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Improving tracheostomy delivery for trauma and surgical critical care patients: timely trach initiative

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ABSTRACT

Background Tracheostomy is recommended within 7 days of intubation for patients with severe traumatic brain injury (TBI) or requiring prolonged mechanical ventilation. A quality improvement project aimed to decrease time to tracheostomy to ≤7 days after intubation for eligible patients requiring tracheostomy in the surgical intensive care unit (SICU).

Local problem From January 2017 to June 2018, approximately 85% of tracheostomies were performed >7 days after intubation. The tracheostomy was placed a median of 10 days after intubation (range: 1–57).

Methods Quality improvement principles were applied at an American College of Surgeons-verified level I trauma centre to introduce and analyse interventions to improve tracheostomy timing. Using the electronic health record, we analysed changes in tracheostomy timing, hospital length of stay (LOS), ventilator-associated pneumonia and peristomal bleeding rates for three subgroups: patients with TBI, trauma patients and all SICU patients.

Interventions In July 2018, an educational roll-out for SICU residents and staff was launched to inform them of potential benefits of early tracheostomy and potential complications, which they should discuss when counselling patient decision-makers. In July 2019, an early tracheostomy workflow targeting patients with head injury was published in an institutional Trauma Guide app.

Results Median time from intubation to tracheostomy decreased for all patients from 14 days (range: 4–57) to 8 days (range: 1–32, p≤0.001), and median hospital LOS decreased from 38 days to 24 days (p<0.001, r=0.35). Median time to tracheostomy decreased significantly for trauma patients after publication of the algorithm (10 days (range: 3–21 days) to 6 days (range: 1–15 days), p=0.03). Among patients with TBI, family meetings were held earlier for patients who underwent early versus late tracheostomy (p=0.008).

Conclusions We recommend regular educational meetings, enhanced by digitally published guidelines and strategic communication as effective ways to improve tracheostomy timing. These interventions standardised practice and may benefit other institutions.

INTRODUCTION

Background

In 2009, the Eastern Association for the Surgery of Trauma (EAST) established guidelines based on evidence from 24 studies recommending trauma patients needing prolonged (>7 days) ventilation receive tracheostomy within 7 days of intubation.[1–3] Evidence for early tracheostomy is strongest for patients with severe traumatic brain injury (TBI) requiring intubation.[1 2 4–7] Early tracheostomy decreases ventilator days,[2 3 5–12] intensive care unit (ICU) length of stay (LOS),[1–3 5–8 10–13] and ventilator-associated pneumonia (VAP).[3 5 8 13] Some studies[6 8 13] suggest improved neurological outcomes and mortality, though others[8 14] call this into question. Compared with an endotracheal tube, tracheostomy facilitates ventilator weaning; decreases need for sedation; and improves patient comfort, communication and mobility.[2 9] A study which looked at ICU costs attributed to mechanical ventilation in four different countries including the USA demonstrated that mechanical ventilation was associated with a 25.8% (4.7%–51.2%) increase in daily ICU costs.[15] The average weighted cost of ICU stay is estimated at $4316 less for patients who undergo early tracheostomy (95% CI $403 to $8229).[16] When indicated, early tracheostomy improves patient outcomes and decreases costs, improving quality and safety of care.

Electronic health record (EHR) data for 117 patients who underwent tracheostomy from the acute care surgery team in our institution's medical–surgical ICU between January 2017 and June 2018 revealed approximately 85% of tracheostomies were performed >7 days after intubation. The median time to tracheostomy was 10 days after intubation (range: 1–57). To address this issue, interventions focused on standardised education for residents and fellows informing on society guidelines, benefits of early tracheostomy and risks of the procedure. EAST guidelines had not yet been widely accepted or taught at our institution, so we deemed education a critical part of improvement. This report describes the root cause analysis

(RCA) for tracheostomy delay and evaluation of interventions designed to improve tracheostomy timing.

METHODS

This report was written following the Revised Standards for Quality Improvement Reporting Excellence V.2.0 Guidelines for quality improvement reports.[17]

Context

This study reviews tracheostomy practices at a tertiary academic hospital and American College of Surgeons-verified level I trauma centre in a mixed medical–surgical ICU. Patients who underwent tracheostomy by the acute care surgery and surgical ICU teams between January 2017 and July 2020 were included. Patients aged <18 years, patients admitted to Stanford after the date of intubation, those who underwent emergency tracheostomy or cricothyroidotomy or those who underwent tracheostomy for SARS-CoV-2 were excluded. We analysed three subgroups: trauma patients, trauma patients with TBI and non-trauma patients. Patients were classified as trauma if the trauma team was their primary service or they required a trauma activation on arrival to the emergency department. Patients were included in the TBI subgroup if they were diagnosed during their admission as recorded in their EHRs.

Interventions

In July 2018, the Acute Care Surgery programme initiated monthly educational meetings on early tracheostomy. Surgical critical care fellows led 45 min meetings for residents and ICU nursing staff, discussing data and guidelines supporting early tracheostomy and encouraging regular assessment for early tracheostomy. The curriculum included society guidelines supporting early tracheostomy, anticipated benefits to patients to discuss in family meetings and potential complications. Fellows also showed procedural videos and images to familiarise attendees with the procedure. In August 2019, meetings transitioned to attending-led educational presentations for residents. After social distancing measures for the COVID-19 pandemic were implemented in February 2020, resident educational meetings were changed to a virtual format. Content and frequency did not change.

In July 2019, Stanford's Trauma Medical Audit Committee approved a treatment algorithm—based on EAST guidelines—published in the institutional Trauma Guide app, which was first launched in May 2019 and is free at the App Store for iOS. The algorithm is entitled 'Suggested Tracheostomy Pathway for Patients Presenting with Severe TBI (figure 1). The algorithm was also disseminated directly to all trauma attending physicians, and a new protocol notification was sent through the app to all users.

Root cause analysis

We performed a formal RCA after implementation of interventions to better understand how our interventions

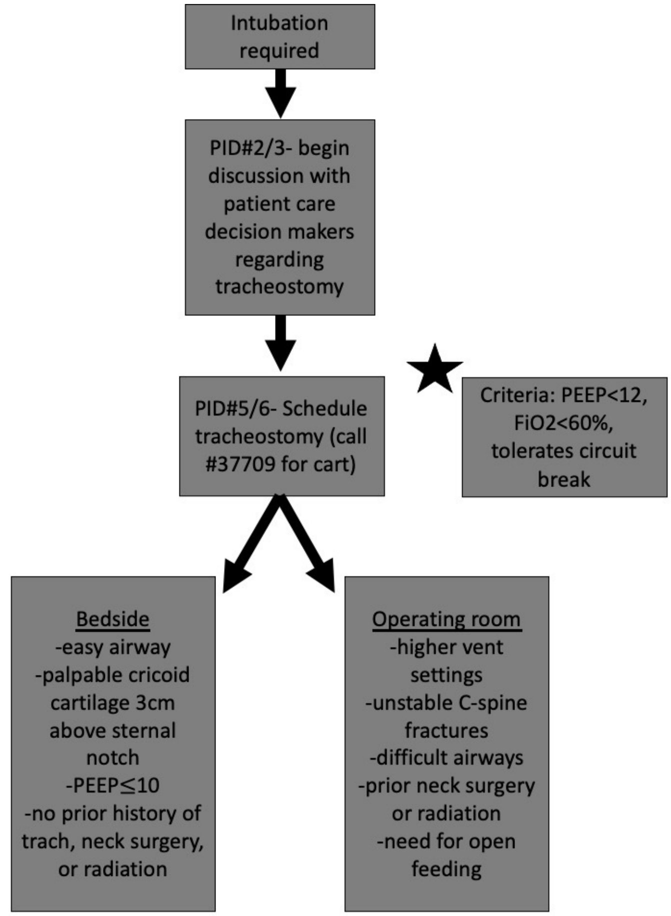

Figure 1 Practice algorithm in the Trauma Guide app. Last updated on 24 November 2019. PID, postintubation day. PEEP, positive end expiratory pressure; FiO2, fraction of inspired oxygen.

addressed root causes and to inform future quality assurance. We developed a process map for tracheostomy, then asked five surgical ICU nursing staff to consider which steps contribute to delay. Two surgery residents and one surgical critical care fellow commented on algorithm use in their cohorts. For patients with TBI, we recorded the procedure type (percutaneous/open), extubation attempts prior to tracheostomy, the date the physician recommended tracheostomy, when family meetings occurred and whether the family consented at the first family meeting to further uncover factors contributing to delay.

Study of the intervention and measures

To assess impact of the interventions, the process measure, time to tracheostomy (defined as the number of days from initial intubation to tracheostomy), was calculated using intubation and tracheostomy dates in the EHR. The outcome measures—hospital LOS and VAP—were also determined from the chart review. These variables are regularly and reliably recorded in the EHR. Time to tracheostomy was chosen because it directly reflects the change in process and impact on the defined problem. Hospital LOS and VAP were chosen as outcome measures based on evidence from previous studies that these outcomes improve with decreased time to tracheostomy. We recorded peristomal bleeding as a balancing measure.

Analysis

To analyse interventions, we compared frequency of late tracheostomy by run-time charting before intervention and after intervention. We determined whether interventions were associated with a data shift to support causal conclusions. Department attending physicians were asked to consider whether other policy changes or major staff changes could have impacted tracheostomy timing. Wilcoxon-Mann-Whitney, two-sided Fisher's exact and χ^2 tests were performed in RStudio V.1.2.5033 to analyse whether preintervention and postintervention data were different.

Patient and public involvement

Patients, care givers or members of the public were not involved in the design, conduction or reporting of this work.

RESULTS

Root cause analysis

Four of five nurses highlighted family meetings as the main delay besides patient physiology. Bedside nurses typically facilitate scheduling, and participants depend on family preference. At a minimum, the patient's designated medical decision-maker meets with a doctor from the team performing the tracheostomy. On rare occasions, consent for tracheostomy is provided without next of kin in collaboration with the ethics board when accurate contact information is not available. When interviewed, nurses said, 'family meetings need to happen much earlier than they do', and advised to 'be aware that the initial conversation on day one or two might not lead to a decision'. They explained that many families have a misconception that tracheostomies are permanent and that family education is important. Four nurses also mentioned a wide practice variation between attending physicians and asked for a standardised definition of 'unable to wean'. One nurse commented, 'it seems like a lot of patients are really close to weaning but keep failing'. Finally, three nurses explained sometimes delay occurs between scheduling and performing the tracheostomy for percutaneous procedures when surgical trays or tools are not properly stocked or when delayed by the operating room add-on scheduler because it is a 'lower ranking surgery'.

Chart review supported family meetings as one cause of delay. Some challenges investigators observed in charts included difficulty contacting family or coordinating schedules, challenging family dynamics, difficult moral decisions (ie, tracheostomy or terminal extubation), language barriers and use of interpretation and coordination of multiple patient-care teams. Tracheostomy delays occurred when the meeting was too late (after day 4), consent was not obtained at the first meeting or both. Family meetings occurred on postintubation day 2 (range: 1–4 days) for patients who underwent early tracheostomy, compared with family meeting on day 4 (range: 1–13 days) for late tracheostomy patients (p=0.008, r=0.5). Only one (7%) early tracheostomy patient was missing documentation of a family meeting or explaining why next-of-kin was unavailable. For late tracheostomy patients, five (30%) were missing the same documentation (p=1.0). More families consented at the first meeting to early tracheostomies compared with late (70% vs 29%, p=1.0).

We recorded date (days postintubation) of the first note recommending tracheostomy to extract physician decision-making. There was no difference in mean day between early (day 1, range: days 0–4) and late (day 2, range: days 0–9) tracheostomy groups (p=0.5, r=0.1). Frequently, after recommendation to perform tracheostomy, physiology prevented safe tracheostomy; family consent delayed the procedure; or the care team delayed tracheostomy to pair with another procedure or with the hopes to extubate the patient. No delays due to surgical tray stock were noted in the EHR.

Study of the intervention

We interviewed two residents and one fellow about their use of the Trauma Guide app as a reference tool. One resident used the app for clinical decision making 'a few times a shift on trauma/SICU' and appreciated having access to institution-specific guidelines in a mobile device. The fellow used the app for clinical decision-making only when guidelines were 'hospital protocol'. None of the respondents had previously seen the 'Suggested Tracheostomy Pathway for Patients Presenting with Severe TBI' but viewed it to provide feedback during the interview. They suggested ways to improve the readability of the algorithm, and we incorporated their feedback into a new version of the algorithm. One interviewee thought scheduling a tracheostomy within 3–4 days of intubation is 'too aggressive' and said the time needed to understand the patient and family was the largest barrier to such an early tracheostomy. View count data from the Trauma Guide app revealed the algorithm had 30 views in the first year of publication (July 2019–June 2020).

All patients

Characteristics of and outcomes for all patients are summarised in table 1. The patient populations were similar in age and sex before and after intervention. Baseline (January 2017–June 2018) frequency of late tracheostomy for all patients was 0.85. Late frequency decreased in the fourth quarter of 2018 (0.61), the same period monthly meetings by surgical ICU fellows were initiated (figure 2). Frequency remained below the baseline median for the remaining seven periods observed, meeting criteria for data shift.[15] Although median frequency of late tracheostomies decreased again (0.56) following publication of the Trauma Guide app algorithm in the third quarter of 2019, it was a moderate decrease and did not meet the criteria for data shift.[13] Median time

Table 1 Summary of data of all patients before and after institution of educational meetings and Trauma Guide app

	All data January 2017–June 2020	Baseline January 2017–June 2018	Educational meetings/algorithm July 2018–June 2020	Comparison test
Patients, N	117	48	69	
Male sex (%)	72 (62)	25 (52)	47 (68)	χ^2=0, p=1
Median age (years) (range)	59 (18–93)	62 (23–92)	58 (18–93)	Mann-Whitney U W=1900, p=0.2, r=0.1
Median time to tracheostomy (days) (range)	10 (1–57)	14 (4–57)	8 (1–32)	Mann-Whitney U W=2268, p≤0.001, r=0.31
Hospital LOS (days) (range)	28 (10–165)	38 (13–116)	24 (10–165)	Mann-Whitney U W=2334, p<0.001, r=0.35
VAP (%)	50 (43)	19 (40)	31 (45)	χ^2=1.7, p=0
Bleeding complication (%)	4 (3)	1 (2)	3 (4)	Fisher's, p=0.06

Data were compared by Mann-Whitney U tests (numerical), χ^2 (categorical, expected values ≥5) and two-sided Fisher's exact tests (categorical, expected values <5).
*All patients were assigned male or female sex at birth.
LOS, length of stay; VAP, ventilator-associated pneumonia.

to tracheostomy during the preintervention period was 14 days (range: 4–57 days). During the postintervention period (June 2018–July 2020), median time to tracheostomy was lower than baseline with a moderate effect size (p<0.001, r=0.31). Rates for VAP (χ^2=1.7, p=0.2) and postoperative peristomal bleeding (p=0.06) did not change after intervention. Median hospital LOS decreased from 38 to 24 days (p<0.001, r=0.35).

Subgroup analysis: trauma patients and patients with TBI

The trauma population was younger than the general tracheostomy population with a median age of 46 (range: 18–82) vs 59 (range: 18–93) years (p=0.004). Characteristics and outcomes for subgroup analysis of these patients are summarised in table 2. Patient populations before and after intervention were similar, though there were

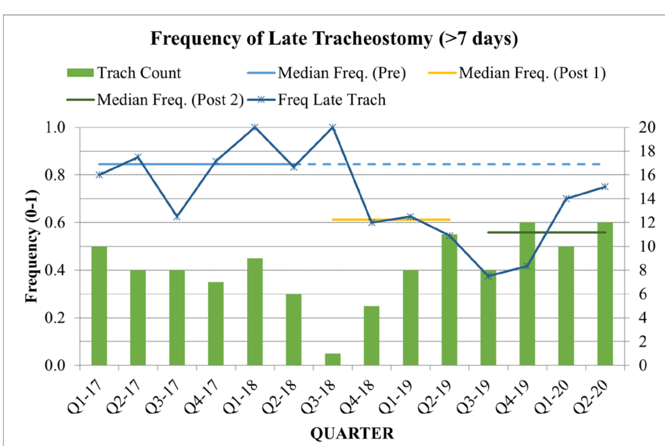

Figure 2 Frequency of late tracheostomy (left axis) and count of tracheostomies (right axis) for all patients. During the third quarter of 2018, informal bimonthly meetings began. During the third quarter of 2019, the early tracheostomy algorithm was published in the Trauma Guide app.

more male trauma patients after intervention (p=0.04). For trauma patients, baseline (January 2017–June 2019) frequency of late tracheostomy was 0.75. Frequency of late tracheostomy decreased to 0.41 following algorithm publication in July 2019 (figure 3). The observation period was too short to meet data shift criteria.[18] Analysing patients with TBI alone, we found that baseline frequency of late tracheostomy was 0.75 (figure 3). Late frequency decreased to 0.45 after intervention. Frequency remained below baseline for the two periods observed after publication of the Trauma Guide app, but again the observation period was too short for shift in data.[18]

At baseline, median time to tracheostomy was 10 days for trauma patients (range: 3–21 days), which decreased to 6 days (range: 1–15 days) following publication of the Trauma Guide app algorithm (p=0.032, r=0.34). For patients with TBI, time to tracheostomy decreased to 6 days (range: 1–15 days) from 11 days (range: 3–21 days). It is unclear whether this decrease can be attributed to the Trauma Guide app algorithm or random variation (p=0.07, r=0.33). For all trauma patients and patients with TBI, there was no change in VAP (p=1.0, p=0.3). For each, we could not compare bleeding rates due to expected values of zero. For trauma patients, median hospital LOS decreased from 28 days (range: 10–116 days) to 23 days (range: 11–47 days) after the algorithm was published, though this was not statistically significant (p=0.07, r=0.33). We saw similar results for patients with TBI, where median LOS changed from 29 days to 24 days but was not significant (p=0.1, r=0.27).

DISCUSSION

Multiple society guidelines support early tracheostomy for trauma patients projected to require prolonged mechanical ventilation.[1 4] To our knowledge, this is the

Table 2 Summary of data for trauma and patients with TBI before and after Trauma Guide app

	All data **January 2017–June 2020**	Baseline **June 2017–June 2019**	Algorithm **July 2019–June 2020**	**Comparison test**
Trauma patients				
Patients, N	40	21	19	
Male sex* (%)	30 (75)	14 (67)	16 (84)	Fisher's p=0.04
Median age (years) (range)	46 (18–82)	49 (18–82)	42 (20–72)	Mann-Whitney U W=238, p=0.3, r=0.1
Median time-to-tracheostomy (days) (range)	8 (1–21)	10 (3–21)	6 (1–15)	Mann-Whitney U W=279, p=0.03, r=0.3
Hospital LOS (days) (range)	25 (10–116)	28 (10–116)	23 (11–47)	Mann-Whitney U W=267, p=0.07, r=0.3
VAP (%)	19 (48)	9 (43)	10 (53)	Fisher's p=1
Bleeding complication (%)	1 (3)	1 (5)	(0)	No results*
Patients with TBI				
Patients, N	31	15	16	
Male sex* (%)	23 (74)	10 (67)	13 (81)	Fisher's p=1
Median age (years) (range)	39 (18–75)	44 (18–75)	37 (26–73)	Mann-Whitney U W=133, p=0.62, r=0.1
Median time to tracheostomy (days) (range)	8 (1–21)	11 (3–21)	6 (1–15)	Mann-Whitney U W=167, p=0.07, r=0.3
Hospital LOS (days) (range)	26 (10–116)	29 (17–116)	24 (11–47)	Mann-Whitney U W=158, p=0.1, r=0.3
VAP (%)	15 (49)	7 (47)	8 (50)	Fisher's, p=0.3
Bleeding complication (%)	0 (0)	0 (0)	0 (0)	No results*

Data were compared by Mann-Whitney U tests (numerical), χ^2 (categorical, expected values ≥5) and two-sided Fisher's exact tests (categorical, expected values <5).
LOS, length of stay; TBI, traumatic brain injury; VAP, ventilator-associated pneumonia.

first quality improvement report focused on improving tracheostomy timing. We sought to determine the root causes of tracheostomy delay at our institution and to analyse whether our interventions improved time to tracheostomy and associated outcomes for medical–surgical ICU patients. We discovered that regular educational meetings, enhanced by a trauma programme TBI tracheostomy algorithm, decreased time to tracheostomy and hospital LOS for our medical–surgical ICU patients. Additionally, commitment to ongoing resident education allowed sustained improvement over a 2-year period. Although cost data are not available for our institution, we anticipate that cost of stay decreased for our patients based on previous cost analyses[1 15 16] and our observed drop in hospital LOS.

Our RCA and chart review supported early family meetings and consent as a key driver of early tracheostomy. The Trauma Guide app algorithm encouraged family meetings within 1–2 days of intubation for patients with TBI. Other institutions had success in the ICU, arming clinicians with informational booklets to be given to patients and families[19] or incorporating families into ICU rounding.[20] Prior studies demonstrate early, informed consent leads to higher family satisfaction with ICU care.[21] Department staff did not report any major policy changes or staffing changes which may have contributed to decreased tracheostomy timing or hospital LOS. Although concern for staff safety might have contributed to hesitancy in performing tracheostomy even for patients not known to have SARS-CoV-2 infection, early robust PCR testing at our facility minimised any potential bias against procedures. RCA also suggested practice variation between attending physicians may contribute to delayed tracheostomy. We recommend standardising methods to identify patients who need early tracheostomy. One potential intervention is to imbed a best practice advisory into the electronic medical system to alert at 48 or 72 hours after documented intubation. Prediction models have been suggested for neurocritical care patients[4 22–24] and burn patients,[25] but more models are still in development. In the future, better prediction models will support standardised criteria for early tracheostomy.[4] Furthermore, establishing guidelines for which patients are poor candidates for spontaneous breathing trials could facilitate early tracheostomy. We did not further address the concern from interviews regarding stocking of surgical trays, as this was not supported by chart review. This suggests that the issue occurs infrequently or is poorly documented.

Figure 3 Frequency of late tracheostomy (left axis) and count of tracheostomies (right axis) for trauma patients (top) and patients with TBI (bottom). During the third quarter of 2019, the early tracheostomy algorithm was published in the Trauma Guide app. TBI, traumatic brain injury.

Previous studies show that educational interventions often fail to create meaningful change.[26] Soong and Shojania's editorial outlines three key ways that educational interventions fail.[26] First, they are applied to problems that do not involve knowledge deficits. Next, education requires too much repetition to sustain. Finally, other factors impede application of the knowledge/skills learnt. Early tracheostomy at our institution was a suitable circumstance to employ education-based interventions. A knowledge deficit did exist among trainees regarding EAST guidelines for early tracheostomy. Although frequency of educational meetings does pose a challenge for maintaining our interventions, regular didactic sessions already exist for resident physicians, providing a platform for each new group of acute care surgery trainees to receive training on early tracheostomy. 'Other factors' that impede early tracheostomy are some of the key drivers identified in this study. An ICU team may have quickly identified a patient who would benefit from early tracheostomy, but they cannot proceed with the procedure unless the family also believes tracheostomy would be beneficial. Interventions to improve communication in family meetings can facilitate practical application of early tracheostomy knowledge.

This initiative was a single-site project at an academic level I trauma centre and may not translate to some sites. This quasi-experimental design does not allow inference of a causal relationship between the interventions and improved outcomes. Recall bias may have impacted interview responses. Evaluation of the educational component could be further validated through surveying programme participants. Chart review lends to human error in both documentation and during data collection, where observer bias can be introduced. Records of family meetings, physician recommendation to perform tracheostomy and reasons for procedure delays depend on provider documentation, so there may be gaps in data that we cannot address retrospectively. Performing RCA prior to initiating interventions would have better addressed the key drivers—family meetings and practice variation. We do not have access to ICU expense data, so we were unable to evaluate cost savings. As an ethical consideration, this report did not stratify by attending physician. There could be considerable interattending variability in time to tracheostomy. This effect is minimised by the extended duration of the study and the number of tracheostomies studied.

CONCLUSIONS

Provider education through meetings, digital algorithms and strategic communication were effective ways to improve time to tracheostomy at our institution. These interventions we associated with sustained improvement over a 2-year observed period. We anticipate meetings and digital guidelines will continue to improve resident education, patient quality of care and cost of stay. A common early tracheostomy guideline, including all intubated patients—rather than patients with TBI alone—might further decrease time to tracheostomy across our ICU cohort. This guideline could be reinforced through multiple platforms (fellow-led meetings, an educational session at trauma faculty meetings and nurse education) to enhance visibility, given current low viewership of our app. In the future, further quality review of family meetings at our institution (both with physicians and social work) could identify opportunities for standardisation of tracheostomy discussions.

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Contributors EKM performed the literature search, study design, data collection, analysis and interpretation, and wrote and revised the manuscript. BJS assisted in the data collection and provided critical revision of the manuscript. PM assisted in the study design and provided critical revision of the manuscript. DAS reviewed the study design and provided critical revision of the manuscript. JDF provided guidance and critical revision at all stages of work, including study design and accepts full responsibility for the finished work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The institutional review board at Stanford University determined retrospective review of data for the purpose of quality assurance to be exempt.

Provenance and peer review Not commissioned; externally peer reviewed.

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