Capnodynamic Estimation of Lung Volumes: Teething Issues of a Potential Early Warning System

To the Editor:

I would like to commend Albu *et al.*[1] for their well-designed study evaluating the correlation between effective lung volume (ELV) and end-expiratory lung volume (EELV) in healthy and surfactant-depleted rabbit lungs with various levels of positive end-expiratory pressure.

The results have indicated that the correlation between ELV and EELV improves with higher positive end-expiratory pressure, and is best in surfactant-depleted lungs, with the ELV being an overestimate of ELV in healthy lungs by as much as 150 ± 13% at 0 cm H_2O. The authors have hypothesized that this is due to carbon dioxide being an intrinsic gas and the ELV/EELV difference is affected by changes in pulmonary capillary volume and ventilation–perfusion mismatch. There are other methodological factors that may affect this correlation, but no method is able to satisfactorily correct for those, and any attempt may potentially require a more complicated set-up than the elegant one Albu *et al.* propose.[2]

However, for neonatal patients (whom a rabbit model is supposed to simulate), lung injury is on a continuum from healthy to surfactant-depleted. Generally a surfactant-depleted state is avoided by the following two interventions—antenatal glucocorticoid therapy and the instillation of exogenous surfactant into the neonatal lung. Therefore, most neonates requiring ventilator support for perioperative or critical care will be somewhere in the middle—having neither healthy nor surfactant-depleted lungs. The lack of demonstrable reliability of ELV in this gray zone undermines the utility of its absolute value as an estimation of the EELV in this setting.

The authors imply that trending the change in ELV would be more useful than the absolute value. I would be concerned however that the percentage change in ELV and EELV postlavage differs significantly between different positive end-expiratory pressure values. The difference is greatest at 0 and 9 cm H_2O, but this mitigates the issue somewhat because an optimal and protective lung ventilation strategy in neonates is unlikely to be at these extremes. Nevertheless, it may be difficult to estimate the degree of change in actual lung volumes after a decrease in ELV, and may lead a provider to utilize an overly aggressive recruitment strategy that could potentially result in barotrauma.

It should be noted that the sensitivity of ELV to changes to effectiveness in ventilation and as a rough measure of physiological dead space could be useful when paired with other indices that together may indicate lung dysfunction.[3] For example, a decreasing ELV with increasing airway resistance and pressures can serve as a preliminary warning before an appreciable increase in ET_{CO_2} or a suboptimal arterial blood gas result. At present, such dysfunction is only detected after an arterial blood gas result, and there is no simple, continuous and noninvasive method to detect lung atelectasis and institute recruitment measures early.

I believe the greatest value of this study is that the method they describe can be easily implemented as part of an early warning protocol for recruitment manoeuvres, and then a gauge of the effectiveness of the intervention.[3] Further studies and modification of the algorithm should be done to improve the accuracy of ELV as an estimate of EELV in various lung states and ventilator settings. This may then allow its potential to be realized as a simple yet powerful tool currently absent from the arsenal available to modern anesthesiologists and intensivists.

Competing Interests

The author declares no competing interests.

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In Reply:

We thank Dr. Zeng for the thoughtful comments regarding our article. We totally agree that estimating effective lung volume (ELV) by the capnodynamic method may offer an early detector for loss in lung volume. In the lavage-depleted lung model, we mimic a heterogeneous lung, a condition that is often encountered in pediatric clinical practice. Although we agree that neonates have a continuum state between normal and surfactant-depleted lungs, we still face a heterogeneous condition with regional differences in ventilation distribution. This condition was well demonstrated recently by our research group[1] and is confirmed by the significant increase in lung clearance index observed in the current study.[2]

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Regarding the percentage change in ELV after lavage, the trend at different positive end-expiratory pressure levels with ELV was more uniform than end-expiratory lung volume, which may reflect that the former is a functional volume parameter and not a measure of anatomical volume. Furthermore, the ELV value is the only lung volume assessment available at bedside for the clinician, and any recruitment maneuver will be based on the changes in this index. Accordingly, the aim of the clinician will be to re-establish its former value by recruitment maneuver, which eliminates the risk of lung overdistension. It is noteworthy that the lavage-induced decreases in ELV follow a more uniform pattern than end-expiratory lung volume.

There is no doubt that measurement of different lung functional parameters is necessary to reinforce the detection of airway closure and/or reopening. Accordingly, it is very hard to promote one single measure in clinical practice to guide ventilation strategy. Measuring ELV may contribute to better understand the changes observed in respiratory mechanics, but it cannot be considered as a single parameter to detect loss in lung volume. Particularly, changes in pulmonary blood volume may interfere with its absolute value as discussed in the article, which is more obvious at low positive end-expiratory pressure levels. Nevertheless, this method is under improvement and continuous development by our research team. We are currently investigating the relation between ELV and structural global and regional changes in the lungs to improve the algorithm.

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Competing Interests

Drs. Wallin and Hallbäck work at the Research Development Department of Maquet, Solna, Sweden, and they established the theoretical bases of the measurement technique tested in the corresponding article.

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Pain-free Surgery or Pain-free Parking: Measuring Patient Satisfaction with Perioperative Care Is Humbling for the Anesthesiologist

To the Editor:

Barnett *et al.*[1] are to be thanked and congratulated for their attempted synthesis of efforts to quantify patient satisfaction with anesthesia care. The authors did not include the Surgical Consumer Assessment of Healthcare Providers and Systems® (CAHPS) in their assessment, which deserves discussion.[2]

Surgical CAHPS is the newest member of the CAHPS family and is the only tool measuring patient satisfaction with surgical (or anesthesia) care which is endorsed (in whole or in part) by the National Quality Forum, the main clearinghouse for performance measurement in health care.* Surgical CAHPS was designed by the American College of Surgeons with the Agency for Healthcare Research and Quality to be psychometrically rigorous. The instrument incorporates information from multiple care streams and providers of perioperative care—surgeon, nurse, anesthesiologist, hospital, and clinic.

Although four of the seven selected measures ask about the "surgeon," none ask about anesthesia care. When adopting and endorsing Surgical CAHPS as a publicly reportable performance measure (NQF #1741), the National Quality Forum included fewer than half of the questions making up the tool. Psychometric properties were ignored. Our specialty and the care we provide for patients were also ignored. Although four of the seven selected components ask about the "surgeon," none ask about anesthesia care.

Rather than feel "snubbed," perhaps we anesthesiologists may find a pause point to imagine care from the perspective of the patient. For a "person" who becomes a "patient," the lines separating surgery, nursing, anesthesia, and pain-free hospital parking can easily blur. This, of course, is why using a psychometrically rigorous instrument can be important, especially for targeting specific areas for improvement. But in practice, applying lengthy instruments for each component of perioperative care may induce survey fatigue in our patients and compromise the results of such surveys. More importantly, our patients are frequently unaware that we are physicians or that anesthesia care matters, as the American Society of Anesthesiologists' "Physician Anesthesiologist" campaign points out.† As physicians practicing medicine, our goal is not to meet quarterly anesthesia satisfaction benchmarks but to earn patient loyalty by assuring that our patients are cared for—period.[3] Embracing this concept would cement our role as perioperative physicians and align our goals with those of surgeons, nurses, hospitals, and, most importantly, our patients.

* Available at: http://www.qualityforum.org. Accessed September 12, 2013.

† Available at: http://www.asahq.org/WhenSecondsCount/. Accessed December 3, 2013.