Neonatal Pulmonary Graphics: Every Breath You Take...

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DATA
The Importance of Graphics
Anatomy of a Pressure Waveform

- Volume Control Ventilation – Triangular Pressure Waveform
- Pressure Control Ventilation – Square Pressure Waveform
Anatomy of a Flow Waveform

- **Peak Inspiratory Flow**
- **Peak Expiratory Flow**
- **Expiratory Time**
- **Inspiratory Time**
- **Zero Flow Baseline**

**Volume Control Ventilation**
- Constant Square or Deceleration Flow

**Pressure Control Ventilation**
- Variable Decelerating Flow
Anatomy of a Flow-Volume Loop

Flow

Inspiration

Expiration

PI FR

PEFR

Volume
Anatomy of a Flow-Volume Loop

BEWARE OF DEVICE DIFFERENCES!
Effect of Pressure Changes

- Oxygenation is proportional to mean Paw
  - PIP
  - PEEP
  - Ti

- Ventilation is proportional to amplitude
  - PIP – PEEP
  - Te
Gas Trapping

- Expiratory flow waveform does not return to baseline
- No zero flow state at end expiration
- More gas enters than leaves

Adjustments:
- Decrease rate
- Increase Te
- Decrease flow
- Consider increase in PEEP
Flow Delivery

► Gas flow during pressure-targeted ventilation generates a sinusoidal wave and in some devices adjusted by rise time

► Gas flow during volume-targeted ventilation generates a square wave and in some devices can be adjusted to decelerate
VOLUME A/C

- **Paw (cmH2O)**
- **Flow (L/min)**
- **Vt (mL)**

**Parameters:**
- **20 cmH2O**
- **30 BPM**
- **5.4 mL**
- **4.2 mL**
- **1.8 mL/kg**

**Values:**
- **-30 BPM**
- **40.1 mL**
- **9.2 L/min**
- **0.00 sec**
- **4 cmH2O**
- **0.5 L/min**
- **40% FiO2**
Elevated Resistance

- Diminished inspiratory and expiratory flow rates
- Note decreased peak flows
- P-V loop also shows some degree of hyperinflation
Tracheomalacia

PI FR

PEFR
Air Hunger

- Inadequate hysteresis
- Little separation between inflation and deflation limbs of P-V loop
- “Figure Eight” appearance at end-inspiration

Adjustments:
- Inspiratory flow
- Rise time
- Ti
PRESSURE A/C

Vt (mL) - Flow (L/min)

Ppeak cmH2O: 24
Vt (mL): 9.2
Vte (mL): 7.6
Vti/kg mL/kg: 3.8
Leak %: 16

Flow Trig cmH2O PEEP: 5
Flow Trig L/min: 0.4
Flow Trig % FiO2: 21

Rate BPM: 30
Insp Pres cmH2O: 17
Insp Time sec: 0.40

1:4.0
Response to Bronchodilator

► Improved lung mechanics
► Increased PIFR and PEFR without changing ventilator settings
► Objective evaluation of a therapy with a narrow therapeutic index
Bronchospasm

PI FR

Vt (mL) - Flow (L/min)

Paw (cmH2O) - Vt (mL)

PEFR

22 cmH2O Ppeak
10.3 mL VTi
8.7 mL Vte
4.3 mL/kg VTi/kg
15 % Leak

30 bpm Rate
17 cmH2O Insp Pres
0.40 sec Insp Time
5 cmH2O PEEP
0.4 L/min Flow Trig
21 % FiO2
Increased Expiratory Resistance

- Prolonged time for decelerating expiratory waveform to reach baseline

- Adjustments:
  - Increase PEEP (stent airways)
  - Adjust cycle time (↓Ti or ↑Te)
  - Bronchodilator
Large ET Tube Leak

► Flow-volume loop does not reach origin
► Pressure-volume loop fails to close
► Tidal volume waveform does not reach baseline at end-expiration
► Adjustments:
  ▪ Change position
  ▪ Consider larger tube
Auto-Cycling

► Trigger misreads a flow leak as patient effort and initiates a mechanical breath
► This results in rhythmic breaths without a pause
► May also be caused by excessive condensation in circuit resulting in flow changes
► Adjustments:
  ▪ Stop leak
  ▪ Remove rain-out and avoid recurrence
  ▪ Increase trigger sensitivity above measured leak
Best PEEP Analysis

- Examine shape of inspiratory limb of P-V loop for early slope
- Sub-optimal PEEP results in “box-like” shape—prolonged inflation without concomitant recruitment of lung volume
- Adjustments:
  - Increase PEEP
  - May need similar increase in PIP
High opening pressure
Turbulence

- Secretions in the path of gas flow create turbulence
- This causes a “noisy” signal on both waveforms and loops
- May enable avoidance of “routine” suctioning of the endotracheal tube
SIMV and Pressure Support

- Inspiratory pressure boost to support spontaneous breaths with something more than just PEEP
- Decreases the work of breathing
- Patient-controlled and fully synchronized
- May be full Vt ($PS_{\text{max}}$) or partial
- $PS_{\text{min}}$ matches imposed work of breathing
Cycling Mechanisms

What causes inspiration to start and end?

- **Time**
  - Inspiration ends after a set time, chosen by the clinician
  - Back-up mechanism on all modes

- **Flow**
  - Inspiration ends at a percentage of PIF

- **Volume**
  - Not in the neonate because of uncuffed ETT
Trend Data

- Multiple parameters can be tracked over time
- May aid in interpreting cause of desaturation episodes or in evaluation of pharmacologic therapy
Practical Hints

➢ Make sure graphs are properly scaled
  - P and V axes should be equal
  - Wave forms should not be off scale

➢ Check for leaks, condensation, and secretions

➢ When all else fails, LOOK AT THE BABY!
Pulmonary Graphics

“You can observe a lot by watching.”

-Yogi Berra