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Cough strength, secretions and extubation outcome in burn patients who have passed a spontaneous breathing trial

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ABSTRACT

The aim of this study was to develop a clinical prediction model to inform decisions about the timing of extubation in burn patients who have passed a spontaneous breathing trial (SBT). Rapid shallow breathing index, voluntary cough peak flow (CPF) and endotracheal secretions were measured after each patient had passed a SBT and just prior to extubation. We used multiple logistic regression analysis to identify variables that predict extubation outcome. Seventeen patients failed their first trials of extubation (14%). CPF and endotracheal secretions are strongly associated with extubation outcome ($p < 0.0001$). Patients with CPF $\leq$ 60 L/min are 9 times as likely to fail extubation as those with CPF $>$ 60 L/min (risk ratio = 9.1). Patients with abundant endotracheal secretions are 8 times as likely to fail extubation compared to those with no, mild and moderate endotracheal secretions (risk ratio = 8). Our clinical prediction model combining CPF and endotracheal secretions has strong predictive capacity for extubation outcome (area under receiver operating characteristic curve = 0.96, 95% confidence interval 0.91–0.99) and therefore may be useful to predict which patients will succeed or fail extubation after passing a SBT.

1. Introduction

Decisions regarding the timing extubation are important aspects of the intensive care management of patients [1]. This is because increasing duration of mechanical ventilation itself is associated with increased mortality [2]. Therefore it is of paramount importance that patients are liberated from mechanical ventilation at the earliest opportunity. However, patients who are prematurely extubated and underwent reintubation have poorer outcomes than those who succeed such that reintubation has been shown to be associated with increased mortality in medical and surgical patients [3–5]. The reasons for this have been attributed to the development of new complications after reintubation [5]. In a previous study, we demonstrated that the negative consequences associated with extubation failure in intensive care patients also apply to burn patients because those who underwent reintubation had a significantly prolonged duration of ventilation, intensive care and hospital length of stay and extubation failure was associated with increased mortality [6].

Liberation of patients from mechanical ventilation consists of two processes firstly, removal of the ventilatory support so that the patient breathes without assistance and secondly, removal of the endotracheal tube or extubation. Assessment of patients' capacity for spontaneous breathing has been extensively studied through evaluation of the spontaneous breathing trial protocol and this has been shown to decrease the duration of ventilation in medical and surgical intensive care patients [7–9]. In earlier work, we also demonstrated that

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burn patients who passed a 30 minute spontaneous breathing trial have a significantly shorter duration of ventilation than their retrospective controls [10].

Over the last 20 years many physiological measures have been proposed as predictors of weaning outcome. Commonly used weaning indices, e.g. negative inspiratory force (NIF) and rapid shallow breathing index (RSBI – respiratory rate: tidal volume ratio) have been reported to have only modest predictive capacity for extubation outcome in ICU patients [11,12]. For successful extubation to occur the patient, having passed a spontaneous breathing trial, must be able to maintain a patent airway by demonstrating adequate cough strength and gag reflexes, and secretion volumes must be manageable. For this reason cough strength and quantity of secretions are commonly incorporated into the decision making process when assessing a patient's readiness for extubation and these factors have performed well as extubation predictors in studies with other patient populations who have passed a spontaneous breathing trial [13–17]. Evidence supporting voluntary cough strength as a good predictor of extubation outcome is provided by Smina et al. and Salam et al. who identified that medical and cardiac patients with weaker cough strength as measured by cough peak flow (CPF) $\leq$ 60 L/min were 5 times as likely to fail extubation compared to patients with a CPF $>$ 60 L/min [13,14]. A subsequent study by Beuret et al. evaluated cough strength as a predictor of extubation outcome in intensive care patients and found that a patient's inability to cough to order or a peak cough expiratory flow optimal cut off value of $\leq$35 L/min predicted extubation failure [16].

Studies evaluating endotracheal secretions as a predictor of extubation outcome include Salam et al. who instigated a protocol involving collecting endotracheal secretions in a sputum trap and performing suction every hour. That study identified that patients were 3 times as likely to fail extubation if their secretions volumes were $>$2.5 ml/h [14]. A subsequent study by Mokhlesi et al. found that moderate or copious endotracheal secretions, measured by suction frequency according to nurses discretion, predicted extubation failure in 122 medical and surgical patients [15].

At present there are no studies that have focused on predictors of extubation outcome in burn patients. In the current study we evaluate a quantitative method of measuring voluntary cough strength (cough peak flow – CPF), rapid shallow breathing index (RSBI) and endotracheal secretions as predictors of extubation outcome in burn patients. The objective is to develop a clinical prediction model to be used at the bedside to assist with decision-making regarding the timing of extubations in burn patients who have passed a SBT.

2. Methods

This is a prospective observational study. The Local Research Ethics Committee and Research Ethics Board of the hospital approved the study and permission was obtained from each patient at the time of recruitment. All adult patients ($>$18 years) undergoing endotracheal intubation and ventilation $>$ 24 h in our burn intensive care unit between July 2005 and December 2010 were eligible for the study. Patients were studied when they had successfully completed a 30 min spontaneous breathing trial and when they were about to be extubated. In our ICU ventilation weaning is guided by a non-mandatory protocol that is performed by nurses, a physiotherapy consultant and anaesthetic specialist registrars who are supervised by consultant intensivists. All patients are screened daily for their readiness for a spontaneous breathing trial by the presence of all of the following: (1) resolution of the disease process necessitating ventilation; (2) PEEP $\leq$ 5 cm H_2O; (3) pressure support $\leq$ 10 cm H_2O for at least 30 min; (4) no further need for vasoactive or intravenous sedative drugs (non-escalating doses were permitted); (5) awake and responsive – Richmond agitation sedation scale 0–1 and able to complete 3 simple tasks (open/close eyes, open/close mouth, poke tongue out of mouth); (6) temperature $<$ 39 °C for the preceding 12 h; (7) haemoglobin $>$ 7 g/dL; (8) no significant airway swelling, cuff leak evident; (9) anaesthetist agrees the patient is in a stable condition and is ready to be weaned from the ventilator.

Spontaneous breathing trial assessments are performed with 40% oxygen using a T-Tube with venturi device, in the upright position (45°) for 30 min arterial blood gas analysis is performed at the end of the SBT or if indicated before. The SBT is terminated by the anaesthetist if any of the following are observed: (1) RR $>$ 35 for 5 min or longer; (2) SpO_2 $<$ 90%; (3) HR $>$ 140 bpm or an increase or decrease $>$ 20% baseline; (4) systolic blood pressure $>$ 180 mmHg or $<$90 mmHg; (5) signs of increased work of breathing-accessory muscle use, paradoxical breathing movements, intercostal retractions, nasal flaring; (6) agitation diaphoresis or signs of anxiety despite attempts by the caregivers to alleviate this; (7) PaO_2 $\leq$ 8 kPa on FiO_2 $\geq$ 0.4. A failed SBT is followed by a period of rest for at least 24 h on the ventilator.

When patients had passed a spontaneous breathing trial and extubation was being considered, the physiological indices under investigation were taken. The patients' were asked to take a deep breath in and to cough as strongly as possible into a mini – Wright peak flow metre via a Filta–Guard breathing filter (intersurgical) attached. Patients were instructed to cough ''maximally'' and the best of three attempts was recorded. In order to calculate the RSBI minute ventilation was measured using a calibrated spirometer (Wrights) with a Filta–Guard breathing filter (intersurgical) attached. The scoring system for endotracheal secretions was based on suction frequency for the preceding 6 h to a spontaneous breathing trial (Table 1). The number of passes becomes important if a patient is suctioned every 3 h, to group the patient into either mild or moderate secretions. Due to the potentially deleterious side effects of performing suction, it was not performed according to a study protocol but when it was deemed to be necessary by the caregivers according to clinical signs e.g. guided by ventilation and gas exchange parameters and audible secretions in the endotracheal tube. A minimum suction frequency of 6 hourly applies in our unit to assess for and ensure endotracheal tube patency. This approach to performing suction reflects commonly accepted practice in ICUs and therefore our method of scoring endotracheal secretions is relevant to clinical practice. All patients received active humidification whilst being ventilated. The consultant intensivists making