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

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Introduction

Meningiomas are the most common primary benign brain tumor. Radiosurgery (primary or adjuvant) allows excellent local control. The Geriatric scoring system (GSS) for pre-operative risk stratification and outcome prediction of patients with meningiomas has been previously reported. The GSS incorporates eight tumor and patient parameters on admission. A GSS score higher than 16 was previously reported 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.

Table 1. The Geriatric Scoring System

Parameter	1 Point	2 Points	3 Points
Size*	>5 cm (>62.5 cm³)	3~5 cm (13.5~62.5 cm³)	<3 cm (<13.5 cm³)
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.

Patient GSS score distribution

Methods

Patients treated with single session GKRS for WHO-1 meningioma during 1989-2013 at the University of Virginia were reviewed. A cohort of 323 patients, 50.2% (n=162) males. Median age was 56 (29-84), and median follow-up was 53.6 (6-235) months. Median tumor volume was 4.5 cm3 (0.2-23). Median margin and maximal doses were 15 Gy (8-36) and 32.3 Gy (20-65), respectively.

Table 2. Patient Demographics and Treatment Data

Parameter	Value
Male sex	50.2% (n = 162)
Age (years) at the time of GKRS	56 (ranges, 29–84)
Median KPS at the time of GKRS	80 (range, 40—100)
Tumor volume at time of GKRS (median)	4.5 cm³ (range, 0.2—23)
Tumor location	
Convexity, overlap*	34% (n = 110)
Skull base, overlap†	6.5% (n = 21)
Parasagittal	13% (n = 42)
If changed elsewhere to "Cerebellopontine", consider changing also here. angle	11.1% (n = 36)
Falx	9.6% (n = 31)
Clivus	8.4% (n = 27)
Tentorial	6.5% (n = 21)
Petroclival	5.6% (n = 18)
Petrous	1.9% (n = 6)
Petroclinoid	1.9% (n = 6)
Clinoid	1.2% (n = 4)
Foramen magnum	0.3% (n = 1)
Venous structures invasion	6.8% (n = 22)
Number of previous surgeries	
Median	1 (range, 0—7)
0	43.3% (n = 140)
1	45.2% (n = 146) — 183
2	9% (n = 29)
≥3	2.5% (n = 8)
Tumor resection (Simpson) grade	
1	4.3% (n = 14)
2	27.9% (n = 90) — 183
3	7.7% (n = 25)
4	13.6% (n = 44)
5	3.1% (n = 10)
Previous embolization	43% (n = 139)
Median margin dose, Gy	15 (range, 8—36)
Median maximal dose, Gy	32.3 (range, 20—65)
Median isodose line, %	45% (range, 28—80)
Median no. isocenters	7 (range, 1—27)
Median maximum edema index	4 (range, 0.08—18.95)
AREs	10.2% (n = 33)
Median time to peak AREs, months	12 (range, 6—48)

GKRS, Gamma-Knife radiosurgery; KPS, Karnofsky Performance Status; CP, cerebellopontine; AREs, adverse radiation effects.
*The term overlap refers to lesion predominantly located in the convexity extending in some aspect to other territories, such as the parasagittal/falx or tentorial locations.
†The term overlap refers to lesions located in the skull base spanning more than a single location.
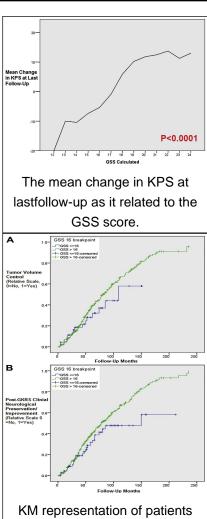
Results

Tumor volume control was achieved in 87% (n=281), and post-GKRS clinical neurological improvement 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).

Table 3. Admission Parameters Grouped based on the GSS Score

Tumor location	
Falcine/parasagittal/foramen magnum	24.8% (n = 80)
Tentorial/posterior fossa/jugular foramen	38.4% (n = 124)
Convexity/intraventricular/sphenoid wing/ tuberculum sellae/cavernous sinus/optic nerve	36.8% (n = 119)
KPS at the time of GKRS	
≤50	1.2% (n = 4)
60—80	33.4% (n = 108)
90—100	65.3% (n = 211)
Diabetes mellitus	
None	83% (n = 268)
Controlled	10.2% (n = 33)
Not controlled	6.8% (n = 22)
Hypertension	
None	73.4% (n = 237)
Controlled	11.8% (n = 38)
Not controlled	14.9% (n = 48)
Pulmonary disease	
None	92.3% (n = 298)
Mild	6.2% (n = 20)
Severe	1.5% (n = 5)
Neurologic deficit	
Progressive	16.7% (n = 54)
Stable severe	28.5% (n = 92)
None/minor	54.8% (n = 177)
Peritumoral edema	
None	55.7% (n = 180)
Mild	30.7% (n = 99)
Severe	13.6% (n = 44)

GSS, Geriatric Scoring System; KPS, Karnofsky Performance Status; GKRS, Gamma-Knife radiosurgery.

Conclusions

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

Table 5. Outcome Parameters Analysis: Multivariate Regression

	Outcome Parameters		
Admission Parameters	Post-GKRS Clinical Neurologic Preservation or Improvement	Post-GKRS Change in KPS at Last Follow-Up	Tumor Volume Control
GSS > 16 (grouped)	<0.0001	<0.0001	0.028
Maximum recorded edema index	0.08	0.77	
Margin dose, Gy	0.79	0.58	0.30
Simpson grade	0.43	0.69	0.16
Tumor location	0.88	0.7	
Pre-GKRS tumor volume	0.98	0.78	0.90

GKRS, Gamma-Knife radiosurgery; GSS, Geriatric Scoring System.

Table 4. Outcome Parameters

Parameter	Value
CN deficits (all causes)	14.2% (n = 46)
Post-GKRS craniotomy attributable to tumor growth	5.3% (n = 17)
GKRS-induced complications	
Intermittent headaches	34.1% (n = 110)
Cranial deficit	12.4% (n = 40)
Dizziness	9% (n = 29)
Weakness	4% (n = 13)
Encephalopathy	2.2% (n = 7)
New or worsening seizures	0.9% (n = 3)
Pain	0.9% (n = 3)
GKRS-induced CN deficit	
Trigeminal (CN-V)	8% (n = 26)
Vestibulocochlear (CN-VIII)	5% (n = 16)
Optic (CN-II)	3.7% (n = 12)
Facial (CN-VII)	3.4% (n = 11)
Hypoglossal	0.9% (n = 3)
Abducens (CN-VI)	0.6% (n = 2)
Oculomotor (CN-III)	0.6% (n = 2)
Vagus (CN-X)	0.6% (n = 2)
Post-GKRS clinical neurologic preservation or improvement	66.3% (n = 214)
Tumor control	87% (n = 281)
Patient died of unrelated causes	5.6% (n = 18)
Patient alive	81.4% (n = 263)
Tumor progression	13% (n = 42)
Median change in KPS last follow-up	+10 (range, −30 to +40)
KPS at last follow-up	
Median	90 (range, 40-100)
≤50	5.3% (n = 17)
60—80	22.9% (n = 74)
≥80	71.8% (n = 232)
Follow-up, median, range	53.6 (6—235) months

CN, cranial nerve; GKRS, Gamma-Knife radiosurgery; KPS, Karnofsky Performance Status.

The mean change in KPS at lastfollow-up as it related to the GSS score.

KM representation of patients according to the GSS at the time of Gamma-Knife radiosurgery shows the strong influence of GSS>16 on overall post-GKRS neurologic preservation or improvemention last follow-up (A) as well as on tumor volume control (B)