



Metastatic Atypical and Anaplastic Meningioma: A Case Series and Review of the Literature

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- **BACKGROUND:** Atypical (World Health Organization grade II) and anaplastic (World Health Organization grade III) meningiomas are rare, accounting for less than 5% of all meningiomas. Histologic grading has a significant impact on prognosis, risk of recurrence, and the need for adjuvant radiation or chemotherapy. Extracranial metastases are even more infrequent and occur in 0.1% of all cases.
- **METHODS:** Retrospective chart review of 168 patients with diagnosis of WHO grade II and III meningiomas was performed. Six patients with histologically confirmed metastatic disease were identified.
- **RESULTS:** We discuss the clinical, radiologic, and histopathologic clinical course of 6 patients with metastasis to the lung, liver, and spine from all patients with atypical or anaplastic meningioma treated at Johns Hopkins Hospital from 1993 to 2014.
- **CONCLUSIONS:** We reviewed the literature pertaining to this phenomenon and subsequently assessed the clinical benefits of adjuvant chemotherapeutic agents in patients with meningioma with metastatic disease.

INTRODUCTION

Meningiomas are the most common central nervous system tumors in adults, constituting more than 30% of all intracranial tumors.¹ They are typically benign solitary intracranial neoplasms, generally found at the skull base

or over the convexity of the brain. Meningiomas are classified by tumor differentiation and mitotic activity by the World Health Organization (WHO) grading scale into 3 types: benign (WHO grade I), atypical (WHO grade II), and anaplastic/malignant (WHO grade III).² WHO grade II and III meningiomas are characterized by more aggressive behavior and a high risk of recurrence, fluctuating between 29% and 52% and 50% and 94%, respectively.^{3,4} Histologic grade, subtotal resection, young age, specific subtypes, brain infiltration, and high proliferative rate are known risk factors for recurrence.^{2,5} Despite substantial advances in modern therapies, surgical resection remains the best treatment option for most patients with malignant meningioma. However, complete resection is often unfeasible.⁶ The current standard of care consists of maximally safe gross total resection (GTR) and subsequent radiotherapy for WHO grade III lesions. Radiotherapy is optional for WHO grade II lesions. WHO grade II meningiomas show 5-year progression-free survival rates of 74%–100% with GTR and radiotherapy, whereas WHO grade III meningiomas show 5-year overall survival of 47%–61% with GTR and radiotherapy.^{7,8} There are no defined U.S. Food and Drug Administration approved chemotherapeutic agents for treatment of refractory meningioma, and those tested have been shown to have limited clinical efficacy.^{9,10} In 2011, the National Comprehensive Cancer Network¹¹ released guidelines advocating only 3 classes of chemotherapeutic agents, interferon α , somatostatin receptor agonists, and vascular endothelial growth factor signaling inhibitors for the medical treatment of meningioma. However, these recommendations are derived from a few small studies, and therefore larger prospective studies and clinical trials are encouraged.¹² Recent clinical trials testing newer treatment of high-grade meningiomas include chemotherapy, immunotherapy, small molecules, and different radiation regimens.^{13–17}

Key words

- Anaplastic
- Atypical
- Meningioma
- Metastasis
- Resection

Abbreviations and Acronyms

- GTR:** Gross total resection
MRI: Magnetic resonance imaging
WHO: World Health Organization

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Extracranial metastasis from meningiomas is a rare phenomenon and presents in 0.1% of cases.¹⁸⁻²² When this phenomenon occurs, the most frequent site of metastasis is the lungs (60%), followed by liver, lymph nodes, and bone.^{5,9,23-26} Because of the rare nature of extracranial metastasis, no standard protocol of management has been established and the prognosis for these patients is unknown.^{5,9}

METHODS

Patient Population

Under an institutional review board approved protocol, medical records of patients with diagnosis of WHO II or III meningioma were retrospectively reviewed from 1993 to 2014 at Johns Hopkins Hospital. The review included operative notes, pathology reports, and clinic visit notes for patients who had a pathologically confirmed atypical or anaplastic meningioma. Patients with metastatic disease were selected for this case series.

Literature Review

We conducted a comprehensive literature search through PubMed to identify case reports, case series, and literature reviews that address atypical or anaplastic meningioma metastasis. We selected the terms atypical meningioma, anaplastic meningioma, and metastasis. All applicable articles were evaluated for their relevance. Exclusion criteria consisted of intracranial metastasis, not atypical/anaplastic meningioma, tumor-to-tumor metastasis, original meningioma was extracranial, iatrogenic metastasis, pediatric patient population, not case report/series, and non-English language. The chosen articles were carefully scrutinized and their information was extracted to provide a comprehensive summary of case reports of WHO grade II or III meningioma metastasis. The initial search identified 50 articles. Two reviewers independently examined the search results to screen for applicable articles. There was agreement on 13 articles. These were then summarized (Table 1).

Case Reports

Case 1. A 24-year-old female patient presented with signs of intracranial hypertension. She was diagnosed with a falcine meningioma and underwent GTR of a WHO I meningioma in 1998. In 2000, she developed severe headaches and was found to have a local recurrence that was managed conservatively. In 2004, the patient underwent a second surgical resection and pathology indicated a WHO grade II meningioma. A few months later, she developed palpable masses in the scalp and underwent removal of extracranial subcutaneous meningioma and adjuvant radiation (total dose, 5580 cGy). In 2007, the patient underwent resection of 3 additional skull masses and she was found to have bilateral lung masses; all these lesions had histology consistent with atypical meningioma. In 2011, the patient presented with right cranial neuropathies. Magnetic resonance imaging (MRI) showed disease in the right cavernous sinus and right skull base. The patient received additional image-guided intensity-modulated radiotherapy to the right middle cranial fossa (total dose, 5040 cGy). In 2012, she underwent further surgical resection and had multiple metastatic lesions found on computed tomography of the chest

Table 1. Patient Data and Clinical Course Summary

Patient	Age at Diagnosis (years)	Sex	Histopathology	Tumor Location	Metastasis Location	Number of Resections	Radiation (Y/N)	Chemotherapy	Outcome	Time to Death (years)
1	24	F	I, then II	Falcine, calvarium, R cavernous sinus, R skull base	Lung	5	Y	Doxorubicin	Death	15
2	69	F	Malignant (II?)	L frontal parasagittal falcine, R temporal fossa, skull base, orbits	Lung	3	Y	Hydroxyurea	Death	5
3	54	F	II, III	L parietal, R frontoparietal, superior sagittal sinus, scalp, falk, L frontal convexity	Lung, mediastinum	7	Y	Hydroxyurea, bevacizumab	Death	32
4	66	M	Malignant (III?)	Frontal extending into frontal sinuses, R cerebellar, R temporal, R occipital	Lung, pleura	1	Y	None	Death	3
5	65	M	II, III	L frontal, L hemisphere extending to calvarium, multiple meningeal masses in entire L hemisphere, falk	Liver, spine	4	Y	Hydroxyurea	Death	10
6	49	M	II	Superior sagittal sinus	Liver	5	Y	Temozolomide	Death	7

Y, yes; N, no; F, female; R, right; L, left; M, male.

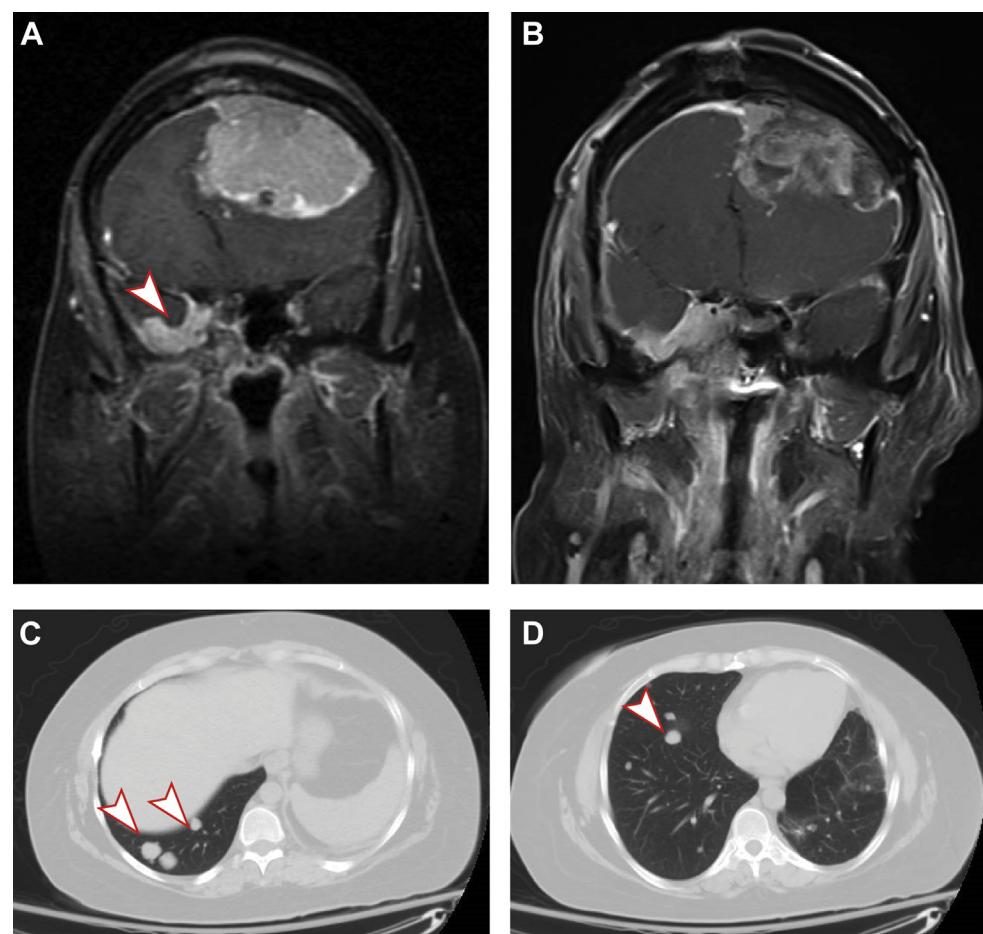


Figure 1. Case 1, 24-year-old female who presented initially with WHO I meningioma that progressed to WHO II. **(A)** Coronal T1 post-contrast of May 2012 image showing tumor recurrence in the region of the falcine meningioma resected several years prior, note

enhancing disease in the right cavernous sinus region (arrowhead). **(B)** Post-operative T1 post-contrast scan on May 2012. **(C and D)** Metastatic meningioma lesions in lung parenchyma (arrowheads).

(**Figure 1**). She received chemotherapy (doxorubicin) but became confined to a wheelchair. In 2013, the patient was directed to hospice care and died shortly thereafter.

Case 2. A 69-year-old female patient presented with a large left frontal falcine meningioma in 1994. She underwent GTR, and pathology showed a WHO grade III tumor. In 1996, a second tumor resection was performed for recurrence and she had a full course of radiotherapy. In 1997, MRI showed a mass in the right temporal fossa and the patient underwent resection, but during preoperative evaluation, chest radiography showed multiple lung nodules. Chest computed tomography again showed multiple lung lesions consistent with metastatic disease. The patient underwent a biopsy of a lung lesion and pathology indicated malignant metastatic meningioma. The patient was treated with hydroxyurea and radiation therapy. Three months later, she presented with left cranial neuropathies. Imaging showed a series of infiltrating lesions involving the skull base and the orbits. The

patient died approximately 2 years after the final surgical resection.

Case 3. A 54-year-old woman with a history of multiple meningiomas presented for thyroid nodule evaluation. She initially presented with a seizure in 1983 and underwent meningioma resection. A subsequent left parietal meningioma was diagnosed and resected in 2002. In 2003, the patient developed leg weakness and gait instability. MRI in June 2003 showed recurrence of a large right frontoparietal meningioma and appearance of multiple new lesions, for which she underwent resection. The resection had clean margins; however, during surgery, the surgeon noted some evidence of a brain lesion and the resection was limited by proximity to eloquent structures. The right frontoparietal lesion was pathologically a grade II meningioma. MRI showed residual tumor in the superior sagittal sinus. She then underwent Gamma Knife (Elekta, Stockholm, Sweden) radiation therapy with 59.4 Gy in 33 fractions to the frontal region. In 2007, repeat MRI showed

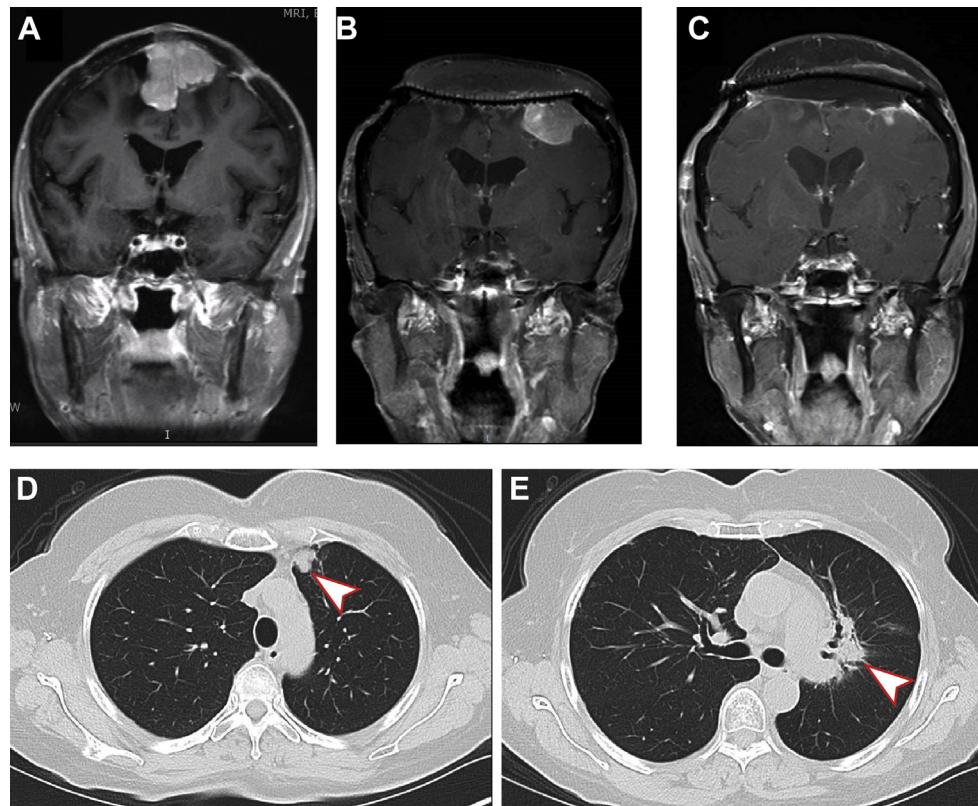


Figure 2. Case 3, 54-year-old woman with history of multiple meningiomas. (A) Coronal T1 post-contrast of March 2008 showing tumor recurrence in the region of a meningioma resected several years prior. (B) The tumor shown in A was resected and in April 2014 there

was a recurrence in the margins of resection. (C) Post-operative T1 post-contrast image after resection of recurrence. (D and E) CT of the lungs showing metastatic meningioma lesions in February 2014 (arrowheads).

the presence of recurrence. One year later, the patient again underwent surgical resection for a midline recurrence over the frontoparietal area with obliteration of the superior sagittal sinus apparent on a magnetic resonance venogram. In addition, in June 2009, the patient underwent resection of a lesion in the scalp consistent with a WHO grade II meningioma. She had 2 more resections and her disease progressed to a WHO grade III meningioma. When her disease showed progression, she was started on hydroxyurea, with a poor response. In June 2011, the patient was found to have a lung nodule and underwent a left lower lobe wedge resection and total removal of the lesion. A diagnosis of metastatic meningioma was made. She had concurrent hydroxyurea and fractionated stereotactic radiosurgery, with no response and continued growth of the intracranial masses (Figure 2). Because of this status and the concurrent clinical decline, she started bevacizumab. With progressive functional decline, seizures, inability to walk, and severe pain, as well as MRI-confirmed progressive meningioma growth, the patient exhausted all therapeutic options and went to a hospice in 2015.

Case 4. A 66-year-old male patient presented with confusion and a mass on the right forehead in 1996. MRI showed a large

frontal lesion extending into the frontal sinuses. Surgical resection was performed and pathology indicated WHO III malignant meningioma. The patient then underwent radiation therapy. In May 1999, he was found to have distant right cerebellar hemispheric lesions and received stereotactic radiosurgery. One month later, the patient presented with a 2-week history of dyspnea. Chest radiography showed complete opacification of the left hemithorax and nodules in the right upper lobe. There was also metastasis to the pleura. The patient underwent thoracentesis and biopsy of a mass in the left lung. Pathology was consistent with meningioma. The patient died 3 months later in September 1999.

Case 5. A 65-year-old male patient presented with a seizure in 2003. Workup showed a left frontal meningioma (WHO grade II). Three months after resection, a small lesion was seen and the patient then underwent Gamma Knife radiation in 2004, with no response. In December 2004, he underwent surgical resection. Three months later, the patient presented with a recurrence and underwent Gamma Knife treatment in July 2005, February 2006, and December 2006. He continued having sporadic seizures, but imaging remained stable. During a routine follow-up in 2008, MRI

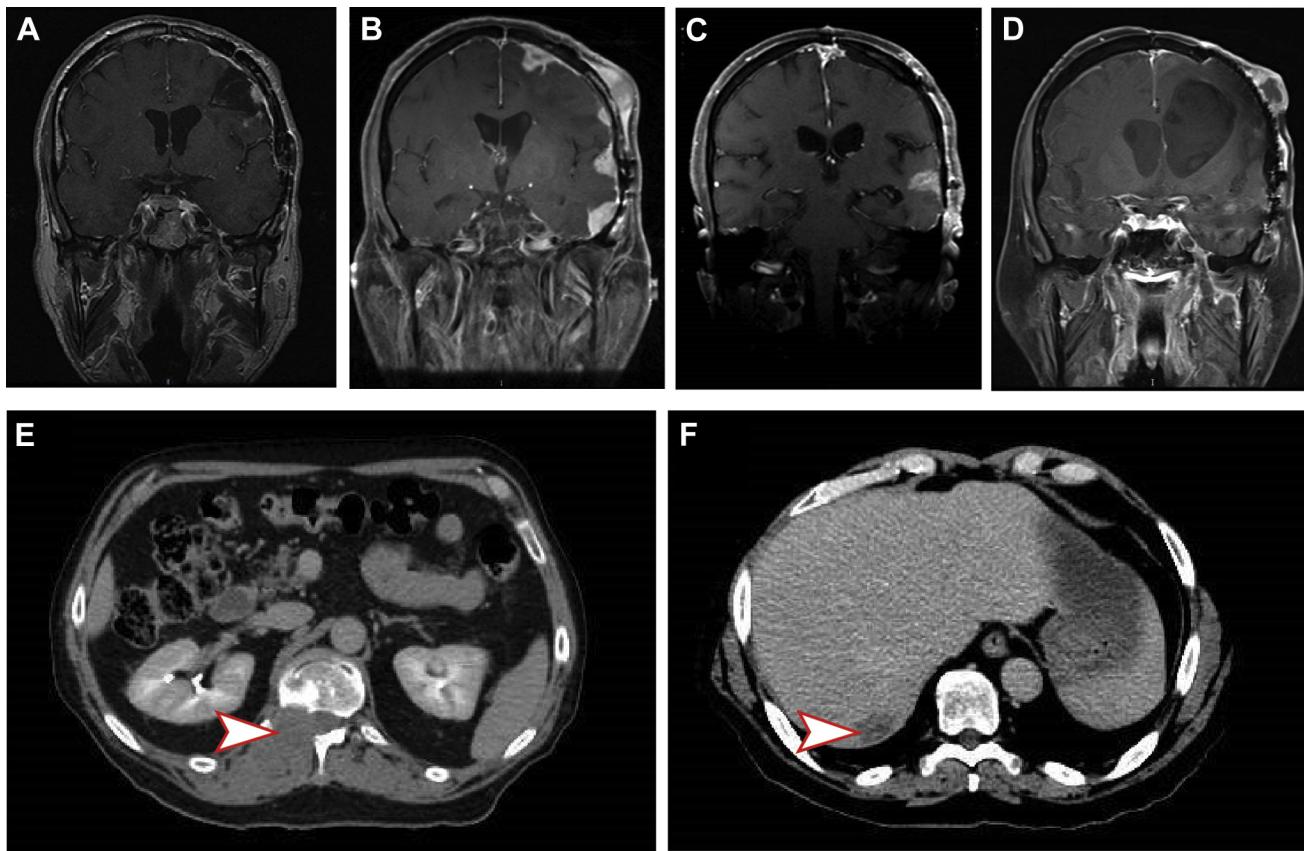


Figure 3. Case 5, 65-year-old man with history of atypical meningioma. **(A)** T1 post-contrast image in June 2007 demonstrating small nodular enhancement in tumor cavity. **(B)** T1 post-contrast image from July 2008 showing multiple contrast-enhancing nodules. **(C)** Post-operative T1

post-contrast image showing resection of multiple enhancing nodules in September 2008. **(D)** Follow-up scan in November 2009. **(E and F)** Body CT scans showing a metastatic lesion in the right pedicle of L2 vertebra (osteolytic) and a hypodense liver nodule.

showed an increase in size of the meningioma overlying the left hemisphere that extended through the calvarium. The patient was started on hydroxyurea, with no response. Because of the increase in size of the recurrent tumor, surgical resection was performed. At this stage, pathology showed WHO III anaplastic meningioma and the patient underwent whole-brain radiation (total dose 40 Gy in 20 fractions of 200 cGy) with an electron boost to 2 left scalp lesions. In January 2009, the patient began hydroxyurea therapy but continued to worsen. Nine months later, the patient had metastatic disease, including the liver and an L2 lesion (**Figure 3**). He died 2 months later.

Case 6. A 49-year-old male patient originally presented in 1999 and was diagnosed with an atypical meningioma. After his resection, he underwent Gamma Knife radiation and standard external beam radiation therapy. He underwent 4 craniotomies in 2001, 2 in 2004, and 1 in June 2005. In 2006, repeat MRI showed a large multilobulated mass extending intracranially and extracranially that invaded the superior sagittal sinus. Before planned surgical treatment of the recurrence, the patient sustained a seizure and head trauma resulting in a left frontoparietal

hemorrhage. He was managed conservatively. On examination, he had flaccid paralysis in the right extremities, receptive and expressive aphasia, and incontinence of bowel and bladder. The patient was sent to home hospice 3 weeks later.

A clinical course outline of these 6 patients and a review of the existing literature are presented in **Tables 1** and **2**, respectively.

DISCUSSION

Most meningiomas are benign tumors; however, a small subset has an aggressive clinical profile typified by high recurrence rates, histologic variability, resistance to treatment, and poor prognosis. The histologic grade of the meningioma determines the type of treatment indicated. Malignant meningiomas (WHO grade III) have a higher rate of recurrence and metastasis. Perry et al.³⁹ reported that the median survival time for malignant meningiomas was 1.5 years, with a 5-year mortality of 68%. Surgical resection is reported to carry the risk of causing iatrogenic metastasis of histologically aggressive meningiomas⁴⁰; however, malignant meningiomas can disperse and propagate with no previous surgery⁴¹ and can appear in surgical sites of previous

Table 2. Summary of the Literature

Reference	Article Type	Gender	Initial Presentation	Recurrence Presentation	Time to Recurrence(s) (months)	World Health Organization Grade	Extracranial Metastasis Location	Treatment	Follow-Up	Outcome
Tao et al. 2014 ²⁷	Case report	F	Headache (R occipital region), blurry vision	Headache, dizziness	12, then 6 months after that	III	Pulmonary lobe, C2	Resection (total) ×3	N/A	Patient died 1 month after thoracotomy from pneumonia
Iwami et al., 2015 ²⁸	Case report	M	Mild headache	Last recurrence: severe headache and gait disturbance	48, then 12 months after that, then 24 months after that	III	Lung and bone	Resection (total), Gamma Knife radiosurgery for first recurrence. Then 3 more surgical resections	N/A	Patient died 2 months after last resection as a result of increased intracranial pressure and multiorgan failure
Baek et al. 2012 ²⁹	Case report	M	History of left-side nasal obstruction, episodes of epistaxis, hyposmia, and postnasal discharge (had endoscopic sinus surgery)	Severe epistaxis and general weakness × 1 month, breathing difficulties	24	II, III (recurrent tumor)	L anterior chest wall	Resection (complete), recurrence: local external radiotherapy	2 weeks after radiation, multiple small subcutaneous tumors occurred all over body	Transfer to palliative care; patient died 3 months later
Kim et al. 2012 ³⁰	Case series (only 1 of 2 patients meets criteria for inclusion)	F	N/S	Last recurrence: back pain over 4 months	19 and again at 45–60 months after first surgery: metastasis	III	Node and posterior element of T11	Resection (total), corpectomy, and posterior fusion for T11 metastasis	N/A	N/A
Moubayed et al., 2011 ³¹	Case report	M	N/S	N/S	24, 12 months after that for metastasis	I, III (recurrence)	Lymph node	Resection ×3 (complete) Modified radical neck dissection, adjuvant helical tomotherapy-based intensity-modulated radiation therapy, radiotherapy for residual lymph nodes	2 years	Absence of recurrence, both locally and in the neck
Sabet et al., 2011 ³²	Case report	F	N/S	N/S	N/S	III	Upper lobe of the L lung (multiple)	Multiple resections and percutaneous radiation. For metastasis: palliative radiopeptide therapy with ¹⁷⁷ Lu-DOTA-octreotate	6 weeks	Patient had significant reduction in facial pain, 30% increase in Karnofsky Performance Scale

Lambert et al., 2011 ³³	Case report	F	N/S	Discrete hemiparesis and a psychomotor deterioration (1); swelling at the R lateral orbit and a general inanition (2)	6, and again at 14 months	II, III (recurrence)	Multiple disseminated opacities in both lungs, large singular hepatic mass, skin	Resection (total) Recurrence: 2 gross resections and radiotherapy Chemotherapy with hydroxyurea (1 dose) for metastasis	N/A	Patient died 19 months after initial operation
Eom et al., 2009 ³⁴	Case report	F	Headache, gait disturbance ×2 months, mild R hemiparesis	Headache, dysarthria, and visual disturbances, R homonymous hemianopia (1). Progressive weakness of the right upper limbs and an unsteady gait, hypoesthesia below C4	38, then 16 months after that	II	Spinal cord (spinal tumor C4-C5, cauda equina tumor)	Resection (complete) ×2 Laminotomy (subtotal), local irradiation	N/A	Patient died 5 months after spinal operation as a result of pneumonia
Lee et al., 2009 ³⁵	Case report	M	L sided motor weakness and dysarthria ×2 weeks	Headache ×2 weeks, dysarthria, drowsiness ×2 days (1). Motor weakness of both legs (grade II), back pain and chest (2)	8, then 6 months after that	I, II (recurrence)	Spine: T5, T10, L1, L3, L4, S1, S2, T7 (total) ×2, radiation both lungs	Gross resection Retroperitoneum, Decompressive total laminectomy of T7 and subtotal T6 with removal of the epidural mass	N/A	Patient died several months later
Shintaku et al., 2007 ³⁶	Case report	F	R occipital headache × several months	Dizziness, nausea, vomiting (1). L hemiparesis and epileptic seizure of L side of body (2). Focal epileptic seizures of L upper limb that progressed to generalized seizures (3)	52, then 2 months after that, and again 2 months after that	III	Spinal cord at T11 level, subarachnoid space of upper cervical cord	Gross total excision, then surgery for resection, Gamma Knife radiosurgery Emergent surgery for spinal cord lesion	N/A	N/A
Erman et al., 2005 ²⁵	Case report	F	N/S	Metastasis: cough, chest pain, hemoptysis, and difficulty breathing	48, then again 24 months after that, then again 24 months after that	I, I, II	Both lungs	Gross resection (total) ×4, radiotherapy Chemotherapy	N/A	Patient died in intensive care unit as a result of respiratory failure

F, female; R, right; N/A, not available; M, male; N/S, not specified.

Continues

Table 2. Continued

Reference	Article Type	Gender	Initial Presentation	Recurrence Presentation	Time to Recurrence(s) (months)	World Health Organization Grade	Extracranial Metastasis Location	Treatment	Follow-Up	Outcome
Pinsker et al., 2005 ³⁷	Case report	M	Persistent headache and nausea	Paresis of R arm and leg (2); neck pain $\times 2$ months, progressive paresis and paresthesia of R arm (3)	19, then 11 months after that, then 27 months after that		C3-C4 with 50% cervical spine cord compression	Resection $\times 3$, radiotherapy Metastasis: hemilaminectomy	N/A	Paresis of the R arm improved, remaining pareses were unchanged
Drummond et al., 2000 ³⁸	Case report	M	Depressed mood, paranoid ideation	Headache, mild L hemiparesis, R proptosis (1), R proptosis and L hemiparesis (2)	108		R lung	Resection ("unsure if total"), radiotherapy	N/A	Patient died 6 months later after progressive drowsiness, L hemiparesis, worsening seizures

F, female; R, right; N/A, not available; M, male; N/S, not specified.

procedures with aggressive behavior complicated by leptomeningeal spread.⁵ Metastatic meningiomas are uncommon and the overall reported incidence is between 0.1% and 0.2%,⁹ whereas the incidence of distant metastases in malignant meningioma is approximately 43%.⁴² Primary therapy for malignant meningiomas consists of maximally safe surgical resection and focal radiation depending on the complexity of the individual case. The role of chemotherapy as a subsequent treatment option for recurrence remains inconclusive in the literature.

In this case series, we report on 6 patients with recurrent WHO grade II or WHO grade III meningiomas with metastasis to lung (2), lung and mediastinum or pleura (2), spine and liver (1), and liver only (1). We report the clinical presentation, radiologic features, surgical management, and outcomes of patients with metastatic atypical or anaplastic meningioma in a tertiary-care academic medical center. We also present a review of the literature of cases of metastatic WHO II and III metastatic meningioma. To our knowledge, this is the largest case series with metastatic disease secondary to WHO II and III meningiomas. In our case series, we present 6 patients with a pathologically confirmed WHO grade II or III meningioma with distant metastasis. All patients had a recurrent tumor, underwent several surgical resections, and underwent radiation therapy at least once. In addition, 5 of the 6 patients had adjuvant chemotherapy. Two patients received hydroxyurea only, 1 patient received hydroxyurea and bevacizumab, 1 patient received doxorubicin, and 1 patient received temozolomide.

There are 3 known case reports discussing chemotherapy as a treatment for malignant intracranial meningioma. Gurberg et al.⁴³ described the case of a recurrent meningioma status post surgical resection, Gamma Knife radiosurgery, and fractionated stereotactic radiation. Reirradiation was given with concomitant temozolamide, and 1 month later, MRI showed tumor progression. A hydroxyurea palliative course was initiated. Five months later, MRI showed a decrease in tumor volume with lesion cavitation. This 2014 report was the first case of a patient with recurrent anaplastic meningioma to show a complete/partial radiologic regression.

Hydroxyurea has also been studied in 1 retrospective review.⁴⁴ Three patients had atypical meningiomas status post fractionated radiotherapy, and one patient had a malignant meningioma status post radiotherapy and stereotactic radiosurgery. In the patients with atypical meningioma, the tumors progressed according to radiologic imaging obtained after 12, 19, and 45 weeks of treatment, respectively. In the patient with malignant meningioma, progression was confirmed at 24 weeks.

Doxorubicin is another chemotherapeutic agent prescribed in treatment of anaplastic meningioma. The sole case report documents the case of a malignant meningioma invasive to the calvarian structures status post 4 surgical resections and radiation. Eight years later, the patient had numerous pulmonary and pleural coin lesions, and received 14 courses of doxorubicin. After chemotherapy, imaging showed reduction in the size of the lesions and complete disappearance of all but 1. This lesion was the largest initially and shrank from 7.8 to 2.8 cm. The patient remained stable with no radiologic signs of tumor recurrence for 6 months after treatment suspension.⁴⁵

Trabectedin had also been minimally investigated as a potential chemotherapeutic agent for treatment of malignant meningioma. Preusser et al.⁴⁶ administered this course to 1 patient who had a heavily pretreated anaplastic meningioma. A significant response was noted with radiologic disease stabilization, distinct reductions in brain edema and corticosteroid requirement, and clinical symptom improvement. However, treatment was discontinued after 5 cycles because of adverse drug effects.

Kaley et al.⁴⁷ conducted a review of 47 publications reporting on the use of chemotherapy or systemic therapy for the treatment of recurrent meningioma. This therapy included a diverse array of agents (hydroxyurea, temozolamide, irinotecan, interferon α , mifepristone, octreotide analogues, megestrol acetate, bevacizumab, imatinib, erlotinib, and gefitinib) from retrospective, pilot, and phase II studies, exploratory arms of other studies, and a single-phase III study. The investigators compiled a progression-free survival 6-month rate for WHO II/III meningioma; the weighted average progression-free survival 6-month rate was 26% (5% confidence interval, 19.3%–32.7%). The investigators then concluded that

medical therapy provides poor outcomes for surgery and radiation-refractory meningioma.

CONCLUSIONS

This report describes, to our knowledge, the largest reported case series of patients with metastatic WHO grade II or III meningioma. We present 6 patients all with recurrent atypical or anaplastic/malignant meningiomas, multiple surgical resections, and at least 1 radiotherapy treatment. In addition, 5 of 6 patients received at least 1 type of chemotherapy because of advanced disease. Four patients received only 1 type of chemotherapy, to include hydroxyurea, doxorubicin, or temozolamide. The other patient treated with chemotherapy received both received hydroxyurea and bevacizumab. Although most patients described in this series received a chemotherapeutic agent and a wide variety of these agents were used, patients did not show any noteworthy benefit or marked clinical improvement. Clinical trials, prospective studies, and further molecular studies are needed to reliably determine whether chemotherapy is an effective treatment for extracranial metastasis of meningioma.

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