Research article

Practising evidence-based medicine: the design and implementation of a multidisciplinary team-driven extubation protocol

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Abstract

Background Evidence from recent literature shows that protocol-directed extubation is a useful approach to liberate patients from mechanical ventilation (MV). However, research evidence does not necessarily provide guidance on how to implement changes in individual intensive care units (ICUs). We conducted the present study to determine whether such an evidence-based strategy can be implemented safely and effectively using a multidisciplinary team (MDT) approach.
Method We designed a MDT-driven extubation protocol. Multiple meetings were held to encourage constructive criticism of the design by attending physicians, nurses and respiratory care practitioners (RCPs), in order to define a protocol that was evidence based and acceptable to all clinical staff involved in the process of extubation. It was subsequently implemented and evaluated in our medical/surgical ICU. Outcomes included response of the MDT to the initiative, duration of MV and stay in the ICU, as well as reintubation rate.
Results The MDT responded favourably to the design and implementation of this MDT-driven extubation protocol, because it provided greater autonomy to the staff. Outcomes reported in the literature and in the historical control group were compared with those in the protocol group, and indicated similar durations of MV and ICU stay, as well as reintubation rates. No adverse events were documented.
Conclusion An MDT approach to protocol-directed extubation can be implemented safely and effectively in a multidisciplinary ICU. Such an effort is viewed favourably by the entire team and is useful in enhancing team building.

Keywords extubation protocol, mechanical ventilation, multidisciplinary team, spontaneous breathing trial, weaning

Introduction

Evidence-based medicine is an approach to practice and teaching that is based on knowledge of clinical trials. However, research evidence does not necessary translate into changed management for individual patients [1]. This might particularly be the case in critical care [2]. Multiple studies have analyzed the integration of evidence-based medicine into the ICU, as well as its barriers and bridges [3–5].

Good evidence supports the use of extubation or weaning protocols in the ICU [6,7], but weaning and extubation protocols are still not part of daily practice in most ICUs. Several

ICU = intensive care unit; MDT = multidisciplinary team; MV = mechanical ventilation; PEEP = positive end-expiratory pressure; PS = pressure support; RCP = respiratory care practitioner; SBT = spontaneous breathing trial.

barriers to designing and implementing RCP-driven weaning protocols have been identified [8,9]. Because multiple studies have demonstrated the positive impact of a multidisciplinary approach on caring for ventilated patients [10–12], we formed a MDT that consisted of attending physicians, RCPs and nurses. With constructive criticism from those individuals, we designed an extubation protocol that was guided by local staff experience, in the hope that we could overcome the barriers referred to above.

Our goals were as follows: to integrate evidence-based medicine into the setting of the ICU by promoting a multidisciplinary approach to extubation, and to design a protocol that was acceptable to all medical staff involved in the extubation process; to potentially accelerate decision-making with regard to extubation; and to assess the safety and feasibility of our approach.

Materials and method

The intervention was carried out in a 14-bed medical/surgical ICU in an academic university-affiliated hospital. Because a protocol-based approach to liberate patients from MV has been demonstrated to be safe in randomized controlled trials [6,7] and because the goal of this intervention was to implement an evidence-based approach into our daily ICU practice, no approval from the ethics committee was required.

Multidisciplinary team approach

During a 3-month period, several joint meetings with ICU-attending physicians, RCPs and nursing staff were held. The first session was devoted to reviewing the literature, followed by group protocol design and refinement.

Approach to protocol compliance

Once a final protocol was agreed on, educational sessions were held before the implementation of the protocol to educate nurses, RCPs and physicians who were not involved in the design of the protocol. The protocol was introduced to housestaff at the start of each ICU rotation.

The protocol

Intubated patients whose underlying indication for MV had stabilized or improved significantly after being ventilated for more than 24 h had an order written in their chart by a physician to commence spontaneous breathing trials (SBTs). All patients were prospectively followed from the time of intubation, and were screened by nurses and RCPs for *a priori* criteria (Fig. 1) on a daily basis. Data regarding demographics, Simplified Acute Physiological Score II [13] and indications for intubation were recorded. Of note, the weaning process was independent of the SBT and was not incorporated in the protocol. In our ICU, weaning generally proceeds as follows: patients are placed on pressure support (PS) and positive end-expiratory pressure (PEEP) once the condition that necessitated MV has improved; and the level of PS and PEEP are decreased by 2–4 cmH_2O once or twice per day, as tolerated by the patients. In the present study, decisions to extubate or to perform a SBT were independent of this process.

Once a patient fulfilled all of the screening criteria, they were given an SBT (Fig. 1) for 60 min while receiving the pre-SBT fractional inspired oxygen. Esteban *et al*. [14] showed that there were no significant differences in rates of extubation, reintubation or mortality between patients given SBTs lasting 30 min as compared with 120 min. However, our MDT members felt more comfortable with a SBT of 60 min. During the SBT, the patient was continuously monitored for any signs of intolerance (Fig. 1). If the patient developed any of these signs that were sustained for more than 5 min (Fig. 1) and could not be corrected with minor interventions, such as suctioning or repositioning, the trial was terminated. If the patient did not show any signs of intolerance and airway patency was ensured, the patient was extubated. Extubation was considered successful if reintubation was not required within 48 h.

Protocol compliance, and responses of the MDT and other clinical team members were recorded. Data on duration of MV, duration of ICU stay and the rate of reintubation were collected.

Safety

The MDT agreed that, in order to provide and ascertain safety of the implemented protocol, patient outcomes should be compared with those from existing literature as well as from a historical control group. The control group was obtained from the database of the Canadian subgroup (eight centres) of 183 patients from the International Study of Mechanical Ventilation [15]. None of these centres used an extubation protocol during the study period.

Results

Team response

During the design of the MDT-driven extubation protocol, the team members showed particular interest in sharing information and experience. The opportunity for all clinical team members to participate in a multidisciplinary project was supported by regular attendance of all team members during the protocol design. The regular attendance and high interest in evidence-based medicine resulted in rapid development of a protocol and integration of evidence-based medicine into our ICU. All ICU staff provided constructive criticism, and feedback was given on a regular basis. Based on the feedback, the protocol was regularly re-evaluated and updated. Nurses and RCPs responded favourably to the MDT-driven extubation protocol because it provided greater autonomy to the staff and apparent earlier extubation of the patient.

Patient outcome

During a 4-month period from May to August 1999, 47 consecutive patients were extubated according to our MDT-driven extubation protocol. All 47 patients were eventually extubated. One patient who was extubated after a successful SBT died 5 h after extubation because of a massive

Figure 1

Yes	No	
❑	❑	**I. Has physician given written approval for daily SBT assessment?**
		If Yes, go to section II at 05:00 of the day, aspirate NG tube if possible and stop feeding
		II. Daily screening of readiness to wean
		1) Mental state:
❑	❑	a) Awake
❑	❑	b) Not on continuous infusion of sedatives/narcotics
		2) Neuromuscular state:
❑	❑	a) Intact airway reflexes
		3) Cardiovascular state:
❑	❑	a) Mean arterial pressure ≥ 60 mmHg
❑	❑	b) Myocardial ischemia is not an ongoing problem
❑	❑	c) Not on continuous infusion of vasopressor (dopamine ≤ 5 μg/kg/min allowed)
❑	❑	d) No drop of hemoglobin level ≥10 g/L over past 24 h or blood transfusion currently
		4) Respiratory state:
❑	❑	a) RR < 35 breaths per min
❑	❑	b) PEEP ≤ 5 cm H_2O
❑	❑	c) VE ≤15 L/min
❑	❑	d) PaO_2 ≥ 60 mmHg while on FiO_2 ≤ 0.5
		If Yes to every question in section II, proceed to sections III and IV at 08:00
		If No to any questions in section II, reassess in 24 h
		Time of start_____
		III. Spontaneous Breathing Trial
❑	❑	1) Inform and explain weaning to patient, reassure patient
❑	❑	2) Ensure adequate pain relief
❑	❑	4) Sit patient up ≥ 45°
❑	❑	5) Suction upper airway
❑	❑	6) Pressure support of 6 cmH_2O, PEEP 0 for 1 h with original FiO_2 level
		IV. Closely monitor for signs of poor tolerance
		(Any of the following that is sustained >5 min despite minor interventions such as suctioning, reassurance)
❑	❑	1) Pulse oximetry < 90%
❑	❑	2) RR > 35 breaths per min
❑	❑	3) Systolic blood pressure > 200 mmHg or < 80 mmHg
❑	❑	4) Heart rate >140 beats per min or > 20% sustained change from baseline
		(Baseline Heart Rate = __/min, 20% ↑= __/min, 20% ↓= __/min)
❑	❑	5) Paradoxical movement of abdomen and rib cage
❑	❑	6) Severe anxiety
❑	❑	7) Decreased level of consciousness
		If the answer to any question is Yes in section IV, proceed to section VI
		Only if all the answers in sections I–III are Yes and all in section IV are No, proceed to section V
		Time of extubation_____
		V. Extubation
❑	❑	1) Cuff leak test
❑	❑	2) Approval and order given by physician for extubation
❑	❑	3) Extubation
❑	❑	4) Continue monitoring after extubation
		VI. Revert to previous ventilator settings
❑	❑	Document termination criteria
❑	❑	Adequate rest for 24 h
❑	❑	Continue daily screening

Respiratory care practitioner-driven extubation protocol. FiO_2 = fractional inspired oxygen; NG = nasogastric; PaO_2 = arterial oxygen tension; PEEP = positive end-expiratory pressure; RR = respiratory rate; SBT = spontaneous breathing trial; VE = expired minute ventilation.

pulmonary embolism. The other 46 patients were eventually discharged from the ICU.

The first SBT was performed at a mean of 4.4 days after intubation, ranging from 24 h after intubation up to 20 days after intubation.

Thirty-nine patients (83%) were extubated after their first SBT. Four of those patients required reintubation within 48 h, but two of them were successfully extubated after their second SBT within the next 4–6 days, and the other two patients were successfully extubated after their third SBT.

Eight patients (17%) were not extubated after their first SBT. Four of these were successfully extubated after their second SBT, one after his third and another after his fourth SBT; one patient was extubated without a preceding SBT; and one patient who passed the first SBT could not be extubated because of compression of the airway secondary to soft-tissue oedema (although this patient was removed from the ventilator after a temporary tracheostomy).

When the first SBT was performed, 27 patients (57.4%) were still in the process of weaning (PS >6 cmH_2O). Those patients were receiving a mean PS of 10 cmH_2O, ranging from 7 to 20 cmH_2O, and PEEP of 5 cmH_2O or less. Two of those patients started the SBT from pressure-control ventilation.

Comparison

Table 1 lists the characteristics of patients in the protocol and the control groups. Indications for MV in the protocol patients and the control group are listed in Table 2. Information regarding indications for intubation and MV in the control group was available for 178 patients.

Table 3 shows the outcomes of the patients in the protocol and the control groups, as well as the outcomes reported in the literature. There was no significant difference between the protocol and the control groups with regard to duration of ICU stay and MV, or rate of reintubation. No adverse effects occurred during the SBT or after extubation.

Discussion

The aim of evidence-based medicine is to integrate current best evidence from research into clinical policy and practice. However, this does not necessarily result in different treatment of individual patients. Difficulties in developing evidence-based clinical policies, organizational barriers and ineffectual educational programmes are identified as barriers to successful application of research evidence to health care [3]. Existing hierarchical structures within and between the different professional groups obstruct routine decision-making processes and integration of evidence-based medicine [4]. In intensive care, clinical practice is still influenced by a combination of theory, experience and evidence [5].

Table 1

Patient characteristics in the protocol and control groups

Characteristics	Protocol group	Control group
n	47	183
Sex (*n* [%])		
Male	19 (40.4)	106 (57.9)
Female	28 (59.6)	77 (42.1)
Age (years; mean ± SD)	60 ± 18	60 ± 18
Type of admission (*n* [%])		
Medical	25 (53.2)	117 (64.2)
Surgical	22 (46.8)	66 (35.8)
SAPS II (mean ± SD)	47 ± 16	47 ± 15
Presence of ARDS during ICU stay (*n* [%])	11 (23.4)	20 (10.9)
Presence of pneumonia during ICU stay (*n* [%])	35 (74.5)	58 (31.7)

ARDS = acute respiratory distress syndrome; ICU = intensive care unit; SAPS = Simplified Acute Physiology Score.

Table 2

Indications for intubation and mechanical ventilation in the protocol and control groups

Indications for intubation	Protocol group (*n* [%])	Control group (*n* [%])
Postoperative	15 (31.9)	37 (20.2)
Pneumonia	11 (23.4)	25 (13.7)
Acute pulmonary oedema	4 (8.5)	15 (8.2)
Sepsis	7 (14.9)	25 (13.7)
Airway protection	4 (8.5)	50 (27.3)
Exacerbation of chronic obstructive pulmonary disease	2 (4.3)	5 (2.7)
Cardiac arrest	2 (4.3)	8 (4.4)
Pulmonary haemorrhage	1 (2.1)	0
Flail chest	1 (2.1)	0
Airway obstruction	0	2 (1.1)
Asthma	0	3 (1.6)
Pulmonary embolism	0	1 (0.5)
Neuromuscular disease	0	2 (1.1)
Inhalation injury	0	3 (1.6)
Other chronic respiratory disease exacerbation	0	2 (1.1)
Unknown	0	5 (2.7)

Percentages may not total to 100% because of rounding.

Table 3

Outcome comparison

Group	*n*	Extubation after first SBT (%)	Duration of mechanical ventilation (days; mean ± SD)	Duration of ICU stay (days; mean ± SD)	Reintubation (*n* [%])
Protocol group	47	83	6.7 ± 6.5	9.3 ± 8.2	5 (10.6)
Historical group	183	–	6.2 ± 7.0	7.2 ± 8.5	23 (17.4)
Esteban *et al.* [17]	205	86	–	12	38 (18.5)
Ely *et al.* [7]	149	75.8	4.5	8	5 (3)
Ely *et al.* [8]	1167	75.4	6	9	149 (14)
Kollef *et al.* [6]	179	–	2.9 ± 5.2	–	23 (12.8)

ICU = intensive care unit; SBT = spontaneous breathing test.

Because of the various problems encountered in the management of a patient in the ICU setting, communication between member of the MDT is of particular importance. Good evidence has demonstrated the positive impact of a MDT approach on caring for ventilator-dependent patients [10–12].

Ventilatory protocols that rely on multidisciplinary ICU expertise are becoming more frequently recommended in the ICU setting [6–9,16]. Because nurses and RCPs also spend more time at the patient's bedside, their input regarding readiness for extubation is invaluable. Hence, we strongly believe that the integration of this evidence into the design of an extubation ICU protocol should take opinions and experiences of the MDT into consideration. Previous studies have shown that protocol-based approaches may shorten the duration of MV in comparison with weaning without a standardized approach [16], but no approach has been established as superior over any other. Our intention was not to show that standardized extubation is a better approach to liberating patients from MV, but that it is possible to design and implement a MDT-driven extubation protocol that has a positive impact on the patient and the MDT, in a safe manner.

The unique feature of the present study is the description of the process undertaken to implement a MDT-driven extubation protocol and what we felt was the best application of evidence-based medicine in our ICU.

Previous studies have identified both unfamiliarity of physicians with a RCP-driven protocol for ventilator weaning and the lack of consistent assignment of the RCPs to the same ward as two important barriers to successful implementation of a weaning protocol [8]. During the design of our protocol, these barriers were taken into consideration in order to decrease the risk of protocol noncompliance. First, our ICU has its own dedicated RCP and nursing staff. Second, educational sessions were held, in which didactic teaching reinforced confidence of staff working with the protocol. Finally, the protocol was introduced to housestaff at the start of their ICU rotation.

The MDT agreed to ensure safety of the implemented protocol. In order to ensure safety and efficacy, we compared durations of MV and ICU stay, as well as rate of reintubation with those from previous literature and a cohort group; we found no significant differences between the protocol group and the control group in this regard. All of our findings are comparable to those from previously published studies (Table 3).

Because a large number of patients from our protocol group were still in the process of weaning at the time that the first SBT was performed, and perhaps would not have been challenged had the protocol not been in place, we feel that in our ICU this protocol probably reduced ventilation time. However, this was not a primary outcome, given that it has already been proven. No serious adverse effects occurred during the SBTs. Finally, the MDT felt that the implementation of the protocol allowed patients to be extubated earlier for two reasons: most patients were still in the process of weaning, because historically we waited until they were on a PS of 5 cmH_2O before extubating; and extubation no longer had to wait until the end of bedside morning rounds.

In order to draw a meaningful conclusion from this intervention, the following weaknesses need to be considered. First, the present study had a small number of subjects ($n = 47$), so any statistical result would be under-powered. Second, the use of historical control individuals limits our ability to draw strong conclusions. Despite these limitations, we felt it was necessary to ensure there was no obvious harm in implementing our protocol by comparing it with previous literature as well as a control group.

Conclusion

A MDT-driven protocol is a useful approach to implementing evidence-based medicine in the ICU stetting. Multidisciplinary input as well as ongoing re-evaluation and modification are essential factors. A MDT-driven extubation protocol was implemented in our ICU, and was shown to be safe and very

well accepted by nurses, RCPs and physicians. Local design increases staff familiarity with the protocol and is an important factor for team building.

Competing interests

None declared.

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References

1. Nigel O, Bateman H: **Treating individuals according to evidence: why do primary care practitioners do what they do?** *J Eval Clin Pract* 2000, **6**:139-148.
2. Cook DJ, Sibbald WJ, Vincent J-L, Cerra FB: **Evidence based critical care medicine: what is it and what can it do for us?** *Crit Care Med* 1996, **24**:334-337.
3. Haynes B, Haines A: **Barriers and bridges to evidence based clinical practice.** *BMJ* 1998, **317**:273-276.
4. Newman M, Papadopoulos I, Sigsworth J: **Barriers to evidence-based practice.** *Intensive Crit Care Nurs* 1998, **14**:231-238.
5. Scheinkestel CD, Davies AR, Bristow PJ: **Evidence-based medicine in intensive care.** *Med J Aust* 2001, **174**:526-527.
6. Kollef MH, Shapiro SD, Silver P, St. John RE, Prentice D, Sauer S, Ahrens TS, Shannon W, Baker-Clinkscale D: **A randomized controlled trial of protocol-directed versus physician-directed weaning from mechanical ventilation.** *Crit Care Med* 1997, **25**: 567-574.
7. Ely EW, Baker AM, Dunagan DP, Burke HL, Smith AC, Kelly PT, Johnson MM, Browder RW, Bowton DL, Haponik EF: **Effect on the duration of mechanical ventilation of identifying patients capable of breathing spontaneously.** *N Engl J Med* 1996, **335**: 1864-1869.
8. Ely EW, Bennett PA, Bowton DL, Murphy SM, Florance AM, Haponik EF: **Large scale implementation of a respiratory therapist-driven protocol for ventilator weaning.** *Am J Respir Crit Care Med* 1999, **159**:439-446.
9. Scheinhorn DJ, Chao DC, Stearn-Hassenpflug M, Wallace WA: **Outcomes in post-ICU mechanical ventilation. A therapist implemented weaning protocol.** *Chest* 2001, **119**:236-242.
10. Cull C, Inwood H: **Weaning patients from mechanical ventilation.** *Prof Nurse* 1999, **14**:535-538.
11. Kaye J, Ashline V, Erickson D, Zeiler K, Gavigan D, Gannon L, Wynne P, Cooper J, Kittle W, Sharma K, Morton J: **Critical care bug team: a multidisciplinary team approach to reducing ventilator-associated pneumonia.** *Am J Infect Control* 2000, **28**: 197-201.
12. Young MP, Gooder VJ, Oltermann MH, Bohman CB, French TK, James BC: **The impact of a multidisciplinary approach on caring for ventilator-dependent patients.** *Int J Qual Health Care* 1998, **10**:15-26.
13. Le Gall J-R, Lemeshow S, Saulnier F: **A new simplified acute physiology score (SAPS II) based on an European/North American multicenter study.** JAMA 1993, **270**:2957-2963.
14. 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 M, Macias S, for the Spanish Lung Failure Collaborative Group: **Effect of spontaneous breathing trial duration on outcome of attempts to discontinue mechanical ventilation.** *Am J Respir Crit Care Med* 1999, **159**:512-518.
15. Esteban A, Anzueto A, Alia I, Tobin MJ, Benito S, Brochard L, Stewart TE, for the International Collaborative Group on Mechanical Ventilation: **Mortality of patients receiving mechanical ventilation [abstract].** *Am J Respir Crit Care Med* 1999, **159**:A47.
16. Marelich GP, Murin S, Battistella F, Inciardi J, Vierra T, Roby M: **Protocol weaning of mechanical ventilation on medical and surgical patients by respiratory care practitioners and nurses.** *Chest* 2000, **118**:459-467.
17. Esteban A, Alia I, Gordo F, Fernandez R, Solsona JF, Vallverdu I, Macias S, Allegue JM, Blanco J, Carriedo D, Leon M, De la Cal MA, Taboada F, Gonzalez de Velaso J, Palazon E, Carrizosa F, Tomas R, Suarez J, Goldwasser RS, for the Spanish Lung Failure Collaborative Group: **Extubation outcome after spontaneous breathing trials with T-tube or pressure support ventilation.** *Am J Respir Crit Care Med* 1997, **156**:459-465.