Meningiomas Engaging Major Venous Sinuses

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Key words
- Gamma-knife radiosurgery
- Parasagittal meningioma
- Proliferation index
- Surgical management
- Venous sinus

Abbreviations and Acronyms
CT: Computed tomography
GOS: Glasgow Outcome Scale
MRI: Magnetic resonance imaging
WHO: World Health Organization

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Citation: World Neurosurg. (2014) 81, 1:116-124.
http://dx.doi.org/10.1016/j.wneu.2013.01.095

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

BACKGROUND: **Meningiomas with growth onto or into the major venous sinuses, that is, venous meningiomas, provide management problems regarding their radical removal and preservation of venous drainage. The relationship to venous structures often precludes radical surgery; the risk of recurrence and aggressive histology is greater for parasagittal meningiomas than in other locations. Older series reflect the conflict between radical surgery and subtotal removal followed by the "wait-and-scan" approach for the residual. This review summarizes our experience of a more contemporary series of venous meningiomas, after to the introduction of gamma-knife radiosurgery, for residual tumors and a long follow-up of 10 years.**

METHODS: **Treatment, histopathology, and follow-up data of 100 consecutive patients undergoing surgery for venous meningiomas were prospectively collected. Gamma-knife surgery was considered as a direct postsurgical adjunct or as an adjunct after a period of radiological follow-up. The proliferation marker MIB-1 was prospectively analyzed. Two patients were lost to follow-up after 5 years, and 98 were followed until their death or a minimum of 10 years.**

RESULTS: **The 6-month outcome was good-to-excellent in 94 patients; one patient died. Eighteen patients died within 10 years. Ten had aggressive or anaplastic meningiomas. In 10 years, tumor recurrence or progression was noted in 23 patients. One important reason was that only 42% of patients undergoing Simpson grade 1 removal had free resection margins at microscopic examination. Patients with Simpson grade 1 surgery had a recurrence rate of 10%. Patients with deliberate nonradical surgery (Simpson grade IV) had a tumor recurrence rate of 72%, whereas a combined treatment of direct gamma-knife radiosurgery after a tailored microsurgical resection (Simpson IV gamma) allowed return to a low recurrence rate of 10%. The tumor proliferation indices (MIB-1/Ki-67) were prognostically relevant for recurrence after either microsurgery or gamma-knife radiosurgery.**

CONCLUSION: **Surgical microscopic radicality was unexpectedly difficult to achieve. Gamma-knife radiosurgery was a useful adjunct but only in patients with tumors of low proliferative index. It should probably be used as part of the initial surgical management. As expected, treatment results for these patients seem to have improved during the last decades but recurrence and malignancy remained a problem, which is not always solved by repeated radiosurgery.**

INTRODUCTION

Venous meningiomas arise in close relationship with the major venous sinuses and are often analyzed separately as parasagittal, torcular, and tentorial meningiomas. Their potential of invading the sinus walls and affecting bridging veins are common denominators that complicate radical surgery. Several series of differently located venous meningiomas have been reported and the clinical features well described (1, 2, 7-9, 15, 19, 23). These series, however, reflect long series obtained without the availability the availability of magnetic resonance imaging (MRI), modern microsurgery, radiosurgery, or histopathology. Recent larger series (24, 30, 31) have begun to reflect recent therapeutic traditions, including access to MRI and modern microsurgery. Other factors that may affect treatment are prospective recording of proliferation indices, adjunctive gamma-knife radiosurgery, and patients' continuously increasing expectations of zero morbidity. Previous series have not fully addressed these matters. In particular, the timing of radiosurgery and the benefit of extensive sinus reconstruction to prevent recurrences is controversial. We reviewed prospectively collected data of 100 consecutive patients to analyze treatment options, results, and concerns with contemporary therapeutic traditions with special emphasis on the benefit of radical surgery and timing of radiosurgery.

MATERIAL AND METHODS

A total of 100 consecutive patients with venous meningiomas who were operated on between January 1, 1993, and December 31, 2002 were analyzed to obtain at least a 10-year follow up. The first author participated as a senior surgeon in all operations. A total of 73 patients belonged to the primary catchment area of

1.8 million, whereas residual patients were referred from other parts of Sweden or abroad. Sixty-seven patients were women (mean age, 56.6 years; range, 26–81) and 33 were men (mean age, 58.0 years; range, 27–81). Nine patients entered the study for surgery of recurrent tumors. Of all tumors, 22 were affecting the anterior one third of the superior sagittal sinus, 38 the middle third, 16 the posterior third, 6 were torcular, 5 affected the straight sinus, and 13 the transverse/sigmoid sinuses. Sixty-five tumors were restricted to one outer wall of a venous sinus, and 34 of them grew through the wall into the lumen of the sinus. Twelve tumors affected two walls, and 23 tumors affected all three walls.

All treatment data and histopathology were recorded prospectively. The tumors were graded I-III according to the World Health Organization (WHO) (16). Radical surgery was classified according to Simpson (28). In addition to regular histology, immunohistology was used. Ki-67/ MIB-1 was analyzed routinely, progesterone and estrogen receptors were analyzed in 67 patients, and other markers were added if needed. Patients were followed with an annual MRI scan. The mean follow-up was 5.9 years (range, 10 days to 12 years). Patients who lived were followed for a minimum of 10 years, and results after the 10-year follow-up were reported. Outcome was assessed as neurological compromise and according to the Glasgow outcome scale (GOS) (12).

Preoperative work-up included angiography, computed tomography (CT), and MRI scanning in all patients. MR angiography and venous blood-flow studies were undertaken in 33 patients. Two patients were lost to follow-up after 5 years, They had radical removal of WHO grade I tumors with low MIB indices (<2%); we have included their 5-year data in the material. Eighteen died before 10 years' follow-up, and the remaining patients were followed for at least 10 years. Routinely, patients underwent radiological follow-up (MRI or CT) with annual scans until 5 years, followed by semiannual scans until 15 years. Three additional patients who underwent radical surgery of WHO grade I tumors with low proliferation indices (<2%) and did not want to undergo scanning the past 2 years were only followed clinically for 14–17 years; their status did not change between the 10-year outcome and the outcome at 14–17 years. Statistical comparisons were undertaken by use of the Fisher exact test.

Surgical Technique

Routine microsurgical techniques were followed. Soft tissues were opened by straight incisions over the tumor centers or via regular flaps. The former allowed minimal preoperative shaving. Bone flaps were designed to allow tumor access from both sides of the respective sinuses and to allow control of all tumor poles. Hyperostotic and bone with tumor growth was removed. For hyperostotic bone adhering to intracranial tumor, the growth was removed with a high-speed drill to minimize blood loss. Bridging veins were dissected and preserved to allow tumor manipulation and access to deeper tumor without venous sacrifice.

Sharp dissection with microscissors was always used for arachnoid dissection to mobilize veins and cerebrum and also to divide tumor vessels and tumors that adhered to other structures. Tumors were devascularized early together with initial tumor decompression when indicated. Tumors were always decompressed sufficiently to allow for sharp dissection of the tumor peripheries under visual control without brain retraction. Self-retaining retractors were only used to hold the brain. To reach lateral extensions, a contralateral transfalcine approach was used when needed. If necessary, ventricular drainage was used intraoperatively to allow the draining of cerebrospinal fluid (n = 4). The anterior third of the superior sagittal sinus (n = 7), a totally occluded middle or posterior superior sagittal sinus (n = 3), or one of two functional transverse sinus (n = 5) was sacrificed if necessary during radical surgery. Care was always taken to preserve the rolandic veins, vein of Labbé, and other major draining veins. Depending on the growth pattern, three different methods were used to try to achieve radical surgery when it was indicated (**Figure 1A-C**).

Surgery aimed at radical removal with minimal risk for neurological deterioration. In younger patients, the goal of radical removal was pursued more aggressively than in older patients. Small residual tumor masses were left in 21 patients, who were either followed up or underwent radiosurgery. The timing of treatment depended on present therapeutic beliefs, which underwent changes during the inclusion period (20). Patients were treated with radiosurgery either as a part of an initial planned combination of tailored microsurgery and radiosurgery (Simpson grade IV gamma) or as treatment for a residual/recurrence that demonstrated progression. After recurrence or progression, radiosurgery was used if technically feasible. Otherwise, microsurgery was used. Radiation therapy was used after repeated surgeries in aggressive/anaplastic tumors (n = 4).

RESULTS

General Outcome

The 6-month outcome was good or excellent (GOS 1–2) in 94 patients, GOS 3 in 4, GOS 4 in 1, and death (GOS 5) in 1. The overall outcome from surgery was improvement in 68 patients, unchanged in 28 (18 of these were virtually asymptomatic before and after surgery), and worse in 4. Ten-year mortality was 18; 10 of these deaths were tumor related: one patient had an early postoperative death and the others died as a result of tumor recurrences. The patients who died from their tumors included the three with initially anaplastic and four with aggressive tumors. Of the latter, three progressed to anaplastic. The seven patients had a mean age of 62.7 years (range, 47–71) and comprised three men and four women. After their initial operations, they underwent a mean of 4.8 (range, 1–9) operations during 5.7 years (range, 7 months to 10 years).

Thirty-six patients had preoperative motor deficits. These patients had tumors that affected the premotor or motor areas. Of these, 26 (72%) improved, 4 (11%) remained unchanged, and 6 (17%) worsened. There were no new permanent motor deficits in the 68 who had no preoperative motor deficits but two patients with parietal tumors noted new sensory disturbances, and one patient with extensive occipital tumor growth suffered from a partial visual field deficit after surgery. Tumor recurrence/progression at 10-year follow-up was noted in 23 patients. (**Tables 1** and **2**).

Microscopic Radicality

A total of 29 patients underwent Simpson grade I removal, i.e., the entire tumor,