GENERAL NEUROSURGERY

# Postoperative Intensive Care Unit Requirements After Elective Craniotomy

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**Key words**
- Craniotomy
- Elective
- ICU
- Postoperative care

**Abbreviations and Acronyms**
**ASA**: American Society of Anesthesiologists
**ICU**: Intensive care unit
**IV**: Intravenous
**OR**: Odds ratio

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OBJECTIVE: **Commonly, patients undergoing craniotomy are admitted to an intensive care setting postoperatively to allow for close monitoring. We aim to determine the frequency with which patients who have undergone elective craniotomies require intensive care unit (ICU)–level interventions or experience significant complications during the postoperative period to identify a subset of patients for whom an alternative to ICU-level care may be appropriate.**

METHODS: **Following Institutional Review Board approval, a prospective, consecutive cohort of adult patients undergoing elective craniotomy was established at the Massachusetts General Hospital between the dates of April 2010 and March 2011. Inclusion criteria were intradural operations requiring craniotomy performed on adults (18 years of age or older). Exclusion criteria were cases of an urgent or emergent nature, patients who remained intubated postoperatively, and patients who had a ventriculostomy drain in place at the conclusion of the case.**

RESULTS: **Four hundred patients were analyzed. Univariate analysis revealed that patients with diabetes ($P = 0.00047$), those who required intraoperative blood product administration ($P = 0.032$), older patients ($P < 0.0001$), those with higher intraoperative blood losses ($P = 0.041$), and those who underwent longer surgical procedures ($P = 0.021$) were more likely to require ICU-level interventions or experience significant postoperative complications. Multivariate analysis only found diabetes ($P = 0.0005$) and age ($P = 0.0091$) to be predictive of a patient's need for postoperative ICU admission.**

CONCLUSIONS: **Diabetes and older age predict the need for ICU-level intervention after elective craniotomy. Properly selected patients may not require postcraniotomy ICU monitoring. Further study of resource utilization is necessary to validate these preliminary findings, particularly in different hospital types.**

## INTRODUCTION

A 1994 retrospective study of national intensive care unit (ICU) costs in Veterans Affairs Hospitals revealed that although ICU beds comprise less than 10% of inpatient hospital beds nationally, they make up 22% of total hospital costs, equating to roughly 1% of the U.S. gross domestic product (10, 11). Recent estimates suggest that ICU costs may approach one third of total inpatient costs at some hospitals, as the cost of a day in the ICU remains roughly three to five times greater than a day on a general medical/surgical floor (7, 17, 18, 22). As a result, considerable efforts have been made to reduce ICU overutilization (26). This may be achieved by minimizing the number of unnecessary ICU admissions by stratifying postoperative patients by need. Morasch et al. used this approach to ICU utilization reduction in demonstrating that patients could be safely transferred to a surgical floor following carotid endarterectomy if they remained neurologically and hemodynamically stable for 3 hours postoperatively (19). Seventy-nine percent of the 185 patients who underwent carotid endarterectomy in this study were successfully transferred to a surgical floor, without a single patient from this group requiring transfer to an ICU or a return to the operating room. Many neurosurgical patients have been managed successfully postoperatively in a non-ICU setting, although the analysis of such cases is limited to retrospective review (3).

Although controversial, it must be noted that a few clinicians in Canada, and more recently in the United Kingdom, have performed craniotomies for tumor resection in select patients on a day-surgery basis (4, 5, 9). The combined results from an 11-year series from the Toronto Western Hospital (Toronto, Canada) and a 1-year series from the Wessex Neurological Centre (Southampton, United Kingdom) showed that of 177 patients scheduled for outpatient craniotomy for supratentorial tumor resection, only 9 required direct postoperative admission and 2 required readmission following discharge (9). Importantly, none of the patients in either series suffered an adverse outcome as a result of their planned early discharge. Of the 177 outpatient craniotomy cases, 163 were performed as awake procedures and 14 following the induction of general anesthesia. Both the UK and Canadian groups only included patients as candidates for outpatient craniotomy if they lived with a responsible adult, had "no comorbidity requiring hospitalization," and had a case completion time prior to 1:00 PM, allowing for a 6-hour observation period prior to the 7:00 PM closing time of the surgical units (9).

Neurosurgeons have generally been reluctant to entertain reductions in postoperative monitoring following craniotomy, with the fear of not being able to recognize complications that would require urgent attention. In particular, the development of a postoperative hematoma is a known complication of any neurosurgical procedure requiring a craniotomy. Historical literature suggests that roughly 2% of patients undergoing an elective craniotomy will develop a postoperative hematoma requiring surgical evacuation. However, it is important to note that the majority of postoperative hematomas will present with clinical signs of deterioration within 6 hours of surgery and are heralded by a clinical change (14, 23). It is our hope that by further characterizing the patient population undergoing elective craniotomy, paying special attention to patient comorbidities and the details of the neurosurgical procedure performed, we may be able to identify a subset of patients for whom an alternative to ICU-level care in the postoperative period is appropriate.

## METHODS

Following approval by the Massachusetts General Hospital Institutional Review Board (Protocol no. 2010P000126), consecutive, adult patients (age >17 years) undergoing elective craniotomy by all providers were prospectively collected and observed from April 2010 to March 2011. Consent was not obtained from patients for this observational study, and the Massachusetts General Hospital Institutional Review Board approved this methodology. Inclusion criteria included intradural cranial operations, both supratentorial and infratentorial, for indications including tumor resection, open brain biopsy, vascular malformation obliteration, temporal lobectomy for epilepsy, microvascular decompression for neurovascular compression syndromes, and Chiari malformation decompressions. As an institutional practice pattern, these patients are routinely admitted to the neurologic sciences ICU, regardless of neurologic status or clinical complexity at the conclusion of the procedure. In the ICU, the patient-nursing ratio is either 1:1 or 2:1. Neurologic examinations are performed by nursing every 1 or 2 hours. Blood pressure is continually monitored with an arterial pressure line for at least the first 24 hours. Continuous cardiac telemetry and oxygen saturation are monitored. This differs from the regular neuroscience floor bed, where neurologic checks and vital signs can be obtained every 4 hours. Also, on the floor, the institution of intravenous (IV) drips requires transfer to the ICU. In rare circumstances, because of bed availability, elective craniotomy patients spent their first postoperative night in the postanesthesia care unit or on the neurosciences floor and were excluded from the study. Additionally, any craniotomy that was performed as an urgent or emergent case, defined in the official anesthesia booking record as requiring a start time in less than four hours or 30 minutes, respectively, was excluded from this study. Furthermore, patients who remained intubated postoperatively or had a ventriculostomy drain in place for intracranial pressure monitoring at the conclusion of the surgery were excluded from the study as these ongoing interventions would always necessitate an ICU admission.

Details of the operative procedure were recorded from the anesthesia and surgical records including the type of procedure performed, estimated intraoperative blood loss, use of blood transfusions, and length of surgery. Tumor volume was calculated with the use of Vitrea Advanced software (Vital Images, Minnetonka, Minnesota, USA). There was insufficient power in our pre-study analysis to divide neoplastic lesions into subcategories based on pathology. The ICU courses of patients meeting criteria were retrospectively studied; each patient's electronic inpatient medical record (including daily progress notes, event notes, medication records, radiology records, and physician orders) was extracted for data. Interventions that required an ICU setting, that is, were not feasible on a general medical/surgical floor unit, were defined as the use of hemodynamic medications delivered by IV infusion (other than low-dose anti-hypertensives: nicardipine at a rate ≤5 mg/hour; cumulative total dose ≤20 mg or labetalol at a rate ≤10 mg/hour; cumulative total dose ≤40 mg), the use of hyperosmolar therapy (defined as the use of 3% NaCl delivered at a rate greater than 30 mL/hour or the use of mannitol), the use of an insulin drip, and the use of an intracranial pressure monitor or ventriculostomy drain. Significant adverse events were defined as the development of a clinically significant postoperative hematoma, ischemic stroke, myocardial infarction, the need to return to the operating room from the ICU, the need for reintubation, goals of patient care being established as comfort measures only, and death.

Statistical analysis was performed using SAS (version 9.3). Fisher's exact test was used to the determine the association between the need for postoperative ICU admission and binary risk factors, $\chi^2$ test was used for categorical risk factors, and Wilcoxon rank–sum tests for continuous factors. A multivariable logistic regression model was used to test the predictive power of these significant risk factors on the need for postoperative ICU admission. Significant variables in the model were selected according to the stepwise selection process. Significance was defined as $P \leq 0.05$.

## RESULTS

Four hundred thirty-two consecutive adult patients underwent elective craniotomy during the study time frame. Thirty-one cases were excluded as the patients spent the first postoperative nights in the postanesthesia care unit or on the neurosciences floor, rather than being admitted to the neurologic sciences ICU. One patient died intraoperatively from complications of air emboli during a craniotomy for tumor and was also excluded from the study. Thereby, 400 elective craniotomy cases were included in the study population.

There were 166 male and 234 female patients. The mean age was 53.0, the mean BMI was 28.2, and the mean American Society of Anesthesiologists (ASA) physical status classification system score was 2.37. Fifty-eight patients were active smokers, and 37 had a known