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Research paper

Factors associated with short versus prolonged tracheostomy length of cannulation and the relationship between length of cannulation and adverse events

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ABSTRACT

Background: Tracheostomy management and care is multifaceted and costly, commonly involving complex patients with prolonged hospitalisation. Currently, there are no agreed definitions of short and prolonged length of tracheostomy cannulation (LOC) and no consensus regarding the key factors that may be associated with time to decannulation.
Objectives: The aims of this study were to identify the factors associated with short and prolonged LOC and to examine the number of tracheostomy-related adverse events of patients who had short LOC versus prolonged LOC.
Methods: A retrospective observational study was undertaken at a large metropolitan tertiary hospital. Factors known at the time of tracheostomy insertion, including patient, acuity, medical, airway, and tracheostomy factors, were analysed using Cox proportional hazards model and Kaplan–Meier survival curves, with statistically significant factors then analysed using univariate logistic regression to determine a relationship to short or prolonged LOC as defined by the lowest and highest quartiles of the study cohort. The number of tracheostomy-related adverse events was analysed using the Kaplan–Meier survival curve.
Results: One hundred twenty patients met the inclusion criteria. Patients who had their tracheostomy performed for loss of upper airway were associated with short LOC (odds ratio [OR]: 2.30 (95% confidence interval [CI]: 1.01–5.25) $p = 0.049$). Three factors were associated with prolonged LOC: an abdominal/gastrointestinal tract diagnosis (OR: 5.00 [95% CI: 1.40–17.87] $p = 0.013$), major surgery (OR: 2.51 [95% CI: 1.05–6.01] $p = 0.038$), and intubation for >12 days (OR: 0.30 [95% CI: 0.09–0.97] $p = 0.044$). Patients who had one or ≥2 tracheostomy-related adverse events had a high likelihood of prolonged LOC (OR: 5.21 [95% CI: 1.95–13.94] $p = \leq 0.001$ and OR: 12.17 [95% CI: 2.68–55.32] $p \leq 0.001$, respectively).
Conclusion: Some factors that are known at the time of tracheostomy insertion are associated with duration of tracheostomy cannulation. Tracheostomy-related adverse events are related to a high risk of prolonged LOC.

1. Introduction

Tracheostomy insertion is a common procedure which is performed in up to 11% of critically ill patients,[1,2] enabling prolonged invasive mechanical ventilation, bypassing known upper airway obstruction, minimising aspiration, and/or enabling suctioning.

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Patients requiring tracheostomy are a high-risk population with a variety of associated medical conditions including respiratory failure, neurological disease, spinal cord injury, head and neck tumours, and major surgery. Risks and potential complications surrounding tracheostomy care include loss of airway, catastrophic bleeding, infection, and death.[3–7] This patient group has a significant mortality rate of approximately 15–26%.[1,8,9] Although the cause of death is usually related to the underlying condition rather than the procedure itself,[4,8,9] adverse events are common and may be preventable.[5,10–12] Patients who require a tracheostomy for prolonged mechanical ventilation often have a protracted length of stay (LOS).[13] The implementation of a multidisciplinary tracheostomy team has been shown to improve clinical outcomes including reducing the length of tracheostomy cannulation (LOC), increasing the use of a one-way speaking valve, reducing adverse events, and reducing time to decannulation.[14–18] These outcomes of various aspects of tracheostomy management have previously been reported, including patient groups receiving a tracheostomy,[1,19] successful decannulation in adults[19–21] and children,[22,23] as well as mortality.[24–26] Additionally, a small number of studies investigating time to decannulation have been published.[13,24,27–29] However, these have occurred in homogenous patient groups, specific clinical population, and paediatric populations, limiting generalisability. There has also been considerable variation in the type and number of factors that have been examined. Understanding the factors associated with short and prolonged LOC in an adult population would be valuable to clinicians for planning targeted care and allocating necessary resources. Additionally, although the prevalence of tracheostomy-related adverse events is well documented,[10,30,31] there is limited literature that explores the relationship between the duration of tracheostomy cannulation and the risk of tracheostomy-related adverse events.

Currently, there are no agreed definitions of short and prolonged LOC and no consensus regarding the key factors that may be associated with time to decannulation. This study aimed to identify the factors associated with short and prolonged LOC and to examine the number of tracheostomy-related adverse events of patients who had short LOC versus prolonged LOC.

2. Materials and methods

A retrospective observational cohort study was undertaken, with patient data collected between August 2015 and July 2017, evaluating time to tracheostomy decannulation and factors associated with early and prolonged LOC. This study is reported according to the Strengthening the Reporting of Observational Studies Guidelines: The STROBE Checklist.[32] The inclusion and exclusion criteria are outlined in Fig. 1. Participants who died, were transferred, or discharged from the facility before tracheostomy decannulation were excluded. Approval was obtained from the Austin Health Research Ethics Committee (LNR/17/Austin/210) before the commencement of this study. Austin Health data were extracted from the GTC Tracheostomy Database using the export data tool via http://redcap.vanderbilt.edu and the patient medical record (Table 1). The Tracheostomy Review and Management Service (TRAMS) at Austin Health, Melbourne, is an early adopter of a team-based tracheostomy care model[14] and is a founding member of the Global Tracheostomy Collaborative (GTC).[31,33–36] The GTC have developed a comprehensive database that can be analysed at a site level and allows benchmarking against other member hospitals.[31] The database contains data fields including demographics, admission details, comorbidities, tracheostomy insertion, tracheostomy-related adverse events, decannulation, survival, and discharge.[31] All patients with a tracheostomy at the Austin Hospital routinely have their data entered in the GTC tracheostomy database, excluding acute ENT patients and patients readmitted with a tracheostomy under the Victorian Respiratory Support Service (long-term ventilation patients). It can be noted that the head and neck cohort included in this study were admitted under the Maxillo-Facial Unit and therefore their data were entered into the database. Data entry into the database was undertaken by a limited number of dedicated clinicians trained in relevant methods and processes to support data quality.

The primary outcome measure was time to decannulation, specifically, the number of days from tracheostomy insertion to decannulation. Although 'delayed decannulation' has previously been described as occurring after 10 days in a head and neck population,[27] this is not widely accepted in the literature, and currently there are no established definitions of short and prolonged LOC, or early and late decannulation in the literature. Therefore, in this study, we referenced the highest and lowest quartiles of the data set to define 'short LOC' as $\leq$12 days (the lower quartile) and 'prolonged LOC' as $\geq$30 days (the upper quartile). Patients at our health service follow a multifaceted decannulation pathway (Supplementary Material e1). Successful decannulation was defined as not requiring recannulation for a period of >72 h after tracheostomy removal, consistent with expert consensus opinion[37]. Seventeen factors were examined based on those that are known at the time of tracheostomy insertion. These factors were categorised into five groups: (i) patients factors, (ii) acuity factors, (iii) medical factors, (iv) airway factors, and (v) tracheostomy factors. These factors either have

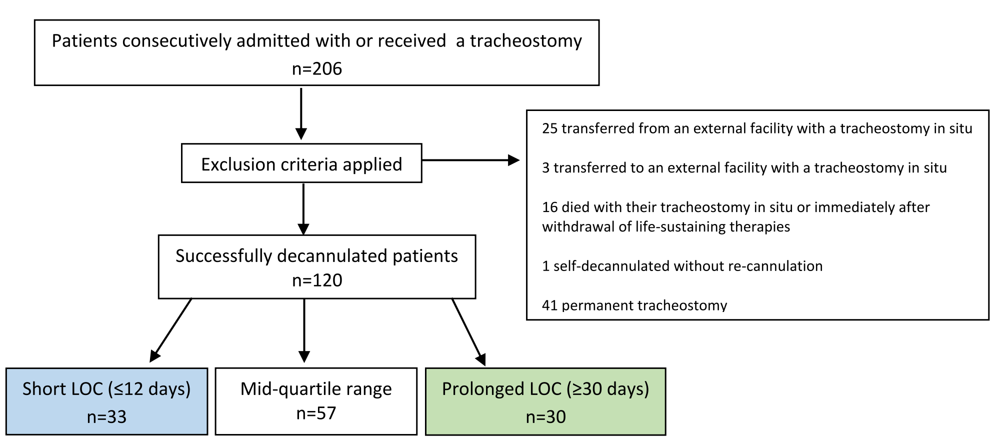

Fig. 1. Patient selection and study flow. LOC = length of tracheostomy cannulation.

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Table 1
Descriptive characteristics of study cohort.

Variables	n	Mean/median/%	SD/IQR
Patient	120		
Male[b]	68	57%	
Language other than English[c]	21	17%	
Age[b]	120	56	17
BMI[b]	79	30	16
Acuity	120		
Number of complications[c]	120	2.8	2
Charlson Comorbidity Index[d]	120	3.5	2
Duration of ICU admission (days)[a,b]	120	19^	7-31^
APACHE III[b]	120	56	24
APACHE III ROD[c]	120	0.26	0.24
Medical	120		
Diagnostic group[b]			
Head and neck	36	30%	
Cardiac surgery	23	19%	
Abdominal/GIT	18	15%	
Neurological	14	12%	
Trauma/spinal	9	8%	
Respiratory/thoracic/oesophageal	14	12%	
Other	6	5%	
Underwent major surgery[b]	86	72%	
Airway	120		
Airway anatomy[b]			
No known atypical airway issues	91	76%	
Difficult airway (excess adipose tissue)	4	3%	
Vocal fold paralysis	4	3%	
Other	21	18%	
Airway grade[b]			
I	52	43%	
II-IV	25	21%	
Unknown	43	36%	
Duration of intubation (days)[a,b]	120	8^	1-11^
Failed extubation[c]	18	15%	
Duration of invasive MV (days)[a,b]	120	14^	4-24^
Reason for tracheostomy insertion[b]			
Ventilation	79	66%	
Loss of upper airway	41	34%	
Tracheostomy	120		
Urgency of insertion[b]			
Elective	117	98%	
Emergency	3	3%	
Type of insertion[b]			
Percutaneous	30	25%	
Surgical	90	75%	
Tracheostomy-related adverse events[b]			
Yes	35	0.39	
0	85	71%	
1	26	22%	
≥2	9	8%	
Tube obstruction with secretions	9		
Excessive bleeding	9		
Malpositioned tube	7		
Accidental decannulation	6		
Significant skin breakdown	3		
Failed decannulation	3		
Major cuff issue—leak or overinflation	3		
One-way valve placement with cuff inflated	2		

BMI = body mass index; ICU = intensive care unit; MV = mechanical ventilation; SD = standard deviation; IQR = interquartile range; APACHE = Acute Physiology and Chronic Health Evaluation; ROD = risk of death; GIT = gastrointestinal tract.
[a] Median/interquartile range.
[b] Data extracted from GTC database.
[c] Data extracted from Medical Record.
[d] Derived from data extracted from Medical Record.

previously been examined in previous studies[13,27,28] and/or were deemed to be of clinical interest as per expert opinion[33,34,37,38] (Table 1).

Statistical analyses were performed using Stata, version 12.1 (StataCorp LP, College Station TX, USA). Descriptive statistics were calculated, using mean, percentage, and standard deviation for normally distributed variables and median and interquartile range for nonparametric data. The Cox proportional hazards model was applied to establish any relationships between factors and LOC. Factors associated with LOC with a p value of ≤ 0.1 were then analysed using univariate logistic regression to examine their relationships to being decannulated early or late. Confidence intervals (CIs) were calculated for the Cox proportional hazards model and univariate logistic regression to reflect the range in which the results were within. Kaplan–Meier survival curves were created to examine the relationship between specific factors and

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the duration of tracheostomy cannulation. A p value of 0.05 or less was accepted as statistically significant.

3. Results

During the study period, 206 adult patients were admitted to Austin Health and underwent a tracheostomy. One hundred twenty patients met the inclusion criteria (**Fig. 1**), comprised of a mix of critically ill patients who had a tracheostomy inserted, and those who had a planned tracheostomy insertion associated with their surgical admission. Characteristics of the cohort (n = 120) are reported in Table 1. The average number of tracheostomy days was 24 (range: 6–110). Fifty-five patients (46%) were decannulated in the intensive care unit (ICU), with the remaining 65 patients (54%) decannulated on the ward. Thirty-three patients (28%) had short LOC (lower quartile), and 30 patients (25%) had prolonged LOC (upper quartile). Fifty-seven patients (48%) were within the middle quartile range. The majority of the study cohort (72%) had undergone major surgery (mostly head and neck or cardiac), with neurological and respiratory conditions also common (Table 1). The mean number of medical complications patients experienced within 24 h of tracheostomy insertion was 2.8 (standard deviation: 2), with the most common complications being cardiovascular and neurological (Table 2). Thirty-five patients (29%) experienced at least one tracheostomy-related adverse event before decannulation.

3.1. Factors associated with the length of cannulation

Cox proportional hazards model (hazard ratio) analysis revealed six factors associated with the LOC that were included in logistic regression models of short and prolonged LOC. These were (i) having an abdominal/gastrointestinal tract (GIT) admission diagnosis, (ii) having had major surgery during the admission before the tracheostomy insertion, (iii) duration of intubation (days), (iv) experiencing medical complications within the 24 h before tracheostomy insertion, (v) a neurological admission diagnosis, and (vi) tracheostomy insertion primarily for loss of upper airway. On average, patients who had a tracheostomy inserted for loss of airway rather than ventilation were decannulated 8 days earlier (Fig. 2) (14 versus 22 days, $p \leq 0.001$). The number of days to decannulation was increased in those patients who had at least one tracheostomy-related adverse event compared with those without events (Fig. 3), with the median number of tracheostomy days of 30 and 15 days, respectively ($p \leq 0.001$).

3.2. Factors associated with short and prolonged length of cannulation

Univariate logistic regression was used to examine these six factors for their relationship with short and prolonged LOC in this cohort (Table 3).

Table 2
Most frequent complications.

Complication category	n	% of cohort[a]
Cardiovascular	42	35%
Neurological	36	30%
Renal	28	23%
Fever/infective	26	22%
Metabolic	19	16%
Respiratory	18	15%
Abdominal/gastrointestinal	11	9%
Other	10	8%

[a] 29% of cohort (n = 35/120) had more than one complication.

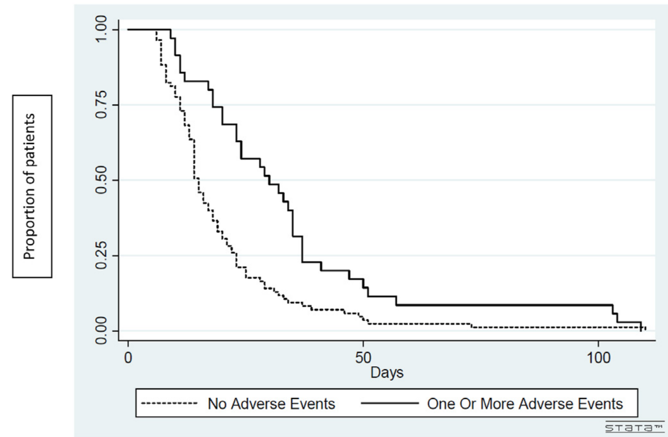

Fig. 2. Kaplan–Meier survival curve of length of cannulation with and without tracheostomy-related adverse events.

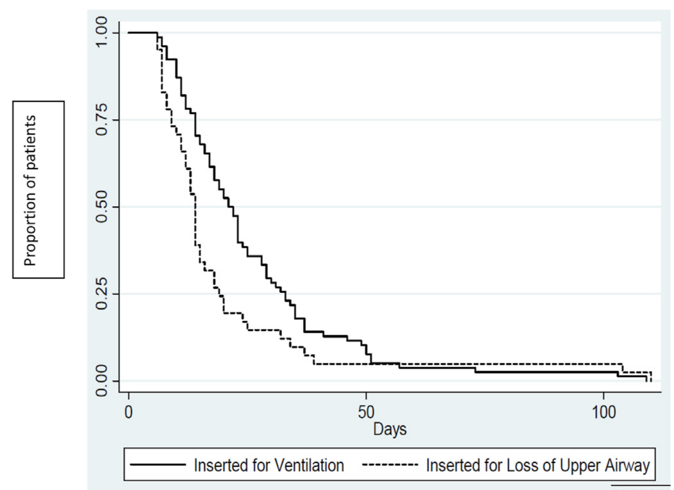

Fig. 3. Kaplan–Meier survival curve of length of cannulation and reason for tracheostomy insertion.

3.3. Short length of cannulation

Patients who had their tracheostomy inserted for loss of upper airway were associated with 2.3 higher odds of short LOC than those who had a tracheostomy inserted primarily for ventilation (odds ratio [OR]: 2.30 [95% CI: 1.01–5.25] p = 0.049). Patients who were admitted with a neurological diagnosis were found to be less likely than the head and neck reference group to have short LOC (OR: 0.22 [0.04–1.11] p = 0.068); however, this was not statistically significant.

3.4. Prolonged length of cannulation

The occurrence of $\geq$2 medical complications within 24 h before tracheostomy insertion, having had major surgery, an abdominal/GIT admission diagnosis, and prolonged duration of intubation were all associated with prolonged LOC. Patients in this cohort who were admitted with an abdominal/GIT diagnosis demonstrated five times higher odds of prolonged rather than short LOC (OR: 5.00 [95% CI: 1.40–17.87] p = 0.013). Patients who had major surgery in their admission before their tracheostomy insertion were 2.51 times more likely to have prolonged LOC (OR: 2.51 [95% CI: 1.05–6.01] p = 0.038). The odds of a patient having short LOC reduced as the

Table 3
Analysis of factors associated with length of cannulation.

Variables	Hazard ratio (95% CI)	p
Patient		
Sex	0.97 (0.70–1.40)	0.855
Age	1.00 (0.99–1.01)	0.470
BMI	1.00 (0.99–1.01)	0.569
Acuity		
Number of complications	0.92 (0.84–1.01)	0.084
Charlson Comorbidity Index	0.98 (0.92–1.06)	0.661
Duration of ICU admission (days)	0.97 (0.96–0.98)	≤0.0001
APACHE III	1.00 (0.99–1.01)	0.683
APACHE III ROD	1.68 (0.77–3.66)	0.191
Medical		
Diagnostic group – head and neck[a]		
Cardiac surgery	0.72 (0.42–1.23)	0.233
Abdominal/GIT	0.54 (0.30–0.96)	0.036
Neurological	0.59 (0.31–1.10)	0.098
Trauma/spinal	1.07 (0.51–2.27)	0.855
Respiratory/thoracic/oesophageal	0.88 (0.47–1.64)	0.679
Other	0.87 (0.37–2.09)	0.760
Underwent major surgery	0.62 (0.41–0.93)	0.021
Airway		
Airway anatomy—no known atypical airway issues[a]		
Difficult airway (excess adipose tissue)	0.69 (0.25–1.87)	0.462
Vocal fold paralysis	0.63 (0.23–1.74)	0.374
Other	1.09 (0.66–1.77)	0.745
Airway grade—I[a]		
II	1.29 (0.71–2.34)	0.399
III	0.54 (0.23–1.28)	0.161
IV	1.18 (0.43–3.29)	0.748
Unknown	1.06 (0.70–1.59)	0.789
Duration of intubation (days)	0.96 (0.93–0.99)	0.010
Failed extubation	1.15 (0.70–1.91)	0.581
Duration of invasive MV (days)	0.97 (0.96–0.98)	≤0.0001
Reason for tracheostomy insertion—ventilation[a]		
Loss of upper airway	1.54 (1.05–2.27)	0.028
Other	0.48 (0.07–3.48)	0.469
Tracheostomy		
Urgency of insertion	1.32 (0.58–2.97)	0.508
Insertion technique—percutaneous[a]		
Surgical	1.10 (0.73–1.70)	0.640
Tracheostomy-related adverse events	0.63 (0.48–0.83)	0.001

MV = mechanical ventilation; APACHE = Acute Physiology and Chronic Health Evaluation; ROD = risk of death; BMI = body mass index; ICU = intensive care unit; GIT = gastrointestinal tract; CI = confidence interval.
[a] Reference group (head & neck).

duration of intubation days increased, with patients who were intubated for 12–27 days having odds of 0.30 of being decannulated ≤12 days (OR: 0.30 [95% CI: 0.09–0.97] p = 0.044). Conversely, this patient group were 4.5 times more likely to have prolonged LOC (OR: 4.58 [95% CI: 1.27–16.57] p = 0.02). Patients who experienced ≥2 medical complications within 24 h of their tracheostomy insertion had four times higher odds of being decannulated ≥30 days (OR: 4.04 [95% CI: 0.87–18.67] p = 0.074) than those patients who had none; however, this was not statistically significant.

3.5. Tracheostomy-related adverse events

Most patients had no tracheostomy-related adverse events (n = 85; 71%); however, those patients who had one adverse event were five times more likely to have prolonged LOC (OR: 5.21 [95% CI: 1.95–13.94] p = ≤0.001). Patients who had two or more adverse events were more than 12 times more likely to have prolonged LOC than those who had no adverse events (OR: 12.17 [95% CI: 2.68–55.32] p ≤ 0.001) (Table 4).

4. Discussion

Patients requiring a tracheostomy often have prolonged hospital admissions and related costs,[13,14] increased morbidity and mortality,[5,10,29] tracheostomy-related adverse events,[9] and medical complications.[3,4,6] This study identified one factor that is associated with short LOC and four factors associated with prolonged LOC. The potential value-add of these findings is twofold: (i) anticipated resource allocation and (ii) a targeted approach to clinical care.

For patients who had their tracheostomy inserted for loss of upper airway where short LOC is anticipated, a targeted rapid approach to tracheostomy management could assist in minimising complications and rapid discharge planning to reduce hospital LOS. This could include interventions such as the provision of preoperative patient education and expedited tracheostomy ward rounds. Additionally, the provision of targeted education to staff caring for patients with a tracheostomy would support follow through of therapeutic recommendations. These therapeutic recommendations could include early cuff deflation and one-way speaking valve use which has been shown to improve cough strength and secretion management,[39] improve swallow function,[40,41] reduce aspiration,[39] and enable phonation[42,43] through the restoration of airflow through the upper airway.

Where time to decannulation is expected to be prolonged, multidisciplinary management with a focus on early intervention and restorative therapies and early planned discharge to a step-down or rehabilitation setting with the tracheostomy in situ may be advantageous. This may require additional educational support

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Table 4
Univariate logistic regression.

Variables	Short (≤12 days) (n = 33)		Prolonged (≥30 days) (n = 30)	
	OR (95% CI)	p	OR (95% CI)	p
Acuity				
Duration of ICU admission (days)	0.95 (0.92–0.98)	≤0.001	1.05 (1.03–1.07)	≤0.001
0–7[a]				
9-19	0.55 (0.20–1.54)	0.254	1.33 (0.27–6.53)	0.723
20-30	0.21 (0.83–0.82)	0.022	1.44 (0.29–7.08)	0.654
31-69	0.03 (0.00–0.29)	0.002	15.55 (3.81–63.36)	≤0.001
Medical complications				
0[a]				
1	0.38 (0.10–1.45)	0.158	3.85 (0.65–22.86)	0.139
≥2	0.27 (0.01–0.73)	0.010	4.04 (0.87–18.67)	0.074
Medical				
Diagnostic group				
Head and neck[a]				
Cardiac surgery	0.49 (0.15–1.63)	0.247	1.76 (0.49–6.34)	0.384
Neurological	0.22 (0.04–1.11)	0.068	2 (0.47–8.56)	0.350
Trauma/spinal[b]	0.98 (0.27–3.56)	0.979		
Respiratory/thoracic/oesophageal	0.22 (0.02–1.97)	0.176	2 (0.47–8.56)	0.350
Abdominal/GIT	0.98 (0.27–3.56)	0.979	5.00 (1.40–17.87)	0.013
Other	0.88 (0.14–5.51)	0.895	1 (0.10–10.17)	1.000
Underwent major surgery	0.93 (0.38–2.28)	0.874	2.51 (1.05–6.01)	0.038
Airway				
Duration of intubation (days)	0.95 (0.91–1.00)	0.048	1.09 (1.02–1.17)	0.013
0–1[a]				
2-7	0.57 (0.18–1.84)	0.347	3.00 (0.73–12.27)	0.126
8-11	0.41 (0.14–1.16)	0.092	2.50 (0.69–9.06)	0.163
12-27	0.30 (0.09–0.97)	0.044	4.58 (1.27–16.57)	0.020
Duration of invasive MV (days)	0.98 (0.97–0.99)	0.006	1.11 (1.06–1.17)	≤0.001
0–4[a]				
5-14	0.72 (0.26–2.00)	0.530	0.96 (0.18–5.20)	0.966
15-23	0.20 (0.55–0.72)	0.013	1.57 (0.32–7.73)	0.582
24-109	0.12 (0.29–0.47)	0.003	15 (3.73–60.28)	≤0.001
Reason for tracheostomy insertion				
Ventilation[a]				
Loss of upper airway	2.30 (1.01–5.25)	0.049	0.41 (0.15–1.11)	0.079
Tracheostomy				
Tracheostomy adverse event(s)	1.91 (0.89–4.12)	0.098	4.01 (2.02–7.97)	≤0.001
0[a]				
1	0.51 (0.17–1.50)	0.222	5.21 (1.95–13.94)	≤0.001
≥2	0.27 (0.03–2.26)	0.226	12.17 (2.68–55.32)	≤0.001

ICU = intensive care unit; GIT = gastrointestinal tract; MV = mechanical ventilation; OR = odds ratio; CI = confidence interval.
[a] Reference group (head & neck).
[b] No eligible patients for late decannulation data set.

and/or training to staff in those areas to support safe tracheostomy management.

4.1. Airway factors

Consistent with earlier research,[13] the 41 patients in this study with a tracheostomy inserted for loss of upper airway were more than twice as likely to have short LOC than those who had the tracheostomy inserted for ventilation. Most of these tracheostomies were performed to manage perioperative loss of the upper airway due to swelling and oedema during maxillofacial surgery, which usually resolves rapidly, resulting in restoration of airway patency and earlier decannulation.

Prolonged intubation was associated with prolonged LOC. These results are unsurprising, given Austin Health's specialist units treating high-acuity populations, such as Victorian Spinal Cord Service and the Victorian Ventilation Weaning Unit, where prolonged and sometimes indefinite ventilation can be required, and therefore, the time to decannulation can be protracted.[44,45] The need for prolonged LOC to enable invasive ventilation is driven by the underlying conditions but demonstrates the need to plan for involvements of ventilator weaning services, long-term acute care, or community respiratory support for this population.[43]

4.2. Acuity factors

Acuity factors, including Acute Physiology and Chronic Health Evaluation (APACHE) III scores, derived at ICU admission were not predictive of duration of tracheostomy cannulation. Additionally, in contrast to the findings of Isaac et al.[27] in a head and neck population, there was no relationship between the Charlson Comorbidity Index and time to decannulation in the present study. This may be attributable to the sample size and patient mix of this cohort.

4.3. Medical factors

In the present study, those who underwent major surgery were two and a half times more likely to have prolonged LOC than those who did not. Whilst prolonged ventilation is uncommonly required for patients after major surgery, for those patients in whom it is

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necessary, tracheostomy is frequently performed.[46–48] Patients in this cohort who were admitted with an abdominal/GIT diagnosis demonstrated five times higher odds of having prolonged LOC than short LOC. It is unsurprising that these patients with complex abdominal/GIT disease and/or sepsis required prolonged ICU support with longer ventilation duration and reliance on their tracheostomy, resulting in a later decannulation. In absolute terms, patients who were admitted with a neurological diagnosis were found to be less likely than the H&N reference group to undergo earlier decannulation (OR: 0.22 [0.04–1.11] $p = 0.068$), although this result did not achieve significance. This is reflective of the population who are referred to the Victorian Spinal Cord Unit and the Victorian Ventilation Weaning Unit who often have a neurological and/or neuromuscular diagnosis, such as Guillain-Barre syndrome, which requires prolonged ventilatory weaning and extended tracheostomy days, with high success rate of weaning and low mortality.[44]

4.4. Patient factors

In homogeneous populations, time to decannulation has been associated with older age in a head and neck population[27] and with age and male sex in patients who had a tracheostomy inserted for prolonged ventilation.[28] In this study, however, no demographic factors were associated with short or prolonged LOC. This is consistent with other research in general ICU patients[13] and is likely explained by the heterogeneity of the cohort and the smaller samples within each group. Although the presence of a tracheostomy in an obese population has previously been associated with perioperative and postoperative complications[49–51] and mortality,[44,52] it was not associated with prolonged LOC in our study for the 42% of the group who were obese.

4.5. Tracheostomy-related adverse events

More than two-thirds of patients did not experience any tracheostomy-related adverse events. The complication rate is consistent with previous reports[3,10,31] and is associated with LOC. This suggests that there may be opportunities to develop interventions that reduce LOC and minimise the risk of tracheostomy-related harm.

4.6. Study limitations

Although this study demonstrated some valuable findings, there are several limitations to note. The retrospective methodology undertaken at a single tertiary metropolitan hospital limits the generalisability of the study findings. There were also small patient numbers in some diagnostic category subgroups. Despite this, we are confident that the results of this study indicate a strong signal of the factors that are associated with LOC. Although a single site, Austin Health is a large and internationally recognised leader in research and clinical care provision, with specialty state-wide services such as liver transplantation, spinal cord injury, and a prolonged ventilator weaning service and an established multidisciplinary tracheostomy team and model of care. Patients at our health service follow a multifaceted decannulation pathway (Supplementary Material e1), and there is considerable multidisciplinary input surrounding readiness for decannulation.

4.7. Future directions

Future directions include the development of a prediction model of short and prolonged LOC in a larger prospective cohort. A multisite study design would also increase the power of the study and its findings to support wider applicability. Further exploration of tracheostomy-related adverse events and the level of harm would be advantageous to modify clinical practices, minimise risk, and reduce LOS.

5. Conclusion

LOC can be predicted by a number of factors, some of which are known early in a patient's admission and at the time of tracheostomy insertion. The results of this study can assist clinicians to anticipate potential LOC for different patient groups, informing patients of the likely course of their care and assisting them to make informed decisions about undertaking treatment that is likely to result in tracheostomy placement. Understanding outcomes for specific diagnostic groups can also assist in the design of efficient inpatient pathways and allocation of resources. Patients who are predicted to have short LOC, for example, could follow a rapid discharge pathway shortening LOS, and those who are predicted to need prolonged LOC could have discharge planning hastened and alternative management options, such as transfer to an appropriate rehabilitation hospital or community care setting considered earlier in the admission. Lastly and importantly, identifying preventable tracheostomy-related adverse events can provide a target for improvement by implementing specific education and training, protocol-driven bundles of care, and standardisation of equipment and procedures, thus improving the quality and safety of tracheostomy care and reducing the likelihood of prolonged tracheostomy.

CRediT authorship contribution statement

Charissa J Zaga: Conceptualisation, Methodology, Investigation, Data curation, Writing – original draft, Writing – review & editing, Project administration. **Joanne M Sweeney**: Conceptualisation, Methodology, Writing – original draft, Writing – review & editing. **Tanis S Cameron**: Conceptualisation, Methodology, Writing – review & editing. **Matthew C Campbell**: Writing – review & editing. **Stephen J Warrillow**: Methodology, Writing – review & editing. **Mark E Howard**: Conceptualisation, Methodology, Formal analysis, Data curation, Writing – review & editing, Supervision.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.aucc.2021.09.003.

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