Original article

Spinal meningiomas: Surgical outcome and literature review

Méningiomes rachidiens : résultats chirurgicaux et revue de la littérature

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ABSTRACT

Background and purpose. – To evaluate the incidence, clinical presentation, operative techniques and long-term outcome of spinal meningiomas following surgery.
Methods. – Fifteen patients harboring spinal meningiomas were treated between 1998 and 2005 in our department. Diagnosis was made on magnetic resonance imaging and confirmed histologically. Microsurgical resection was carried out through a posterior approach in all cases.
Results. – Follow-up extended from 60 to 156 months (mean: 99 and median 105 months). The most common site of spinal meningiomas was the thoracic region. Tumors were strictly intradural and extramedullary in 14 patients (93%) and macroscopic resection was considered as complete in all cases. Neurological improvement was observed in 13 patients (87%). There was no operative mortality and morbidity was low (20%). No patient underwent radiotherapy and the recurrence rate is 8%.
Conclusion. – Spinal meningiomas are benign tumors for which advances in imaging tools and microsurgical techniques have yielded better results. The goal of surgery should be the total resection, which significantly reduces the risk of recurrence with an acceptable morbidity.

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RÉSUMÉ

Objectifs. – Préciser les caractéristiques épidémiologiques et cliniques des méningiomes rachidiens. Rappeler les modalités techniques opératoires et évaluer le devenir à long terme des patients après un traitement chirurgical.
Patients et méthode. – Quinze patients atteints d’un méningiome rachidien sont traités chirurgicalement dans notre institution entre 1998 et 2005. Pour chaque malade, le diagnostic est confirmé par l’étude anatomopathologique de la pièce opératoire. Dans tous les cas, le traitement est effectué par une approche chirurgicale postérieure.
Résultats. – La moyenne et la médiane de suivi des patients est de 99 et 105 mois (extrêmes 60–156 mois). La topographie de prédilection est la région thoracique. La tumeur était strictement intradurale et extramédullaire chez 14 patients (93%). Une résection jugée macroscopiquement complète était effectuée dans tous les cas. Une amélioration neurologique était observée chez 13 patients (87%). La mortalité opératoire était nulle et la morbidité faible (20%). Toutes les tumeurs étaient classées grade 1 de la classification de l’OMS et aucun patient n’a bénéficié d’une radiothérapie au cours de la période de suivi. Le taux de récidive était de 8%.
Conclusion. – Les méningiomes rachidiens sont des tumeurs bénignes. L’objectif du traitement chirurgical est d’aboutir à une résection complète en réduisant au maximum la morbidité et celui d’une récidive. Les progrès technologiques tant dans le domaine diagnostique que thérapeutique permettent d’afficher de bons résultats et d’envisager une chirurgie y compris chez des patients très âgés.

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1. Introduction

Spinal meningiomas account for 25 to 46% of primary spinal cord tumors (Roux et al., 1996; Gezen et al., 2000; Cohen-Gadol et al., 2003; Gottfried et al., 2003; Morandi et al., 2004; De Verdelhan...
et al., 2005; Haegelen et al., 2005; Hijiya et al., 2007; Cavanaugh et al., 2008; Dagain et al., 2009). Most spinal meningiomas occur in women older than 50 years (80%) and the most common location is thoracic (two thirds of cases). They are usually benign tumors with slow growth, occupying the intradural extramedullary space; purely extradural tumors are very rare (Solero et al., 1989; Roux et al., 1986; Gezen et al., 2000; Dagain et al., 2009).

The most frequent clinical findings are back pain, sensorimotor deficit and sphincter dysfunction. Magnetic resonance imaging (MRI) is the preferred imaging tool, allowing early diagnosis, operative planning and long-term follow-up (De Verdelhan et al., 2005; Schaller, 2005). Advances in surgical techniques (microsurgery, ultrasonic dissection, peroperative monitoring) increase the rate of complete resection. Prognosis of surgically treated patients is satisfactory, even when preoperative neurological status is poor (Levy et al., 1982; King et al., 1998; Klekamp and Samii, 1999; Gezen et al., 2000; Morandi et al., 2004; Yoon et al., 2007).

In the present retrospective study, we report on a single-center experience (Neurosurgery department at Montpellier Hospital, France) of spinal meningiomas operated on a 7-year period (1998–2005). Our primary objective is to assess clinical and radiological outcome in patients surgically treated. Secondary aim is to define potential prognosis factors associated with these lesions.

2. Material and methods

We found 15 patients harboring a spinal meningioma that were surgically removed at our institution over the predefined period. Medical records were retrospectively reviewed in order to collect clinical and radiological data. Demographic characteristics, neurological status, postoperative complications, neurological outcome and recurrence were noted. All patients underwent a preoperative MRI with injection of gadolinium: spinal levels were determined using sagittal T1 or T2 sequences; topography, tumor insertion and extradural extension were assessed on axial sequences.

All patients had a clinical and radiological follow-up: neurological and MRI evaluation was performed at 3 months postoperatively, annually after this point. Extent of surgical resection was assessed using the 3-month MRI and was considered as complete when all the tumoral part of the tumor was removed, regardless of the insertion site. Indeed, Simpson’s score, frequently used for intracranial meningiomas, is not validated in spinal meningiomas. Evidence of tumoral calcifications were classified as either complete, partial or absent.

3. Results

3.1. Demographic and baseline data

Mean age was 67.6 years (min: 28; max: 85; median: 61). There were 13 females for two males (sex ratio = 6.5), showing a clear predilection for women. Clinical presentation was mostly slow spinal cord compression, with a mean interval between onset of symptoms and imaging diagnosis of 11 months (min: 2; max: 48). Mean and median follow-up were respectively 99 and 105 months (min: 60; max: 156). A preoperative sensorimotor deficit was noted in 80% of the cases: gait disability involved 93% of patients, 33% were not independent; 60% of the patients reported back pain (Table 1).

Spinal levels were mostly thoracic (Table 1), while insertion site was respectively: antero-lateral (46%) to the cord, postero-lateral (27%), lateral (20%) and posterior (7%).

3.2. Surgery

A median posterior approach was performed in all patients. Under fluoroscopic guidance, a laminectomy exposing the superior and inferior poles of the tumor was made. After a regular midline dura opening, tumor was removed under operating microscope through either ultrasonic dissection and/or fragmentation. Insertion site was coagulated or resected. Gross total resection of the tumoral part of the tumor was performed in all patients, and confirmed subsequently on MRI at 3 months. Dural plasty was performed in two patients, while insertion site was coagulated in all other patients (87%).

3.3. Pathology

Partial intra-tumoral calcifications were observed in two cases (13%). Histological examination concluded to meningothelial meningioma in 53% of the cases (n = 8) and psammomatous meningioma in all other patients (n = 7). There was no sign of malignancy found in any specimen and all lesions were classified as grade 1 of the World Health Organization (WHO). None of the patients underwent adjuvant radiotherapy.

3.4. Clinical outcome

There was no postoperative mortality. At one year after surgery, sensitive and/or motor improvement was noted in 87% of the patients, while it remained stable in two patients (13%). Eighty-five percent of the patients who presented with gait disability were able to walk without assistance. The McCormick functional classification of spinal cord tumors at initial care and at follow-up is represented in Table 2.

Six out of nine (67%) patients who had preoperative sphincter dysfunction achieved complete resolution 2 years after surgery. Morbidity rate was 20% (three patients): one patient presented a neurological deterioration due to a compressive epidural hematoma, which was surgically evacuated leading to complete resolution; one patient sustained deep venous thrombosis requiring anticoagulation, and the last patient developed a cerebrospinal fluid (CSF) fistula, successfully managed with medical treatment (bed-rest, diuretic, acetazolamide).

3.5. Recurrence

There was only one recurrence (6%), at 8 years after initial surgery, in a patient who had a duro-plasty. Given to the fact that this recurrence was asymptomatic, no surgical treatment was undertaken.

<table>
<thead>
<tr>
<th>Table 1</th>
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<tbody>
<tr>
<td>Preoperative clinical presentations and meningiomas distribution along spinal levels.</td>
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<tr>
<td>Présentations cliniques préopératoires et niveaux de distribution des méningiomes le long de la colonne vertébrale.</td>
</tr>
<tr>
<td>Symptoms</td>
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<tr>
<td>Gait disability</td>
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<td>Motor deficit</td>
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<td>Paraparesia</td>
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<td>Radiculopathy</td>
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<td>Sensory deficit</td>
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<td>Pain</td>
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<td>Back pain</td>
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<td>Radiculopathy</td>
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<td>Pyramidal signs</td>
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<tr>
<td>Sphincter dysfunction</td>
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<tr>
<td>Localization</td>
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<tr>
<td>Cervical</td>
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<td>Thoracic</td>
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<tr>
<td>Lumbar</td>
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</table>
Table 2
McCormick functional classification of spinal cord tumors at initial care and at follow-up.
Classification de McCormick : classification fonctionnelle des tumeurs de la moelle épineère lors de la prise en charge initiale et au cours du suivi.

<table>
<thead>
<tr>
<th>Grade description</th>
<th>Number of patients (n = 15) at initial care</th>
<th>Number of patients (n = 15) at follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Neurologically normal, mild focal deficits, normal gait</td>
<td>7% (1)</td>
<td>80% (12)</td>
</tr>
<tr>
<td>II. Sensorimotor deficits affecting function, Severe pain, gait difficulties, can still walk</td>
<td>67% (10)</td>
<td>13% (2)</td>
</tr>
<tr>
<td>III. Moderate neurological deficit, request cane for ambulation, ± arms affected, ± independent</td>
<td>26% (4)</td>
<td>7% (1)</td>
</tr>
<tr>
<td>IV. As above + arms affected, usually not independent</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

4. Discussion

4.1. Epidemiology

Meningiomas are benign tumors, arising from arachnoidal cells and mostly intracranial. Spinal meningiomas are rare, totaling 1.2% of all meningiomas (Solero et al., 1989; Sandalcioglu et al., 2008). Most meningiomas are discovered in patients aged between 60 and 80 years (Levy et al., 1982; Solero et al., 1989; Roux et al., 1996; King et al., 1998; Klekamp and Samii, 1999; Gezen et al., 2000; Gottfried et al., 2003). Several studies showed that spinal meningiomas are more frequently observed in women, with a sex ratio (F/M) between 3 and 4.2/1 (Levy et al., 1982; Cohen-Gadol et al., 2003; Misra and Morgan, 2003; Yoon et al., 2007; Sacko et al., 2008; Sandalcioglu et al., 2008). In our study, this sex ratio is even more pronounced (6.5/1). Female predominance could be explained by hormonal factors as evidenced by progesterone and estrogen receptors frequently found on histological examination, as well as the reports of an association between meningioma and breast cancer, or tumor growth and hormonal phases (pregnancy, menopause) (Barnholtz-Sloan and Kruchko, 2007). External radiotherapy has been proven to be a risk factor, with a latency period that can be long (19–35 years) (Neglia et al., 2006; Hijiya et al., 2007; Umansky et al., 2008). One of our patients underwent spinal radiotherapy for leukemia as a child, which probably caused his spinal meningioma.

4.2. Clinical diagnosis

Delay in diagnosis is frequent in spinal meningiomas: mean interval between onset symptoms and surgical treatment is 1 to 2 years (Levy et al., 1982; Roux et al., 1996; King et al., 1998; Klekamp and Samii, 1999). Heterogeneous clinical presentation might explain the delay before appropriate imaging investigation. In our series as well, variability in clinical symptoms, ranging from gait disorders to sensorimotor and sphincter deficits, can explain this delay. Before the era of MRI, differential diagnosis included multiple sclerosis, syringomyelia, pseudo-tumoral herniated discs (Levy et al., 1982; Gezen et al., 2000), with a significant misdiagnosis rate (33% in Levy et al., 1982).

4.3. Imaging and topography

Nowadays, MRI is the diagnostic tool of choice for spinal meningiomas (Alorainy, 2006; Saraceni and Harrop, 2009): in their study spanning before and after MRI advent, Klekamp and Samii (1999) showed that MRI allowed a 6-month gain in diagnosis. Generally speaking, spinal meningiomas are isointense to the spinal cord in T1 and T2 sequences, and are strongly enhanced after injection of gadolinium (Fig. 1) (Gezen et al., 2000). In most series, as in ours, dorsal localization is strongly predominant (75% in Levy et al., 1982, 83.5% in King et al., 1998, and 79.5% in Roux et al., 1996), followed by cervical (14–27%) and lumbar (2–14%) meningiomas (Gottfried et al., 2003; Setzer et al., 2007). Most spinal meningiomas are intradural, extradural meningiomas being a differential diagnosis of epidural metastasis (Frank et al., 2008; Dagain et al., 2009).

4.4. Surgery and histology

The aim of the treatment is to protect neurological structures through surgical removal of the tumor. Advances in operating techniques, such as operating microscope and peroperative monitoring, make surgery for spinal meningioma safer (Fig. 2) (Sandalcioglu et al., 2008). In our series, gross total resection was achieved in all patients; in the literature, this rate is between 82 and 98% (Solero et al., 1989; Roux et al., 1996; Gezen et al., 2000; Morandi et al., 2004; Schaller, 2005). On the contrary to intracranial meningiomas, resection of the site of insertion is less achieved in spinal meningiomas (Levy et al., 1982; Solero et al., 1989; Roux et al., 1996; King et al., 1998; Klekamp and Samii, 1999; Gezen et al., 2000; Yoon et al., 2007). Indeed, anterior localization, risk of CSF fistula and intra-tumoral calcifications, make complete surgical resection very difficult (Levy et al., 1982; Solero et al., 1989; Roux et al., 1996; Naderi et al., 2001; Saito et al., 2001). In the ventrally

Fig. 1. Illustrative case of a 82-year-old female with an anterior located thoracic meningioma at T2–T3 level. The tumor displayed intermediate signal intensity on sagittal and coronal T2 weighted MRI (A). Marked enhancement after intravenous paramagnetic agent administration on axial T1-weighted MRI (B).
located meningiomas a partial facetectomy (30–40%) and a pedicles removal can be performed in order to increase the viewing angle to the tumor mass. Secondly Dentate ligament section is essential on one side to facilitate spinal cord handling and to expose the tumor. Tumor removal begins laterally on the side where dural attachment is the largest, in order to minimize injury to the spinal cord. A microcavitron ultrasonic aspirator (CUSA) may be used to debulk the tumor but extreme caution is recommended with this tool. It may cause significant injury to the cord. Therefore, tissue resection followed by dural coagulation is deemed appropriate and efficient (Sandalcioglu et al., 2008). The histological subtypes encountered in decreasing order are psammomatous, meningothelial, fibroblastic and transitional (Solero et al., 1989; King et al., 1998; Klekamp and Samii, 1999, Gezen et al., 2000; Schaller, 2005). The histological subtype (apart from signs of malignancy) does not seem to influence prognosis (Roux et al., 1996; King et al., 1998). Even though surgery is considered the treatment of choice, radiosurgery has been proposed, in particular to treat recurrences (Roux et al., 1996; Gezen et al., 2000; Gottfried et al., 2003); it can also be an alternative for patients in which surgery is contraindicated and as an adjuvant therapy for malignant meningiomas. Roux et al. (1996) reported two cases of recurrences that were treated with radiosurgery: at 5 years follow-up, patients were stable clinically and radiologically.

4.5. Neurological outcome

After surgery, functional outcome is usually satisfactory (Levy et al., 1982; Solero et al., 1989; Roux et al., 1996; King et al., 1998; Klekamp and Samii, 1999). In our series, neurological improvement was observed in 87% of cases at one year. Among those who had sphincter dysfunction, 67% experienced some improvement. This is consistent with other studies: Klekamp and Samii (1999) found that 80% of the patients were able to walk at one year post-surgery and neurological improvement was observed in 79 to 98% of the cases (Levy et al., 1982; Solero et al., 1989; Roux et al., 1996; Klekamp and Samii, 1999; Gezen et al., 2000; Schaller, 2005; Yoon et al., 2007). Nevertheless, pejorative prognosis factors do exist: intra-tumoral calcifications make surgery more difficult, leading to increased risk of neurological damage (Levy et al., 1982), while postoperative arachnoiditis are associated with neuropathic pain and sensory deficits (Klekamp and Samii, 1999). On the other hand, older patients do not seem to perform worse than others: indeed, Morandi et al. (2004) report functional improvement in all 30 patients older than 70 years who underwent surgery for spinal meningiomas.

4.6. Complications and recurrences

Mortality rate reported in the literature is between 0 and 4% (Table 3). Most frequent causes include pulmonary embolism, pneumonias, stroke, and myocardial infarct (Levy et al., 1982; Solero et al., 1989; King et al., 1998; Klekamp and Samii, 1999). Incidence of CSF fistulae is low 0–4% (Gottfried et al., 2003; Setzer et al., 2007). Tumor recurrences are uncommon, with rates varying between 1.3 and 40.3% (Table 3), and may occur from 1 to 17 years after surgery; slow growth rate and old age at diagnosis might also explain those low rates (Levy et al., 1982; Solero et al., 1989; King et al., 1998; Gezen et al., 2000; Nadkarni et al., 2005). Indeed, we believe that spinal meningiomas have such a low rate of recurrence because of both their poor trend for growth (they are mostly psammomatous calcifying tumors) and their prevalence in an aged population in whom the follow-up period is relatively short. In our cohort, we found only one case of asymptomatic recurrence for which no surgery was indicated. Klekamp and Samii observed a 29.5% rate of recurrence at 5 years post-surgery in patients with complete resection, whereas all patients who had partial resection presented a recurrence (Klekamp and Samii, 1999). On the contrary to intracranial meningiomas, there is no correlation between insertion base treatment (resection or coagulation) and rate of recurrence (Solero et al., 1989; King et al., 1998; Klekamp and Samii, 1999; Gezen et al., 2000). As an illustration, our only recurrence case happened following dural resection and plastic.

As a general rule, spinal meningiomas have a more favorable outcome compared to intracranial localizations. Indeed, Mirimanoff et al. report a recurrence rate of 13% at 10 years for spinal meningiomas, as opposed to 3–25% for convexity meningiomas and 18–24% for sagittal meningiomas (Mirimanoff et al., 1985).

5. Conclusion

Spinal meningiomas are benign tumors whose prognosis is very favorable following surgical removal. The severity of clinical presentation should not be a contraindication for surgery. MRI is the modality of choice for radiological diagnosis, operative planning and follow-up. Advances in microsurgery led to a low morbimortality rate, so that age neither should be considered as a surgical contraindication. Risk of recurrence is lower for spinal compared to

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Table 3

<table>
<thead>
<tr>
<th>Articles</th>
<th>Number of patients</th>
<th>Total resection (%)</th>
<th>Morbidity (%)</th>
<th>Mortality (%)</th>
<th>Recurrence rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roux et al., 1996</td>
<td>54</td>
<td>92.6</td>
<td>2</td>
<td>0</td>
<td>3.7</td>
</tr>
<tr>
<td>King et al., 1988</td>
<td>78</td>
<td>98</td>
<td>4</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Klekamp and Samii, 1999</td>
<td>117</td>
<td>89</td>
<td>0.8</td>
<td>1.5</td>
<td>40.3 (after 5 years)</td>
</tr>
<tr>
<td>Schaller, 2005</td>
<td>33</td>
<td>85</td>
<td>21</td>
<td>0</td>
<td>3</td>
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<tr>
<td>Sandalcioğlu et al., 2008</td>
<td>131</td>
<td>97</td>
<td>3</td>
<td>0.8</td>
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<tr>
<td>Our study</td>
<td>15</td>
<td>100</td>
<td>20</td>
<td>0</td>
<td>6</td>
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Fig. 2. Operative posterior view of the same case after dento-rect section. Même cas : vue postérieure peropératoire, après section du ligament dentelé.
intracranial meningiomas, even though extent of resection is often less optimal.

**Disclosure of interest**

The authors declare that they have no conflicts of interest concerning this article.

**References**


