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Research paper

Endotracheal suction in intensive care: A point prevalence study of current practice in New Zealand and Australia

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ABSTRACT

Background: Despite the evidence and available guidelines about endotracheal suction (ETS), a discrepancy between published guidelines and clinical practice persists. To date, ETS practice in the adult intensive care unit (ICU) population across New Zealand and Australia has not been described.
Objective: To 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 preoxygenation, measures of oxygenation, and ETS at extubation.
Results: There were 682 patients in the ICUs on the study day, and 230 were included in the study. Three of 230 patients were excluded for missing data. A total of 1891 ETS events were performed on 227 patients during the study day, a mean of eight 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 (standard deviation = 189), 67% of patients received preoxygenation (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.

1. 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 unit (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 developed clinical practice guidelines (CPGs) for ETS, ventilation, and extubation.[6–8] Current recommendations include suction only when necessary, consider preoxygenation if there is a clinically significant reduction in oxygen saturation with suctioning, using positive end-expiratory pressure 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

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effectively clear secretions, less than −150 mmHg is recommended.[6,11] Patient assessment should include listening for course sounds over the trachea and assessing ventilator waveforms.[12]

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 study investigated nurses' adherence to best practice in one Australian ICU.[18] There is nothing describing nursing ETS practice in the adult ICU population across New Zealand and Australia. This study aimed to describe current practice and triggers influencing nurses' decisions to perform suction to assess congruence with CPG recommendations.

2. 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, binational, 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 were collected on either 15th September or 14th October, 2015. Trained research staff at each site collected data on all adult ($\geq$16 years) patients in their ICU at 10:00 h 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 were collected.

In addition, all patients who were intubated and ventilated at 10:00 h on the study day had the following data collected:

1. Number of ETS episodes during the 24 h study period;
2. at the time of four consecutive ETS episodes:
   a. partial pressure of oxygen (PaO_2) and partial pressure of carbon dioxide in arterial blood ($PaCO_2$) before ETS,
   b. peripheral capillary oxygen saturation (SpO_2) before and after ETS,
   c. suction canister pressure,
   d. the triggers for performing ETS, and
   e. use of preoxygenation; and
3. incidence of extubation or decannulation between 10:00 and 14:00 h, and whether ETS was performed before extubation.

For this study, the following definitions were used, hypoxia $PaO_2 \leq 60$ mmHg/8.0 kPa, hypercapnia $PaCO_2 \geq 50$ mmHg/6.6 kPa, decreased $SpO_2 \leq 88\%$. Routine ETS included both “routine” and “routine as per unit policy”. Preoxygenation was defined as the delivery of 100% FiO_2 for 3–6 breaths or 1–2 min before ETS was performed, and suction at extubation was defined as during the removal of the ETT or up to 5 min before extubation.

Data were entered into a single electronic database (Research Electronic Data Capture (REDcap)—Vanderbilt University, Tennessee).[20] Data were 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 were tested for normality and the mean and standard deviation (SD) are reported.

3. 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. Three of 230 patients were excluded for missing data. Baseline characteristics of the intubated patients are shown in Table 1. Compared to non-intubated patients, intubated patients were younger (54.8 years [SD = 16.2 years] versus 62.0 years [SD = 16.5 years]), had a higher APACHE II score on ICU admission (20.0 [SD = 8.0] versus 15.9 [SD = 6.9]), and 4 kg weight difference (85.2 kg [SD = 26.5] versus 81.3 kg [SD = 21.7]). More intubated patients met the criteria for sepsis on the study day (intubated patients n = 100/230 (43%), non-intubated n = 74/452 (16%)).

A total of 1891 ETS episodes were recorded on 227 intubated patients during the study day. Of these, 614 (32.5%) were considered as four consecutive ETS episodes and were analysed. There was an average of eight interventions per patient (range 1–33) in the 24 h study day period, and mean canister pressure was −337 mmHg (SD = 189).

Nineteen patients were extubated in the first 4 h of the study day (10:00–14:00); of these, 16 (84%) received ETS at the time of extubation. 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 before ETS was 68% increasing to 80% following ETS. As seen in Table 2, using the ventilator waveforms as an indicator for ETS was infrequent, and there was no record of listening for coarse crackles over the trachea.

Hypoxia (n = 33, 5.3%) and hypercapnia (n = 4, 0.7%) as measured on arterial blood gas taken prior to ETS were among the least frequent reasons for 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),

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

Patient characteristics	
Age, years mean (SD)	55 (16)
Sex (male), n (%)	141 (61%)
Weight,[a] 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; SD = standard deviation.
[a] Body weight is estimated or measured.

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Table 2
Trigger for endotracheal suction events ($n = 614$).

Triggers for endotracheal suction	*n*	%
Audible secretions	385	63%
Visible secretions	239	39%
Auscultation	142	23%
Reduced SpO_2	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%

ABG = arterial blood gas; CXR = chest X-Ray.

respectively. In contrast to the SpO_2, these were outside the normal physiological range.

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

4. 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 preoxygenation before ETS was common, that suction canister pressure was higher than recommended in CPGs and that there was inadequate patient assessment before ETS.

These results show that nursing practice in New Zealand and Australia 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 and lack of appropriate patient assessment prior to ETS. Although there are currently no guidelines about ETS best practice at extubation, the majority of patients in our study received ETS before extubation.

The most frequently cited reasons for performing ETS were audible and visible secretions and following auscultation. This is similar to other studies where the top five 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 should be assessed at least 4 hourly for indicators that ETS is needed.[12] If this was 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 positive end-expiratory pressure 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, preoxygenation prior to ETS was common, unit policy being the biggest driver. Our results showed a higher number of nurses preoxygenating patients than previous self-reported results.[28] However, nursing preoxygenation practice is consistent with described physiotherapist practice in New Zealand and Australia.[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 preoxygenation[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 on 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 −150 mmHg 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]

5. 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/coordinators 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 New Zealand and Austraila. This study will provide a platform for units to review their practice protocols and develop robust education programs for ICU nursing staff, incorporating the best available evidence.

6. Conclusions

This study highlights the need for ongoing education in ICU as practitioner education is influential in changing practice[34] and may help reduce the gap between CPG and clinical practice.

We have identified key areas where improvements can be made to ICU nursing practice. These include education about patient assessment prior to performing ETS, improved guidance regarding preoxygenation, and the need for further research about what is the best practice at the time of extubation. Improving practice in these areas may prevent patients being exposed to unsafe and potentially harmful clinical practice. The availability of high quality evidence about ETS continues to present challenges for clinicians, and the available guidelines are not being implemented into clinical practice both in our study and internationally.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.aucc.2018.03.001.

Appendix 1

List of participating sites and study investigator
Point Prevalence Study Day 9–15th September and 14th October 2015

Intensive care unit	Principal investigator/s	Research coordinator/s
Canberra Hospital	Frank van Haren	Helen Rodgers; Rebecca Millar; Mary Nourse
Middlemore Hospital	Tony Williams	Anna Tilsley
Calvary Mater Newcastle	Katrina Ellem	Katrina Ellem
Concord Hospital	Rosalba Cross	Helen Wong
Gosford Hospital	Rob Cameron	Katrina Ellis
John Hunter Hospital	Peter Harrigan	Miranda Hardie
Liverpool Hospital	Michael Parr	Sharon Micallef
Nepean Hospital	Ian Seppelt	Leonie Weisbrodt; Anne Ritchie; Maria Nikas; Rebecca Gresham
North Shore Private Hospital	Anthony Delaney	Dena-Louise Hogben; Joanna Hallam
Royal North Shore Hospital	Simon Finfer	Elizabeth Yarad; Anne O'Connor; Simon Bird; Frances Bass; Naomi Hammond
Royal Prince Alfred Hospital	David Gattas	Heidi Buhr; Debra Hutch
St George Hospital	John Myburgh	Jennene Miller; Rebecca Sidoli; Deborah Inskip
St Vincents, Sydney	Priya Nair; Hergen Buscher	Serene Leow; Claire Reynolds
Westmead Hospital	Ashoke Banerjee; Vineet Nayyar	Jing Kong
Macquarie University	Michael Parr; Anders Aneman	
Orange Hospital	Karen Smith	
Bathurst	Anne Morrison	
St Vincents Private Hospital Sydney	Sam Rudham	Serene Leow
Royal Darwin Hospital	Dianne Stephens	Jane Thomas
Auckland City Hospital—CVICU	Rachael Parke	Eileen Gilder; Keri-Anne Cowdrey; Stephnie Long
Auckland City Hospital —DCCM	Colin McArthur	Lynette Newby; Yan Chen; Rachael McConachie
Christchurch Hospital	Seton Henderson/David Knight	Jan Mehrtens
Hawke's Bay Hospital	Ross Freebairn	Lesley Chadwick
Middlemore Hospital	Alex Kazemi	Rima Song
Wellington Hospital	Dick Dinsdale	Anna Hunt; Leanlove Navarra; Raulle Cruz
North Shore Hospital - NZ	Janet Liang	Danni Hacking
Tauranga Hospital	Troy Browne	Jennifer Goodson; Julia Braid
Dunedin Hospital	Sam Rudham	Robyn Hutchison; Dawn France
Nelson Hospital	Bruce King	Jill Norton; Joy Tomlinson; Robyn Price
Princess Alexandra	Chris Joyce	Jason Meyer
Nambour	Peter Garrett	Anne Buckley; Loretta Forbes
Robina Hospital	Julio Alonso Babarro	Julie Pitman; Sharon McDowell Skaines
Flinders Medical Centre	Santosh Verghese	Elisha Matheson; Kate Schwartz
Lyell McEwin Hospital	Peter Thomas	Natalie Soar
Queen Elizabeth Hospital	Sandra Peake	Patricia Williams; Cathy Kurenda
Royal Adelaide Hospital	Stephanie O'Connor	Justine Rivett
Austin Hospital	Rinaldo Bellomo	Glenn Eastwood; Leah Peck; Helen Young
Bendigo Hospital	Jason Fletcher	Julie Smith
Cabrini	Jonathan Barrett	Gabrielle Hanlon
Geelong Hospital	Neil Orford	Tania Salerno; Allison Bone; Tania Elderkin
Royal Melbourne Hospital	Christopher Macisaac	Deborah Barge; Andrea Jordan
St Vincents, Melbourne	John Santamaria	Jennifer Holmes; Roger Smith
Western Health	Craig French	Samantha Bates; Anna Tippett
Sunshine	Craig French	Samantha Bates; Anna Tippett
Royal Perth	Ed Litton	Lizzie Jenkinson
Sir Charles Gairdner Hospital	Stuart Baker; Paul Woods; Katherine Creeper	Brigit Roberts
Rockingham General Hospital	Ravi Sonaware	
St John of God, Subiaco	Ed Litton	Janet Ferrier
Fiona Stanley	Ed Litton	Anne-Marie Palermo
St John of God, Murdoch	Adrian Regli	Anne-Marie Palermo

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