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CRITICAL CARE

LETTER

Comments on the use of expiratory time constant for determinations of plateau pressure, respiratory system compliance, and total resistance

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See related research by Al-Rawas *et al*., http://ccforum.com/content/17/1/R23

In the previous issue of *Critical Care*, Al-Rawas and colleagues [1] presented a method for assessing elastic and resistive properties of the respiratory system in patients with respiratory failure. The method assumes a first-order resistance-compliance (RC) model of breathing mechanics.

Although the procedure for estimating expiratory time constant (τ_E) is correct and efficient, some clarifications need to be made about the use of equations 3 to 5 in mechanically ventilated patients, in whom an intrinsic positive end-expiratory pressure (PEEPi) can be present [2,3].

Equations 3 to 5 are correct only if the term indicated with the acronym PEEP accounts not only for external PEEP but also for PEEPi. Neglecting PEEPi can lead to significant errors, as demonstrated by the following model-to-model analysis, in which data were generated by using a first-order RC model. Table 1 shows the true model values and their corresponding estimates, which were obtained with the method of Al-Rawas and colleagues and which neglect PEEPi.

The estimate of τ_E is correct for both patients because, in the first-order RC model, the relationship between lung volume changes and expiratory flow does not depend on PEEP (intrinsic or external or both). The estimates of total resistance (R_{tot}), respiratory system compliance (C_{rs}), and plateau pressure (P_{plt}) for patient A (in whom PEEPi is 0) are identical to the true values. For patient B (in whom PEEPi is equal to about 3 cm H_2O), the percentages of error of the estimations of R_{tot}, C_{rs}, and P_{plt} are 17%, −14.5%, and −18.2%, respectively. This confirms that these estimates necessitate the measurement of PEEPi and this requires, for example, the end-expiratory occlusion technique [4,5].

Table 1. True model values and corresponding estimates

Patient	Parameter or variable	True value	Estimated value	Percentage error
A	τ_E	0.25 s	0.25 s	0%
	R_{tot}	5 cm H_2O×s/L	5 cm H_2O×s/L	0%
	C_{rs}	0.05 L/cm H_2O	0.05 L/cm H_2O	0%
	P_{plt}	13 cm H_2O	13 cm H_2O	0%
B	τ_E	1.995 s	1.995 s	0%
	R_{tot}	21 cm H_2O×s/L	24.6 cm H_2O×s/L	17%
	C_{rs}	0.095 L/cm H_2O	0.0812 L/cm H_2O	−14.5%
	P_{plt}	9.78 cm H_2O	8.00 cm H_2O	−18.2%

A volume-controlled continuous mandatory ventilation was simulated with a constant inspiratory flow, a tidal volume of 0.65 L, a breathing frequency of 15 breaths per minute, an inspiration time of 1.3 seconds, a post-expiratory pause of 0.3 seconds, and an expiration time of 2.4 seconds. No external positive end-expiratory pressure was simulated. For each patient, 10 breathing cycles were simulated to allow the steady state to be reached. Data from the last simulated cycle were used to estimate expiratory time constant (τ_E), plateau pressure (P_{plt}), respiratory system compliance (C_{rs}), and total resistance (R_{tot}).

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Authors' response

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We thank the editor for the opportunity to respond to this letter. At this time, it is unclear whether PEEPi or some critical level of PEEPi may confound determinations of P_{plt}, C_{rs}, and R_{tot} when the τ_E method is used as we described [1]. A proper and scientific way to address this matter is through a carefully conducted, follow-up clinical study of patients with acute or chronic forms of respiratory failure (such as chronic obstructive pulmonary disease), in which total PEEP (including its component parts of PEEPi and applied PEEP) is correctly determined for an appropriate number of patients by using our τ_E method.

Abbreviations

C_{rs}, respiratory system compliance; PEEP, positive end-expiratory pressure; PEEPi, intrinsic positive end-expiratory pressure; P_{plt}, plateau pressure; RC, resistance-compliance; R_{tot}, total resistance; τ_E, expiratory time constant.

Competing interests

MJB is a consultant for Convergent Engineering (Newberry, FL, USA), which is a developer of software used in the related research. NRE is president of and holds stock in Convergent Engineering. CT is an associate of Convergent Engineering. The authors of the related research received clinical research funds from Philips-Respironics Inc. (Hartford, CT, USA), the study sponsor, and have applied for a patent. All other authors declare that they have no competing interests.

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