Gamma surgery for intracranial metastases from renal cell carcinoma

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Object. The goal of this study was to evaluate the effectiveness and limitations of gamma surgery (GS) in the treatment of renal cell carcinoma that has metastasized to the brain.

Methods. The authors performed a retrospective analysis of a consecutive series of 21 patients with 37 metastatic brain deposits from renal cell carcinoma who were treated with GS at the University of Virginia from 1990 to 1999.

Clinical data were available in all patients. No patient died of progression of intracranial disease or deteriorated neurologically following GS. Eight patients clinically improved. Follow-up imaging studies were available for 23 tumors in 12 patients. Nine patients did not undergo follow-up imaging. One patient lived 17 months and succumbed to systemic disease; no brain imaging was performed in this case. Another patient refused further imaging and lived 7 months. Seven patients lived up to 4 months after the procedure; however, their physicians did not require these patients to undergo follow-up imaging examinations because of their general conditions—all had systemic progression of disease. Of the 23 tumors that were observed posttreatment, one remained unchanged in volume, 16 decreased in volume, and six disappeared. No tumor progressed at any time, and there were no radiation-induced changes on follow-up imaging an average of 21 months after GS (range 3–63 months).

Conclusions. Gamma surgery provides an alternative to surgical resection of metastatic brain deposits from renal cell carcinoma. Neurological side effects were seen in only one case; freedom from progression of disease was achieved in all cases.

Key Words • brain neoplasm • gamma knife • metastasis • radiosurgery • renal cell carcinoma

Brain metastases from systemic malignancies are a significant cause of morbidity and mortality. The most common form of treatment is fractionated radiation therapy, which is dependent on the radiosensitivity of the tumor type for its efficacy. In large series of patients in whom brain metastases of various histological types were treated with radiation therapy alone since 1975, the median survival time among 5396 patients was 16.5 weeks.1–3,7,8,10,12,25 Surgical excision adds significant improvement in outcomes over the use of radiation therapy alone. However, surgery is limited to reasonably healthy patients with accessible tumors. In several series in which surgery was performed in the treatment of cerebral metastases, the median length of survival among 447 patients was 39.8 weeks, with an average operative mortality rate of 7%.6,16,21,22

Renal cell carcinomas are responsible for approximately 2% of cancer deaths in the United States annually, and they have an 11% incidence of developing into brain metastases.18 Within the United States, this represents approximately 1100 patients per year with renal cell carcinoma metastases to the brain. The combination of resistance to fractionated radiation therapy and a tendency for a single metastasis or few metastases is the rationale for the use of single high-dose management with GS in the management of renal cell carcinoma metastases to the brain.

The purpose of this study is to review the results of a single center at which renal cell carcinoma metastases to the brain are treated by GS, and to compare these results with those of published series in which microsurgery and GS have been used in the treatment of this disease.

Clinical Material and Methods

Patient Population

All renal cell carcinoma patients with metastatic deposits in the brain who were treated with GKS at the University of Virginia and were observed for at least 3 months were included in this study. Patients were treated between 1990 to 1999. Clinical follow-up data are available in all
21 patients and follow-up imaging studies are available in 12 (Table 1). Of the 21 patients, there were 14 men and seven women. The average age of the patients at the time of the initial GS was 61 years (range 41–85 years). The average KPS score at the time of the initial GS was 60 (range 30–90). One patient was treated twice and another patient was treated four times for different tumors. Four patients presented with ataxia, six with a paresis, three with new-onset seizures, two with changes in mental status, and one each with diplopia and visual field defect. Four patients had asymptomatic tumors that were discovered during screening.

The 21 patients harbored 37 metastatic deposits in the brain that were all treated with GS. The average tumor volume was 4.4 cm$^3$ (range 0.1–51 cm$^3$) at the time of surgery. No tumor was treated more than once.

**Treatment Parameters**

The mean maximum radiation dose delivered to a tumor was 51.8 Gy (range 21–76.7 Gy). The mean peripheral (minimum) dose was 20 Gy (range 10.5–40 Gy). The average number of isocenters used per patient was 2.1 (range one–eight). Gamma surgery was performed using the Leksell gamma unit (model U; Elekta, Instruments, Inc., Norcross, GA). The source output for the unit during the study period was between 329.7 and 161.0 cGy/minute for those patients treated before 1996 and between 340.5 and 239.6 cGy/minute for those treated after $^{60}$Co reloading, which took place in October 1995.

**Evaluation of Treatment**

We have developed software at the University of Virginia that allows estimation of tumor volume on the basis of MR and CT imaging performed without a stereotactic frame. The program is used to evaluate the area of interest on each slice, as drawn by the observer, using polygonal estimation techniques.$^{20}$ The area in each slice is multiplied by the slice thickness and integrated over the relevant slices. On evaluation the margin of error of this method is ± 7% for lesions smaller than 1 cm$^3$ and ± 2% for volumes larger than 1 cm$^3$. Changes in volume were rounded off to the nearest tenth.

**Results**

**Illustrative Cases**

**Case 12.** This 85-year-old man presented with complaints of diplopia and dizziness 3 years after he had undergone a right-sided radical nephrectomy with gross-total removal of a renal cell carcinoma. Gamma surgery was performed on the single metastatic lesion found in his left insula. Figure 1 demonstrates the regression of the tumor over a 29-month period. The patient is alive and well 36 months following GS, but still complains of dizziness while playing golf.

**Case 8.** This 55-year-old man presented with changes in his mental status. Imaging evaluation revealed a tumor in the pineal region, which extended to the thalamus and rostral midbrain. A stereotactic biopsy procedure secured the diagnosis of metastatic renal cell carcinoma. Subsequently, a right-sided nephrectomy was performed with gross-total resection of the primary tumor. The patient was treated for his metastasis with GS 2 months following the nephrectomy. At the time, the patient was bedridden with a KPS score of 30 and the tumor measured 21 cm$^3$ (Fig. 2A). There was a marked reduction in tumor volume during the following 13 months and the final examination demonstrated no tumor (Fig. 2C). Control imaging performed after this patient’s first GS revealed three new lesions located in the right frontal lobe, right temporal lobe, and the region of the left trigone. These three tumors were treated with GS 4 months after the initial procedure. At that time, the patient’s KPS score had improved to 80. Two of the lesions disappeared and one shrank 40% during the next 14 months. Neurologically intact, the patient died of systemic disease 19 months after his initial GS.

**Imaging Outcome**

In 12 patients follow-up images were available for 23 tumors. Of the remaining nine patients, one lived for 17 months and died of systemic disease; this patient did not undergo any follow-up imaging examinations. Another patient lived 7 months and died of systemic progression; he had refused to undergo follow-up MR imaging. The
<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>KPS Score</th>
<th>Presenting Symptom</th>
<th>Other Treatment</th>
<th>Extracranial Dz</th>
<th>Interval (mos)</th>
<th>No. of Met</th>
<th>Volume (cm³)</th>
<th>Dose (Gy) Max/Min</th>
<th>No. of Isocenters</th>
<th>Clinical Response</th>
<th>Decrease in Tumor Size on Imaging</th>
<th>Patient Outcome</th>
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<tbody>
<tr>
<td>1</td>
<td>62, M</td>
<td>30</td>
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<td>nephrectomy</td>
<td>yes</td>
<td>17</td>
<td>4.8</td>
<td>1</td>
<td>50/25</td>
<td>4</td>
<td>unknown</td>
<td>4</td>
<td>unknown</td>
<td>died of SD at 3 mos</td>
</tr>
<tr>
<td>2</td>
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<td>80</td>
<td>hemiparesis</td>
<td>nephrectomy</td>
<td>no</td>
<td>3</td>
<td>51</td>
<td>3</td>
<td>40/12</td>
<td>4</td>
<td>unchanged</td>
<td>2</td>
<td>29% at 10 mos</td>
<td>died of SD at 12 mos</td>
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<td>40</td>
<td>hemiparesis</td>
<td>nephrectomy</td>
<td>yes</td>
<td>53</td>
<td>4.4</td>
<td>1</td>
<td>51/4/18</td>
<td>4</td>
<td>unchanged</td>
<td>2</td>
<td>NA</td>
<td>died of SD at 6 mos, KPS score 90</td>
</tr>
<tr>
<td>4</td>
<td>41, M</td>
<td>90</td>
<td>ataxia</td>
<td>nephrectomy, craniotomy</td>
<td>yes</td>
<td>19</td>
<td>1.1, 0.8, 0.8</td>
<td>3</td>
<td>48.9/22, 47.7/22</td>
<td>1</td>
<td>1</td>
<td>10% at 3 mos, 25% at 3 mos</td>
<td>died of SD at 4 mos</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>50, M</td>
<td>70</td>
<td>LUE mono-paresis</td>
<td>nephrectomy, 40-Gy WBRT</td>
<td>no</td>
<td>2</td>
<td>5.1, 1.2, 1.2</td>
<td>3</td>
<td>60/18, 60/18, 60/61</td>
<td>2</td>
<td>1</td>
<td>NA</td>
<td>died of SD at 48 mos</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>68, M</td>
<td>70</td>
<td>ataxia</td>
<td>nephrectomy, 40-Gy WBRT</td>
<td>yes</td>
<td>75</td>
<td>0.6, 1.5</td>
<td>2</td>
<td>32/16, 21/10.5</td>
<td>3</td>
<td>1</td>
<td>unchanged</td>
<td>NA</td>
<td>died of SD at 19 mos</td>
</tr>
<tr>
<td>7</td>
<td>66, M</td>
<td>70</td>
<td>none</td>
<td>none</td>
<td>yes</td>
<td>—</td>
<td>2.1</td>
<td>1</td>
<td>46/23</td>
<td>1</td>
<td>unchanged</td>
<td>2</td>
<td>95% at 18 mos, 42% at 14 mos, 100% at 14 mos, 100% at 14 mos</td>
<td>died of SD at 4 mos</td>
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<tr>
<td>8</td>
<td>55, M</td>
<td>30†</td>
<td>decreased MS</td>
<td>pineal met Bx, nephrectomy</td>
<td>no</td>
<td>2</td>
<td>21, 2.6, 0.5, 0.1</td>
<td>3</td>
<td>34/11, 51/18, 57/20, 57/20</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>NA</td>
<td>died of SD at 27 mos</td>
</tr>
<tr>
<td>9</td>
<td>56, F</td>
<td>90</td>
<td>incidental finding on post-craniotomy imaging seizure</td>
<td>nephrectomy, craniotomy, whipple, partial nephrectomy</td>
<td>yes</td>
<td>116</td>
<td>0.2, 0.8</td>
<td>2</td>
<td>60/18, 60/18</td>
<td>1</td>
<td>unchanged</td>
<td>50% at 6 mos, 50% at 6 mos</td>
<td>died of SD at 9 mos</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>80, M</td>
<td>80</td>
<td>hemiparesis</td>
<td>nephrectomy</td>
<td>yes</td>
<td>110</td>
<td>0.5, 1.7</td>
<td>2</td>
<td>40/20, 46/23</td>
<td>2</td>
<td>seizure free</td>
<td>60% at 9 mos, 71% at 9 mos</td>
<td>alive at 12 mos, KPS score 80</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>56, F</td>
<td>70</td>
<td>hemiparesis</td>
<td>nephrectomy</td>
<td>yes</td>
<td>22</td>
<td>1.2, 3.9, 0.7</td>
<td>6</td>
<td>60/18, 60/18, 60/61</td>
<td>2</td>
<td>2</td>
<td>unchanged</td>
<td>NA</td>
<td>died of SD at 4 mos</td>
</tr>
<tr>
<td>12</td>
<td>85, M</td>
<td>80</td>
<td>diplopia (resolved pre-Tx), dizziness</td>
<td>nephrectomy, 30-Gy WBRT</td>
<td>no</td>
<td>40</td>
<td>1.3</td>
<td>1</td>
<td>67/20</td>
<td>3</td>
<td>unchanged</td>
<td>69% at 28 mos</td>
<td>alive at 36 mos, KPS score 80</td>
<td></td>
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<tr>
<td>13</td>
<td>72, F</td>
<td>70</td>
<td>rt hemiparesis</td>
<td>nephrectomy</td>
<td>yes</td>
<td>36</td>
<td>0.9, 0.1</td>
<td>2</td>
<td>60/30, 50/40</td>
<td>2</td>
<td>unknown</td>
<td>unknown</td>
<td>NA</td>
<td>died of SD at 7 mos</td>
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<tr>
<td>14</td>
<td>49, F</td>
<td>70</td>
<td>visual field deficit</td>
<td>54-Gy regional RT, chemotherapy</td>
<td>yes</td>
<td>31</td>
<td>5.0</td>
<td>5</td>
<td>34/17</td>
<td>8</td>
<td>unknown</td>
<td>unknown</td>
<td>NA</td>
<td>died of SD at 17 mos</td>
</tr>
<tr>
<td>15</td>
<td>54, M</td>
<td>90</td>
<td>none (met w/u)</td>
<td>nephrectomy</td>
<td>yes</td>
<td>—</td>
<td>1.0</td>
<td>1</td>
<td>76/7/23</td>
<td>2</td>
<td>unchanged</td>
<td>50% at 3 mos, 100% at 23 mos, 100% at 18 mos (new adjacent Dz, 0.4 cm³), 100% at 11 mos, 100% at 4 mos</td>
<td>died of SD at 6 mos, KPS score 80</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>67, M</td>
<td>80</td>
<td>ataxia</td>
<td>chemotherapy</td>
<td>yes</td>
<td>17</td>
<td>10, 20, 9.9, 4.2</td>
<td>1</td>
<td>60/24, 60/18, 60/61, 66/23</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>unchanged</td>
<td>KPS score 80</td>
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<tr>
<td>17</td>
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<td>90</td>
<td>seizure</td>
<td>nephrectomy</td>
<td>no</td>
<td>44</td>
<td>1.7</td>
<td>1</td>
<td>48/21.6</td>
<td>3</td>
<td>seizure free</td>
<td>unknown</td>
<td>94% at 63 mos</td>
<td>alive at 64 mos, KPS score 90</td>
</tr>
<tr>
<td>18</td>
<td>59, F</td>
<td>30</td>
<td>aphasia, confusion</td>
<td>20-Gy RT to primary tumor</td>
<td>yes</td>
<td>—</td>
<td>2.5</td>
<td>1</td>
<td>67/22</td>
<td>2</td>
<td>unchanged</td>
<td>NA</td>
<td>NA</td>
<td>died of SD at 2 mos</td>
</tr>
<tr>
<td>19</td>
<td>63, F</td>
<td>70</td>
<td>ataxia</td>
<td>nephrectomy, subtotal brainstem met resection</td>
<td>yes</td>
<td>48</td>
<td>4.6</td>
<td>1</td>
<td>40/20</td>
<td>1</td>
<td>gait improved &amp; then worsened w/ progression unchanged</td>
<td>32% at 15 mos</td>
<td>died of SD at 41 mos</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>48, F</td>
<td>70</td>
<td>none (met w/u)</td>
<td>nephrectomy</td>
<td>yes</td>
<td>21</td>
<td>4.4</td>
<td>1</td>
<td>36/18</td>
<td>2</td>
<td>seizure free</td>
<td>NA</td>
<td>25% at 3 mos</td>
<td>died of SD at 3 mos</td>
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<tr>
<td>21</td>
<td>56, M</td>
<td>90</td>
<td>seizure</td>
<td>nephrectomy</td>
<td>yes</td>
<td>24</td>
<td>10.6</td>
<td>2</td>
<td>45/18</td>
<td>2</td>
<td>seizure free</td>
<td>NA</td>
<td>25% at 3 mos</td>
<td>died of SD at 3 mos, KPS score 90</td>
</tr>
</tbody>
</table>

* Bx = biopsy; Dz = disease; LUE = left upper extremity; max = maximum; met = metastases; met w/u = incidental finding during metastasis workup; min = minimum; MS = mental status; NA = not available; RT = radiation therapy; SD = systemic disease;Tx = treatment; — = not applicable.
† Interval from nephrectomy to GS.
‡ At first GS.
§ At second GS.
¶ At third GS.
** At fourth GS.
seven other patients all died within 4 months after treatment; despite requests for follow-up MR imaging examinations, none were performed by the referring physicians because of the general conditions of the patients, all of whom had systemic progression of disease.

Six tumors in two patients disappeared completely within an average follow-up period of 14 months. Sixteen tumors decreased in volume an average of 52% (range 10–95%) within an average follow-up period of 14.5 months (range 3–63 months). One tumor was unchanged in volume at 27 months. No tumor increased in volume post-GS. There were no radiation-induced changes in surrounding brain observed on follow-up imaging in any case.

During 208 total months of radiographic follow up in 12 patients, six new tumors were identified. All new tumors were treated with GS and all responded to treatment.

Neurological Outcome

No clinical complications were associated with any GS. Eight patients experienced improvement in symptoms associated with the treated tumors. Five patients displayed no symptoms from their brain metastases at the time of GS and did not worsen. Four experienced no improvement in their symptoms, but only one of these patients lived longer than 4 months. No clinical data except cause of death could be obtained in three patients who died of systemic disease 3, 7, and 17 months after GS.

Length of Patient Survival

Survival data are available for all patients. Six patients are still alive at an average of 29 months after their first GS (range 3–64 months). One patient has been treated four times and the other patients have been treated once. These patients harbored an average of two tumors. The KPS scores in the survivors were 80 or greater at the time of GS and did not worsen. Four experienced no improvement in their symptoms, but only one of these patients lived longer than 4 months. No clinical data except cause of death could be obtained in three patients who died of systemic disease 3, 7, and 17 months after GS.

The 13 patients with active extracranial disease at the time of their initial GS lived 4 months and that for the seven patients without extracranial disease was 19 months. The median length of survival for the 16 patients with a KPS score 70 or greater was 11 months; that for the five patients with a KPS score less than 70 was 3 months.

Discussion

Radiation Therapy

Renal cell carcinoma that has metastasized to the brain is relatively radioresistant, and outcomes after fractionated radiation therapy are poor. Subjective improvement following radiation therapy alone has been reported by several authors, but no objective benefit has been noted. Among 119 patients reported by Wróński, et al., the average length of survival after WBRT was 4.4 months and the median survival time was 3.3 months. Notably, 78% of these patients died of progression of their brain disease. Median survival periods following radiation therapy alone reported by other authors ranged from 2 to 4 months. Maor, et al., concluded that for renal cell carcinoma that has metastasized to the brain, WBRT was neither curative nor palliative. Nieder and associates, concluded that standard palliative WBRT led to unsatisfactory results in these patients. According to these authors, stereotactic radiotherapy and surgery seem to be superior, but are not always available and/or indicated. Therefore, they propose that use of higher total doses of radiation should be investigated for patients in whom the extent of local disease makes WBRT the treatment of choice. Gamma knife radiosurgery allows the delivery of higher focal doses of radiation.

Some authors have speculated that the addition of WBRT in conjunction with definitive treatment for individual lesions may prevent recurrent disease; however, data to support this are lacking. The incidence of new seeding of existing brain deposits within the brain following microsurgery or GS is not reduced by WBRT. Although Mori and colleagues and Schöggel and associates contend that the addition of WBRT may decrease the incidence of progression of CNS disease post-GS, we fail to see the justification for this argument because, in our patients, we have observed no progression of disease.
whereas they did observe it in three of 96 tumors. In addition, radiographic evidence of radiation-induced injury was found in five patients, all of whom had received WBRT in addition to GS. Following definitive treatment of renal cell carcinoma that has metastasized to the brain, long-term survival (> 5 years) is possible. Unless there is a reasonable benefit to the addition of WBRT to definitive treatments, the risk of long-term complications associated with this therapy should be considered carefully before it is used.

**Microsurgical Treatment**

Wróński and coworkers reviewed the results of microsurgical management in 50 cases of renal cell carcinoma metastases and found a median survival time of 12.6 months. Five patients died within 30 days after surgery; at least two of these deaths were directly attributable to the operation. Fourteen other patients (28%) had significant operative complications. Progression of CNS disease occurred in nine cases (18%) and new lesions appeared in 13 cases (26%). Radiation therapy seemed to offer no protection against tumor recurrence. Among patients who received WBRT after surgical extirpation of the tumor, relapse (local or distant) occurred in 48%. Among patients who did not receive WBRT postoperatively, relapse occurred in 38%.

Other authors have reported extended survival times in patients who underwent surgical extirpation of renal cell carcinoma metastases compared with those who underwent fractionated radiation therapy or medical therapy. In the study by Salvati and coworkers, among 29 patients who had a solitary metastasis and a good clinical status, the median survival time was longer than 2 years. Neurological progression of the disease was the cause of death in 28% of these cases.

Indications for surgical extirpation of renal cell carcinoma metastases to the brain are the need for definitive tissue diagnosis and significant mass effect and associated hemorrhage. Surgery requires that the lesion be accessible and that the patient be reasonably medically stable. Results obtained with microsurgery are superior both to the natural history of the disease and to treatment with fractionated radiation alone. However, the local recurrence rate and the procedure-related morbidity and mortality rates are higher than those associated with GS.

**Gamma Surgery**

There have been two other reports on the use of GS in the treatment of renal cell carcinoma that has metastasized to the brain. The results of these studies, as well as those of our own, are presented in Table 2.

Gamma surgery is effective in controlling individual metastatic deposits of renal cell carcinoma in the brain. Of the 79 patients treated for this disease at three centers, only two died of progression of a lesion treated with GS. Progression of CNS disease was seen in only 5% of treated tumors. Among five instances of radiation-associated changes related to treatment, which appeared on follow-up imaging, there was only one clinical complication. Three percent of patients died of progression of a treated tumor, and 4% died of intracranial disease overall.

A comparison of major indicators of outcome among microsurgery, radiation therapy, and GS are given in Table 3. Despite obvious flaws in comparing published retrospective data, there are several salient points that arise. The most remarkable finding in this comparison is the near absence of deaths from progression of brain disease in patients treated with GS (4%), compared with microsurgery (42%) or radiation therapy (78%). In the three series of patients treated with GS, 17 (68%) of 25 patients in whom new metastases or local recurrences developed were retreated with GS. In the microsurgery series only nine (41%) of 22 patients underwent reoperation; in none of these cases were the metastatic lesions new. The presence of new inoperable tumors or clinical deterioration, which would make patients poor candidates for a major

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**TABLE 2**

Comparison of three studies in which GS was used to treat renal cell carcinoma metastases

<table>
<thead>
<tr>
<th>Authors &amp; Year (Location of Center)</th>
<th>No. of Patients</th>
<th>No. of Tumors</th>
<th>Total No.</th>
<th>Unchanged (%)</th>
<th>Decreased or Disappeared (%)</th>
<th>Total</th>
<th>W/O ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mori, et al., 1998 (Pittsburgh, PA)</td>
<td>35</td>
<td>52</td>
<td>39</td>
<td>26</td>
<td>65</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Šchojgl, et al., 1998 (Vienna, Austria)</td>
<td>23</td>
<td>44</td>
<td>33</td>
<td>0</td>
<td>97†</td>
<td>3†</td>
<td>0</td>
</tr>
<tr>
<td>Present study (Charlottesville, VA)</td>
<td>21</td>
<td>36</td>
<td>23</td>
<td>4</td>
<td>96</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>132</td>
<td>105</td>
<td>11</td>
<td>75</td>
<td>5</td>
<td>3‡</td>
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</table>

* Among patients in whom follow-up imaging was available. Abbreviation: ASD = active SD.
† At 12 weeks.
‡ Two of 58 patients who died.

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**TABLE 3**

Comparison of results of published microsurgery, radiation therapy, and GS series

<table>
<thead>
<tr>
<th>Type of Treatment</th>
<th>No. of Patients</th>
<th>Median Survival (mos)</th>
<th>Deaths Due to Treatment (%)</th>
<th>Neurological Disease (%)</th>
<th>Deaths From Neurological Disease (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsurgery</td>
<td>50</td>
<td>12.6</td>
<td>10</td>
<td>18</td>
<td>42</td>
</tr>
<tr>
<td>Radiation therapy</td>
<td>119</td>
<td>4.4</td>
<td>0</td>
<td>NA</td>
<td>78</td>
</tr>
<tr>
<td>GS‡</td>
<td>79</td>
<td>10.0</td>
<td>0</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

* Data obtained from Wróński, et al., 1996.
† Data obtained from Wróński, et al., 1997.
‡ Data obtained from Mori, et al., 1998; Šchojgl, et al., 1998; and the present series.
Gamma surgery for renal cell carcinoma metastases

intracranial procedure, could explain at least part of the deaths related to brain disease in the microsurgical series. Although no conclusions can be based on the findings in Table 3, they still reveal a trend that is noteworthy.

Conclusions regarding the usefulness of GS in the treatment of patients with poor KPS scores are difficult to assess. In our series, three of the five patients with KPS scores less than 70 and four of the seven patients with KPS scores of 70 before treatment represent all seven patients who succumbed to their illness before the first follow-up MR image could be obtained. However, one patient with a KPS score of 30 and two with a KPS score of 70 had extended survival. Although the KPS is a general guide to prognosis, there may be a place for aggressive treatment of patients with poor KPS scores, if their systemic disease can be controlled. The benefit of treating patients with high KPS scores is clearly demonstrated.

Conclusions

Gamma surgery offers the neurosurgeon the opportunity to use focused ionizing beam energy as a substitute for the open surgical method. In the specific case of renal cell carcinoma metastases, GS provides an effective way to use ionizing beams in these otherwise radioresistant tumors. We have reviewed the series in the literature and presented our experience as an attestation of this fact. The complication and local treatment failure rates remain low. The subject of new seeding is open to study. Whether there is logic in using WBRT in patients with a type of tumor known to be radioresistant requires more data to defend or disprove. The gamma knife can supplement or replace the open surgical method. In the specific case of renal cell carcinoma, the benefits of gamma surgery are evident.

References


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