Tracheostomy after Severe Ischemic Stroke: A Population-based Study

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Background: Stroke can result in varying degrees of respiratory failure. Some patients require tracheostomy in order to facilitate weaning from mechanical ventilation, long-term airway protection, or a combination of the two. Little is known about the rate and predictors of this outcome in patients with severe stroke. We aim to determine the rate of tracheostomy after severe ischemic stroke. *Methods:* Using the Nationwide Inpatient Sample database from 2007 to 2009, patients hospitalized with ischemic stroke were identified based on validated *International Classification of Diseases, 9th revision, Clinical Modification* codes. Next, patients with stroke were stratified based on whether they were treated with or without decompressive craniectomy, and the rate of tracheostomy for each group was determined. A logistic regression analysis was used to identify predictors of tracheostomy after decompressive craniectomy. Survey weights were used to obtain nationally representative estimates. *Results:* In 1,550,000 patients discharged with ischemic stroke nationwide, the rate of tracheostomy was 1.3% (95% confidence interval [CI], 1.2-1.4%), with a 1.3% (95% CI, 1.1-1.4%) rate in patients without decompressive craniectomy and a 33% (95% CI, 26-39%) rate in the surgical treatment group. Logistic regression analysis identified pneumonia as being significantly associated with tracheostomy after decompressive craniectomy (odds ratio, 3.95; 95% CI, 1.95-6.91). *Conclusions:* Tracheostomy is common after decompressive craniectomy and is strongly associated with the development of pneumonia. Given its impact on patient function and potentially modifiable associated factors, tracheostomy may warrant further study as an important patient-centered outcome among patients with stroke. **Key Words:** Brain edema—brain injuries—decompressive craniectomy—intracranial pressure—stroke—tracheostomy.

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Stroke is a devastating event that results in high rates of disability and death.[1-3] During the acute hospitalization period, patients with severe stroke are routinely admitted to intensive care units because of the potential for intracranial hypertension, secondary neurologic deterioration, and multisystem organ failure, in addition to the need for supportive treatment.[4,5]

Despite best efforts, there remains a subpopulation of stroke patients that will go on to develop progressive, life-threatening "malignant" cerebral edema.[6-12] When this occurs, it is usually managed with an escalating level of care, ranging from optimization of ventilation to hyperosmolar therapy to decompressive craniectomy.[13] The care of any single patient is individualized, and

innovations including novel pharmacologic therapies[14,15] and neurosurgery[16-19] are expanding the armamentarium of available treatment options for this condition. While long-term neurologic outcome and mortality are commonly used outcome measures to measure the effect of these interventions, other patient-centered outcomes may also be important for comparison.

For stroke patients in particular, the severity of respiratory failure can be used as a quantifiable outcome metric. Intubation and mechanical ventilation are central tools that are frequently used in the acute care of severe ischemic stroke.[20-23] These procedures address the mechanical aspects of airway failure (i.e., obstruction and secretion clearance) associated with neurologic injury. In addition, mechanical ventilation can optimize gas exchange to prevent cerebral vasoconstriction and the progression of cerebral edema. Subsequently, some patients require tracheostomy in order to facilitate weaning from mechanical ventilation, long-term airway protection, or a combination of the two.[24] No studies have specifically identified the rate of tracheostomy in a general sampling of patients with severe ischemic stroke. While the clinimetric properties of various outcomes scales are criticized,[25] the rate of tracheostomy is a well-documented patient-centered outcome. We sought to establish the rate and predictors of tracheostomy in patients with severe ischemic stroke.

Methods

Hospital discharge data were obtained from the Nationwide Inpatient Sample (NIS), part of the Healthcare Cost and Utilization Project (HCUP), a federal/state/industry partnership sponsored by the Agency for Healthcare Research and Quality.[26] The NIS is a 20% stratified sample of all US community hospitals as defined by the American Hospital Association: nonfederal, short-term, general, and specialty hospitals whose facilities are open to the public. Hospitals are selected for inclusion in the NIS based on 5 characteristics: rural/urban location, number of beds, region of the country, teaching status, and ownership. The NIS includes all discharges from the sampled hospitals and includes between 5 and 8 million discharges from an average of 1000 hospitals each year. Further information about the methodology used to create the dataset is available at http://www.hcup-us.ahrq.gov/nisoverview.jsp. The Partners Institutional Review Board approved the use of the NIS for this study. A waiver of informed consent was obtained for use of this publicly available, deidentified database.

Patient Population

Using the NIS, we designed a retrospective study covering 2007 through 2009. The study dates were selected to coincide with the time period after the publication of several randomized trials for decompressive craniectomy in ischemic stroke.[16-19] These studies helped to standardize routine stroke care protocols, allowing for analysis of a more homogenous population. Adult patients (≥18 years of age) who had an ischemic stroke were identified using *International Classification of Diseases, 9th revision, Clinical Modification* (ICD-9-CM) codes 433.x1, 434.x1, and 436. Patients with ICD-9-CM codes for hemorrhagic stroke (code 431), trauma (codes 800-804 and 850-854), and subarachnoid hemorrhage (code 430) were excluded. Care performed in the rehabilitation setting after the initial hospitalization was also excluded using ICD-9-CM code V57. This algorithm has been shown to have 86% sensitivity and 95% specificity for acute ischemic stroke.[27]

Subgroup Analysis

Patients were stratified into 2groups: (1) those undergoing craniectomy for the development of malignant cerebral edema (ICD-9-CM codes 01.25 and 02.01), and (2) those receiving only medical management of stroke (the remainder of patients with stroke). The main outcome measure was performance of a tracheostomy (ICD-9-CM codes 31.1, 31.2, 31.21, and 31.29).

Statistical Analysis

For the purposes of statistical analysis, we summed the data from 2007 through 2009. Chi-square testing was used to compare categorical variables, and the Wald test was used to compare continuous variables between the 2 groups. To obtain national estimates, proper weights were applied as indicated in the HCUP–NIS *Calculating NIS Variances Guide*. For all statistical analyses, we used Stata software (version 12; StataCorp, LP, College Station, TX). Statistical significance was predefined at $P < .05$ (2-tailed). Logistic regression analysis was performed to determine predictors of tracheostomy. Independent variables studied included potential confounders based on known risk factors for stroke complications, among others. This was represented in the composite Elixhauser comorbidity score, in addition to individual variables of age, sex, race, coronary heart disease, congestive heart failure, deep vein thrombosis, renal insufficiency, chronic obstructive pulmonary disease, atrial fibrillation, pneumonia, and sepsis.[28-40] We also evaluated for potential confounders that could independently affect the likelihood of an invasive procedure being offered: hospital size (small, medium, or large), hospital type (teaching or nonteaching), median household income in the patient's ZIP code, and primary insurance payer (Medicare, Medicaid, private insurance, or other).

Results

Between 2007 and 2009, there were an estimated 1,550,000 (95% confidence interval [CI], 1,500,000-1,600,000) patients discharged with ischemic stroke