Awake Craniotomy for Removal of Intracranial Tumor: Considerations for Early Discharge

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We retrospectively reviewed the anesthetic management, complications, and discharge time of 241 patients undergoing awake craniotomy for removal of intracranial tumor to determine the feasibility of early discharge. The results were analyzed by using univariate analysis of variance and multiple logistic regression. The median length of stay for inpatients was 4 days. Fifteen patients (6%) were discharged 6 h after surgery and 76 patients (31%) were discharged on the next day. Anesthesia was provided by using local infiltration supplemented with neurolept anesthesia consisting of midazolam, fentanyl, and propofol. There was no significant difference in the total amount of sedation required. Overall, anesthetic complications were minimal. One patient (0.4%) required conversion to general anesthesia and one patient developed a venous air embolus. Fifteen patients (6%) had self-limiting intraoperative seizures that were short-lived. Of the 16 patients scheduled for ambulatory surgery, there was one readmission and one unanticipated admission. It may be feasible to discharge patients on the same or the next day after awake craniotomy for removal of intracranial tumor. However, caution is advised and patient selection must be stringent with regards to the preoperative functional status of the patient, tumor depth, surrounding edema, patient support at home, and ease of access to hospital for readmission.

(Anesth Analg 2001;92:89–94)

Awake craniotomy using local anesthesia and monitored sedation for removal of intracranial tumor involving eloquent cortex is an accepted technique. It allows intraoperative mapping that facilitates radical tumor resection while minimizing morbidity by preserving functional tissue (1).

Traditionally, the technique of awake craniotomy was used for removal of epileptic foci and tumors involving functional cortex. Recently, awake craniotomy has been described as an approach for removal of all supratentorial tumors, regardless of the involvement of eloquent cortex. This technique had a small complication rate and resulted in a considerable reduction in resource use by minimizing intensive care time and total hospital stay without compromising patient care (2). Indeed, with improving anesthetic and surgical techniques, awake craniotomies are now being performed in our center as same day discharge 6 h after surgery or after one overnight stay. This maximizes the efficient use of resources and may reduce the potential for infection and increase patient satisfaction.

To evaluate the efficacy and safety of this procedure, we reviewed retrospectively the anesthetic management, complications, and discharge of such patients to determine the feasibility of same-day or 23-h discharge. Such studies of feasibility are necessary to expand the use of ambulatory surgery and to ensure patient safety. Statistical analysis was used to see if factors predictive of early discharge could be identified.

Methods

After obtaining IRB approval, we reviewed the hospital medical records of all patients who had an awake craniotomy for removal of intracranial tumor performed by a single surgeon (MB) at The Toronto Western Hospital, a tertiary referral center for neurosurgery, between December 1992 and February 1999. These included tumors involving both functional and nonfunctional cortex. Exclusion criteria for awake craniotomy at this center included the patient's inability to cooperate because of profound dysphasia and confusion. Also excluded were

Accepted for publication September 26, 2000.

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0003-2999/01

patients with low occipital tumors requiring prone positioning and patients with tumors involving significant dural invasion, which cause significant pain on resection. There were 247 patients. Sixteen patients were selected by the surgeon preoperatively as suitable for ambulatory surgery. They had a small anticipated complication rate, lived locally, had a safe home environment, and were interested in having their surgery as an ambulatory procedure. Exclusion criteria for same-day discharge included patients with a poor Karnofsky score, inadequate support at home, and deep tumors with extensive edema or midline shift. The remaining patients were admitted for surgery with the intention to stay as inpatients. Patient presentation, comorbid conditions, tumor location and histology, anesthetic technique, including drugs used and patient monitoring, perioperative complications, and time of discharge were recorded.

Patients were categorized as discharged on the same day, admitted for 23 h, or admitted for longer than 23 h. Twenty-three hours was used to signify those patients who stayed in hospital overnight and were discharged the next morning. Patient characteristics were compared among the three groups by using analysis of variance for continuous variables and χ^2 test for categorical variables. Multiple logistic regression with backward stepwise elimination procedure was used to identify independent predictors for a hospital stay of 23 h or shorter duration (i.e., patients with same day discharge and 23-h admission were combined in the multivariate analyses). Associations with $P < 0.05$ were considered as statistically significant. Odds ratios and 95% confidence intervals, along with the corresponding P values, were presented for the significant associations. All statistical analyses were performed by using SAS Version 6.12™ statistical software (SAS, Cary, NC).

Results

Two hundred and forty-one medical records were reviewed. The remaining six medical records were unavailable. Ninety-one patients (38%) were discharged home on the same or next day and 15 patients (6%) had their surgery performed successfully as an ambulatory procedure.

The patient's age, sex, ASA physical status, and body mass index were assessed along with their concurrent medical problems and their preoperative Karnofsky Performance Status (KPS) score (Table 1). The KPS score is a simple functional status scale used to categorize physical ability (3). Scores range from 0 to 100, in steps of 10, with a score of 100 meaning normal, no complaints, and no evidence of disease and a score of 0 signifying dead. There were 119 females and 112 males ranging in ages from 12 to 84 yr. Gliomas were found in 149 cases (62%), metastases were found in 77 cases (32%), and miscellaneous histology in the remaining 15 patients (6%). The miscellaneous histology included meningioma, abscess, infarct, cavernous malformation, radiation necrosis, cystercercosis, lymphoma and demyelination. The locations of the tumors are tabulated in Table 2. The patient's preoperative KPS score was found to be significantly lower in the inpatient group, as opposed to the ambulatory and one-night stay patients (Table 1). When analyzed by multiple logistic regression we found that a 10-unit decrease in preoperative KPS score was associated with an increased likelihood of a stay more than one night (odds ratio 2.37, 95% confidence interval 1.75–3.19). Age and preoperative ASA physical status were not found to be predictors of length of stay.

Routine monitoring used on all patients included noninvasive blood pressure, pulse oximetry, and an electrocardiogram. End-tidal CO_2 was monitored and supplemental oxygen was administered via nasal prongs. The aim of the capnography was to detect respiration rather than to accurately determine end-tidal CO_2. Only 8 (3%) patients had a Foley catheter. These were either inserted preoperatively inpatients with a small KPS score who required inpatient-nursing care or intraoperatively for patients whose operation was predicted to last more than 4 h. Four patients (1.6%) received mannitol, three of whom were not catheterized, without any adverse sequelae. Most patients did not receive mannitol, even with tumors with large mass effect and midline shift, if a good surgical decompression was anticipated. Arterial lines were inserted in 27 patients (11%). Brain swelling was never a problem, and thus the indication for insertion of an arterial line to measure and thus manipulate the carbon dioxide level was no longer relevant. Arterial lines were not inserted in the last 74 consecutive patients. A central venous catheter was used in four patients (11%) with no documented complications. Indications for central venous catheter insertion included expected large blood loss or the operation performed in the sitting position. Patients were positioned in the lateral (57%), supine (37%), sitting (4%), or semi-prone positions. No routine prophylactic antithrombotic therapy was administered perioperatively.

Anesthesia was provided by using local infiltration with 2% lidocaine for the insertion of the pins for rigid head fixation, when used, and 0.25% bupivacaine with epinephrine for the surgical incision. This was supplemented with sedation consisting of combinations of short-acting drugs, such as midazolam, propofol, fentanyl, or remifentanil, depending on the anesthetist's preference. Sedation was given in particular to lessen discomfort on infiltration of local anesthetic and during craniotomy opening and closure. All sedation was discontinued before brain mapping to ensure full patient cooperation in stimulation testing. The total

Table 1. Patient Characteristics

	Ambulatory (n = 15)	23-h stay (n = 76)	Inpatient (n = 150)	P value
Age (yr)	55 ± 15	50 ± 15	54 ± 16	
Gender (F/M)	10/5	37/39	72/78	
ASA physical status (II/III/IV)	9/6/0	52/23/0	93/56/1	
Body mass index	26 ± 5	26 ± 6	26 ± 4	
Preoperative KPS	85 ± 12	84 ± 11	72 ± 14*	0.0001

Results are expressed as mean ± SD.
KPS = Karnofsky Performance Status.
* $P < 0.05$ compared to other groups.

Table 2. Location of Tumor

	Frontal	Parietal	Temporal	Occipital
Right	39	60	12	2
Left	43	43	34	6

Results are expressed as number of patients.

amount of sedation given for each case was calculated and did not vary significantly according to length of operation (Table 3).

Of the 241 patients, there were 19 reports (8%) of focal seizures. These occurred during brain mapping, and were usually self-limiting. Three patients received 50 mg sodium thiopental. Only one patient (0.4%) had a generalized seizure, which resulted in loss of the airway and conversion to a general anesthetic. There was one case (0.4%) of intraoperative venous air embolism. This occurred at dural closure while the patient was in the sitting position and resolved with irrigation of the surgical field. There were two reported incidences of intraoperative vomiting, but there were no airway sequelae.

Postoperative care was given initially either in the intensive care unit (ICU), or the postanesthetic care unit (PACU). During the period reviewed, there was a change in practice. Initially, all patients were admitted to the ICU, but subsequently, only those patients that either had a premorbid medical condition or a postoperative neurological condition that necessitated close monitoring were admitted to the ICU. Once this change of practice was implemented only 14 (7%) of the 198 patients were admitted to the ICU. The remaining 184 patients (93%) were transferred directly to the PACU where they stayed for a minimum of 4 h before going to the ward. One patient, who was an alcoholic, deteriorated neurologically while in the PACU, and a computed tomographic scan revealed an intracranial hemorrhage. He was reoperated on immediately, this time under general anesthetic as a result of his decreasing Glasgow Coma Scale score. No patient deteriorated in the first 24 h after going back to the ward.

The mortality rate for the 241 patients was 0.8% for the first 30 postoperative days. One patient who was treated for a deep vein thrombosis postoperatively developed a fatal pulmonary embolus 24 days after surgery and the other had a massive bleed 4 days postoperatively.

The overall morbidity rate, which included neurological, systemic and regional complications, was 32%. The morbidity rate for ambulatory, 23-h stay and inpatient groups was 13%, 17%, and 41% respectively.

Neurological complications occurred mainly in the inpatient group (Table 4). In total, 39 patients (16%) sustained a neurological deficit, and of these patients, 26 (11%) sustained a transient deterioration in function and 13 patients (6%) had a permanent deficit at discharge.

Systemic complications included treated urinary tract infections, urinary retention requiring intermittent catheterization, urinary incontinence, deep vein thrombosis, pulmonary embolus, hyponatremia with a serum sodium <135 meq/L, nausea and vomiting, and drug reactions. Sixteen patients (7%) experienced episodes of moderate nausea and vomiting. Four patients (2%) had problems with either urinary retention requiring intermittent catheterization or problems with urinary incontinence. Urinary tract infections were diagnosed in two patients, neither of whom were catheterized. Four patients (2%) developed clinical evidence of deep vein thrombosis, whereas eight (4%) developed biochemical evidence of hyponatremia. This presented with drowsiness, nausea, seizure, and transient neurological deterioration secondary to edema.

Regional complications included postoperative seizures, hydrocephalus, hematoma in the surgical cavity or at the wound site, wound infection, and cerebrospinal fluid leak. Three patients (1%) developed a major postoperative hematoma. As mentioned above, one patient deteriorated in the PACU. Another patient was noted to have excessive intraoperative bleeding and required a computed tomographic scan postoperatively, which showed some intratumoral cavity blood. This patient was observed to deteriorate clinically on the third postoperative day, and therefore the clot was evacuated. The third patient was operated on for recurrence of glioma. Cerebrospinal fluid taken

Table 3. Patient Sedation

		Ambulatory (n = 15)	23-h stay (n = 76)	Inpatient (n = 150)	P value
Operating Room time (h)		2.5 ± 0.7	3.0 ± 0.7	3.4 ± 1.0*	0.007
Blood loss (mL)		70 ± 40	140 ± 80	210 ± 180*	0.025
Intravenous fluid (mL)		550 ± 310	620 ± 300	820 ± 500†	0.002
Midazolam	No. (%)	15 (100)	71 (93)	120 (80)	
	Dose (mg)	2.0 ± 1.5	2.0 ± 1.5	2.5 ± 2.0	0.19
Fentanyl	No. (%)	14 (93)	74 (97)	140 (93)	
	Dose (μg)	75 ± 20	120 ± 60	125 ± 75	0.39
Propofol	No. (%)	15 (100)	74 (97)	127 (85)	
	Dose (mg)	260 ± 350	420 ± 320	390 ± 290	0.22

Results are expressed as mean ± SD.
* $P < 0.05$ compared with other groups.
† $P < 0.05$ compared with 23-h stay group.

Table 4. Complications

	Ambulatory (n = 15)	23-h stay (n = 76)	Inpatient (n = 150)	P value
Intraoperative complications				
Focal seizure (%)	1 (6.7)	3 (3.9)	15 (10)	0.28
Conversion to general anesthetic	0	0	1	
Hypotension	0	0	2	
Venous air embolism	0	0	1	
Systemic complications				
Urinary incontinence/retention	0	0	4	0.46
Urinary tract infection	0	0	2	
Nausea and vomiting (%)	0	7 (9)	9 (6.0)	0.86
Hyponatremia	1	0	7	0.14
Pulmonary Embolus	0	0	1	
Deep Vein Thrombosis	0	0	4	
Regional complications				
Wound dehiscence	0	0	2	
Hematoma	0	0	3	
Neurological complications				
Transient deficit (%)	1 (6.7)	2 (2.6)	23 (16)*	0.01
Permanent deficit (%)	0	2 (2.6)	11 (7)	0.21
Any complication (%)[a]	1 (6.7)	13 (17)	62 (41)*	0.001

[a] Any patient may have more than one complication.
* $P < 0.05$ compared with other groups.

intraoperatively was positive for coagulase negative staphylococcus infection. The patient received a course of IV antibiotics, but had a fatal intracranial hemorrhage on the fourth postoperative day.

Of the sixteen patients scheduled for ambulatory surgery, one (6%) was readmitted after a seizure at home. This patient developed hyponatremia and a computed tomographic scan demonstrated mild postoperative edema. The unanticipated admission rate for ambulatory surgery was also 6%, after another patient was admitted overnight with nausea and headache. Of the 76 23-h stay patients, three (4%) were readmitted within 30 days of discharge. One patient developed an allergic reaction to phenytoin, another developed increasing hemiparesis secondary to edema, and the third patient developed a subdural hygroma that required a cystoventricular shunt. Two of the 150 inpatients (1%) were also readmitted within the same time span. One deteriorated neurologically and required reoperation for tumor recurrence and old hematoma. The other patient died of a pulmonary embolus, as previously mentioned.

The data were analyzed by multiple logistic regression to determine independent variables, which were predictive of early discharge. Factors analyzed and found to not be predictive were age, sex, ASA physical status, sedation given, blood loss, and complications such as neurological deficit, nausea and vomiting, seizures and urinary retention. The five factors found to be statistically significant independent predictors of early discharge were the preoperative KPS score, a histological diagnosis of glioma or metastases, the length of surgery, the amount of fluid infused intraoperatively, and the time to tolerate oral fluids after surgery (Table 5). The statistical analysis suggests that for every 10-unit increase in the KPS score, the patient

Table 5. Predictors of Early Discharge

	Odds ratio (95% CI)	*P* value
Pre KPS (per 10-unit score)	2.37 (1.75–3.19)	0.0001
Histology miscellaneous (versus Glioma or Metastases)	0.06 (0.01–0.51)	0.01
Length of surgery (h)	0.48 (0.31–0.76)	0.002
Fluid intravenous (per 100 mL)	0.84 (0.75–0.94)	0.003
Time to tolerate oral fluids (h)	0.90 (0.84–0.96)	0.001

CI = confidence interval; KPS = Karnofsky Performance Status.

is 2.4 times more likely to be discharged within the first 23 h. Similarly, if the histological diagnosis is other than glioma or metastatic, a patient is 94% less likely to be discharged early. For each hour increase in the length of surgery, there is a 10% decrease in the probability of being discharged early. For every 100 mL extra fluid given IV, the patient has a 16% less chance of early discharge. Finally, for every hour longer it takes the patient to tolerate oral fluids, the patient has a 10% less chance of early discharge.

Discussion

Ambulatory surgery now encompasses 70% of all elective surgery in North America (4). As this includes more complex procedures on higher-risk patients, it is increasingly important to evaluate patients' recovery after their discharge from hospital. Data on postdischarge recovery are crucial as an indicator for quality assurance.

Mortality and morbidity are generally infrequent in ambulatory patients because surgery is usually in low-risk patients for minor or intermediate procedures. Mortality ranges from 1:11,273 to 1:100,000, with the main causes being myocardial infarction, pulmonary embolus, respiratory failure, and cerebrovascular accident (5,6). In-hospital morbidity factors, such as unanticipated admission and delayed discharge, have been used as indicators of adverse outcome for ambulatory anesthesia (7,8). Unanticipated admission rates varied from 0.4% to 18% depending on the type of surgery (7). The most common reasons for admission were pain, excessive bleeding, and intractable vomiting (7,8). Postdischarge morbidity leading to readmission and the presence of postoperative symptoms have both been used as indicators of an adverse outcome (9). Readmission rates have been reported at 3.2% for microdiscectomy for lumbar disk prolapse (10). In this study, 85% of patients would, if necessary, have their operation again as an ambulatory case.

There is little in the literature concerning the morbidity and mortality of inpatients undergoing awake craniotomy for removal of intracranial tumor, and what studies there are have involved small patient numbers. Danks et al. (11) reported that 6 of 21 patients (28%) studied developed a postoperative complication other than a neurological deficit and two patients who were neurologically intact preoperatively sustained a neurological deficit. There was no mortality within the first postoperative month. Larger studies have been published on patients undergoing the same procedure under general anesthesia. In one study the morbidity rate was 32% including neurological, systemic, and regional complications (12). Our overall morbidity rate of 32% is comparable with this. Even though our study may underestimate complications because of failure of reporting, we have included other minor morbidity such as nausea and vomiting and self-limiting intraoperative focal seizures secondary to brain mapping.

There are no data in the literature on morbidity and mortality rates inpatients undergoing craniotomy for removal of tumor on an ambulatory basis, so a direct comparison is not available. We realize that the actual number of patients who were scheduled for ambulatory surgery is small, and therefore any one complication will skew the results. However, the readmission, unanticipated admission, and morbidity rates are acceptable as initial outcome data in these patients.

Although severe morbid complications such as postoperative bleeding only occurred rarely, it is important that they are treated quickly once recognized because the consequences of a hematoma have a profound effect on outcome if not treated early. Thus, postoperative observation is imperative, either in hospital or at home. A large retrospective study in 2305 patients on the timing of postoperative intracranial hematomas showed that there appeared to be two distinct time periods during which the hematoma became clinically apparent (13). The first was in the initial six postoperative hours, as a result of active bleeding at the site. All of our patients were monitored in the PACU for four hours after surgery and none left hospital before six hours. They were all seen by the surgeon before discharge to ensure there was no neurological deterioration and to assess their "home readiness." The second time period for presentation of bleeding occurred after 24 hours and represented secondary swelling and edema formation around the hematoma. Thirty-eight percent of our patients were at home after 24 hours. All were given written instructions similar to those instructions given to patients after a head injury to inform the surgeon or report to the emergency department if they experienced specific symptoms. In addition, a home care nurse visited all outpatients on the evening of surgery and the next morning. If clinical deterioration did occur between 6 and 24 hours postoperatively, then the risks of sending the patient home on the first postoperative day would outweigh the benefits.

Two of our inpatients had clinical deterioration secondary to edema around a hematoma, which occurred later than 24 hours on the third and fourth postoperative days respectively. In both of these patients there was a potential for postoperative complications and early discharge was not considered. These high-risk patients should probably be observed for at least four days, although more outcome data are required to clarify this. In low-risk patients who live near the surgical center and have a responsible adult at home, where there is no clinical deterioration in the first six hours postoperatively, we would argue they could be discharged early and resources used for other patients. Obviously, if there are other complications, such as severe postoperative nausea and vomiting or inadequate social support, then the patient should be admitted.

We used a statistical model to determine independent predictors of early discharge. Only 15 patients were discharged on the same day as surgery, and thus this group of patients was too small to be directly compared with the other groups. However, a combination of the early discharge groups allowed useful information to be obtained.

As with any statistical model, the results must be reviewed with caution, because of the relatively small numbers for some of the statistical computations. It follows intuitively that the patient with a better preoperative functional status is more likely to be discharged earlier. Conversely, the fact that a histological diagnosis of glioma or metastasis, as opposed to "miscellaneous," was predictive of early discharge is more difficult to accept or use practically because the diagnosis is not known until after intraoperative quick section.

In summary, we found that it may be feasible to perform awake craniotomy for removal of intracranial tumor on an ambulatory basis. However our study had small numbers, therefore caution is advised. Selection criteria need to be stringent. Many factors need to be considered, including the expertise of the surgeon, the facilities of the ambulatory unit, the ease of access to the hospital for readmission, the patient's preoperative functional status, the type of tumor, location and surrounding edema, the length of surgery, and the amount of fluid administered intraoperatively. A further large prospective study is needed to confirm this.

We thank Dr. G. Mezei for assistance with the statistical analysis.

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