CLINICAL TECHNIQUE

Finding Safe Driving Pressure

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Abstract

Driving pressure (ΔP) has been directly associated with mortality in acute respiratory distress syndrome (ARDS) and should be monitored and limited to <15 cm of water. Its calculation in a passively ventilated patient is straightforward but requires invasive and expensive techniques like esophageal pressure monitoring in patients with spontaneous respiratory effort. Recently described novel bedside techniques can be used to estimate ΔP in patients on assisted mechanical ventilation.

Keywords: Acute care medicine, Acute respiratory distress syndrome, Critical care unit, Mechanical ventilation.

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Introduction

Driving pressure (ΔP) has been directly associated with mortality in acute respiratory distress syndrome (ARDS).[1] A ΔP of <15 cm of water has been recommended to improve outcomes by reducing lung stress and risk of ventilator-induced lung injury (VILI).[1] Its calculation in a passively ventilated patient is straightforward—plateau pressure (Pplat) minus positive end-expiratory pressure (PEEP). Patients recovering from ARDS, who are on spontaneous but assisted ventilation are still at risk of VILI and patient self-inflicted lung injury. Higher ΔP during assisted mechanical ventilation is associated with increased intensive care unit (ICU) mortality.[2] Here, both pressure generated by the ventilator and pressure generated by the patient's inspiratory muscles (P-mus) are contributing to ΔP. Estimating ΔP requires quantification of pressure generated by inspiratory muscles by esophageal pressure monitoring which is unavailable in most ICUs.[3] Recently novel methods have been described and validated by several researchers to obtain parameters of lung mechanics using simple maneuvers.[2,4,5] These can be performed easily at the bedside on most traditional ventilators and can provide the clinician with an estimate of ΔP and resulting lung stress.

Case and Technique

We describe a case of a 40-year-old male diagnosed with severe ARDS (according to Berlin definition[6]) due to aspiration pneumonia (secondary to head injury). Initially, he received lung-protective passive mechanical ventilation and muscle paralysis. By day 4, his lung infiltrates cleared significantly and his fractional inspired oxygen (FIO_2) requirement was down to 40% on a PEEP of 6 cm of water. His sedation was tapered and ventilator mode was changed to pressure support (PS) with a PEEP of 6 and PS above PEEP of 6 (Fig. 1). The spontaneous respiratory rate (RR) was 22 and he maintained an oxygen saturation of 94% on FIO_2 of 40%. Now the question arose, what would be the ΔP in this patient recovering from ARDS, who is on spontaneous but assisted ventilation? Quantification of P-mus required esophageal pressure monitoring which wasn't available. The following maneuvers were performed at the bedside.

- A short duration inspiratory pause leads to relaxation of the inspiratory muscle contraction and revealing of true Pplat (Fig. 2). In our patient the true Pplat obtained on inspiratory pause was 22 cm of water. Thus, the ΔP was (Pplat–PEEP) 16 cm of water.
- Another maneuver is to apply an expiratory pause (Fig. 3). When the patient takes his next breath during occlusion, a negative swing in the pressure scalar is obtained reaching a nadir known as the pressure at occlusion or Δ-pressure at occlusion (ΔPocc) which is correlated with P-mus. ΔPocc needs to be corrected by a factor of 0.75 as validated by original researchers. Dynamic ΔP (ΔPdyn) can then be calculated by adding the set PS above PEEP (which is the ventilator component of ΔP) with corrected Pocc. In our patient, the ΔPdyn was calculated to be 26 cm of water. Note that this dynamic ΔP was significantly higher than the (static) ΔP calculated by the previously described method in Figure 2. This difference is due to the inclusion of the resistive load in addition to the elastic load in estimating ΔPdyn.
- Lastly, transpulmonary ΔP (ΔPLdyn) can be derived from ΔPocc. ΔPLdyn is the component of the ΔP used to inflate the lung (and not the chest wall). Pocc when corrected with a factor of 0.66 can be used to estimate ΔPLdyn (Fig. 3). In our patient ΔPLdyn was calculated to be 23.8 cm of water.

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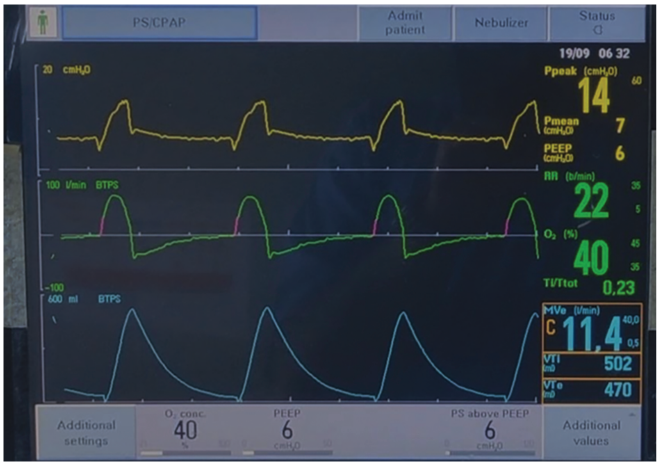


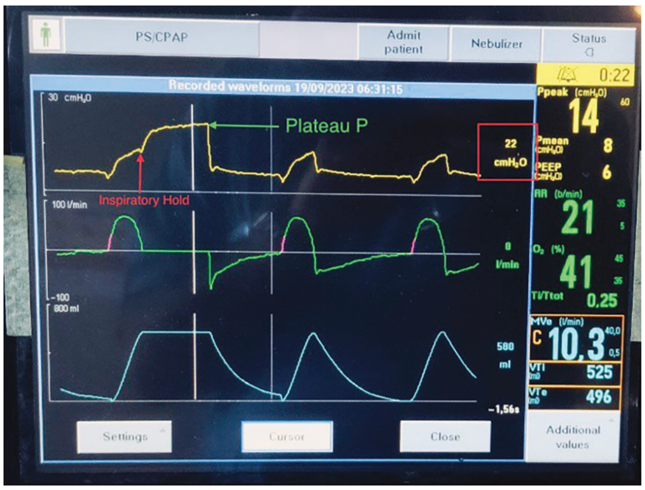
Patient ventilated on pressure support (PS) mode.

PEEP = 6

PS above PEEP = 6

RR (spontaneous) = 22

Fig. 1: Patient ventilated on PS mode



Inspiratory pause

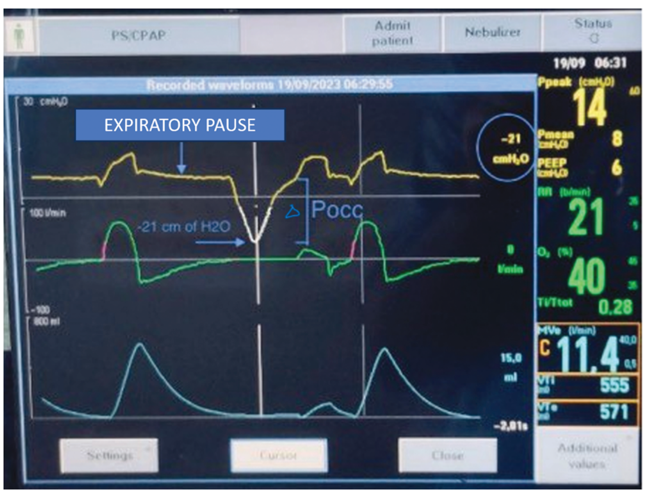
Plateau pressure = 22

ΔP = Pplat – PEEP

=22–6

ΔP = 16

Fig. 2: Application of inspiratory pause to determine Pplat



Expiratory pause

ΔPocc = PEEP – (–21) = 27

ΔPdyn = PS + (0.75 x ΔPocc)

= 6 + (0.75 x 27)

ΔPdyn = 26

ΔPLdyn = PS + 0.66 x ΔPocc

= 6 + 0.66 x 27

ΔPLdyn = 23.8 cm of water

Fig. 3: Application of the expiratory hold to determine Pocc

Conclusion

Lung stress should be minimized in patients with ARDS on assisted mechanical ventilation; however, maintaining spontaneous respiratory effort. Simple bedside maneuvers with the help of any ventilator can be used to estimate ΔPs.

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References

1. Amato MB, Meade MO, Slutsky AS, et al. Driving pressure and survival in the acute respiratory distress syndrome. N Engl J Med 2015;372(8):747–755. DOI: 10.1056/NEJMsa1410639
2. Bellani G, Grassi A, Sosio S, et al. Driving pressure is associated with outcome during assisted ventilation in acute respiratory distress syndrome. Anesthesiology 2019;131(3):594–604. DOI: 10.1097/ALN.0000000000002846
3. Yoshida T, Brochard L. Esophageal pressure monitoring: why, when and how? Curr Opin Crit Care 2018;24(3):216–222. DOI: 10.1097/MCC.0000000000000494
4. Bellani G, Grassi A, Sosio S, et al. Plateau and driving pressure in the presence of spontaneous breathing. Intensive Care Med 2019;45(1):97–98. DOI: 10.1007/s00134-018-5311-9
5. Bertoni M, Telias I, Urner M, et al. A novel non-invasive method to detect excessively high respiratory effort and dynamic transpulmonary driving pressure during mechanical ventilation. Crit Care 2019;23(1):346. DOI: 10.1186/s13054-019-2617-0
6. ARDS Definition Task Force; Ranieri VM, Rubenfeld GD, et al. Acute respiratory distress syndrome: the Berlin definition. JAMA 2012;307(23):2526–2533. DOI: 10.1001/jama.2012.5669