Abstract

Background

Despite the evidence and available guidelines about endotracheal suction, a discrepancy between published guidelines and clinical practice persists. To date endotracheal suction (ETS) practice in the adult ICU population across New Zealand and Australia has not been described.

Objective

Describe ICU nurses' ETS practice in New Zealand and Australia including the triggers for performing endotracheal suction.

Methods

A single day, prospective observational, binational, multicentre point prevalence study in New Zealand and Australian ICUs. All adult patients admitted at 10:00 on the study day were included.

Main outcome measures

In addition to patient demographic data, we assessed triggers for ETS, suction canister pressures, use of pre-oxygenation, measures of oxygenation, and ETS at extubation.

Results

A total of 682 patients were included of which 230 were intubated. A total of 1891 ETS events were performed on 227 patients during the study day, a mean of 8 interventions per patient. The main triggers reported were audible (n=385, 63%) and visible (n=239, 39%) secretions. Less frequent triggers included following auscultation (n=142, 23%), reduced oxygen saturations (n=140, 22%) and ventilator waveforms (n=53, 9%). Mean suction canister pressure was -337 mmHg (SD 189), 67% of patients received pre-oxygenation (n=413) and ETS at extubation was performed by 84% of nurses.

Conclusion

Some practices were inconsistent with international guidelines, in particular concerning patient assessment for ETS and suction canister pressure.

Key words: Airway management, endotracheal suction, intensive care, mechanical ventilation.

Introduction

Endotracheal suction (ETS) is performed to maintain patency of the airway and remove secretions in patients with an endotracheal tube (ETT) in situ. It is an important part of airway management in ventilated Intensive Care (ICU) patients. Patients with an ETT may be at increased risk of respiratory infections as they are unable to clear secretions by coughing. Recognised potential complications following ETS include hypoxia, tissue trauma, increased risk of infection, cardiovascular instability and atelectasis.[1,2] Care and management of the patient and the ETT has been discussed in the literature since 1945.[3-5] To ameliorate the risks, the American Association for Respiratory Care (AARC) developed clinical practice guidelines (CPG) for ETS, ventilation and extubation.[6-8] Current recommendations include; suction only when secretions are present,[6] consider pre-oxygenation if there is a clinically significant reduction in oxygen saturation with suctioning, using positive end-expiratory pressure (PEEP) or recruitment manoeuvres (applying a transient increase in pulmonary pressure to open collapsed alveoli) when required,[9,10] and setting the suction pressure as low as possible to effectively clear secretions, less than -150mmHg is recommended.[6,11] Patient assessment should include listening for coarse sounds over the trachea, assessing ventilator waveforms,[12] assessment of oxygenation or presence of pulmonary secretions.[6]

Previous studies have shown that there is variability between clinical practice and adherence to practice guidelines.[13-15] Less than 10% of nurses use the recommended suction catheter size with suction canister pressure monitored 55% of the time[13] and differing practice about the use of 0.9% sodium chloride prior to ETS,[13,14] although this is no longer a recommendation.[6]

Recent work investigated ETS practice of Australian paediatric nurses,[16] and physiotherapists[17] while an earlier paper investigated nurses' adherence to best practice in one Australian ICU.[18] There is no published literature describing current nursing ETS practice

in the adult ICU population across New Zealand and Australia (ANZ). This study aimed to describe current practice and triggers influencing nurses' decisions to perform suction in order to assess congruence with CPG recommendations.

Methods

This observational study was conducted as part an existing Point Prevalence Program (PPP), using cross-sectional research methodology.[19] The PPP is a prospective, bi-national, single day research initiative to facilitate researchers conducting observational research that will underpin future research. The George Institute for Global Health coordinates the PPP on behalf of the Australian and New Zealand Intensive Care Society Clinical Trials Group. Ethics approval was obtained in New Zealand (MEC/09/28/EXP) and for all Australian sites a waiver of consent was granted.

To facilitate data collection, data was collected on either 15th September or 14th October 2015. Trained research staff at each site collected data on all adult (≥16 years) patients in their ICU at 10:00 hours on the chosen study day. Demographic data including age, gender, admission diagnosis, Acute Physiology and Chronic Health Evaluation (APACHE) II score on admission, admission source and 28-day mortality was collected. All patients intubated and ventilated by way of either an endotracheal or tracheostomy tube at 10:00 hours on the study day were included in this study.

The following data was collected:

1. Number of ETS episodes during the 24 hour study period,
2. For four consecutive ETS episodes:
    a. Partial pressure of oxygen (PaO_2) and partial pressure of carbon dioxide in arterial blood ($PaCO_2$) prior to ETS,
    b. Peripheral capillary oxygen saturation (SpO_2) pre and post ETS,
    c. Suction canister pressure,
    d. The triggers for performing ETS,
    e. Use of pre-oxygenation.

3. Incidence of extubation or decannulation between 10:00 – 14:00 hours, and whether ETS was performed prior to extubation.

For this study, definitions of the triggers for a suction event were: hypoxia $PaO_2 \leq$ 60mmHg/8.0kPa, hypercapnia $PaCO_2 \geq$ 50mmHg/6.6kPa, decreased $SpO_2 \leq 88\%$, auscultation that identified reduced air entry, wheezes or crackles necessitating ETS, audible secretions (heard without the use of a stethoscope), visible secretions (secretions or sputum seen in the ET tube). Routine ETS included both "routine" and "routine as per unit policy". Pre-oxygenation was defined as the delivery of 100% FiO_2 for 3 - 6 breaths or 1 - 2 minutes before ETS was performed and suction at extubation was defined as during the removal of the ETT, or up to 5 minutes prior to extubation.

Data was entered into a single electronic database (Research Electronic Data Capture (REDcap) – Vanderbilt University, Tennessee).[20] Data was extracted into Excel (version 15.32 Microsoft Corporation, Santa Rosa, California) and analysed using SPSS (IBM SPSS Statistics for Macintosh, Version 24.0. Armonk, NY: IBM Corp.). Descriptive statistics were used to describe the cohort. Data was tested for normality and the mean and standard deviation (SD) are reported.

Results

In total 682 patients were enrolled at 51 ICUs across New Zealand and Australia, of whom 230 (34%) were intubated and ventilated on the study day. Baseline characteristics of the intubated patients are shown in Table 1.

A total of 1891 ETS episodes were recorded on 227 intubated patients during the study day, data was not provided for 3 patients. A total of 614 (32.5%) were recorded as four consecutive ETS episodes and were analysed. There was an average of 8 interventions per patient (range 1-33) in the 24 hour study day period, and mean canister pressure was -337 mmHg (SD 189). Nineteen patients were extubated in the first four hours of the study day (10:00 -14:00); of these, 16 (84%) received ETS at the time of extubation.

Overall on the study day the most frequently cited reasons for ETS were audible secretions (n= 385, 63%), visible secretions (n= 239, 39%), following auscultation (n=142, 23%) and reduced SpO_2 (n=140, 22%). Additional reasons for the patient receiving ETS can be seen in Table 2.

Although reduced SpO_2 was cited as the trigger for 22% of ETS interventions, it was frequently recorded as being within the normal physiological range (94-98%).[21] Over four consecutive suction episodes, the mean SpO_2 before and after ETS was 96% (SD 4.1) and 97% (SD 3.1) respectively. The lowest recorded SpO_2 prior to ETS was 68% increasing to 80% following ETS. As seen in Table 2, ventilator waveforms as an indicator for ETS were used infrequently as has been recommended in the literature.[6]

The least frequent reasons for ETS were hypoxia (n=33, 5.3%) and hypercapnia (n=4, 0.7%) as measured on arterial blood gas (ABG) taken prior to ETS. The mean PaO_2 and $PaCO_2$ prior to ETS were 68.2 mmHg (SD 10.7) and 60.4 mmHg (SD 10.9) respectively. In contrast to the SpO_2, these were outside the normal physiological range.

Pre-oxygenation prior to ETS was provided prior to the majority of ETS episodes (n=413, 67%). The most frequent rationale for pre-oxygenation was documented as unit policy (n=309, 75%). Other reasons included patient condition (n = 45, 11%) and reduced SpO_2 (n=40, 10%).

Discussion

This is the first time that nursing practice regarding ETS across New Zealand and Australia has been described. We found that the most frequent triggers for performing ETS were audible or visible secretions; that ETS was performed at extubation for the majority of patients extubated during the study period; that pre-oxygenation prior to ETS was common; that suction canister pressure was higher than recommended in CPGs and that the rationale for performing ETS varied among nurses.

These results show that ANZ nursing practice deviates from CPG recommendations and that

the discrepancies are similar to those found in other studies,[13-15] including non-adherence to recommended suction canister pressure. Although there are currently no guidelines about ETS best practice at extubation, the majority of patients in our study received ETS prior to extubation.

The most frequently cited reasons for performing ETS were audible and visible secretions and following auscultation as defined for this study. This is similar to other studies where, among the top 5 self-reported triggers for nurses and respiratory therapists were the patient coughing, chest auscultation and audible secretions.[22,23] In our study, ventilator data, for example, waveforms such as saw tooth patterns and raised inspiratory pressures, were seldom used as a triggers for ETS and nurses were not listening for coarse crackles over the trachea as recommended.[6,12] It has been suggested that patients are assessed at least 4 hourly for indicators that ETS is needed.[12] and that coarse breath sounds over the trachea are an good indicator for the need for ETS.[12] If this is incorporated into clinical practice, it would have the potential to improve patient care and maintain safe airway management in the ICU, while avoiding unnecessary ETS.

For patients extubated during the study period, the majority received ETS at the time of extubation. This is comparable to previously described practice, where suctioning the ETT and asking the patient to cough were among the most common nursing practices at extubation.[24,25] However, ETS may increase atelectasis[26] and consideration of a positive pressure breath,[26] or the use of PEEP at extubation[10,25-27] may reduce the risk of aspiration and atelectasis. Further research is required to determine best practice at extubation in the ICU setting.

In this cohort, pre-oxygenation prior to ETS was common, unit policy being the biggest driver. Our results showed a higher number of nurses pre-oxygenating patients than previous self-reported results.[28] However, nursing pre-oxygenation practice is consistent with described physiotherapist practice in ANZ.[17]

Although hyperoxygenation is recommended in the CPG[6], much of the evidence is based upon literature prior to the availability of closed or quasi-closed ETS apparatus.[23] There remains a

knowledge gap regarding the optimum FiO_2 delivery for pre-oxygenation [29-32] and which patients may likely benefit. The current guidelines do not define hypoxia and there is recognition that the available evidence is weak.[33] Given the known side effects of hyperoxygenation upon absorption atelectasis, [30-32] there is a need for more robust data to guide practice.

We found that the mean negative canister pressure on the study day was greater than that recommended in the CPG of "less than -150mmHg in adults".[6] This is a similar finding to other studies which have shown that suction canister pressure is frequently outside the recommended level.[13,15] The consensus in the literature is that negative pressure should be set no higher than the minimum level required,[6,11] thereby reducing the risk of trauma to the lung mucosa, atelectasis and pulmonary oedema. Nurse education and unit policies have been shown to influence practice, [34,35] therefore this gap in practice should be addressed by effective education and meaningful, evidence based protocols.[34, 35]

Patients who survive ICU consistently describe ETS as one of the most painful procedures [36-39] and there is evidence that those who have experienced ventilation have poorer quality of life outcome measures up to 5 years following their ICU stay, continuing to recall pain and ETS.[40] It has been reported that during their ICU admission 30% of ICU patients report pain at rest, with up to 50% of patients reporting pain during common ICU procedures including turning and ETS[39] and that there is frequently no analgesia provided either immediately prior to or within 2 hours of the patient receiving ETS.[41] This may be due to reasons including staff being de-sensitised to the procedure and ETS being a brief intervention.[38] However, given the evidence that ETS is painful and distressing anything that can be done to mitigate these effects for patients will be beneficial, potentially aiding physical and psychological recovery. This study highlights the need for ongoing nurse education in ICU, including how to assess the need and prepare the patient for ETS and increasing awareness about the experience and pain

associated with ETS. Practitioner education is influential in changing practice [34] and may help reduce the gap between CPG and clinical practice.

Strengths and limitations

Strengths of this study include the prospective design and a binational approach involving a large number of ICUs across a variety of settings. Data collection was undertaken by experienced research nurses/co-ordinators all working within the ICU speciality ensuring consistency across the data collection.

Although the study is a snap shot of nursing practice, describing practice only on the study day, this is the first-time ICU nursing practice of ETS has been documented across ANZ. This study will provide a platform for units to review their practice protocols and develop robust education programmes for ICU nursing staff, incorporating the best available evidence.

Conclusions

The lack of availability of high quality evidence surrounding ETS continues to present challenges for clinicians. This study has identified key areas where improvements could be made to ICU nursing practice including education regarding patient assessment prior to performing ETS, guidance regarding pre-oxygenation and the need for further research to determine what is the best practice to prevent atelectasis at the time of extubation, including the effect of ETS at extubation, the use of recruitment manoeuvres, PEEP or asking the patient to cough. Improving practice will prevent patients being exposed to unsafe and potentially harmful clinical practice. The pain and distress caused by ETS and experienced by the patient may be reduced by improving nurses' knowledge and awareness of how and when to safely perform ETS.

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Table 1. Baseline characteristics of intubated patients (*n*=230)

Characteristic	
Age, years mean (SD)	55 (16)
Sex (male), n (%)	141 (61%)
Weight, * kg, mean (SD)	85 (26%)
APACHE II score, mean (SD)	20.0 (8.0)
ICU admission source, n (%)	
Emergency department	70 (30%)
Operating theatre, emergency	55 (24%)
Hospital ward	51 (22%)
Another ICU	23 (10%)
Operating theatre, elective	16 (7%)
Transfer from other hospital	15 (7%)
APACHE III diagnostic categories, n (%)	
Respiratory	55 (24%)
Cardiovascular	42 (18%)
Neurological	37 (16%)
Trauma	30 (13%)
Sepsis	24 (10%)
Gastrointestinal	21 (9%)
Other	21 (9%)
Discharged from ICU at day 28 (alive or dead), number (%)	194 (84%)
Alive at ICU discharge, number (%)	159 (69%)

APACHE = Acute Physiology and Chronic Health Evaluation. ICU = intensive care unit. * Body weight is estimated or measured.

Table 2

Triggers for endotracheal suction events (*n* = 614)

	n	%
Audible secretions	385	63%
Visible secretions	239	39%
Auscultation	142	23%
Reduced SpO2	140	22%
Routine	104	17%
Patient coughing	75	12%
Ventilator waveforms, e.g. saw tooth pattern	53	9%
Hypoxia –on ABG	33	5.3%
Patient or family request	27	4%
Physiotherapy	14	2%
Hypercapnia –on ABG	4	0.7%
CXR changes	2	0.3%