

Continuous Exhaled Breath Condensate Measurements in Ventilated Patients: “I Don’t Know What You Guys Are Measuring, But You’re Certainly Measuring It!”

An increasing number of papers indicate the usefulness of exhaled-breath condensate (EBC) in respiratory medicine. A European Respiratory Society statement on this subject was recently published.¹ For the purpose of estimating the extent of inflammation in the airways, EBC seemed to perform well and might enable physicians to monitor the therapy of, for instance, asthma and chronic obstructive pulmonary disease. EBC has also been examined for its specific information in interstitial lung disease, acute respiratory distress syndrome, and lung transplantation.^{2,3} Investigations of EBC have focused on H₂O₂,^{4–6} 8-isoprostanes,^{7–9} eicosanoids,¹⁰ and cytokines.^{11,12} A more recent focus of interest in EBC analysis is the pH of this noninvasively-acquired material. A decreased EBC pH was first described by Hunt et al in acute asthma, and this effect was normalized following steroid therapy.¹³ A reduced EBC pH was also demonstrated in chronic obstructive pulmonary disease¹⁴ following cardiothoracic surgery,¹⁵ in acute lung injury,¹⁶ and during allograft rejection following lung transplantation.³ Because EBC pH measurement is rapid and does not require extensive instrumentation, it may be useful for estimating the extent of acute lung injury and as a repeated monitoring variable in ventilated patients.

SEE THE ORIGINAL STUDY ON PAGE 1125

In this issue of *RESPIRATORY CARE*, Walsh and co-workers provide what are believed to be the first continuous measurements of EBC pH in ventilated patients.¹⁷ EBC collection was found to be safe and without any disturbance to the process of ventilation or monitoring. pH remained fairly constant, although the method of some sample collections prior to equilibration may have favored blunting of pH variability to some extent. In general, an increasing acidification during clinical deterioration was observed, with normalization during recovery.¹⁷ This is the first study to investigate EBC pH changes in patients for a more extended period. A special device was developed that was adapted to a conventional ventilator. This could constitute the first methodological step toward a biological signal-driven intelligent interactive ventilator

that constantly watches the lung while doing its mechanical job.

Returning to earth for now, we of course recognize that the pH of the exhalate is one of the more enthusiastically debated variables in medicine. Much has been discussed in this regard and almost all is true. An important aspect in this discussion is the role of ammonia in EBC. Hunt et al observed reduced ammonia levels in acute asthma,¹³ and it was suggested that glutaminase activity in human airway epithelium was reduced.^{18,19} Effros, on the contrary, suggested saliva as the source of ammonia.²⁰ Wells and co-workers investigated this point and reached the conclusion that oral ammonia concentration was not an important determinant of EBC pH.²¹

The point here is that airway pH is not completely mechanically accounted for as of now. It is evident that volatile acids entering the exhalate or the sample during collection will be part of what is measured as EBC pH. In spontaneously breathing individuals, volatile acids and bases might have their origin in the mouth.²² Gastric-acid aspiration can lead to airway acidification.^{23,24} However, acidification of EBC in mechanically ventilated, intubated patients is not realistically caused by saliva or gastric acids. Airway epithelial cells may actively participate in influencing the pH of the extracellular fluid.²⁵ Metabolically derived acids and bases, such as lactate¹⁶ and ammonia,¹⁸ have also been investigated for their influence on EBC pH, at least in specific clinical situations. Very much remains to be resolved in terms of whether EBC pH is what it appears to be: a useful source of clinical information.²⁶

An important aspect of the study by Walsh et al¹⁷ is its setting in the intensive care unit, and that they investigated mechanically ventilated patients. The majority of studies that have reported clinical results of EBC investigations have been performed in spontaneously breathing patients, but EBC analysis may be at its best in ventilated patients, in whom we have few means to monitor upcoming respiratory conditions. The usefulness of EBC monitoring was nicely shown in a pediatric population by Muller and co-workers,²⁷ and in adult patients with acute respiratory distress syndrome.^{7,16} Nitrite from EBC has also been reported to correlate with both the tidal volume (adapted to ideal body weight) and to the extent of lung injury, and

thus it may be indicative of mechanical stress in ventilated lungs.²⁸ The study by Walsh et al¹⁷ takes it one step further in integrating the dimension of time into the analysis of new biochemical information from deep within the lungs.

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