Capnography and Respiratory Care in the 21st Century

If a medical anthropologist were to ask me to name a characteristic peculiar to the respiratory care profession, I would respond that we have an enormous fondness for formulas. Thirty years ago, memorization and application of formulas were essential elements of clinical competency. Respiratory therapists frequently were called upon to apply formulas to predict everything from the mundane (estimating how long an H-size cylinder of oxygen would last) to the exotic (predicting the P_{aO_2} after an adjustment in oxygen concentration). There was a virtue to this, in that it kept practitioners mentally sharp: forcing them to recall and reason (often with paper and pencil). Although the image of a respiratory therapist hunched over a ventilator scribbling calculations is vaguely romantic, the reality was that formulas were of limited value in the clinical environment and provided only a general guide to making adjustments.

A consequence of the computer revolution for respiratory care has been the breathtaking advance in sophisticated pulmonary physiology monitoring now available at the bedside. Frequently, this has obviated the paper, pencil, and formulas. One example is the possibility opened up by the advent of volumetric capnography. Thirty years ago, measurement of physiologic dead-space fraction (ratio of dead space to tidal volume [V_D/V_T]) was a time-consuming, cumbersome procedure, seldom done at the patient's bedside, except for research purposes. Even when dead-space fraction was measured clinically, serial measurements were highly impractical.

Yet the usefulness of measuring V_D/V_T to avoid pulmonary over-distention in patients with acute respiratory failure was apparent even in the 1970s.[1] In the intervening years, the negative consequences of pulmonary over-distention have become apparent.[2-4] Also V_D/V_T was recently found to be a strong, pulmonary-specific predictor of mortality in patients with early acute respiratory distress syndrome (ARDS) ventilated with large tidal volumes.[5] As our understanding of ventilator-induced lung injury in ARDS continues to unfold, volumetric capnography has the *potential* for playing an increasingly useful role, both in terms of understanding the pathophysiology and guiding therapies. For example, a decreased V_D/V_T in response to prone positioning was associated with improved survival in patients with ARDS,[6] and also was found to be an important physiologic variable in predicting the amount of recruitable lung.[7] As recently reported in this journal,[8]

volumetric capnography may, in the near-future, be utilized to rapidly measure functional residual capacity: an important element for assessing lung recruitment. As elegantly stated by Suter and colleagues,[1] ventilator management in ARDS must carefully balance the benefits of lung recruitment against the risk of lung over-distention, because they occur simultaneously. Accurate and easy-to-use volumetric capnography monitors are now widely available,[9] which provide clinicians with rapid, sophisticated measurements of pulmonary physiology that were not available just a few decades ago.

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In this issue of the Journal, Brewer et al[10] present convincing data that formulaic estimates of anatomic (or, more appropriately, airway) dead space based on body weight correlate poorly with actual measurements with a variation of the Fowler method.[11] Brewer et al are to be commended for doing the hard work of demonstrating what was widely assumed but never proven over the past 50 years: namely, formulaic estimates only provide a starting point for addressing a clinical issue but cannot reliably substitute for actual measurements. Brewer et al also provide a succinct historical discussion of this point. As they observe, the clinical importance of anatomic dead space during mechanical ventilation was a minor consideration when patients were managed with a super-normal V_T of 10–15 mL/kg.

In the era of lung-protective ventilation, when V_T as low as 4 mL/kg are needed to manage patients with severe ARDS, the assessment of anatomic dead space is clinically relevant for interpreting changes in carbon dioxide partial pressure. Moreover, even a lung-protective strategy of 6 mL/kg and plateau pressure of ≤ 30 cm H_2O may still result in substantial lung over-distention.[12] Therefore, measurement of V_D/V_T and the assessment of the anatomic component *may* become an essential element in the further refinement of ventilator management in ARDS. Of course the potential utility of volumetric capnography will require verification from future prospective clinical studies.

As respiratory care moves into the 21st century, advances in mechanical ventilation that may improve patient outcomes further are likely to come from increasingly sophisticated pulmonary physiology monitoring capabilities.

It is reassuring to know that some of the promising technology is practical and already available at the bedside.

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