Outpatient brain tumor surgery: innovation in surgical neurooncology

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Object. Recent studies of conventional craniotomies and image-guided biopsies have afforded a solid characterization of surgical morbidity and the timing of its occurrence. This report outlines a novel 11-year experience with outpatient image-guided biopsy and outpatient craniotomy for supratentorial intraxial brain tumors.

Methods. During the period between August 1996 and May 2007, 117 awake image-guided biopsies and 145 elective craniotomies for tumor resection were prospectively selected to be performed as outpatient procedures. Data were recorded for each patient regarding tumor histological type, reasons for admission if planned early discharge failed, and surgical complications.

Results. Successful discharge from the Day Surgery Unit was possible in 109 (93%) of 117 biopsy cases and 136 (94%) of 145 craniotomy cases (only 2 of which [1.5%] required unplanned readmission after discharge). Neurological worsening occurred in 5.1% of the patients who underwent image-guided biopsies, and in 5.5% of those who underwent outpatient craniotomies (based on intent-to-treat group analysis). No patient suffered an adverse event with alteration in outcome because of planned outpatient discharge.

Conclusions. Outpatient image-guided brain biopsy and outpatient craniotomy for tumor resection are safe and effective procedures in selected patients. (DOI: 10.3171/JNS/2008/108/4/0649)

KEY WORDS • ambulatory outpatient surgery • brain biopsy • brain tumor • craniotomy • resection

Abbreviations used in this paper: CT = computed tomography; ICU = intensive care unit.
tential complications of the procedure, and informed consent was obtained. Because many questions arise outside of the initial visit, the patients were provided with an information pamphlet and contact information for the neuro-oncology nurse practitioner. The surgeon was available for additional office visits as required.

**Outpatient Image-Guided Biopsy**

All consecutive cases in which ambulatory patients required an image-guided biopsy for treatment of an intraxial brain lesion between August 1996 and May 2007 were prospectively studied in this report. Patients who underwent outpatient image-guided procedures for other purposes (for example, Ommaya reservoir insertion) are not included.

On the day of surgery, patients arrived at the Day Surgery Unit and underwent brain imaging after the application of the image-guided base ring and localizer under local anesthesia. Details of this procedure are outlined in an earlier publication. More recently the StealthStation image-guidance system (Medtronic) was employed for image-guided localization using similar biopsy techniques as with the frame-based method. A twist drill was used to enter the cranium and the biopsy was performed using a side-cutting Sedan needle. Typically, a single core of tissue was obtained and submitted to an experienced neuropathologist for frozen section and smear for confirmation of lesional tissue and for permanent analysis.

After surgery the patient was transferred to the Post Anesthetic Care Unit for observation for 2 hours. Postoperative CT scan was performed 2 hours postoperatively. Once deemed medically fit, the patient was transported to the Day Surgery Unit for an additional 2 hours of observation. Final assessment by the neurosurgeon was performed 4 hours after surgery. Patients and their loved ones were given explicit instructions to return to the emergency room if the patient experienced any clinical deterioration (that is, decreased level of consciousness, weakness, or seizures). All patients were given a postoperative appointment for 1 week at the neurosurgeon’s office, at which final histopathological findings were reviewed and scheduling of subsequent treatments and visits arranged.

**Outpatient Craniotomy**

Patients requiring awake image-guided craniotomy for the treatment of supratentorial intraxial tumors between November 1996 and May 2007 were selected for outpatient craniotomy using the selection criteria outlined earlier in this paper. Patients were similarly admittied to the Day Surgery Unit on the day of their surgery at 6:00 a.m. and underwent magnetic resonance imaging for the Stealth frameless navigation system before being transported to the operating room. Use of arterial lines, urinary catheters, and central venous lines was not routine and was, in fact, extremely rare. Nasal prongs for oxygen administration were placed along with standard leads for electrocardiographic monitoring, pulse oximeter to measure oxygen saturation, and an automatic blood pressure cuff. The patient was then positioned as desired (lateral decubitus, supine, or sitting position) and his or her head was fixed in the Sugita headrest (Mizuho Medical Co.) after administration of pin-site local anesthesia (2% xylocaine injection). The frameless navigation system was then registered. Prophylactic antibiotics and steroids were administered but neither mannitol nor prophylactic antiepileptic medications were routinely used.

Once the scalp flap had been localized, the desired area was infiltrated with 0.25% bupivacaine as a regional field block. Sterile draping of the surgical area was placed such that the anesthesiologist had free access to the patient’s face and arms. A microphone was placed near the patient’s mouth to facilitate communication with the surgeon. During the opening and closing of the craniotomy, short-acting sedative agents, such as propofol, midazolam, and fentanyl were titrated to patient comfort.

Standard craniotomy and tumor localization was performed with use of the frameless navigation system as needed. With the cortical surface exposed, the patient participated in cortical mapping of language, sensory, and motor modalities. The corticotomy was made in electrically silent regions and standard microneurosurgical resection of the tumor was undertaken.

After 4 hours of observation in the Post Anesthetic Care Unit, a routine CT scan was performed and the patient returned to the Day Surgery Unit for further observation. Around 6:00 p.m. the neurosurgeon assessed the patient for discharge and provided appropriate prescriptions and information pamphlets. The patient was discharged home a minimum of 6 hours after surgery with clear instructions to return if new signs or symptoms developed. Routine follow-up was similar to that of the patients who underwent biopsy procedures.

**Results**

Admission status during the study period (1996–2007) for patients undergoing image-guided biopsy and craniotomy for tumor resection is depicted in Fig. 1.

**Outpatient Image-Guided Biopsy**

During the period between August 1996 and May 2007, 241 awake image-guided biopsies were performed. Of these 241 biopsies, 117 (49%) were selected prospectively to undergo the procedure as an outpatient. Of the 117 patients selected as outpatients, 109 (93%) were successfully discharged from the Day Surgery Unit. Seven of the 8 unscheduled inpatient conversions were decided at the time of afternoon assessment, and only 1 of the 8 inpatient conversions occurred in a patient discharged from the hospital. Table 1 lists the reasons for inpatient conversion. Despite the isolated next-day admission for headache, no patient who was discharged as an outpatient image-guided biopsy patient suffered an adverse event related to their early hospital departure.

Complications of image-guided biopsy occurred in 11 (9.4%) of the 117 patients (Table 2). Hemorrhage occurred in 6 patients (5.1%). One person died of a massive subarachnoid hemorrhage from a seemingly uncomplicated biopsy for glioblastoma multiforme. Only one major neurological worsening occurred because of a hemorrhage: brisk intraoperative bleeding developed following a needle biopsy of a deep dominant temporal glioblastoma, necessitating total tumor resection for hemostasis. Hemiplegia and apha...
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sia resulted, with modest recovery prior to the patient’s transfer for rehabilitation. Histopathological diagnoses for all biopsies is shown in Fig. 2.

Outpatient Craniotomy

During the period between November 1996 and May 2007, 789 craniotomies were performed for supratentorial intraxial tumor, 503 in awake patients and 286 after induction of general anesthesia. Of the 789 patients, 145 (18% of the overall group but 29% of the awake craniotomy group) were prospectively selected for outpatient craniotomy. The vast majority of outpatient craniotomies (95%) were performed awake; 7 patients underwent the procedure after induction of general anesthesia. Successful discharge from the Day Surgery Unit was possible in 136 of the 145 cases (94%). Figure 3 illustrates a representative case.

Reasons for inpatient admission are outlined in Table 1. Seven of the 9 inpatient conversions were determined in the Post Anesthetic Care Unit or in the Day Surgery Unit. Two admissions occurred in delayed fashion; one occurred later the same evening because of headache and the other occurred when the patient presented to another hospital with a seizure 18 hours postoperatively. Thus only 1.4% of patients in the outpatient craniotomy protocol required unplanned readmission. In spite of the inpatient conversions and the readmissions, no patient suffered an adverse event with alteration in their outcome because of planned outpatient discharge.

Complications of tumor resection via craniotomy are listed in Table 2. No mortality or major neurological morbidity occurred, and new or worsened motor deficits typically consisted of a slightly weaker extremity. Histopathological diagnoses for all tumor resections are represented in Fig. 2.

Discussion

The greatest obstacle to outpatient brain surgery is the perception that a significant fraction of patients are at risk for delayed neurological deterioration following an invasive procedure such as image-guided brain biopsy or craniotomy.31 The fact that postoperative neurological deterioration occurs with any frequency is thought to necessitate inpatient admission with close observation. Image-guided brain biopsy and craniotomy for tumor resection are commonly performed procedures in the management of gliomas and metastatic brain tumors, and thus their complications are well characterized.2,7,12,16,17,22,24–26,30,31 Based upon the literature and our almost 11-year experience, we propose that image-guided brain biopsy and craniotomy for tumor resection are safe for outpatient consideration.

Safety of Image-Guided Biopsy and Craniotomy

Image-guided brain biopsy is still associated with combined morbidity and mortality rates of 1.2–6.3%,2,7,8,17,22,26 and craniotomy carries a 2.9–19.7% risk of neurological impairment.12,16 Common complications include perilesional edema and seizures, but it is intracranial hemorrhage that contributes the greatest risk.

Routine post-biopsy CT not infrequently demonstrates clinically silent hemorrhage, with the authors of one study reporting an incidence of almost 54%.22 Large hematomas that produce neurological deterioration are much less frequent and require close observation in hospital and often

TABLE 1

<table>
<thead>
<tr>
<th>Procedure &amp; Reason for Conversion</th>
<th>No. of Patients (%)</th>
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<tbody>
<tr>
<td>biopsy (117 patients)</td>
<td></td>
</tr>
<tr>
<td>hemorrhage w/ worsened deficit</td>
<td>3 (2.6)</td>
</tr>
<tr>
<td>progressive deficit w/out hemorrhage</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>headache</td>
<td>2 (1.7)</td>
</tr>
<tr>
<td>expedition of neurooncology referral</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>abscess</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>total</td>
<td>8 (6.8)</td>
</tr>
<tr>
<td>craniotomy (145 patients)</td>
<td></td>
</tr>
<tr>
<td>familial anxiety</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td>headache</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td>seizures</td>
<td>3 (2.1)</td>
</tr>
<tr>
<td>hemiparesis</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>air embolus</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>total</td>
<td>9 (6.2)</td>
</tr>
</tbody>
</table>
surgical evacuation. Fortunately, the timing of hematoma occurrence is quite predictable. Clinical events are almost always evident by 4 hours after the biopsy procedure. In one series of 300 stereotactic biopsies, only 3 patients developed clinically significant hematomas > 4 hours postoperatively, and none presented in a catastrophic manner.7 An additional study demonstrated that postoperative hematomas present either within 6 hours or beyond 24 hours, and the authors concluded that discharge from an ICU environment to the ward would be safe if the patient was neurologically stable at 6 hours.30 A clinically significant hematoma developed in only 1 (0.3%) of the 288 patients who underwent image-guided biopsies in that study; whereas there were 29 clinically significant hematomas in the 1427 patients who underwent elective craniotomy (2%).30 Longer observation times beyond 6 hours did not provide any additional benefit in detecting postoperative he-

![Graph showing histopathological diagnoses expressed as percentages of total cases (y-axis) for outpatient image-guided biopsy (black bar) and craniotomy (white bar).](image)

**Fig. 2.** Graph showing histopathological diagnoses expressed as percentages of total cases (y-axis) for outpatient image-guided biopsy (black bar) and craniotomy (white bar).

![Axial images obtained in a 38-year-old woman with headaches and nausea. Left: Gadolinium enhanced T1-weighted preoperative magnetic resonance image demonstrating a large heterogeneous lesion in the right parietal region. Right: Unenhanced CT scan acquired 4 hours after resection. The patient remained well and was discharged home 2 hours after the CT. The final histopathological finding was anaplastic ependymoma.](image)

**Fig. 3.** Axial images obtained in a 38-year-old woman with headaches and nausea. Left: Gadolinium enhanced T1-weighted preoperative magnetic resonance image demonstrating a large heterogeneous lesion in the right parietal region. Right: Unenhanced CT scan acquired 4 hours after resection. The patient remained well and was discharged home 2 hours after the CT. The final histopathological finding was anaplastic ependymoma.
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TABLE 2
Complications associated with biopsy and craniotomy

<table>
<thead>
<tr>
<th>Procedure &amp; Complication</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>biopsy (117 patients)</td>
<td></td>
</tr>
<tr>
<td>hemorrhage, death</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>hemorrhage, worsened deficit</td>
<td>2 (1.7)</td>
</tr>
<tr>
<td>hemorrhage, no deficit</td>
<td>3 (2.6)</td>
</tr>
<tr>
<td>worsened neurological deficit</td>
<td>3 (2.6)</td>
</tr>
<tr>
<td>failed penetration of lesion</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>equipment failure</td>
<td>1 (0.9)</td>
</tr>
<tr>
<td>total</td>
<td>11 (9.4)</td>
</tr>
<tr>
<td>craniotomy (145 patients)</td>
<td></td>
</tr>
<tr>
<td>seizures</td>
<td>4 (2.8)</td>
</tr>
<tr>
<td>worsened motor deficit</td>
<td>6 (4.1)</td>
</tr>
<tr>
<td>dysphasia</td>
<td>2 (1.4)</td>
</tr>
<tr>
<td>hemorrhage</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>delayed wound healing</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>air embolus</td>
<td>1 (0.7)</td>
</tr>
<tr>
<td>total</td>
<td>15 (10.3)</td>
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</tbody>
</table>

matomas in another study of image-guided biopsy, and the authors advocated for the safety of early discharge from the hospital. The first series to demonstrate the safety of outpatient craniotomy was reported in 2001. In this pilot study of outpatient craniotomy for brain tumor resection, the protocol was successfully completed in 89% of cases, and no adverse outcomes occurred in those patients who were discharged home.

The results of a parallel study reported in 2002 demonstrated similar success and safety profiles for outpatient image-guided biopsy. Of 76 patients, almost 98% were discharged home, with none experiencing an adverse outcome because of outpatient status. A rising awareness among neurosurgeons about the possibility of early discharge prompted a survey of members of the American Association of Neurological Surgeons and the Congress of Neurological Surgeons about their practice of outpatient image-guided biopsy. Only 6% engaged in outpatient image-guided biopsy (up to 23 hours in hospital), whereas the majority were equally divided between ICU and ward inpatient admission. Both a retrospective and prospective study by the same group concluded that clinically significant hematomas presented in the first 2 hours after the procedure, and that CT should be reserved for those with known intraoperative hemorrhage or new postoperative neurological deficit. They further proposed that discharge home on the same day of surgery is both safe and reasonable for uncomplicated image-guided biopsy.

The current study shows the feasibility of biopsy and craniotomy on an outpatient basis. The admitted patients were identified either intraoperatively or during their recovery in the Day Surgery Unit. Importantly, no patient suffered an adverse event related to the unique aspect of outpatient discharge. These data suggest a reassessment of current attitudes that cranial procedures necessitate inpatient admission for the safety and benefit of the patient. We believe that an outpatient protocol is a reasonable option for cranial procedures with now-documented feasibility and an excellent safety profile.

In fact, many patient benefits can be derived from awake craniotomy and early discharge. The use of awake craniotomy shortens total operative time, does not require Foley catheter insertion, and minimizes the use of invasive central venous or intraarterial lines, while neurolept anesthesia obviates the risks associated with intubation and general anesthesia. Because the hospital stay is shortened to just a few hours, the chances for nosocomial infection, thromboembolism, and medical error are reduced. It may also diminish patients’ fear and anxiety about undergoing brain tumor surgery. Outpatient status also ensures that elective cases proceed independent of ICU and ward bed availability. Outpatient biopsy and craniotomy may also be psychologically attractive to patients and feasible for use at physician-owned outpatient surgical facilities.

Limitations of This Study

The present report is intended to communicate the senior author’s experience with outpatient cranial procedures over the last 11 years. Attempts were made to formalize inclusion criteria by exclusively selecting patients with intracranial supratentorial tumors. Despite prospective enrollment and complete follow-up, no attempts were made to formalize the evaluation of patient satisfaction. The absence of negative feedback from patients does not guarantee complete satisfaction. This aspect could be better ascertained through the use of validated satisfaction surveys. No limitations exist with regard to the assessment of safety, as all patients were available for follow-up and all complications were logged prospectively.

Applicability of outpatient brain tumor surgery may differ between various health care systems. Admission of a patient to a Canadian hospital, for example, results in expenditure of money from the hospital’s global budget, whereas in the American system it generates revenue for the hospital. This difference, combined with concerns about litigation (as outpatient brain tumor surgery is not considered standard practice), could limit the wide adoption of this procedure. These facts are not, however, written in stone, and fiscal and other circumstances should not stand in the way of surgical innovation when there are justifiable reasons for it.

Conclusions

Outpatient cranial procedures in the form of image-guided biopsy and image-guided awake craniotomy for tumor resection represent feasible treatment options. The procedures are well tolerated with good patient satisfaction and an excellent safety profile. Individual neurosurgeons’ well-established track record of complication rates will hopefully empower them to embrace innovative techniques like that described herein, possibly resulting in more widespread use of such techniques.

Disclaimer

Neither author has any financial interests or conflicts associated with this report.

References

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