The Early Phase of the Minute Ventilation Recovery Curve Predicts Extubation Failure Better Than the Minute Ventilation Recovery Time*

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Study objectives: **To determine, in patients who had successful outcomes in spontaneous breathing trials (SBTs), whether the analysis of the minute ventilation ($\dot{V}E$) recovery time obtained by minute-by-minute sequential monitoring after placing the patient back on mechanical ventilation (MV) may be useful in predicting extubation outcome.**
Design: **Twelve-month prospective observational study.**
Setting: **Medical-surgical ICU of a university hospital.**
Patients: **Ninety-three patients receiving > 48 h of MV.**
Interventions: **Baseline respiratory parameters (*ie*, respiratory rate, tidal volume, and $\dot{V}E$) were measured under pressure support ventilation prior to the SBT. After tolerating the SBT, patients again received MV with their pre-SBT ventilator settings, and respiratory parameters were recorded minute by minute.**
Measurements and results: **Seventy-four patients (80%) were successfully extubated, and 19 patients (20%) were reintubated. Reintubated patients were similar to non-reintubated patients in baseline respiratory parameters and baseline variables, except for age and COPD diagnosis. The recovery time needed to reduce $\dot{V}E$ to half the difference between the $\dot{V}E$ measured at the end of a successful SBT and basal $\dot{V}E$ (RT50%$\Delta\dot{V}E$) was lower in patients who had undergone successful extubation than in those who had failed extubation (mean [± SD] time, 2.7 ± 1.2 vs 10.8 ± 8.4 min, respectively; $p < 0.001$). Multiple logistic regression adjusted for age, sex, comorbid status, diagnosis (*ie*, neurocritical vs other), and severity of illness revealed that neurocritical disease (odds ratio [OR], 7.6; $p < 0.02$) and RT50%$\Delta\dot{V}E$ (OR, 1.7; $p < 0.01$) were independent predictors of extubation outcome. The area under the receiver operating characteristic curve for the predictive model was 0.89 (95% confidence interval, 0.81 to 0.96).**
Conclusion: **Determination of the RT50%$\Delta\dot{V}E$ at the bedside may be a useful adjunct in the decision to extubate, with better results found in nonneurocritical patients.**

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Key words: extubation; mechanical ventilation; outcome; weaning

Abbreviations: APACHE = acute physiology and chronic health evaluation; CI = confidence interval; End-SBT-$\dot{V}E$ = minute ventilation measured at the end of a successful spontaneous breathing trial; FIO_2 = fraction of inspired oxygen; GCS = Glasgow coma scale; MV = mechanical ventilation; PEEP = positive end-expiratory pressure; PSV = pressure-support ventilation; ROC = receiver operator characteristic; RR = respiratory rate; RT = recovery time; SBT = spontaneous breathing trial; $\dot{V}E$ = minute ventilation; VT = tidal volume; RT50%$\Delta\dot{V}E$ = recovery time needed to reduce minute ventilation to half the difference between the minute ventilation measured at the end of a successful spontaneous breathing trial and basal minute ventilation

The standard method for deciding to extubate mechanically ventilated patients is to conduct a spontaneous breathing trial (SBT) lasting from 30 to 120 min.[1] Most studies measure ventilatory parameters every 5 to 15 min,[1] but, to date, a minute-by-minute protocol of monitoring ventilatory parameters during the SBT has not been fully validated. When the patient tolerates the SBT, the decision to remove the artificial airway is based on the assessment of airway patency and the capability to protect the airway.

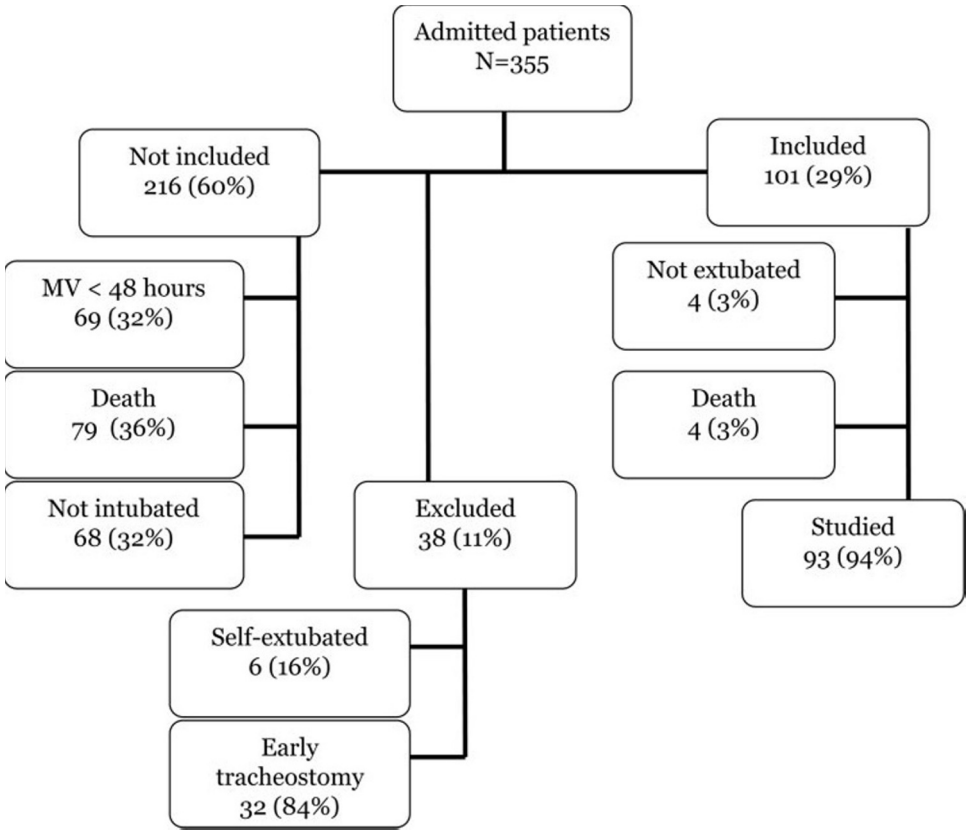

FIGURE 1. Flowchart of the patients.

Nevertheless, even when this standard is correctly implemented, the reintubation rate remains high. The incidence of extubation failure ranges from 2 to 25%, depending mainly on the case mix of patients and the 24-h vs 72-h period used to define extubation failure.[1–4] The importance of this issue is the severe increase (up to sixfold) in mortality observed in patients needing reintubation.[5]

A few options have been suggested to improve extubation success. These include serial measurements of several variables, such as the respiratory rate (RR)/tidal volume (V_T) ratio,[6] respiratory effort,[7] oxygen uptake,[8] dead space,[9] and respiratory patterns.[8,10–13] Some of these measurements increase the predictive capacity of the extubation outcome in the studied populations but scarcely translate into the predictive capacity in individual patients.

A 2003 study[14] investigated the behavior of ventilatory variables during reconnection to the ventilator after a successful SBT. The authors found that the longer the time needed to recover basal minute ventilation ($\dot{V}_E$), the higher the likelihood of extubation failure, suggesting an occult impairment in the ventilatory reserve.

Clinical observation suggests that $\dot{V}_E$ is predominantly recovered in the early phase after reconnecting patients to MV. Our hypothesis was that continuous objective minute-by-minute monitoring of the recovery time (RT) might improve the predictive power of the previously reported method.[14] The objective of the present study was thus to serve as a second validation of this method and to explore whether a deeper analysis of RT could improve performance.

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