The Laryngoscope

Impact of Obesity on Timing of Tracheotomy: A Multi-institutional Retrospective Study

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Objective: To examine the impact of increased body mass index (BMI) on (1) tracheotomy timing and (2) short-term surgical complications requiring a return to the operating room and 30-day mortality utilizing data from the Multi-Institutional Study on Tracheotomy (MIST).

Methods: A retrospective analysis of patients from the MIST database who underwent surgical or percutaneous tracheotomy between 2013 and 2016 at eight institutions was completed. Unadjusted and adjusted logistic regression analyses were used to assess the impact of obesity on tracheotomy timing and complications.

Results: Among the 3369 patients who underwent tracheotomy, 41.0% were obese and 21.6% were morbidly obese. BMI was associated with higher rates of prolonged intubation prior to tracheotomy accounting for comorbidities, indication for tracheotomy, institution, and type of tracheostomy ($p = 0.001$). Morbidly obese patients (BMI ≥35 kg/m^2) experienced a longer duration of intubation compared with patients with a normal BMI (median days intubated [IQR 25%–75%]: 11.0 days [7–17 days] versus 9.0 days [5–14 days]; $p < 0.001$) but did not have statistically higher rates of return to the operating room within 30 days ($p = 0.12$) or mortality ($p = 0.90$) on multivariable analysis. This same finding of prolonged intubation was not seen in overweight, nonobese patients when compared with normal BMI patients (median days intubated [IQR 25%–75%]: 10.0 days [6–15 days] versus 10.0 days [6–15 days]; $p = 0.36$).

Conclusion: BMI was associated with increased duration of intubation prior to tracheotomy. Although morbidly obese patients had a longer duration of intubation, there were no differences in return to the operating room or mortality within 30 days.

Key Words: obesity, prolonged intubation, short-term complications, tracheotomy.

Level of Evidence: 3

***Laryngoscope*, 134:4674–4681, 2024**

INTRODUCTION

In the United States, obesity remains a major public health issue. In 2017, the prevalence in adults, according to The National Health and Nutrition Examination Survey (NHANES), was upward of 41%.[1] As obesity rates continue to rise in the United States, understanding the impact of obesity on surgical outcomes is a timely question and may provide valuable insights for optimizing patient care and improving clinical outcomes in this population.[2]

Tracheotomy is a widely performed procedure in the United States, with 60,000–100,000 procedures completed annually.[3,4] Although generally a safe procedure, it is associated with several potential complications. Early postoperative complications (<7 days) include bleeding, pneumothorax, subcutaneous emphysema, and infection; whereas late postoperative complications (>7 days) can involve tracheal stenosis, delayed stoma closure with persistent tracheacutaneous fistula, tracheomalacia, stomal granulation, and cosmetic deformity.[5] Despite the above,

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Editor's Note: This Manuscript was accepted for publication on June 03, 2024.

The authors have no funding, financial relationships, or conflicts of interest to disclose.

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DOI: 10.1002/lary.31586

return to the operating room (OR) within the first 30 days for tracheotomy-related complications is relatively rare.

Obesity is a potential risk factor for intraoperative and perioperative complications associated with tracheotomy procedures due to distinct challenges related to surgical access, ventilation, and obesity-associated comorbidities, including type II diabetes, coronary artery disease, and hypertension.[6] Similarly, obesity is also a known risk factor for cardiovascular failure and thus these patients are at increased risk for prolonged intubation thus necessitating a tracheotomy.[7] Although significant extant literature characterizes perioperative risk associated with obesity in other procedures, only a few studies have effectively delineated the risk of obesity with respect to tracheotomies.[8–11]

Due to potential concerns about the complications of performing tracheotomies on patients with obesity, such as difficulties with surgical access, optimization of tracheotomy tube sizes, and postoperative wound issues,[9,12] along with their higher rate of other health issues,[13] these patients may face delays in surgery, resulting in longer durations of orotracheal intubation Timely implementation of tracheotomies has been shown to be correlated with a favorable reduction in mortality rates,[14–16] lower occurrence of ventilator-associated pneumonia,[14,15] shorter intensive care unit stays,[17] decreased need for sedation,[18] earlier initiation of oral feeding,[18] and earlier patient mobilization.[19] From a long-term perspective, prolonged intubation is a known risk factor for posterior glottic stenosis, subglottic, and tracheal stenosis.[20] Furthermore, in a cost analysis study, early tracheotomy placement in ventilator-dependent patients resulted in significantly lower hospital charges for room and ventilator care per patient ($36,609) compared with late tracheotomy placement ($73,714).[21] Despite all the potential benefits of early tracheotomy in intubated patients, there remains a paucity of literature evaluating tracheotomy timing and obesity.

In this study, we aim to examine the impact of increased BMI on (1) tracheotomy timing, (2) surgical complications requiring a return to the operating room within 30 days, and (3) 30-day mortality utilizing data from the Multi-Institutional Study on Tracheotomy (MIST).

METHODS

Patient Selection

This multi-institutional retrospective study collected data from tracheostomies completed between 2013 and 2016. Electronic medical records at participating sites were queried for Common Procedural Terminology (CPT) codes 31600, 31601, 31603, 31605, 31610, and 31612. Our protocols have been previously described.[22,23] Participating institutions included University of California San Diego, Mayo Clinic, University of California Davis, University of Wisconsin, Stanford, University of Michigan, Medical University of South Carolina, University of Colorado, Cleveland Clinic, and Loma Linda. Patients were identified from a central database and included if they (1) underwent tracheotomy (CPT codes 31600, 31601, 31603, 31605, 31610 and 31612) following a period of intubation, (2) were over 18 years old, and (3) had a documented BMI at the time of tracheotomy. Patients were excluded if they did not meet the above criteria or if the institution that completed the tracheotomy had an incomplete data set with less than 100 tracheotomies completed over the course of the study (30 patients from two institutions). Ultimately, data from 2013 to 2016 from 8 institutions were included in the final analysis. The University of California, San Diego Institutional Review Board (IRB) approved the study procedures.

Data Collection

Demographics data including age, gender, race, BMI, comorbidities, and timing of tracheotomy were collected and input into the MIST database. Patients were stratified based on their BMI according to the National Institute of Health (NIH) Obesity Classification.[24] Based on the National Institute of Health (NIH) guidelines, patients were classified as normal ($18.5\ kg/m^2 \le \times < 25.0\ kg/m^2$), overweight ($25.0\ kg/m^2 \le \times < 30.0\ kg/m^2$), and as having class I Obesity ($30.0\ kg/m^2 \le \times < 35.0\ kg/m^2$), class II Obesity ($35.0\ kg/m^2 \le \times < 40.0\ kg/m^2$), or class III Obesity ($\ge 40.0\ kg/m^2$). Obesity was defined as any patient with a BMI $\ge 30.0\ kg/m^2$. Morbid obesity was defined as BMI $\ge 35\ kg/m^2$.

Details regarding each tracheotomy were collected by chart review including indication for tracheotomy, days intubated prior to tracheotomy, tracheotomy approach (percutaneous versus open), tracheotomy present at time of discharge, and major complications. Prolonged intubation was defined as intubation for 10 or more days prior to tracheotomy based on prior studies that looked at complications associated with prolonged intubation.[20,25–27] Outcome measures defined as complications were either return to the operating room within 30 days for reasons related to the tracheotomy or death within 30 days of tracheotomy. Minor complications that did not require a return to the OR were not included due to logistical challenges of data collection and heterogeneity.

Statistical Analysis

For descriptive statistics, means, medians, and frequencies were calculated as appropriate. Chi-square and Fisher's exact tests were used to compare categorical variables between obesity groups. Demographics variables with p-values <0.1 on univariate analysis were then included in a multivariable model. Institution was included in all multivariable analyses to control for any inter-institutional differences. ANOVA and ANCOVA were used for continuous variables. A multivariable logistic regression analysis was performed to identify delays in the timing of tracheotomy and complications associated with BMI, morbid obesity (BMI $\ge 35\ kg/m^2$), and being overweight (BMI $25–29.9\ kg/m^2$).

Post hoc analysis was completed to determine if morbid obesity affected outcomes. Multivariable logistic regression analysis was completed to determine if morbid obesity was associated with a higher risk of complications and delayed tracheotomy compared with normal BMI patients. We then sought to determine if being overweight was associated with a higher risk of complications or delayed tracheotomy compared with patients with a normal BMI. Lastly, we sought to determine what factors were associated with prolonged intubation prior to tracheotomy. 95% confidence intervals (CIs) and p-values were reported. Statistical significance was set at $p < 0.05$. All statistical analyses were performed using STATA version 18.[28]

TABLE I.
Demographics and Clinical Information by NIH Obesity Classification.

Cohort	Normal BMI (BMI 18.5–25.0)	Overweight (BMI 25–29.9)	Obese Class I (BMI 30–34.9)	Obese Class II (BMI 35–39.9)	Obese Class III (BMI >40)
N (%)	1091 (32.5)	881 (26.3)	655 (19.5)	306 (9.1)	421 (12.6)
Male (%)*	675 (61.9)	582 (66.1)	376 (57.4)	179 (58.5)	207 (50.0)
Age (SD)	56.1 (18.9)	57.7 (17.3)	58.8 (15.5)	58.7 (15.0)	55.8 (16.3)
Race (%)					
White	647 (59.3)	508 (57.7)	366 (55.9)	170 (55.6)	240 (58.0)
Black/African American	208 (19.1)	173 (19.6)	132 (20.1)	72 (23.5)	82 (19.8)
Asian/Pacific Islander	123 (11.0)	110 (12.5)	73 (11.1)	39 (12.8)	43 (10.4)
Hispanic	50 (4.5)	36 (4.1)	18 (2.8)	6 (2.0)	5 (1.2)
Other	33 (3.1)	27 (3.1)	34 (5.2)	9 (3.0)	19 (0.7)
Comorbidities (%)					
Prior radiation*	48 (4.4)	25 (2.8)	6 (0.9)	6 (2.0)	7 (1.7)
Prior MI	137 (12.6)	107 (12.2)	79 (12.1)	45 (14.7)	48 (11.6)
CHF	245 (22.5)	181 (20.5)	139 (21.3)	69 (22.6)	105 (25.4)
PVD	83 (7.6)	71 (8.1)	55 (8.4)	29 (9.5)	27 (6.5)
CVA/TIA*	271 (24.8)	301 (34.2)	224 (34.2)	119 (38.9)	123 (29.8)
COPD	206 (18.9)	130 (14.8)	103 (15.7)	62 (20.3)	68 (16.4)
AIDS	8 (0.8)	4 (0.5)	1 (0.2)	1 (0.4)	1 (0.3)
CKD (mod – severe)	192 (17.6)	130 (14.8)	107 (16.3)	48 (15.7)	68 (16.4)
Diabetes*					
Uncomplicated	190 (17.4)	148 (16.8)	161 (24.6)	81 (26.5)	137 (33.1)
End organ damage	50 (4.6)	62 (7.0)	54 (8.2)	29 (9.5)	37 (8.9)
CTD	41 (3.8)	32 (3.6)	24 (3.7)	14 (4.6)	17 (4.1)
Malignancy					
Solid tumor*	131 (12.0)	87 (9.9)	66 (10.1)	28 (9.2)	37 (8.9)
Metastatic disease	70 (6.4)	33 (3.8)	23 (3.5)	15 (4.9)	9 (2.2)
Leukemia	10 (0.9)	5 (0.6)	5 (0.7)	1 (0.4)	4 (1.0)
Lymphoma	20 (1.8)	16 (1.8)	8 (1.2)	2 (0.7)	4 (1.0)
Prior neck surgery (%)	115 (10.5)	100 (11.4)	56 (8.6)	35 (11.4)	42 (10.0)
Active blood thinner (%)†	90 (8.3)	86 (9.8)	67 (10.2)	33 (10.8)	27 (6.4)

AIDS = acquired immunodeficiency syndrome; BMI units = kg/m^2; CHF = congestive heart failure; CKD = chronic kidney disease; COPD = chronic obstructive pulmonary disease; CTD = connective tissue disease; CVA = cerebrovascular accident; PVD = peripheral vascular disease; TIA = transient ischemic attach.

*$p < 0.05$.

†Includes all patients that were on any full-dose antiplatelet or anticoagulant that was not held on the day of surgery.

RESULTS

Study participant demographic features and clinical information are displayed in Table I. A total of 3369 patients who underwent tracheotomy were included in our analysis.

Differences in Patient Characteristics and Outcomes Stratified by Degree of Obesity

We first sought to determine the overall effects of the degree of obesity on patient characteristics and outcomes. We stratified patients based on the National Institute of Health Obesity into five groups: Normal (BMI 18.5–25 kg/m^2; $n = 1091$), Overweight (BMI 25–29.9 kg/m^2; $n = 881$), Obese I (BMI 30–34.9 kg/m^2; $n = 655$), Obese II (BMI 35–39.9 kg/m^2; $n = 306$), Obese III (BMI ≥40 kg/m^2; $n = 421$). There were differences between groups in gender ($X^2 = 34.4$, $p < 0.001$), radiation history ($X^2 = 21.8$, $p < 0.001$), history of prior stroke ($X^2 = 35.8$, $p < 0.001$), history of diabetes ($X^2 = 89.3$, $p < 0.001$), and current malignancy ($X^2 = 23.5$; $p = 0.003$) (Table I). There were no differences between groups in age, race, history of myocardial infarction or congestive heart failure, peripheral vascular disease, COPD, CKD, connective tissue disease, history of prior neck surgery, or active blood thinner use on univariate analysis.

On multivariable analysis accounting for significant comorbidities and institution, there were significant differences between obesity groups in indication for tracheotomy with higher rates of cardiopulmonary failure as the primary indication for tracheotomy in more obese groups (95% CI: 1.01–1.25; $p = 0.033$) and lower rates of

TABLE II.
Tracheotomy Outcomes by NIH Obesity Classification.

Cohort	Normal BMI (<25)	Overweight (BMI 25–29.9)	Obese Class I (BMI 30–34.9)	Obese Class II (BMI 35–39.9)	Obese Class III (BMI >40)
Median days intubated prior to tracheotomy (SE)	9.0 (0.24)	10.0 (0.25)	11.0 (0.28)	10.0 (0.36)	11.0 (0.40)
Indications for tracheotomy (%)					
Cardiopulmonary failure	987 (89.2)	817 (92.7)	608 (92.8)	280 (91.5)	393 (93.4)
Obstructive malignancy	71 (6.4)	33 (3.7)	20 (3.1)	11 (3.6)	8 (1.9)
Progressive nonmalignant airway obstruction	48 (4.3)	32 (3.6)	35 (5.3)	13 (4.2)	12 (2.9)
Conversion from perc trach or cricothyroidotomy	5 (0.5)	3 (0.3)	3 (0.5)	4 (1.3)	3 (0.7)
Tracheotomy approach (%)					
Percutaneous	428 (38.7)	349 (39.6)	267 (40.7)	104 (34.0)	151 (36.5)
Open	677 (61.3)	532 (60.4)	388 (59.3)	202 (66.0)	263 (63.5)
Complications (%)					
Return to OR within 30 days	18 (1.6)	20 (2.3)	15 (2.3)	12 (3.9)	12 (2.9)
Death within 30 days	115 (10.4)	96 (10.9)	75 (11.5)	33 (10.8)	46 (10.9)
Procedure terminated intra-op	2 (0.2)	2 (0.2)	0 (0.0)	1 (0.3)	2 (0.5)
Tracheotomy present at time of discharge (%)	719 (65.4)	590 (67.0)	444 (67.9)	202 (66.9)	273 (66.1)

malignant obstruction as the primary indication for tracheotomy in more obese groups (95% CI: 0.68–0.93; $p = 0.004$). There were differences in rates of percutaneous versus open tracheotomy between groups (95% CI: 1.06–1.20; $p < 0.001$) when accounting for institution, comorbidities, and indications for tracheotomy.

More obese groups had higher rates of prolonged intubation on both univariate (95% CI: 1.07–1.18; $p < 0.001$) and multivariable analysis accounting for comorbidities, indication for tracheotomy, institution, and type of tracheostomy (95% CI: 1.04–1.16; $p = 0.001$) (Table II, Fig. 1A). When looking at major complications, there were differences between obesity groups in rates of return to the operating room within 30 days on univariate analysis (95% CI: 0.005–0.323; $p = 0.04$) and multivariable analysis (95% CI: 1.00–1.40; $p = 0.048$). There were no differences between groups in mortality within 30 days (95% CI: 0.95–1.12; $p = 0.39$) or rates of tracheotomy decannulation prior to discharge (95% CI: 0.92–1.06; $p = 0.66$).

Effect of Morbid Obesity on Characteristics and Outcomes

Post hoc analysis was then completed to determine if morbid obesity was correlated with outcomes following tracheotomies. This was completed with the hypothesis that the significant differences seen between groups were largely driven by patients with very high BMIs. Morbid obesity was defined as BMI ≥35 kg/m^2 or patients in NIH obesity class II and class III. When compared with patients with a normal BMI (18.5 kg/m^2 ≤ × < 25.0 kg/m^2), patients with morbid obesity had tracheotomies performed later on multivariable analysis (median days of intubation [IQR 25%–75%]: 11.0 days [7–17 days] versus 9.0 days [5–14 days]; $F = 4.43$, $p < 0.001$) and had higher rates of prolonged intubation as defined by >10 days (58.9.% vs. 48.3%; 95% CI:1.04–1.16; $p = 0.001$).

A total of 40 patients (2.4%) required a return to the operating room for tracheotomy-related complications within 30 days. Of this, 24 patients (3.3%) with a BMI ≥35 kg/m^2 required return to the operating room within 30 days compared with 16 patients (1.7%) with a normal BMI. This was significant on univariate analysis (95% CI: 1.01–3.65; $p = 0.04$, Fig. 1B), but this lost significance on multivariate analysis (95% CI: 0.87–3.44; $p = 0.12$). There was no difference between the two groups in mortality within 30 days (11.1% versus 10.9%; 95% CI: 0.37–1.42; $p = 0.90$), or rates of tracheotomy decannulation prior to discharge (22.5% versus 24.8%; 95% CI: 0.74–1.28; $p = 0.87$).

Effect of Overweight Classification on Characteristics and Outcomes

Similarly, post hoc analysis was completed to determine if being overweight (BMI 25–29.9 kg/m^2) but not obese affected outcomes in tracheotomies. The previously seen differences in morbid obesity were not similarly seen in overweight patients. There was no difference in days intubated prior to tracheotomy based on being overweight when compared with patients with a normal BMI (median days of intubation [IQR 25%–75%]: 10 days [6–15] vs. 10 days [6–15]; $F = 0.83$, $p = 0.36$). There was also no difference in overweight patients compared with normal BMI patients in likelihood to return to the operating room within 30 days (95% CI: 0.59–1.67; $p = 0.98$) or mortality within 30 days (95% CI: 0.80–1.33; $p = 0.77$).

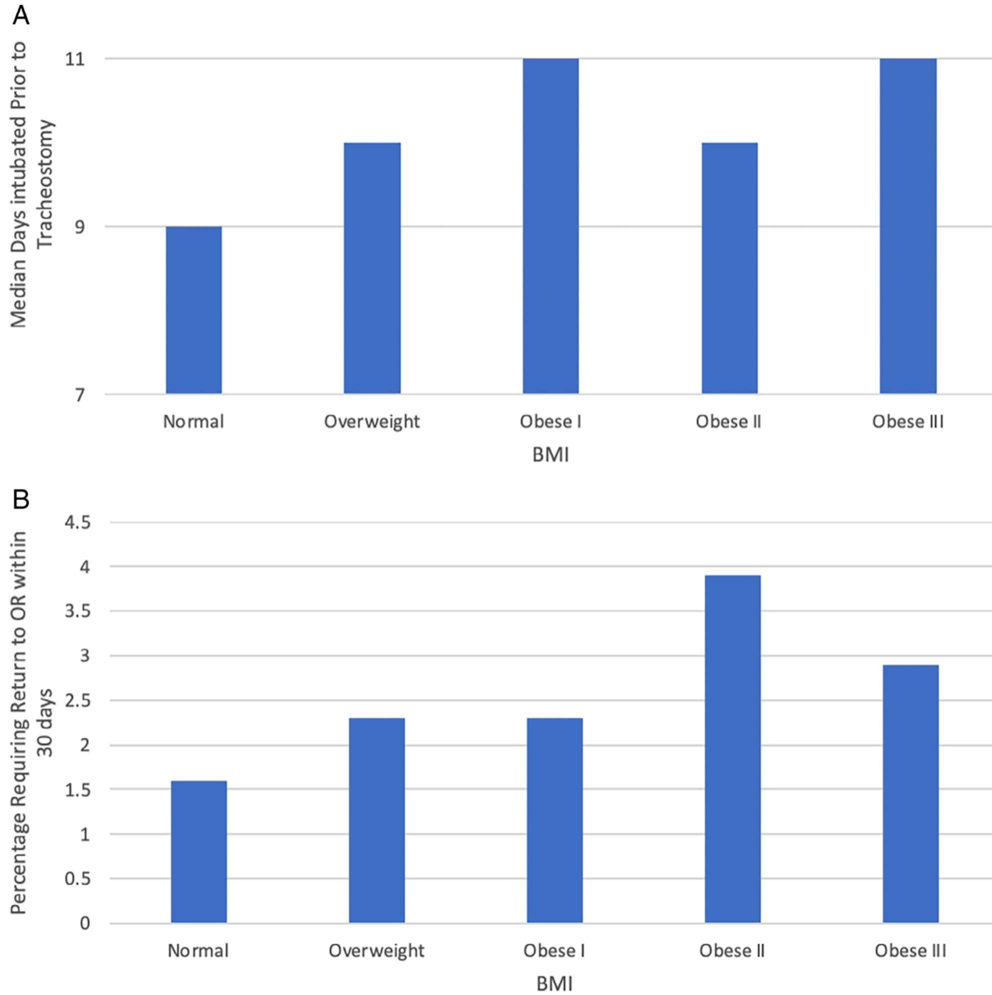

Fig. 1. (A) Days intubated prior to tracheotomy stratified by obesity classification. (B) Percent requiring return to operating room within 30 days by obesity classification. [Color figure can be viewed in the online issue, which is available at www.laryngoscope.com.]

Factors Associated with Prolonged Intubation

Lastly, we sought to determine what other variables were associated with prolonged intubation prior to tracheotomy. On univariate analysis, history of prior stroke (57.8% versus 52.0%; $X^2 = 9.83$; $p = 0.002$), history of diabetes (57.0% vs. 52.5%; $X^2 = 5.49$; $p = 0.02$), and obesity (58.2% vs. 48.4%; $X^2 = 21.4$; $p < 0.001$) were the only demographic factors that were associated with prolonged intubation. Age, gender, race, history of radiation, prior myocardial infarction, congestive heart failure, COPD, peripheral vascular disease, history of connective tissue diseases, AIDS, history of prior neck surgery, and malignancy were not associated with prolonged intubation. Cardiopulmonary failure was the only indication for tracheotomy that was associated with prolonged intubation (54.7% vs. 45.4%; $X^2 = 8.91$; $p = 0.003$). Benign obstruction as an indication for tracheotomy was found to have lower rates of prolonged intubation (32.1% vs. 54.8%, $p < 0.001$). Percutaneous tracheotomies were also associated with prolonged intubation compared with open tracheotomies (56.5% vs. 52.0%, respectively; $X^2 = 9.83$; $p = 0.002$). There were also institutional differences in the timing of tracheotomy after intubation on univariate analysis with median days intubated ranging from 8 to 12 days depending on at which institution each patient received their tracheotomy ($X^2 = 51.45$; $p < 0.001$). On multivariable model accounting for all variables significant on univariate analysis, obesity (95% CI: 1.13–1.62, $p = 0.001$), history of stroke (95% CI: 1.03–1.50; $p = 0.024$), and some institutional differences (Table III) remained significant factors associated with prolonged intubation and benign obstruction remained a protective indication for prolonged intubation (95% CI: 0.12–0.67; $p = 0.004$).

DISCUSSION

The work herein seeks to investigate the impact of obesity on the timing of tracheotomy, short-term tracheotomy complications requiring a return to the operating room, and 30-day mortality. It addresses several gaps in the existing literature stemming from smaller studies with limited statistical evaluation and a paucity of studies investigating the relationship between obesity and tracheotomy timing. This work, with its substantial sample size, provides adequate power to categorize patients

TABLE III.
Multivariable Logistic Regression Model Assessing Predictors of Prolonged Intubation.

Variable	Odds Ratio	95% CI	*p*-value
Trach type (percutaneous versus open)	0.91	0.76–1.08	0.270
Indication			
Cardiopulmonary failure	0.67	0.28–1.56	0.348
Obstructive malignancy	0.70	0.29–1.71	0.439
Progressive nonmalignant obstruction	0.28	0.12–0.67	0.004*
Conversion from perc trach or cricothyroidotomy	0.44	0.12–1.59	0.210
Comorbidity			
Obesity	1.37	1.15–1.63	<0.001*
Prior stroke	1.26	1.05–1.51	0.014*
Diabetes	1.13	0.94–1.36	0.181
Institution			
Institution #2	0.64	0.43–0.97	0.034*
Institution #3	0.93	0.66–1.32	0.714
Institution #4	1.12	0.74–1.70	0.596
Institution #5	1.04	0.76–1.43	0.788
Institution #6	1.76	1.22–2.56	0.003*
Institution #7	0.88	0.65–1.21	0.437
Institution #8	1.47	1.04–2.06	0.027*

Only comorbidities that were statistically significant on univariate analyses were included in the multivariable model.
CI = confidence interval.
*$p < 0.05$.

based on the degree of obesity, novel analyses assessing tracheotomy timing according to the degree of obesity, as well as a post hoc analysis examining overweight nonobese patients.

In this study, higher BMI was associated with a longer duration of translaryngeal orotracheal ventilation prior to tracheotomy. Post hoc comparisons were performed to assess whether morbid obesity and overweight status had similar associations in tracheotomy delays and complications. Morbid obesity was found to be associated with delays in tracheotomy and a higher likelihood of returning to the operating room within 30 days on univariate analysis, but this lost significance on multivariate analysis. This same effect of delays in tracheotomy timing was not seen in overweight patients. Lastly, this study sought to take advantage of the large sample size to determine factors associated with prolonged intubation showing that obesity, history of stroke, cardiopulmonary failure, and institutional differences were associated with prolonged intubation.

The finding that BMI was related to delays in the timing of tracheotomy is novel and not previously described in the literature. This finding could be related to a number of potential factors. Surgeons may be more reticent to operate on obese patients given anatomic challenges.[9] Obesity also comes with several other comorbidities which may make medical stabilization more difficult leading to additional delays.[29,30] For example, titrating ventilator settings to levels that are safe for tracheotomy may be more difficult in patients with obesity.[29] Our initial hypothesis for another factor in this delay in tracheotomy was the type of tracheotomy being completed (percutaneous versus open) with the idea that there may be delays related to an open approach, such as surgeon and operating room availability.[23] However, when accounting for this variable, BMI still remained a significant factor for delays in timing of tracheotomy. Although we see a statistically significant correlation between BMI and delays in timing of tracheotomy, further prospective studies are necessary to determine factors associated with this delay in care.

Prior studies of obese patient groups have described the duration of intubation, but no studies have specifically evaluated and analyzed timing to tracheotomy in the setting of degrees of obesity. For example, Fattahi et al. completed a retrospective study on obese patients to evaluate the difficulties and challenges associated with open tracheotomy. Although not the primary aim of the study, they found that obese patients had an average intubation duration of 11 days before tracheotomy, which is similar to that observed in this study.[9] Although the exact ideal timing of tracheotomy for prolonged intubation remains somewhat controversial, studies have shown that early tracheotomy is related to reduced ICU/hospital stay,[31] lower rates of ventilator-associated pneumonia (VAP),[32] and less sedation.[33] An analysis conducted by Alhajhusain et al. examined critically ill obese patients who underwent a tracheotomy and found that early tracheotomies (<9 days) were associated with shorter ICU and hospital length of stay and lower rates of nosocomial pneumonia compared with obese patients that received late (≥9 days) tracheotomy.[34] Although 2 days extra of intubation in morbidly obese may not seem to be clinically significant, these studies show that early tracheotomy can lead to improved short-term patient outcomes, decreased morbidity, and decreased length of stay.

Multiple previous studies have explored the relationship between obesity and tracheotomy outcomes, though all with different limitations. Mamidi et al. conducted a study utilizing the American College of Surgeons National Quality Improvement Program (ACS-NSQIP) and found that obesity (BMI ≥30) is an independent risk factor for various adverse outcomes after tracheotomy, including increased risk of overall complications and unplanned 30-day readmission.[10] In line with the findings of this study, they also did not show a significant independent correlation between unplanned reoperation compared with nonobese patients. Although a large study, it was limited by the typical limitations of national database studies with potentially unclear coding and limited ability to interpret the indications for an unplanned reoperation. Roy et al. completed a meta-analysis to assess the complications rate of percutaneous tracheotomies in critically ill patients with obesity and found a higher rate of complications in patients with obesity compared with nonobese patients.[11] Although a well-done meta-analysis, it is difficult to compare our findings due to multiple reasons. First, their analysis evaluating complications in patients with obesity was largely powered by minor non-life-threatening complications. This differs from our methodology as minor complications were not included in our analysis and thus may explain why there was no difference in complication rates in our study compared with theirs. Second, their analysis was limited by being a meta-analysis and was unable to evaluate potential confounders. Therefore, comorbidities may play a role in their findings, but evaluation of this was limited. Barrera et al. completed a retrospective review of 387 patients who underwent open tracheotomies at their institution and found that postoperative complication rates were higher among obese patients (20.9%) compared with nonobese patients (15.8%) on univariate analysis. When stratified by the WHO classification system, patients with a BMI ≥35 kg/m^2 and BMI ≥40 kg/m^2 (Class II and III) had even higher complication rates than those in Class I (BMI ≥30 kg/m^2) and nonobese patients on univariate analysis.[35] Similarly, Cordes et al. completed a prospective study of 151 patients undergoing tracheotomies and observed an increase in total complication rates during and after open tracheotomy among patients with a BMI ≥35 kg/m^2, but not at BMI ≥30 kg/m^2 on univariate analysis.[8] These studies support our initial findings on univariate analysis that morbid obesity may impact tracheotomy outcomes. However, their limited sample sizes prevented a robust multivariate analysis that allowed for the evaluation of confounding variables. When accounting for these confounding variables in our study, complications requiring return to the operating room within 30 days was no longer significantly increased in morbid obesity. This is important to differentiate as all the prior studies have assumed that elevated BMI alone was a risk factor for major complications. However, we show that comorbidities, indication for tracheotomy, and institutional differences can play a role in these complications and that morbid obesity alone does not explain the whole picture.

This study's post hoc analysis focusing on overweight nonobese patients showing no difference in tracheotomy timing or complications brings a novel analysis to the current tracheotomy literature. Although prior studies have stratified patients based on the NIH obesity classification, none have been powered enough to determine if overweight status has similar outcomes as obese status.[8,10] Findings in this work show overweight status is not associated with an increased risk of returning to the operating room within 30 days, delays in tracheotomy timing, or rates of decannulation.

The main study limitation here is inherent to the retrospective nature of this study. This study design limits the variables that were able to be assessed and thus the conclusions that can be made from these data. For example, indications for return to the operating room within 30 days for tracheotomy-related issues (such as bleeding, loss of airway, etc.) were unable to be delineated further. However, this study provides additional information for the clinician in stratifying tracheotomy risks in obese patients. It also calls attention to the possibility of bias in provider decision-making in the context of obese patients. Lastly, data from this study was collected from 2013 to 2016, which limits conclusions that can be made with changes in tracheotomy practices with the COVID-19 pandemic. However, outside of the COVID pandemic, decision-making regarding tracheotomy timing has not changed significantly since 2016 and thus these findings are still important for the clinician to consider when determining the timing of tracheotomy.

CONCLUSION

Obesity poses distinct challenges in tracheotomies and leads to significant delays in surgical timing in this large multi-institutional study. On multivariable analysis, delays were found to be associated with obesity, history of stroke, and institutional differences, but were not associated with type of tracheotomy (percutaneous versus open) or other comorbidities. Postoperatively, patients with morbid obesity had a higher likelihood of returning to the operating room for a tracheotomy complication on univariate analysis, but this lost significance on multivariable analysis. These findings are of clinical significance showing that obese patients may have a delay in tracheotomy despite a comparable 30-day safety profile compared with nonobese patients.

ACKNOWLEDGMENTS

AY and PAW had full access to all the data in the study and take responsibility for the integrity of the data and accuracy of the data analysis. SIS and IS contributed substantially to the data analysis and writing of the manuscript. DOF, JP, DK, AA, AA, SW, MT, PCB, CBT, EEZ, AOR, CSM, DRG, CKW, WPL, JMT, BKC, SR, AB, RK, TBH, MC, ITJ, KS, MK, TAA, MMK, DGL contributed substantially to study design, study recruitment, and manuscript revision.

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