Evaluation of a Non-Invasive Respiratory Volume Monitor in Subjects Under Non-Invasive Ventilatory Support

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Introduction: Non-Invasive Ventilatory Support (NIVS, e.g., CPAP, BiPAP, High-flow O_2) is currently used across the continuum of care. This has created a unique challenge for clinicians who need to be able to evaluate not only the need but also the effectiveness of NIVS. We wanted to test the ability of a recently developed non-invasive respiratory volume monitor (RVM, Exspiron, Respiratory Motion, Waltham, MA, USA) that provides continuous measurement of minute volume (MV), tidal volume (TV), and respiratory rate (RR) to provide this monitoring in such conditions of ventilation. The RVM has previously been shown to have better than 10% accuracy for MV, TV, and RR in both non-intubated and intubated patients.[1,2] Here, we evaluated the RVM's accuracy when monitoring healthy subjects under NIVS.

Methods: Six healthy subjects completed this pilot study (3 males, BMI=21.1 kg/m^2 (19.1-23.1)). MV, TV, and RR data were simultaneously recorded by the RVM and ventilator (vent) for 3, 5min-long trials under different vent settings: CPAP 0 cmH_2O (CPAP0), CPAP 5 cmH_2O (CPAP5), and pressure support 5cmH_2O with PEEP 2 cmH_2O (PS5). Relative errors between RVM and vent measurements of MV, TV, and RR were calculated over 1min segments and bias, precision, and accuracy were calculated using Bland-Altman analyses. All data are presented as mean±SEM.

Results: Subjects maintained an average MV of 7.1±0.9 L/min, with individual breath TV ranging from 81 to 1371mL and RR ranging from 5.0 to 35.7bpm. During spontaneous breathing (CPAP0) measurement bias in TV measurements between the RVM and the vent was 3.5±3.1% with a precision of 4.3±1.4% and an overall accuracy of 8.3±1.5%, corresponding to measurement error of 51.6±9.4mL. During the NIVS trials (CPAP5 and PS5) the measurement bias, precision and accuracy remained practically unchanged (p=0.66, 0.42, and 0.54, respectively, 1-way ANOVAs, see Fig 1A). Fig 1B shows the strong correlation between RVM and ventilator measurements whereas Fig 1C depicts their Bland-Altman plot.

Conclusion: We show that the RVM provides clinically-relevant accuracy when monitoring healthy subjects under non-invasive ventilatory support with various settings.

References: [1] Voscopoulos, C et al. Anesth Analg 117:91-100, 2013; [2] Voscopoulos, C et al. J Clin Monit Comput 29:223-39, 2015

A	CPAP0	CPAP5	PS5	P-value
Bias	3.5%	6.0%	3.7%	0.66
Precision	3.3%	3.3%	6.1%	0.42
Accuracy	8.3%	11.8%	10.1%	0.54

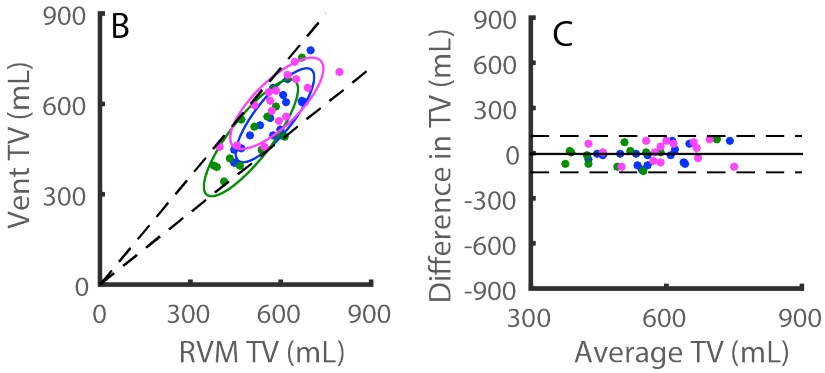

Figure 1. Measurement analysis for 6 subjects. A: Average biases, precisions, and accuracies. B: Correlation plots between RVM and ventilator TV measurements under three vent settings (CPAP 0 cmH_2O (blue), CPAP 5 cmH_2O (green), PS 5 5 cmH2O with PEEP 2 cmH_2O (pink). Markers: 1 min averages; dashed lines: 20% relative error; confidence ellipses: ±1 SD. C: Bland-Altman error analysis. Solid line: average bias: -1.5 mL; dashed lines: 95% limits of agreement: -125 to 128 mL.