Reference values and prediction equations for Volumetric Capnography indices in lung healthy mechanically ventilated children

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Introduction

Volumetric capnography provides the clinician more insight into physiological and ventilatory parameters like physiological and alveolar dead space (Vdphys, VDalv), alveolar ventilation (AV) and volume expired of carbon dioxide (VCO₂). Reference values for Vcap are unknown especially for children. This study has examined whether there is a difference between the Vcap parameters in mechanically ventilated patient with or without a lung disease. Secondly, we aimed to construct an equation able to predict the Vcap parameters in lung healthy mechanically ventilated patients

Methods

266 mechanically ventilated children were included. Oxygenation Index ≤ 2.5 defined absence of lung disease. Outcome variables included physiological and alveolar dead space VCO₂ and alveolar ventilation. Univariate comparison of baseline characteristics, ventilation and physiological parameters and Vcap indices was performed using Student's t-test. Correlations were calculated between several patient's characteristics and Vcap indices. Multivariable linear regression analysis was performed to formulate the best fitted prediction equation for VCO₂ and VDalv.

A prediction equation for these indices was defined. VCO₂ found to be dependent on tube size, tidal volume, inspiratory time and gender (adjusted R² = 0.88), whereas VDalv was dependent on tidal volume (adjusted R² = 0.52). Correlation analysis and visual evaluation of scatter plots indicated actual body weight to be the best variable to standardize Vcap indices.

Table 1 | Demographic table and summary of ventilation parameters

	N	Overall	N	No lung disease ^a	N	Lung disease ^b	P value ^{c,d}
Patient's characteristics							
N (%)		265 (100)		77 (29.1)		188 (70.9)	<0.001
Sex	265		77		188		<0.001
Female, N (%)		103 (38.9)		29 (37.7)		74 (39.4)	
Male, N (%)		162 (61.1)		48 (62.3)		114 (60.6)	
Age in years (IQR)	265	0.63 (0.12 - 3.59)	77	2.17 (0.48-8.70)	188	0.47 (0.10-1.63)	<0.001
Weight in kg (IQR)	263	8.00 (4.00 - 14.70)	76	12.00 (6.70 - 28.00)	187	6.20 (4.00 - 12.00)	<0.001
PICU length of stay in days (IQR)	263	6.00 (4.00 - 10.00)	77	4.00 (2.00-7.00)	186	6.00 (4.00 - 10.00)	<0.001
Duration ventilation in hours (IQR)	259	90.00 (44.00 - 159.00)	75	39.00 (22.00 - 93.00)	184	103.50 (68.00 - 168.00)	<0.001
Tube Size in mm (IQR)	265	4.00 (3.50 - 4.50)	77	4.50 (3.75 - 5.50)	188	3.50 (3.50 - 4.00)	<0.001
Volumetric capnography based indices							
VCO ₂ in mL/kg (IQR)	263	7.29 (4.54 - 8.57)	75	5.90 (4.97 - 7.46)	188	7.63 (6.13 - 9.01)	<0.001
VDphys in mL/kg ($\pm$ SD)	260	2.62 (1.21)	75	2.01 (1.70)	185	2.87 (1.16)	0.402
VDalv in mL/kg (IQR)	225	1.15 (0.60 - 1.75)	51	0.64 (0.42 - 1.06)	174	1.34 (0.74)	<0.001
VD/VT ($\pm$ SD)	262	0.38 (0.17)	75	0.28 (0.16)	187	0.41 (0.16)	0.842
Ventilation index (IQR)	265	2.30 (1.49 - 4.19)	77	1.32 (1.01-1.63)	188	3.19 (2.11-4.69)	<0.001
Alveolar ventilation in mL/kg ($\pm$ SD)	260	138.56 (113.75)	75	139.22 (82.62)	185	138.28 (64.84)	0.617

^a: Group defined as OI $\leq$ 2.5

^b: Group defined as OI>2.5

^c: P value of difference between OI<2.5 and OI>2.5 groups.

^d: statistical significant values (p<0.05) in bold

Table 2 | Prediction equations for VCO₂ and VDalv

Prediction equation: <i>Expected value</i> = $k + \sum(b \times \text{PREDICTOR})$	
VCO₂	
Males: $-11.558 + (24.961 \times \text{Tube size}) + (0.372 \times \text{Tidal volume}) + (-68.490 \times \text{Inspiratory time})$	
Females: $9.983 + (24.961 \times \text{Tube size}) + (0.372 \times \text{Tidal volume}) + (-68.490 \times \text{Inspiratory time})$	
VDalv	
$1.377 + (0.061 \times \text{Tidal Volume})$	

Conclusion

Reference values and equations could be defined for VDalv and VCO₂. More subsequent research is warranted to confirm the current findings and validate the presented prediction equations