



## Predicting Short-Term Outcome After Surgery for Primary Spinal Tumors Based on Patient Frailty

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■ **OBJECTIVE:** Frailty, decreased physiologic reserve and increased vulnerability to stressors beyond what is expected for normal aging, is associated with increased risk of morbidity and mortality. The objective of this study was to develop a preoperative frailty index for patients undergoing surgery for primary spinal column tumors that predicts morbidity, mortality, and length of stay.

■ **METHODS:** The Nationwide Inpatient Sample database from 2002 to 2011 was used to identify patients who underwent surgery for a primary spinal tumor. The spinal tumor frailty index, consisting of 9 items, was applied to each patient. Patients were characterized as “not frail” (0), “mildly frail” (1), “moderately frail” (2), and “severely frail” ( $\geq 3$ ).

■ **RESULTS:** Inclusion criteria were met by 1589 patients. Overall major complication rate was 10.6%. Compared with patients without frailty, patients with mild (odds ratio 3.83; 95% confidence interval, 2.63–5.58), moderate (odds ratio 6.80; 95% confidence interval, 4.10–11.3), and severe frailty (odds ratio 13.05; 95% confidence interval, 6.34–26.87) had significantly increased odds of developing complications (all  $P < 0.001$ ). Mean length of stay was 6.4 days  $\pm$  0.2, 9.8 days  $\pm$  0.6, 14.4 days  $\pm$  1.7, and 18.3 days  $\pm$  2.6 for patients without frailty, with mild frailty, with moderate frailty, and with severe frailty ( $P < 0.05$  between all groups).

■ **CONCLUSIONS:** Compared with patients without frailty, patients with mild, moderate, and severe frailty had

significantly increased odds of developing postoperative complications. Systematic evaluation of preoperative frailty should play a key role in decision making for patients undergoing surgery for primary spinal tumors.

### INTRODUCTION

Although metastatic neoplasms are the most common tumors of the spine, primary tumors represent approximately 10% of all tumors of the spine. These can be either benign (e.g., osteblastomas, chondromas, hemangiomas) or malignant (e.g., plasmacytomas, chordomas, chondrosarcomas, osteosarcomas) neoplasms.<sup>1-3</sup> The clinical prognoses and treatment of primary tumors of the spine can be estimated based on several factors, including the malignant nature, location, and general pathologic and morphologic characteristics, using a wide variety of classification systems (i.e., modified Enneking classification and Weinstein-Boriani-Biagini classification) that provide guidelines for determining appropriate surgical treatment and anatomic classification for preoperative planning.<sup>4-7</sup>

The surgical treatment for patients with neoplasms of the spinal column is dictated primarily by the pathologic diagnosis but is based on providing local control and/or total removal of the cancerous lesion, while minimizing morbidity and mortality. En bloc resection, or the complete removal of a tumor in a non-violated piece with normal margins throughout, is considered the mainstay of treatment for several primary tumor types.<sup>4</sup> However,

#### Key words

- Frailty
- Frailty index
- Spinal tumor
- Spine surgery

#### Abbreviations and Acronyms

**ACS-NSQIP:** American College of Surgeons National Quality Improvement Program

**CI:** Confidence interval

**ICD-9:** International Classification of Diseases, 9th Revision

**LOS:** Length of stay

**NIS:** Nationwide Inpatient Sample

**OR:** Odds ratio

**STFI:** Spinal tumor frailty index

**TRIPOD:** Transparent Reporting of multivariable prediction model for Individual Prognosis Or Diagnosis

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Citation: *World Neurosurg.* (2017) 108:393-398.

<https://doi.org/10.1016/j.wneu.2017.09.034>

Journal homepage: [www.WORLDNEUROSURGERY.org](http://www.WORLDNEUROSURGERY.org)

Available online: [www.sciencedirect.com](http://www.sciencedirect.com)

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given the invasiveness of this procedure, en bloc resection is associated with substantial morbidity, with an incidence of complications reported to be 13%–56%.<sup>8–10</sup> Common complications associated with en bloc resection include hardware failure (owing to the complex spinal reconstruction often warranted in these cases); wound infection; cerebrospinal fluid leaks; vascular injuries; and neurologic deficits of weakness, paresthesias, sexual dysfunction, bowel bladder dysfunction, and paralysis.<sup>8,11–14</sup>

Frailty, a multisystem phenomenon involving decreased physiologic reserve and increased vulnerability to stressors beyond what is expected for normal aging,<sup>15,16</sup> is considered a predictor of adverse events and mortality.<sup>17–20</sup> In terms of surgical outcomes, frailty is associated with increased risk for postoperative complications, such as delirium, longer hospital stays, increased readmission rates, and decreased long-term survival rates.<sup>19,21–23</sup> Although the risks associated with surgical treatment of primary tumors are known, there are limited studies regarding the ability to predict postsurgical morbidity and mortality in patients with primary spinal tumors, and there are fewer studies examining the association between frailty and short-term outcomes after surgery for primary spinal tumors. Thus, the aim of our study was to develop an index for patients undergoing surgical resection of a primary spinal tumor that could predict perioperative complications, length of stay (LOS), and in-hospital mortality.

## MATERIALS AND METHODS

### Study Design and Participants

The U.S. Nationwide Inpatient Sample (NIS) database for the years 2002–2011 was examined. The NIS is a nationwide multicenter administrative database that contains data on all discharges from a 20% sample of hospitals across the United States. It contains approximately 8 million admissions per year, with data encoded in the form of *International Classification of Diseases, Ninth Revision (ICD-9)* codes and *Clinical Classifications Software* diagnostic codes. The database undergoes quality control procedures, which have previously demonstrated data accuracy and reliability.<sup>24</sup> This study was exempt from review by our institutional review board (IRB00096323).

### Inclusion and Exclusion Criteria

Patients with a primary discharge diagnosis of benign neoplasm of vertebral column (ICD-9 213.2), benign neoplasm of sacrum and coccyx (ICD-9 213.6), malignant neoplasm of vertebral column (ICD-9 170.2), or malignant neoplasm of sacrum and coccyx (ICD-9 170.6) were identified ( $n = 4182$ ). Patients who did not undergo spinal decompression and/or fusion were excluded ( $n = 2593$ ).

### Recorded Data

Individual admission information, such as patient age, sex, race, tumor type (benign vs. malignant), comorbidities, presence of pathologic fracture, use of corpectomy, partial or total vertebrectomy, red blood cell transfusion, and LOS, was gathered from the database. The objective of the present study was to predict short-term outcomes in patients undergoing surgical resection for primary spinal tumors, similar to and based on a previously developed metastatic index.<sup>25</sup> The variables used in the current

study were unique to patients with primary tumors, not patients with metastatic tumors, accounting for the minor variability between the current index and a previously published index.<sup>25</sup> Variables that significantly predicted short-term outcomes were obtained from the NIS database and externally validated on 297 patients from the American College of Surgeons National Quality Improvement Program (ACS-NSQIP) database, in a similar method to the previous index. This index consists of 9 distinct items: anemia, congestive heart failure, chronic obstructive pulmonary disease, coagulopathy, electrolyte abnormalities, pulmonary circulation disorders, renal failure, malnutrition, and pathologic fractures. Patients with 0 comorbidities are categorized as having “no frailty,” patients with 1 comorbidity are categorized as having “mild frailty,” patients with 2 comorbidities are categorized as having “moderate frailty,” and patients with  $\geq 3$  comorbidities are categorized as having “severe frailty.” This index has been previously shown to significantly predict morbidity, mortality, and LOS for patients undergoing surgery for metastatic spinal tumors.<sup>25</sup>

### Outcomes

The primary endpoint of this study was assessing the development of at least 1 major perioperative complication. These complications included acute respiratory distress syndrome; pleurisy, pneumothorax, or pulmonary collapse; reintubation; pneumonia; pulmonary embolism; cardiac arrest; myocardial infarction; iatrogenic stroke; and acute renal failure.

### Statistical Analysis

General descriptive statistics were conducted for the entire study population, with results presented as mean  $\pm$  SD, median with interquartile range, or frequency. The complication rate was compared between frailty groups via  $\chi^2$  test and via logistic regression analysis. For internal validation, a random bootstrapping algorithm with 10,000 runs was performed. For external validation, a cohort of patients with primary spinal tumors who underwent surgery were identified from the ACS-NSQIP database for the years 2007–2013. Given that not all variables are shared between the NIS and NSQIP databases, the frailty index included only anemia, congestive heart failure, chronic lung disease, coagulopathy, electrolyte abnormalities (only sodium alterations), renal failure, and weight loss. A  $P$  value  $< 0.05$  was considered statistically significant. All analyses were done in Stata SE 12 (StataCorp LLC, College Station, Texas, USA).

## RESULTS

### Demographic Data

This study included 1589 patients who met our inclusion criteria. Median age at surgery was 47 years, 51.8% of all patients were male ( $n = 823$ ), and 74.7% were Caucasian ( $n = 1187$ ). More than half of patients (55.0%) had a primary benign tumor, and 45.0% had a primary malignant tumor. The 3 most common comorbid conditions were electrolyte abnormalities (9.3%), chronic lung disease (8.6%), and anemia (8.4%). A pathologic fracture occurred in 60 patients (3.8%). The median STFI score was 0 (interquartile range, 0–3); 71.7% of patients had a score of 0, 20.1% had a score

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