# Short-Term Adverse Outcomes After Deep Brain Stimulation Treatment in Patients with Parkinson Disease

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■ BACKGROUND: **Despite ongoing progress in our understanding of long-term outcomes after neuromodulation procedures, acute adverse outcomes shortly after deep brain stimulation (DBS) treatment have remained remarkably limited.**

■ OBJECTIVE: **To identify risk factors associated with acute 30-day outcomes after DBS treatment in patients with Parkinson disease (PD).**

■ METHODS: **We evaluated patients who underwent DBS treatment for PD from 2005 to 2014 through the American College of Surgeons National Surgical Quality Improvement Program database. We used bivariate analysis and multivariate logistic regression to identify short-term postoperative outcomes, including 30-day complication, discharge destination, and unplanned readmission.**

■ RESULTS: **Overall, 650 patients with PD underwent DBS procedures and complications were identified in 32 patients (4.9%). Of 481 patients who had complete discharge data, 18 patients (3.7%) were discharged to a facility and 16 patients (3.3%) experienced an unplanned readmission. Patients with PD who were obese ($P = 0.045$), who had preoperative anemia ($P = 0.008$), and who experienced longer operative durations ($P = 0.01$) had increased odds of postoperative complications. Inpatient status ($P = 0.001$), dependent functional status ($P < 0.001$), and anemia ($P = 0.043$) were all associated with discharge to a facility other than home. Longer operative duration ($P = 0.013$), anemia ($P = 0.036$), and dependent functional status ($P = 0.03$) were significantly associated with unplanned readmission. As expected, complications increased the likelihood of unplanned readmission ($P < 0.001$).**

■ CONCLUSIONS: **This study provides individualized estimates of the risks associated with short-term adverse outcomes based on patient demographics and comorbidities. These data can be used as an adjunct for short-term risk stratification of patients with PD being considered for DBS treatment.**

## INTRODUCTION

Parkinson disease (PD) is a relatively common diagnosis in the elderly population, with an incidence of approximately 1%–2% in those older than 65 years in the United States.[1,2] Deep brain stimulation (DBS) is a minimally invasive intracranial neurostimulation technique that targets specific structures in the brain, including intracranial depth lead implantation and the neurostimulator pulse generator placement.[3,4] Since subthalamic nucleus and globus pallidus pars internus stimulation were approved for PD treatment in 2002,[5,6] DBS treatment has proved to be a well-established treatment. However, as the number of DBS

**Key words**
- Complication
- Deep brain stimulation
- Discharge destination
- NSQIP
- Parkinson disease
- Unplanned readmission

**Abbreviations and Acronyms**
**ACS-NSQIP**: American College of Surgeons National Surgical Quality Improvement Program
**BMI**: Body mass index
**CI**: Confidence interval
**CPT**: Current Procedural Terminology
**DBS**: Deep brain stimulation
**OR**: Odds ratio
**UTI**: Urinary tract infection

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treatment in PD cases has increased over the years, intraprocedural and postprocedural complications have also continued to increase.[7-10]

Most previous studies have examined patient outcome from within single high-volume academic centers,[5,11-16] and most have investigated long-term outcomes after DBS treatment rather than immediate or short-term perioperative results during or shortly after hospitalization.[17-20] Moreover, studies from single academic centers often limit the ability to generalize conclusions because of inherent selection bias. Therefore, patient-based factors and surgical characteristics that increase the risk of perioperative outcomes in patients with PD undergoing DBS treatment in 30 days are not well understood. Understanding these factors is also important because acute perioperative complications and hospital readmission are a major burden on the health care system.[21-24] Studies that examine DBS treatment outcomes in patients with PD from a large data sample are rare,[25-27] and all of them use the Nationwide Inpatient Sample database based on the *International Classification of Diseases, Ninth Revision* codes. Use of the NSQIP database and Current Procedural Terminology (CPT) codes can, therefore, provide a different aspect of the description for patients with PD after DBS treatment procedure and determine their acute perioperative outcome.

The purpose of this study was to identify independent predictors associated with adverse 30-day short-term perioperative outcomes after DBS treatment in patients with PD and evaluate predictive factors associated with the disposition in a data set that includes hospitals across the United States.

## METHODS

### American College of Surgeons National Surgical Quality Improvement Program Data Set and CPT Codes Used

To identify patients with PD undergoing DBS treatment, we used the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database and included patients from 2005 to 2014. The ACS-NSQIP database contains patient data from 121 participating U.S. hospitals in 2005 and has since grown to include more than 500 hospitals in 2014. It includes data from a heterogeneous collection of academic and private centers, as well as urban and rural hospitals. Patients are prospectively identified and then systematically and randomly sampled from eligible hospitals by trained and frequently audited personnel. Data are collected from these patients for the entire 30-day postoperative period, regardless of the discharge date.[28]

More than 150 patient variables are extracted from medical records, operative reports, and patient interviews, including preoperative risk factors, intraoperative variables, and 30-day postoperative mortality and morbidity outcomes, for patients undergoing major surgical procedures. We used CPT codes 61863, 61864, 61867, 61868, 61885, and 61886 to identify DBS treatment procedures. Patients who had the CPT codes of depth lead implantation, generator insertion, or both were extracted. Cortical lead implantation (61850, 61860) and revision or removal procedures (61880, 61888) were excluded. To further stratify, *International Classification of Diseases, Ninth Revision* codes 332.0 were used to ensure that the patients' primary diagnosis was PD (Table 1).

This study received an exempt determination from the Massachusetts General Hospital investigational review board, because the data are Health Insurance Portability and Accountability Act compliant.

### Variable Selection

The primary patient-based demographic predictors included age (categorized as $\leq$69 vs. $\geq$70 years old), sex, body mass index (BMI, calculated as weight in kilograms divided by the square of height in meters; BMI $\leq$29.9 kg/m$^2$, not obese vs. BMI $\geq$30 kg/m$^2$, obese[29]), functional status (independent vs. partially/totally dependent), transfer status (admitted from home vs. admitted from acute care/nursing home/outside emergency department/other), selected preoperative laboratory values (preoperative anemia was defined as a hematocrit concentration of less than 36.0% for women and less than 39.0% for men according to World Health Organization sex-based criteria[30]), and medical comorbidities. The surgical risk factors evaluated included the American Society of Anesthesiologists classification (3/4 vs. 1/2), the type of anesthesia (spinal/epidural/regional/others vs. general) used, and operative duration.

### Outcomes Measure

Our primary outcomes of interest were the development of any surgical complications, including systemic complications (urinary tract infection [UTI], pneumonia, unplanned intubation, cardiac arrest, deep vein thrombosis, pulmonary embolism, acute kidney injury, cerebrovascular accident, thrombophlebitis, sepsis, septic shock, and death), surgical site wound complications (superficial and deep), and events requiring a return to operation room (by examining the postoperative diagnosis) within 30 days. Unplanned hospital readmission and discharge destination were also obtained as secondary outcomes. These secondary outcomes were extracted from 2011 to 2014 because hospital readmission and discharge destination data are not available in the NSQIP before 2011.

### Statistical Analysis

Multivariate logistic regression was conducted for factors that maintained frequencies greater than 10 and also had $P$ values $<$0.2 in the initial univariate testing.[31] Variables with unknown or missing values, when encountered, were omitted from analysis.[32] Variables that were missing in more than 20% of the cohort were excluded to avoid model distortion. Odds ratio (OR) and 95% confidence interval (CI) were reported for both the bivariate and the multivariate analyses. Significant independent predictor variables were determined to be those that maintained $P$ values $<$0.05 with OR and 95% CI exclusive of 1.0 after multivariate testing.[33] The C statistic was used to measure the discriminative capacity, and the Hosmer and Lemeshow goodness-of-fit test was used to assess the model calibration. All analyses were performed using Stata version 14.0 MP (StataCorp, College Station, Texas, USA).

## RESULTS

### Participants and Descriptive Data

A total of 650 patients with PD who underwent DBS treatment (depth lead implantation, generator insertion, or both) were