Plateau Pressure and Driving Pressure in Volume- and Pressure-Controlled Ventilation: Comparison of Frictional and Viscoelastic Resistive Components in Pediatric Acute Respiratory Distress Syndrome

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Pablo Cruces, MD[1–3]
Diego Moreno, RT[1]
Sonia Reveco, MD[1]
Yenny Ramirez, MD[1]
Franco Díaz, MD, MBA[1,3,4]

OBJECTIVES: To examine frictional, viscoelastic, and elastic resistive components, as well threshold pressures, during volume-controlled ventilation (VCV) and pressure-controlled ventilation (PCV) in pediatric patients with acute respiratory distress syndrome (ARDS).

DESIGN: Prospective cohort study.

SETTING: Seven-bed PICU, Hospital El Carmen de Maipú, Chile.

PATIENTS: Eighteen mechanically ventilated patients less than or equal to 15 years old undergoing neuromuscular blockade as part of management for ARDS.

INTERVENTIONS: None.

MEASUREMENTS AND MAIN RESULTS: All patients were in VCV mode during measurement of pulmonary mechanics, including: the first pressure drop (P1) upon reaching zero flow during the inspiratory hold, peak inspiratory pressure (PIP), plateau pressure (P_{PLAT}), and total positive end-expiratory pressure (tPEEP). We calculated the components of the working pressure, as defined by the following: frictional resistive = PIP–P1; viscoelastic resistive = P1–P_{PLAT}; purely elastic = driving pressure (ΔP) = P_{PLAT}–tPEEP; and threshold = intrinsic PEEP. The procedures and calculations were repeated on PCV, keeping the same tidal volume and inspiratory time. Measurements in VCV were considered the gold standard. We performed Spearman correlation and Bland-Altman analysis. The median (interquartile range [IQR]) for patient age was 5 months (2–17 mo). Tidal volume was 5.7 mL/kg (5.3–6.1 mL/kg), PIP cm H_2O 26 (23–27 cm H_2O), P1 23 cm H_2O (21–26 cm H_2O), P_{PLAT} 19 cm H_2O (17–22 cm H_2O), tPEEP 9 cm H_2O (8–9 cm H_2O), and ΔP 11 cm H_2O (9–13 cm H_2O) in VCV mode at baseline. There was a robust correlation (rho > 0.8) and agreement between frictional resistive, elastic, and threshold components of working pressure in both modes but not for the viscoelastic resistive component. The purely frictional resistive component was negligible. Median peak inspiratory flow with decelerating-flow was 21 (IQR, 15–26) and squared-shaped flow was 7 L/min (IQR, 6–10 L/min) ($p < 0.001$).

CONCLUSIONS: P_{PLAT}, ΔP, and tPEEP can guide clinical decisions independent of the ventilatory mode. The modest purely frictional resistive component emphasizes the relevance of maintaining the same safety limits, regardless of the selected ventilatory mode. Therefore, peak inspiratory flow should be studied as a mechanism of ventilator-induced lung injury in pediatric ARDS.

KEY WORDS: acute respiratory distress syndrome; critical care; mechanical ventilation; respiratory mechanics; work of breathing

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DOI: 10.1097/PCC.0000000000003291

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