Neurosurgical Infection Rates and Risk Factors: A National Surgical Quality Improvement Program Analysis of 132,000 Patients, 2006–2014

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■ BACKGROUND: **The existing body of literature on postoperative neurosurgical infections lacks large multicenter reports on postoperative neurosurgical infections. This is the largest study to date of postoperative neurosurgical infections rates, time to event, and risk factors.**

■ METHODS: **Demographics, medical history, and postoperative infections were assessed for all adult patients in the large, randomized, multicenter American College of Surgeons–National Surgical Quality Improvement Program (ACS-NSQIP) database undergoing an operation with a surgeon whose primary specialty was neurological surgery from 2006 to 2014.**

■ RESULTS: **Of 3,723,797 cases from 517 institutions in the NSQIP from 2006 to 2014, 132,063 neurosurgery cases were identified. Within these patients, the 30-day rate of postoperative infections was 5.3%. Postoperatively, 1.8% of patients developed surgical site infections (SSI), and 3.9% developed other infections including pneumonia and urinary tract infections. Superficial SSI had a cumulative incidence of 0.8% at a median of 16 (interquartile range [IQR], 11–22) days. Pneumonia had a cumulative incidence of 1.4% at a median of 5 days (IQR, 2–10 days). Systemic inflammatory response syndrome had a cumulative incidence of 1.6% at a median of 3 days (IQR, 8–16 days). Predictors of postoperative infections on multivariable analysis included female sex, older age, obesity, functionally dependent status before surgery, ventilator dependence, preoperative steroid use, bleeding disorders, hyponatremia, lymphocytosis, anemia, thrombocytosis, emergent case status, wound class II–IV, American Society of Anesthesiologists class 3–5, and longer operative times.**

■ CONCLUSION: **The overall ACS-NSQIP reported rate of postoperative infections was 5.3% from 2006 to 2014. Multivariable analysis demonstrated several predictive factors for postoperative infections.**

INTRODUCTION

Postoperative infections lead to increased morbidity, mortality, cost, unplanned readmission, reoperation, and prolonged length of stay after neurological surgery.[1-12] Incidence of neurosurgical infections remains highly variable. Reported rates of surgical site infections, for example, vary from 1%–8% in cranial cases to 0.5%–18% in spine operations.[1,2,5,6,8,10,13-18] Similarly, reports of predictive factors have yet to establish a clear picture of the risks for infection after neurosurgery.[1,6-8,10,15,19-21] The majority of reports regarding infections in neurosurgical patients have assessed complications from single institutions across limited time frames, and few studies have used

Key words
- Complications
- Infection
- Neurosurgery
- NSQIP
- Quality improvement
- Organ space infections
- Surgical site infections
- Urinary tract infections

Abbreviations and Acronyms
ACS: American College of Surgeons
ASA: American Society of Anesthesiologists
BMI: Body mass index
COPD: Chronic obstructive pulmonary disease
INR: international normalized ratio
IQR: Interquartile range
NSQIP: National Surgical Quality Improvement Program
PTT: Partial thromboplastin time
RVU: Relative value unit
SIRS: Systemic inflammatory response syndrome
SSI: Surgical site infections
UTI: Urinary tract infection

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a large, multi-institutional sample to analyze the rates of all infections after neurosurgery.[2,4,6,7,14,21-23]

The purpose of this study was to characterize the incidence of and predictive factors for postoperative neurosurgical infections of any type. The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) is a large, prospectively collected, nationwide, multicenter database of 30-day postoperative outcomes.[9,11,20,24] The ACS initiated the NSQIP project in 2004, and the database now includes more than 3.7 million patient cases from more than 500 institutions. The database includes objective criteria, internal audits to filter reported data, and more than 130,000 neurosurgical records from 2006 to 2014.[9,11,12,20,24-29] We analyzed the NSQIP database to create predictive models for postoperative infections after neurological surgery.

METHODS

Data Source

The prospective National Surgical Quality Improvement Program (NSQIP) registry was used for the years 2006–2014, and it is maintained by the American College of Surgeons (ACS). Trained surgical reviewers prospectively collect data for NSQIP using a uniform protocol. Hospitals, ranging from small rural community hospitals to large academic centers, included within NSQIP require sufficient financial and institutional resources to maintain high-quality data collection and analysis required by the standards of the database. Patients enrolled in NSQIP are followed for 30 days postoperatively, and all complications (among those collected in the NSQIP algorithm) that occurred during this period are recorded; there is no administrative censoring or loss to follow-up of patients entered. Our institutional review board has exempted the deidentified NSQIP data set from individual review.

Inclusion and Exclusion Criteria

Patients who were included met the following criteria: 1) age 18 years or older; 2) the attending surgeon was a neurosurgeon. Of 3,723,797 cases in NSQIP from 2006 to 2014, 132,063 neurosurgery cases were identified.

Covariates

Pertinent covariates collected by NSQIP were extracted. Age was examined categorically by quartile. Sex, American Society of Anesthesiology (ASA) physical classification (1–2, 3, 4–5, or missing), and preoperative functional status (dependent versus independent) were assessed. Comorbidities evaluated included: smoking (within the past year), hypertension requiring medication, chronic obstructive pulmonary disease, dyspnea, diabetes mellitus, and a bleeding disorder (defined by NSQIP as vitamin K deficiencies, hemophilia, thrombocytopenia, and long-term anticoagulant usage). Body mass index was determined based on height and weight, with obesity defined using World Health Organization criteria: class I obesity as 30–34.99 kg/m^2 and class II or III is greater than 35 kg/m^2. Disseminated cancer is defined by NSQIP as multiple metastases indicating that the cancer is widespread. Preoperative laboratory values were extracted and stratified (stratification was based on previous neurosurgical studies that have used NSQIP as a data source)[30,31]: hematocrit (by 36%), international normalized ratio (by 1.4), partial thromboplastin time (by 40 seconds), and platelets (by 450,000 per microliter). Preoperative steroid use (within 30 days) was also extracted. An open wound is defined by NSQIP as any incision that directly communicates with air. Preoperative systemic inflammatory response syndrome (SIRS) is indicated in any patient with at least two of the following criteria: body temperature greater than 38°C or less than 36°C, heart rate greater than 90 beats per minute, respiratory rate greater than 20 breaths per minute, leukocytosis or leukopenia (white blood cell [WBC] count greater 12,000 cells/μL and less than 4000 cells/μL, respectively), or anion gap acidosis. Admission type, preoperative intubation (within 48 hours), case urgency (emergent or elective), and operative time (by quartile) were also extracted. Wound classification compared class I (clean) operations to class II (clean-contaminated), III (contaminated), or IV (dirty) designations.

Outcomes

The outcomes evaluated were any infection (superficial surgical site infection, organ/space surgical site infection, deep surgical site infection, wound dehiscence, urinary tract infection, pneumonia, systemic inflammatory response syndrome), surgical site infections (superficial surgical site infection, organ/space surgical site infection, deep surgical site infection, wound dehiscence), and other infections (urinary tract infection, pneumonia, systemic inflammatory response syndrome).

Missing Data

Patients with missing data for demographics were placed in a separate category for that variable, allowing for appropriate use of missing data in logistic regression.

Statistical Analysis

Statistical analyses were conducted with SPSS version 23 (IBM, Armonk, NY). Descriptive statistics were performed on baseline variables, and χ^2 measures assessed their association with the specific outcome evaluated. Multivariable logistic regression models were thereafter constructed using backward selection using the likelihood ratio test. A probability value less than 0.05 was determined to be statistically significant.

RESULTS

Demographics

Of 132,063 neurosurgical patients in the ACS-NSQIP database from 2006 to 2014, the 30-day rate of postoperative infections was 5.3%. Over this period, the 30-day mortality was 1.5%, the median length of total hospital stay was 2 days (interquartile range [IQR], 1–5 days), and the median operative time was 128 minutes (IQR, 82–200 minutes). Postoperatively, 1.8% of patients developed surgical site infections (SSI) and 3.9% developed other infections including pneumonia, urinary tract infections, or systemic inflammatory response syndrome (SIRS). Overall, 48.8% of patients were women and the median age was 58 years (IQR, 47–68 years; Table 1).