Original Article
Clinical characteristics and causes of emergency reoperation after skull base surgery: a report of 14 cases

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Abstract: Objective: To investigate the clinical characteristics and causes of the patients who received an emergency reoperation involving a craniotomy after neurosurgery for skull base tumors. Materials and methods: A retrospective analysis was performed with 14 patients who underwent an emergency reoperation involving a craniotomy after received skull base surgery in the Skull Base and Brainstem Division of the Neurosurgery Department at Beijing Tiantan Hospital, Capital Medical University, between October 2008 and October 2013. The clinical characteristics and causes for reoperation were analyzed and determined by the surgeons and a group of experts and confirmed via consultation of the entire department. Results: There were 6 cases of skull base meningiomas, 3 cases of schwannoma, and 1 case each of pituitary adenoma, craniopharyngioma, osteochondroma, angioleiomyoma, and glomus jugular tumor. The mean length of the first surgery was 9.2 hours, and the mean blood loss was 2750 mL. Among the patients who underwent reoperation, 9 patients exhibited declined consciousness and vitality, 2 patients were identified as having an abnormal postoperative recovery from anesthesia, 2 patients were identified by a routine postoperative computed tomography (CT) examination and 1 patient had sudden bleeding from the wound. The average time to detect abnormalities via CT exam was 16.9 hours after surgery. There were 4 cases of intratumoral hemorrhage, 4 cases of intracerebral hematoma accompanied by cerebral laceration, 2 cases of massive cerebral infarction, 1 case of intracerebral hematoma complicated by subdural hematoma, 2 cases of epidural hematoma, and 1 case of bleeding from the vertebral artery. Conclusions: Perioperative management should be strengthened for patients who receive skull base surgery to reduce the incidence of reoperation.

Keywords: Causes, clinical characteristics, emergency reoperation, neurosurgery, skull base tumor

Introduction
Skull base tumors have a deep location, and surgical treatment is difficult, risky, and time consuming [1, 2]. Early postoperative craniotomy is considered as a severe complication and seriously affects the prognosis of patients [3, 4]. The skull base surgeon should strive to avoid such situations. However, there are still few researches focus this point on skull base surgery. This report analyzes the clinical characteristics of 14 patients who underwent an early emergency reoperation involving craniotomy after they received skull base surgery in the Skull Base and Brainstem Division of the Neurosurgery Department at Beijing Tiantan Hospital, an affiliated hospital of Capital Medical University, between October 2008 and October 2013. The aim of our study was to investigate the clinical characteristics and causes of the patients who received an emergency reoperation involving a craniotomy after neurosurgery for skull base tumors.

Patients and methods
Clinical data
There were a total of 14 cases, 8 males and 6 females, accounting for 0.6% of skull base elective surgery during the same period (14/2500). The patients, aged 19-69 years, with a mean
### Table 1. The clinical characters and causes of 14 cases with skull base tumor surgery reoperation

<table>
<thead>
<tr>
<th>No.</th>
<th>Gender</th>
<th>Age</th>
<th>Primary disease</th>
<th>Surgery approach</th>
<th>Tumor size (cm)</th>
<th>Bleeding volume (ml)</th>
<th>Surgery length (h)</th>
<th>CT abnormality after surgery (h)</th>
<th>Cause for first surgery</th>
<th>Cause for second surgery</th>
<th>Post operative GOS score</th>
<th>Cause for second surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>58</td>
<td>recurrent glomus jugular tumor</td>
<td>far-lateral retro-condylar approach</td>
<td>4×5×5</td>
<td>5500</td>
<td>14</td>
<td>0</td>
<td>ruptured vertebral artery</td>
<td></td>
<td>1</td>
<td>vertebral artery rupture and hemorrhage</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>64</td>
<td>sphenoid ridge meningiomas</td>
<td>subtemporalpreauricular approach</td>
<td>4×5×5</td>
<td>800</td>
<td>5</td>
<td>18</td>
<td>subdural and intracerebral hematoma</td>
<td></td>
<td>1</td>
<td>liver dysfunction induced coagulopathy</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>50</td>
<td>pituitary adenoma</td>
<td>subfrontal approach</td>
<td>4×5×6</td>
<td>800</td>
<td>8</td>
<td>12</td>
<td>brain infarction</td>
<td></td>
<td>1</td>
<td>residual tumor hemorrhage induced large area of brain infarction</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>40</td>
<td>anterior skull base meningiomas</td>
<td>subfrontal approach</td>
<td>6×6×5</td>
<td>9000</td>
<td>15</td>
<td>8</td>
<td>intracerebral hematoma</td>
<td></td>
<td>2</td>
<td>postoperative cerebral perfusion pressure breakthrough induced intracerebral hemorrhage</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>27</td>
<td>parasellar meningiomas</td>
<td>subtemporalpreauricular approach</td>
<td>4×4×5</td>
<td>8000</td>
<td>16</td>
<td>12</td>
<td>brain infarction</td>
<td></td>
<td>3</td>
<td>blood supply of tumor is too rich to hemostasis completely</td>
</tr>
<tr>
<td>6</td>
<td>F</td>
<td>23</td>
<td>parasellarangi-oleiomysoma</td>
<td>subtemporalpreauricular approach</td>
<td>7.7×5.5×5.5</td>
<td>5000</td>
<td>10</td>
<td>12</td>
<td>tumor cavity hemorrhage</td>
<td></td>
<td>3</td>
<td>blood supply of tumor is too rich to hemostasis completely</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>54</td>
<td>petroclival osteochondroma</td>
<td>subtemporal approach via the petrous bone</td>
<td>2×3×3</td>
<td>200</td>
<td>7.5</td>
<td>19</td>
<td>intracerebral hematoma</td>
<td></td>
<td>4</td>
<td>temporal vein contusion</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>69</td>
<td>petroclival schwannoma</td>
<td>subtemporal approach via the petrous bone</td>
<td>3×3×4</td>
<td>100</td>
<td>6</td>
<td>3</td>
<td>intracerebral hematoma and contusion</td>
<td></td>
<td>4</td>
<td>temporal vein disconnection</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>41</td>
<td>petroclivalmeningiomas</td>
<td>fronto-orbitozygomatic approach</td>
<td>4.5×5×6</td>
<td>4000</td>
<td>12.5</td>
<td>2.5</td>
<td>epidural hematoma</td>
<td></td>
<td>5</td>
<td>meningeal artery incompletely hemostasis</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>42</td>
<td>petroclivalmeningiomas</td>
<td>presigmoid approach</td>
<td>4×5×5</td>
<td>2000</td>
<td>14</td>
<td>8</td>
<td>epidural hematoma</td>
<td></td>
<td>5</td>
<td>dural stripping</td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>23</td>
<td>suprasellarcarcinopharyngioma</td>
<td>transc Yugoslavalsal approach</td>
<td>3×4×4</td>
<td>200</td>
<td>4.5</td>
<td>10</td>
<td>tumor cavity hematoma</td>
<td></td>
<td>5</td>
<td>incompletely hemostasis</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>19</td>
<td>cerebellopontine-schwannoma</td>
<td>retrosigmoidal approach</td>
<td>5.5×5.5×6</td>
<td>600</td>
<td>6</td>
<td>20</td>
<td>tumor cavity hematoma</td>
<td></td>
<td>5</td>
<td>incompletely hemostasis</td>
</tr>
<tr>
<td>13</td>
<td>M</td>
<td>45</td>
<td>anterior clinoidmeningiomas</td>
<td>fronto-orbitozygomatic approach</td>
<td>4.5×4.5×5</td>
<td>2200</td>
<td>6.5</td>
<td>94</td>
<td>tumor cavity hematoma</td>
<td></td>
<td>5</td>
<td>incompletely hemostasis</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>58</td>
<td>petroclivalmeningiomas</td>
<td>subtemporal approach via the petrous bone</td>
<td>2×3×3</td>
<td>100</td>
<td>4</td>
<td>2</td>
<td>intracerebral hematoma</td>
<td></td>
<td>5</td>
<td>excessive traction on brain tissues</td>
</tr>
</tbody>
</table>
age of 43.8 years, included 1 patient with a history of hypertension, 2 patients with a history of hepatitis, 1 patient with a recurrent glomus jugular tumor, and 1 patient with pre-operative embolization for a large endothelial meningioma.

Primary disease site and pathology

The most common primary disease site included petroclival, parasellar and sellar or suprasellar (Table 1). Postoperative pathology including 7 cases of meningiomas, 2 cases of schwannoma, and 1 case each of pituitary adenoma, craniopharyngioma, osteochondroma, angiomyxoma, and glomus jugular tumor.

First surgery

The surgical approach was selected based on the location of the tumors, including subtemporal approach via the petrous bone, subtemporal-preauricular approach to the middle cranial fossa, fronto-orbitozygomatic approach and so on (Table 1). The length of the surgery ranged from 4 to 16 hours, with an average of 9.2 hours. The mean intraoperative blood loss ranged from 100 to 9000 mL, with an average of 2750 mL. There were 12 cases of total resection and 2 cases of subtotal resection. The patients were monitored in the intensive care unit (ICU) after the surgery.

Analysis of the cause for reoperation

The cause was determined through analysis by the surgeon and the expert group and confirmed via consultation of the entire department.

Results

First symptoms of the reoperated patients

Nine patients exhibited a decline in consciousness and vitality after waking from the first surgery, 2 patients were identified due to abnormal postoperative recovery from anesthesia, 2 patients were identified during a postoperative routine computed tomography (CT) examination, and 1 patient had sudden bleeding from the wound.

CT findings

Among this group of patients, 13 exhibited abnormalities in the CT examination before the emergency reoperation at 2 to 94 hours after the first surgery, with an average of 16.96 hours. There were 4 cases of intratumoral hemorrhage, 4 cases of intracerebral hematoma accompanied by cerebral laceration, 2 cases of massive cerebral infarction, 1 case of intracerebral hematoma with complication of subdural hematoma, and 2 cases of epidural hematoma. A patient who had bleeding wounds directly underwent surgical exploration, without CT examination.

Surgery and prognosis

Eight patients had a surgical approach via the original incision, while 6 patients had a surgical approach through an expanded incision. Six patients had well-subsided brain tissues with a restored bone flap, whereas the remaining patients underwent decompressive craniectomy. According to the Glasgow Outcome Scale (GOS), there were 6 cases of grade V, 2 cases of grade IV, 2 cases of grade III, 1 case of grade II, and 3 cases of grade I.

Causes of reoperation

There were 4 cases of incomplete hemostasis, 2 cases of injured subtemporal vein (Figure 1), 2 cases of massive cerebral infarction due to vasospasm (Figure 2), 2 cases of epidural hematoma caused by dural stripping, 1 case of coagulation disorder, 1 case of cerebral hemorrhage from traction and contusion, 1 case of hemorrhage from rupture of the vertebral artery, and 1 case of intracerebral hematoma from perfusion pressure in remote regions.

Discussion

The present study found that the most common symptom was declined consciousness and vitality after waking from the first surgery, the average time of exhibited abnormalities in CT examination after the first surgery was 16.96 hours, and the most common causes of reoperation including incomplete hemostasis, injured subtemporal vein, massive cerebral infarction due to vasospasm and epidural hematoma caused by dural stripping. To the best of our knowledge, this report is the first study to demonstrate the clinical characteristics and causes analysis of emergency reoperation after skull base surgery.

With a better understanding of the skull base anatomy and improved instruments, neurological protection has been greatly improved.
Nevertheless, surgery on skull base tumors is associated with objective risks [5]. When emergency reoperation is required after skull base surgery, patients frequently had a poor outcome and even died [3]. Tahara et al. reported surgical treatment of 15 cases of petroclival meningioma, with 2 deaths due to hematoma and massive cerebral infarction in the surgical region [6]. It is difficult for physicians and patients to accept a mortality rate of 13.3%. Therefore, retrospective analysis is necessary for reoperation after skull base surgery.

The causes for emergency reoperation following skull base surgery include postoperative hematoma, severe cerebral infarction, cerebral edema, and other unexpected causes such as vertebral artery rupture in the patients of this

Figure 1. Patient, male, 69 years of age. Magnetic resonance imaging (MRI) revealed a space-occupying mass in the left petrous apex (A, B). The patient was operated on via the left subtemporalanteropetrosal approach and did not awaken until 3 hours after the surgery. Cranial CT indicated a left temporal intracerebral hematoma (C). The hematoma was surgically removed, with satisfactory results (D). Cause analysis: The intracerebral hematoma was caused by injury to the subtemporal vein.
Emergency reoperation after skull base surgery

A

B

C

D

E

F
Furthermore, when postoperative cerebral tumor and the patient underwent reoperation. Examination indicated an intracerebral hematoma remained unconscious after the surgery. CT dura during a craniotomy in a patient, who vein was accidentally injured while cutting the several pieces. In this study, the subtemporal attached to the dura, the dura must be cut into times, to protect the drainage veins that are skull base fluid and tumor resection. Some- bone flap, and cutting the dura to draining the cal process, from drilling the skull, milling the must be protected throughout the entire surgery at the skull base. Second, the drainage veins ing to the entry sinus type of the drainage veins gical approach may need to be selected accord course of drainage veins. Furthermore, the sur resonance venography imaging exam, such as enhanced magnetic extracerebral hematoma and avoid reoperation after the patient regains consciousness. In addition, in this study, there were 4 cases of postoperative hematoma caused by incomplete hemostasis, with 3 cases exhibiting massive intraoperative bleeding (2 cases of angiomatic meningioma and 1 case of angioleiomyoma). Preoperative superselective embolization may reduce intraoperative bleeding for tumors with a rich blood supply. Special care is required for this type of tumor to control bleeding during the surgery and to avoid post-operative hematoma.

Intracerebral hematoma and brain contusion and laceration are common in skull base surgery due to excessive traction on brain tissues. Skull base surgery has stringent technical requirements. Exposing the skull base can reduce traction on brain tissues. In elderly patients, excessive intraoperative traction can lead to brain contusion due to increased fragility of brain tissues. In this study, a 69-year-old patient with hypertension for 25 years had a smooth surgery but still experienced postoperative intracerebral hematoma, which was likely caused by excessive intraoperative traction on the brain tissues.

In reoperation for skull base tumors, the intracranial pressure must be reduced first. Regardless of whether it is intracerebral hematoma or massive cerebral infarction, hematoma removal, in combination with decompressive craniectomy, can well reduce the intracranial pressure to save the patients’ lives. The goal of reoperation is to mitigate the impact from a hematoma on the cerebral nerves and deep blood vessels. For example, in the case of sellar tumors, mild bleeding can cause visual impairment, and surgical removal of the hematoma can save the patient’s vision. In addition, all of major blood vessels travel through the skull base and bleeding into the surgical cavity.
Emergency reoperation after skull base surgery
during skull base surgery can lead to vaso-
spasm in the Circle of Willis, basilar artery, or
brainstem perforator vessels. If the hematoma
is not removed in time, vasospasm of the perfo-
rator vessels will not be improved after the sur-
gery, even with effective conservative treat-
ment. In this study, one patient with an invasive
pituitary adenoma suffered a postoperative
hematocele in the surgical area, with generally
stable conditions and conservative treatment.
However, the patient experienced a massive
cerebral infarction 3 days after the surgery and
died. Furthermore, bloody cerebrospinal fluid
causes clogging of the arachnoid granules and
increases the incidence of hydrocephalus.
Therefore, if necessary, the reoperation after
skull base surgery should be performed as
soon as possible to benefit the patients.

Serious postoperative complications can only
be avoided through continuing education in
skull base surgical techniques and incorporat-
ing clinical training and experience. In situa-
tions when emergency surgery is necessary, it
is important to have a positive attitude during
active surgical treatment.

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Disclosure of conflict of interest
None.

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Unplanned reoperation rates in pediatric neu-
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