Spontaneous Breathing Trials: Should We Use Automatic Tube Compensation?

Weaning from mechanical ventilation is a 2-step process. First, objective criteria are used to determine whether sufficient recovery from acute respiratory failure has occurred to allow the patient to breathe independently. This "readiness test" is followed by a spontaneous breathing trial (SBT) to assess whether the patient still requires mechanical ventilatory support. When the patient tolerates the SBT, the clinician addresses the separate question of whether the endotracheal tube (ETT) is still required; that is, can the patient be safely extubated?

There has been considerable interest in determining the best approach for conducting the SBT and how long it should be. The ideal SBT would accurately mimic the work of breathing (WOB) done without ventilatory support and without the ETT in place. Numerous investigations have compared T-piece, CPAP, low-level pressure support ventilation (PSV), and more recently, automatic tube compensation (ATC). Interest in providing some level of support stems from the belief that, in some patients, the resistive WOB imposed by the ETT may prevent successful unsupported breathing, causing "iatrogenic" (ie, ETT-induced) weaning failure. A PSV level of 7 cm H_2O was considered sufficient to compensate for the resistance imposed by the ETT, when compared to T-piece, in a large randomized controlled trial.[1] However, the group weaned with T-piece had a higher rate of unsuccessful SBT (22%) than the PSV group (14%) ($P = .03$), whereas the percentage of patients successfully extubated after 48 h was similar in both groups (T-piece 63%, PSV 70%, $P = .14$). In a non-randomized study of patients who failed a 30-min T-piece SBT, immediate conversion to PSV of 7 cm H_2O for an additional 30 min led to weaning success in 21 of 31 patients, which suggests that the ETT can contribute to iatrogenic weaning failure.[2] Unfortunately, it is challenging to predict the exact PSV level required to overcome this imposed WOB in a given patient. Too little support may result in SBT failure because the imposed WOB from the ETT is insufficiently negated. This may lead to repeated SBT failure and unnecessarily prolonged mechanical ventilation. On the other hand, too much support may allow the patient to succeed the SBT without accurately gauging whether the patient is truly capable of unsupported breathing. This may lead to premature extubation and re-intubation. Therefore, methods to accurately compensate for the added ETT resistance have the potential to improve the weaning process.[3]

ATC, a relatively new commercially available built-in ventilation mode, is designed to compensate for the nonlinear pressure drop across the ETT during spontaneous breathing. ATC provides dynamic support for each spontaneous breath, to deliver the exact pressure needed to overcome the ETT resistance. Theoretically, conducting the SBT with ATC simulates spontaneous breathing without the added resistance of the ETT. Studies comparing ATC to PSV suggested that ATC is more effective in overcoming the WOB,[4] and is more comfortable,[5] with less patient-ventilator asynchrony.[6] Haberthür et al[4] found that ATC decreased the total WOB, in comparison to PSV and continuous positive airway pressure (CPAP), in 10 ventilator-dependent patients ventilated through tracheostomy. Similarly, Fabry et al[7] found that the advantage of ATC in relieving additional WOB depended on the patient's pulmonary condition. In intubated spontaneously breathing patients, Fabry et al found that in postoperative patients ATC and PSV of 10 cm H_2O or 15 cm H_2O were sufficient to compensate for the added WOB. In contrast, only ATC was able to compensate for the added WOB in patients with lung injury. Despite these encouraging findings, a task force on weaning from mechanical ventilation[3] concluded that there is a lack of controlled trials to make any meaningful recommendations about ATC.

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In this issue of RESPIRATORY CARE, Figueroa-Casas et al[8] assess the role of ATC during SBT. They conducted a prospective randomized controlled trial in a mixed medical surgical and trauma intensive care unit of a university teaching hospital. Seventy-one percent of the enrolled patients had multiple trauma, postoperative respiratory failure, or neurologic emergencies. They randomized 118 patients to receive either a once-daily 30-min SBT on ATC plus CPAP, or CPAP alone, according to a predetermined protocol. The study was powered to detect a 1-day difference in the duration of weaning between the 2 groups. They used the ATC mode on the Puritan-Bennett 840 ventilator to provide 100% compensation during the SBT and positive end-expiratory pressure of 5 cm H_2O, whereas the

CPAP-only group received the same positive end-expiratory pressure but without added pressure support. Figuroa-Casas et al used predefined criteria for SBT failure, and the overall failure rate was 6%, with no statistical difference between the ATC group (5%) and the CPAP group (7%). More patients in the CPAP group failed their first SBT (13% v 3%) and required repeated SBTs. However, that difference did not reach statistical significance (P = .09). The weaning time (time from first SBT to extubation) was similar in both groups. Ninety-seven percent of the patients assigned to ATC were extubated immediately after the first SBT, in comparison to 87% in the CPAP group. The rate of failed extubation was also similar in both groups (5% in the ATC group vs 7% in the CPAP group). A trend toward failing the first SBT in the CPAP group was also noted in previous studies.[9,10] Figuroa-Casas et al concluded that, while performing SBT with ATC is safe, it does not confer a benefit in expediting liberation from mechanical ventilation, in comparison to CPAP.[8]

The study has a few limitations. First, the power analysis did not take in consideration the lower rate of failed extubation usually observed in surgical settings. The low rate of unsuccessful extubation raises the possibility of type-2 error (failure to reject the null hypothesis when it is false). Second, the patient selection may have introduced a selection bias that would reduce the predictive value of the SBT with ATC to identify patients who are not ready for extubation. In this study, the predominant causes of respiratory failure were trauma, postoperative, and neurological emergencies, and those patients are usually less challenging to wean than are patients with a primary pulmonary cause of respiratory failure, and the value of ATC may depend on the patient selection.[7] Overall, the study was well designed and demonstrated at least non-superiority of ATC to CPAP when applied in a respiratory-therapy driven protocol.

The results of the Figuroa-Casas trial are less encouraging than those in previous studies. In a randomized controlled trial in a medical intensive care unit, 90 patients received a 2-hour SBT with either ATC, conventional PSV (5 cm H_2O), or T-piece.[10] There was a higher SBT success rate in the ATC group (97%) than in the other 2 groups (PSV 83% vs T-piece 80%), but there was no difference in the rate of successful extubation between the modes. Interestingly, 50% of those patients who failed the SBT on T-piece or PSV were successfully extubated after a subsequent SBT using ATC.

Another study enrolled 99 patients who were randomized to either a 1-hour SBT with ATC (100% compensation) and CPAP (5 cm H_2O) or CPAP (5 cm H_2O) alone.[9] Significantly more patients in the ATC-plus-CPAP group (42/51, 82%) "met criteria" for successful extubation, compared to the CPAP-only group (31/48, 65%) (P = .04). However, there was no difference in the rate of passing the SBT and undergoing successful extubation (ATC 96% vs CPAP 85%, P = .08). The re-intubation rate in the CPAP group was nonsignificantly higher (ATC group 14%, CPAP group 24%, P = .28). The results are intriguing since it would have been expected that the ATC group would be more prone to providing excessive ventilatory support, therefore potentially allowing more marginal patients to tolerate an SBT, with ventilatory failure only occurring after extubation. A subsequent trial by the same investigators compared 1-hour SBT on PSV of 7 cm H_2O to ATC and found no difference in the need for re-intubation (ATC 18% vs CPAP 13%, P = .4).[11]

Given the strong theoretical advantages of ATC, why does it lack unequivocal superiority to other SBT methods? First, for ATC to be superior to other weaning modes, failure would need to frequently result from the imposed WOB rather than other causes. Large studies that would indicate the relative frequencies of different types of weaning failure are not available. In addition, approximately 75% of patients pass their initial SBT and can be successfully extubated. Therefore, only a minority of patients fail their initial SBT, and many of those probably fail SBT for reasons other than the ETT-imposed WOB. Second, in those cases where imposed WOB is relevant, one would predict ATC to be superior to T-piece and perhaps CPAP. In contrast, to outperform PSV, ATC would need to be superior in avoiding excessive or insufficient pressure support. Although the ideal level of pressure support varies widely, the typically used pressure range of 5–8 cm H_2O may actually prove adequate in most patients; this range may infrequently lead to either excessive or inadequate support. Taking all this into account, very large studies with hundreds of patients would be required to demonstrate ATC superiority. Third, the pressure delivered by ATC depends on the characteristics of the ETT. It is now clear that those characteristics change soon after the ETT has been inserted in the airway. Wilson et al evaluated the pressure drop (at 3 flow rates) across ETTs removed from 71 extubated patients, and compared those values to controls.[12] Approximately 75% of the patient ETTs had a pressure drop of greater than 3 standard deviations of those in the size-matched controls. Of great importance, the pressure drop could not be predicted based on the duration of intubation. In approximately half of the cases the pressure drop was equivalent to the next smaller size of the controls; in other words, a #8 ETT behaved like a #7 ETT. This is important, because the pressure-support level during ATC would be that appropriate for the wider #8 ETT, so ATC would inadequately compensate for ETT resistance and thus provide inadequate support.

What if ATC more often avoids excessive support than PSV? Under these circumstances the rate of extubation failure should be lower with ATC because fewer patients would be "prematurely" extubated. As noted above, the published studies do not convincingly demonstrate a lower extubation failure rate with ATC. Here too, superiority of ATC can be demonstrated only with much larger studies than those conducted to date. Only 10–15% of extubated patients fail extubation and require re-intubation. Many of those result from upper-airway obstruction, excessive secretions, inadequate cough, or abnormal mental status—a combination of factors that compromise the patient's ability to protect the airway and have little to do with the SBT ventilation mode. Of the remainder, it is likely that only a minority can be attributable to extubation after an SBT in which 5–8 cm H_2O of pressure support provided excessive support. Thus, as indicated in the argument above, in heterogeneous patient populations very large studies would be required to demonstrate ATC superiority.

In conclusion, at present there is no convincing evidence that ATC is a superior mode for SBT. That said, there might be a cohort of patients—predominantly those with very high imposed WOB—who may benefit from ATC during SBT. Studies that include heterogeneous patients with a broad array of weaning-failure etiologies are unlikely to demonstrate ATC superiority unless those studies are conducted on much larger cohorts than have been studied to date.

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