Interventions to Optimize Oxygenation During Mechanical Ventilation
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Post-session question & answer responses

What is the amount of time that transpired between PEEP intervals in the patient case referenced?

In the case shown in the presentation, the time interval between PEEP changes was 3 – 5 minutes. This time interval might be too short to appreciate a full change in respiratory mechanics and gas exchange. However, the time required for a complete equilibrium must be balanced against the practical time constraints in a busy ICU and the patient's degree of hypoxemia at the time.

This was recently studied by Chiumello (Chiumello D, Coppola S, Froio S, et al. Time to reach a new steady state after changes of positive end expiratory pressure. Intensive Care Med 2013;39:1377-1385). When PEEP was decreased from 15 to 10 or from 15 to 5 cm H_2O, changes in oxygenation variables were complete within 5 min; respiratory system compliance decreased slowly and modestly over 60 min. When PEEP was raised from 10 to 15 and from 5 to 15 cm H_2O, changes in oxygenation variables appeared not to have reached equilibrium after 60 min; changes in respiratory system compliance were complete within 5 to 10 min. The potential mechanisms to explain these findings were explored by Brower in an editorial (Brower RG. Time to reach a new equilibrium after changes in PEEP in acute respiratory distress syndrome patients. Intensive Care Med 2013;39:2053-2055).

I think that it is reasonable to wait 5 minutes between changes when doing a PEEP titration, recognizing that equilibrium might not be complete for as long as an hour. Thus, following the PEEP titration, a re-assessment is reasonable after an hour.

What range of frequency is suggested for using high levels of PEEP and lower tidal volume for moderate ARDS patients?

I assume this means breathing frequency. For patients with ARDS, the target tidal volume is 6 mL/kg ideal body weight. This will often result in a tidal volume of about 400 mL. Due to the increased dead space associated with ARDS, a minute ventilation of 10 to 12 L/min is often necessary. This results in a respiratory rate of 25 to 30 breaths/min. Thus, regardless of the level of PEEP, patients with ARDS are ventilated with a higher than normal breathing frequency. In the ARDSnet study, rates as high as 35 breaths/min were used.

How are ARDS and ALI defined by PaO_2/FIO_2 in these studies?

According to the Berlin definition (JAMA. 2012;307:2526-2533), ARDS is defined as mild (200 mm Hg $< PaO_2/FIO_2 \leq$ 300 mm Hg), moderate (100 mm Hg $< PaO_2/FIO_2 \leq$ 200 mm Hg), and severe ($PaO_2/FIO_2 \leq$ 100 mm Hg). Previous to the Berlin definition, mild ARDS was called acute lung injury (ALI). According to the contemporary definition, the term "ALI" is no longer used.

What is your opinion on the use of sighs superimposed on lung protective mechanical ventilation with optimal PEEP?

A sigh has been used for lung recruitment (Foti G, Cereda M, Sparacino ME, De Marchi L, Villa F, Pesenti A. Effects of periodic lung recruitment maneuvers on gas exchange and respiratory mechanics in mechanically ventilated acute respiratory distress syndrome (ARDS) patients. Intensive Care Med 2000;26(5):501-507). More recently, the benefits of a sigh added to pressure support ventilation as a 35 cm H2O continuous positive airway pressure lasting 3 to 4 seconds has been described (Mauri T, Eronia N, Abbruzzese C, et al. Effects of Sigh on Regional Lung Strain and Ventilation Heterogeneity in Acute Respiratory Failure Patients Undergoing Assisted Mechanical Ventilation. Crit Care Med 2015;43:1823-1831). However, the benefit of sign is likely limited if PEEP is set appropriately (MacIntyre N. Crit Care Med 2015;43:2021-2022). My opinion is that appropriately set PEEP is preferable to sigh.

Some ventilators do not show static compliance but rather dynamic compliance. Can this be used to determine an optimal level?

My preference is to set PEEP by compliance calculated in the usual manner: C = VT/(Pplat – PEEP). Dynamic compliance uses PIP instead of Pplat. I do not prefer this approach because it includes the resistive as well as the elastic characteristics of the lungs. With PEEP titration, what is important is the change in the elastic properties of the lungs. Some ventilators display compliance and resistance determined by least squares fitting of the Equation of Motion. Again, my preference is to calculate compliance in the usual manner using Pplat.

Doesn’t the ventilator derive pressure-volume curves use a different algorithm than a manually derived one?

The traditional manual method for determining the pressure-volume curve uses step changes in volume and measurement of the corresponding pressure at each volume increase (or decrease). Some ventilators have a maneuver that uses a slow flow inflation (or deflation) to display the pressure-volume curve. If the flow is slow and constant, this is likely a reasonable proxy for the manually derived pressure-volume curve. To my knowledge, this is only available on one commercially available ventilator. Unless the ventilator has a pressure-volume curve algorithm, the dynamic curve displayed on the ventilator is not useful to detect inflection points or for PEEP titration.