$EtCO_2$ Ventilatory Ratio: a new and continuous method to estimate physiological dead-space?

Maj R.[1], Palermo P.[1], Romitti F.[1], Busana M.[1], Gattarello S.[1], D'Albo R.[1], Velati M.[1], Brusatori S.[1], Zinnato C.[1], Lombardo F.[1], Chiumello D.[2], Camporota L.[3], Gattinoni L.[1]

1 Department of Anesthesiology, Emergency and Intensive Care medicine, University of Göttingen, Germany
2 Department of Anesthesiology, Emergency and Intensive Care medicine, ASST Santi Paolo e Carlo Hospital, University of Milan
3 Department of Adult Critical Care, Guy's and St Thomas' NHS Foundation Trust, Health Centre for Human and Applied Physiological Sciences, London, UK.

Background: Ventilatory ratio (VR) is a bedside tool which estimates physiological dead-space (V_d/V_t) and often reported as a substitute of the direct measurement of V_d/V_t. VR calculation needs $PaCO_2$ measurement and it has been demonstrated to be a strong prognostic factor in ARDS patients. We aimed to assess whether including $EtCO_2$ in the VR calculation may provide additional physiological and/or prognostic value.

Methods: The study includes two cohorts of patients (n_1= 193, n_2=448) admitted to ICU suffering from ARDS, mechanically ventilated without Extracoporeal Membrane Oxygenation (ECMO). The measured variables were: CO2 consumption (VCO_2), minute ventilation (VE), V_d/V_t, $PaCO_2$, and $EtCO_2$. The VR was calculated as $VR = \frac{VE*PaCO2}{0.1*PBW*40}$, while VR_{etCO2} was recalculated as

$$VR\text{etCO2} = \frac{\frac{VE}{EtCO2}}{\frac{0.1 * PBW}{33}}$$

Results: Among all patients, 26 presented with $PaCO_2$ and V_d/V_t values within physiological ranges (35-45 mmHg and 0.25-0.35, respectively). In this group, the ideal value of $EtCO_2$ needed for a VR_{etCO2} equal to 1 was 33 mmHg, which was inserted in the denominator of the VR_{etCO2} formula. Mean values were 0.54 (±0.15) for V_d/V_t, 1.51 (±0.5) for VR, and 1.31 (±0.52) for VR_{etCO2}, respectively. Bland-Altman analysis showed a VR_{etCO2} bias of -0.19 [0.87, -1.25]. R^2 for V_d/V_t and VR was 0.6, V_d/V_t and VR_{etCO2} was 0.12. R^2 for alveolar dead-space (V_d/V_{talv}) and VR was 0.12, V_d/V_{talv} and VR_{etCO2} was 0.16. V_d/V_t, VR, and VR_{etCO2} are all prognostic factors for mortality (p= 0.001 for every variable).

Conclusions: VR_{etCO2} represents a further simplification for the estimation of V_d/V_t with the noteworthy advantage of being non-invasive while maintaining a substantial predictivity of mortality.