Ventral foramen magnum meningiomas

KENAN I. ARNAUTOVIĆ, M.D., OSSAMA AL-MEFTY, M.D., AND MUHAMMAD HUSAIN, M.D.

Departments of Neurosurgery and Pathology, University of Arkansas for Medical Sciences, and Laboratory Service, Veterans Administration Medical Center, Little Rock, Arkansas

Object. Ventral foramen magnum meningiomas (VFMMs) are rare lesions that account for more than 3% of all meningiomas. These are among the most challenging of all meningiomas to treat. The authors comprehensively analyzed multiple features in a series of VFMMs.

Methods. A retrospective study was performed of 18 patients who harbored a meningioma in the ventral foramen magnum (mean follow-up period, 40 months) and underwent surgery via a transcondylar approach. Sixteen patients underwent surgery for the first time: 12 underwent gross-total (75%), two near-total (12.5%), and two subtotal (12.5%) tumor removal. The remaining two patients were treated for a recurrent tumor. After obtaining postoperative Karnofsky Performance Scale (KPS) scores at follow up, statistically significant improvement was demonstrated compared with the preoperative scores. The extent of surgery and higher preoperative KPS scores were variables that showed statistically significant favorable influence on outcome. Ninth and 10th cranial nerve deficits were the most common complications contributing to a prolonged hospital stay. There were no perioperative deaths. Four patients died during the follow-up period. The first patient died of multiple myeloma. The second patient, in whom surgery was performed to treat a recurrent tumor, died 3 years after the surgery of new tumor recurrence at the age of 80 years. The remaining two patients died 1.5 and 5 months postsurgery of pulmonary embolus and endocarditis, respectively.

Conclusions. Ventral foramen magnum meningiomas can be radically resected in a majority of patients, with frequent but transient morbidity caused by lower cranial nerve deficits. Radical removal of a recurrent tumor provides a relatively long, stable postoperative course. In patients presenting with a low KPS score a poor prognosis is demonstrated, and early diagnosis and treatment are recommended to avoid it.

KEY WORDS • foramen magnum • meningioma • outcome • skull base surgery • transcondylar approach

Abbreviations used in this paper: CSF = cerebrospinal fluid; CT = computerized tomography; FMM = foramen magnum meningioma; KPS = Karnofsky Performance Scale; LOS = length of stay; MR = magnetic resonance; SCS = suboccipital cavernous sinus; VA = vertebral artery; VFMM = ventral foramen magnum meningioma.
time. Herein, we describe our experiences, as well as the complications, pitfalls, and lessons learned from this series. In addition, we briefly describe the histological relevance of our series.

Clinical Material and Methods

We retrospectively analyzed our series of patients with VFMM in whom surgery was performed by the senior author (O.A.) over a period of 8 years and 4 months (December 1990 through April 1999). Eighteen patients with VFMM were treated surgically in three neurosurgical departments at the following institutions: the University of Mississippi Medical Center (1990), Loyola University Medical Center (1991–1993), and the University of Arkansas for Medical Sciences (1993–1998). In our study we excluded patients with dorsal FMMs or those originating elsewhere and extending into the FM (for example, the jugular foramen, upper clivus, cerebellopontine angle, and the spinal canal). We also excluded patients who harbored malignant or aggressive histologically proven meningioma. Data obtained from each patient’s medical chart, follow-up examination, neuroradiology evaluation, and histological analysis were reviewed. For patients who could not be followed on a regular basis, we obtained medical and radiological reports or contacted the patients directly by using phone interviews and questionnaires. A score obtained from administering the KPS was used to evaluate the patient’s clinical course. The differences between the pre- and postoperative KPS scores were tested using a paired t-test. Cox’s proportional-hazard model was used to test the influence of variables such as age, sex, preoperative KPS score, and the extent of tumor resection on the clinical outcomes.

Grade of Tumor Resection

The grade of tumor resection was based on the surgeon’s observation recorded in the operative report and on postoperative neuroradiological findings. If these elements did not agree, we relied on the postoperative images. We divided the degree of tumor resection into three categories: 1) gross-total resection, including excision of the dural attachment and drilling of adjacent bone (Simpson Grades I and II); 2) near-total resection, in which a few millimeters of tumor were left on the VA or other vital structure if the arachnoidal plane could not be established (Simpson Grade III); and 3) subtotal removal of more than 50% of the tumor mass (Simpson Grade IV).39

Perioperative Protocol

The perioperative protocol was based on our experience over the years as well as that of others in treating FMMs and general perioperative skull base management principles. Treatment was individualized for each patient. The neuroradiological workup consisted of MR imaging, MR angiography (both arterial and venous), and CT scanning. The surgeon must carefully analyze the local anatomy of the FM, the condyles, the C1–2 complex, the area of tumor origin (by using CT), the tumor features (by using CT and MR imaging with/without contrast), the regional vascular anatomy, the bilateral VA patency, and the dominance of venous sinuses (by using MR angiography). We abandoned the routine use of four-vessel angiography unless MR angiography revealed particularly unusual findings that required further visualization. Intraoperative use of image-guided frameless stereotaxy was introduced in 1995. Perioperative multidisciplinary management routinely included speech pathology and otolaryngological evaluations, pre- and postoperative swallowing studies, and “nothing per mouth” postoperative regimens in which clearance was indicated by swallowing studies. If a patient had swallowing difficulties, appropriate actions such as instigation of parenteral nutrition, insertion of an orogastric or a gastric tube, vocal cord injections and medialization, and tracheostomy were taken as needed.

Intraoperative Neurophysiological Monitoring

Intraoperative neurophysiological monitoring includes use of somatosensory evoked potential and brain auditory evoked potentials recording bilaterally. The 10th cranial nerve is monitored via an electromyographic endotracheal tube. The 11th and 12th cranial nerves are also monitored, unilaterally or bilaterally as needed.

Operative Management

Awake endoscopic intubation is performed routinely to avoid neck hyperextension. Perioperative spinal cord trauma steroid drug protocol (for 24 hours) and antibiotic drugs (for approximately 72 hours) are administered to the patient when anesthesia is induced. We used the transcondylar approach to resect all VFMMs in this series (Fig. 1). The technique was tailored to each patient according to the findings of image-guided frameless stereotaxy. Intraoperative use of somatosensory evoked potentials recording bilaterally. The 10th cranial nerve is monitored via an electromyographic endotracheal tube. The 11th and 12th cranial nerves are also monitored, unilaterally or bilaterally as needed.

Operative Management

Awake endoscopic intubation is performed routinely to avoid neck hyperextension. Perioperative spinal cord trauma steroid drug protocol (for 24 hours) and antibiotic drugs (for approximately 72 hours) are administered to the patient when anesthesia is induced. We used the transcondylar approach to resect all VFMMs in this series (Fig. 1). The technique was tailored to each patient according to the findings of image-guided frameless stereotaxy. Intraoperative use of somatosensory evoked potentials recording bilaterally. The 10th cranial nerve is monitored via an electromyographic endotracheal tube. The 11th and 12th cranial nerves are also monitored, unilaterally or bilaterally as needed. The approach was greatly in-
fluenced by microsurgical anatomical studies of this complex area.\textsuperscript{1,15} and has been described in detail elsewhere.\textsuperscript{1–4,22,41,42} The transposition of the VA complex depended on the encasement of the VA by the tumor, the extension of the tumor inferiorly beyond C-1, the more ventral and contralateral C-1 extension, and the involvement of the other side VA. The portion of condyle drilling was directly proportional to the tumor location and extension to the contralateral side, allowing its safer dissection from vital anatomical structures. In other words, the more medial the tumor or the more it extended across the midline, the more the condyle was drilled. The complex venous compartment in the suboccipital area,\textsuperscript{3,4,10,46} which cushions the VA complex, was previously named the SCS. Its engorgement, which cannot be predicted by using current diagnostic modalities, can be troublesome, causing prolonged VA complex dissection and transposition. In such cases, the surgery may be divided into extradural and intradural stages (as required in three of our cases).

Results

Demographic Data

In the series of 18 patients with VFMMs, age ranged from 36 to 77 years (mean 58 years). The most common age range was 45 to 64 years. The series comprised 13 women (72\%) and five men (28\%): a ratio of 2.6 to 1. The LOS was 18 days. The follow-up period ranged from 0 to 84 months (mean 40 months).

Presenting Symptoms, Signs, and Findings

The time between when the symptoms first occurred and surgery ranged from 1 month to 10 years (mean 45 months). The most common symptoms were occipital pain and headache followed by ataxic incoordination, gait problems, and swallowing difficulties (Table 1). A combination of two or more of the aforementioned symptoms, signs, or findings was more the rule than the exception. One patient harbored a sizable VFFM that was discovered incidentally.

Surgery-Related Data

Of the 18 patients in our series, 16 underwent surgery for the first time, whereas two had undergone surgery 1 and 11 years earlier, respectively, returning for treatment of a recurrent tumor (Table 2). Of the 16 patients receiving treatment for the first time, 12 underwent gross-total, two near-total, and two subtotal resection of their tumors (Fig. 2). In both patients seeking treatment for recurrent tumors a subtotal resection was performed. In the four patients in whom subtotal resection was performed (two in the first group and two in the second), the tumor tightly adhered to the brainstem, the VA and basilar artery and their perforators (Table 2 and Fig. 2). In these patients, after maximal possible tumor resection, the tumor’s origin was cauterized extensively and the vascular supply was interrupted as much as possible. All four patients then underwent fractionated radiotherapy or radiosurgery (two and two, respectively), and a stable tumor size was revealed in three during the follow-up period (mean 5.5 years). In two patients (Cases 10 and 11; Table 2) there was an isolated, cauterized cuff of tumor a few millimeters thick and long that surrounded the VA (Fig. 3). An arachnoidal plane could not be established between the arterial wall and the tumor. After 54 and 48 months of follow up, respectively (mean 51 months), MR imaging demonstrated no change in tumor size. After 54 and 48 months of follow up, respectively (mean 51 months), MR imaging demonstrated no change in tumor size. Eventually, all but one patient, who died during the follow-up period, recovered to an increased average LOS. Eventually, all but one patient, who died during the follow-up period, recovered to a functional swallowing function, progressing from a dysphagia diet to a regular diet within a range of 10 days to 8 months (mean 66 days). Two patients suffered a deficit of the 11th cranial nerve, one of whom was the patient who had undergone transection and reconnection of the nerve. Both recovered to the preoper-

---

**TABLE 1**

<table>
<thead>
<tr>
<th>Finding</th>
<th>No. of Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pain/sensory changes</td>
<td>13 (72)</td>
</tr>
<tr>
<td>occipital pain/headache</td>
<td>4 (22)</td>
</tr>
<tr>
<td>facial numbness/pain</td>
<td>4 (22)</td>
</tr>
<tr>
<td>hand numbness</td>
<td>1 (6)</td>
</tr>
<tr>
<td>hemihypesthesia</td>
<td>1 (6)</td>
</tr>
<tr>
<td>leg numbness</td>
<td>1 (6)</td>
</tr>
<tr>
<td>decreased hearing (VIII CN)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>CN deficits (motor)</td>
<td>6 (33)</td>
</tr>
<tr>
<td>swallowing difficulties (IX, X)</td>
<td>5 (28)</td>
</tr>
<tr>
<td>diplopia (vi)</td>
<td>3 (17)</td>
</tr>
<tr>
<td>shoulder weakness (XI)</td>
<td>2 (11)</td>
</tr>
<tr>
<td>tongue weakness/spasms (XII)</td>
<td>1 (6)</td>
</tr>
<tr>
<td>u ncoordination/loss of dexterity</td>
<td>6 (33)</td>
</tr>
<tr>
<td>ataxic incoordination/gait difficulties</td>
<td>1 (6)</td>
</tr>
<tr>
<td>dysarthria</td>
<td>1 (6)</td>
</tr>
<tr>
<td>weakness</td>
<td>2 (11)</td>
</tr>
<tr>
<td>hemiparesis</td>
<td>2 (11)</td>
</tr>
<tr>
<td>quadriparesis</td>
<td>1 (6)</td>
</tr>
<tr>
<td>paraparesis</td>
<td>1 (6)</td>
</tr>
<tr>
<td>hydrocephalus</td>
<td>1 (6)</td>
</tr>
<tr>
<td>tumor found incidentally</td>
<td>1 (6)</td>
</tr>
</tbody>
</table>

* Roman numerals listed in parentheses indicate the respective cranial nerve related to the deficit. Abbreviation: CN = cranial nerve.
ative level of function. Seven patients developed a 12th and one patient a sixth nerve deficit that resolved completely, except in two patients who recovered from their 12th cranial nerve deficit only partially.

Of four patients who developed a CSF leak, two received additional skin sutures and two were treated with external lumbar drainage and operative revision. One patient developed hydrocephalus and required placement of a shunt.

Clinical Outcomes

Clinical outcomes are presented in Table 2. All but two patients (Case 9; KPS Score 30 and Case 12; KPS Score 40) presented with a KPS score of 60 and higher (89%). In all but three patients (83%) improved KPS scores were observed during the follow-up period compared with the preoperative scores; this improvement (Table 2) was statistically significant ($p < 0.0001$). The difference was also statistically significant at 12, 18, and 24 months postoperatively ($p < 0.0001$, respectively). In three patients the KPS score remained unchanged postoperatively. Scores improved by 10 to 30 points. In five patients (28%) an improved score of 10 points was shown (mean follow up 29 months); in seven (39%), 20 points (mean follow up 50 months); and in three (17%), 30 points (mean follow up 46 months). In patients who underwent near-total or subtotal tumor resection a stable tumor size was demonstrated on yearly follow-up MR images (mean 64 months), except in one patient who eventually died. Use of Cox’s proportional-hazard model revealed that radical tumor resection (gross total or near total, as defined herein, Figs. 3 and 4) and higher preoperative KPS score were factors that had a statistically significant impact on the favorable outcome in our series ($p < 0.03$ and $p < 0.02$ respectively), whereas sex and, interestingly, age did not.

There were no perioperative deaths. Four patients died during the follow-up period (Table 2). The first patient in this series (Case 1) underwent a gross-total tumor removal. Postoperatively she made a full recovery, and she had an uneventful postoperative course for 3 years until she developed multiple myeloma. She underwent radiotherapy and chemotherapy but died 18 months later at 79 years of age. One patient (Case 4) died more than 3 years after undergoing surgery for tumor recurrence. He presented with intractable facial pain, gait difficulties, ataxia, and diplopia caused by a sixth cranial nerve deficit. He underwent a subtotal resection and satisfactory decompressive surgery. The tumor was cauterized extensively at its origin and the vascular supply was interrupted as much as possible. He underwent radiotherapy. He recovered from all of his symptoms and returned to normal life for 3 years; the tumor size was judged to be stable on annual follow-up MR images. However, his symptoms then recurred with worsening of his heart condition, gait difficulties, and swallowing problems, and the tumor had in-

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Extent of Resection</th>
<th>KPS Score</th>
<th>Preop</th>
<th>Postop</th>
<th>Follow Up (mos)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>74, F</td>
<td>GT</td>
<td>70</td>
<td>100</td>
<td>44</td>
<td>died of multiple myeloma, 62 mos postop</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>62, F</td>
<td>ST</td>
<td>60</td>
<td>70</td>
<td>32</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>50, F</td>
<td>ST</td>
<td>70</td>
<td>90</td>
<td>84</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>77, M</td>
<td>ST</td>
<td>70</td>
<td>90</td>
<td>35</td>
<td>op for recurrence; died 37 mos postop</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>73, F</td>
<td>GT</td>
<td>70</td>
<td>100</td>
<td>84</td>
<td>op for recurrence; tumor stable</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>50, F</td>
<td>ST</td>
<td>60</td>
<td>60</td>
<td>83</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>53, F</td>
<td>GT</td>
<td>80</td>
<td>100</td>
<td>75</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>56, M</td>
<td>GT</td>
<td>70</td>
<td>90</td>
<td>62</td>
<td>died 5 mos postop</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>63, F</td>
<td>GT</td>
<td>30</td>
<td>40</td>
<td>4</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>36, M</td>
<td>NT</td>
<td>90</td>
<td>100</td>
<td>54</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>50, M</td>
<td>NT</td>
<td>70</td>
<td>90</td>
<td>47</td>
<td>tumor stable</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>77, F</td>
<td>GT</td>
<td>40</td>
<td>40</td>
<td>1</td>
<td>died 1.5 mos postop</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>53, F</td>
<td>GT</td>
<td>70</td>
<td>90</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>48, M</td>
<td>GT</td>
<td>80</td>
<td>90</td>
<td>33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>63, F</td>
<td>GT</td>
<td>90</td>
<td>100</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>49, F</td>
<td>GT</td>
<td>80</td>
<td>100</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>56, F</td>
<td>GT</td>
<td>70</td>
<td>100</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>52, F</td>
<td>GT</td>
<td>90</td>
<td>90</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* GT = gross-total resection; NT = near-total resection; ST = subtotal resection.

Fig. 2. Pie chart depicting the extent of the tumor resection in 16 patients who underwent first-time surgery for VFMMs.
creased in size. The patient refused further therapy, his condition progressively worsened, and he died 3 weeks later at the age of 80 years. The third patient (Case 9) presented with severe quadriparesis and had difficulties with swallowing and diplopia. In her case an aggressive post-operative course included placement of a gastric tube, early tracheostomy, and vocal cord medialization. She developed a CSF leak, which was surgically revised, followed by hydrocephalus, which required placement of a shunt. Her condition gradually stabilized, and she was transferred to a rehabilitation facility and subsequently to a nursing home. At 4-month follow-up examination, her quadriparesis had improved and she was ambulating with a walker. One month later, she was admitted to a local hospital for a deep venous thrombosis and received an inferior vena cava filter. Subsequently, she developed endocarditis and died 5 months after the surgery at 64 years of age. The fourth patient who died during the follow-up period (Case 12) presented with quadriparesis, dysarthria, and difficulties swallowing. She also had a history of atrial fibrillation and myocardial infarction. Her postoperative neurological status was unchanged. A gastric tube was placed and a tracheostomy was performed early, and she was transferred to a rehabilitation facility where she developed a pulmonary embolus and died 1.5 months after the surgery at the age of 78 years.

Histological Examination
In this series, the most common histological subtype was meningotheliomatous (39%). In all but one patient who underwent near-total or subtotal removal this tumor type was demonstrated. The transitional type was slightly more common (28%) than the psammomatous type (22%).

Discussion
Clinical Outcomes
Because of their location, VFMMs remain one of the most challenging meningiomas to treat. Often, they are not discovered until they are large, and the patient may be asymptomatic during a relatively long period. Their rare incidence (< 3% of all meningiomas) limits experience in their treatment. Yaşargil, et al.,43 have reviewed 114 patients who were surgically treated for FMM whose cases were reported between 1924 and 1976. They found an overall mortality rate of approximately 13%, an overall good outcome of 69%, a fair outcome of 8%, and a poor outcome of 10%. The Mayo Clinic experiences were reported in three different studies26,29,45 and included cases of all benign extradural tumors of the FM. Therefore, the surgery-related results of isolated VFMMs cannot be assessed.
Of seven FMMs series, which included VFMMs as defined herein, reported in the last 15 years, four were conducted in Europe. Fourteen cases of VFMMs were reported by Guidetti and Spalone (100% total removal; 14% mortality rate); five by Sen and Sekhar (60% total removal; 20% perioperative mortality rate); seven by Kratimenos and Crockard (86% total removal; 29% perioperative mortality rate); and eight by Babu, et al. (75% total removal; 13% mortality rate). The largest VFMM series (39 cases) was reported by George, et al., who achieved Simpson Grade I tumor resection in 56% and Grade II removal in 31% of cases, with an 8% perioperative mortality rate. Samii, et al., have reported 40 cases of craniovertebral meningiomas (63% total and 30% subtotal removal; 6% perioperative mortality rate). Their series probably included 25 cases of VFMMs as defined in this paper. Unfortunately, the surgery-related results for this subgroup cannot be isolated. Finally, Salas, et al., have recently reported 24 craniocervical meningiomas (66% total and 33 subtotal removal; 0% mortality rate).

Because our series deals only with ventrally located FMMs, comparisons with other series may be biased. Furthermore, it is difficult and, in part, scientifically inaccurate to make comparisons among series of patients with different variables (such as age, sex, exact tumor location and size, preoperative symptoms and meningioma type). Nonetheless, some conclusions can be drawn. We were able to achieve total resection in 75% of our cases at first surgery; in surgery for tumor recurrence, both resections were subtotal. This fact strongly suggests that radical tumor surgery should be pursued with zeal at initial surgery. As our results indicate, this time is best to effect a “cure.” A radical tumor resection proved to be a feature with a statistically significant impact on favorable clinical outcome. On the other hand, the feasibility of radical resection cannot be predicted prior to surgery in patients presenting with a recurrent tumor, and it is less likely to be achieved. Nonetheless, our results indicate that the surgeon should still endeavor to achieve the maximum possible decompression and cauterization of the capsule and tumor origin. This strategy appeared to contribute to a relatively satisfactory quality of life (in our series patients had KPS scores from 60–90, mean 75) and a relatively long period in which the patient’s condition was stable (mean 59 months). Furthermore, surgery itself has shown statistically significant impact on the improved KPS score when pre- and postoperative scores are compared. Age and sex, on the other hand, did not have an impact on the outcome. Naturally, a follow-up period longer than the current one (mean 40 months) is necessary for confirmation of results.

Although there were no surgery-related deaths, four patients died during the follow-up period. The first patient died of an unrelated disease (multiple myeloma). The second, who underwent surgery for a recurrent tumor, lived independently and her tumor size was documented to be stable, until it recurred again. Such a relatively long, stable follow-up period in this patient, along with that of the other patient who underwent surgery for a recurrent tumor and who is still alive and in good condition, lends credence to an aggressive treatment in such cases. Two other patients died 1.5 (Case 12) and 5 months (Case 9) after surgery of causes not directly related to surgery (pulmonary embolus and endocarditis, respectively). Nonetheless, these cases must be analyzed closely with respect to the surgery. These
two patients (63 and 77 years of age, respectively) were the only who presented with very low KPS scores (30 and 40, respectively), progressive deterioration of their quadriparesis, and swallowing problems. In fact, a low preoperative KPS score was a feature that had a statistically significant impact on an unfavorable outcome. The difficult decision to proceed with treatment was reached with these patients and their families. Although gross-total resection was achieved without technical difficulties and aggressive treatment initiated postoperatively (for example tracheostomy and placement of gastric tubes), both patients (particularly Case 9) experienced a series of complications. The conditions of both patients eventually stabilized, and they were transferred to a rehabilitation facility and neurological status improved minimally (Case 12) or remained unchanged (Case 9). Based on the results obtained in these patients, we learned that a low preoperative KPS score, a progressive clinical course, and quadriparesis are factors that portend a poor prognosis and a significant risk. Hence, early diagnosis and operative treatment is recommended.

Radiosurgical experience in the treatment of meningiomas is accumulating. However, because of the low incidence of VFMMs, the reported cases treated with radiosurgery are limited in number. Nonetheless, this treatment modality certainly should be considered in high-risk patients or for those who experience resection or tumor recurrence, as we did in two patients in our series.

Operative Techniques

Treatment of VFMM was begun by neurosurgical pioneers who opened a door into what was once considered a “no man’s land.” Traditionally, posterior midline suboccipital approaches and C-1 laminectomy have been used in the operative treatment of VFMM. Although the transoral approach has been advocated because it provides direct access to the craniovertebral junction, it has serious limitations in cases of intradural lesions: poor access to laterally placed or broad-based tumors, crossing of a contaminated operative field (oropharynx) causing meningitis or a CSF fistula, difficult dural closure, and destabilization of the craniovertebral junction. We found, as have other investigators, that the transcondylar approach is greatly advantageous in the treatment of VFMM. Although this approach is referred to by different names, in essence it is one approach in which there are variations in the patient’s position, the skin incision, muscle reflection, the VA complex transposition, amount of condyle drilling, and craniotomy. It should, of course, be tailored to fit the local anatomy and tumor characteristics in each patient.

Our experience indicates that drilling of the condyle is very important to performing a safe and radical tumor resection. In our series, the drilling ranged from approximately one third to one half of the condyle. This amount of drilling did not cause any craniovertebral instability. Another important factor is the size and development of the complex suboccpital venous compartment, earlier named as the SCS. Recently, Caruso and colleagues have described an elegant diagnostic MR imaging modality that seems to be an important contribution to preoperative evaluation of the SCS and planning of the operative tactics. The SCS provides an alternative anastomotic route for intracranial venous return. In some patients, this sinus can be engorged because the tumor compresses the basilar and epidural venous plexi. Thus, the sinus becomes a troublesome source of bleeding and potential air embolism. This risk may lead to a prolonged, complex dissection and transposition of the VA complex cushioned in the SCS. For this reason, we staged the intradural part of surgery at different times in three of our patients. Hyperostosis associated with the VFMM indicates tumor invasion. Aggressive bone drilling of the hyperostotic site is recommended to prevent regrowth from this nidus and tumor recurrence.

Surgery-Related Complications

In our series, the most common complication was the deficit of lower cranial nerves, the ninth and 10th in particular. As other authors have also pointed out, these deficits are the most dangerous, and they contributed significantly to the prolonged hospital LOS in our series. Fortunately, almost all patients in this series recovered or compensated for the function within a maximum of 8 months and on average within 66 days after surgery. We found it useful to try to predict the appearance of cranial nerve deficit and establish a preoperative baseline evaluation, including a formal or at least bedside swallowing study. This may have prevented occurrence of aspiration, pneumonia, and possible lethal outcome in our series. Postoperative management of these deficits should be cautiously undertaken and tailored to the patient’s circumstances. We advocate early placement of nasogastric or gastric tubes, as well as ear, nose, and throat monitoring with vocal cord injections or medialization and tracheotomies as indicated. Close follow-up examination by a speech pathologist and adjustment of feeding and types of diet are very beneficial. Almost all patients recover from deficits of other cranial nerves (sixth, 11th, and 12th cranial nerves) as long as the nerves are anatomically preserved and manipulated “cautiously” during surgery.

Four patients in our series developed postoperative CSF leak. Although watertight closure after transposition of the VA complex may be difficult, meticulous dural closure with fascial and fat autografts remains the only way to prevent this potentially dangerous complication. Nonetheless, there appears to be a learning curve with this complication, which is suggested by the fact that all cases were in the early phase of our series. In addition, hydrocephalus may be the underlying cause of the leak that requires insertion of a shunt. If a CSF leak occurs, additional sutures and external lumbar drainage should be attempted first. If this approach fails, revision is warranted.

Histological Findings

The histological findings of FMM have been reported only sporadically. Although the meningotheliomatous type was most common in our series (39%), it was not as frequent as reported by Yasuoka, et al. (68%) and George, et al. (55%). The psammomatous type was represented in only 22% of our patients, contrary to the results in the study by Stein et al., in which it comprised the majority. Although the histological type of meningioma may have had some yet unknown impact on the extent of tumor removal (the meningotheliomatous type was present
Ventral foramen magnum meningiomas

in all but one case in which near-total or subtotal tumor removal was achieved), it does not seem to have influenced the clinical outcome in our series.

Conclusions

In the majority of patients, a VFMM can be radically removed via the transcandylar approach, with a frequent but transient morbidity caused by lower cranial nerve deficits. Radical tumor removal should be attempted during the first surgery because this is the best time to effect a “cure.” Radical removal of a recurrent tumor, although less likely to be achieved, is also recommended, because most patients live a relatively long, stable period in good neurological condition. Patients with progressive motor weakness and a low preoperative KPS score have a poor prognosis. Hence, early diagnosis and operative treatment is recommended.

Acknowledgments

We are indebted to Ms. Julie Yamamoto for editorial assistance, Ms. Carolyn H. Thompson, M.S., for statistical analysis, and Mr. Ron M. Tribell for original artwork. We thank Drs. Kevin Yoo, (Loyola University), Alfred Bowles, and Ms. Kathy Suber (University of Mississippi) for providing necessary data for study completion. We are grateful to Ms. Sanja Arnautovic for tireless data gathering and processing.

References


Manuscript received April 22, 1999.
Accepted in final form September 27, 1999.
An earlier version of this manuscript was published in *Neurosurg Focus* **6** (6): Article 5, 1999.

Address reprint requests to: Ossama Al-Mefty, M.D., Department of Neurosurgery, University of Arkansas, 4301 West Markham, Slot 507, Little Rock, Arkansas 72205. email: almeftyosama@exchange.uams.edu.