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The author has disclosed no conflicts of interest.

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*The Authors Respond:*

Haynes raises an interesting point regarding the performance of spirometry based on the findings of our static lung volume study.[1] For the majority of subjects, the expiratory and inspiratory volumes measured during a forced spirometry maneuver match, resulting in a closed flow-volume loop. Haynes observes that the volume of the complete inspiratory breath performed after a maximal forced expiration exceeds the volume of the forced expiratory maneuver preceding it. This observation suggests that the maximal expiratory maneuver has, in fact, not been performed from a position of maximal inhalation and, as a consequence, $FEV_1$ and FVC values may be underestimated.

We are unable to offer alternative explanations to those proposed by Haynes for this occurrence, and agree that subject coordination or performance issues resulting in this pattern can be improved with feedback and re-instruction from the operator. Differences in mechanical advantage for a maximal inhalation from FRC, compared to RV, may be more difficult to overcome. Equipment issues, particularly differences in correction factors for inspiratory and expiratory volumes, may play a role in loop closure issues, though in the case cited by Haynes this is unlikely, as the subject was able to achieve a closed loop with a second expiratory effort.

An alternative management strategy for subjects presenting with this pattern who are unable to close the loop with feedback and re-instruction, may be to ask them to exhale gently to RV from FRC after a couple of tidal breaths. Once at RV, to then take a maximal forced inspiratory vital capacity breath to TLC and finish the effort with a forced expiratory maneuver.

Further study into the frequency of and mechanisms resulting in this phenomenon is warranted. Test operators, in the meantime, should coach subjects to achieve maximal expiratory and inspiratory efforts and inspect for loop closure. When greater volumes are detected on maximal inspiration following maximal expiration, alternative methodologies should be used to maximize expiratory results and limit the possibility of underestimating $FEV_1$ and FVC.

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## Predicting Noninvasive Mechanical Ventilation Outcome: Early May Be Too Early!

*To the Editor:*

The main determinants of noninvasive ventilation (NIV) efficacy and benefit are represented by the type of acute respiratory failure indication and patient selection (severity of disease, comorbidities), the technical aspects of NIV (choice of the interface, choice of the ventilator, the ventilatory mode used, and its settings applied), as well as the environmental conditions (team experience and motivation, location of NIV initiation, NIV surveillance and monitoring). Based on these determinants, several predictive factors of NIV success or failure have been previously described at NIV initiation or within 1-2 hours after NIV initiation.[1,2]

In the October 2012 issue of RESPIRATORY CARE, Berg et al[3] attempt to define an early predictive factor of NIV success or failure by measuring the rapid shallow breathing index (RSBI) within 15 min after NIV initiation. The authors' hypothesis was that an early predictor of NIV outcome can be very useful to not unduly delay the time of intubation. This is a potential relevant hypothesis, but, in our view, some concerns must be underlined regarding the use of RSBI and its measurement during NIV.

First, as stated by the authors in the discussion,[3] the RSBI measurement may be greatly influenced by the NIV settings used. Indeed, the expiratory tidal volume, as well as the respiratory frequency, is largely linked to the inspiratory pressure or pressure support level applied during NIV or invasive mechanical ventilation.[4] In addition, the authors used very low inspiratory positive airway pressure of 5–10 cm $H_2O$ for the majority of their patients (63%) (ie, an equivalent of pressure support level of 3–5 cm $H_2O$, according to the level of expiratory positive airway pressure used: a mean of 5 cm $H_2O$). Therefore, the authors may have increased the risk of NIV failure because of the NIV settings used by themselves, and, based on their hypothesis, may have largely over-estimated the predictive value of NIV failure with an RSBI $> 105$.

Second, although the authors used the expiratory rather than the inspiratory tidal volume to calculate the RSBI, the expiratory tidal volume may also greatly depend on the air leak volume around the mask. In the study by Berg et al,[3] it is not clear whether or not air leaks were well controlled and minimized before recording expiratory tidal volume to calculate the RSBI. In addition, the authors did not provide the mean inspiratory tidal volume. The difference between that and the expiratory tidal volume would have been very useful to estimate the level of air leaks at the time of measurement.

Third, the RSBI has been measured very early (15 min) after NIV was started with the initial settings. In current practice we know that NIV settings must be frequently adjusted initially, according to the clinical tolerance of patients, interface tightness and application, air leaks, and monitoring of respiratory parameters, including breathing frequency and expiratory tidal volume, as well as arterial blood gases control.[5] Therefore, recording RSBI within 15 min after NIV initiation may not represent the best time if the NIV settings are not yet optimized.

Fourth, the RSBI cutoff value of 105 developed by Yang and Tobin in their original publication[6] and also proposed by the authors[3] could also depend on the type of acute respiratory failure for which NIV is applied. Indeed, it has been demonstrated that a cutoff value of 85 could be more relevant to predict the weaning outcome from invasive mechanical ventilation in COPD patients,[7] in whom NIV is highly recommended in case of hypercapnic acute respiratory failure.[1,2]

Fifth, the RSBI has been proposed as a predictor of weaning success for invasively ventilated patients where there were no leaks.[6] Although there are some encouraging data, several studies underlined that this index could be significantly affected not only by the level of ventilator support but also by some other conditions.[8] Recently, it has also been proposed by Segal et al[9] that the percent change of RSBI during a spontaneous breathing test may be a better predictor of successful extubation than a single determination of RSBI. Based on these 2 studies conducted during invasive mechanical ventilation,[8,9] therefore, we must be highly cautious in interpreting this index during NIV, as the value of RSBI may be significantly influenced by common variations in measurement conditions and technique.

Finally, clinicians already have useful and simple criteria at bedside to guide NIV settings and eventually predict early NIV outcome, such as respiratory frequency and expiratory tidal volume, once NIV settings are optimized. Keeping in mind that these parameters are closely linked to the level of ventilatory support applied and of air leaks around the interface, it may be hazardous to use these parameters and calculate too early an RSBI to predict NIV outcome. Further studies are therefore absolutely needed and should probably consider the RSBI measurement only after optimization of initial NIV settings and air leak control.

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*The Authors Respond:*

We thank Dr Girault and colleagues for their comments on our paper, and provide the following to help address their concerns. First, we would like to clarify the NIV settings. When we refer to the inspiratory positive airway pressure, this is in addition to the PEEP being provided. Thus, a patient who is on settings of 10/5 cm $H_2O$ is receiving a total of 15 cm $H_2O$ on inspiration (PEEP of 5 cm $H_2O$ plus an additional 10 cm $H_2O$). That stated, we agree that some settings might be considered inadequate, and we acknowledged this in the limitations section. Regarding the way in which the assisted RSBI (aRSBI) was measured, our choice stemmed from the purpose for which we were using the measurement. As we mention in our discussion, Tobin and Yang used the RSBI to predict the likelihood of success once ventilatory support was withdrawn. Therefore, they measured RSBI on no support. We were using the aRSBI to predict success *on* a given level of support. Since that level of support was different for each patient, we chose to measure the aRSBI on those individually tailored settings.

Second, regarding the problem of air leaks, we agree that this is an issue that could confound our results. We chose to use the exhaled tidal volume as we felt that the tidal volume a patient was exhaling would be most likely to reflect the tidal volume that he or she was actually receiving. The majority of air leak generally occurs with inspiration, when the most positive pressure is being delivered. In our current validation study we are excluding patients who are noted to have substantial air leak at the time of measurement.

Third, in terms of timing, most prior attempts at prediction of NIV success or failure have focused on measurements done at 1–2 hours. We were seeking a very early measurement that could signal to the treating team that a patient might be at higher risk of failure, and therefore decided to use a measurement at 15 min. We are actively engaged in a follow-up study that will evaluate early aRSBI as well as changes over the initial hour; this work will help address the differences in predictability of outcome based on the time point of measurement.

Fourth, regarding the choice of the cutpoint of 105, we chose to use 105 initially because it had been used by Tobin and Yang, but this choice was validated after statistical analysis. As written in our discussion, "We graphically inspected the receiver operating characteristic curves for RSBI as a continuous variable for each of the outcome variables. We used the Youden index (the distance between the receiver operating characteristic curve and a 45° line) to sug-

gest an optimal cut-point. This index score identified approximately 105 as the optimal cut-point in both models."

Fifth, Girault and colleagues mention that alternative approaches to interpreting the RSBI when preparing a patient for extubation have been proposed recently. Since we were using the aRSBI for an entirely different purpose (NIV failure risk), those findings may not be relevant to our study.

Regarding their final comments, we agree that breathing frequency and exhaled tidal volume are often useful in assessing how a patient is doing on NIV. Because of this, we hypothesized that combining these parameters in an assisted RSBI might be even more helpful in predicting the likelihood of patient success or failure on NIV. We also agree, as stated in our conclusion, that validation of this concept in a larger study is warranted.

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