Large peritumoral and intratumoral cysts in the central nervous system are often associated with severe neurological symptoms due to their mass effect.\textsuperscript{1,10} Resection of tumor and tumor-associated cysts may provide rapid symptom relief and sometimes cure the disease.\textsuperscript{1,10} Resection is not always appropriate, however, if the lesion is located in a deep or critical area. In addition, resection is not a safe choice for patients with severe systemic diseases or advanced age, because their physical condition may be poor and not suitable for general anesthesia.\textsuperscript{3,16} For these patients, a multimodal treatment approach may be employed for the alleviation of clinical symptoms and the control of tumor growth.\textsuperscript{13}

Image-guided stereotactic aspiration of tumor-associated cysts is a minimally invasive procedure performed to relieve mass effect.\textsuperscript{4–6} With the aid of modern imaging techniques and improved surgical instruments, the stereotactic aspiration needle can safely reach most locations in the brain.

Gamma Knife surgery is an important therapeutic procedure used to treat intracranial lesions.\textsuperscript{9} It directs conformal radiation to the intracranial target in a single session. Large lesions are treated with a decreased prescription dose to avoid radiation-associated complications. An insufficient total dose, however, leads to an unsatisfactory outcome with respect to tumor control. Following aspiration of tumor-associated cysts, the volume of the tumor may be significantly reduced. This makes GKS safer and more effective in controlling tumor growth.

**Clinical article**

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**Object.** The goal of this study was to evaluate the efficacy and safety of same-day stereotactic aspiration and Gamma knife surgery (GKS) for cystic intracranial tumors.

**Methods.** Between 1996 and 2007, 77 patients harboring cystic intracranial tumors underwent a same-day procedure of MRI-guided cyst aspiration followed by GKS. The diagnoses were metastatic tumor in 43 patients, glial tumor in 12 patients, vestibular schwannoma in 10 patients, craniopharyngioma in 9 patients, and hemangioblastoma in 3 patients.

**Results.** An improvement in symptoms was achieved in 68 patients (88.3%) immediately after cyst aspiration. The mean tumor volume in this group of patients was 25.1 cm\textsuperscript{3} before aspiration and 11.1 cm\textsuperscript{3} afterward. Hemorrhage during the course of aspiration was encountered in 1 patient. Transient nausea after cyst aspiration developed in 3 patients. There was no treatment-related hematoma, seizure, neurological deficit, or infection. The median follow-up period was 16 months (range 6–108 months). Tumor control was achieved in 50 (80.6%) of 62 patients who participated in follow-up for at least 6 months.

**Conclusions.** The same-day stereotactic aspiration and GKS procedure was safe in patients with cystic brain tumors. Prompt symptom relief was obtained after cyst aspiration. The decrease in tumor volume following aspiration made GKS more effective because a higher prescription dose could be administered with a lower possibility of radiation-induced side effects. (http://thejns.org/doi/abs/10.3171/2012.7.GKS121019)

**KEY WORDS**

- Gamma Knife surgery
- stereotactic radiosurgery
- cystic tumor
- stereotaxy
- aspiration

*Abbreviation used in this paper: GKS = Gamma Knife surgery.\textsuperscript{8} Drs. Xiaomin Liu and Qi Yu contributed equally to this work.
more effective. In the present study we analyzed 77 cases of tumor-associated cysts treated with same-day stereotactic aspiration and GKS to evaluate the efficacy and safeness of this combined treatment modality.

**Methods**

Between 1996 and 2007, 77 patients with imaging-defined cystic brain tumors were treated using same-day stereotactic cyst aspiration and GKS at the Gamma Knife Center, Department of Neurosurgery, Second Hospital of Tianjin Medical University. The patient group consisted of 41 male and 36 female patients with a median age of 49 years (range 22–75 years). The diagnoses in this group were metastatic tumor in 43 patients, vestibular schwannoma in 10 patients, craniopharyngioma in 9 patients, and hemangioblastoma in 3 patients (Table 1). Thirty-nine patients had undergone at least one prior open resection. Eight patients had received chemotherapy at an earlier time. Presenting symptoms at the time of treatment included headache, nausea and vomiting, hemiparesis, visual deterioration, and diplopia. Informed consent was obtained from each patient.

On the morning of the treatment day, the patients’ scalps were shaved. A local scalp anesthetic agent and a mild sedative was administered to each patient before a Leksell model G stereotactic head frame (Elekta AB) was affixed to the head. High-resolution MRI with contrast enhancement was performed after frame application. A series of T1-weighted axial images (2- to 3-mm thick slices) with no slice interval was obtained and transferred to the workstation. Leksell SurgiPlan was used for cyst volume calculation and trajectory planning.

Cyst aspiration was performed carefully after twist-drill craniotomy and catheter placement. Following stereotactic aspiration, the patients underwent an additional MRI study in which the same sequences and slice thickness were used. Tumor volume and radiation dose were calculated using Leksell Gamma Plan software (versions 3.0–5.31). Gamma Knife surgery was performed using the Leksell Gamma Knife model B and model C. The mean tumor margin dose was 17 Gy (range 12–20 Gy).

In patients harboring more than 1 metastatic tumor, other noncystic lesions were also treated by GKS. After treatment the head frame was removed and patients were kept in the hospital for at least 3 days.

Approval for this study was obtained from the Second Hospital of Tianjin Medical University ethics board. For patients with malignant intracranial tumors MRI and clinical evaluations were scheduled at 3-month intervals after GKS; for patients with benign tumors, 6-month intervals were used for follow-up. Fifteen patients who were lost to follow-up or participated in follow-up less than 6 months were excluded from the assessment of tumor control. The evaluation of tumor control was made only for cystic tumors treated by stereotactic aspiration before GKS. The mean duration of follow-up was 16 months (range 6–108 months).

**Results**

The mean tumor volume in this patient group was 25.1 cm³ before aspiration and 11.1 cm³ afterward. An immediate improvement in symptoms was achieved in 68 patients (88.3%) following cyst aspiration. A small amount of bleeding was encountered in 1 patient at the end of cyst aspiration. In that case blood was allowed to drain out of the catheter until it stopped spontaneously within 1 minute. A CT scan obtained in this patient after the aspiration procedure revealed no hematoma in the cyst. Three patients experienced transient new symptoms of nausea after aspiration, but these resolved within several hours (Table 2). There was no treatment-related hematoma, seizure, neurological deficit, or infection.

The median follow-up period was 16 months (range 6–108 months) in the 62 patients who participated in follow-up for at least 6 months. Follow-up MRI in 5 patients showed disappearance of the cystic tumor, which in these instances was a metastatic lesion. Decreases in tumor size were found in 38 patients, and stable tumor sizes were found in 7 patients during the follow-up period. Tumor progression was observed in 12 patients after GKS. Nine patients underwent later resection and 2 patients underwent repeated GKS. One patient received external beam radiotherapy (Table 3). Fourteen patients eventually required repeated aspiration and Ommaya reservoir placement.

**Discussion**

The underlying mechanism of tumor-associated cyst formation in the central nervous system remains unknown. Tumor degeneration, blood-brain barrier disruption...
Stereotactic aspiration and radiosurgery for cystic brain tumors

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>median follow-up in mos (range)</td>
<td>16 (6–108)</td>
</tr>
<tr>
<td>tumor control—no. of patients (%)</td>
<td>50 (80.6)</td>
</tr>
<tr>
<td>total</td>
<td>5 (8.1)</td>
</tr>
<tr>
<td>disappearance</td>
<td>38 (61.3)</td>
</tr>
<tr>
<td>decreased size</td>
<td>7 (11.3)</td>
</tr>
<tr>
<td>stable size</td>
<td>12 (19.4)</td>
</tr>
<tr>
<td>tumor progression—total no. of patients (%)</td>
<td>14 (22.6)</td>
</tr>
</tbody>
</table>

Stereotactic cyst aspiration is rarely associated with the risk of hemorrhage, neurological deficits, seizures, or infection. Successful stereotactic cyst aspiration depends on appropriate patient selection and correct imaging interpretation. In particular, the determination of trajectory is the most important consideration before the procedure. Small hemorrages are always self-limited; in most situations one only needs to allow the blood to drain out of the catheter. It is also important to calculate cyst volume carefully before aspiration and not to be too radical in suctioning.

Conclusions

The same-day combined stereotactic aspiration and GKS procedure was safe in patients with cystic brain tumors. Prompt symptom relief was achieved after cyst aspiration. The decrease in tumor volume made the following GKS more effective because a higher prescription dose could be administered with a lower possibility of radiation-induced side effects.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Xu. Acquisition of data: X Liu, Yu, Z Zhang, Y Zhang, Li, D Liu, Jia, Zheng. Analysis and interpretation of data: X Liu, Yu, Zheng. Drafting the article: X Liu, Yu. Reviewed submitted version of manuscript: Xu. Approved the final version of the manuscript on behalf of all authors: Xu. Administrative/technical/material support: Z Zhang, Y Zhang, Li, D Liu, Jia. Study supervision: Xu.

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