Analysis of Patient Factors Associated With 30-Day Mortality After Tracheostomy

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**Objective:** Mortality has been reported to be 22% to 45% in patients with a tracheostomy. To better counsel patients and families, we aimed to determine the effect of body mass index (BMI), socioeconomic status (SES), and the 17 conditions of the Charlson comorbidity index (CCI) on 30-day survival posttracheostomy.

**Methods:** This retrospective cohort study identified adult patients enrolled from our institution in the Global Tracheostomy Collaborative database from March 2014 to June 2015. Data collected included age, BMI, residential zip code, and comorbidities. Cox proportionate univariate and multivariate analyses were used to measure the impact of BMI, SES, and CCI variables with 30-day posttracheostomy survival. We used geocoding as a surrogate for patients’ SES. We used Deyo’s modification of the CCI, which utilized International Classification of Diseases, 9th Revision, codes to identify comorbidities.

**Results:** Of 326 tracheostomies identified, the 30-day mortality rate was 15.6%. No significant differences were noted in BMI or in any of the SES categories between survivors and nonsurvivors. CCI was significantly higher in the 30-day mortality group. Congestive heart failure (hazard ratio [HR] = 2.39), severe liver disease (HR = 3.15), and peripheral vascular disease (HR = 2.62) were found to significantly impact 30-day survival.

**Conclusion:** Higher CCI and specifically severe liver disease, congestive heart failure, and peripheral vascular disease were associated with increased 30-day mortality posttracheostomy. No association was found between BMI or SES and 30-day survival. This study identified three comorbidities that independently affect mortality in tracheostomy patients, which should be discussed with patients and families before tracheostomy.

**Key Words:** Charlson comorbidity index, tracheostomy, mortality, morbidity, BMI, socioeconomic status.

**Level of Evidence:** 3

**INTRODUCTION**

Tracheostomy is commonly performed in intensive care unit (ICU) patients, with 6% of that population undergoing the procedure.1,2 The most common indication for tracheostomy is ventilator-dependent respiratory failure (VDRF).3,4 Over the past few decades, significant advancements have been made in posttracheostomy care, and new methods of performing the procedure have been developed.5 Despite these improvements, patients undergoing tracheostomy typically have a multitude of comorbidities, and thus posttracheostomy mortality has been shown to range from 22% to 45%.6

Multiple studies have described factors influencing the mortality of patients undergoing a tracheostomy.7,8 However, information is limited on the association of posttracheostomy mortality with the presence of comorbidities and body mass index (BMI), and no studies were found on association of socioeconomic status (SES) with survival posttracheostomy. One single-institution study analyzed the association of the Charlson Comorbidity Index9 (CCI) with 30-day survival in tracheostomy patients10 but did not reveal which CCI-listed comorbidities impacted survival. Due to these gaps in knowledge, we used the Global Tracheostomy Collaborative (GTC) database to determine the effect of CCI patient comorbidities, BMI, and SES on 30-day survival following tracheostomy.11

**MATERIALS AND METHODS**

This retrospective cohort study, approved by our hospital’s institutional review board, included all patients enrolled from our institution in the GTC database from March 2014 to June 2015. The GTC was created in 2012 with an aim to identify and fix issues related to the tracheostomy experience. Specifically, the collaborative was formed to disseminate validated posttracheostomy care protocols, create a large multi-institutional database for research purposes, and develop standardized metrics that help hospitals benchmark their performance and track their improvement.

We obtained GTC records for patients aged ≥ 18 years who underwent either an open or percutaneous tracheostomy by the otolaryngology, general surgery, or thoracic surgery services at our institution. Patient-specific data collected included age, BMI, date of tracheostomy, CCI, socioeconomic data, and survival 30 days posttracheostomy. To determine survival, death records were obtained from the Michigan Department of Health and Human Services.
Body Mass Index
Patients’ weight and height were collected from the GTC database. BMI was classified as nominal variables with four categories based on CDC criteria: underweight (BMI < 18.5), normal (BMI = 18.5–24.9), overweight (BMI = 25–29.9), and obese (BMI ≥ 30). A Cox proportional hazards ratio model was used to determine BMI impact significance with the obese class as the reference group. The outcome variable was 30-day postoperative survival.

Socioeconomic Status
We used geocoding as a surrogate for the patients’ SES. This methodology has been described previously. In brief, using the 2010 U.S. Census block group and patients’ residential zip codes, we obtained median household income, proportion of residents living with a high school diploma or less, percentage of homes occupied, percentage of homes owned and percentage of homes rented, and percentage of households living below the federal poverty level. Cox proportionate univariate analysis was performed to evaluate for any significant association between a specific covariate and 30-day survival.

Charlson Comorbidity Index
The comorbidity list of the CCI is shown in Figure 1. This study utilized Deyo’s modification of the CCI, which uses International Classification of Diseases, 9th Revision, codes to identify comorbidities. Higher total scores indicate more severe comorbidities and a worse prognosis. The outcome variable was 30-day posttracheostomy survival. Cox proportionate univariate analysis was performed to evaluate for any significant association between a specific covariate and the outcome variable. A multivariate analysis was then performed on those variables found to have a significant association with 30-day survival on univariate analysis. Hazard ratios for all comorbidities were also obtained to gain a detailed perspective on which CCI-listed comorbidities had a significant impact on survival during the 30-day postoperative period.

RESULTS
A total of 326 adult tracheostomy patients were identified. All tracheotomies were performed at our institution. The most common primary indication for a tracheostomy was for VDRF. Thirty-one patients underwent a percutaneous tracheostomy, and 295 underwent an open tracheostomy. The average age of the study population was 61 years. There were 51 deaths (84.4% survival) within the 30-day period and 147 deaths (44% survival) by the end of data collection on deaths in June 2017 (24–33 months from the time of the tracheostomy). No deaths were directly attributed to the tracheostomy procedure itself.

Body Mass Index
In the study population, 9.5% of patients were underweight; 30.6% were within the normal range; 25.1% were overweight; and 34.8% were obese (BMI ≥ 30). The average BMI was 28.87 in the 30-day survival group and 29.91 in the 30-day death group, which was not statistically significant (Table I). There were no significant differences noted with 30-day survival between the BMI categories.

Socioeconomic Status
Based on zip codes, the median household income for our patient population was $43,346. Overall, 48.1% of...
residents of the patient-reported zip codes had a high school
education or less. On average, 20% of the household incomes
fell below the federal poverty level (i.e., income < $22,050 for
a family of four, < $10,830 for an individual). Almost 85% of
homes were occupied; 64.3% of the houses were owned by the
occupying residents; and 35.7% of the houses were rented. In
the univariate analysis, none of the socioeconomic variables
were associated with 30-day survival or overall mortality in
our patient population (Table II).

**Charlson Comorbidity Index**
CCI was significantly associated with 30-day sur-

vival \( (P = 0.034) \) (Table III). Every 1-unit increase in CCI
corresponded to a 12% increase in risk of death within
30 days. In both univariate and multivariate analyses of
the 17 comorbidities that comprised the CCI, peripheral
vascular disease (PVD), severe liver disease (SLD), and
congestive heart failure (CHF) were found to significantly
affect 30-day mortality (Table IV). A patient with CHF
was 2.39 times as likely to die as one without CHF. A
patient with SLD was 3.15 times as likely to die as one
without liver disease. A person with PVD was 2.62 times
as likely to die as one without PVD. Because the patients
with AIDS (\( n = 2 \)) and dementia (\( n = 4 \)) all survived, the
Cox proportional hazards model was not performed in
these variables; there was no death group for comparison.

**DISCUSSION**

This single-institution study found that neither
BMI nor SES was associated with 30-day survival
posttracheostomy, but CCI presented a mortality risk
that increased with each point. Specifically, patients with
PVD, SLD, and CHF had a higher risk of 30-day mortal-
ity compared to their counterparts without the condition.

Patients undergoing tracheostomy often have multi-
ple comorbidities; identifying their association with sur-
vival can help improve counseling and care.\(^1\)\(^5\) Our study’s
objective was to assess patient factors that increase the
risk of short-term mortality in this cohort so that the
patient, family, and care team are more aware of the
risks. Identification of modifiable risk factors in advance
may help to improve outcomes by mitigating such risk
factors.

The prevalence of obesity has been on the rise, dou-
bling from 1980 to 2014, and its association with negative
patient outcomes—especially in the ICU—has been stud-
ied.\(^1\)\(^6\) Management of obese patients in the ICU has been
shown to be associated with increased frequency of
mechanical ventilation and longer ICU stays compared to
nonobese patients.\(^1\)\(^7\) Although 25% of patients in the ICU
are classified as obese, limited literature exists regarding
the association of obesity with mortality in the tracheos-
tomy population.\(^1\)\(^8\) A study compared the complication
and mortality rate of 89 morbidly obese patients and
326 nonobese patients, finding that obese patients are at
increased risk of complications from the tracheostomy
and concluding that obese patients who receive a tracheos-
tomy are at increased risk of death.\(^1\)\(^8\) Our study had
113 obese patients and no deaths related to the tracheos-
tomy procedure. Our findings suggest that obesity does
not appear to be associated with an increased risk of
death following tracheostomy in the 30-day postoperative

| Table II. Associations of Socioeconomic Markers and 30-Day Outcomes. |
|--------------------------|------------------|----------------|------------------|------------------|
|                          | Hazard Ratio (Confidence Interval) | P Value | 30-Day Survival Mean ± SD or % | 30-Day Death Mean ± SD or % |
| Education % ≤ high school per 10% | 1.07 (0.88, 1.31) | 0.498 | 47.82 ± 15.26 | 49.62 ± 14.59 |
| Median house income per Log | 0.90 (0.49, 1.68) | 0.748 | $43,413 ± $21,441 | $42,946 ± $21,210 |
| Houses below poverty level, per 10% | 1.10 (0.93, 1.31) | 0.281 | 20.14 ± 16.19 | 23.10 ± 19.11 |
| Houses occupied, per 10% | 0.94 (0.71, 1.23) | 0.54 | 84.92 ± 10.57 | 83.96 ± 11.97 |
| Houses owned, per 10% | 1.11 (0.95, 1.30) | 0.172 | 63.63 ± 21.25 | 68.45 ± 18.63 |
| Houses rented, per 10% | 0.90 (0.77, 1.05) | 0.172 | 36.37 ± 21.25 | 31.55 ± 18.63 |
| Age divided by 10 | 0.98 (0.84, 1.16) | 0.897 | 60.86 ± 16.47 | 66.34 ± 20.11 |

SD = standard deviation.
period. The difference in study findings may reflect different criteria for obesity (BMI ≥ 40 in El Solh and Jaafar's study vs. BMI ≥ 30 in ours).

In our study population, CCI was independently associated with increased mortality posttracheostomy. CCI has been shown to have similar validity for predicting risk of mortality based on the Acute Physiologic Assessment and Chronic Health Evaluation (APACHE) score in ICU patients in a 30-day period. Furthermore, CCI has been utilized in studies that associate comorbidities of patients with VDRF. Song et al. studied the prognostic value of CCI in patients with prolonged mechanical ventilation, noting significant differences in CCI between 60-day survivors and nonsurvivors, where the non-survivors had an average CCI score ≥ 5.

Kejner et al. highlighted the importance of patient comorbidity because identifying factors that affect mortality can increase selectivity for the procedure and potentially improve hospital quality ratings for surgical teams. In their study, 129 subjects from a Veterans Administration hospital were stratified by 30-day survivors and nonsurvivors. The overall 30-day mortality rate was 25%, with a significant difference in CCI between the two groups. However, the study did not assess the specific comorbidities within the CCI that significantly affected 30-day survival. Like Kejner et al., we found a significant difference in CCI between the survivors and nonsurvivors within the 30-day postoperative period.

In the literature, a select number of comorbidities that are accounted for by the CCI were found to significantly affect survival. Arabi et al. conducted an observational cohort study of 531 tracheostomy patients and performed a multivariate analysis on patient factors associated with in-hospital mortality. The study found patients with chronic liver disease to be 8.35 times more likely to die in the hospital. Our study supports these findings, although our patients with severe liver disease had a lower rate of mortality risk (3.15 times more likely to die within the 30-day postoperative period). CHF was also noted to be significant on multivariate analysis in our study, with a hazard ratio of 2.39. CHF is a known factor in complicating the course of ICU patients because it may prolong mechanical ventilation secondary to pulmonary edema and can be associated with renal failure and cardiac arrhythmias. Limited literature exists with regard to its association with survival in tracheostomy patients. However, one study noted that there was no risk of in-hospital mortality in tracheostomy patients with CHF. Multivariate analysis in our study also showed PVD to independently decrease the chances of survival, with a hazard ratio of 2.62. This contradicts the findings by Engoren et al., who found no association of PVD with mortality in 429 tracheostomy patients but noted coronary artery disease, renal disease, and hypertension to be significant.

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<th>TABLE III. Association of Comorbidities and 30-Day Outcomes</th>
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<td>Hazard Ratio (Confidence Interval)</td>
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<td>CCI</td>
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<tr>
<td>Myocardial infarction</td>
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<td>Cerebrovascular disease</td>
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<td>Chronic pulmonary disease</td>
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<td>Rheumatic disease</td>
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<td>Peptic ulcer disease</td>
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<td>Mild liver disease</td>
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<td>Diabetes</td>
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<td>Diabetes with complications</td>
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<td>Hemiplegia or paraplegia</td>
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<td>Renal disease</td>
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<td>Malignancy</td>
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<td>Metastatic disease</td>
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<td>Severe liver disease</td>
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<td>Peripheral vascular disease</td>
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<td>Congestive heart failure</td>
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<td>Dementia</td>
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<td>AIDS</td>
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CCI = Charlson Comorbidity Index; SD = standard deviation

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<th>TABLE IV. Multivariate Analysis of Comorbidities</th>
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<td>Comorbidity</td>
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The impact of socioeconomic status on mortality has not been extensively studied in tracheostomy patients. humble et al. studied risk factors associated with tracheostomy placement in patients who suffered traumatic brain injury.25 Notably, the study found that patients with private insurance were more likely to receive a tracheostomy than uninsured patients; however, there was no association with mortality. That study was limited in that insurance coverage does not encompass the many elements of socioeconomic status such as education level, income, and social support. Our study assessed various aspects of socioeconomic status and found no significant difference in 30-day postoperative survival. Although our study had the advantage of defining SES with more variables, the use of geocoding as a surrogate marker for patient data is a limitation. Additionally, our study looked at mortality in the short term, in which socioeconomic status might not play as strong of a role in patient care. Further investigation should be implemented to evaluate the effect of socioeconomic status on mortality over a longer period of time.

Our study has limitations. First, given that our patient population is from an urban setting, the results of this study cannot be reliably generalized to all tracheostomy patients. Because the GTC includes data from other institutions around the world, a multi-institutional analysis can be performed in the future to provide more universal results on comorbidities impacting survival. Finally, because death data were obtained from the state of Michigan, subjects who traveled to and died in a different state within the 30-day period would have been falsely accounted for as surviving. Going forward, this database can be used to aggregate data to perform a similar analysis across multiple member institutions to provide greater statistical power and generalizability. It is unusual for mortality to be caused specifically by tracheostomy complications; however, patients undergoing tracheostomy have a high mortality rate due to the underlying conditions that might lead to needing the operation.

CONCLUSION

Our study found no association between BMI or SES and 30-day survival after a tracheostomy. A higher CCI—and specifically SLD, CHF, and PVD—were associated with increased 30-day mortality posttracheostomy. This study highlights the comorbidities that independently affect mortality in tracheostomy patients and should be taken into account when discussing tracheostomy placement with patients and their families.

ACKNOWLEDGMENTS

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BIBLIOGRAPHY