Preoperative Charlson Comorbidity Score Predicts Postoperative Outcomes Among Older Intracranial Meningioma Patients

Rachel Grossman[1], Debraj Mukherjee[1], David C. Chang[2], Richard Bennett[3], Henry Brem[1], Alessandro Olivi[1], Alfredo Quiñones-Hinojosa[1]

Key words
- Charlson score
- Elderly meningioma
- Preoperative risk assessment

Abbreviations and Acronyms
ASA: American Society of Anesthesiologists
KPS: Karnofsky Performance Status
LOS: Length of stay
NIS: Nationwide Inpatient Sample

From the Departments of [1]Neurosurgery, [2]Surgery, and [3]Medicine, Johns Hopkins School of Medicine, Neuro-Oncology Surgical Outcomes Research Laboratory, Johns Hopkins School of Medicine, Baltimore, Maryland, USA

Rachel Grossman and Debraj Mukherjee are co-first authors of this manuscript.

To whom correspondence should be addressed: Alfredo Quiñones-Hinojosa, M.D. [E-mail: aquinon2@jhmi.edu]

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OBJECTIVE: **Preoperative determinants of surgical risk in elderly patients with meningioma are not fully defined. This study was undertaken to determine whether the Charlson comorbidity index could be used to accurately predict postoperative outcomes among older patients with meningiomas undergoing neurosurgical resection and thereby make a selection for surgery easier.**

METHODS: **We performed a multi-institutional retrospective cohort analysis via the Nationwide Inpatient Sample (1998-2005). Patients 65 years of age and older who underwent tumor resection of intracranial meningiomas were identified by International Classification of Diseases, 9th revision, coding. The primary independent variable in multivariate regression was the Charlson comorbidity score, and the primary outcome was inpatient death. Secondary outcomes included inpatient complications, length of stay, and total hospital charges.**

RESULTS: **We identified 5717 patients (66.6% female, and 81.8% white) with mean age of 73.6 years. Mean Charlson comorbidity score was 0.99. Inpatient mortality was 3.2%. Mean length of stay was 9.1 days, and mean total charges were $62,983. In multivariate analysis, the only factors consistently associated with worse outcome were increased Charlson comorbidity score and increased patient age (ie, >65 years of age). Only greater Charlson scores were additionally associated with greater odds of all major complications such as neurological, respiratory, and cardiac complications. Elective procedures were consistently associated with less inpatient death, length of stay, and total charges. All associations were statistically significant ($P < 0.05$).**

CONCLUSIONS: **The safe surgical resection of intracranial meningiomas among older patients is possible through the ninth decade of life. The Charlson comorbidity score has been shown to be a strong, consistent predictor of inpatient outcomes.**

INTRODUCTION

Meningiomas account for nearly one-fourth of all primary brain tumors, with one-half of these lesions presenting in patients older than 65 years of age (11, 14, 16). There is an increasing incidence of these tumors, likely related to population demographics and the greater use of diagnostic imaging. Given the increasing numbers of patients in advanced age who will be diagnosed with meningioma in the coming decades, there is an increasing need to define reliable, preoperative predictors of safe neurosurgical intervention for these older patients (11, 18).

During the past 20 years, ambiguity has arisen regarding the decision of whether to resect meningiomas in older adults because of wide variability in reported mortality rates, which range from 1.8% to 45% (2-6, 15, 17, 19-21, 23, 25, 26). Some investigators have attempted to define preoperative indicators for safe neurosurgical intervention, with several demonstrating the predictive value of patient age, sex, tumor size, and general health indicators, such as American Society of Anesthesiologists (ASA) (6, 31) and Karnofsky Performance Status (KPS) (13, 15, 17) scores, whereas the authors of other series have negated the value of such measures (3-6, 8, 12-15, 17, 19, 21-23, 25-27, 29, 30, 32, 34).

In light of viable nonoperative management approaches, including conservative management or stereotactic radiosurgery, identification of reliable preoperative markers associated with successful tumor excision remains an important goal and allows for more informed operative decision-making and truly informed consent (7, 24). Through this multicenter, retrospective cohort study of the Nationwide Inpatient Sample, we demonstrate that the Charlson score is predictive of inpatient postoperative outcome among elderly patients with meningioma.

MATERIALS AND METHODS

Data Source

We obtained the National Inpatient Sample (NIS) in-hospital discharge database for the years 1998 through 2005. Compiled by the

Table 1. Comorbidities Included in the Charlson Comorbidity Score

Weights	Clinical Conditions
1	Myocardial infarct, congestive heart failure, peripheral vascular disease, dementia, cerebrovascular disease, chronic lung disease, connective tissue disease, peptic ulcer disease, or chronic liver disease
2	Hemiplegia, moderate or severe kidney disease, uncomplicated diabetes, diabetes with complications, tumor, leukemia, lymphoma
3	Moderate or severe liver disease
6	Malignant tumor, metastasis, acquired immune deficiency syndrome

Agency for Healthcare Research and Quality (Rockville, Maryland, USA), the NIS contains discharge information from a stratified random sample of 20% of all hospitals in 37 participating states (1). This publicly available, deidentified dataset was exempt for review by the Johns Hopkins Institutional Review Board.

Inclusion and Exclusion Criteria

Inclusion criteria included patients 65 years of age and older with a meningioma (International Classification of Diseases, 9th revision diagnosis codes 225.2, 192.1, and 237.6 for meningiomas of benign, malignant, and uncertain behavior) who underwent a surgical resection, as identified by International Classification of Diseases, 9th revision procedural codes (01.51 and 01.59) for resection.

Characteristics of Interest and Outcome Variables

The primary independent variable was the Charlson comorbidity score. The Charlson score is a well-validated, weighted patient comorbidity index that was recorded from the NIS database as a value between 0 and 15. It provides a score accounting for various comorbidities, including history of cancer, as well as cardiac, vascular, pulmonary, neurological, endocrine, renal, hepatic, gastrointestinal, and immune disorders (**Table 1**) (10). Other covariates included patient age, tumor grade, sex, race/ethnicity, and elective status of the procedure. Age was analyzed as a continuous variable for all patients 65 years of age or older. Tumor grade was analyzed in multivariate regressions as a binary covariate, either benign or malignant. Sex was a binary covariate, either male or female. Race/ethnicity was categorized as white, African American, Hispanic, Asian, or Native American. Elective procedure status was analyzed as a binary covariate.

The primary outcome was inpatient death. Secondary outcomes included total hospital charges (adjusted to 2008 inflation), total hospital length of stay (LOS), and postoperative complications, including neurological deficits, stroke, respiratory complications, and cardiac complications.

Statistical Analysis

Univariate analysis included a descriptive account of the patient population, including mean and median values to describe continuous variables and proportions to describe categorical variables. Multivariate logistic and linear regression models were constructed to analyze binary and continuous outcomes, respectively. Multivariate analyses were adjusted for Charlson comorbidity score, patient age, tumor grade, sex, race/ethnicity, and elective status. P values less than 0.05 were considered to be statistically significant. All data were analyzed by use of the software package STATA/MP 10 (College Station, Texas, USA).

RESULTS

Univariate Analysis

A total of 5717 patients were identified; among these, we found a slight female predominance (66.6%). Most patients (93.1%) had benign or low-grade (World Health Organization grade I), meningiomas. Mean age was 73.6 years (median, 73 years), and most patients were white (81.8%). Patients had a mean Charlson score of 0.99 (median, 0). Most (67.4%) patients underwent elective surgical procedures. Mean length of stay was 9.1 days (median, 6 days). Patients had mean total hospital charges of $62,983 (median, $44,669). Overall inpatient mortality was 3.2%. Postoperative complications include new neurological deficits (5.7%), stroke (5.3%), respiratory complications (4.8%), and cardiac complications (1.7%) (**Table 2**).

Factors Associated with Inpatient Death

In multiple logistic regression models adjusted for patient age, tumor grade, sex, race/ethnicity, Charlson comorbidity score, and elective procedure status, only Charlson score, patient age, and elective status of the procedure were significantly associated with greater odds of death. Each one-point increase in Charlson score was associated with 18% increased odds of inpatient death (odds ratio [OR] 1.18, $P = 0.001$), and each 1-year increase in patient age beyond 65 years of age was associated with 9% greater likelihood of inpatient death (OR 1.09, $P < 0.001$). Elective procedure status (OR 0.51, $P < 0.001$) was the only factor associated with significantly decreased odds of inpatient death. Patient sex, tumor grade, and race/ethnicity were not associated with greater odds of inpatient death (**Table 3**).

Factors Associated with Inpatient Complications

In multiple logistic regression models adjusted for patient age, tumor grade, sex, race/ethnicity, Charlson comorbidity score, and elective procedure status, the only factor consistently associated with greater odds of developing all major complications such as new neurological deficits, stroke, respiratory complications, and cardiac complications was Charlson comorbidity score. Each one-point increase in Charlson comorbidity score was associated with between a 20% and 35% greater odds of developing an inpatient complication ($P < 0.001$).

Although each 1-year increase in patient age greater than 65 years trended toward a significant relationship with all four complications, such trends between patient age and complications only reached statistical significance for new neurological deficits (OR 1.03, $P = 0.008$) and respiratory complications (OR 1.03, $P = 0.004$). Similarly, although the presence of higher grade meningioma (vs World Health Organization