Assessment of the accuracy of ventilator simulation softwares

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Introduction

In intensive care unit, many simulators are used to teach clinicians, nurses and respiratory therapists the principles of mechanical ventilation. Modelling the mechanical properties of the respiratory system allow them to learn settings and monitoring of mechanical ventilators. In volume controlled mode, the airway pressure (P_{aw}) is an important parameter to monitor for an optimal management of ventilated patients. It can be calculated from the following equation of motion of the inspired gas (EMIG):

$$\mathbf{P_{aw} = P0 + (Ers \times Vt) + (Rrs \times Q)}$$

P0: Start Pressure / Ers: elastance of respiratory system / Vt: Tidal Volume / Rrs: Resistance of respiratory system / Q: inspiratory flow.
The purpose of the study was to compare P_{aw} calculated from the EMIG and P_{aw} measured with 3 different teaching tools: a two-compartment adult lung model and 2 ventilator simulation softwares.

Material and methods

Using the EMIG formula, we measured P_{aw} of 50 lung mechanics (range of elastance and resistance, respectively: 11 to 77 cm H_2O/L and 5 to 31 cm H_2O / L.sec-1). These values were compared, in the same conditions with P_{aw} measured with a Maquet Servoi® ventilator connected to a two compartment lung model (Dual Test Lung ® Michigan Instrument – TTL 1600) and 2 ventilator simulation softwares (Dräger Evita 4 ® simulator SW 3.99 (DS) and Hamilton simulator version 2.2. (HS)).

All set in volume controlled mode (Vt: 0,5 L; Rf: 20 cpm; inspiratory flow: 30L.min-1; I/E ratio:1/2; pressure trigger sensitivity: -20cm H_20; inspiratory plateau pressure: 25%; inspiratory rise time: 0%; peep: 0 cm H_2O). Statistical method: Bland Altman method and multiple linear regression.

Results

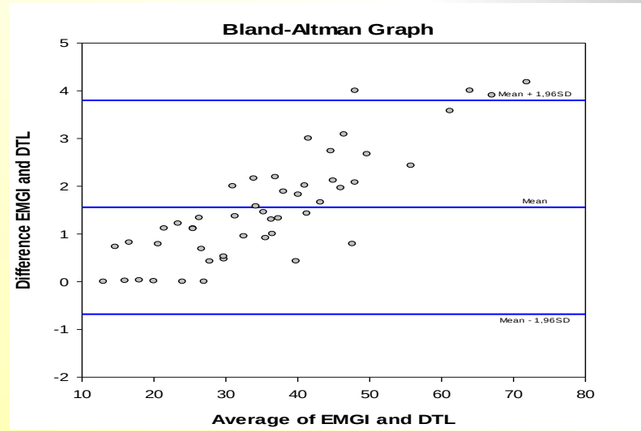
	Bias (SD) cm H_2O	Limits of agreement (cm H_2O)	Bias (95% CI) (cm H_2O)	Lower Limit of Agreement (95% CI)	Upper Limit of Agreement (95% CI)	R^2	P value
EMIG vs DTL	1,6 (1.1)	-0,7 to 3,8	1,2 to 1,9	-1,2 to -0,1	3,2 to 4,4	0,99	<0,001
EMIG vs HS	-0,2 (1,9)	-3,8 to 3,5	-0,7 to 0,3	-4,8 to -2,9	2,5 to 4,4	0,98	<0,001
EMIG vs DS	-1,0 (2,1)	-5,1 to 3,1	-1,6 to -0,4	-6,2 to -4,1	2,1 to 4,2	0,97	<0,001
HS vs DS	-0,8 (1)	-2,7 to 1,1	-1,1 to -0,5	-3,2 to -2,2	0,6 to 1,6	0,99	<0,001

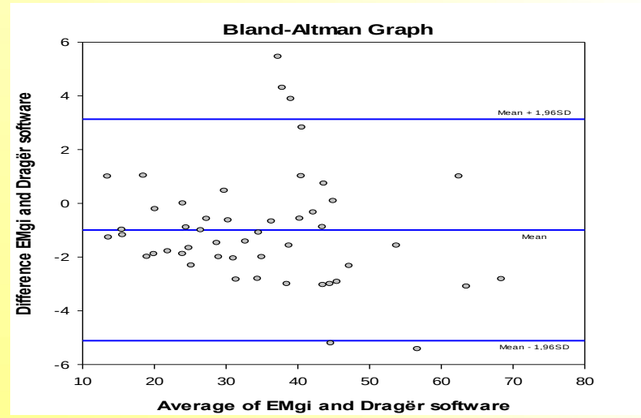
Pressure (P_{aw}) measured by different technique (EMIG, DTL, HS, DS)
EMIG: Equation of motion of inspired gas / DTL: Dual Test Lung ® /HS: Hamilton simulator/ DS: Dragër simulator

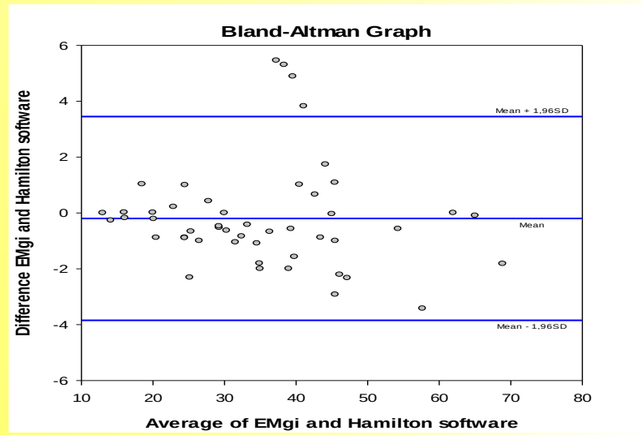
Discussion

The responses to several respiratory system characteristics showed that the teaching tools react appropriately. The bias between EMIG and different tools was in narrow limits of agreement. We conclude that pressure values obtained from EMIG, are similar of values recorded with a two-compartment adult lung model connected to a volume ventilator, HS and DS. These methods are relevant and realistic for teaching principles of mechanical ventilation.

Comparison Paw calculated from EMIG and DTL, HS, DS by Bland Altman method







Reference: Yan Shi.Pressure Dynamic Characteristics of Pressure Controlled Ventilation System of a Lung Simulator.Comput and Mathematical Methods in Medicine.Vol 2014 (2014)