
  - Use inflection points to select initial pressures
- Patient may need initial sedation

Upper And Lower Inflection Points

- Manage oxygenation through PEEP$_L$ and ventilation with PEEP$_H$ gradient
- Reduce MAP by manipulating PEEP$_H$ PEEP$_L$ and frequency
  - As spontaneous ventilation increases, PEEP$_H$ and frequency may be reduced
  - Gradually decrease gradient to minimal settings (maintain minimal PEEP$_L$ level)
- Tailor breath delivery to maximize synchrony with Rise Time and Esens

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APRV Case Study - Mr. WH

33 year old male with ARDS secondary to lung contusions. 6 days on SIMV/PSV, Cs = 17, FiO₂ 0.65, PIP 65, PEEP 25, Vₑ 22, PaO₂/FiO₂ = 186, PaCO₂-PetCO₂ = 27

PCIRV not tolerated due to necessity of NMBA

Patient placed on APRV

APRV Case Study - Mr... WH

Using a high to low PEEP gradient of 30 cm (35/5) H₂O, frequency of 12 breath/min, FiO₂ 0.50 the following data were obtained 1 hour after APRV was started: Cs 20, PaO₂/FiO₂ 237, PaCO₂-PetCO₂ 12, Vₑ 14. The patient had a STV of 4 mL/kg, at a rate of 15 - 20 breaths per minute. He was eventually weaned over the next several days to CPAP/PSV

Clinical Advantages

• Results in maintenance of lung volume with a lower PIP, and higher FRC at similar MAP
• Better cardiovascular performance (intrathoracic pump)

Comments and Questions

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