Mechanical Ventilation

Ventilator Graphics

Graphic Waveforms
- Scalar graphics
  - pressure vs. time
  - flow vs. time
  - volume vs. time
- Loop graphics
  - flow vs. volume
  - pressure vs. volume

Graphic Waveform Use
- Monitor ventilator function
- Improve patient/ventilator interaction
- Identify autoPEEP
- Calculate respiratory mechanics
Remember! (VC)

- vol delivered depends on flow, $T_i$
- vol delivery is same each breath
- flow waveform is same each breath
- flow waveform does not change with changing $C_L$, $R_{AW}$
- pressure produced varies with $C_L$, $R_{AW}$, type of flow waveform

Pressure vs. Time

$VC_{SIMV}$

$x = T_i$

$y = \text{pause}$

$X + y = T_i$

$z = T_E$

$A = \text{start of insp}$

$B = \text{PIP}$

$C = \text{start of pause}$

$D = P_{PE}$

$E = \text{early exp press}$

$F = EEP$

$PC_{SIMV}$

$x = T_i$

$z = T_E$

$A = \text{start of insp}$

$B = \text{PIP}$

$C = \text{early insp press}$

$D = P_{PE}$

$E = \text{early exp press}$

$F = EEP$
Also examine negative pressure deflection:

- too deep
- lasts too long

⇒ ↑ WOB
Pressure vs. Time

- Summary - Use PT graphics to:
  - ID breath type
  - adjust flow rate
  - assess work to trigger breath
  - detect autoPEEP
  - assess plateau & calculate $C_S$

Flow vs. Time

$VC_{SIMV} (VC)$

- $x = T_i$
- $y = \text{pause}$
- $X + y = T_i$
- $z = T_e$
- $G = \text{PIFR}$
- $H = \text{zero flow phase}$
- $I = \text{PEFR}$
- $J = \text{decelerating exp flow}$
- $K = \text{end exp flow}$

Flow vs. Time

$PC_{SIMV} (PC)$

- $x = T_i$
- $z = T_e$
- $G = \text{PIFR}$
- $H = \text{decel insp flow}$
- $I = \text{PEFR}$
- $J = \text{decelerating exp flow}$
- $K = \text{end exp flow}$
Flow vs. Time

Flow Wave Type

- rectangular = square
- descending = decelerating
- ascending = accelerating
- sinusoidal = sine

EXTREMELY IMPORTANT!!

AutoPEEP = air-trapping = hyperinflation

↑ risk of barotrauma

↑ mean airway pressure

hemodynamic compromise
Flow vs. Time

- Summary - Use FT graphics to:
  - ID breath type
  - ID waveform type
  - detect autoPEEP
  - evaluate T\textsubscript{i} in PCV

Volume vs. Time

\begin{align*}
x &= T_i \quad &L &= \text{start of insp} \quad &O &= \text{exhalation of } V_T \\
y &= \text{pause} \quad &M &= \text{delivery of } V_T \quad &P &= \text{end exp} \\
z &= T_e \quad &N &= \text{end insp}
\end{align*}
Volume vs. Time

\[ \text{if} \ \text{Insp} \ V_T \neq \ \text{Exp} \ V_T = ? \]

Volume vs. Time

- Summary - Use VT graphics to:
  - ID leaks in the ventilator system
  - ID air-trapping

Flow-Volume Loops

\[ \begin{align*}
A &= \text{insp start/end exp} \\
B &= \text{PIFR} \\
C &= \text{end insp/start exp} \\
D &= \text{PEFR}
\end{align*} \]
Flow-Volume Loops

A = insp/start end exp  
B = PIFR  
C = end insp/start exp  
D = PEFR

PC SIMV (PC)

Flow-Volume Loops

*Tracing should start at zero and end at zero
*If not =

Flow-Volume Loops

Before

After

• Gauge effect of bronchodilator therapy
Flow-Volume Loops

- Summary - Use FV Loops to:
  - ID leaks in the ventilator system
  - ID air-trapping
  - Evaluate the effect of bronchodilator therapy

Volume-Pressure Loops

A = start insp/end exp
B = insp press level
C = end insp/start exp
D = exp press level
E = vol end insp
ABC = inspiration
CDA = expiration
AC = C2 slope

Volume-Pressure Loops

I = inspiration
E = expiration
Volume-Pressure Loops

1 = normal
2 = slope ↓, shape is same
↓
What happened?

Volume-Pressure Loops

1 = normal
2 = slope ↓, widens
↓
What happened?

Volume-Pressure Loops

Duck bill thingy
(P ↑ w/o change in V_t)

What happened?
Volume-Pressure Loops

- Re-expansion interval (big press/little vol) - shows high press needed to open alveoli
- Rx?

alveolar re-expansion interval

Volume-Pressure Loops

- Summary - Use VP Loops to:
  - ID breath type
  - Assess work to trigger breath
  - Assess WOB
  - Assess $C_L$ and $R_{AW}$
  - Detect overdistention
  - Titrate PEEP