Franco Laghi

Stratification of difficulty in weaning

Received: 12 January 2011

Accepted: 18 January 2011

Published online: 4 March 2011

© Copyright jointly held by Springer and ESICM 2011

This editorial refers to the article available at:
doi:[10.1007/s00134-011-2179-3](https://doi.org/10.1007/s00134-011-2179-3).

F. Laghi (✉)

Division of Pulmonary and Critical Care Medicine,
Edward Hines, Jr. VA Hospital,
111 N, 5th Avenue and Roosevelt Road, Hines,
IL 60141, USA
e-mail: flaghi@lumc.edu
Tel.: +1-708-2022705
Fax: +1-708-2027907

F. Laghi

Loyola University, Maywood, IL, USA

The panelists of a recent International Consensus Conference on weaning from mechanical ventilation [1] proposed that weaning be categorized into three groups according to the difficulty and duration of the weaning process. According to the proposed classification, patients with simple weaning are those extubated at the first attempt of spontaneous breathing. Patients with difficult weaning are extubated within 7 days from the first trial of spontaneous breathing. Patients with prolonged weaning are those who fail at least three weaning attempts or who require more than 7 days of weaning [1]. In 2010, Funk et al. [2] assessed the usefulness of this classification by determining the outcome of more than 250 patients cared for in five Viennese general medical–surgical intensive care units (ICU). In that study, ICU and hospital mortality were greater in patients with prolonged weaning than in patients with simple or with difficult weaning. Ventilator-

free days and ICU-free days were less in difficult and prolonged weaning than in simple weaning.

In the current issue of *Intensive Care Medicine*, Sellares et al. [3] expand on the Austrian study [2]. The new study had two goals: first, to compare the clinical characteristics and outcomes in the three groups; second, to identify predictors associated with increased risk of prolonged weaning and increased risk of death. In this study of nearly 200 patients admitted to a Spanish respiratory ICU, about 40% of patients had simple weaning, about 40% had difficult weaning, and about 20% had prolonged weaning.

The results of the Spanish study [3] largely confirm the Austrian findings [2]. First, clinical characteristics and outcome of patients with simple and difficult weaning were similar. Second, as reported in the past [4–6], prolonged weaning was associated with more complications and greater mortality. Finally, in both studies [2, 3] the total duration of mechanical ventilation and the duration of ICU stay were longer with prolonged weaning than with simple weaning. The latter finding is not surprising considering how the weaning categories were defined. Any other result in a study involving circular reasoning would have been counterintuitive.

In contrast to the Austrian study [2], however, the duration of mechanical ventilation in the simple group in Spain [3] was equivalent to the duration of mechanical ventilation in the difficult group. (The Spanish investigators [3] do not explicitly state whether they assessed readiness to weaning every day—as the Austrians did [2]). On univariate analysis, Sellares et al. [3] report an association between prolonged weaning and a higher frequency to tidal volume ratio (f/V_T) and a higher value of arterial partial pressure of carbon dioxide (PaCO_2). On multivariate analysis, however, hypercapnia—and not f/V_T —was associated with prolonged weaning. This result is expected because f/V_T is a critical determinant of PaCO_2 [7].

In the Spanish study [3], the mean f/V_T at the start of the first weaning trial of patients with prolonged weaning was 98 ± 55 (standard deviation, SD) breaths/min/liter. This suggests that many of these patients were not ready for a weaning trial [8, 9]. If weaning duration is defined as the time between the first trial of spontaneous respiration until extubation [3], then undertaking the first weaning trial before a patient is quite ready for it will result in an artificial prolongation of weaning duration.

One of the goals of the Spanish investigators [3] was to evaluate potential predictors for prolonged weaning and survival. One of such predictors was the value of PaCO_2 at the end of spontaneous breathing. A PaCO_2 of 54 mmHg or more was associated with a higher risk of prolonged weaning. A PaCO_2 of 45 mmHg or more was associated with a higher risk of death.

Why should hypercapnia be associated with worse outcome? Arterial CO_2 levels are determined by CO_2 production and alveolar ventilation [10]. A sole increase in CO_2 production, however, is never sufficient to constitute a primary cause of hypercapnia [10]. Hence, the hypercapnia in the Spanish patients [3] must have been the result of decreased alveolar ventilation. Alveolar ventilation can be decreased as a result of respiratory muscle weakness [11]. Weakness can occur early in ventilated patients [12], and it is highly prevalent in

patients considered for weaning [13]. These observations suggest that hypercapnia was not only a marker of disease severity but was mechanistically linked to patient outcome. An additional mechanism responsible for decreased alveolar ventilation and hypercapnia is a decrease in respiratory drive [14]. Limited and indirect evidence, however, suggests that most patients who fail a weaning trial have an increase in respiratory motor output [7, 14].

Sellares et al. [3] correctly observe that the vast overlap in the PaCO_2 values in the three groups makes it impossible to recommend the use of the PaCO_2 thresholds in the individualized care of patients. That such overlap exists is not surprising. Many other factors, besides respiratory muscle weakness, can make weaning from mechanical ventilation challenging. These factors include abnormal respiratory mechanics [15], impaired gas exchange [16], cardiac dysfunction [17], psychological distress [18], and other factors [14]. Figuring out the reason why a particular patient fails weaning requires an astute clinician. Few aspects of critical care medicine are more dependent on diagnostic acumen and individualized care than weaning patients from the ventilator [14].

Acknowledgments This work was supported by Veterans Administration Research Service.

References

- Boles JM, Bion J, Connors A, Herridge M, Marsh B, Melot C, Pearl R, Silverman H, Stanchina M, Vieillard-Baron A, Welte T (2007) Weaning from mechanical ventilation. *Eur Respir J* 29:1033–1056
- Funk GC, Anders S, Breyer MK, Burghuber OC, Edelmann G, Heindl W, Hinterholzer G, Kohansal R, Schuster R, Schwarzmaier-D'Assie A, Valentin A, Hartl S (2010) Incidence and outcome of weaning from mechanical ventilation according to new categories. *Eur Respir J* 35:88–94
- Sellares J, Ferrer M, Cano E, Loureiro H, Valencia M, Torres A (2011) Predictors of prolonged weaning and survival during ventilator weaning in a respiratory ICU. *Intensive Care Med*. doi:10.1007/s00134-011-2179-3
- Esteban A, Anzueto A, Frutos F, Alia I, Brochard L, Stewart TE, Benito S, Epstein SK, Apezteguia C, Nightingale P, Arroliga AC, Tobin MJ (2002) Characteristics and outcomes in adult patients receiving mechanical ventilation: a 28-day international study. *JAMA* 287:345–355
- Vallverdu I, Calaf N, Subirana M, Net A, Benito S, Mancebo J (1998) Clinical characteristics, respiratory functional parameters, and outcome of a two-hour T-piece trial in patients weaning from mechanical ventilation. *Am J Respir Crit Care Med* 158:1855–1862
- Esteban A, Alia I, Tobin MJ, Gil A, Gordo F, Vallverdu I, Blanch L, Bonet A, Vazquez A, de Pablo R, Torres A, de La Cal MA, Macias S (1999) Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation. Spanish Lung Failure Collaborative Group. *Am J Respir Crit Care Med* 159:512–518
- Tobin MJ, Perez W, Guenther SM, Semmes BJ, Mador MJ, Allen SJ, Lodato RF, Dantzker DR (1986) The pattern of breathing during successful and unsuccessful trials of weaning from mechanical ventilation. *Am Rev Respir Dis* 134:1111–1118
- Yang KL, Tobin MJ (1991) A prospective study of indexes predicting the outcome of trials of weaning from mechanical ventilation. *N Engl J Med* 324:1445–1450
- Tobin MJ, Jubran A (2008) Meta-analysis under the spotlight: focused on a meta-analysis of ventilator weaning. *Crit Care Med* 36:1–7
- Younes M (1993) Mechanisms of ventilatory failure. *Curr Pulmonol* 14:243–292
- Laghi F (2009) Weaning from Mechanical Ventilation. In: Gabrielli A, Layon AJ, Yu M (eds) *Civetta, Taylor, and Kirby's Handbook of Critical Care*, 4th edn. Lippincott Williams & Wilkins, Philadelphia, pp 1991–2028
- Jaber S, Petrof BJ, Jung B, Chanques G, Berthet JP, Rabuel C, Bouyabrine H, Courouble P, Koechlin-Ramonatxo C, Sebbane M, Similowski T, Scheuermann V, Mebazaa A, Capdevila X, Mornet D, Mercier J, Lacampagne A, Philips A, Matecki S (2010) Rapidly progressive diaphragmatic weakness and injury during mechanical ventilation in humans. *Am J Respir Crit Care Med* 183:364–371
- Laghi F, Cattapan SE, Jubran A, Parthasarathy S, Warshawsky P, Choi YS, Tobin MJ (2003) Is weaning failure caused by low-frequency fatigue of the diaphragm? *Am J Respir Crit Care Med* 167:120–127

-
14. Tobin MJ, Jubran A (2006) Weaning from mechanical ventilation. In: Tobin MJ (ed) *Principles and practice of mechanical ventilation*, 2nd edn. McGraw-Hill, New York, pp 1185–1220
 15. Appendini L, Purro A, Patessio A, Zanaboni S, Carone M, Spada E, Donner CF, Rossi A (1996) Partitioning of inspiratory muscle workload and pressure assistance in ventilator-dependent COPD patients. *Am J Respir Crit Care Med* 154:1301–1309
 16. Ferrer M, Iglesia MR, Roca J, Burgos F, Torres A, Rodriguez-Roisin R (2002) Pulmonary gas exchange response to weaning with pressure-support ventilation in exacerbated chronic obstructive pulmonary disease patients. *Intensive Care Med* 28:1595–1599
 17. Zapata L, Vera P, Roglan A, Gich I, Ordonez-Llanos J, Betbese AJ (2011) B-type natriuretic peptides for prediction and diagnosis of weaning failure from cardiac origin. *Intensive Care Med* 37:477–485
 18. Jubran A, Lawm G, Kelly J, Duffner LA, Gungor G, Collins EG, Lanuza DM, Hoffman LA, Tobin MJ (2010) Depressive disorders during weaning from prolonged mechanical ventilation. *Intensive Care Med* 36:828–835