Quality tracheotomy care can be maintained for non-COVID patients during the COVID-19 pandemic

Jacqueline Tucker BS1 | Nicole Ruszkay MD2 | Neerav Goyal MD MPH FACS1,2 | John P. Gniady MD FACS1,2 | David Goldenberg MD FACS1,2

Abstract

Objective(s): To analyze changes in tracheotomy practices at the onset of the COVID-19 pandemic, and determine if quality patient care was maintained.

Methods: This was a single institution retrospective study that included patients undergoing tracheotomy from May 2019 to January 2021. Patients were divided into two groups, pre-COVID and post-COVID. Only three patients tested positive for COVID-19, and they were excluded from the study. Data were collected from the electronic medical record. Statistical analyses were performed using 2-tailed independent t-tests, Wilcoxon Rank Sum tests, Chi-Square tests, and Kaplan–Meier curves.

Results: There were 118 patients in the pre-COVID group and 91 patients in the post-COVID group. The main indication for tracheotomy in both groups was prolonged intubation. There were no significant differences in overall length of stay, time to tracheotomy, duration of tracheotomy procedure, or time to initial tracheotomy change between the two groups. Due to protocols implemented at our institution to limit viral transmission, there were significant increases in the percent of tracheotomies performed in the OR ($p = .02$), and those performed via open technique ($p = .04$). Additionally, the median time to decannulation significantly decreased in the post-COVID group ($p = .02$).

Conclusion: Several variables regarding the timing of patient care showed no significant differences between groups which demonstrates that quality patient care was maintained. It is important to note that this data was collected early in the Pandemic, and additional trends may become apparent over time.

Level of evidence: 4.

KEYWORDS

airway reconstruction, COVID-19, decannulation, outcomes, tracheotomy
1 INTRODUCTION

Coronavirus 2019 (COVID-19) originated in Wuhan, China in late 2019 and quickly spread to other countries, becoming a serious public health concern.\textsuperscript{1,2} COVID-19 is spread via contact droplets and aerosolization from human to human.\textsuperscript{3,4} Therefore, aerosol-producing procedures, such as endotracheal intubation and tracheotomy placement, put healthcare workers at an increased risk of infection.\textsuperscript{5} As a result, guidelines were published to ensure patient and healthcare worker safety.\textsuperscript{6} These protocols vary between institutions and continue to evolve throughout the Pandemic. Most recommendations focus on the safest tracheotomy practices for COVID-19 positive patients. However, resources and testing were limited at the onset of the Pandemic. Therefore, patients were presumed to be COVID-19 positive and protocols were applied universally.\textsuperscript{7} Some of the widely used guidelines include: (1) limiting the number of personnel involved in the procedure, (2) performing tracheotomy in a controlled environment, with negative pressure capabilities if possible, and (3) wearing personal protective equipment (PPE) that helps guard against airborne transmission.\textsuperscript{8–10} The protocols at our institution were adapted from those published by UK-ENT authors.\textsuperscript{9} Current literature demonstrates that following safety recommendations decreases the spread of infection to healthcare workers.\textsuperscript{6,11,12}

These changes in protocols have shifted treatment paradigms. These shifts, along with increased attention given to COVID-19 patients, left COVID-19 negative patients at risk of receiving sub-optimal care.\textsuperscript{13} For instance, there were delays in surgery and increased mortality reported in elective orthopedic surgeries during the Pandemic for COVID-19 negative patients.\textsuperscript{13–15} In addition, there was a decreased number of emergency department visits and hospitalizations for COVID-19 negative patients, which suggests that patients had limited access to care during these times or were avoiding hospitals altogether.\textsuperscript{16} With unprecedented times and the implementation of new protocols, it is essential to maintain all aspects of patient care, regardless of COVID-19 status.

Length of stay, time to tracheotomy, duration of tracheotomy procedure, and time to initial tracheotomy change can be used as variables to determine the quality of patient care. Previous literature shows that longer times to tracheotomy were associated with increases in mortality and length of ICU stays.\textsuperscript{17} In addition, several reports have demonstrated that prolonged operative time is associated with increased rates of complication.\textsuperscript{18} Likewise, a systematic review and meta-analysis demonstrated a 14% increase in the likelihood of complications for every 30 min of additional operative time.\textsuperscript{18}

The goals of this study were two fold. The first aim was to determine if guidelines to decrease transmission of COVID-19 were adhered to. The second aim was to determine if those changes in protocols negatively impacted the care of patients without COVID-19. The factors examined include time to tracheotomy, duration of tracheotomy procedure, time to initial tracheotomy change, time to decannulation, and type, location, service, and indication for tracheotomy. Understanding if optimal patient care is maintained helps guide management and determines if adjustments must be made during this Pandemic or for future global crises.

2 MATERIALS AND METHODS

This was a single-institution, retrospective study that included patients over 18 years of age who underwent tracheotomy between May 2019 and January 2021. Cohorts were created based on the date of tracheotomy placement. March 22, 2020 was designated as the “beginning of the Pandemic” in our study due to dissemination of new tracheotomy guidelines. Therefore, the pre-COVID cohort included patients who had a tracheotomy placed between May 22, 2019 and March 21, 2020. The post-COVID cohort included patients who had a tracheotomy placed between May 22, 2019 and March 21, 2020.

| TABLE 1 Patient characteristics |
|---------------------------------|-------------------|-----------------|-----------------|
|                                  | Pre-COVID         | Post-COVID      | p value         |
| Age\textsuperscript{a} (Mean ± SD) | 60.8 ± 17.5      | 60.5 ± 17.4     | .88             |
| % female\textsuperscript{b}      | 32.2 (38/118)    | 30.8 (28/91)    | .77             |
| Indication for trach\textsuperscript{c} (n [% of team]) | 49 |
| Prolonged intubation             | 60 (51%)         | 42 (46%)        |                 |
| Airway protection                | 18 (15%)         | 18 (20%)        |                 |
| Airway obstruction               | 12 (10%)         | 8 (9%)          |                 |
| Adjunct to major head and neck surgery | 21 (18%)       | 21 (23%)        |                 |
| Inability to intubate            | 6 (5%)           | 1 (1%)          |                 |
| More efficient pulmonary hygiene | 1 (1%)           | 1 (1%)          |                 |
| Service performing tracheotomy\textsuperscript{d} | .54 |
| Otolaryngology                   | 39 (33%)         | 36 (40%)        |                 |
| Trauma surgery                   | 42 (36%)         | 29 (32%)        |                 |
| Thoracic surgery                 | 24 (20%)         | 19 (21%)        |                 |
| Pulmonology                      | 11 (9%)          | 4 (4%)          |                 |
| Unknown                          | 2 (2%)           | 3 (3%)          |                 |

\textsuperscript{a}t test assuming unequal variances.
\textsuperscript{b}Chi-square tests.
between March 22, 2020 and January 22, 2021. Patients who tested positive for COVID-19 positive were removed from the dataset. The new tracheotomy guidelines recommended tracheotomies be performed in the OR via open technique to decrease the spread of COVID-19. Patients in the study were pulled from the electronic medical record (EMR) using the Business Objects Web Intelligence program, which identified patients with tracheotomy-related CPT or ICD 9 and 10 codes referenced in Table A1. Data was collected and stored in a secure institutional database, REDCap.

The impact of the Pandemic on tracheotomy practices was evaluated using the following variables: length of stay, length of mechanical ventilation, duration of tracheotomy procedure, time to tracheotomy, time to initial tracheotomy change, time to decannulation, and location, type, service, and indication for tracheotomy. Definitions of these variables can be found in Table B1. The indication for tracheotomy variable was categorized as one of six known indications: prolonged intubation, airway protection, airway obstruction, adjunct to major head and neck surgery, inability to intubate, and more efficient pulmonary hygiene. Statistical analyses were completed via (1) 2-tailed independent t tests for continuous data with a normal distribution, (2) Wilcoxon Rank Sum tests for continuous data without a normal distribution, (3) Chi-Square tests for categorical data, and (4) Kaplan–Meier survival curves using Microsoft Excel (Redmond, WA, USA) version 10.0.14393 and IBM SPSS (Armonk, NY, USA) version 27. This study was approved by the Institutional Review Board (STUDY00010063).

3 | RESULTS

There was a total of 209 patients that met the inclusion criteria. A total of 118 patients were in the pre-COVID cohort. There were

| Outcome                  | Pre-COVID median in days (min, max) | Post-COVID Median in days (min, max) | p value |
|--------------------------|-------------------------------------|-------------------------------------|---------|
| Length of stay (LOS)     | 19.4 (4.3, 374.0)                   | 20.5 (3.2, 251.0)                  | .94     |
| Length of mechanical ventilation | 13.0 (0, 92.0)                    | 12.0 (0, 118.0)                   | .82     |
| Time to tracheotomy      | 8.0 (0, 65.0)                       | 8.6 (0, 54.5)                     | .95     |
| Time to initial tracheotomy change | 5.0 (1.0, 26.0)                 | 5.5 (2.0, 21.0)                   | .58     |

| Outcome                  | Pre-COVID n (%) | Post-COVID n (%) | p value |
|--------------------------|-----------------|------------------|---------|
| Open tracheotomy         | 68 (58%)        | 65 (71%)         | .04     |
| Performed in OR          | 81 (69%)        | 75 (82%)         | .02     |

Wilcoxon rank sum test.
Chi-square tests.
91 patients in the post-COVID cohort after three patients who were confirmed to be COVID-19 positive were removed. There was no significant difference in patient characteristics between the groups (Table 1). This study included patients with an average age of 60.7 years (SD = 17.42 years), 32% of which were females (Table 1). The most common reason for tracheotomy was prolonged intubation (n = 102, 49%), followed by adjunct to head and neck surgery (n = 42, 20%) (Table 1). Otolaryngology (n = 75, 36%) performed the most tracheotomies, followed by trauma surgery (n = 71, 34%), thoracic surgery (n = 43, 21%), and pulmonology (n = 15, 7%) (Table 1). The remaining 2% of tracheotomies were performed by unknown services (Table 1).

When comparing the pre- and post-COVID groups, a few variables were significantly different. One was the type of tracheotomy performed which demonstrated an increase in the percent of open procedures (58%–71%, p = .04). Not unexpectedly, there was also a significant increase in the percent of procedures performed in the OR (69%–82%, p = .02). These results can be referenced in Table 2. A Kaplan–Meier analysis was performed to determine differences in time to decannulation. The results showed that the median time to decannulation before COVID-19 was 20.3 days (95% CI, 29.1–108.9 days), and after COVID-19 was 10.2 days (95% CI, 12.9–53.1 days), as seen in Figure 1 (p = .02).

The remainder of the studied variables were not significantly influenced by changes in policies during the COVID-19 pandemic. The duration of procedure slightly increased from 49 to 53 min (p = .74) and median length of stay increased from 19.4 to 20.5 days (p = .94) (Table 2). Additionally, the median times to tracheotomy (p = .95) and initial tracheotomy change (p = .58) had a small but insignificant increase (Table 2). The median length of mechanical ventilation showed a decrease from 12.0 to 13.0 days after the start of the COVID-19 pandemic (p = .82) (Table 2).

### DISCUSSION

Implementation of new protocols can have a significant impact on patient care. Our study differs from current literature in two specific ways. First, to our knowledge, no previous studies assessed changes in tracheotomy practices over time. Whereas most studies reported results from the post-COVID era, our study assessed differences in practices from before the Pandemic to after its onset.7,19–27 Secondly, the majority of the published literature discusses tracheotomy outcomes in confirmed COVID-19 positive patients.7,19–27 However, our study only analyzed COVID-19 negative patients.

At the start of the Pandemic, our institution published a protocol, which advised physicians to perform tracheotomies in the OR via open technique due to the higher risk of aerosolization with percutaneous tracheotomy.20 In addition, it influenced physicians’ decisions to decannulate patients sooner due to the risk of transmission with routine tracheotomy care. Our results showed a significant increase in tracheotomies performed in the OR via open technique, as well as faster time to decannulation after the start of the Pandemic. This ultimately demonstrates that the new institutional tracheotomy guidelines were appropriately followed.

Controversy exists over the ideal timing for tracheotomy placement.29–31 However, Filice et al. demonstrated that patients who underwent tracheotomy placement less than 7 days after intubation had decreased mortality rates compared to patients whose tracheotomies were delayed until 9 to 16 days after intubation. Additionally, another study investigating tracheotomy care found that patients who underwent tracheotomy more than 3 weeks after intubation had increased complication rates and lengths of ICU stay.32 During the COVID-19 pandemic, delays were considered acceptable due to the high risk of transmissibility and the fear of contracting COVID-19. However, when assessing time to tracheotomy, the current study demonstrates no difference before and after the Pandemic.

In addition to time to procedure, surgeons have been wary of how the Pandemic and the logistics necessary to decrease transmission can influence the duration of surgeries. For example, a recent report observed increases in operative times for head and neck surgery during the Pandemic.33 Research has shown that increased durations of surgical procedures have been associated with increased patient complications.34 Thus, operative times must remain efficient even in the midst of a pandemic. When assessing duration of tracheotomy placement, the current study found there was no difference between patients treated before and after implementation of the COVID-19 protocol.

Post-operative care is another aspect of patient care that may have been impacted by the Pandemic. In order to ensure quality patient care is maintained, the initial tracheotomy change should be completed in a timely manner to reduce the risk of granulation and infection.35 According to the literature, the initial tracheotomy change typically occurs within three to 14 days.36,37 Our results showed there was no significant difference in time to initial tracheotomy change before and after the implementation of our COVID-19 protocol, with the median time being approximately five days for both groups. The consistency in time to tracheotomy change is encouraging because it demonstrates that there was no delay in treatment.

While the current study gives insight into changes in tracheotomy practices after the implementation of COVID-19 protocols, there is an inherent limitation due to the study being a retrospective chart review. Some of the constraints of this type of study design include poor documentation in the EMR and the utilization of a convenience sample. Future studies should continue to assess trends over time in tracheotomy practices as protocols adapt. In addition, in order to further assess patient safety, prospective studies should include follow-up data regarding morbidity and mortality.

### CONCLUSION

At the onset of the COVID-19 pandemic, protocols were implemented to ensure patient and healthcare worker safety. There were shifts in practices at our institution after the start of the Pandemic, including increases in open tracheotomies and tracheotomies performed in the
OR, as well as decreases in time to decannulation. Most notably, there were no delays in time to tracheotomy, duration of tracheotomy procedure, and time to initial tracheotomy change, which suggests that quality care was kept a priority throughout the Pandemic. Protocols are ever changing during these unprecedented times and it is important to provide patient centered care regardless of COVID-19 status.

ACKNOWLEDGMENTS
We would like to acknowledge Tonya King, PhD for biostatistical support.

FUNDING INFORMATION
This study was deemed exempt by the Penn State College of Medicine Institutional Review Board (STUDY00010063).

CONFLICT OF INTEREST
This study was deemed exempt by the Penn State College of Medicine Institutional Review Board (STUDY00010063).

FUNDING INFORMATION
This study was deemed exempt by the Penn State College of Medicine Institutional Review Board (STUDY00010063).

REFERENCES
1. Hui DS, Azhar IE, Madani TA, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health—the latest 2019 novel coronavirus outbreak in Wuhan, China. Int J Infect Dis. 2020;91:264-266. doi:10.1016/j.ijid.2020.01.009
2. Chen N, Zhou M, Dong X, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet. 2020;395(10223):507-513. doi:10.1016/S0140-6736(20)30211-7
3. Zuo M, Huang Y, Ma W, et al. Expert recommendations for tracheal intubation in critically ill patients with coronavirus disease 2019. Chin Med Sci J. 2020;35(2):105-109. doi:10.24920/003724
4. Foster P, Cheung T, Craft P, et al. Novel approach to reduce transmission of COVID-19 during tracheostomy. J Am Coll Surg. 2020;230(6):1102-1104. doi:10.1016/j.jamcollsurg.2020.04.014
5. Tay JK, Khoo MLC, Loh WS. Surgical considerations for tracheostomy during the COVID-19 pandemic: lessons learned from the severe acute respiratory syndrome outbreak. JAMA Otolaryngol Head Neck Surg. 2020;146(6):517-518. doi:10.1001/jamaoto.2020.0764
6. Aodeng S, Wang W, Chen Y, et al. Safety and efficacy of tracheotomy for critically ill patients with coronavirus disease 2019 (COVID-19) in Wuhan: a case series of 14 patients. Eur J Cardiothorac Surg. 2020;58(4):745-751. doi:10.1093/ejcts/ezaa312
7. Shiba T, Ghazizadeh S, Chhetri D, John M, Long J. Tracheostomy considerations during the COVID-19 pandemic. OTO Open. 2020;4(2):2473974X2092252. doi:10.1177/2473974X20922528
8. Radhakrishnan S, Perumbally HA, Surya S, Ponneth MS. Guidelines for surgical tracheostomy and tracheostomy tube change during the COVID-19 pandemic: a review article. Ind J Otolaryngol Head Neck Surg. 2020;72(3):398-401. doi:10.1007/s12070-020-01893-y
9. Harrison L, Ramsden J. Tracheostomy guidance during the COVID-19 pandemic: Guidance for surgical tracheostomy and tracheostomy tube change during the COVID-19 pandemic. ENTUK. 2020. Accessed May 3, 2022.
10. Kalita S, Gosoi B, Khaund G, et al. Optimizing airway surgery in COVID 19 era. Ind J Otolaryngol Head Neck Surg. 2021;1-8. doi:10.1007/s12070-020-02326-6
11. Chao TN, Harbison SP, Braslow BM, et al. Outcomes after tracheotomy in COVID-19 patients. Ann Surg. 2020;272(3):e181-e186. doi:10.1097/SLA.0000000000002641
12. Yeung E, Hopkins P, Auzinger G, Fan K. Challenges of tracheostomy in COVID-19 patients in a tertiary Centre in inner city London. Int J Oral Maxillofac Surg. 2020;49(11):1385-1391. doi:10.1016/j.ijom.2020.08.007
13. Golimelli D, Sanmarchi F, Capodici A, et al. Variations of the quality of care during the COVID-19 pandemic affected the mortality rate of non-COVID-19 patients with hip fracture. PLOS One. 2022;17(2):e0263944. doi:10.1371/journal.pone.0263944
14. Liebensteiner MC, Khosravi I, Hirschmann MT, Heuberer PR, Thaler M. Massive cutback in orthopaedic healthcare services due to the COVID-19 pandemic. Knee Surg Sports Traumatol Arthrosc. 2020;28(6):1705-1711. doi:10.1007/s00167-020-06032-2
15. Napoli N, Elderkin AL, Kiel DP, Khosla S. Managing fragility fractures during the COVID-19 pandemic. Nat Rev Endocrinol. 2020;16(9):467-468. doi:10.1038/s41574-020-0379-z
16. Santi L, Golimelli D, Tampieri A, et al. Non-COVID-19 patients in times of pandemic: emergency department visits, hospitalizations and cause-specific mortality in northern Italy. PLOS One. 2021;16(3):e0248995. doi:10.1371/journal.pone.0248995
17. Adly A, Youssef TA, El-Begarmy MM, Younis HM. Timing of tracheostomy in patients with prolonged endotracheal intubation: a systematic review. Eur Arch Otorhinolaryngol. 2018;275(3):679-690. doi:10.1007/s00404-017-4838-7
18. Cheng H, Clymer JW, Po-Han Chen B, et al. Prolonged operative duration is associated with complications: a systematic review and meta-analysis. J Surg Res. 2018;229:134-144. doi:10.1016/j.jss.2018.03.022
19. Bassi M, Ruberto F, Poggi C, et al. Is surgical tracheostomy better than percutaneous tracheostomy in COVID-19—positive patients? Anesth Analg. 2020;131(4):1000-1005. doi:10.1213/ANE.0000000000005100
20. Rovira A, Tricklebank S, Surda P, et al. Open versus percutaneous tracheostomy in COVID-19: a multicentre comparison and recommendation for future resource utilisation. Eur Arch Otorhinolaryngol. 2021;278(6):2107-2114. doi:10.1007/s00404-020-06597-1
21. Shah R, Priyadarshini G, Parsana M. A systematic review on guidelines and recommendations for tracheostomy during COVID-19 pandemic. Ind J Otolaryngol Head Neck Surg. 2021;1-12. doi:10.1007/s12070-021-02517-9
22. Mahmood K, Cheng GZ, van Nostrand K, et al. Tracheostomy for COVID-19: multidisciplinary, multicenter data on timing, technique, and outcomes. Ann Surg. 2021;274(2):234-239. doi:10.1097/SLA.0000000000004955
23. Meister KD, Pandian V, Hillel AT, et al. Multidisciplinary safety recommendations after tracheostomy during COVID-19 pandemic: state of the art review. Otolaryngol Head Neck Surg. 2021;164(5):984-1000. doi:10.1177/0194599820965190
24. Joong JY, Kim Y, Kyoung K, et al. The effect of systematic approach to tracheostomy care in patients transferred from the surgical intensive care unit to general ward. Acute Crit Care. 2018;33(4):252-259. doi:10.4266/acc.2018.00248
25. Tornari C, Surda P, Takhir A, et al. Tracheostomy, ventilatory wean, and decannulation in COVID-19 patients. Eur Arch Otorhinolaryngol. 2020;278:1595-1604. doi:10.1007/s00404-020-06187-1
26. Botti C, Lusetti F, Peroni S, et al. The role of tracheotomy and timing of weaning and Decannulation in patients affected by severe COVID-19. Ear Nose Throat J. 2021;100(2_suppl):1165-1195. doi:10.1177/1007/s12070-021-02517-9
27. Pauli N, Eeg-Olofsson M, Bergquist H. Tracheotomy in COVID-19 patients: a retrospective study on complications and timing. Laryngoscope Investig Otolaryngol. 2021;6(3):446-452. doi:10.1002/lino.2560
28. Erdem AF, Tomak Y, Balaban O, Demir G. Percutaneous Dilational tracheostomy in a patient with SARS-CoV-2 (COVID-19) disease: a case report with implications in staff safety. Cureus. 2021;13:e13769. doi:10.7759/cureus.13769

29. Gomes Silva BN, Andriolo RB, Saconato H, Atallah ÁN, Valente O. Early versus late tracheostomy for critically ill patients. In: Gomes Silva BN, ed. Cochrane Database Syst Rev. John Wiley & Sons; 2012. doi:10.1002/14651858.CD007271.pub2

30. Esteban A, Anzueto A, Alia I, et al. How is mechanical ventilation employed in the intensive care unit? An international utilization review. Am J Respir Crit Care Med. 2000;161(5):1450-1458. doi:10.1164/ajrccm.161.5.9902018

31. Young D, Harrison DA, Cuthbertson BH, Rowan K. TracMan collaborators for the. Effect of early vs late tracheostomy placement on survival in patients receiving mechanical ventilation. JAMA. 2013;309(20):2121. doi:10.1001/jama.2013.5154

32. Mahafza T, Bsoul N, Qudaisat I, Batarseh S, Massad E, AI- LA. Early vs. late tracheostomy for the ICU patients: experience in a referral hospital. Saudi J Anaesth. 2012;6(2):152-154. doi:10.4103/1658-354X.97029

33. Wai KC, Xu MJ, Lee RH, et al. Head and neck surgery during the coronavirus-19 pandemic: the University of California san Francisco experience. Head Neck. 2021;43(2):622-629. doi:10.1002/hed.26514

34. Cheng H, Chen BPH, Soleas IM, Ferko NC, Cameron CG, Hinoul P. Prolonged operative duration increases risk of surgical site infections: a systematic review. Surg Infect (Larchmt). 2017;18(6):722-735. doi:10.1089/sur.2017.089

35. Ng J, Hamrang-Yousefi S, Agarwal A. Tracheostomy tube change. StatPearls. Vol 19. Treasure Island (FL); 2022.

36. Bontempo LJ, Manning SL. Tracheostomy emergencies. Em Med Clin North Am. 2019;37(1):109-119. doi:10.1016/j.emc.2018.09.010

37. Tabae A, Lando T, Rickert S, Stewart MG, Kuhel WI. Practice patterns, safety, and rationale for tracheostomy tube changes: a survey of otolaryngology training programs. Laryngoscope. 2007;117(4):573-576. doi:10.1097/MLG.0b013e318030455a

How to cite this article: Tucker J, Ruszkay N, Goyal N, Gniady JP, Goldenberg D. Quality tracheotomy care can be maintained for non-COVID patients during the COVID-19 pandemic. Laryngoscope Investigative Otolaryngology. 2022;7(5):1337-1342. doi:10.1002/lio2.885

APPENDIX

| CPT  | Definition                                                                 |
|------|---------------------------------------------------------------------------|
| 31600 | Tracheostomy, planned (separate procedure)                                |
| 31601 | Tracheostomy, planned (separate procedure); younger than 2 years          |
| 31603 | Tracheostomy, emergency procedure; transtracheal for a transtracheal approach |
| 31605 | Tracheostomy, emergency procedure; cricothyroid membrane                  |
| 31610 | Tracheostomy, fenestration procedure with skin flaps                       |

| ICD 10 | Definition                          |
|--------|-------------------------------------|
| Z93.0  | Tracheostomy status/tracheostomy dependent |
| Z43.0  | Encounter for attention to tracheostomy |
| J95.0  | Tracheostomy complications           |

| ICD 9  | Definition                          |
|--------|-------------------------------------|
| V44.0  | Tracheostomy status                 |
| V55.0  | Attention to tracheostomy           |
| 519.09 | Other tracheostomy complications    |

| Variable            | Definition                                                      |
|---------------------|-----------------------------------------------------------------|
| Length of stay      | Time from admission to the hospital to discharge                 |
| Length of mechanical ventilation | Total number of days spent on a mechanical ventilator |
| Time to tracheotomy | Time from intubation to tracheotomy procedure                   |
| Time to initial tracheotomy change | Time from tracheotomy procedure to first documented tracheotomy change |
| Location            | Whether tracheotomy procedure was performed in the operating room or at the bedside |
| Type                | Whether an open or percutaneous tracheotomy was performed       |

TABLE A1 Diagnosis codes used to identify patients with tracheotomy

TABLE B1 Variable definitions