Are Blood Gases Necessary in Mechanically Ventilated Patients Who Have Successfully Completed a Spontaneous Breathing Trial?

Shawn R Pawson MD and Jack L DePriest MD

BACKGROUND: The utility of routinely obtaining arterial blood gas analyses (ABGs) prior to extubation in patients who have successfully completed a spontaneous breathing trial is not known. OBJECTIVE: Review our practices and determine our extubation success rate with a policy of selective ABG utilization. METHODS: Retrospective chart review. RESULTS: We reviewed 54 extubations of 52 patients. Sixty-five percent of the extubations were performed without obtaining an ABG after the spontaneous breathing trial. The extubation success rate was 94% for the entire group and was the same regardless of whether an ABG measurement was obtained (94.7% vs 94.3%, respectively). CONCLUSION: ABG measurement does not appear to be a prerequisite to extubation following a clinically successful spontaneous breathing trial. *Key words: mechanical ventilation, endotracheal intubation, ventilator weaning, clinical protocols, arterial blood gas, spontaneous breathing trial*. [Respir Care 2004;49(11):1316–1319. © 2004 Daedalus Enterprises]

Introduction

One of the primary goals of managing the mechanically ventilated patient is to attempt a trial of extubation as soon as the patient may be ready. The recent literature has shown that weaning protocols are the most efficient means of achieving that goal.[1–4] These protocols are based on respiratory therapists using a simple screening procedure to identify patients ready to attempt a spontaneous breathing trial (SBT) and immediately initiating the SBT.

In 2 studies[1,4] all patients had arterial blood gas (ABG) samples drawn after they had successfully completed an SBT as part of their routine protocol. The other 2 studies did not specify how ABGs were utilized within the protocol.[2,3] An evidence-based guideline for weaning and discontinuing ventilatory support lists ABG results as an objective criterion for successfully completing an SBT,[5] and some authors have suggested that all patients should have an ABG analysis after successfully completing an SBT.[6]

Shawn R Pawson MD and Jack L DePriest MD are affiliated with the Department of Internal Medicine, Memorial Medical Center, Johnstown, Pennsylvania.

Correspondence: Jack L DePriest MD, Department of Internal Medicine, Memorial Medical Center, 1086 Franklin Street, Johnstown PA 15905. E-mail: jdeprie@conemaugh.org.

At our institution a weaning protocol (Appendix 1) was being developed for the medical intensive care unit (ICU) service by the attending investigator (JLD). Because it had long been this investigator's policy to not obtain routine ABGs after a patient had successfully completed an SBT, this was not incorporated into the protocol. Instead, the decision to obtain an ABG was left to the discretion of the attending physician. Additionally, most of the referenced protocols[1–3] used a cutoff P_{aO_2}/F_{IO_2} (ratio of arterial partial pressure of oxygen to fraction of inspired oxygen) of > 200 mm Hg as an eligibility criteria for an SBT. Again based on institutional experience, the decision was made to use a threshold value of > 150 mm Hg for the protocol.

Because the decision to not include routine ABGs as part of the weaning protocol was not consistent with the recent literature, we decided to perform a retrospective chart review to ensure that this policy might be expected to have outcomes consistent with those published. The primary objective of this review was to determine the extubation success rate for a medical/surgical ICU patient population managed by the attending investigator with a policy of selective ABG utilization. Demographic information would be collected to see if the study population was comparable with those in the published weaning protocol trials. The percentage of patients who had ABGs drawn after their SBTs prior to extubation would be determined. Because the lower P_{aO_2}/F_{IO_2} ratio was also being included in the new protocol, a secondary end point would be the

extubation success rate for patients extubated with P_{aO_2}/F_{IO_2} ratios < 200 mm Hg.

Methods

Study Design

The study was a retrospective chart review of sequential ICU patients extubated by the investigator over the period of July 2002 through July 2003. The medical ICU team also routinely consults on surgical patients, with the exception of trauma and cardiothoracic patients, so the study population included medical and surgical patients. The attending investigator is one of 3 full-time medical intensivists. The patients were treated and the study was conducted at a community teaching hospital in Johnstown, Pennsylvania. The study protocol was approved by the institutional review board of the hospital.

Enrollment

Patients were identified by reviewing the daily patient data sheets maintained by the service's nurse practitioner as well as the unit admission/discharge log books. Patients with unplanned endotracheal extubation and patients who were extubated to comfort care and were not to be reintubated were excluded. Extubation failure was defined as requirement of reintubation within 48 hours of extubation. The use of noninvasive positive-pressure ventilation after extubation (without subsequent reintubation) was not considered extubation failure.

Data Collection and Statistical Analysis

Data were collected on basic patient demographics to include reason for intubation, chart diagnosis of chronic obstructive pulmonary disease, total duration of mechanical ventilation, ABG data prior to extubation, and outcomes. Clinical differences between the groups that did and did not have ABGs drawn after their SBTs were analyzed. The chi-square test was used for nominal data, and Student's *t* test was used for continuous data.

Results

Fifty-four extubations involving 52 patients were identified (Table 1). Thirty-five of the extubations (65%) were performed without obtaining an ABG after the SBT. There were 3 extubation failures, for an extubation success rate of 94% (Table 2). Two of those 3 patients were subsequently extubated on the next attempt. Extubation success rates were the same for both groups (94.3% vs 94.7%).

Seven extubations occurred without an ABG being drawn the day of extubation (after midnight). Twelve patients were extubated with a P_{aO_2}/F_{IO_2} ratio < 200 mm Hg documented the day of extubation, all successfully. Three patients had noninvasive ventilation initiated immediately after extubation and another patient had noninvasive ventilation placed within 48 hours.

The duration of mechanical ventilation was shorter in the group not having an ABG after the SBT (mean 42.3 h) compared with those who did have an ABG (mean 76.3 h, p = 0.023). There was no statistical difference in age, diagnosis of chronic obstructive pulmonary disease, or presence of more severe hypoxemia (P_{aO_2}/F_{IO_2} ratio < 200 mm Hg) between the 2 groups, though the numbers were small.

Table 1. Characteristics of the Study Patients*

Characteristic	No ABG After SBT (*n* = 35)	Acceptable ABG After SBT (*n* = 19)
Age (mean ± SD y)	63.2 ± 21.3	66.4 ± 18.0
Male sex (*n* and %)	22 (62.8)	9 (47.3)
White race (*n* and %)	35 (100)	19 (100)
Diagnosis	*n* (%)	*n* (%)
COPD	3 (8.6)	4 (21.1)
Pneumonia	3 (8.6)	3 (15.8)
Other pulmonary	2 (5.7)	3 (15.8)
Sepsis (nonpneumonia)	6 (17.1)	3 (15.8)
CHF	2 (5.7)	1 (5.3)
ACS/cardiogenic shock	5 (14.3)	1 (5.3)
Other cardiac	3 (8.6)	0
Neurologic	2 (5.7)	0
Overdose	6 (17.1)	2 (10.5)
Other	3 (8.6)	2 (10.5)
Hours of ventilation (mean ± SD)†	42.3 ± 41.2	76.3 ± 65.3
P_{aO_2}/F_{IO_2} < 200 mm Hg (*n* and %)	7 (20)	5 (26)

*Total patients: 52. Total extubations: 54 (2 patients included in analysis failed extubation on the first attempt and then were successfully extubated on a second attempt).
†p = 0.023
COPD = chronic obstructive pulmonary disease
CHF = congestive heart failure
ACS = acute coronary syndrome
P_{aO_2}/F_{IO_2} = ratio of arterial partial pressure of oxygen to fraction of inspired oxygen

Table 2. Comparison of Study Group Outcomes*

No ABG After SBT *n* (%)		Acceptable ABG After SBT *n* (%)	
35 (65)		19 (35)	
Success *n* (%)	Failure *n* (%)	Success *n* (%)	Failure *n* (%)
33 (94.3)	2 (5.7)	18 (94.7)	1 (5.3)

*Total patients: 52. Total extubations: 54 (2 patients included in analysis failed extubation on the first attempt and then were successfully extubated on a second attempt).

Discussion

To be considered for extubation, a patient must successfully complete an SBT and not have any other requirement for leaving the endotracheal tube in place. An essential component of meeting the criteria to attempt, as well as successfully complete, an SBT is demonstrating acceptable oxygenation and ventilation. The ABG remains the accepted standard for evaluating gas exchange. However, the utility of an ABG as a predictor of extubation success is virtually unstudied.

As reinforced in this series, many ICU patients can have markedly impaired oxygenation and still be successfully extubated. It has not been determined what degree of hypoxia precludes successful extubation. Clearly, the patient's clinical picture is much more important than an isolated number. A patient with a P_{aO_2}/F_{IO_2} ratio of 175 mm Hg may require a lung-protective strategy for acute respiratory distress syndrome or may be ready for extubation, depending on his or her clinical status.

Even less is known about what defines minimally acceptable ventilation in this patient population. Arguably, even more factors (eg, chronic lung disease, depth of sedation, ventilation mode, form of humidification) other than just oxygenation, could be expected to impact on ventilation. The general expectation seems to be that the patient should have a fairly normal pH prior to and during the SBT. Forty-two percent of our patients who had an ABG drawn the day of extubation had a pH outside the normal range: 3 patients had pH $<$ 7.3, and 5 had pH $>$ 7.5. All 8 of those patients were successfully extubated, whereas all 3 patients who failed extubation had a normal pH.

Salam et al published results from a prospective trial that examined whether ABGs obtained after SBTs change extubation decisions.[7] They found that ABGs did not change management of 93% of patients when added to the clinical assessment. Though Salam et al suggest that it might still be appropriate to get ABGs from all patients if that could prevent extubation failure in even a few patients, they acknowledge that some of those study patients not extubated because of their unacceptable ABGs might have tolerated extubation if given a chance. Salam et al also allude to the potential cost of not extubating a patient who is in fact ready to be liberated. Given all the known complications of intubation (eg, increased sedation requirements, prolonged immobility, bypassed defense mechanisms, increased instrumentation), one can argue that the risks of leaving a patient intubated unnecessarily are much greater, and more costly, than those associated with having to re-intubate a patient who fails a trial. Using any test with an unknown negative predictive value as a major criteria to prevent extubation risks leaving some patients intubated who need not be. The presence of on-site intensivists should further minimize the risk of delayed or uncontrolled intubations in those patients who do fail extubation.

As stated earlier, it was largely because of the uncertainty of how to apply a test with unknown predictive values that the decision was made to leave routine ABGs off the protocol. Most of the patients in this series were extubated prior to or during the early implementation of our protocol. Thus most patients were placed on an SBT at the direction of the attending (JLD) after evaluating the patient on daily rounds with the medical ICU team. P_{aO_2}/F_{IO_2} ratios were not routinely calculated to assess oxygenation. Oxygenation was generally considered adequate if the patient could maintain a pulse-oximetry-measured oxygen saturation $>$ 90% on $\leq$ 50% inspired oxygen and 5 cm H_2O of positive end-expiratory pressure.

Using this approach to assessing gas exchange, we demonstrated an extubation success rate of 94%. This is consistent with the 87–97% success rates reported in the recent randomized trials.[1–3] Our study population appears comparable to those in several of the recent published trials in regard to age and disease mix.[1,2] The median total duration of mechanical ventilation was shorter in our group than in those studies (35 h vs 78 h vs 4.5 d, respectively). Though that difference might imply a less sick patient population, it more likely reflects differences in study design and screening criteria.

In one study, patients had already been on mechanical ventilation for a mean of 56 hours before study entry—presumably the first point they would be eligible to be screened and placed on an SBT.[1] The patients in our series were eligible for an SBT the morning after they were admitted. In addition, patients had to have a P_{aO_2}/F_{IO_2} ratio $>$ 200 mm Hg to attempt an SBT in both of the other trials.[1,2] Twelve patients in our series had P_{aO_2}/F_{IO_2} ratios $<$ 200 mm Hg the day they were successfully extubated. If those patients had been in one of the other trials, they would have had to wait another 12 hours (in the study by Marelich et al[1]) to 24 hours (in the study by Ely et al[2]) to be re-evaluated for a chance to attempt an SBT. Applying that delay to one quarter of the patients evaluated would have significantly increased the overall duration of mechanical ventilation.

The present small pilot study has many limitations. It is retrospective and reflects the outcome data for a single clinician at one center. Because of the original motivation for the chart review, the attending chose to begin with his outcome data. Neither of the other 2 intensivists routinely obtain ABGs in all of their patients, so there was no control group with which to compare outcomes.

Only patients who were extubated were reviewed. Thus patients who might have successfully completed an SBT but were not extubated because they had an unacceptable ABG were not captured. We believe that even if we iden-

tified those patients, we would not know what importance to ascribe to that group. As with the study by Salam et al,[7] a patient not extubated because of a marginal ABG would not validate its negative predictive value, because we wouldn't know whether the patient could have tolerated extubation or not. With our limited logistical support for data retrieval and the time it would take to identify what we believed would be only a few patients, we chose not to pursue those patients.

Conclusions

A study of this limited scope can only hope to raise questions for further investigation. ABGs serve an important role in managing the mechanically ventilated patient. However, their utility as a predictor of extubation outcome has not been determined. It has now been shown that ABGs influence decision making in the small minority of patients being considered for extubation. Within this context, our results do further question the appropriateness of using ABGs as a routine component of a weaning protocol at the present time. Further research is required to define criteria of minimally acceptable gas exchange as well as to prospectively validate these criteria in appropriate patient populations.

REFERENCES

1. Marelich GP, Murin S, Battistella F, Inciardi J, Vierra T, Roby M. Protocol weaning of mechanical ventilation in medical and surgical patients by respiratory care practitioners and nurses. Chest 2000; 118(2):459–467.
2. Ely EW, Baker AM, Dunagan DP, Burke HL, Smith AC, Kelly PT, et al. Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously. New Engl J Med 1996; 335(25):1864–1869.
3. Kollef MH, Shapiro SD, Silver P, St John RE, Prentice D, Sauer S, et al. A randomized controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation. Crit Care Med 1997;25(4):567–574.
4. Horst HM, Mouro D, Hall-Jenssens RA, Pamukov N. Decrease in ventilation time with a standardized weaning process. Arch Surg 1998;133(5):483–489.
5. MacIntyre NR, Cook DJ, Ely EW Jr, Epstein SK, Fink JB, Heffner JE, et al. Evidence-based guidelines for weaning and discontinuing ventilatory support: a collective task force facilitated by the American College of Chest Physicians; the American Association for Respiratory Care; and the American College of Critical Care Medicine. Chest 2001;120(6 Suppl):375S–395S.
6. Hendra KP, and Celli BR. Weaning from mechanical ventilation. Int Anesthesiol Clin 1999;37(3):127–143.
7. Salam A, Smina M, Gada P, Tilluckdharry L, Upadya A, Amoateng-Adjepong Y, Manthous CA. The effect of arterial blood gas values on extubation decisions. Respir Care 2003;48(11):1033–1037.

APPENDIX

Intensive Care Unit Ventilator Weaning Protocol

Patient screen

- P_{aO_2}/F_{IO_2} ratio $\geq$ 150 mm Hg on $F_{IO_2} \leq 0.50$ and PEEP $\leq$ 5 cm H_2O (or $S_{pO_2} \geq 90\%$ on $\leq 40\%$ F_{IO_2} and PEEP $\leq$ 5 cm H_2O if no ABG is available)
- Minute volume $\leq$ 15 L/min
- Mean arterial pressure $\geq$ 60 mm Hg while off vasopressors
- No continuous infusions of sedative/analgesics, with exception of propofol
- Adequate cough/does not require suctioning more than every 2 h
- Awake and follows simple commands

Spontaneous Breathing Trial

- If patient meets all above criteria, place patient on pressure support of 10 cm H_2O and PEEP 5 cm H_2O and current F_{IO_2}

Spontaneous Breathing Trial Failure

- S_{pO_2} drops $\leq 90\%$
- Respiratory rate consistently $\geq$ 35 breaths/min
- Heart rate changes by $\geq 20\%$ in either direction
- Clinical respiratory distress (eg, accessory muscle use or diaphoresis)

If Patient Tolerates Spontaneous Breathing Trial for 2 h

- Contact medicine resident to determine whether to:
  - Extubate patient
  - Leave patient on SBT
  - Return to original ventilation mode