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Surgical complications following malignant brain tumor surgery: An analysis of 2002–2011 data

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ABSTRACT

Objectives: To estimate the incidence of surgical complications and associated in-hospital morbidity and mortality following surgery for malignant brain tumors.
Patients and methods: The Nationwide Inpatient Sample (NIS) database was queried from 2002 to 2011. All adult patients who underwent elective brain surgery for a malignant brain tumor were included. Surgical complications included wrong side surgery, retention of a foreign object, iatrogenic stroke, meningitis, hemorrhage/hematoma complicating a procedure, and neurological complications. A regression model was conducted to estimate the odds ratios (OR) with their 95% confidence intervals (95% CI) of in-hospital mortality for each surgical complication.
Results: A total of 16,530 admissions were analyzed, with 601 (36.2 events per 1000 cases) surgical complications occurring in 567 patients. Over the examined 10-year period, the overall incidence of surgical complications did not change ($P = 0.061$) except for iatrogenic strokes, which increased in incidence from 14.1 to 19.8 events per 1000 between 2002 and 2011 ($P = 0.023$). Patients who developed a surgical complication had significantly longer lengths of stay, total hospital costs, and higher rates of other complications. Patients who experienced an iatrogenic stroke had a significantly increased risk of mortality (OR 9.6; 95% 6.3–14.8) and so were patients with a hemorrhage/hematoma (OR 3.3; 95% CI 1.6–6.6).
Conclusion: In this study of an administrative database, patients undergoing surgery for a malignant brain tumor who suffered from a surgical complication had significantly longer lengths of stay, total hospital charges, and complication rates. Having a surgical complication was also an independent risk factor for in-hospital mortality. Nonetheless, it is unclear whether all surgical complications were clinically relevant, and further research is encouraged.

1. Introduction

Malignant brain tumors are the most common primary brain tumor, with an estimated incidence in adults of 5.26 cases per 100,000 persons per year in the United States [1]. Although newer treatment modalities such as chemotherapy and immune therapy have emerged as potential adjuvants for management of these tumors, surgery continues to be first-line therapy [1,2]. The importance of this, however, is that newer evidence has supported more aggressive resections as a mode to improve survival [3,4]. Nonetheless, more aggressive resections carry an increased risk of potentially catastrophic surgical complications, including irreversible neurological deficits.

The purpose of this study is to estimate the incidence of surgical complications, (including sentinel events) in patients undergoing malignant brain tumor surgery using a large administrative database, and analyze their impact on in-hospital morbidity and mortality.

2. Patients and methods

2.1. Study design and data source

In this retrospective cohort study, the Nationwide Inpatient Sample (NIS) administrative database was queried for the years 2002–2011. The NIS, as part of the Healthcare Cost and Utilization Project (HCUP), is the largest inpatient administrative database

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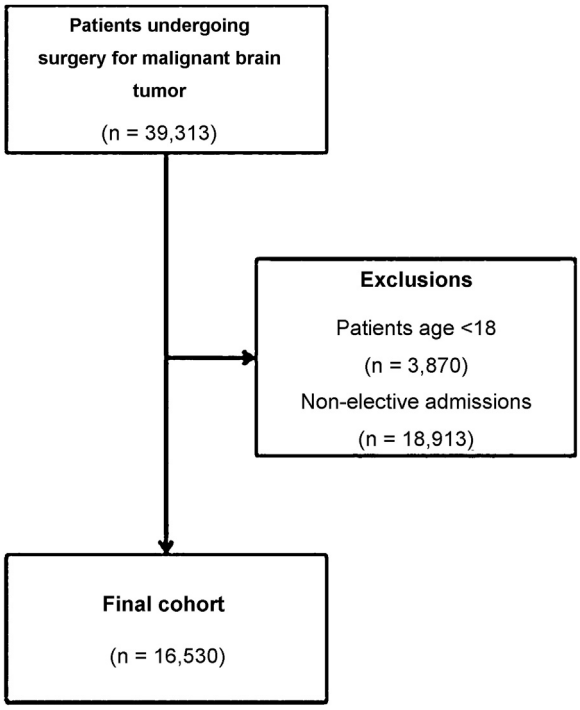

Fig. 1. Framework for patient selection shows inclusion/exclusion criteria.

in the United States, reporting approximately 8 million admissions from a 20% sample of all non-federal hospitals per year. The NIS database reports diagnoses, procedures and complications in the form of ICD-9-CM (International Classification of Disease-9th Edition-Clinical Modification) codes.

2.2. Inclusion and exclusion criteria

Patients with a primary diagnosis of a malignant brain tumor (codes 191.0–1.919) that underwent a craniotomy or craniectomy (01.20–01.29), incision of brain and cerebral meninges (01.31–01.39) or excision/destruction of lesion or tissue of brain (01.59) were included. Patients under the age of 18 years and with non-elective admissions were excluded from this study (Fig. 1).

2.3. Data collection

Patients were divided into two cohorts: non-surgical complication and surgical complication. In accordance with the Joint Commission guidelines, patients with retention of a foreign object (codes E870.1 and 998.4) and patients who received wrong side surgery (E876.5–E876.9) were classified as having a surgical complication [5]. Additionally, patients who experienced an iatrogenic stroke (997.02), meningitis (320.0–320.9) or hemorrhage/hematoma complicating a procedure (998.1–998.13) were included in the surgical complication cohort [6]. These complications were chosen based on the work by Landriel-Ibañez et al., who proposed a new classification for complications in neurosurgery. In the proposed system, the aforementioned complications are considered "Grade III" surgical complications, and refer to "life-threatening adverse events requiring treatment and care in a more complex hospital area" [6]. Patients with codes 997.00–997.09 were also classified as having a neurosurgical complication, in accordance to a recent study utilizing the NIS to examine outcomes after brain tumor resection [7].

Demographic variables such as age, sex, hospital location, and teaching status were collected for each admission. Hospital location is determined via use of Core Based Statistical Area (CBSA) codes. Hospitals located in counties with a CBSA type of metropolitan were considered "urban" hospitals, whereas hospitals with a CBSA type of micropolitan were classified as "rural" hospital. Hospitals are considered "teaching hospitals" if they meet any of the following criteria: (1) an approved residency program, (2) is member of the Council of Teaching Hospitals, or (3) has a ratio of interns/residents to beds of 0.25 or higher. Overall preoperative comorbidity was calculated via the Elixhauser comorbidity score, an established method to calculate a score from administrative databases; this method adds 1 point per comorbidity (from a list of 30 comorbidities) to produce a final score [8].

2.4. Outcomes

Both cohorts were analyzed to compare outcomes in the form of other complication development, average length of stay, total hospital charges and mortality. Other complications included: pneumonia (481, 482, 483), myocardial infarction (410.0–410.91), acute kidney injury (584.5–584.9), pulmonary complications (518.5–518.53), pancreatitis (577.0), urinary tract infection (UTI; 595.0, 595.9, 599.0), deep vein thrombosis (453.4–453.42, 453.8, 453.9) pulmonary embolism (415.22, 415.13, 415.19) and surgical site complication (998.83, 998.32, 998.51, 998.59, 998.6) [6].

2.5. Statistical analysis

Descriptive statistical analyses were performed to compare demographic variables between cohorts. Results are presented as mean ± standard deviation when applicable or as mean with interquartile ranges (IQR) for non-parametric data. Continuous data was compared via the Student's T-test and non-continuous data was compared via the χ^2 test. A linear regression analysis was used to analyze trends of surgical complications, length of stay and total hospital charges over time. A multivariable logistical regression analysis was conducted to estimate odds ratios (OR) of mortality with their 95% confidence intervals (CI). OR analyses were controlled for patient age, sex and comorbidities. *P*-values <0.05 were considered significant. Statistical analyses were performed using STATA SE 12 (StataCorp LP, College Station, Texas).

3. Results

A total of 16,530 patients who underwent surgery for a malignant brain tumor between 2002 and 2011 were identified, with 567 patients (3.4%) in the surgical complication cohort [Table 1]. Patients in the surgical complication and non-surgical complication cohorts were similar in terms of age and sex. However, the median number of comorbidities in the surgical complication cohort was two, compared to one in the non-surgical complication cohort ($P < 0.001$). The proportion of patients treated at urban and teaching hospitals was not statistically different between cohorts.

When analyzing hospital resource utilization, patients with a surgical complication had significantly longer average lengths of stay (11.8 vs. 4.4 days, $P < 0.001$) and double the total hospital charges ($111,518 vs. $53,638, $P < 0.001$). Length of stay significantly decreased over time from an average of 5.2 days in 2002 to 4.0 days in 2011 ($P < 0.001$) [Fig. 2]. On the other hand, total hospital charges increased from a mean of $33,210 in 2002 to $75,774 in 2011 ($P < 0.001$) [Fig. 3].

Additionally, patients in the surgical complication cohort had significantly higher rates of other complications (19.2% vs. 5.4%, $P < 0.001$), including pneumonia, acute kidney injury, respiratory complications, UTI, DVT, PE and surgical site complications (including wound infection).