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CLINICAL ARTICLE

Hemangiopericytomas grade II are not benign tumors

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Abstract
Background Hemangiopericytomas (HPs) of the central nervous system are rare tumors and afflicted with a high propensity of recurrences and metastases. Histopathologically, HPs correspond to differentiated (WHO grade II) and anaplastic (WHO grade III) tumors. With respect to the available literature and our own experiences, the aggressiveness, especially of differentiated grade II HPs, seems to be underestimated.
Methods Thus, in this retrospective study, we describe tumor behavior and examined the effect of radio- and chemotherapy on tumor control with respect to the WHO classification of grade II and III neoplasms. This study consists of 15 patients with cerebral (n=10) and spinal (n=5) HPs.
Results Seven HPs were histopathologically classified as grade II and eight as anaplastic grade III tumors. Complete surgical resection could be achieved in 60% of cerebral and in 25% of spinal HPs. In total, local recurrences occurred in 20% of patients within 17.3 months after the primary operation. Recurrences occurred both from differentiated (n=1) and anaplastic (n=2) neoplasms. Treatment comprised re-operation followed by radio- and chemotherapy. Pointing out the importance of the extent of surgical resection, in this study, we could not detect a single patient showing any recurrences or systemic metastases after complete surgical resection of grade II HPs. During primary diagnostics, four patients showed systemic metastases. Although these tumors could be controlled via surgery, systemic metastases appeared in further four patients within 60.4 months. Interestingly, two of them were classified as differentiated tumors (WHO grade II). To control tumor progress, radiotherapy seemed to be partially effective. On the other hand, however, chemotherapy did not show any effect on tumor control. With respect to these results, screening investigations seem to be indispensable and are highly recommended during primary diagnostics and after the appearance of recurrences or metastases, independent of the histopathological staging of the tumor.
Conclusion With respect to our results, radical surgical resection offers the best treatment option to control tumor progress. In case of subtotal resection or histopathologically diagnosed anaplasia (WHO III), radiotherapy seems to be indicated; however, chemotherapy did not show effectiveness to control tumor progress.

Keywords Hemangiopericytoma · Surgical resection · Radiotherapy · Chemotherapy · Stating examination

Introduction

Hemangiopericytomas (HPs) of the central nervous system (CNS) are rare but afflicted with a high propensity of recurrences and metastases. Referring to all CNS tumors, the incidence of HPs amounts to <1% [11]. HPs occur most frequently in the fifth decade of life, with an almost equal sex incidence [4]. HPs are characterized by an overall 5-year local recurrence and metastasis rates of 65% and 33%, respectively [4, 11]. Histopathologically, HPs arise from

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perivascular pericytes and can be graded as differentiated (WHO grade II) and anaplastic (WHO grade III) tumors. Thereby, anaplastic HPs can reach recurrence rates of up to 85% associated with a considerable reduced average survival time of only 62 months [17]. Despite significant improvements in diagnosis, surgical techniques, and radiotherapy, treatment of these tumors remains challenging, especially due to the small number of patients and, thus, few experience in its therapy.

Radical resections in conjunction with radiotherapy seem to be effective approaches in treating HPs [2–5, 8–10, 13, 24]. Especially with respect to low-grade HPs, however, indication and time of radiotherapy are still debatable. According to the available literature and our own experiences, the aggressiveness of differentiated grade II HPs seems likewise to be underestimated. In this study, we share our experiences and results in the treatment of HPs, and we will attempt to offer recommendations improving its therapy.

Methods

Patient characteristics

This retrospective study consists of 15 patients with HPs of the CNS treated at our University Hospital between 1998 and 2010. All information on clinical history, symptoms, surgical approaches, adjuvant treatment, outcome, and follow-up were retrospectively obtained by review of the patients' charts and radiological images.

The average age of patients was 53.2±17.9 years (range 24–78 years). Gender distribution was nearly equal, but with slightly more female patients (n=9; 60%). The follow-up time ranged from 10 to 146 months, with a mean of 67 months.

Tumors originated both from the brain (n=10; 66.6%) and the spine (n=5; 33.3%). A significant predominance in location could not be observed: HPs arise from the frontal lobe in 3, from the occipital and parietal lobes in 2, each, and further from the temporal lobe, petroclival, tentorial, and from the orbit in 1 case, respectively (Table 1). Patients' symptoms varied due to the location of the tumors and included headache, nausea, vomiting, hemi- or paraparesis, aphasia, hemianopia, and hydrocephalus with disturbance of consciousness. One patient with an occipital HP was suffering from an acute intracerebral hemorrhage with acute hydrocephalus causing somnolence.

Imaging

All patients underwent evaluation by magnet resonance imaging (MRI) or additional computer tomography (CT). T1- and T2-weighted MR imaging were performed in three planes to analyze tumor configuration and vascular involvement. All examinations were complemented with contrast medium-enhanced images. Additionally, in three patients, angiography (DSA) was performed and embolization of cerebral tumors could subsequently be achieved in two patients followed by operation.

Therapeutic approach

As far as possible, following diagnosis, complete surgical resection was aspired. Due to the different locations of the HPs, surgical approaches varied correspondingly. To plan surgical resection accurately, neuronavigation was used in all brain tumor surgeries.

Histopathology

HPs are highly cellular and vascularized mesenchymal tumors exhibiting a characteristic monotonous low-power appearance and a well-developed variably thick-walled, branching "staghorn" vasculature. HPs correspond histopathologically to WHO grade II, with anaplastic HPs

Table 1 Survey of all 15 patients with respect to the tumor localization and associated tumor cysts

Location	Location	Number of patients (n)	Cysts (n)
Brain (n=10), 66.6%	Frontal lobe	3	1
	Parietal lobe	2	1
	Occipital lobe	2	1
	Temporal lobe	1	1
	Tentorial	1	1
	Orbit	1	0
Spine (n=5), 33.3%	Cervical spine	2	0
	Thoracic spine	1	0
	Lumbar spine	2	0

corresponding to WHO grade III [15]. Signs of anaplasia are high or brisk mitotic activity (more than 5 mitosis per 10 HPF) and/or necrosis, plus at least two of the following hemorrhage, moderate to high nuclear atypia and cellularity. A rich network of reticulin fibers, typically investing individual cells, is one of the most characteristics but not invariable features of this neoplasm. HP cells are diffusely positive for vimentin (85%) and for CD34 (33–100%). The latter is usually patchy. Tumor cells are negative for S100 and CD31. Although the immunoreactivity pattern of HPs is diverse and no single antibody is either 100% sensitive or specific, its immunoprofile is generally sufficiently distinctive to permit the exclusion of meningioma and solitary fibrous tumor, the differential diagnoses. Typical histopathological features of HPs WHO II and III are summarized in Figs. 1 and 2, respectively.

Statistics

For statistical analysis, a standard software package (SigmaStat) was used. For statistical comparisons for independent samples from normally distributed continuous variables, Student's t test was used. Mann–Whitney U statistics for nonparametric testing was used when normal distribution could not be assumed or was ruled out by the Kolmogoroff–Smirnov method. For two dependent samples, Wilcox test was used, and for more than two independent samples the Kruskal–Wallis H test. All averaged data are reported as mean±standard error of the mean (SEM) if not indicated otherwise. A threshold value for significance (p value) of less than 0.05 was applied.

Results

Images

In T2-weighted MR images, cerebral HPs appeared hyperintense. After application of contrast medium, HPs showed an intensive enhancement of chordoid meningioma (CM) and a broad onset at the dura. The maximal diameter reached 63×40 mm in average. Especially in comparison to

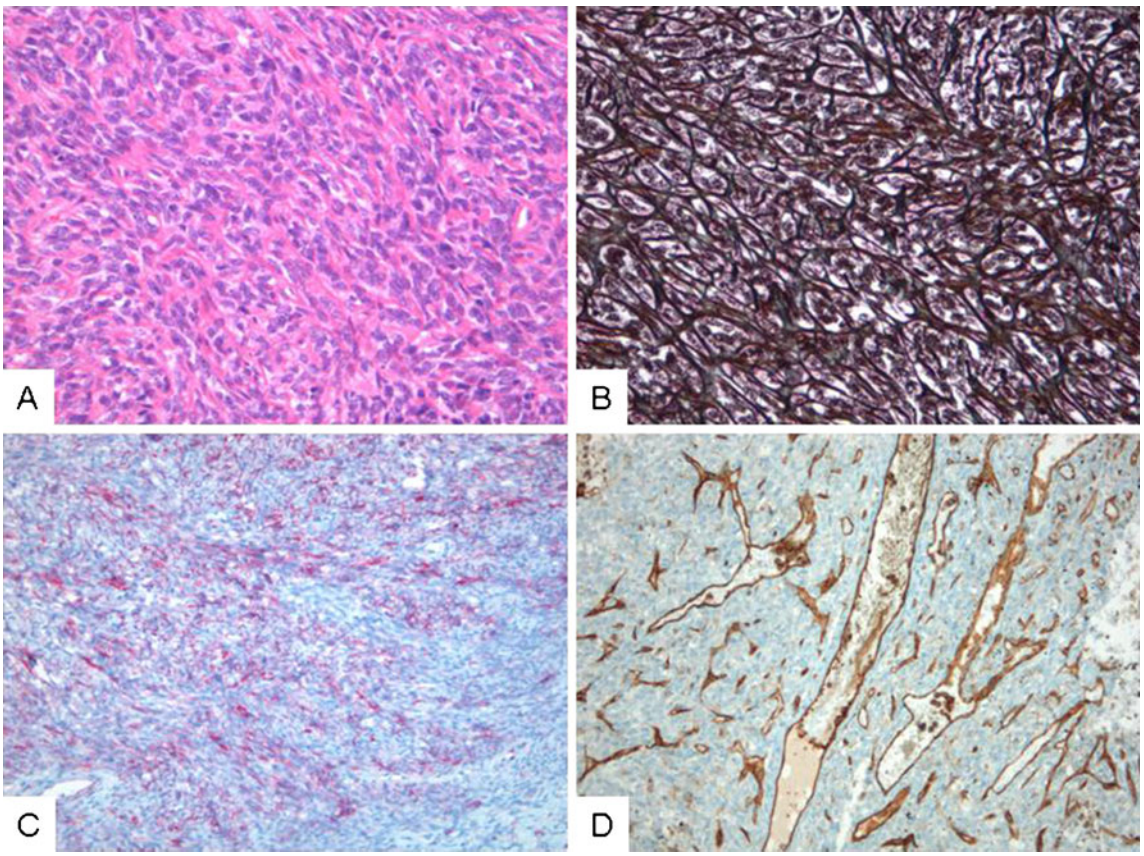

Fig. 1 Histopathology of HP (WHO grade II). **a** Tumor with closely packed, monomorphous, randomly oriented tumor cells with intervening fibrosis (H&E, ×200); **b** rich network of reticulin fibers, investing individual tumor cells (reticulin silver stain, ×200); **c** tumor cells immunostained diffusely and patchy positive for CD34 (CD34, ×100); **d** tumor cells are negative for endothelial marker CD31. Note typical dilated, staghorn-type vessels (CD31, ×200)

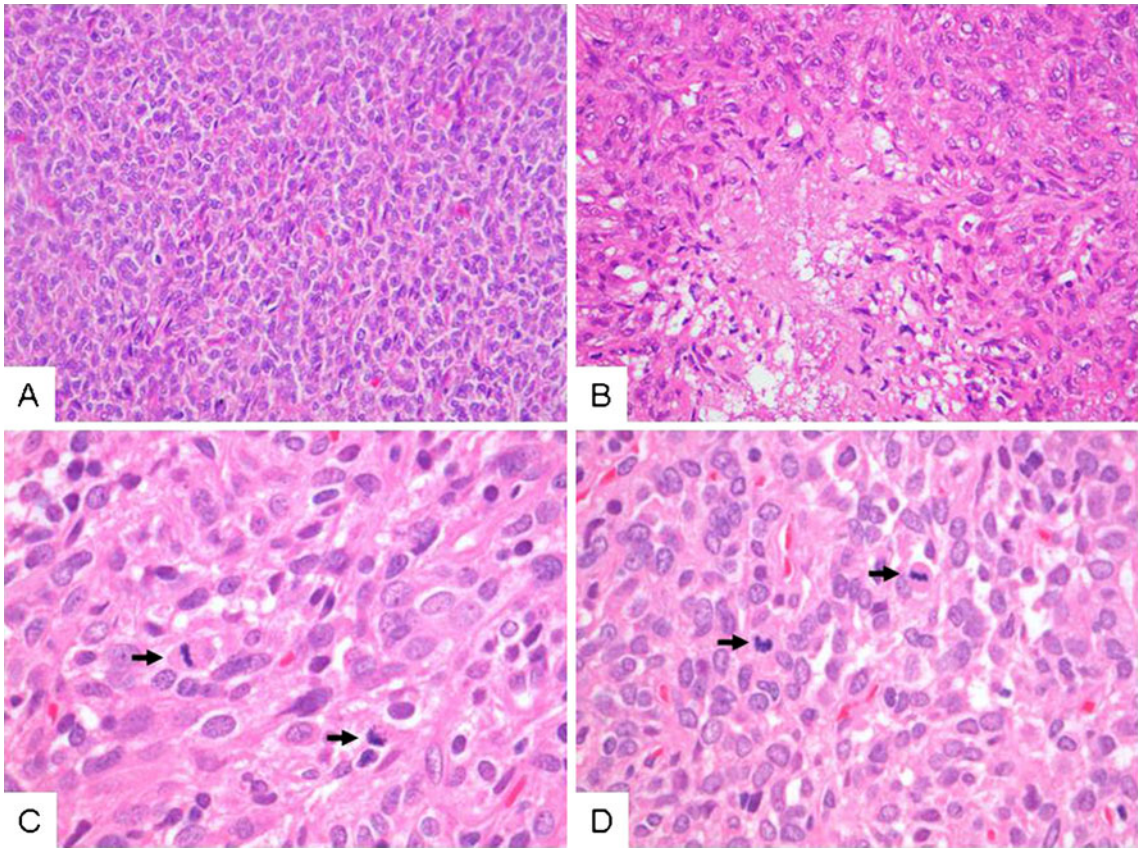

Fig. 2 Histopathology of HP (WHO grade III). Signs of anaplasia in HPs. Increased tumor cell density (**a**, H&E, ×200), focal areas of necrosis (**b**, H&E, ×200), and brisk mitotic activity (**c**, **d**, H&E, ×400; *arrows* mark mitotic figures)

meningiomas, cerebral HPs showed more irregularities after CM application and multiple cysts in 50%, respectively (Figs. 3 and 4**;** Table 1). Especially in comparison to meningiomas, no hyperostosis or tumor calcification could be observed. In spinal HPs, contrast enhancement appeared more homogeneous and cysts could not be detected in the evaluated patients (Fig. 5).

Surgery

With respect to the diverse locations of the tumors, surgical approaches varied correspondingly. Cerebral HPs were microsurgically resected with the aid of a neuronavigation device. Overall complete surgical resection, however, could be achieved in only 53%. Thereby, in cerebral located HPs,

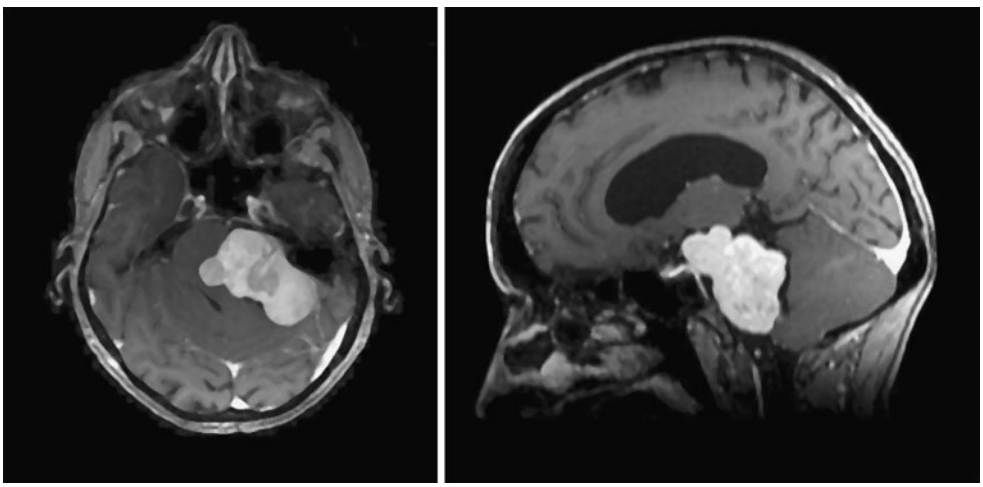

Fig. 3 T1-weighted, contrast-enhanced MR images showing a multilobulated infra- and supratentorial located hemangiopericytoma. Within the tumor, two cystic formations could be depicted. Due to the size of the tumor, the brain stem was significantly compressed

complete resection could be achieved in 60%, but only 40% in spinal HPs. Neurosurgeons described the texture of HPs as being soft, but intensively vascularized.

Complications

In three patients, perioperative complications occurred. Two of them were somnolent due to brain swelling or an epidural hematoma, which were treated with anti-edematous medication or immediate surgical evacuation of the hemorrhage. The third patient showed a CSF fistula because of a dura leakage that was insufficiently treated by lumbar drainage and, thus, required revision surgery. In the case of this latter patient, the tumor had spread widely into the dura and could only be removed subtotally. Coincidentally, all complications occurred in patients with HPs graded as anaplastic tumors (WHO III). Fortunately, all three patients recovered well.

Histopathological examination

All HPs presented in this current study were histopathologically graded according to the guidelines of the WHO [15]. Of the presented series, seven tumors corresponded to WHO grade II. Eight HPs revealed signs of anaplasia corresponding to WHO grade III.

In more detail, we examined five patients with spinal HPs and ten patients with cerebral HPs. Three of the spinal HPs corresponded to WHO grade II—the remaining two represented anaplastic HPs (WHO grade III). Four cerebral HPs corresponded to WHO grade II and the remaining six represented anaplastic HPs (WHO grade III).

Treatment and follow-up

Due to a lack of treatment guidelines in the literature, postoperative therapy and oncological follow-up were individually configured.

Screening

After primary diagnosis, whole body screening, including CT of the abdomen and the lungs, was performed in only half of the patients, equally distributed to both histopathological groups. In these staging examinations, one patient after complete resection of a cerebral HP (WHO II) showing pulmonal metastasis could be identified. He was operated by thoracic surgeons and, as a result, has been tumor-free to date (Table 2). In the other patients that were examined, no further metastases could be observed due to staging examinations. In contrast, in half of the patients who had not received staging examinations, local recurrences and metastases occurred in 55% in the follow-up, and remarkably, two of these patients were graded as differentiated HPs (WHO II).

Local recurrences

In total, local recurrences occurred in 3 of 15 patients (Table 2). The first patient was histopathologically graded as a differentiated tumor (WHO II); the others as grade III. On average, recurrences occurred within 17.3 months after primary surgery. In two of these patients, no complete resection could be achieved during the first operation. The grade II tumor originated from the cervical spine, whereas grade III tumors originated from the occipital or temporal cerebral lobes. Although complete resection could be attained in the patient with HP grade III located in the temporal lobe, local recurrence occurred 25 months after the first surgery. Treatments of local recurrences comprise re-operation followed by radio- and chemotherapy (Table 2). Nevertheless, two of three patients developed systemic metastases after 15 and 96 months, respectively.

Grade of resection

The grade of resection plays an important role for tumor control. In this trial, we could not detect a single patient with grade II HPs that showed any local tumor recurrence or metastases after complete surgical resection. Due to the small total number of patients, however, these results did not reach significance. Exclusively, in patients with HP grade II that could only subtotally be resected, local recurrences and metastases could be observed.

In anaplastic tumors (WHO III), a correlation between the grade of resection and tumor control could not be confirmed. Despite complete resection, two patients with local recurrences and with systemic metastases could be detected during follow-up (Table 2). Local recurrences occurred 12 and 25 months after the primary operation, while systemic metastases could be detected after 78 months on average.

Metastases

Metastases play an important role in long-time tumor control and treatment of HPs (Table 2). At the time of diagnosis in four patients, metastases were known, both originating from grade II and III tumors in two cases each. In patients with grade II HP, pulmonal and paraspinal metastases could be detected. They were treated by surgery and additional radiotherapy in the second patient (Table 2). In patients with grade III HPs, metastases were located extracranially in the skull and the skin. In both cases, metastases could be surgically resected during the primary

Table 2 Overview of all patients suffering from hemangiopericytoma emphasizing the location and histological grading, the grade of surgical resection, time of the appearance and treatment of metastases, and recurrences as well as the follow-up

Patient	WHO	Location	Metastasis at primary diagnosis	Therapy	Grade of resection	Recurrence	Metastasis during follow-up	Time (months)	Therapy	Follow-up
1	II	Frontal lobe	Pulmonal	Operation	Complete	–	–	–	–	Tumor-free for 19 months
2	II	Parietal lobe	–	Operation	Complete	–	–	–	–	Tumor-free
3	II	Occipital lobe	–	Operation	Complete	–	–	–	–	Tumor-free
4	II	Orbit	–	Operation	Subtotal		–	–	–	Stable disease for 11 months
5	II	Cervical spine	–	Operation + radiation	Subtotal	15 months re-operation + radiation	Lumbar spine	15	Radiation Chemotherapy	Cerebral metastases 12 months after surgery
6	II	Cervical spine	–	Operation	Subtotal		Costae BWK 6	72	Re-operation Chemotherapy Radiation	Tumor progress
7	II	Lumbar spine	Paraspinal	Operation + radiation	Subtotal		–	–	–	Stable disease for 15 months
8	III	Parietal lobe	Skull	Operation	Complete	–	–	–	–	Tumor-free for 25 months
9	III	Occipital lobe	Skin	Operation	Subtotal	12+48 months re-operation + radiation	–	–	–	Tumor-free for 70 months
10	III	Tentorial	–	Operation	Subtotal		–	–	–	Stable disease for 6 years
11	III	Temporal lobe	–	Operation	Complete	–	Hip Thoracic spine	60	Re-operation Chemotherapy	Tumor progress (hips)
12	III	Frontal lobe	–	Operation Radiation	Complete	–	Hip Thoracic spine	60	Re-operation Radiation	Tumor progress (lumbar spine)
13	III	Frontal lobe	–	Operation	Subtotal		–	–	–	Stable disease for 146 months
14	III	Lumbar spine	–	Operation	Complete	–	–	–	–	Tumor-free
15	III	Thoracic spine	–	Operation	Complete	–	–	–	–	Tumor-free

operation. While one patient kept tumor-free in the follow-up for 25 months, the other developed local recurrences 12 and 48 months after primary resection.

Although these primary diagnosed metastases could be controlled, new systemic metastases occurred in a further four patients during follow-up. Interestingly, in two of these patients, metastases appeared in grade II neoplasms, both achieving only subtotal resection. In both patients, primary tumors were located in the cervical spine. Metastases occurred 15 and 72 months after the primary diagnosis in the lumbar spine and the ribs. Several attempts were made to control tumor progress by way of surgeries and radio- and chemotherapy (themozolamide or vincristine and cyclophosphamide) (Table 2). Nevertheless, both patients showed further tumor progress and further metastases.

Additionally, further metastases could be detected in two patients with HPs classified and graded as anaplastic tumors (WHO III) (Table 2). In both patients, the temporal and frontal located neoplasms could be completely removed by surgery. In one patient, radiotherapy followed immediately after surgery and, in the other, after the appearance of a local recurrence that was removed by re-operation. Systemic metastases appeared in the ribs, liver, and chest after 96 months, as well as in the hip and the thoracic spine after 60 months, respectively. As far as possible, treatment of choice was surgery added by radio- and chemotherapy (Coagrovil). Despite of these, tumor progress could not be controlled and further metastases occurred during the follow-up (Table 2; Figs. 4 and 5).

Postoperative radiotherapy

Postoperative radiotherapy was performed in five patients instantaneously after primary surgery. In two patients,

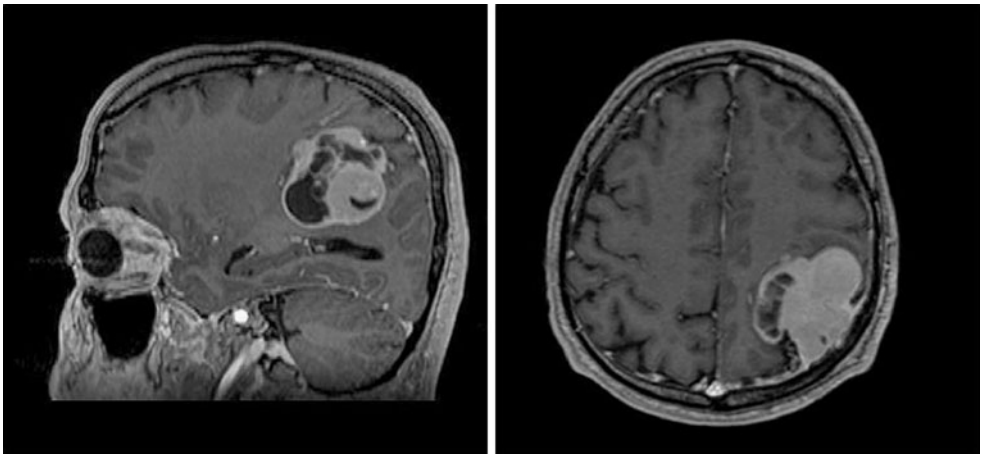

Fig. 4 T1-weighted, contrast-enhanced MR images demonstrating a large parieto-occipital hemangiopericytoma with multiple cysts and a broad onset at the dura

differentiated HPs (WHO II), and in three, anaplastic tumors (WHO III) were diagnosed. In both patients, ranked as grade II neoplasms, only subtotal surgical resection could be achieved. While in one patient no further tumor progress or metastases could be observed in a follow-up of 15 months, the second patient with a HP of the cervical spine developed metastases at the lumbar spine within 15 months. Despite further operation and radiotherapy, cerebral metastases could not be avoided after further 12 months (Table 2). Both patients received fractionated photon radiation therapy of 60 Gy.

Additionally, we could detect a patient after subtotal resection of a HP grade II of the cervical spine who developed systemic metastases after 72 months (Table 2). The patient did not receive radiotherapy after primary operation. Despite revision surgery and radiotherapy (60 Gy photon therapy) after the appearance of metastases, tumor control could not be achieved.

In grade III, HPs initial radiotherapy was performed in three of eight patients. As mentioned above, the first patient with frontal HP showed pulmonal metastases at primary diagnosis and has been tumor-free after complete surgical resection and radiotherapy to date (24 months) (Table 2). In the second patients with frontal lobe HP and subtotal resection, but instantaneous radiotherapy, nonlocal recurrences or metastases could be observed in the follow-up of 140 months. But on the other hand, the third patient developed systemic metastases after 60 months, although the frontal HP was completely resected and initial radiotherapy was performed (Table 2). All patients were treated with fractionated photon radiation therapy of 60 Gy.

Remarkably, five of eight patients with HP grade III did not receive initial radiotherapy, although in two of these patients, only subtotal surgical resection could be achieved. In one of them with an occipital HP, local recurrences occurred after 12 and 48 months followed by revision

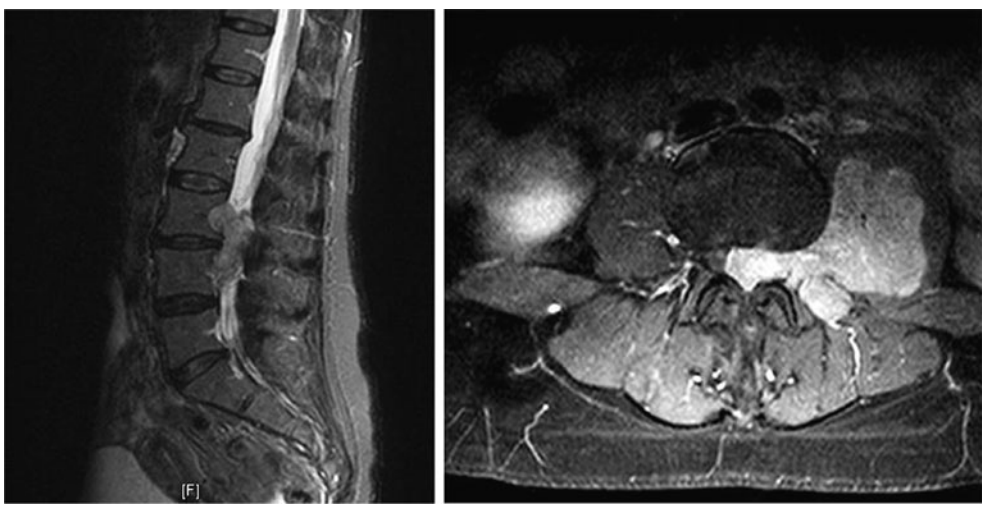

Fig. 5 T2-weighted, contrast-enhanced MR images showing a hemangiopericytoma of the lumbar spine. The tumor displaces the dura and the nerves and grew into the extraspinal space and into the paraspinal tissue and muscles

surgery and radiotherapy. In the further follow-up, the patient was tumor-free for 70 months (Table 2). With the second patient, although complete resection of a temporal HP could be achieved, local recurrences occurred 25 months later. Despite revision surgery and radiotherapy, however, tumor progress and the development of systemic metastases could not be avoided.

In all patients, radiotherapy was performed as a fractionated photon therapy of 60 to 65 Gy. In one patient with a frontal HP grade III and progressive systemic metastases, multiple radiations had to be performed, and thus, doses were reduced accordingly. No patients received hardron therapy or radiosurgery.

Postoperative chemotherapy

Chemotherapy was applied only in exceptional cases (n=3), especially if surgical treatment and radiotherapy could evidently not control tumor progress (Table 2). Two out of three cases were HPs grade II, both originating from the spine. After subtotal resection, followed by re-operation and radiotherapy in the case of development of systemic metastases, a combination of cyclophosphamide and vincristine or themozolamide was used. In both cases, significant tumor control could not be achieved. In the third patient with cerebral HP grade III of the temporal lobe, multiple metastases occurred after complete surgical resection that, despite revision operation following radiotherapy, could not be controlled. A treatment with Coagrovil was initiated. Notwithstanding this treatment, tumor control could not be achieved.

Discussion

Despite significant improvements in diagnostics and surgical as well as radio- and chemotherapy, treatment of HPs remains a challenge. Apart from some case reports, due to the small number of patients, little data are available in the literature. The aggressiveness, especially of differentiated grade II tumors, thereby seems to be underestimated. Hemangiopericytomas, however, are aggressive tumors that have a high rate of local recurrences and also a high propensity for late and distant metastases [2, 16, 23].

According to the existing literature, we could demonstrate in MR diagnostics that cerebral HPs appear as multilobulated, extra-axial tumors; are attached to the dura; and show bone erosions [7]. In comparison with the data of Ruscalleda et al., who could present calcification in 2 of 6 tumors [21], Chiechi et al. [7] and Akiyama et al. [1] could not show any calcification in cerebral HPs in 34 and 7 cases, respectively, confirming our results.

Consistent with our data, several case reports and smaller series are available showing the aggressiveness of HPs and their tendency for local recurrence and metastasis [12, 16, 19, 23]. In the largest available study performed by our colleagues of neuropathology, 57 of 94 (60.6%) patients had one or more recurrences or showed metastases in 23.4%. Thirty-five of 56 (62.5%) patients with differentiated HPs, while 22 of 26 (85%) patients with anaplastic HPs, developed recurrences [17].

Management of these tumors still remains a challenge. Due to our data we could show that independent of their origin from the spine or the brain, HPs classified as differentiated grade II did not show any local recurrences or systemic metastases after complete surgical resection. If resection remains subtotal, or tumors are histopathologically classified as anaplastic grade III, local recurrences or metastases occurred frequently in 20% and 53.3%, respectively. These results are consistent with the data of Bassiouni et al. [3] who reported about a recurrence rate of 42% after subtotal surgical resection. Irrespective of its histopathological classification, in the literature, there is a significant self-consistency of data that total tumor resection during the first operation is the most important factor for tumor control [2, 3, 5, 8–10, 24].

Patients received postoperative radiotherapy in all the studies referred to above [2, 3, 5, 8–10, 24]. With respect to the data, effectiveness of radiotherapy, however, seems likely to be not as effective as complete surgical resection. Nevertheless, authors suited that radiotherapy has a positive impact on tumor control. It should be noted that recurrences appear at a later stage and that may create the false impression that these tumors might be curable with surgical resection alone. Bastin et al. clearly demonstrated that recurrences occurred in 90% of cases within 9 years, but in less than 33% within the first 5 years after surgical resection [4]. Additionally, it should be seen critical if Borg et al. describe that local recurrences are avoidable with adequate wide excision of the primary tumor followed by radiotherapy demonstrated in a series consisting of only four patients [5]. With respect to our own data, we could show that postoperative radiotherapy could avoid the development of recurrences or metastases, even after subtotal resection in anaplastic tumors. But we also detected systemic metastases that occurred even after complete surgical resection followed by radiotherapy in anaplastic HPs. In conformity with the literature, this emphasizes that radiotherapy might improve treatment of HPs, but cannot provide any guarantee for tumor control.

In a follow-up imaging study, Kano et al. demonstrated that adjuvant stereotactic radiosurgery might be an option for patients with residual or recurrent HPs and is further particularly effective for less aggressive tumors. Progres-

sion-free survival rate of these tumors can reach up to 89% for 5 years. In high grade tumors, however, survival rates amount to only 88.9%, 66.7%, and 0% after 1, 3, or 5 years [14]. First data have been available from 2000 published by the Virginia group, showing the effect of radiosurgery in ten patients. In nine patients, tumor volume decreased after gamma knife therapy, but showed further progression after 22 months [20]. According to the literature, radiosurgery offers a reasonable treatment option for recurrent HPs after surgical resection. Tumor control or volume reduction seems to be well proven [6, 18, 22]; however, no data are available with respect to the outcome after 5 or 10 years. With the knowledge that metastases or recurrences show up especially between 5 and 10 years after the initial therapy, the role of radiosurgery thus must be discussed critically, and finally, more data showing long-time follow-up seem necessary [4].

Due to the aggressiveness of HPs in four cases, tumor control could not be achieved in our patients, despite surgery, revision surgery, and radiotherapy. In three of these cases, additional chemotherapy with themozolamide, vincristine, and cyclophosphamide, or Coagrovil was initiated. No chemotherapy led to any improvement of tumor control in our data. Similar results have also been described in the work of Bassiouni et al. (n=12) [3]. The authors initiated salvage chemotherapy following unsuccessful attempts to reach tumor control by surgery, revision surgery, and radiotherapy in two patients, but without any positive effect. There is only one retrospective trial consisting of 15 patients that investigated the effect of different salvage chemotherapies demonstrating a modest success with an overall survival rate of 14 months [16].

In summary, in concurrence with the prevailing findings in the literature and our own experiences, it is our view that the aggressiveness of HPs, and especially of differentiated grade II tumors, has been underestimated to date. Due to our data, we could clearly demonstrate that total surgical resection seems to be the best treatment option to avoid recurrences or systemic metastases in patients suffering from low-grade hemangiopericytoma grade II. In both histopathological groups, however, metastases occurred, and therefore, primary staging examinations of the whole body, especially CT of the chest, the abdomen, and the spine, seem to be indispensable and are highly recommended. Achieving tumor control in high grade anaplastic HP still remains a challenge. Corresponding to the available literature and our own results, subsequent radiotherapy seems to be recommended in all high grade HPs. In case of subtotal resection of low-grade HPs (WHO grade II), radiotherapy should be considered individually. Chemotherapy, at least in our study, did not improve outcome.

Due to the small number of patients suffering from hemangiopericytomas, it seems to be desirable that prospective multicenter trials should be conducted to evaluate the efficiency of different treatment options due to improve treatment of these highly aggressive tumors.

Conflicts of interest None.

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Comment

I read with much interest this well-written article reporting the authors' experience on a relatively large series of this rare pathological entity. The authors' major issue that hemangiopericytomas grade II may exhibit a biologically malignant course is well-documented and convincingly discussed. This paper will serve as a reference for future clinical and molecular biology studies on these tumors.

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