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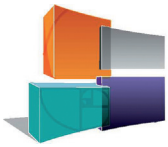

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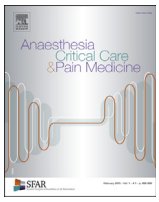

Original Article

Postoperative complications after craniotomy for brain tumor surgery

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ABSTRACT

Introduction: After elective craniotomy for brain tumour surgery, patients are usually admitted to an intensive care unit (ICU) for monitoring. Our goal was to evaluate the incidence and timing of neurologic and non-neurologic postoperative complications after brain tumour surgery, to determine factors associated with neurologic events and to evaluate the timing and causes of ICU readmission.
Patients and methods: This prospective, observational and analytic study enrolled 188 patients admitted to the ICU after brain tumour surgery. All postoperative clinical events during the first 24 hours were noted and classified. Readmission causes and timing were also analysed.
Results: Twenty-one (11%) of the patients were kept sedated after surgery; the remaining 167 patients were studied. Thirty one percent of the patients presented at least one complication (25% with postoperative nausea and vomiting (PONV), 16% with neurologic complications). The occurrence of neurological complications was significantly associated with the absence of preoperative motor deficit and the presence of higher intraoperative bleeding. Seven patients (4%) were readmitted to the ICU after discharge; 43% ($n = 3$) of them had a posterior fossa surgery.
Conclusion: Postoperative complications, especially PONV, are frequent after brain tumour surgery. Moreover, 16% of patients presented a neurological complication, probably justifying the ICU postoperative stay for early detection. The absence of preoperative motor deficit and intraoperative bleeding seems to predict postoperative neurologic complications. Finally, patients may present complications after ICU discharge, especially patients with fossa posterior surgery, suggesting that ICU hospitalization may be longer in this type of surgery.
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1. Introduction

Following intracranial tumour surgery, admission to an intensive care unit (ICU) is considered a common practice. Management in an ICU during the postoperative period allows a rapid detection of neurologic deterioration and maintenance of systemic and neurologic homeostasis [1]. Major complications after intracranial surgery occur in 13–27% of patients [2]. These complications may be neurologic, haemodynamic, metabolic or respiratory in nature. Major neurologic complications include postoperative haematomas, cerebral oedema and seizures, and should be differentiated from minor events, such as postoperative nausea and vomiting (PONV), pain and hyperglycaemia. However, there is a possible relationship between events. An event considered as moderate and easily treatable may precede a more severe one. Hypertension may lead to postoperative haematoma [3]. Acute physiological changes during anaesthesia recovery (sympathetic activation, increase in cerebral blood flow and intracranial pressure, shivering and coughing) may be responsible for intracranial complications [2].

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Nevertheless, criteria for admission to the ICU remain unclear. ICU resources are scarce and expensive, and postoperative admissions may limit the availability for emergency admissions [4]. The careful selection of patients admitted to the ICU for postoperative care may reduce hospital lengths of stay and costs [5].

We performed a prospective, observational study involving patients admitted to the ICU after craniotomy for brain tumour surgery. Our first aim was to determine the incidence and timing of neurologic and non-neurologic complications during the first 24 hours. Our second goal was to determine factors associated with a neurologic event. Finally, our study evaluated the incidence, timing and causes of readmission to the ICU.

2. Patients and methods

2.1. Study participants

This prospective observational analytic study was conducted between January 2011 and January 2012 in a University Hospital in France. This study was approved by our local ethics committee (Number: 29-0611), who decided that no written consent was needed for participation given the observational nature of the study. All patients aged 18 years and above who underwent craniotomy for intracranial tumour surgery were enrolled in this study, including emergent (defined by patients receiving preoperative osmotherapy) and elective procedures. All were admitted to a 12-bed neuro-ICU for monitoring during the first 24 hours. Patients aged less than 18 years old were not included.

2.2. Perioperative management

For surgery under general anaesthesia, patients were anaesthetised using sufentanil, propofol and cisatracurium; and anaesthesia was maintained with sevoflurane and sufentanil, except for emergent procedures (total intravenous anaesthesia). Mechanical ventilation was adjusted to obtain an end-tidal carbon dioxide level between 30 and 35 mmHg and an arterial pulse oximetry above 95%. For awake surgery, patients were anaesthetized by using propofol and sufentanil or remifentanil in order to maintain spontaneous breathing with an oxygen facemask at 6 to 8 L/min to maintain arterial pulse oximetry above 95%.

For all patients, during surgery, ephedrine was used in order to maintain a mean arterial pressure (MAP) above 65 mmHg. Neosynephrine or norepinephrine was started after failure of ephedrine. During anaesthesia, a warming blanket was used to prevent hypothermia. No systematic PONV prophylaxis was administered. Droperidol and ondansetron were given to treat PONV in the postoperative period. If steroids were introduced before surgery, they were continued for the perioperative period. Methylprednisolone at 2 mg/kg was given, even in patients who did not receive steroids before, at the beginning of the procedure, and was continued during the postoperative period. Anticonvulsants (levetiracetam at 1 g twice a day) was started the day before surgery and continued for 7 days, except for posterior fossa tumours. Other anticonvulsants, if the patient was under treatment, were continued at the same dosage. Acetaminophen and tramadol or nefopam were given 30 minutes before the end of surgery, and followed after surgery. After awakening, morphine or nalbuphine was used to reduce pain. According to local protocols, antithrombotic prophylaxis with low molecular weight heparin was introduced 48 hours after the surgery.

Patients were woken early after surgery and extubated in the operating room or in the post-anaesthesia care unit (PACU) as soon as possible, if they were stable. Patients with signs of intracranial hypertension were kept sedated, intubated and transferred to the ICU after a CT scan. CT scans were indicated in cases of unexpected motor deficits, dysphasia, seizures and deterioration of consciousness defined by a decrease in the Glasgow coma score of more than 2. Hospital mortality was evaluated for all procedures. Patients who were kept mechanically ventilated for more than three hours were excluded from the final analysis.

Postoperative complications during the first 24 hours were defined and classified into several groups: neurologic (new motor deficits, dysphasia, seizures and deterioration of consciousness defined by a decrease in the Glasgow coma score of more than 2), haemodynamic (bradycardia < 45 b/min, arterial hypertension defined as MAP > 110 mmHg, arterial hypotension defined as MAP < 60 mmHg, and myocardial ischaemia), respiratory (respiratory failure requiring invasive or non-invasive ventilation, hypopnoea defined as respiratory rate < 8/min, hypoxaemia defined as arterial pulse oximetry $< 90\%$), PONV (early PONV < 4 h, h, late PONV between 4 and 24 h), metabolic (hyperglycaemia > 200 mg/dL, diabetes insipidus, dysnatraemia), haemorrhage (blood loss > 500 mL), hyperthermia (core temperature > 38.5 °C) and pain (> 6 on a visual analogical scale after morphine or nalbuphine administration).

2.3. Data collection

Demographic data, preoperative neurological assessment and treatment (steroids, anticonvulsants), tumour type and location, mass effect on CT scan, peroperative data (length of anaesthesia and surgery, type of anaesthesia, position, vasopressor use, quantity and type of fluids, blood loss) and all complications (type and timing) during the first 24 hours were recorded.

Patients were separated into two groups: patients presenting a neurological complication and patients without a neurological complication. The comparison was made to determine the risk factors for neurological complications. Date and cause of readmission in the ICU after discharge were also reported.

2.4. Statistical analysis

Statistical analysis was performed using STATA statistical software, release 11.2 (STATA Corporation, College station, TX, USA). We described patient characteristics using numbers and frequencies for qualitative data and medians (interquartile range [IQR]) for quantitative data. Qualitative variables were compared between groups (neurological complications versus no neurological complications group) using χ^2-tests (or Fisher's exact tests in the case of small expected numbers). Student's t-tests were used to compare the distribution of quantitative data (or Mann–Whitney's tests when distributions departed from normality or when homoscedasticity was rejected). All reported P-values were two-sided and the significance threshold was < 0.05.

3. Results

During the study period, 188 patients were enrolled, including 178 elective and 10 emergent procedures. Three patients died (1.6%): 2 after non-elective procedures (20%), 1 after an elective procedure (0.5%). Twenty-one patients (11%) were excluded (all patients after non-elective procedures and 11 after elective procedures), because they were still sedated and mechanically ventilated 3 hours after the end of surgery (Fig. 1).

The remaining 167 patients were therefore evaluated. Demographic data are reported in Table 1. Eighty-six (51%) patients were male, with a median age of 57 years. It was the first surgery for 124 (74%) patients. The most encountered tumour types were malignant glioma (31%) and meningioma (28%). In the preoperative setting, 49 (29%) patients had seizures and 42 (25%) a motor

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