Improving Oxygenation

Chapter 14

Oxygenation

- Assessed by FiO_2, SaO_2, PaO_2, Hb
- Ideal to keep FiO_2 < .4/.5, PaO_2 60-90 mmHg, and CaO_2 20mL/dL
- The SpO_2 can be used to titrate FiO_2; goal is >90%
- FiO_2 may be adjusted using the following equation:

$$\text{Desired } FiO_2 = \frac{PaO_2 \text{ desired} \times FiO_2 \text{ known}}{PaO_2 \text{ known}}$$

Clinical Rounds 14-1, p. 296

A patient with myasthenia gravis is started on mechanical ventilation. The CXR is normal. Breath sounds are clear. Initial ABG's on .25 FiO2 after 20 minutes on the ventilator are 7.31/62/58/31. What changes in ventilator settings might improve this patient's ABG findings?

This patient has respiratory acidosis. The PaO2 indicates moderate hypoxemia. A common reaction by clinicians in this situation is to increase the FiO2. However the cause of the hypoxemia is the elevated PaCO2. An increase in CO2 of 1mmHg reduces the O2 by 1.25mmHg. The PaCO2 is about 40mmHg above normal therefore the PaO2 will be about 50mmHg below its actual value. The most appropriate action is to increase ventilation

Selection of FiO_2

- Levels >0.6 can result in oxygen toxicity
- 100% Oxygen can cause the rapid formation of absorption atelectasis and increase pulmonary shunting
- When PaO_2 remains low on high FiO_2 significant shunting, V/Q abnormalities and/or diffusion defects are present

Clinical Rounds 14-2, p. 298

After being supported on a ventilator for 30 minutes, a patient's PaO_2 is 40mmHg on an FiO_2 of 0.75. Acid-base status is normal and all other ventilator parameters are within the acceptable range. PEEP is 3 cmH_2O. What FiO_2 is required to achieve a desired PaO_2 of 60 mmHg? Is this possible? Can you think of another form of therapy to improve oxygenation?

Desired FiO_2 = (60x0.75)/40= 1.13

You cannot give more than 100% O_2. The appropriate change is the FiO_2 to 100% and increasing PEEP

Strategies to Improve Oxygenation

- Increase the mean airway pressure
  - PIP
  - Total PEEP
  - I:E ratios
  - Respiratory rate
  - Inspiratory flow pattern
- Paw affects mean alveolar pressure and alveolar recruitment and therefore oxygenation

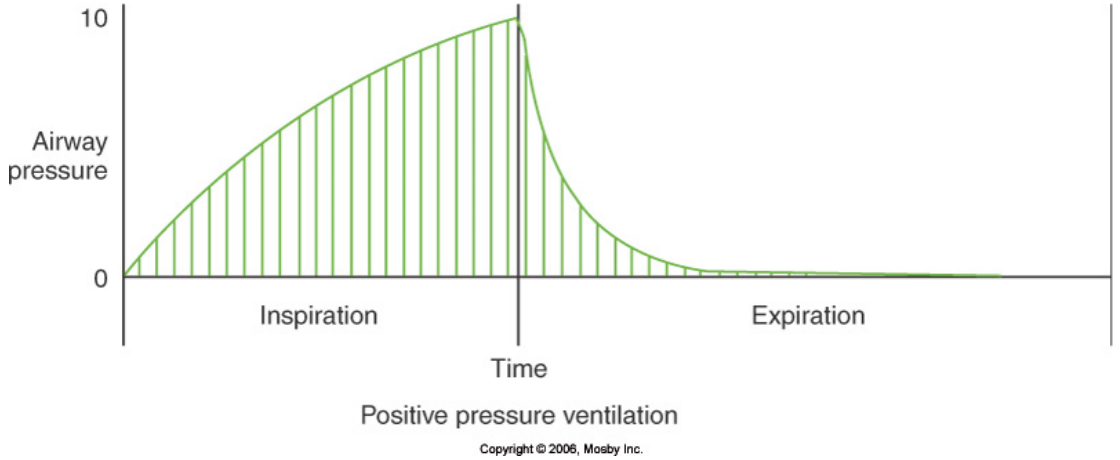


Figure 14-01. A pressure-time waveform illustrating mean airway pressure (aw). Vertical lines under the pressure-time curve represent frequent readings of pressure over the total respiratory cycle. The sum of these pressure readings (i.e., the area under the curve) divided by the cycle time will give the value for mean airway pressure. (See text for additional information.)

Goals of PEEP

- Enhance tissue oxygenation
- Maintain a PaO_2 > 60mmHg and SpO_2 >90% at an acceptable pH
- Recruit alveoli and maintain them in an aerated state
- Restore FRC
- Opportunity to decrease FiO_2 to safer levels

Atelectasis

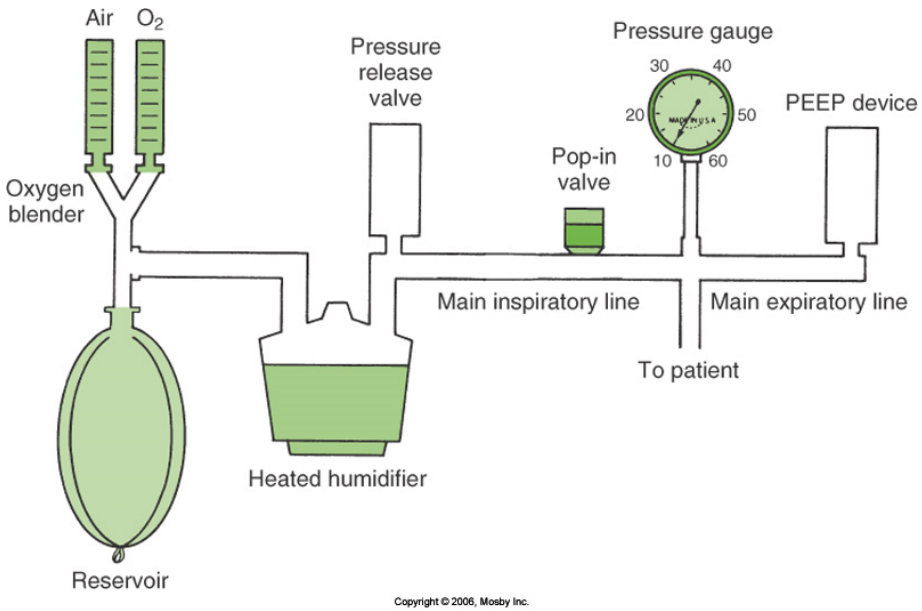
- Partial or complete collapse of alveoli
- Result of:
  - Blocked airways
  - Shallow breathing
  - Sufactant deficiency
- Treat what is causing the problem

PEEP = ventilatory support
CPAP = spontaneous ventilation

Interface

- Mask CPAP
- Nasal CPAP
- Endotracheal or Tracheostomy tubes
- Flow resistors
- Threshold resistors

Free standing CPAP systems



PEEP Ranges

- Minimum or Low PEEP
  - 3-5cmH2O
  - Preserves normal FRC
- Therapeutic PEEP
  - >/= 5cmH2O
  - Used to treat refractory hypoxemia
  - High levels are only beneficial to a small %
  - Associated with cardiopulmonary complications
- Optimum of Best PEEP
  - Level at which the maximum beneficial effects of PEEP occur and is not associated with profound cardiopulmonary side effects and it is accomplished at safe FiO2 levels

Indications for PEEP/CPAP

- Bilateral infiltrates on CXR
- Recurrent atelectasis with low FRC
- Reduced lung compliance
- PaO_2 <60mmHg on high FiO_2 >0.5
- PaO_2/FiO_2 ratio <200 for ARDS and <300 for ALI
- Refractory hypoxemia: PaO_2 increases 10mmHg with FiO_2 increase of 0.2

Specific Disorders that benefit from PEEP

- ALI
- ARDS
- Cardiogenic pulmonary edema
- Bilateral diffuse pneumonia

Initiating PEEP

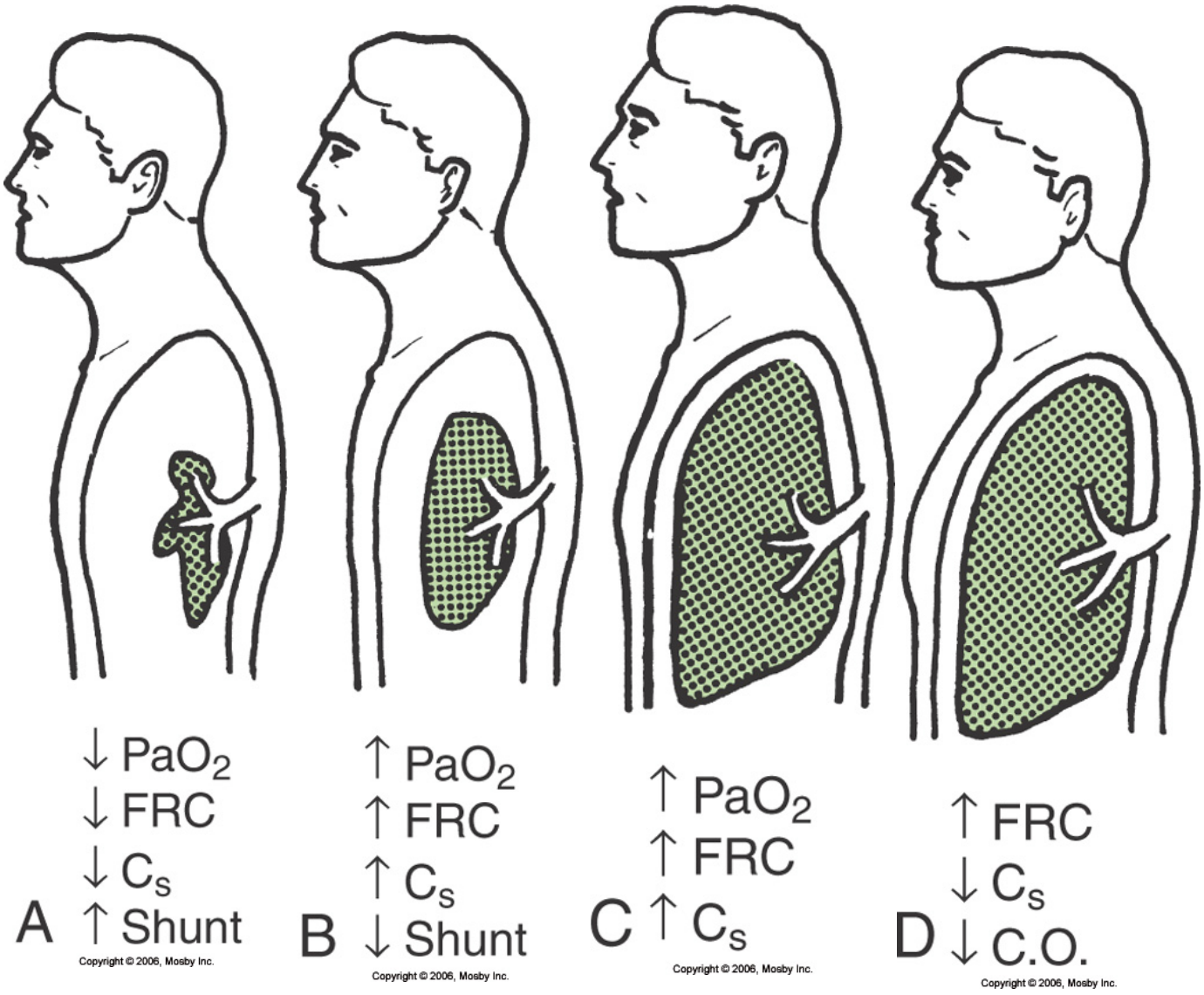
- PEEP should be started as soon as possible
- Best to look at several factors when deciding if the best PEEP level has been achieved
- Increases in PEEP are generally done in 3-5cmH2O in adults 2-3cmH2O in infants
- Cardiovascular status is closely monitored

Optimum PEEP study

- Reserved for patients requiring a PEEP of 10cmH2O or greater
- Extensive monitoring during the study
- Target Goals:
  - A PaO2 of 60mmHg on FiO2 <0.4
  - Optimum oxygen transport is present
  - A shunt of less than 15%
  - A minimal amount of cardiovascular compromise – adequate BP, decrease of <20% cardiac output and stable pulmonary vascular pressures
  - Improving lung compliance and improved lung aeration
  - A PaO2/FiO2 ratio of more than 300
  - The point of minimum arterial to end-tidal PCO2 gradient
  - Optimum mixed venous oxygen values

Figure 14-2

A, The stiff lungs and increased shunt result in a drop in FRC and PaO_2. **B** and **C,** as PEEP is increased, C_S and PaO_2 improve as the FRC increases, resulting in a lowering of the shunt effect. **D,** Too much PEEP has been used, and C_S and cardiac output decrease as the FRC is increased above the optimum level.



Assessment during PEEP Study

- Patient Appearance
- Blood Pressure
- Breath Sounds
- Ventilator Parameters
- Static Compliance
- PaO2/FiO2
- Adequacy of ventilation
- P(A-a)O2
- P(a-et)CO2
- Hemodynamics
- C(a-v)O2
- PvO2
- Cardiac Output

PEEP(cm H_2O)	0	5	10	15	20	25	30
Minutes/time	15	30	45	60	75	90	105
Blood pressure (mm Hg)	117/80	120/85	120/80	110/70	115/75	115/75	90/65
C_S (mL/cm H_2O)	36	36	37	35	40	45	36
PaO_2 (F_IO_2 = 1.0)	43	59	65	73	103	152	167
CaO_2 (vol %)	15.3	17.8	18.3	18.9	19.2	19.4	19.6
$PaCO_2$ (mm Hg)	37	37	38	37	39	37	38
pH	7.41	7.42	7.42	7.42	7.40	7.41	7.41
$P(A-a)O_2$ (mm Hg)	607	591	585	577	547	498	483
$PaCO_2 - P_{ET}CO_2$ (mm Hg)	16	15	13	10	9	8	15
$P\bar{v}O_2$ (or $S\bar{v}O_2$) mm Hg (or %)	27	37	38	38	39	40	34
C.O. L/min	4.1	4.2	4.0	4.5	4.4	4.4	3.3
$C(a-\bar{v})O_2$ (vol %)	5.3	5.2	5.4	5.0	4.9	4.9	6.7
PCWP (mm Hg)	3	5	8	11	12	13	18
PAP (mm Hg)	37/21	39/25	41/24	43/25	40/21	38/24	45/30
C.O. × CaO_2 Oxygen transport	627	748	732	851	845	854	647

Contraindications for PEEP

- Hypovolemia
- Untreated or significant pneumothorax
- Elevated ICP
- Pre-existing hyperinflation – emphysema
- Unilateral lung disorders

Overdistention vs hyperinflation

Weaning from PEEP

- Exact length of time PEEP is required is not known
- Trial reductions can be attempted when:
  - Patient demonstrates an acceptable PaO2 on an FiO2 <0.40
  - Patient is hemodynamically stable and nonseptic
  - Patient's lung condition should have improved

Recruitment Maneuvers

- A sustained increase in pressure in the lungs with the goal of opening as many collapsed lung units as possible
- Once recruited the lungs are kept open by maintaining an adequate PEEP
- Consists of three parts
  1. An inflation maneuver to open as much of the lung as possible
  2. A deflation maneuver to determine the point at which a majority of the lung begins to collapse
  3. Another inflation recruitment maneuver to reopen the lung following its collapse

Hazards of Recruitment Maneuvers

- Significant increases in thoracic pressure for an extended period of time can result in:
  - Decreased venous return
  - Drop in cardiac output
  - Drop in BP
  - Uneven effects in the lungs
- Variability among patients

Recruitment Maneuvers

Types of RM

- Sustained Inflation
- PCV with high PEEP
- PCV with increased PEEP
- Sighs

Summary

- ↑ oxygenation, ↓ shunt, ↑ pulmonary compliance
- Work early in ARDS
- No uniform way of performing this maneuver
- May reduce atelectasis post-op
- Generally safe
- Important to set PEEP to prevent alveolar collapse post RM