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RESEARCH ARTICLE

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Utilization and outcomes of tracheostomies in the intensive care unit in Iceland in 2007–2020: A descriptive study

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Abstract

Background: Tracheostomies are commonly utilized in ICU patients due to prolonged mechanical ventilation, upper airway obstruction, or surgery in the face/neck region. However, practices regarding the timing of placement and utilization vary. This study provides a nationwide overview of tracheostomy utilization and outcomes in the ICU over a 14-year period.

Methods: A retrospective study including all patients that received a tracheostomy during their ICU stay in Iceland between 2007 and 2020. Data were retrieved from hospital records on admission cause, comorbidities, indication for tracheostomy insertion, duration of mechanical ventilation before and after tracheostomy placement, extubation attempts, complications, length of ICU and hospital stay and survival. Descriptive statistics were provided, and survival analysis was performed using Cox regression.

Results: A total of 336 patients (median age 64 years, 33% females) received a tracheostomy during the study period. The most common indication for tracheostomy insertion was respiratory failure, followed by neurological disorders. The median duration of mechanical ventilation prior to tracheostomy insertion was 9 days and at least one extubation had been attempted in 35% of the cases. Percutaneous tracheostomies were 32%. The overall rate of complications was 25% and the most common short-term complication was bleeding (5%). In-hospital mortality was 33%. The one- and five-year survival rate was 60% and 44%, respectively.

Conclusions: We describe a whole-nation practice of tracheostomies. A notable finding is the relatively low rate of extubation attempts prior to tracheostomy insertion. Future work should focus on standardization of assessing the need for tracheostomy and the role of extubation attempts prior to tracheostomy placement.

KEYWORDS
intensive care, intensive care unit, mechanical ventilation, tracheostomy

Editorial Comment

This report describes recent clinical practice regarding utilization of tracheostomies in a well-defined population across a small country. The authors have assessed a range of patient factors and extubation attempts or process in this context.

1 | INTRODUCTION

Tracheostomy is a common procedure performed in patients requiring prolonged invasive ventilation in the intensive care unit (ICU). While the majority are performed due to anticipated prolonged mechanical ventilation in acute illness, a portion is performed due to upper airway obstruction or surgery in the face/neck region.[1] Tracheostomies have many perceived advantages over prolonged endotracheal intubation, including increased patient comfort, reduced sedative use and easier patient mobilization. They also facilitate ventilatory weaning by easing bronchopulmonary suction and decreasing airway resistance and dead space.[2] There are several potential complications to the procedure that can be divided into short-term and long-term/post-decannulation complications. The most frequent short-term complications are usually minor, such as bleeding and wound infections. However, serious and even life-threatening complications can occur, such as tube blockage, tube misplacement during the procedure itself and tube dislodgement after insertion.[3] Examples of long-term complications include tracheomalacia and tracheal stenosis.[4,5]

Today, both surgical and percutaneous techniques for tracheostomy insertion are used, and the overall complication rate is similar, except for infections which are more common with open surgical tracheostomies.[6–10] The optimal timing of the procedure is a subject of controversy and recent systematic reviews and meta-analyses of randomized controlled trials comparing early and late tracheostomies have shown conflicting results. While some studies have indicated that early tracheostomy can be associated with shorter ICU stay, shorter duration of mechanical ventilation, lower incidence of ventilator-associated pneumonia (VAP) and less need for sedation, other studies did not show any differences.[6,11–18]

The main aim of this study was to provide a detailed overview of tracheostomy utilization in critically ill patients, in particular indications for tracheostomy insertion and extubation trials performed prior to tracheostomy, timing of the procedure and duration of tracheostomy utilization. We also aimed to provide information about short- and long-term complications and overall survival of the cohort.

2 | MATERIAL AND METHODS

Before the study started an approval was obtained from the Institutional Review Board of Landspitali and the National Bioethics Committee (VSNb2020020008/03.01) that waived individual consent. This was a retrospective cohort study including all patients 3 months and older that received a tracheostomy during their ICU stay at Landspitali—the National University Hospital of Iceland and Akureyri Hospital between 1st of January 2007 and 31st of December 2020, with follow-up through February 9th 2021. These are the only two hospitals in Iceland that offer intensive care with invasive ventilation. Patients that received a tracheostomy as a part of a planned surgical procedure were excluded from the analysis as well as patients with unknown duration of mechanical ventilation, length of stay in the hospital or ICU and survival status at follow-up.

Prior to 2017, ventilatory weaning was mostly based on daily spontaneous breathing trials but in 2017 a new sedation protocol was introduced that focused on reduced baseline levels of sedation by a shifted emphasis on the prevention of pain, agitation and delirium rather than focusing on sedation alone. The decision to extubate a patient was ultimately a clinical decision factoring in the level of consciousness, ventilatory settings, secretions and a clinical estimate of the need for ventilatory support. During removal, a 4 mm inner diameter mini-tracheostomy (Portex® Mini-Trach® II Kit) was occasionally inserted to facilitate access to the airway for suctioning.

Information was collected from hospital records on age, sex, admission cause, length of ICU and hospital stay and place of discharge (home vs. rehabilitation vs. skilled nursing facility). Furthermore, information regarding the indication for tracheostomy insertion, the duration of mechanical ventilation prior to and following tracheostomy and number of extubation attempts preceding tracheostomy was registered. Severity of illness at ICU admission was assessed using the APACHE II scoring system[19] and the van Walraven-modified Elixhauser comorbidity index[20] was used to estimate the comorbidity burden at admission. Data from repeated ICU admissions during the same hospital stay were combined, including duration of mechanical ventilation and ICU length of stay. For readmitted patients, the cause of readmission was classified as related to a respiratory problem or due to other causes. Patients with missing APACHE II score (23 patients) and Elixhauser comorbidity index (six patients) were included in the analysis without imputation of missing values.

Based on our patient population, indications for tracheostomy insertion were categorized into respiratory failure, neurological diseases, ENT (ear-nose and throat)-related disorders, burns and anticipated prolonged mechanical ventilation after cardiac arrest. Most tracheostomies in our ICUs are performed by either ENT or cardiothoracic surgeons using surgical or percutaneous technique, but a handful of tracheostomies were performed by anesthesiologists using the percutaneous technique.

Both short- and long-term complications related to the procedure were registered from hospital charts. Short-term complications included bleeding, tube blockage, leak that required intervention, misplacement of the tube during the procedure or dislodgement shortly thereafter. Additionally, short-term complications were divided into early (≤48 h from insertion) and late (>48 h from insertion). Long-term complications were categorized into tracheal stenosis, dysphagia, and other long-term complications.

Major complications were defined as death due to a tracheostomy complication, major bleeding, tube blockage that resulted in substantial change in vital signs and tube misplacement or dislodgement.

The duration of tracheostomy utilization was defined as the number of days from insertion until the tracheostomy tube was removed. In cases were the tracheostomy tube needed to be reinserted, the number of days with a tracheostomy were combined.

2.1 | Statistical analysis

Statistical analysis was performed in R studio version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria). Non-normally distributed data was presented as median and interquartile range (IQR) and compared using the Mann–Whitney test. Survival was presented with Kaplan–Meier curves and compared using the long-rank test. To estimate the effect of early (≤7 days of mechanical ventilation) versus late (≥8 days of mechanical ventilation) tracheostomy insertion on mortality, a multivariate Cox regression model was used, adjusting for age and Elixhauser and APACHE II values. The age variable was stratified to meet the proportionality assumption. Results were presented as hazard ratios (HR) with a 95% confidence interval.

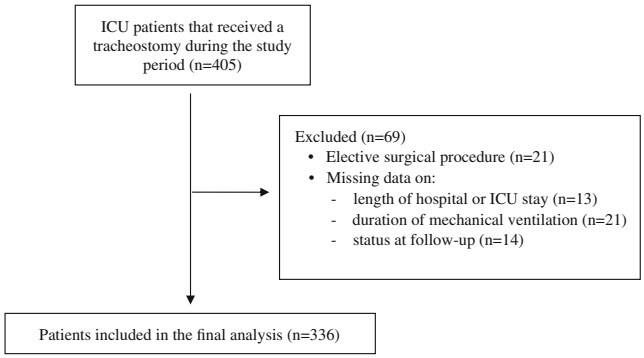

FIGURE 1 Flow of patients included and excluded in the study

3 | RESULTS

Tracheostomy was performed on 405 ICU patients during the study period. After excluding patients with missing data ($N = 48$) and those admitted after a planned surgical procedure ($N = 21$) a total of 336 patients were included in the final analysis (see Figure 1). A total of 22,988 patients were admitted to the ICU during the study period so the percentage of patients receiving a tracheostomy was 1.46%. Basic patient demographics by indication are shown in Table 1.

The median duration of mechanical ventilation before tracheostomy insertion was 9 days (IQR 5–13) and this did not change over the course of the study period. The number of patients that got an early (≤7 days of mechanical ventilation) and late (≥8 days of mechanical ventilation) tracheostomy was 135 (40%) and 201 (60%), respectively.

Six patients (2%) were not intubated prior to tracheostomy insertion. This was due to unanticipated difficult airway situations where orotracheal intubation was not successful and an acute tracheostomy needed to be inserted. In 22 patients (6%), a tracheostomy procedure was performed on the same day as the first endobronchial intubation. In these patients, a difficult airway and/or prolonged need of tracheostomy was anticipated, for example in patients with severe facial trauma, neurodegenerative disorders or cancer in the face or neck region. In five of those cases, mechanical ventilation was never required.

A total of 119 patients (35%) received a tracheostomy after one or more failed extubations. The median duration of each extubation trial until reintubation was between 0 and 2 days (see Table 2). The proportion of patients who had at least one extubation trial was

TABLE 1 Basic characteristics of all patient groups. Data presented as median values (interquartile range)

	All patients ($N = 336$)	Respiratory failure ($N = 209$)	Neurological disease ($N = 80$)	ENT-related disorders ($N = 34$)	Burns ($N = 3$)	Cardiac arrest ($N = 10$)
Age, years	64 [53–74]	67 [58–75]	55 [36–66]	60 [41–76]	57 [51–70]	66 [61–78]
APACHE II value	20 [15–25]	21 [16–25]	18 [12–21]	15 [11–20]	17 [13–19]	26 [22–29]
Elixhauser value	2 [0–8]	3 [0–10]	0 [0–3]	0 [0–9]	−2 [−2–2]	2 [0–4]
ICU LOS, days	22 [15–30]	25 [19–35]	19 [13–25]	4 [2–7]	29 [20–56]	16 [13–18]
Hospital LOS, days	47 [27–73]	47 [29–73]	50 [31–78]	23 [12–57]	126 [70–141]	33 [18–47]
Duration of mechanical ventilation, days	17 [11–25]	20 [15–28]	13 [10–19]	1 [1–5]	22 [14–48]	13 [8–16]

TABLE 2 Number of intubations and duration of extubation trials prior to tracheostomy insertion. For each extubation trial, time until reintubation is shown in days (interquartile range)

Number of intubations	*n* (%)	Extubation trial 1, days	Extubation trial 2, days	Extubation trial 3, days
0	6 (2)	–	–	–
1	211 (63)	–	–	–
2	96 (29)	2 [1–4]	–	–
3	19 (6)	1 [0–3]	1.5 [0–4]	–
4	4 (1)	0.5 [0–2]	0 [0–0.5]	1 [0.75–1.75]

similar for patients with an early and late tracheostomy or 30% ($N = 40$) and 39% ($N = 79$).

Surgical tracheostomies were 216 (64%) and 107 (32%) tracheostomies were performed using the percutaneous technique. In 13 cases (4%), the technique used was unknown.

A total of 85 (25%) patients had a complication related to the tracheostomy. Short-term complications occurred in a total of 49 (15%) patients (see Table 3); 23 (7%) of those were classified as major complications. Bleeding occurred in 16 (5%) cases, but this was considered a major complication in only one patient. Out of 11 (3%) cases of tube blockage, nine were classified as major complications. All tube misplacements ($N = 3$) and dislodgements ($N = 10$) were categorized as major complications. A dislodgement of a tracheostomy was potentially involved in one death during the study period.

Potential long-term complications were observed in 44 patients (13%). Dysphagia was reported in 40 cases (12%), although it was unclear if this was related to the tracheostomy or the underlying disorder necessitating mechanical ventilation. Similarly, one patient suffered vocal cord injury and it was unclear whether that was due to the tracheostomy. Two patients were diagnosed with tracheal stenosis, and one had problems with wound healing requiring surgical revision.

A total of 89 patients (26%) died with the tracheostomy tube in situ. The tracheostomy tube was removed in the ICU in 111 cases (33%) and at the ward after ICU discharge in 97 patients (29%). Six patients received a permanent tracheostomy due to ENT-related or neurological disorders. In five cases, the tracheostomy tube was removed at another facility after hospital discharge and four patients had the tube removed at an out-patient clinic. In 24 cases (7%), information about the location of tracheostomy tube removal was missing. A mini-tracheostomy tube was used temporarily in 54 (16%) patients after decannulation.

After excluding patients that needed permanent tracheostomy ($N = 6$), those with unknown date of removal ($N = 49$) and those who died prior to tracheostomy removal ($N = 89$), the median duration of tracheostomy utilization was 14 days (IQR 8–28, range 1–730 days). There was not a significant difference in the median duration of tracheostomy utilization in those who got an early (11 days) compared to late (16 days) tracheostomy ($p = .06$). In 23 patients (7%), the tracheostomy needed to be reinserted.

TABLE 3 Number of early (≤48 h from insertion) and late (>48 h from insertion) short-term complications in all patient groups

	All patients ($N = 336$)
Early (≤48 h from tracheostomy insertion)	
Bleeding	9 (3%)
Tracheostomy tube leak	5 (2%)
Tracheostomy tube misplacement	3 (1%)
Late (>48 h from tracheostomy insertion)	
Bleeding	7 (2%)
Incision site infection	4 (1%)
Tracheostomy tube blockage	11 (3%)
Tracheostomy tube dislodgement	10 (3%)

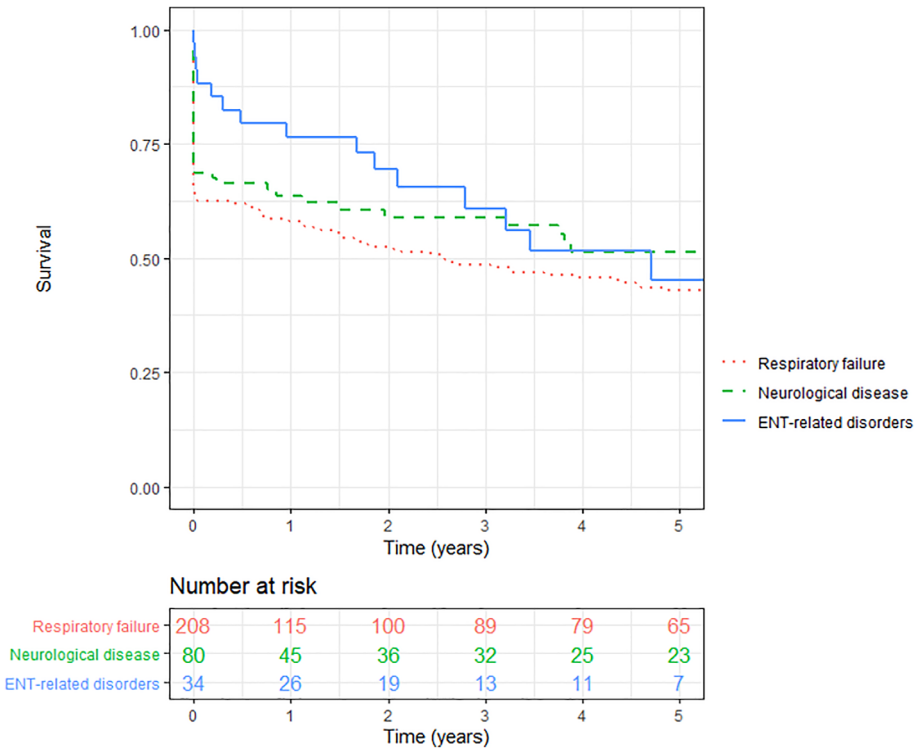

FIGURE 2 Five-year survival shown for each indication group. Patients who received a tracheostomy due to burn injury or after cardiac arrest are not included since those groups included too few patients.

A total of 86 patients (26%) were readmitted to the ICU during the same hospital stay. Out of 143 readmissions for this group, 77 (54%) readmissions were related to respiratory problems. The ICU readmission rate was similar regardless of tracheostomy tube removal during the ICU stay (28%) or in the ward after ICU discharge (27%).

Median follow-up time for survival was 613 days (IQR 0–2234). A total of 62 patients (18%) died in the ICU and 49 (14%) died in the hospital after ICU discharge, resulting in an in-hospital mortality of 33%. Out of those who survived ($N = 225$), 48 (21%) were discharged to home but 176 (79%) were discharged to other facilities. The one-and five-year survival rate was 60% and 44%, respectively (see Figure 2 and Figure S1). There was no difference in the survival of those that got an early compared to late tracheostomy (HR 1.14, 95% CI 0.66–1.16) even after adjusting for age and Elixhauser and APACHE II values (HR 1.21, 95% CI 0.57–1.19) (see Figure S2).

4 | DISCUSSION

In this study, we provide a detailed nationwide overview of the clinical practice regarding utilization of tracheostomies, including indications for tracheostomy insertion, complication rate, and factors regarding the decision to offer tracheostomy. As expected, most tracheostomies were performed when prolonged mechanical ventilation was anticipated, that is, due to respiratory failure or neurological disorders. The median duration of mechanical ventilation prior to tracheostomy insertion was 9 days and an extubation trial had been attempted in 35% of the patients. The overall complication rate related to tracheostomy was 25%, although most of those were minor complications.

The optimal timing of tracheostomy insertion remains uncertain and published guidelines do not provide clear instructions on this issue.[3,6,21] Therefore, the decision is mostly individualized and based on the clinical evaluation of the need of prolonged mechanical ventilation for each patient. Currently, there is no consensus on when mechanical ventilation is considered prolonged. Furthermore the prediction of prolonged mechanical ventilation is likely highly subjective and prone to bias[3,22] and there is evidence that physicians have a limited accuracy in predicting the duration of mechanical ventilation.[23] The median duration of mechanical ventilation prior to tracheostomy is not easily compared with other studies as their results are most often presented as either early or late tracheostomies and this definition varies between studies. Our results are in line with the findings of the Project IMPACT database, a comprehensive database system including over 100 ICUs, which showed that tracheostomy placement most frequently occurred at median of 9 days after ICU admission.[24] In the study by Flaatten et al from a mixed ICU in Norway, the median time to tracheostomy from ICU admittance was 6 days.[1] It should be kept in mind that we report time from mechanical ventilation initiation until tracheostomy placement, but the vast majority of patients in our cohort received mechanical ventilation shortly after ICU admission.

Failed extubation is an important factor in predicting prolonged mechanical ventilation and determining the need for tracheostomy. One might make the argument that most patients ought to have an attempt at extubation prior to committing to tracheostomy, given that an extubation attempt is considered to have a reasonable success rate and the risk of adverse events related to reintubation is acceptable. Our results show that only 35% of the cohort had at least one failed extubation prior to tracheostomy insertion and the duration of each extubation trial was less than 2 days. This could indicate that some of the patients could have been spared a tracheostomy with a more aggressive approach to extubation trials. Failed extubation is on the other hand associated with poor outcomes and high mortality rates.[25,26] Patient factors that have been associated with increased risk of extubation failure include neurological disorders, abundant secretions and/or weak cough, age over 65 years, duration of mechanical ventilation and underlying chronic or respiratory disease.[26] It is also known that caregivers´ prediction of need for reintubation is highly inaccurate.[25]

The optimal technique used for tracheostomy insertion has been a subject of debate. As mentioned above, the results of multiple meta-analyses have shown an increased risk of infection with surgical tracheostomies compared to percutaneous tracheostomies but the two methods have an otherwise similar complication rate.[7–10] In the current study, surgical and percutaneous tracheostomies were 64% and 32%, respectively, and this represents preference and experience of the operator.

The reported incidence of tracheostomy-related complications varies substantially in the literature. One possible explanation for this is a lack of consensus on how to define and classify these complications. A systematic review including 12 studies found that the overall incidence of complications was between 0 and 39%[11] and our overall complication range of 25% falls within this range. The rate of short-term complications was 15% in our study which is somewhat higher than the rate seen in a study by de Kleijn et al, that found a short-term complication rate of 8%.[27] However, in that study high-risk patients were excluded, such as those with history of radiation therapy, previous neck/thoracic surgery or previous tracheotomy, which could explain this difference.

A total of 7% of the patients had short-term complications were defined as major complications. According to the results of a Cochrane meta-analysis,[10] intra-operative and direct postoperative serious, life-threatening adverse events were 4.2% and 4.4%, respectively. Short-term complications in our study did not only include adverse events that occurred perioperatively but also those that occurred in the first 48 h postoperatively, which could explain the difference of our study and the Cochrane meta-analysis.[10]

Tube dislodgement occurred in 10 patients (2.9%) which is similar to the reported incidence in the literature which generally falls within the range of 0.35%–2.6%.[4] Even though it is relatively uncommon, tube dislodgement carries one of the highest mortalities of any tracheostomy complication with a reported mortality as high as 25%–100%.[4] This emphasizes the need for clear protocols and regular training in reactions to tube dislodgement in all canters caring for patients with tracheostomy.

The long-term complications in our study were 13%. This is similar to the results of the earlier mentioned study by de Kleijn et al[27] where the long-term complications were 12%. Given that the most common reported long-term complication was dysphagia, and this was most common in patients with a neurological disorder or ENT procedure, it is unclear whether this was directly related to the tracheostomy.

The strength of this study is that it is population-based and therefore provides information on a diverse patient population. Also, the results of this study are likely transferrable to other similar health-care systems, such as those in the Nordic countries. The use of personal identification numbers in most national registries in Iceland enables excellent follow-up. The main limitation is the retrospective design which carries the risk of missed information, especially on of tracheostomy-related complications. The classification of major and minor complications is somewhat subjective and could cause overestimation of major complications.

In conclusion, we found that the most common indication for tracheostomy insertion was respiratory failure followed by neurological disorders. The decision of tracheostomy insertion was made after a median of 9 days of mechanical ventilation and in 35% of patients, extubation had been attempted at least once with a median duration of each extubation trial of 1–2 days. Potential areas of improvement and future work include standardizing assessment for the need of tracheostomy, including patient-related factors. Furthermore, a carefully planned and executed extubation trial should be considered prior to the decision to perform tracheostomy.

AUTHOR CONTRIBUTIONS

Concept and design: EAK, KS, SK, RJJ, RB, OO, GT, TG, MIS; Data aquisition: EAK, OO, MIS; Analysis: EAK, MIS; Supervision: MIS; Drafting of manuscript: EAK; Critical revision of manuscript: EAK, KS, SK, RJJ, RB, OO, GT, TG, MIS.

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CONFLICT OF INTEREST

None.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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