Mortality Risk Factors in Patients Admitted with the Primary Diagnosis of Tracheostomy Complications: An Analysis of 8026 Patients

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Abstract: Background: Tracheostomy is a procedure commonly conducted in patients undergoing emergency admission and requires prolonged mechanical ventilation. In the present study, the aim was to determine the prevalence and risk factors of mortality among emergently admitted patients with tracheostomy complications, during the years 2005–2014. Methods: This was a retrospective cohort study. Demographics and clinical data were obtained from the National Inpatient Sample, 2005–2014, to evaluate elderly (65+ years) and non-elderly adult patients (18–64 years) with tracheostomy complications (ICD-9 code, 519) who underwent emergency admission. A multivariable logistic regression model with backward elimination was used to identify the association between predictors and in-hospital mortality. Results: A total of 4711 non-elderly and 3315 elderly patients were included. Females included 44.5% of the non-elderly patients and 47.6% of the elderly patients. In total, 181 (3.8%) non-elderly patients died, of which 48.1% were female, and 163 (4.9%) elderly patients died, of which 48.5% were female. The mean (SD) age of the non-elderly patients was 50 years and for elderly patients was 74 years. The mean age at the time of death of non-elderly patients was 53 years and for elderly patients was 75 years. The odds ratio (95% confidence interval, \( p \)-value) of some of the pertinent risk factors for mortality showed by the final regression model were older age (OR = 1.007, 95% CI: 1.001–1.013, \( p < 0.02 \)), longer hospital length of stay (OR = 1.008, 95% CI: 1.001–1.016, \( p < 0.18 \)), cardiac disease (OR = 3.21, 95% CI: 2.48–4.15, \( p < 0.001 \)), and liver disease (OR = 2.61, 95% CI: 1.73–3.93, \( p < 0.001 \)). Conclusion: Age, hospital length of stay, and several comorbidities have been shown to be significant risk factors in in-hospital mortality in patients admitted emergently with the primary diagnosis of tracheostomy complications. Each year of age increased the risk of mortality by 0.7% and each additional day in the hospital increased it by 0.8%.

Keywords: tracheostomy; in-hospital mortality; hospital length of stay; emergency admission

1. Introduction

Tracheostomy is one of the most frequently performed procedures in intensive care medicine [1] aiming to facilitate the recovery of critically ill patients via Liberating them from mechanical ventilation, increasing the ability to mobilize patients with chronic respiratory failure, and reducing the dosage of sedation [2]. Every year, approximately 800,000 U.S. residents need invasive mechanical ventilation [3] accounting for at least 25% of intensive care admissions in many hospitals [4]. Tracheostomy use increased rapidly through 2008, at which point we began to observe yearly declines [5]. In recent years, the number of chronically critically ill patients requiring prolonged mechanical ventilation (MV) and receiving a tracheostomy is steadily increasing [6]. Tracheostomy may improve aspects of care for MV patients [5], such as sedation requirements, mobility, and oral feeding [7,8].
Complication rates currently exceed 50% and can result in life threats such as decannulation, obstruction, and hemorrhage [9]. The use of tracheostomies has substantial implications on cost, resource use, and outcomes during acute hospitalization and following hospital discharge [10–12]. Insufficient emphasis had been placed on drawing a clear personalized patient profile and developing practices for the management and understanding of the individual clinical, socioeconomic, and demographic differences of patients undergoing emergency surgery for tracheostomy complications. These personal data are essential for clinical decision-making through early initiation of treatment in high-risk patients, and therefore is a determinant of a successful outcome of the treatment. The use of artificial intelligence through machine-learning classifiers was suggested for the early identification of patients at risk for prolonged mechanical ventilation and tracheostomy. The application of these identification techniques could lead to improved outcomes by allowing for early intervention [13]. This would require elucidating the pertinent risk factors of mortality, complications, and a longer hospital length of stay.

The variation in demographic, clinical, and hospitalization characteristics of the patients requires a thorough analysis of clinical data, management implementation, and treatment outcomes [14]. It is incumbent for the emergency team to be able to promptly identify the signs of tracheostomy-related emergencies, issue preventive strategies, allocate resources, and provide stabilization. The clinical relevance of these complications is crucial, as their exemplifications range from barely symptomatic to failure to wean from the mechanical ventilator to life-threatening hemorrhage. Sound knowledge of tracheostomy risks and the increasing rate of complications is crucial for the performing surgeon and the supporting health care team. As such, the aim of this study is to evaluate the specific risk factors for mortality in patients admitted emergently with the primary diagnosis of tracheostomy.

2. Materials and Methods

The Healthcare Cost and Utilization Project (HCUP) was instituted to produce multi-state, administrative, and population-based statistics on patients in a systematic format. The data are directed toward health services research to reinforce healthcare provision. The National Inpatient Sample (NIS), a broad administrative database formed by the Agency for Healthcare Research and Quality (AHRQ), has been progressively employed as a country-wide public data source and carries much potential and supports the assessment of patterns of care and outcomes for research. It enables an innovative perspective to examine disease conditions, optimal care, and patient outcomes. The NIS applies the process of weighting when generating the sample of discharges from community hospitals in the US, excluding rehabilitation centers and long-term acute care facilities. This approach of stratification makes it feasible to produce a national estimate of hospitalizations for attainable factors. This retrospective cohort study extracted data on adult and elderly patients with tracheostomy complications that had emergency general surgery (EGS) procedures. The sample was pulled from the NIS 2005–2014. The ICD-9 code to identify patients with tracheostomy complications was 519. Table 1 summarizes the ICD-9 codes for the operations and invasive diagnostic procedures on both the digestive and respiratory systems. The following characteristics of patients and hospitals were collected and analyzed: Age, gender, race, income quartile, hospital location (rural, urban–non-teaching, urban–teaching), healthcare insurance (Medicare, Medi-caid, private insurance, self-paid, and no charge), tracheostomy complication (infection, mechanical complication, unspecified, other), required an invasive diagnostic procedure vs. not, required surgical procedure vs. not, days to the first procedure, length of hospital stay, and total charges. Post-procedure mortality was limited to immediate hospitalization, not including future clinical courses in referral wards or institutions. R software was used for the statistical analysis, and $p < 0.01$ was set as significant.
Table 1. Procedures of emergently admitted patients with the primary diagnosis of tracheostomy complications.

| Operations on the Digestive System (ICD 9) |
|-------------------------------------------|
| Operations on Esophagus (42.01–42.19, 42.31–42.99) |
| Operations on Stomach (43.0–44.03, 44.21–44.99) |
| Operations on Intestine (45.00–45.03, 45.30–46.99) |
| Operations on Appendix (47.01–47.99) |
| Operations on Rectum, Rectosigmoid, and Perirectal Tissue (48.0–48.1, 48.31–48.99) |
| Operations on Anus (49.01–49.12, 49.31–49.99) |
| Operations on Liver (50.0, 50.21–50.99) |
| Operations on Gallbladder and Biliary Tract (51.01–51.04, 51.21–51.99) |
| Operations on Pancreas (52.01–52.09, 52.21–52.99) |
| Operations on Hernia (53.00–53.9) |
| Operations on Other Operations on Abdominal Region (54.0–54.19, 54.3–54.99) |

| Invasive Diagnostic Procedures on the Digestive System (ICD 9) |
|---------------------------------------------------------------|
| Invasive Diagnostic Procedure on Esophagus (42.21–42.29) |
| Invasive Diagnostic Procedure on Stomach (44.11–44.19) |
| Invasive Diagnostic Procedure on Intestine (45.11–45.29) |
| Invasive Diagnostic Procedure on Rectum, Rectosigmoid, and Perirectal Tissue (48.21–48.29) |
| Invasive Diagnostic Procedure on Anus (49.21–49.29) |
| Invasive Diagnostic Procedure on Liver (50.11–50.19) |
| Invasive Diagnostic Procedure on Gallbladder and Biliary Tract (51.10–51.19) |
| Invasive Diagnostic Procedure on Pancreas (52.11–52.19) |
| Invasive Diagnostic Procedure on Other Operations on Abdominal Region (54.21–54.29) |

| Operations on the Respiratory System (ICD 9) |
|---------------------------------------------|
| Operations on Larynx and Trachea (30.01–31.3, 31.5–31.99) |
| Operations on Lung and Bronchus (32.01–33.1, 33.31–33.99) |
| Operations on Chest Wall, Pleura, Mediastinum, and Diaphragm (34.01–34.1, 34.3–34.99) |

| Invasive Diagnostic Procedures on the Respiratory System (ICD 9) |
|---------------------------------------------------------------|
| Invasive Diagnostic Procedure on Larynx and Trachea (31.41–31.49) |
| Invasive Diagnostic Procedure on Lung and Bronchus (33.20–33.29) |
| Invasive Diagnostic Procedure on Chest Wall, Pleura, Mediastinum, and Diaphragm (34.20–34.29) |

Statistical Analysis

Descriptive and analytical statistical indicators were used to present the findings. The mean, standard deviation (SD), and confidence interval at 95% (CI) were calculated for numerical variables. The comparisons used a chi-square test for categorical variables and a t-test for continuous variables. The data were compared in three different ways. The first way examined gender within the two age categories. The second compared the surviving vs. deceased patients for both adult and elderly patients. Finally, we looked at adult and elderly patients who either underwent an operation or did not. The ability of different variables to predict mortality was evaluated by a backward multivariable logistic regression analysis. P-values less than 0.05 were considered significant. All analyses were performed using SPSS software version 26 (SPSS Inc., Chicago, IL, USA) and R statistical software (Foundation for Statistical Computing, Vienna, Austria).

3. Results

3.1. Gender Differences

3.1.1. Non-Elderly Patients

The mean age of the 181 patients who passed away during the study period was 53 years, of which 94 were males (52%) and 87 were females (48%). Most patients were white, of income quartile 1, funded mostly by Medicaid, and were admitted to a teaching hospital. The main comorbidities were hypertension, deficiency anemias, congestive heart failure, uncomplicated diabetes, obesity, and renal failure. Males had substantially greater
rates of alcohol abuse, metastatic cancer, and solid tumor as females manifested higher rates of congestive heart failure, chronic pulmonary disease, uncomplicated diabetes, hypothyroidism, depression, and obesity. No significant difference was shown between genders in terms of the invasive diagnostic procedure rate, surgical procedure rate, or mortality rate. Patients’ characteristics and clinical data are summarized in Table 2.

### Table 2. Characteristics of emergently admitted patients with the primary diagnosis of tracheostomy complications (NIS 2005–2014). Data were stratified according to gender categories. *p < 0.05.

| Patient Characteristics                  | Adults (18–64), N (%) | Elderly (65+), N (%) |
|------------------------------------------|-----------------------|---------------------|
| All Cases                                | 2616 (55.5%) *        | 1737 (52.4%) *      |
| Race                                     |                       |                     |
| White                                    | 2095 (44.5%) *        | 1578 (47.6%) *      |
| Black                                    | 1278 (57.0%) *        | 1058 (70.4%) *      |
| Asian/Pacific Islander                   | 60 (2.7%) *           | 46 (3.1%) *         |
| Native American                          | 10 (0.4%) *           | 5 (0.3%) *          |
| Other                                    | 77 (3.4%) *           | 49 (3.4%) *         |
| Quarter 1                                | 894 (35.4%) *         | 477 (28.2%) *       |
| Race Quartile                            |                       |                     |
| Quartile 2                               | 630 (25.0%) *         | 426 (25.2%) *       |
| Quartile 3                               | 402 (20.5%) *         | 251 (21.5%) *       |
| Quartile 4                               | 396 (15.2%) *         | 318 (25.1%) *       |
| Private Insurance                        | 640 (24.5%) *         | 159 (9.2%) *        |
| Medicare                                 | 845 (32.3%) *         | 1475 (85.0%) *      |
| Medicaid                                 | 902 (34.5%) *         | 502 (32.0%) *       |
| Self-Fat                                 | 103 (3.9%) *          | 16 (0.9%) *         |
| No Charge                                | 8 (0.3%) *            | 0 (0.0%) *          |
| Other                                    | 115 (4.4%) *          | 31 (1.8%) *         |
| Rural                                    | 142 (5.4%)            | 100 (5.8%)          |
| Hospital Location                        | 772 (29.5%)           | 590 (34.0%)         |
| Location                                 |                       |                     |
| Urban: Non-Teaching                      | 1702 (65.1%)          | 1047 (60.3%)        |
| Urban: Teaching                          | 1380 (50.0%)          | 971 (51.6%)         |
| Alcohol Abuse                            | 155 (5.9%) *          | 73 (4.4%) *         |
| Deficiency Anemia                        | 541 (20.7%) *         | 485 (27.9%) *       |
| Rheumatoid Arthritis                     | 17 (0.6%) *           | 20 (1.2%) *         |
| Chronic Blood Loss                       | 31 (1.2%)             | 26 (1.5%)           |
| Congestive Heart Failure                 | 351 (13.4%) *         | 375 (21.6%) *       |
| Chronic Pulmonary Disease                | 884 (33.8%) *         | 828 (47.7%) *       |
| Coagulopathy                             | 122 (4.7%)            | 83 (4.8%)           |
| Diabetes, Uncomplicated                  | 661 (25.3%) *         | 542 (31.2%) *       |
| Diabetes, Chronic Complications          | 76 (2.9%) *           | 58 (3.3%)           |
| Drug Abuse                               | 83 (3.2%)             | 70 (4.0%)           |
| Hypertension                             | 1209 (46.2%) *        | 1048 (60.3%)        |
| Hypothyroidism                           | 249 (9.6%) *          | 283 (16.3%) *       |
| Liver Disease                            | 103 (3.9%) *          | 31 (1.8%) *         |
| Lymphoma                                 | 13 (0.5%)             | 11 (0.6%)           |
| Fluid/Electrolyte Disorders              | 602 (20.0%)           | 481 (29.4%) *       |
| Metastatic Cancer                        | 175 (6.7%) *          | 124 (7.1%) *        |
| Other Neurological Disorders             | 454 (17.4%)           | 235 (13.5%) *       |
| Obesity                                  | 422 (16.1%)           | 122 (7.0%)          |
| Periperal Vascular Disorders             | 75 (2.9%)             | 129 (7.4%) *        |
| Psychoses                                | 107 (4.1%) *          | 43 (2.5%)           |
| Pulmonary Circulation Disorders          | 110 (4.2%) *          | 57 (3.3%) *         |
| Renal Failure                            | 276 (10.6%)           | 290 (16.7%)         |
| Solid Tumor                              | 333 (13.5%) *         | 294 (16.9%) *       |
| Peptic Ulcer                             | 0 (0.0%)              | 0 (0.0%)            |
| Valvular Disease                         | 56 (2.1%)             | 95 (5.5%)           |
| Weight Loss                              | 237 (9.1%)            | 178 (10.2%)         |
| Complication                             | 23 (0.9%) *           | 17 (1.0%) *         |
| Infection                                | 341 (13.0%) *         | 172 (9.9%) *        |
| Mechanical Complication                  | 802 (30.7%) *         | 469 (27.0%) *       |
| Other Tracheostomy Complication          | 1450 (51.4%) *        | 1079 (62.1%) *      |
| Invasive Diagnostic Procedure            | 979 (37.4%)           | 640 (36.8%) *       |
| Surgical Procedure                       | 727 (27.8%)           | 373 (21.5%) *       |
| Deceased                                 | 94 (3.4%)             | 50 (3.0%)           |
| Weight, Years (Mean (SD))                | 49.51 (12.32)         | 74.15 (6.86)        |
| Time to Invasive Diagnostic Procedure, Days | 1.72 (3.49) *       | 1.95 (3.44)         |
| Time to Surgical Procedure, Days         | 2.43 (4.12)           | 2.6 (3.84)          |
| Hospital Length of Stay, Days            | 6.33 (9.95) *         | 6.43 (4.83) *       |
| Total Charges, Dollars (Mean (SD))       | 50,206 (77,755)       | 56,312 (91,444)     |
3.1.2. Elderly Patients

Most patients were white, of income quartile 1, funded mainly by Medicare, and were admitted to an urban-teaching hospital. Some of the most common comorbidities were hypertension, congestive heart failure, uncomplicated diabetes, and fluid/electrolyte disorders. Males demonstrated a substantially greater rate of alcohol abuse, metastatic cancer, and solid tumors and females manifested a significantly higher rate of congestive heart disease, depression, uncomplicated diabetes, hypothyroidism, pulmonary circulation disorders, and obesity. Women also had a higher surgical procedure rate and a longer hospital length of stay (HLOS). No significant discrepancy was recognized between genders in terms of the invasive diagnostic procedure rate or mortality rate. Patients’ characteristics and clinical data are summarized in Table 2.

3.2. Mortality

3.2.1. Non-Elderly Patients

In total, 96.2% survived and 3.8% died. The mean (SD) age of the patients who survived was significantly lower than the patients who died, at 50 vs. 54 years, respectively. Of the deceased patients, 94 were males (52%) and 87 were females (48%), with a similar mean age. When comparing the deceased to the surviving patients, significant differences were identified in the comorbidities. The deceased manifested significantly greater rates of coagulopathy, liver disease, fluid/electrolyte disorders, metastatic cancer, and renal failure. Furthermore, the deceased had significantly higher rates of tracheostomy complications, which were not mechanical nor infections. Findings are summarized in Table 3. Most digestive tract surgical procedures were operations on the stomach (ICD-9 codes 43.0–44.03, 44.21–44.99) at 56.0%, which included gastrostomy and vagotomy. Furthermore, 65.3% of digestive tract invasive diagnostic procedures were those on the intestines (ICD-9 codes 45.11–45.29) such as endoscopy and biopsy. In total, 88.2% of surgical procedures on the respiratory system (ICD-9 30.01–31.3, 31.5–31.99) were operations on the larynx and trachea. However, when it comes to invasive diagnostic procedures, 63.0% were performed on the lungs and bronchus (ICD-9 codes 33.20–33.29).

3.2.2. Elderly Patients

In total, 95.1% survived and 4.9% passed away (Table 3). In the surviving group, 1495 were females (47.5%) and 1650 were males (52.5%). In the deceased group, 79 were females (48.5%) and 84 were males (51.5%). When comparing the deceased to the surviving patients, differences were recognized in several comorbidities. Most elderly patients with tracheostomy complications were Caucasian males. The main comorbidities were hypertension, uncomplicated diabetes, and fluid/electrolyte disorders. The deceased had significantly greater rates of comorbidities with fluid/electrolyte disorders and coagulopathy. Patients’ characteristics and clinical data are summarized in Table 3. In total, 63.8% of the mentioned surgical procedures on the gastrointestinal system in this patient group were performed on the stomach, which includes operations such as gastrostomies. On the other hand, 70.3% of the invasive diagnostic procedures on the gastrointestinal tract were performed on the intestines, which includes biopsies and endoscopies. Looking at the respiratory system, 85.1% of the surgical procedures were performed on the larynx and trachea, for example, operations such as laryngectomies and tracheostomies. Moreover, 62.9% of the respiratory system’s invasive diagnostic procedures were performed on the lung and bronchus in this population, which include tissue biopsies and bronchoscopies.
Table 3. Characteristics of emergently admitted patients with the primary diagnosis of tracheostomy complications. Data were classified according to outcome categories, NIS 2005–2014.

| Patients' Characteristics | Adult (18–64), N (%) | Elderly (65+), N (%) | p  |
|--------------------------|----------------------|----------------------|----|
| All Cases                |                      |                      |    |
| Gender, Female           |                      |                      |    |
| White                    | 2006 (44.3%)         | 87 (48.1%)           |    |
| Black                    | 1113 (28.7%)         | 38 (25.3%)           |    |
| Hispanic                 | 433 (11.1%)          | 12 (8.0%)            |    |
| Asian/Pacific Islander   | 99 (2.5%)            | 5 (3.3%)             |    |
| Native American          | 19 (0.5%)            | 1 (0.7%)             |    |
| Other                    | 120 (3.3%)           | 4 (2.7%)             |    |
| Quartile 1               | 1662 (37.8%)         | 54 (31.4%)           |    |
| Quartile 2               | 1075 (24.4%)         | 44 (25.6%)           | 0.380 |
| Quartile 3               | 980 (22.3%)          | 44 (25.6%)           |    |
| Quartile 4               | 882 (15.5%)          | 30 (17.2%)           |    |
| Private Insurance        | 1056 (23.4%)         | 52 (28.7%)           |    |
| Medicaid                 | 1493 (33.1%)         | 65 (35.9%)           | 0.051 |
| Medicaid Self-Pay        | 149 (3.3%)           | 7 (1.5%)             |    |
| No Charge                | 16 (0.4%)            | 0 (0%)               |    |
| Other                    | 158 (3.5%)           | 7 (2.9%)             |    |
| Rural                    | 265 (5.9%)           | 7 (3.9%)             |    |
| Hospital Location        |                      |                      |    |
| Urban: Non-Teaching      | 1297 (28.7%)         | 58 (32.0%)           |    |
| Urban: Teaching          | 2962 (65.5%)         | 116 (64.1%)          |    |
| All AIDS                 | 35 (0.8%)            | 0 (0%)               |    |
| Alcohol Abuse            | 189 (4.2%)           | 6 (3.3%)             | 0.640 |
| Deficiency Anemias       | 992 (21.9%)          | 45 (24.9%)           |    |
| Rheumatoid Arthritis     | 77 (1.7%)            | 5 (2.8%)             |    |
| Chronic Blood Loss       | 46 (1.0%)            | 3 (1.7%)             |    |
| Congestive Heart Failure | 726 (16.0%)          | 42 (23.2%)           |    |
| Chronic Pulmonary Disease| 1723 (38.1%)         | 89 (38.1%)           |    |
| Congulopathy             | 170 (3.8%)           | 7 (2.7%)             |    |
| Depression               | 622 (13.7%)          | 31 (10.1%)           |    |
| Diabetes, Uncomplicated  | 1323 (29.2%)         | 62 (34.2%)           |    |
| Diabetes, Chronic Complications | 184 (4.1%) | 6 (3.3%) |     |
| Drug Abuse               | 150 (3.3%)           | 3 (1.7%)             |    |
| Hypertension             | 2299 (49.9%)         | 79 (43.6%)           |    |
| Hypothyroidism           | 563 (12.4%)          | 22 (12.2%)           |    |
| Liver Disease            | 136 (3.0%)           | 5 (3.2%)             | 0.230 |
| Lymphoma                 | 18 (0.4%)            | 1 (0.6%)             |    |
| Fluid/Electrolyte Disorders | 1054 (23.3%)   | 75 (41.4%)           |    |
| Metastatic Cancer        | 225 (5.0%)           | 10 (5.3%)            |    |
| Other Neurological Disorders | 784 (17.3%) | 28 (15.5%) | 0.570 |
| Obesity                  | 974 (21.3%)          | 47 (26.0%)           |    |
| Paralysis                | 663 (14.7%)          | 35 (21.8%)           |    |
| Peripheral Vascular Disorders | 114 (2.5%) | 4 (2.2%) | 0.750 |
| Psychoses                | 231 (5.1%)           | 6 (3.5%)             |    |
| Pulmonary Circulation Disorders | 223 (4.9%) | 9 (5.0%) | 0.290 |
| Renal Failure            | 525 (11.6%)          | 37 (20.4%)           | 0.001 |
| Solid Tumor              | 473 (10.5%)          | 22 (12.2%)           |    |
| Peptic Ulcer             | 0 (0%)               | 0 (0%)               |    |
| Valvular Disease         | 116 (2.6%)           | 2 (1.1%)             |    |
| Weight Loss              | 381 (8.4%)           | 20 (10.0%)           |    |
| Unspecified Complication | 46 (1.0%)            | 0 (0%)               |    |
| Tracheostomy Infection   | 545 (12.0%)          | 12 (6.6%)            |    |
| Tracheostomy Complication | 1539 (34.0%)        | 36 (19.9%)           |    |
| Other Tracheostomy Complication | 2394 (52.9%) | 91 (49.5%) | 0.001 |
| Invasive Diagnostic Procedure | 1715 (37.9%) | 61 (33.7%) | 0.250 |
| Surgical Procedure       | 1312 (29.0%)         | 35 (19.3%)           |    |

| Comorbidities | Survived Mean (SD) | Deceased Mean (SD) | p  |
|---------------|--------------------|--------------------|----|
| Lymphoma      | 18 (0.4%)          | 1 (0.6%)           |    |
| Fluid/Electrolyte Disorders | 1054 (23.3%) | 75 (41.4%) |    |
| Metastatic Cancer | 225 (5.0%) | 10 (5.3%) |    |
| Other Neurological Disorders | 784 (17.3%) | 28 (15.5%) |    |
| Obesity       | 974 (21.3%)        | 47 (26.0%)         |    |
| Paralysis     | 663 (14.7%)        | 35 (21.8%)         |    |
| Peripheral Vascular Disorders | 114 (2.5%) | 4 (2.2%) |    |
| Psychoses     | 231 (5.1%)         | 6 (3.5%)           |    |
| Pulmonary Circulation Disorders | 223 (4.9%) | 9 (5.0%) |    |
| Renal Failure | 525 (11.6%)        | 37 (20.4%)         |    |
| Solid Tumor   | 473 (10.5%)        | 22 (12.2%)         |    |
| Peptic Ulcer  | 0 (0%)             | 0 (0%)             |    |
| Valvular Disease | 116 (2.6%) | 2 (1.1%) |    |
| Weight Loss   | 381 (8.4%)         | 20 (10.0%)         |    |
| Unspecified Complication | 46 (1.0%) | 0 (0%) |    |
| Tracheostomy Infection | 545 (12.0%) | 12 (6.6%) |    |
| Tracheostomy Complication | 1539 (34.0%) | 36 (19.9%) |    |
| Other Tracheostomy Complication | 2394 (52.9%) | 91 (49.5%) |    |
| Invasive Diagnostic Procedure | 1715 (37.9%) | 61 (33.7%) |    |
| Surgical Procedure | 1312 (29.0%) | 35 (19.3%) |    |

3.3. Operation vs. Non-Operation
3.3.1. Non-Elderly Patients

The stratified analysis, based on the surgical procedure status, is presented in Table 4. In total, 1348 (28.6%) had a surgical procedure. In both groups, most patients were males. The mean (SD) age in the surgical group was significantly lower in comparison to the non-operated group. The racial breakdown by the proportion of cases in decreasing order was White, Black, Hispanic, Asian/Pacific Islander, and Native American. Most patients were of income quartile...
1, funded mainly by Medicaid, and were admitted to urban teaching hospitals. In the group that had a surgical procedure, the rate of solid tumors was significantly lower in comparison to the other group. They had a substantially greater rate of mechanical complications and a significantly lower rate of other categories of tracheostomy complications in comparison to the non-operated group, a significantly greater rate of respiratory system invasive diagnostic procedures, a higher rate of digestive system invasive diagnostic procedures, as well as a longer time to invasive diagnostic procedures and longer HLOS.

Table 4. Characteristics of emergently admitted patients with the primary diagnosis of tracheostomy complications. Data were stratified according to surgery status, NIS 2005–2014.

| Patients' Characteristics | Adult (18–64), N (%) | Elderly (65+), N (%) |
|--------------------------|----------------------|----------------------|
|                          | No Surgery | Surgery | p    | No Surgery | Surgery | p    |
| All Cases                | 3363 (71.4%) | 1348 (28.6%) | 0.160 | 2551 (77.0%) | 764 (23.0%) | 0.024 |
| Gender, Female           | 1474 (43.8%) | 621 (46.1%) | 0.550 | 1187 (46.5%) | 794 (53.5%) | 0.290 |
| White                    | 1555 (53.9%) | 637 (55.2%) | 0.910 | 1436 (65.6%) | 443 (34.4%) | 0.001 |
| Black                    | 838 (29.0%) | 313 (27.1%) | 0.370 | 429 (19.6%) | 109 (16.5%) | 0.110 |
| Hispanic                 | 319 (11.1%) | 128 (11.3%) | 0.100 | 182 (8.3%) | 65 (9.8%) | 0.550 |
| Asian/Pacific Islander   | 74 (2.6%) | 30 (2.6%) | 0.550 | 63 (2.9%) | 15 (2.3%) | 0.001 |
| Native American          | 11 (0.4%) | 9 (0.8%) | 0.370 | 8 (0.4%) | 0 (0.0%) | 0.001 |
| Other                    | 88 (3.1%) | 36 (3.1%) | 0.370 | 71 (3.2%) | 26 (3.9%) | 0.001 |
| Race                     | 1230 (37.6%) | 487 (37.3%) | 0.550 | 729 (29.3%) | 225 (30.2%) | 0.001 |
| Quartile 1               | 799 (24.4%) | 322 (24.6%) | 0.910 | 621 (24.9%) | 184 (24.7%) | 0.001 |
| Quartile 2               | 738 (22.4%) | 267 (20.7%) | 0.910 | 609 (24.4%) | 183 (24.4%) | 0.940 |
| Quartile 3               | 503 (15.4%) | 211 (16.1%) | 0.910 | 530 (21.4%) | 153 (21.5%) | 0.001 |
| Private Insurance        | 772 (23.0%) | 338 (25.1%) | 0.910 | 198 (7.8%) | 59 (7.7%) | 0.001 |
| Medicare                 | 1156 (34.4%) | 402 (29.9%) | 0.910 | 2204 (86.6%) | 666 (87.3%) | 0.001 |
| Medicaid                 | 1212 (36.1%) | 496 (36.8%) | 0.910 | 90 (3.5%) | 24 (3.1%) | 0.480 |
| Insurance                | 99 (2.9%) | 53 (3.9%) | 0.250 | 17 (0.7%) | 5 (0.7%) | 0.001 |
| Location                 | 13 (0.4%) | 4 (0.3%) | 0.250 | 0 (0.0%) | 1 (0.1%) | 0.001 |
| Hospital Length of Stay, Days | 5.46 (7.70) | 9.51 (14.17) | <0.001 | 5.81 (7.70) | 9.07 (10.49) | <0.001 |
| Total Charges, Dollars   | 42,032 | 48,88 (12.27) | <0.001 | 48,88 (12.27) | 73,97 (6.76) | 0.001 |

Mean (SD) Mean (SD) p Mean (SD) Mean (SD) p

| Age, Years               | 50.12 (11.77) | 48.88 (12.27) | <0.001 | 74.48 (6.97) | 73.97 (6.76) | 0.001 |
| Time to Invasive Diagnostic Procedure, Days | 1.47 (2.62) | 2.25 (3.90) | <0.001 | 1.54 (3.07) | 2.55 (4.44) | <0.001 |
| Hospital Length of Stay, Days | 5.46 (7.70) | 9.51 (14.17) | <0.001 | 5.81 (7.70) | 9.07 (10.49) | <0.001 |
| Total Charges, Dollars   | 42,032 | 80,147 | <0.001 | 48,88 (12.27) | 73,97 (6.76) | 0.001 |
3.3.2. Elderly Patients

The stratified analysis, based on the surgery status, is presented in Table 4. In total, 764 (23.0%) had surgery while 2551 (77.0%) did not. The racial breakdown by the proportion of cases in decreasing order was White, Black, Hispanic, Asian/Pacific Islander, and Native American. Most patients were of income quartile 1 and were admitted to urban teaching hospitals. The operated group demonstrated a substantially higher rate of mechanical complications and a significantly lower rate of other categories of tracheostomy complications compared to the non-operated group, a substantially greater rate of respiratory system invasive diagnostic procedure, a higher rate of digestive system invasive diagnostic procedure, as well as a longer time to an invasive diagnostic procedure and a longer HLOS.

3.4. Risk Factors of Mortality

The findings of the multivariable backward logistic regression model for risk factors of mortality are presented in Table 5. Common variables included in the model were age, gender, social factors, lifestyle elements, and comorbidities. Age, HLOS, and several comorbidities emerged as significant risk factors for in-hospital mortality in patients admitted emergently with the primary diagnosis of tracheostomy complications. In patients with tracheostomy complications, each additional year of age was associated with a 0.7% increase in the odds of mortality. Each additional day in the hospital raised the odds of mortality by 0.8%. Cardiac disease increased the odds of dying by 3.21-fold, while liver disease raised it by 2.61-fold (Table 5).

Table 5. Multivariable backward logistic regression analysis to evaluate the associations between mortality and different risk factors in patients emergently admitted with a primary diagnosis of tracheostomy complications (NIS 2005–2014). Mortality was the dependent variable.

| Patients' Characteristics                                      | N = 9306 | R² = 0.142 |
|---------------------------------------------------------------|----------|------------|
| Number of Events                                              | N = 364  |            |
| Age, Years                                                    | 1.007 (1.001, 1.013) | 0.02 |
| Hospital Length of Stay, Days                                 | 1.008 (1.001, 1.016) | 0.018 |
| Bacterial Infections (Other than Tuberculosis)                | 1.44 (1.12, 1.85) | 0.004 |
| Cardiac Diseases                                              | 3.21 (2.48, 4.15) | <0.001 |
| Liver Diseases                                                | 2.61 (1.73, 3.83) | <0.001 |
| Gastrointestinal System Diseases                              | 1.39 (1.10, 1.76) | 0.006 |
| Fluid and Electrolyte Disorders                               | 1.55 (1.24, 1.95) | <0.001 |
| Neoplasms                                                      | 1.63 (1.26, 2.10) | <0.001 |
| Neurological Diseases                                          | 1.94 (1.54, 2.44) | <0.001 |
| Platelet and White Blood Cell Diseases                        | 1.52 (1.11, 2.10) | 0.01 |
| Trauma, Burns, and Poisonal                                   | 1.90 (1.50, 2.42) | <0.001 |
| Gender, Female                                                |          |            |
| Invasive Procedure                                             |          |            |
| Surgical Procedure                                             |          |            |
| Tracheostomy Complication Type                                |          |            |
| Respiratory Diseases                                          |          |            |
| Coagulopathy                                                  |          |            |
| Peripheral Vascular Diseases                                  |          |            |
| Cerebrovascular Diseases                                      |          |            |
| Tuberculosis                                                  |          |            |
| Nonbacterial Infections                                       |          |            |
| Anemia and/or Hemorrhage                                      |          |            |
| Digestive Diseases other than Liver                           |          |            |
| Diabetes                                                      |          |            |
| Drug Abuse/Withdrawal/Dependence                              | Removed Via |
| Alcohol Abuse/Withdrawal/Dependence                           | Stepwise |
| Tobacco Use                                                   | Backward |
| Hypertension                                                  | Elimination |
| Endocrine Diseases                                            |          |            |
| Nutritional/Weight Disorders                                  |          |            |
| Musculoskeletal System and Connective Tissue Diseases          |          |            |
| Psychiatric Diseases                                          |          |            |
| Skin Diseases                                                 |          |            |
| Long Term Medication Usage                                    |          |            |
| Diseases of Oral Cavity, Salivary Glands, and Jaw              |          |            |
| Sleep Disorders                                               |          |            |
| Lack of Physical Evidence                                     |          |            |
| Inappropriate Diet and Eating Habits                          |          |            |
| High Risk Lifestyle Behaviors                                 |          |            |
| Social Factors                                                |          |            |
3.5. Lifestyle, Comorbidities, and Secondary Diagnoses

Table 6 summarizes the lifestyle, comorbidities, and secondary diagnoses of patients. There was no significant difference in lifestyle elements between the surviving and deceased patients. Almost the same comorbidities that stayed in the final regression model as the significant predictors of mortality were significantly more prevalent in deceased patients than in surviving ones.

Table 6. Lifestyle, comorbidities, and secondary diagnoses of patients emergently admitted with a primary diagnosis of tracheostomy complications (NIS 2005–2014). Data were stratified according to survival status.

| Lifestyle, Comorbidities and Secondary Diagnoses (ICD-9 Codes) | Adult, N (%) | p Value | Elderly, N (%) | p Value |
|---------------|----------------|----------|----------------|----------|
| Observations | Survived | 4524 (96) | 181 (4) | 3145 (95) | 163 (5) |
| Bacterial Infections | 806 (18) | 67 (37) | <0.001 | 609 (19) | 68 (42) |
| Nonbacterial Infections | 433 (10) | 9 (5) | 0.038 | 198 (6) | 15 (9) |
| Diabetes | 1513 (33) | 71 (39) | 0.110 | 1255 (40) | 49 (30) |
| Hypertension | 2262 (50) | 79 (44) | 0.090 | 1987 (63) | 85 (52) |
| Anemia and/or Hemorrhage | 1219 (27) | 57 (32) | 0.180 | 1109 (35) | 70 (43) |
| Respiratory Diseases | 3604 (80) | 162 (90) | 0.001 | 2665 (85) | 150 (92) |
| Cardiac Diseases | 1705 (38) | 126 (70) | <0.001 | 1867 (59) | 129 (79) |
| Liver Diseases | 335 (7) | 17 (9) | 0.320 | 323 (10) | 13 (8) |
| Peripheral Vascular Diseases | 282 (6) | 18 (10) | 0.045 | 317 (10) | 23 (14) |
| Liver Diseases | 168 (4) | 20 (11) | <0.001 | 66 (2) | 11 (7) |
| Diseases of Digestive System other than Liver | 1494 (33) | 57 (32) | 0.670 | 1152 (37) | 72 (44) |
| Diseases of Oral Cavity, Salivary Glands, and Jaws | 51 (1) | 2 (1) | 0.980 | 23 (1) | 1 (1) |
| Nutritional/Weight Disorders | 1911 (42) | 84 (46) | 0.270 | 1352 (43) | 64 (39) |
| Endocrine Diseases | 1970 (44) | 84 (46) | 0.450 | 1659 (53) | 71 (44) |
| Neurological Diseases | 1264 (28) | 89 (49) | <0.001 | 1203 (38) | 94 (58) |
| Neurological Diseases | 1699 (38) | 109 (60) | <0.001 | 1053 (34) | 74 (45) |
| Fluid and Electrolyte Disorders | 680 (15) | 22 (12) | 0.290 | 524 (17) | 24 (15) |
| Fluid and Electrolyte Disorders | 1325 (29) | 88 (49) | <0.001 | 1001 (32) | 87 (53) |
| Neoplasms | 1225 (27) | 56 (32) | 0.160 | 1143 (36) | 52 (32) |
| Platelet and White Blood Cell Diseases | 311 (7) | 31 (17) | <0.001 | 249 (8) | 21 (13) |
| Psychiatric Diseases | 2411 (42) | 84 (46) | 0.270 | 1352 (43) | 64 (39) |
| Trauma, Burns and Poisoning | 1187 (26) | 33 (18) | 0.016 | 624 (20) | 30 (18) |
| Drug Abuse/Withdrawal/Dependence | 937 (21) | 69 (36) | <0.001 | 613 (20) | 80 (49) |
| Alcohol Abuse/Withdrawal/Dependence | 154 (3) | 3 (2) | 0.200 | 16 (1) | 0 (0) |
| Tobacco Use | 189 (4) | 6 (3) | 0.570 | 66 (2) | 1 (1) |
| Long-Term Medications/Radiationtherapy | 1003 (22) | 27 (15) | 0.021 | 585 (19) | 21 (13) |
| Social Factors (V60.0–V62.6, V63.0–V64.3, V65.81) | 343 (8) | 13 (7) | 0.840 | 244 (8) | 7 (4) |
| Sleep Disorders (327, 780.5, 781.0) | 183 (4) | 1 (1) | 0.017 | 62 (2) | 1 (1) |
| Lack of Physical Exercise (V69.0) | 852 (19) | 23 (13) | 0.038 | 346 (11) | 7 (4) |
| Inappropriate Diet and Eating Habits (V69.1) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| High Risk Lifestyle Behaviors (V69.2, V69.3) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Body Mass Index of Less than 18.9 (V85.0) | 73 (16) | 1 (4) | 0.388 | 38 (18) | 3 (23) |
| Body Mass Index of 19–24.9 (V85.1, V85.9) | 27 (6) | 2 (9) | 0.388 | 23 (11) | 3 (23) |
| Body Mass Index of 25.0–29.9 (V85.2, V85.3) | 20 (4) | 0 (0) | 0.300 | 20 (9) | 0 (0) |
| Body Mass Index of 30.0 and over (V85.4–V85.5) | 345 (74) | 20 (67) | 0.300 | 134 (62) | 7 (54) |
4. Discussion

The primary aim of this study was to evaluate associations between demographics, socioeconomic status, surgical status, comorbidities, and HLOS with overall mortality in emergently admitted patients with the primary diagnosis of tracheostomy complications. Older age and increased hospital length of stay were among the most important significant risk factors for mortality.

4.1. The Impact of HLOS on Mortality

Longer hospital stay was associated with adverse outcomes. Prolonged HLOS for older patients in the emergency department has been shown to be associated with a higher risk of hospitalization and adverse outcomes [15]. Mowery et al. collected evidence that the emergency department length of stay is an independent predictor of hospital mortality in trauma activation patients [16]. Bohm et al. showed that shorter time to surgery and decreased HLOS improved in-hospital and 1-year mortality [17]. Furthermore, Zhang added that prolonged EDLOS is independently associated with an increased risk of hospital mortality in patients with sepsis requiring ICU admission [18].

4.2. The Impact of Gender on Mortality

In agreement with our results, Mehta et al. [5] have shown that across all study years, the likelihood of tracheostomy complications was significantly affected by gender and was highly prevalent in males. However, our findings showed that mortality was not affected by gender.

4.3. The Impact of Age on Mortality

Additionally, we have demonstrated that age is a major risk as well, correlating with the increase in comorbidities, the increased rate of complications, and an increased mortality rate in non-elderly. The older the patient, the lower the likelihood of survival. These results are supported by Tamir et al. who have shown that comorbid conditions and subject age had a greater association with the 30-day mortality rate [19].

Overall, mortality associated with tracheostomy complications was relatively low at 3.8% for adults and 4.9% in elderly patients, but this is higher than that of Kligerman et al.’s study who showed 1.4% in a cohort of 38,293 patients with the primary diagnosis of tracheostomy complication [20].

4.4. The Impact of Comorbidities on Mortality

Our results have shown that comorbidities such as coagulopathy, fluid/electrolyte disorders, and metastatic cancer were significant predictors of mortality in non-elderly patients, and fluid/electrolyte disorders were the single significant predictor of mortality in elderly patients. In contrast, Kligerman et al. manifested that tracheostomy infection was the most significant predictor of mortality [20].

In the design of these surveys, considerable effort was dedicated to attaining a representative sample to eliminate biases that may have been present in smaller or regional surveys. The management of emergent tracheostomy complications may be further complicated by the underlying condition of the patient who originally necessitated the placement of the tracheostomy. Among elderly and non-elderly primary diagnosis patients, tracheostomy complications were shown to be comorbid in males, chiefly with alcohol abuse, solid tumors, and metastatic cancer, while in females, they were comorbid regarding congestive heart failure, chronic pulmonary disease, uncomplicated diabetes, obesity, and hypothyroidism. Numerous studies have manifested the adverse impact that obesity, anemia, hypertension, diabetes, and cardiovascular disease have on tracheostomy patients’ conditions. Diabetes mellitus is one of the most prevalent conditions in the elderly and is associated with increased susceptibility to infectious diseases, and considerable morbidity and mortality, mainly from cardiovascular and renal complications [21]. Kumarasinghe
et al. manifested that diabetes is associated with an increase in colonization and infection of tracheostomy tubes [22].

Stomal stenosis develops secondarily to bacterial infection, which conspires to weaken the anterior and lateral tracheal walls. Stomal granulation tissue frequently develops, and nearly all patients have some degree of tracheal narrowing at the site of the tracheostoma [23].

A high percentage of prolonged mechanically ventilated patients showed anemia on admission [24]. Retrospective studies of critically ill patients showed a positive correlation between transfusions with prolonged mechanical ventilation, increased mortality rates, and increased risk of nosocomial infections, which in turn could adversely affect weaning outcomes [25]. The tracheostomy-related complication rate is significantly higher for obese patients [26], especially with a body mass index $\geq 35$ and especially in the intraoperative and early postoperative time periods [27]. Obesity was found to be independently associated with an increased risk of overall complications, developing acute renal failure, and having unplanned 30-day readmission following tracheostomy [28]. Obese patients have a greater likelihood of complications and an increased risk of remaining tracheostomy-dependent [29]. Although open tracheostomy in morbidly obese patients is increasing in demand, the procedure can be predictably performed albeit at a much longer duration and a higher perioperative complication rate compared with the traditional tracheostomy [30]. Studies showed that hypertensive patients have an exaggerated hemodynamic stress response [31]. In critically ill patients, this stress response might result in slower recovery and an increased risk of mortality. Studies have shown that bleeding is the most common cause of morbidity and mortality after tracheostomy. However, in the ED setting, some bedridden cardiovascular patients are on full anticoagulation to prevent thromboembolic events in bedridden patients [32,33]. The management of a preoperative cancer patient should consider that functional patient assessment and pulmonary function testing are key to preoperative assessment. By optimizing the patients’ condition ahead of the tracheostomy, the risk of complications is limited.

4.5. The Impact of an Invasive Diagnostic Procedure on Complications on Mortality

Our results demonstrate that white male patients, non-elderly as well as elderly, who had an invasive diagnostic procedure had a high positive correlation with mechanical complications, infection, and other complications, as well as a higher rate of respiratory or digestive systems surgical procedures and significantly prolonged HLOS. Invasive diagnostic procedures are complementary to serologic and non-invasive studies and assist in rapidly establishing an accurate diagnosis, which allows the initiation of appropriate therapy and may improve outcomes with relative safety [34]. Halliday et al. have presented similar results showing elevated complication rates in a study of invasive diagnostic procedures for lung abnormalities [35]. Evaluating patients based on invasive diagnostic procedures outcomes enables forming a management plan for surgical vs. non-surgical treatment.

4.6. Strengths of the Study

The primary strengths of this study relate to the large, nationally representative patient population across a wide spectrum of hospitals and geographic locations. This analysis was recorded in an exhaustive nationwide distinctive database during a 10-year period in the United States during 2005–2014. The large patient population enabled us to identify the predictors of mortality and increased HLOS associated with tracheostomy complications. Thus, our results are likely to be generalizable across a range of locations and practice settings. The sample size was large enough for accurate analysis with each statistical method. Most previous studies assessing the prevalence of tracheostomy complications were confined to small populations from single hospitals or geographic regions. Given the numerous gaps in our understanding of tracheostomy complications, the time has come for research to be designed to expand the evidence base. Our study provides avenues for
future investigations. Understanding potential trajectories in morbidity and mortality is crucial to guiding long-term investments and policy implementation.

4.7. Limitations of the Study

Analysing the data, several limitations are noted in this study. First, future surveys should aim to include the exact type of tracheostomy used such as surgical tracheostomy, percutaneous dilatational tracheostomy, ultrasound-guided percutaneous tracheostomy, conventional percutaneous tracheostomy, or bronchoscopic guided percutaneous tracheostomy. Lately, ultrasound-guided percutaneous tracheostomy (USPCT) has become a routine practice in ED with evident advantages [36]. It facilitates the clinician to identify the vascular structures and thyroid, delineate the airway [37], evaluate the thickness of the skin over the neck, and visualize the needle and guide wire passage [38]. A percutaneous approach offers fewer surgical-site infections and postsurgical bleeding than a surgical approach [39]. A surgical placement, on the other hand, possesses a lower risk of injury to the posterior tracheal wall [39]. Furthermore, the timing of the tracheostomy appears to be crucial [40]. Early’ and ‘late’ tracheostomies are two categories of the timing of tracheostomy. Evidence on the advantages attributed to early vs. late tracheostomy shows it reduces sedative use, allows early oral feeding [41], early mobility [42], and improves physiology [43], decreases the duration of mechanical ventilation and ICU stay, shortens hospital stays, and lowers mortality rates [44]. Additionally, indicating the exact specification data of the surgeon’s years of experience is essential. Otorhinolaryngology-Head and Neck Surgeons (ORL-HNS), for example, are familiar with the anatomy of upper airways, which is an important underlying factor in reducing the incidence of possible complications [26]. Furthermore, the severity of comorbidity, the type of anesthesia (local or general), the type of tracheal incision, and the exact cause of death should be specified for future analysis as well. Moreover, it is advised to classify the complication severity according to the Clavien Dindo classification [45]. Differentiative analysis including all these factors will shed light and guide future practice management of emergency departments.

5. Conclusions

Little is known about population-based trends in the use of a tracheostomy for mechanical ventilation in the United States. The results of the present study may be instrumental in reducing the risk of complications after a tracheostomy and decreasing HLOS and its associated mortality. The risk factors for mortality were advanced age, increased HLOS, cardiac disease, and liver disease. Some of the causes of death included tuberculosis, coagulopathy, cardiac disease, and tobacco use, among many others. Identifying system factors and standardizing care among specialties will help guide management when patients arrive in the emergency department.

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