The Geriatric Scoring System (GSS) for Risk Stratification in Meningioma Patients as a Predictor of Outcome in Patients Treated with Radiosurgery

Or Cohen-Inbar[1], Cheng-chia Lee[2,3], David Schlesinger[1], Zhiyuan Xu[1], Jason P. Sheehan[1]

■ INTRODUCTION: **Meningiomas are the most common primary benign brain tumor. Radiosurgery (primary or adjuvant) allows excellent local control. The Geriatric Scoring System (GSS) for preoperative risk stratification and outcome prediction of patients with meningiomas has been reported previously. The GSS incorporates 8 tumor and patient parameters on admission. A GSS score greater than 16 was reported previously to be associated with a more favorable outcome. We assessed the validity of the GSS score and its influence on outcome in patients treated with Gamma-Knife radiosurgery (GKRS).**

■ PATIENTS AND METHODS: **Patients treated with single-session GKRS for World Health Organization grade I meningioma during 1989–2013 at the University of Virginia were reviewed. The cohort comprised 323 patients, 50.2% ($n = 162$) male. Median age was 56 years (29–84 years), and median follow-up was 53.6 months (6–235 months). Median tumor volume was 4.5 cm^3 (0.2–23). Median margin and maximal doses were 15 Gy (8–36) and 32.3 Gy (20–65), respectively.**

■ RESULTS: **Tumor volume control was achieved in 87% ($n = 281$), and post-GKRS clinical neurologic improvement was reported in 66.3% ($n = 214$). The median change in KPS was +10 (range −30 to +40). The most common complication was intermittent headaches (34.1%, n = 110) and cranial nerve deficits (14.2%, $n = 46$). The GSS (calculated and grouped as GSS > 16 and GSS ≤ 16) was found to correlate with different post-GKRS functional status ($P < 0.0001$) and tumor control ($P = 0.028$).**

■ CONCLUSION: **The GSS, used for risk stratification and outcome prediction in patients with meningiomas, seems valid for patients undergoing single-session GRKS. A GSS score greater than 16 is associated with a better long-term functional status and tumor control.**

INTRODUCTION

Meningiomas are the most common primary benign brain tumor and account for approximately 12%–20% of all primary intracranial tumors.[1] The risk of developing meningioma increases with age, dramatically so after the age of 65 years.[1] Surgical resection traditionally has been referred to as the primary treatment option. Despite a dramatic decrease in surgical morbidity for meningiomas reported during the last 2 decades, a complete resection while preserving neurologic function is not always feasible. Incomplete resection can lead to lower local rates of control and increased risk of tumor progression or recurrence.[2,3] Patients harboring an incompletely resected meningioma often require multiple treatments, leading to increased morbidity and even mortality.[2-4]

In patients with meningioma who are treated with resection, the use of the Geriatric Scoring System (GSS) for preoperative risk stratification and outcome prediction has been reported (Table 1).[5,6] The GSS incorporates 8 independent tumor- and patient-related parameters on admission, each assigned a value ranging from 1 to 3 points. Tumor size and location, peritumoral edema, neurologic deficits, and Karnofsky Performance Status (KPS),[7] as well as patient's diabetes, hypertension, or the presence of lung disease and medical control thereof comprise the GSS. Seven different surgical and functional outcome parameters were tested via use of the scoring system. A GSS score greater than 16 was reported previously to be associated with a significantly more favorable outcome in patients undergoing a resection.[5,6]

Key words
- Gamma knife
- GSS score
- Meningioma
- Outcome prediction

Abbreviations and Acronyms
GKRS: Gamma-Knife radiosurgery
GSS: Geriatric Scoring System
KPS: Karnofsky Performance Status
SRS: Stereotactic radiosurgery
WHO: World Health Organization

From the [1]Department of Neurological Surgery, University of Virginia, Charlottesville, Virginia, USA; [2]Neurological Institute, Taipei Veteran General Hospital, Taipei, Taiwan; and [3]National Yang-Ming University, Taipei, Taiwan

To whom correspondence should be addressed: Or Cohen-Inbar, M.D., Ph.D. [E-mail: oc2f@virginia.edu]

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Table 1. The Geriatric Scoring System

Parameter	1 Point	2 Points	3 Points
Size*	>5 cm (>62.5 cm^3)	3–5 cm (13.5–62.5 cm^3)	<3 cm (<13.5 cm^3)
Neurologic deficit	Progressive	Stable severe	None, minor
KPS	≤50	60–80	90–100
Location	Falcine, parasagittal, foramen magnum	Tentorial, Posterior fossa Jugular foramen	Convexity, intraventricular, sphenoid wing, tuberculum sellae, cavernous sinus, optic nerve
Peritumoral edema	Severe	Mild	None
Diabetes mellitus	Not controlled	Medically controlled	None
Hypertension	Not controlled	Medically controlled	None
Pulmonary disease	Severe	Mild	None

KPS, Karnofsky Performance Status.
*Size expressed in maximal diameter in centimeters and converted to volume equivalent.

Stereotactic radiosurgery (SRS) is a well-established approach in the primary or adjuvant management of inaccessible, recurrent, or incompletely resected benign meningiomas and also for large, inoperable lesions close to critical structures.[8,9] The safety and efficacy of SRS have been demonstrated in the control of benign tumors, particularly for small-to-moderately sized meningiomas. For World Health Organization (WHO) grade I meningiomas, the 5- and 10-year actuarial tumor control rates after SRS are 91% and 88%, respectively.[10-13]

To date, there has been no predictive score for SRS outcomes of patients with meningioma that incorporates both clinical- and tumor-related parameters. In the present study, we reviewed data of adult patients (of all ages) harboring meningiomas treated with single-session Gamma Knife radiosurgery (GKRS) in an attempt to assess the validity of the GSS score and its influence on different outcome parameters.

PATIENTS AND METHODS

Patient Population

This is a retrospective analysis of a prospectively maintained database approved by the University of Virginia institutional review board. The database was assessed from 1989 to 2013 for adult patients with WHO grade I meningiomas treated with a single-session GKRS at the University of Virginia (n = 323). Patients harboring more than a single meningioma, who had a history of cancer, a neurofibromatosis-II or other genetic predisposition, as well as meningioma grades WHO II and WHO III were excluded. A minimum of 6 months' follow-up was defined for inclusion. The diagnosis was confirmed either by tissue pathology or characteristic findings for meningiomas on neuroimaging studies. Tumors typically exhibited radiologic features of a meningioma, including dural base, extra-axial location, uniform contrast enhancement, and intratumoral calcification.

The specific patient and tumor attributes as well as the pre-GKRS GSS score are detailed in Tables 2 and 3. A total of 323 patients were included in the cohort, 50.2% male (n = 162). Median age was 56 years (range, 29–84 years), and median pre-GKRS KPS was 80 (range, 40–100). At the time of GKRS, a progressive neurologic deficit was noted in 16.7% (n = 54), a stable severe deficit was noted in 28.5% (n = 92), whereas minor or no neurologic deficit was noted in 54.8% (n = 177). Patient's medical diseases and control level were logged as well. Poorly controlled diabetes mellitus was noted in 6.8% (n = 22), poorly controlled hypertension was noted in 14.9% (n = 48) and severe pulmonary disease was noted in 1.5% (n = 5) patients. The majority of lesions (34%, n = 110) involved the convexity and some aspect of the skull base; 6.5% (n = 21) of lesions involved several skull base territories. The most common single location in this cohort was parasagittal (13%, n = 42), followed by cerebellopontine angle (11.1%, n = 36), falx (9.6%, n = 31), clivus (8.4%, n = 27), tentorial (6.5%, n = 21), and petroclival (5.6%, n = 18).

Patient underwent a median of 1 previous open surgery for the meningioma (range, 0–7) before GKRS, with 43.3% (n = 140) having had no previous surgery. A total of 43% (n = 139) of patients underwent previous embolization for the meningioma (as a preoperative procedure, not as a pre-SRS procedure). Tumor resection grade (using the Simpson grading system) was defined as complete extensive (Simpson = 1) in 4.3% (n = 14), complete with dural coagulation (Simpson = 2) in 27.9% (n = 90), gross total resection (Simpson = 3) in 7.7% (n = 25), and subtotal resection or debulking (Simpson 4+5) in 16.7% (n = 54). The median tumor volume at the time of GKRS was 4.5 cm^3 (range, 0.2–23). Venous sinus occlusion or invasion by the tumor as noted on neuroimaging studies was noted in 6.8% (n = 22) of cases. A total of 55.7% (n = 180) presented with no peritumoral vasogenic edema on imaging; 30.7% (n = 99) presented with a mild peritumoral vasogenic edema, whereas 13.6% (n = 44) presented with a severe peritumoral vasogenic edema. For further details, refer to Tables 2 and 3.

Patient and Tumor Attributes

Demographic, medical, and clinical patient's parameters at different time points were logged. Detailed clinical and radiologic presentations as well as outcome parameters were recorded. Neurologic deficit was defined as progressive if a clear history of worsening could be elicited, as severe if it was debilitating and resulted in a reduction in the patient's functional status (assessed by the KPS), and minor if it caused subjective or minimal discomfort, without affecting the patient's functional status.

Radiosurgical Technique

The details of GKRS procedures performed at our center have been reported previously.[14,15] The Leksell Gamma Knife Unit Model U (Elekta Instrument AB, Stockholm, Sweden) was used from May 1989 to July 2001, and the Model C was used from July 2001 to September 2006. The Gamma Knife Perfexion model (Elekta Instrument AB) was used after September 2006. Kula software (Kula, Honolulu, Hawaii, USA) was used for dose planning until June 1994, and then it was replaced with Leksell Gamma Plan software (Elekta Instrument AB). Radiosurgical parameters and dose plans were formulated by the treating neurosurgeon in consultation with a medical physicist and a radiation oncologist.