Cavernous sinus meningioma

Cavernous sinus (CS) meningiomas are by definition those supratentorial skull base meningiomas which originate from the parasellar region.

Meningiomas occupying the CS represent a heterogeneous group of tumors originating and extending over different anatomical skull base surfaces.

History

Initially, CSMs were deemed inoperable due to the considerable mortality and morbidity related to removal of the tumor from what was deemed a surgically inaccessible area. With the introduction of the operating microscope and advances in neuroimaging, resection of Cavernous sinus meningiomas became a realistic goal. The advances in Microneurosurgical procedures in the 1980s and early 1990s allowed attempts at aggressive resection of these tumors.

Since final 1990s, the enthusiasm for aggressive resection has been tempered and the pendulum has swung toward a more conservative surgical strategy for treating the tumors of the parasellar region. Major factors that seem to be responsible for this paradigm shift include the efficacy and safety of postoperative radiosurgery on subtotally resected meningiomas, histological evidence supporting cranial nerve (CN) infiltration by meningiomas, and greater consideration of the impact of postoperative outcomes on the patients’ quality of life.

Epidemiology

Cavernous sinus meningiomas (CSMs) occur in 0.5 per 100,000 persons in the general population. There are an increasing number of asymptomatic patients with CSMs because CT scans or MR is commonly used for evaluation of other medical conditions, as cranial trauma and allows the diagnosis in the preclinical phase.

Classification

Sekhar’s Classification

Grade I— tumors involve 1 region of the sinus & do not invoke the ICA

Grade II—tumors occupy multiple regions of the sinus & displace but do not encase the ICA

Grade III—tumors encase the ICA w/o narrowing

Grade IV—tumors encase & narrow the ICA

Grade V—tumors involve both CSs & encase the ICA
Sphenocavernous, clinoidocavernous, and sphenoclinoidocavernous meningiomas

DeMonte's grading of tumour resection

Grade Definition

I Complete removal of tumour and dural attachment with any abnormal bone

II Complete removal of tumour and coagulation of its dural attachment

IIa Complete removal of intra- and extradural tumour without resection or coagulation of its dural attachment

IIb Complete removal of intradural tumour without resection or coagulation of its dural attachment or any extradural tumour extensions

IVa Intentional subtotal removal to preserve cranial nerve or blood vessels with complete removal of its dural attachment

IVb Subtotal removal leaving <10% tumour volume

V Subtotal removal leaving >10% tumour volume or decompression with or without biopsy

Diagnosis

For deciding the most appropriate surgical strategy, surgeons need detailed preoperative neuroimaging. The vicinity of the tumor with the vital and highly functional neurovascular structures, tumor extensions into the basal cisterns and skull base structures, and the arterial vascularization and venous drainage pathways, as they shape operative strategy, are important preoperative data to take into account. Thin section CT scan with bone windows, 3D spiral CT reconstruction, MRI, MR angiography, and DSA performed with selective arteriography including late venous phases give those required detailed informations about the tumor and its relation with neurovascular and bony structures.

Treatment

see Cavernous sinus meningioma treatment.

Outcome

Despite technical advances regarding microsurgical resections of cavernous sinus meningiomas, they are rarely completely resected and are often accompanied by a high rate of neurological disturbances. After partial or subtotal tumour removal, the probability of recurrence remains significant (13% at 3 years; 38% at 5 years).

The treatment of CSMs aims the best survival and local control coupled with the least possible morbidity. It includes close observation, surgical resection, radiotherapy, systemic therapy or a combination of these approaches. Management decisions obviously should have to take into account the patient-related factors (age, performance status, co-morbidities, and symptoms), and tumor features (size, localization, and histological grade). Given the high incidence of local recurrence,
radiotherapy usually is indicated when surgical access is difficult, poses a high risk of permanent neurological damage, resulting in incomplete resection and the tumors are Grades II or III.

Stereotactic radiosurgery (SRS) and fractionated Stereotactic radiotherapy (SRT) have been used in the treatment of symptomatic CSMs for more than 15 years. However, there are very few publications about the long-term disease-free survival rates and monitorization of the neurological abnormalities, radiological findings, and toxicity \(^{10}\).

**Complications**

A carotid cavernous fistula developed in a 62-year-old woman during an attempt of embolization. The cause is thought to be perforation by the guide wire during catheterization of the meningohypophyseal trunk at the sharp bend at its origin \(^{11}\).

**Case series**

Amelot et al., published the natural history using a prospective series of 53 consecutive patients. The median follow-up duration was 10.2 years (range 2-25 years), from 1990 to 2016.

Patients ranged in age from 30 to 72 years (mean 53 years). The meningiomas were diagnosed by major symptoms (mainly oculomotor nerve palsy and neuralgia experienced in 28 patients), minor symptoms (headache, intermittent diplopia in 15 patients), or incidental findings (10 patients). Simple symptomatic treatment (short courses of corticosteroids and carbamazepine) allowed patients to become asymptomatic in 19 (67.9%) of 28 cases experiencing major symptoms, and for 12 (80%) of 15 patients with initial minor symptoms (p < 0.0001). All patients with incidental findings remained asymptomatic. Forty four (83%) of 53 MCSs did not show any significant growth and 42 (80%) of 53 patients were not symptomatic at the end of follow-up (p < 0.001). The radiographic progression-free survival rates (± SD) at 5, 10, and 20 years were 90% ± 4.2%, 82% ± 5.7%, and 70% ± 10.2%, respectively. Five patients (9.4%) with no evidence of any effect of the initial medical treatment desired additional conventional radiation therapy.

Because of the capricious, unpredictable, and slow growth of MCSs, together with high growth variability from one patient to the next, the symptomatic medical treatment of these tumors is a highly effective method. This series shows that these lesions are naturally, clinically, and radiologically indolent \(^{12}\).

**2016**

In 65 patients, Sekhar's classification, modified Kobayashi grading, and the Karnofsky Performance Scale were used to define tumor extension, tumor removal, and clinical outcomes, respectively.

Preoperative CN dysfunction was evident in 64.6% of patients. CN II deficits were most common. The greatest improvement was seen for CN V deficits, whereas CN II and CN IV deficits showed the smallest degree of recovery. Complete resection was achieved in 41.5% of cases and was not significantly associated with functional CN recovery. Internal carotid artery encasement significantly limited the complete microscopic resection of CSM (p < 0.0001). Overall, 18.5% of patients showed symptomatic recurrence after their initial surgery (mean follow-up 60.8 months [range 3-199 months]). The use of adjuvant stereotactic radiosurgery (SRS) after microsurgery independently decreased the recurrence rate (p = 0.009; OR 0.036; 95% CI 0.003-0.430).

Modified Kobayashi tumor resection (Grades I-IIIb) was possible in 41.5% of patients. CN recovery and tumor control were independent of extent of tumor removal. The combination of resection and
adjuvant SRS can achieve excellent tumor control. Furthermore, the use of adjuvant SRS independently decreases the recurrence rates of CSM \(^{13}\).

2010

Sughrue et al. systematically analyzed the published literature and found more than 3000 patients treated for CSMs. Separate meta-analyses were performed to calculate pooled rates of recurrence and cranial neuropathy after 1) gross-total resection, 2) subtotal resection without adjuvant postoperative radiotherapy or radiosurgery, and 3) stereotactic radiosurgery (SRS) alone. Results were expressed as pooled proportions, and random-effects models were used to incorporate any heterogeneity present to generate a pooled proportion. Individual studies were weighted using the inverse variance method, and 95% CIs for each group were calculated from the pooled proportions.

A total of 2065 nonduplicated patients treated for CSM met inclusion criteria for the analysis. Comparisons of the 95% CIs for recurrence of these 3 cohorts revealed that SRS-treated patients experienced improved rates of recurrence (3.2% [95% CI 1.9-4.5%]) compared with either gross-total resection (11.8% [95% CI 7.4-16.1%]) or subtotal resection alone (11.1% [95% CI 6.6-15.7%]) (p < 0.01). The authors found that the pooled mixed-effects rate of cranial neuropathy was markedly higher in patients undergoing resection (59.6% [95% CI 50.3-67.5%]) than for those undergoing SRS alone (25.7% [95% CI 11.5-38.9%]) (p < 0.05).

Radiosurgery provided improved rates of tumor control compared with surgery alone, regardless of the subjective extent of resection \(^{14}\).

One hundred and seventeen patients with cavernous sinus meningiomas had LINAC radiosurgery in the period 1993-2007. Six cases were lost and 9 had less than 1 year follow up. The remaining 102 patients were prospectively followed up at 1 year intervals with clinical, neuro-ophthalmological and MRI examinations. Patients' age ranged between 31 and 86 years (mean 57). Seventy percent were females. The mean tumor volume was 7 cc. Thirty-three patients had previous microsurgery. Tumors were defined with high resolution MRI obtained 1-2 days before treatment and fused to stereotactic CT. Treatment was mostly delivered through a miniumultileaf collimator and multiple dynamic arcs. The minimal dose to the tumor margin was 12-17.5 Gy (mean 13.5) encompassed by the 80% isodose shell. Radiation dose to the optic apparatus was kept below 10 Gy. Follow up ranged from 12 to 180 months (mean 67 months). Tumor control (lack of growth) was 98% (58% of the tumors reduced their volumes). Sixty-four patients presented with cranial nerve deficit. Thirty-nine percent improved or resolved following radiosurgery. Cranial neuropathy had significantly higher resolution rates when radiosurgery was performed early (<1 year) after its appearance (53% as opposed to 26%) even in patients with deficits post surgery. Complications were seen in five patients (1 with deafferentation pain, 1 with facial hypesthesia, 1 with visual loss and 2 with partial VI neuropathy). Radiosurgery had a high control rate for meningiomas of the cavernous sinus with few and mild complications. Cranial neuropathy can be solved by treatment, particularly those of recent onset \(^{15}\).

100 patients (23 male/77 female) with meningiomas involving the cavernous sinus received GKS at the Department of Neurosurgery at Haukeland University Hospital, Bergen, Norway, between November 1988 and July 2006. They were followed for a mean of 82.0 (range, 0-243) months. Only 2 patients were lost to long-term follow-up. Sixty patients underwent craniotomy before radiosurgery, whereas radiosurgery was the primary treatment for 40 patients.
Tumor growth control was achieved in 84.0% of patients. Twelve patients required re-treatment: craniotomy (7), radiosurgery (1), or both (4). Three out of 5 patients with repeated radiosurgery demonstrated secondary tumor growth control. Excluding atypical meningiomas, the growth control rate was 90.4%. The 1-, 5-, and 10-year actuarial tumor growth control rates are 98.9%, 94.2%, and 91.6%, respectively. Treatment failure was preceded by clinical symptoms in 14 of 15 patients. Most tumor growths appeared within 2.5 years. Only one third grew later (range, 6-20 yr). The complication rate was 6.0%: optic neuropathy (2), pituitary dysfunction (3), worsening of diplopia (1), and radiation edema (1). Mortality was 0. At last follow-up, 88.0% were able to live independent lives.

GKS gives long-term growth control and has a low complication rate. Most tumor growths manifest within 3 years following treatment. However, some appear late, emphasizing the need for long-term follow-up.

2007

Sindou et al. report on the long-term outcome in 100 consecutive patients with meningiomas arising from the cavernous sinus (CS) with compressive extension outside the CS. The treatment in all cases was surgery alone without adjuvant radiosurgery or radiotherapy. The aim of this study was to evaluate the percentage of patients in whom surgery alone was able to produce long-term tumor control.

All 100 patients harbored meningiomas with supra- and/or laterocavernous extension, and 27 had petroclival extension. Surgery was performed via frontopterionotemporal craniotomy associated with orbital and/or zygomatic osteotomy in 97 patients. Proximal control of the internal carotid artery at the foramen lacerum was undertaken in 65 patients; the paraclinoid carotid segment was exposed extradurally at the space made by the anterior clinoidectomy in 81 patients. For the petroclival tumor extension, a second-stage surgery was performed via a presigmoid-retrolabyrinthine or retrosigmoid approach in 13 and 14 patients, respectively.

The mortality rate was 5% and two patients had severe hemiplegic or aphasic sequelae. The creation or aggravation of disorders in vision, ocular motility, or trigeminal function occurred in 19, 29, and 24% of patients respectively, with a significantly higher rate of complications when resection was performed inside the CS (p < 0.05). Gross-total removal of both the extra- and intracavernous portions was achieved in 12 patients (Group 1), removal of the extracavernous portions with only a partial resection of the intracavernous portion in 28 patients (Group 2), and removal only of the extracavernous portions was performed in 60 patients (Group 3). The follow-up period ranged from 3 to 20 years (mean 8.3 years). There was no tumor recurrence in Group 1. In the 83 surviving patients in Groups 2 and 3 combined, the tumor remnant did not regrow in 72 patients (86.7%); regrowth was noted in 11 (13.3%).

The results suggest that there is no significant oncological benefit in performing surgery within the CS. Because entering the CS entails a significantly higher risk of complications, radiosurgical treatment should be reserved for remnants with secondary growth and clinical manifestations.

2004

38 consecutive patients with sphenocavernous, clinoidocavernous, and sphenoclinoidocavernous meningiomas who underwent surgical treatment were assessed early and late cranial nerve morbidity, extent of resection, and long-term outcome (mean, 96 mo).

In all patients, tumors exceeded 3 cm diameter. In 22 of 24 patients, total microscopic excision was achieved in tumors that involved only the lateral compartment of the cavernous sinus and touched or
partially encased the cavernous internal carotid artery (i.e., modified Hirsch Grades 0 and 1, respectively). In 2 of 24 patients, remaining tumor infiltrated the superior orbital fissure. All 14 patients who had tumors that encased (with or without narrowing) the cavernous segment of the internal carotid artery (Hirsch Grades 2-4) underwent incomplete resection. Among 38 patients, mortality was 0%, late cranial nerve deficits remained in 6 (16%), and late Karnofsky Performance Scale scores exceeded 90 in 34 patients (90%). Four patients (10.5%) developed a recurrence or regrowth. Of 20 patients who were treated with either linear accelerator-based stereotactic radiosurgery or fractionated conformal radiotherapy, 11 had residual tumor and a moderate to high proliferative index, 4 had atypical tumors and 1 had angioblastic meningioma after total excision, 2 had regrowth, and 2 had recurrent tumors. In 18 (90%) of the 20 patients who underwent radiation, tumor size was reduced or controlled.

On the basis of this study and a review of the literature, we demonstrate that sphenocavernous, clinoidocavernous, and sphenoclinoocavernous meningiomas of Hirsch Grades 0 and 1 can be excised from the lateral compartment of the cavernous sinus without postoperative mortality and with acceptable rates of morbidity. Residual tumor in the medial compartment (Hirsch Grades 2-4) may be treated with some form of radiation therapy or observation.

Follow-up periods for the 40 patients ranged from 12 to 123 months (median 42 months), and the overall tumor control rates were 86.4% at 3 years and 82.3% at 10 years. Factors associated with tumor recurrence in univariate analysis were histological malignancy (p < 0.0001), partial treatment (p < 0.0001), suprasellar tumor extension (p = 0.0201), or extension in more than three directions outside the CS (p = 0.0345). When the tumor was completely covered with a dose to the margin that was higher than 14 Gy (Group A, 22 patients), no patient showed recurrence within the median follow-up period of 37 months. On the other hand, when a part of the tumor was treated with 10 to 12 Gy (Group B, 15 patients) or did not receive radiation therapy (Group C, three patients), the recurrence rates were 20% and 100%, respectively. Neurological deterioration was seen in nine patients, but all symptoms were transient or very mild.

The data indicate that stereotactic radiosurgery can control tumor growth if the whole mass can be irradiated by dosages of more than 14 Gy. When optimal radiosurgical planning is not feasible because of a tumor's large size, irregular shape, or proximity to visual pathways, use of limited surgical resection before radiosurgery is the best option and should provide sufficient long-term tumor control with minimal complications.

During the years 1985 to 1992, Knosp et al., encountered 59 patients with meningiomas involving the space of the cavernous sinus. In 29 of these patients, meningiomas were primarily located within the space of the cavernous sinus and were operated on without mortality and with low morbidity. A small subtemporal surgical approach was favored, which allowed initial tumor resection from the posterior aspect, where the Parkinson's triangle is wide, thus avoiding the additional morbidity of large-scale approaches. According to the relationships of the all-important cranial nerves passing within the lateral wall of the cavernous sinus, we divided the primary intracavernous meningiomas into four types, which reflected not only the preoperative cranial nerve deficit but also the feasibility of surgical resection. Cranial nerve function deteriorated after operations in 14% of oculomotor nerves, in one abducent nerve, in 58% of trochlear nerves, and in 21% of trigeminal nerves. We encountered improvement of function in 43% of oculomotor nerves, in 50% of abducent nerves, and in approximately 30% of the second and third but in only 7% of the first branches of trigeminal nerves.
There was no improvement in trochlear nerve function. Improvement of oculomotor nerve function was observed only in moderately impaired nerves, which indicates that surgery should be undertaken early to preserve or improve oculomotor nerve function. 

1993

Hirsch et al. retrospectively reviewed the CT, MR, and postoperative clinical findings in 65 consecutive patients with pathologically proved cavernous sinus meningiomas who had surgery during the period 1985-1991. Tumors were categorized on the basis of their relationship to the cavernous carotid artery. The presence of tumor in three anatomic sites (the sella, the sphenoid sinus, and the orbital apex) was also correlated with surgical complications.

Category 1 tumors, which do not completely encircle the cavernous carotid artery, were dissected without injury, sacrifice, or grafting of the artery in 91% of cases. Category 2 lesions completely encircle the artery but do not narrow its lumen; they could be dissected from the cavernous carotid artery without arterial injury in 61% of cases, but imaging failed to discriminate differences within this group. Category 3 lesions, which completely encircle and narrow the cavernous carotid artery, are usually difficult to dissect free from the artery. The categories also correlated with recovery of extraocular motility; 84% of category 1 lesions compared with only 36% of category 2 or 3 lesions will recover to good or excellent extraocular motility after cavernous sinus surgery. Tumor involvement of the sella, orbital apex, and sphenoid sinus correlated with postoperative endocrine dysfunction, decreased visual acuity, and CSF leak, respectively.

Imaging studies can frequently predict the difficulty of resecting cavernous sinus meningiomas from the cavernous carotid artery and the likelihood of permanent loss of extraocular motility after surgery on these lesions. This information is helpful in appropriate preoperative planning and in providing information to patients about to undergo such surgery.

Case reports

A 33-year-old female patient presented with diplopia and left eye ptosis 26 weeks into her first pregnancy. No investigation was conducted at the time and her symptoms subsided 4 weeks post partum. This same phenomenon occurred during second pregnancy at 20 weeks of gestation, with patient becoming symptom-free again 6 weeks after giving birth. MRI revealed a lesion in the left cavernous sinus in keeping with a meningioma. Due to the surgically challenging location, the lesion was treated with gamma knife radiosurgery. To date, the patient remains asymptomatic with no progression on follow-up imaging 9 years on.

References

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