

## Technique and the Rapid Shallow Breathing Index

No practice has changed more dramatically during my career than ventilator weaning. My training in the late 1980s and early 1990s was often spent at the bedside, debating whether to wean, when to do it, and which technique to use. Experts touted diverse modes and testing parameters, some rational, some not.

Fortunately, critical care has evolved since then. The dangers of prolonged intubation are widely recognized, along with mandates to “liberate” patients quickly once respiratory failure resolves.<sup>1</sup> The focus on gradual weaning has shifted to using spontaneous breathing trials for promptly identifying extubation candidates.<sup>2</sup> Weaning protocols administered by non-physicians have achieved a status close to standard of care.<sup>3,4</sup>

A diverse array of screening tests have long played a role in weaning.<sup>5</sup> Perhaps the most extensively investigated is the rapid-shallow-breathing index (RSBI), which reflects the respiratory pattern adopted by many patients who fail weaning trials.<sup>6,7</sup> In its classic description,<sup>7</sup> weaning candidates in the medical intensive care unit (MICU) were disconnected from the ventilator and breathed through a T-piece. Using a Wright spirometer, the RSBI was calculated by dividing the respiratory rate (in breaths/min) by the tidal volume (measured in liters). Compared to other parameters, an RSBI  $\leq 105$  breaths/min/L demonstrated a superior combination of sensitivity (97%), specificity (64%), positive predictive value (78%), and negative predictive value (95%) when predicting weaning success. The RSBI was also attractive because it was unaffected by patient effort, simple to measure, and easy to remember, especially when rounded off to 100.

The RSBI has since been applied to diverse populations and settings, incorporated into weaning protocols, and used to predict outcomes ranging from tolerance of decreased ventilator support to weaning to extubation.<sup>5</sup> Although many embrace the RSBI, others have questioned its value, leading to substantial debate about its role.<sup>4,5,8,9</sup>

The calculation and utility of the RSBI vary significantly with the population studied, the question asked, and the measurement technique used. With its high sensitivity and negative predictive value, the index is most accurate when used to identify patients likely to fail weaning, as opposed to those likely to succeed. The positive predictive value decreases after a week of mechanical ventilation.<sup>7</sup> The RSBI's value is limited when respiratory failure is caused by problems besides pulmonary strength-load im-

balance,<sup>1</sup> such as upper-airway obstruction or central-nervous-system disease.<sup>10,11</sup> High RSBI occur more commonly in the elderly and women with small endotracheal tubes, suggesting that different thresholds for success might be considered.<sup>12,13</sup> Finally, practice variation may undermine the RSBI: some respiratory therapists use a T-piece, some use continuous positive airway pressure (CPAP), and some use pressure support to measure the RSBI, all of which could impact the measurements obtained.<sup>14</sup> Unfortunately, variation in the way the RSBI has been used since its original description precludes a simple summary statement regarding its value and role.<sup>8</sup>

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In this issue of *RESPIRATORY CARE*, Patel and colleagues investigated 3 important technical issues that might influence the RSBI.<sup>15</sup> Using a convenience sample of 60 MICU patients eligible for weaning after 72 hours of mechanical ventilation, the investigators compared the RSBI measured (1) at different times of the day, (2) using digital output on the ventilator versus a Wright spirometer, and (3) during T-piece breathing versus CPAP of 5 cm H<sub>2</sub>O. Time of day and measurement technique did not affect RSBI. In contrast, CPAP decreased the median RSBI from 90 breaths/min/L with the T-piece to 71 breaths/min/L, indicating that positive pressure mitigated rapid shallow breathing. Importantly, the switch from one technique to the other would significantly impact the number of patients for whom the RSBI would predict weaning success.

Patel and colleagues' carefully done study adds clarity to the weaning literature. Prior work has also shown that ventilator support can decrease the RSBI. For example, in postoperative cardiac surgery patients, CPAP decreased the RSBI by 49%.<sup>16</sup> In another study, both CPAP of 5 cm H<sub>2</sub>O and pressure-support ventilation at 5 cm H<sub>2</sub>O lowered the RSBI.<sup>17</sup> Approximately one third of those with an RSBI  $\leq 105$  breaths/min/L with ventilator support had an RSBI  $> 105$  breaths/min/L with a T-piece. None of these patients were extubated successfully, leading the authors to recommend that the RSBI be used only if measured similar to the way it was originally described.<sup>7</sup>

The results of these studies, along with the present one by Patel and colleagues, should come as no surprise. It would be naïve to think that changes in measurement tech-

nique would not impact the results and value of a diagnostic test.<sup>18,19</sup> In chronic obstructive pulmonary disease, extrinsic positive end-expiratory pressure has long been known to decrease work of breathing by mitigating intrinsic positive end-expiratory pressure,<sup>20-22</sup> which in turn might decrease the respiratory load as well as the RSBI. In congestive heart failure, positive pressure can improve cardiac function,<sup>23</sup> which could also lower the RSBI.

How should the RSBI be used then, if at all? Whether an RSBI is even necessary if a spontaneous breathing trial is going to be done anyway remains unsettled.<sup>4</sup> However, when used as originally described,<sup>7</sup> particularly in MICU patients given no ventilatory support, a high RSBI would still be expected to portend weaning failure. Patel and colleagues have shown us convincingly that changes in measurement technique can substantially change the results of this classic test. However, if used, the RSBI should be measured using the carefully described techniques that have stood the test of nearly 20 years.

**Mark D Siegel MD**

Pulmonary and Critical Care Section  
Department of Internal Medicine  
Yale School of Medicine  
New Haven, Connecticut

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Correspondence: Mark D Siegel MD, Pulmonary and Critical Care Section, Department of Internal Medicine, Yale School of Medicine, 333 Cedar Street. PO Box 208057, New Haven CT 06520-8057. E-mail: mark.siegel@yale.edu.