Complicated cases during mechanical ventilation

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Case I

Presentation

Male COPD 50 YO, respiratory failure, on mechanical ventilator

MV settings:

Mode: VCV
TV 500 ml
Flow: decelerate 50 L/min
FiO2 0.5
RR 16/min
PEEP 0 cmH_2O

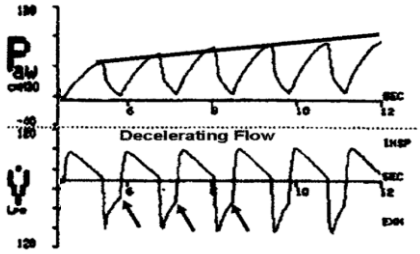
ABG

pH 7.12
pCO2 65 mmHg
pO2 70 mmHg
HCO3- 23 mmol/L

Lung mechanics

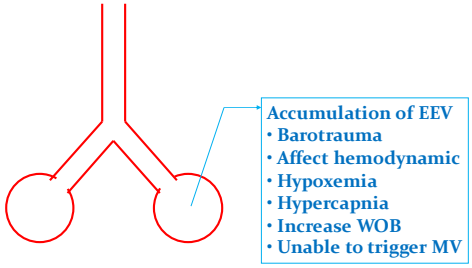
PIP = 50 cmH2O
High pressure alarm

Waveform



Identify problems

1. CO2 retension → acidosis
2. High PIP ← airtrapping



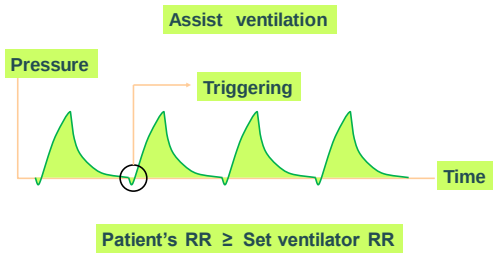
AIM

1. Decrease trapped air
2. Prevent further air-trapping

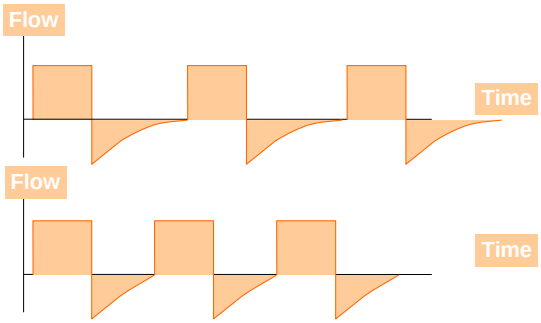
How to correct?

A. Increase respiratory rate
B. Increase tidal volume
C. Increase flow rate
D. Change to square flow
E. Increase PEEP

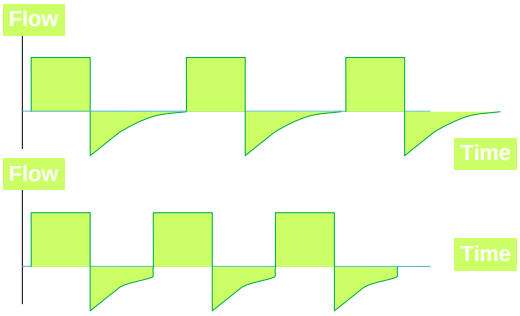
Preset RR & assist/control ventilation



Relatioship between Ti, Te, and RR



Relatioship between Ti, Te, and RR



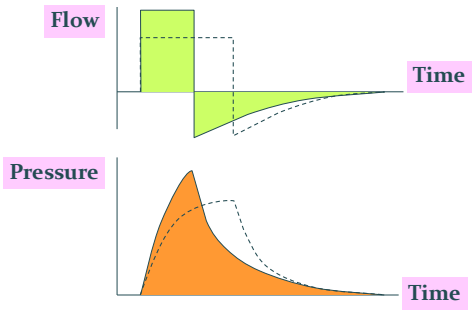
How to correct?

~~A. Increase respiratory rate~~
B. Increase tidal volume
C. Increase flow rate
D. Change to square flow
E. Increase PEEP

How to correct?

A. ~~Increase respiratory rate~~
B. ~~Increase tidal volume~~
C. Increase flow rate
D. Change to square flow
E. Increase PEEP

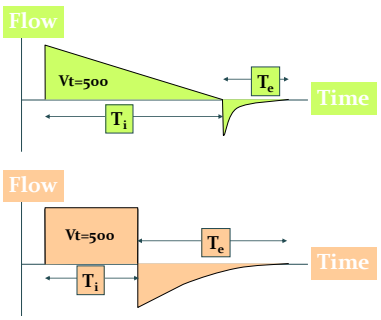
Effect of changes of flow rate



How to correct?

A. ~~Increase respiratory rate~~
B. ~~Increase tidal volume~~
C. **Increase flow rate - applicable**
D. Change to square flow
E. Increase PEEP

Effect of changes of flow pattern



How to correct?

A. ~~Increase respiratory rate~~
B. ~~Increase tidal volume~~
C. **Increase flow rate - applicable**
D. **Change to square flow**
E. Increase PEEP

Bad effect of too short Ti

Create turbulence flow
Air flow not deliver to alveoli
  Cause dysnea
  Cause hypoventilation

How to correct?

~~A. Increase respiratory rate~~

~~B. Increase tidal volume~~

C. Increase flow rate - applicable

D. Change to square flow

E. Increase PEEP

Case I

Presentation

Male COPD 50 YO, respiratory failure, on mechanical ventilator

MV settings:

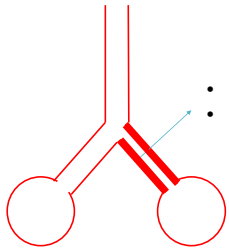
Mode: VCV
TV 500 ml → 450 ml.
Flow: decelerate 50 L/min → 60 L/min
FiO2 0.5
RR 16/min
PEEP 0 cmH_2O

ABG

pH 7.12 → 7.05
pCO2 65 mmHg → 70 mmHg
pO2 70 mmHg → 65 mmHg
HCO3- 23 mmol/ L

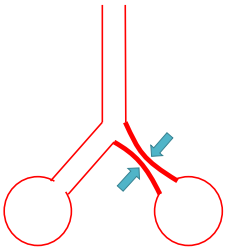
Poor air entry

Fact of airway narrowing

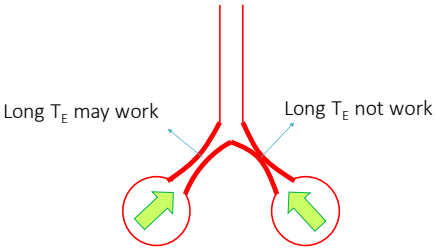


- Turbulence flow
- Long time constant

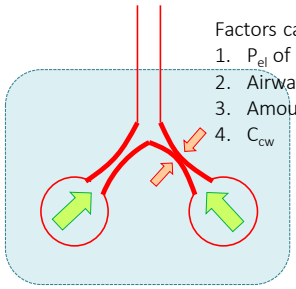
Fact of airway narrowing



Fact of airway narrowing

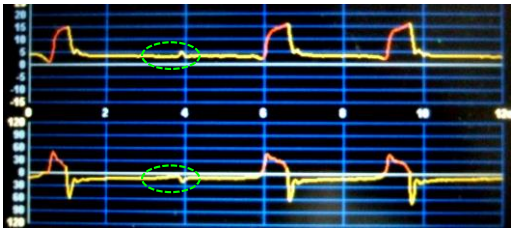


Fact of airway narrowing

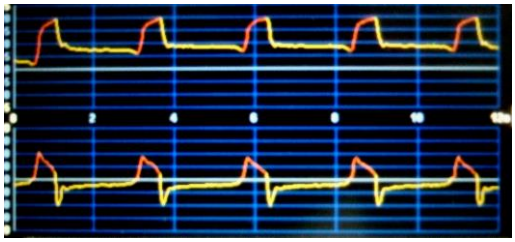


Factors cause collapse
1. P_{el} of alveoli
2. Airway compliance
3. Amount of intrinsic PEEP
4. C_{cw}

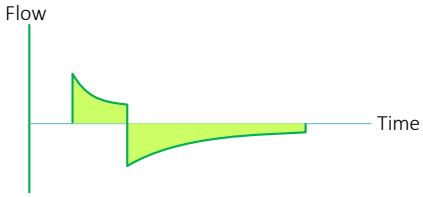
Difficult to trigger rom PEEPi



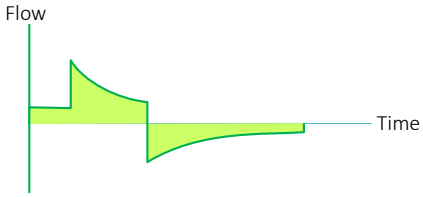
Waveform after applied PEEP



Lower tv + Higher flow (short T_i) + Slow rate (long T_e) will work in some circumstance



Lower tv + PEEP + longer T_i



Case I

Presentation

Male COPD 50 YO, respiratory failure, on mechanical ventilator

MV settings:

Mode: VCV → PCV
TV 500 ml → 450 ml.
Flow: decelerate 50 L/min → longer Ti
FiO2 0.5
RR 16/min
PEEP 0 cmH_2O → 8 cmH2O

ABG

pH 7.12 → 7.05 → 7.32
pCO2 65 mmHg → 70 → 50 mmHg
pO2 70 mmHg → 65 → 80 mmHg
HCO3- 23 mmol/ L

Better air entry

Case II

Presentation:
- *Fever, dyspnea*

ABG:
- *pH 7.3*
- *pCO2 55 mmHg*
- *pO2 50 mmHg*
- *HCO3- 19 mmol/L*

Case II CXR

Case II ARDS

Ventilator setting:
- *Mode: PCV*
- *I:E ratio – 1:2*
- *IP – 20*
- *PEEP – 10 cmH2O*
- *FiO2 1.0*
- *RR 16*
- *Exhaled Tv – 400 ml.*

ABG:
- *pH 7.32*
- *pCO2 50 mmHg*
- *pO2 65 mmHg*
- *HCO3- 20 mmol/L*

Meaning of PaO2

A. PaO2 50 at room air
B. PaO2 100 at room air
C. PaO2 100 at FiO2 0.4
D. PaO2 100 at FiO2 0.8
E. PaO2 100 at FiO2 0.4 + Hct 20%
F. PaO2 100 at FiO2 0.4 + Hct 38% + CO 1.5 L

Meaning of PaO2 vs. SpO2

A. PaO2 80 → SpO2 100%
B. PaO2 90 → SpO2 100%
C. PaO2 100 → SpO2 100%
D. PaO2 120 → SpO2 100%

PaO2 / FiO2 ratio

PaO2 100, FiO2 0.4
P/F ratio = 250

PaO2 100, FiO2 0.8
P/F ratio = 125

PaO2 100, FiO2 1.0
P/F ratio = 100

Compliance of respiratory system

Compliance
Definition: the ability of alveoli to expand from specific pressure
Formula

$$Compliance = \frac{tidal\ volume}{plateau\ pressure - PEEP}$$

Compliance of respiratory system

	PEEP = 0 cmH2O	PEEP = 10 cmH2O
PIP	40	40
Plateau pressure	35	30
Tidal volume	500	500
Compliance	14.3	25

**Lungs with PEEP 10 are better than that with PEEP 0
**If compliance improves, P/F ratio increases

Case II ARDS

Ventilator setting:
Mode: PCV
I:E ratio – 1:2
IP – 20
PEEP – 10 cmH2O
FiO2 1.0
RR 16
Exhaled Tv – 400 ml.

ABG:
pH 7.32
pCO2 50 mmHg
pO2 65 mmHg
HCO3- 20 mmol/L

Ventilator induced lung injuries

Shear stress | Optimum | Overdistension

PEEP tritration form

Mode: VCV, TV 8 ml/kg, Square flow, RR 16

Parameters	PEEP 5	PEEP 7	PEEP 9	PEEP 11	PEEP 13	PEEP 15	PEEP 17	PEEP 19
Static compliance	30	32	35	39	40	38	36	
Mean airway pressure	18	18.6	19.2	20	21.7	22.3	25	
Plateau pressure	20	21	22	22.6	24.3	26.8	29.5	
PIP	30	31	33	34	36.5	40	43	
Mean arterial pressure	80	78	77	78	77	77	77	

Case II ARDS

Ventilator setting:

- *Mode: PCV*
- *I:E ratio – 1:2*
- *IP – 20*
- ***PEEP – 13 cmH2O***
- *FiO2 1.0*
- *RR 16*
- *Exhaled Tv – 400 ml.*

ABG:

- *pH 7.32*
- *pCO2 50 mmHg*
- *pO2 70 mmHg*
- *HCO3- 20 mmol/L*

CXR after best PEEP

Recruitment maneuver

PCV IP 20
PEEP 20
I:E 1:1
RR 10

→ 2 minutes

↓

Decremental PEEP titration

PEEP tritration form

Mode: VCV, TV 8 ml/kg, Square flow, RR 16

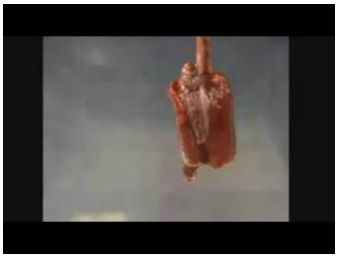
Parameters	PEEP 20	PEEP 18	PEEP 16	PEEP 14	PEEP 12	PEEP 10	PEEP 8	PEEP
Static compliance	35	40	45	42	39	37	33	
Mean airway pressure	18	18.6	19.2	20	21.7	22.3	25	
Plateau pressure	20	21	22	22.6	24.3	26.8	29.5	
PIP	30	31	33	34	36.5	40	43	
Mean arterial pressure	80	78	77	78	77	77	77	

CXR after best PEEP 16 cmH2O

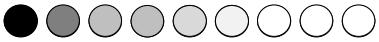
ABG:

- *pH 7.32*
- *pCO2 50 mmHg*
- *pO2 120 mmHg*
- *HCO3- 20 mmol/L*

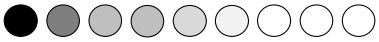
Sample of alveolar recruitment



Patterns of alveolar recruitment in ARDS

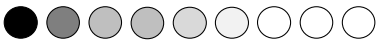
Pattern 1 

Patterns of alveolar recruitment in ARDS

Pattern 1 

Pattern 2 

Three patterns of alveolar recruitment in ARDS

Pattern 1 

Pattern 2 

Pattern 3 

Summary

Major problem of AECOPD is airtrapping
- Aim to release trapped air and improve ventilation
- Prolonged Te is useful in some cases.
- PEEP is beneficial in particular cases.

Major problem of ARDS is ventilator induced lung injuries
- Do not create VILI
- Lower tidal volume
- Adequate PEEP
- Different between PaO2 and SaO2
- Monitor compliance of the lungs
- Try to keep most alveoli opened

Thank you for your attention