Neurosurgical management of cerebellar cavernous malformations

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Object. The aim of this study was to analyze cerebellar cavernous malformations (CMs) with respect to epidemiological, clinical, radiological, and therapeutic aspects.

Methods. Between 1984 and 2004, 100 patients were surgically treated for intracranial CMs at the Division of Neurosurgery of Federal University of São Paulo. The authors reviewed the records of 10 patients whose lesions were located in the cerebellum.

There were four male and six female patients (ratio 1:1.5) whose ages ranged from 14 to 45 years (mean age 33 years). Clinical presentation was sudden or acute in all cases, and neuroimaging examinations performed in all patients demonstrated signs of bleeding. The mean size of the malformations was 4.6 cm, and in all but one patient the lesions were totally removed without complications. After a mean follow-up period of 70 months, all patients were considered to be in good or excellent clinical condition.

Conclusions. Cerebellar CMs should be analyzed separately from other posterior fossa CMs. These lesions can reach large sizes and cause massive hemorrhages, resulting in acute or sudden presentation. Surgery is a safe and effective option that provides a curative treatment when a complete removal is achieved.

KEY WORDS • cavernous malformation • cavernoma • cerebellum • surgical treatment

ANGIOGRAPHICALLY occult vascular malformations are divided into four types: AVMs, CMs, venous angioma or DVAs, and capillary telangiectasias. Cavernous malformations are hamartomas of the blood vessels and are pathologically defined as thin-walled capillary spaces without intervening brain tissue.^{33,50}

The incidence of CMs ranges from 0.4 to 0.9% of the general population. They constitute 8 to 15% of all cerebrovascular malformations,^{13,29,32,39,44,48} and they occur in the supratentorial compartment in 63 to 90% of cases.^{8,18,23,24} Posterior fossa CMs represent 7.8 to 35.8% of all cases and the brainstem is the most common site of involvement in this compartment (9–35% of all cases).⁴⁴

In large series, cerebellar CMs constitute 1.2 to 11.8% of all intracranial cases^{21,47} and 9.3 to 52.9% of infratentorial cases.^{20,27} However, data in the literature about CMs localized in the cerebellum are limited to case reports. Consequently, epidemiological, clinical, neuroimaging,

and therapeutic aspects of cerebellar CMs are neglected because these lesions are analyzed together with other infratentorial CMs that have specific features. We present a relatively large series of cerebellar CMs, focusing on the clinical, neuroimaging, and therapeutic aspects of these lesions.

Clinical Material and Methods

Between 1984 and 2004, 100 patients harboring CMs involving the CNS were surgically treated at the Division of Neurosurgery of Federal University of São Paulo. We excluded all cases that lacked histopathological confirmation, supratentorial cases, and CMs localized primarily in the brainstem with extension to the cerebellum as well as those CMs located at the CPA, tentorium, and posterior fossa cisterns. Ten patients with CMs localized exclusively in the cerebellum were included.

Patient Population

Patient characteristics are summarized in Table 1. There were four male and six female patients (ratio 1:1.5). The age range of the patients studied was 14 to 45 years, with a mean age of 33 years at presentation.

Abbreviations used in this paper: AVM = arteriovenous malformation; CM = cavernous malformation; CNS = central nervous system; CPA = cerebellopontine angle; CT = computed tomography; DVA = developmental venous anomaly; MR = magnetic resonance.

TABLE 1
Summary of patients presenting with cerebellar CMs*

Case No.	Age (yrs), Sex	Clinical Presentation	Radiological Findings							Op	FU (mos)	Outcome (deficit)
			Angiography	CT	MRI†	Hydrocephalus	Bleeding	Side	Size (cm)			
1	30, F	sudden HA, vomiting, ataxia, & dysmetria	avascular mass	hyperdense	Type II	no	yes	lt	4	GTR	96	excellent
2	40, F	sudden ataxia, dysmetria, DDK, & cerebellar speech	ND	hyperdense	Type II	no	yes	lt	6	GTR	96	excellent
3	14, M	sudden HA, vomiting, ataxia, dysmetria, & nystagmus	ND	hyperdense	Type II	no	yes	rt	4.8	GTR	72	excellent
4	29, M	acute HA, ataxia, & cerebellar speech	avascular mass	hyperdense	Type II	no	yes	rt	5.5	GTR	60	good (ataxia)
5	35, M	sudden HA, vomiting, & ataxia	ND	hyperdense	Type II	no	yes	lt	4.5	GTR	60	excellent
6	38, M	acute ataxia, nystagmus, dysmetria, & cerebellar speech	ND	hyperdense	Type II	yes	yes	rt	5	STR & ES	108	excellent
7	34, F	sudden HA & ataxia	ND	hyperdense	Type II	no	yes	rt	3	GTR	96	excellent
8	45, F	acute ataxia, nystagmus, & vomiting	avascular mass	hyperdense	Type II	no	yes	rt	5	GTR	60	good (nystagmus)
9	28, F	sudden HA, vomiting, & ataxia	ND	hyperdense	Type I	no	yes	lt	3.5	GTR	30	excellent
10	37, F	sudden HA, vomiting, ataxia, & dysmetria	avascular mass	hyperdense	Type II	yes	yes	lt	4.5	GTR & ES	24	excellent

* DDK = dysdiadochokinesia; ES = external shunt; FU = follow up; GTR = gross-total removal; HA = headache; ND = not done; STR = subtotal removal.

† Results were analyzed and then classified as one of the four types described by Zabramski, et al.

Results

The clinical presentation was acute or sudden in all cases and characterized by cerebellar syndrome. Regarding neuroimaging findings, only four patients underwent angiography, and in all four an avascular mass was demonstrated. In each case, CT scans revealed a hyperdensity consistent with hemorrhage. Preoperative MR imaging revealed Type II CMs in all but one patient (who had a Type I lesion) according to the Zabramski, et al.,⁵⁵ classification (Table 2). The malformations were equally located on the right and left sides (five patients each). The sizes of the lesions ranged from 3 to 6 cm, with a mean size of 4.6 cm. All 10 patients underwent a standard posterior fossa approach through a craniectomy. Two additional patients with obstructive hydrocephalus underwent placement of an external shunt device immediately before CM removal (Cases 6 and 10). In all but one patient the lesions were totally removed without complications. The patient whose lesion was partially removed (Case 6) was found to be asymptomatic and without increase in the size of the residual lesion on follow-up MR imaging performed 7 years later. No treatment was undertaken because this patient preferred conservative management. After a mean follow-up duration of 70 months, eight patients were in excellent condition, free of any neurological deficit and symptom free. Two patients had a good outcome with persistent signs and/or symptoms that were no different from their preoperative condition.

Illustrative Cases

Case 1

History and Examination. This 30-year-old woman with no significant medical history presented with sudden headache followed by vomiting and was referred to our

department. On admission she was alert and the neurological examination disclosed only gait ataxia accompanied by left dysmetria. Because a CT scan revealed a heterogeneous hyperdense lesion on the left cerebellar hemisphere (Fig. 1A), the patient underwent angiography studies, which revealed an avascular mass (Fig. 1B). Admission MR images were also obtained and the results were consistent with CMs and hemorrhage (Fig. 2).

Operation and Postoperative Course. A standard suboccipital approach was performed and a large, hemorrhagic, mulberry-like lesion (Fig. 3A) was encountered. A complete removal was performed without complications and the histological diagnosis confirmed a CM (Fig. 3B). The postoperative period was uneventful and at her 96-month follow-up evaluation the patient presented without neurological deficit. A follow-up MR image confirmed complete removal of the CM (Fig. 4).

Case 2

History and Examination. This 40-year-old woman presented to the emergency department because she experienced a sudden gait disturbance and speech impairment. On admission she was awake, alert, and oriented. The neurological examination disclosed cerebellar speech, gait ataxia, dysmetria, and dysdiadochokinesia. Admission CT scans revealed a hyperdense lesion on the vermis and left cerebellar hemisphere (Fig. 5). An MR image demonstrated a typical CM Type II lesion (Fig. 6).

Operation and Postoperative Course. The patient was admitted to the neurosurgical department and a standard suboccipital approach was recommended, during which a large, hemorrhagic, mulberry-like lesion (Fig. 7A) was encountered. Complete removal was achieved without complications and the postoperative period was uneventful. Histological examination of the specimen was consistent with a CM (Fig. 7B). At her 96-month follow-up eval-

TABLE 2
Magnetic resonance imaging classification for cavernous malformations*

Lesion Type	MR Signal Characteristics	Pathological Characteristics
Type I	T ₁ -weighted: hyperintense core T ₂ -weighted: hyper- or hypointense core w/ surrounding hypointense rim	subacute hemorrhage, surrounded by a rim of hemosiderin-stained macrophages & gliotic brain
Type II	T ₁ -weighted: reticulated mixed signal core T ₂ -weighted: reticulated mixed signal core w/ surrounding hypointense rim	loculated areas of hemorrhage & thrombosis of varying age, surrounded by gliotic, hemosiderin-stained brain; in large lesions, areas of calcification may be seen
Type III	T ₁ -weighted: iso- or hypointense T ₂ -weighted: hypointense w/ a hypointense rim that magnifies the size of the lesion gradient-echo: hypointense w/ greater magnification than T ₂	chronic resolved hemorrhage, w/ hemosiderin staining w/in & around the lesion.
Type IV	T ₁ -weighted: poorly seen or not visualized at all T ₂ -weighted: poorly seen or not visualized at all gradient-echo: punctate hypointense lesions	two lesions in the category have been pathologically documented to be telangiectasias

* Reprinted from Zabramski, et al.

uation the patient had completely recovered from her neurological deficit, and MR images confirmed complete removal of the lesion (Fig. 8).

Discussion

Cavernous malformations are encountered in 0.4 to 0.9% of the general population and constitute between 8 and 15% of all CNS vascular malformations.^{13,29,32,38,44,48} Cavernous malformations are more commonly located in the supratentorial compartment (in as many as 90% of cases).^{3,5,9,13,18,23,29,38,41,43,48,51,53} Most of the posterior fossa CMs are located in the brainstem,²⁴ and therefore cerebellar CMs are rare lesions.

Age and Sex of the Patients

The majority of CMs present between the 3rd and 5th decades of life.²⁴ The median age of patients at presentation in clinical series of intracranial CMs ranges from 32.2 to 37.6 years.^{1,5,9,13,29,31,38,43,48,49} The mean age of our patients, 33 years, is no different compared with the age of patients who have CMs in other locations.

Some authors have observed a higher incidence of CMs

in the CNS of male patients,^{18,41,55} and others have found a higher incidence in females.^{11,39,51,52} In most series, however, an equal distribution between the sexes^{13,24,26,31,40,43,48,53} has been reported, and this was also the case in ours. Some authors have suggested a higher propensity for bleeding episodes in female patients,^{16,48} often during pregnancy.⁴⁵ There has also been a report of sudden death in a pregnant patient, in whom a cerebellar CM was diagnosed at autopsy.¹⁹

Clinical Presentation

In general, CMs are associated with a wide range of clinical syndromes,⁴⁷ although they can be found incidentally in up to 21% of all intracranial cases.²⁴ The most common presentation of CMs located in the supratentorial compartment is seizures.³⁶ Nevertheless, there is an unusual description of posterior fossa CMs presenting with seizures.⁶

Because of their anatomical proportions, even small lesions located in the brainstem or cranial nerves in the posterior fossa can cause symptoms.⁸ The exception is extra-axial lesions arising from the CPA; these can reach a large size and cause symptoms by compressing the cerebellum, brainstem, and cranial nerves.¹⁴

FIG. 1. Case 1. A: Preoperative CT scan revealing a hyperdense lesion on the left cerebellar hemisphere. B: Angiography study revealing an avascular mass on the left cerebellar hemisphere.

Fig. 2. Case 1. Axial T₁- (A) and T₂-weighted (B) MR images consistent with a Type II CM lesion.

Patients harboring infratentorial CMs tend to present with progressive focal neurological deficits.⁴⁸ Among our 10 patients, however, eight had a sudden and two an acute presentation, with signs and symptoms of cerebellar syndrome. An acute or sudden presentation caused by hemorrhage is found in approximately 33% of intracranial CMs.⁸

Neuroimaging Findings

Cavernous malformations are angiographically occult vascular malformations. Nevertheless, when they are large they may appear as an avascular mass on angiography studies.^{46,51} We performed angiography in four of our 10 patients, and an avascular mass was present in all of them.

Findings on CT scans are nonspecific; CMs generally appear as a heterogeneous hyperdense lesion without enhancement. This hyperdensity corresponds to either hemorrhage or calcification.^{23,46} Perilesional hypodensity can be found, and it may represent edema, hemosiderin, or even atrophy.^{23,52} The CMs can be present as a cystic lesion that is isodense or hypodense on CT scans, with or

without a wall nodule, and consequently, differentiation from posterior fossa gliomas is very difficult based on CT findings alone.^{7,23,25} All patients in our series underwent CT scanning. In all cases, a hyperdense lesion in the posterior fossa was present.

Magnetic resonance imaging has dramatically changed our ability to diagnose CMs.^{8,46} Based on MR imaging findings, CMs were classified in four types by Zabramski, et al.⁵⁵ Whereas 93% of the Type I and II lesions were symptomatic, only 33% of the Type III and IV lesions caused corresponding symptoms. Among our patients, nine had a Type II lesion and in only one case the MR imaging findings were consistent with Type I.

An association between CM and DVA has a variable incidence.^{5,44} This association shows a preference for the posterior fossa location and female patients, and this kind of lesion tends to bleed and rebleed more frequently than isolated CMs.¹ Nevertheless, there was no associated DVA in any patient in our series.

The mean size of CMs reported in several large series was between 15 and 19 mm in diameter.^{2,9,29,48} According to some authors, the larger the lesion the higher the chance

Fig. 3. Case 1. A: Intraoperative photograph obtained after opening the dura mater through a suboccipital approach, showing a hemorrhagic, mulberry-like lesion. B: Photomicrograph of a histological specimen of the resected CM. H & E, original magnification $\times 200$.

Fig. 4. Case 1. Postoperative T₁- (A) and T₂-weighted (B) MR images demonstrating complete removal of the CM.

that symptoms will appear.²⁴ Bertalanffy, et al.,⁸ reported that most symptomatic patients present with lesions larger than 1 cm. Cavernous malformations arising from the posterior fossa may be smaller at the time of diagnosis.^{8,14} Interestingly, all patients in our series presented with large lesions (mean 4.6 cm).

Treatment Options

Just as in aneurysms and AVMs, the decision about the best treatment for CMs must compare the risk of bleeding with the risk inherent to the therapeutic option. Because the natural history of CMs is not completely understood, the rates of hemorrhage as well as the rates of morbidity and mortality from the lesion itself vary greatly in the literature.⁸ Consequently, in the management of CMs the surgeon must consider each patient individually.

The annual risk of bleeding for CMs is reported to be 2.2% per patient. For those who have suffered previous

bleeding, the annual risk increases to 4.3% per patient.¹⁶ In those harboring posterior fossa CMs and those who have experienced a previous hemorrhage it is 6.75 and 7.78 times more likely, respectively, that they will present with neurological sequelae.^{39,45} Cantu, et al.,¹⁰ reported that the risk of intracerebral hemorrhage was only 1.22% per patient per year in lobar CMs and 2.33, 2.39, and 2.82% per patient per year for brainstem, cerebellum, and deep hemispheric CMs, respectively.

The current literature about CM management defines three therapeutic options: conservative (observation), radiosurgery, and surgery.^{28,34,37} All patients included in our series underwent surgical treatment.

Conservative Management. Overall, conservative management is recommended for patients harboring asymptomatic lesions without bleeding, especially if deeply located, in eloquent areas, or in patients with multiple lesions.^{33,34} Patients who underwent conservative treatment

Fig. 5. Case 2. Admission CT scans revealing a hyperdense lesion on the vermis and the left cerebellar hemisphere.

Fig. 6. Case 2. Preoperative T₁- (A) and T₂-weighted (B) MR images demonstrating a Type II CM in the left cerebellar hemisphere.

were prospectively analyzed and, after a mean of 34 months of clinical follow up, the annual rate of rebleeding was 2.6%.³¹ Some authors described a silent hemorrhage of CM and defined the annual rate of asymptomatic bleeding as 13% per patient and 2% per lesion. In addition, due to the dynamic behavior of CMs, periodic follow-up MR images are recommended.⁵⁵

Radiosurgery. There is no evidence that radiosurgery is an effective treatment for CMs. This is particularly true because there is no reliable neuroimaging modality that can be used to document total lesion occlusion.²⁸ Consequently, the only way to evaluate the effectiveness of radiosurgery in CMs is to analyze the reduction in the bleeding rate. In high-flow vascular malformations such as AVMs, the gap between radiosurgery and lesion obliteration is approximately 2 years.³¹ Nevertheless, the role of radiosurgery for low-flow vascular malformations like CMs remains controversial.⁸

Although some authors report a reduction in the rate of hemorrhage in patients whose CMs are treated with radiosurgery,^{21,30} others not only failed to confirm such a reduction but also showed a high incidence of complications induced by radiation.^{4,26,42} Gewirtz, et al.,¹⁷ found no evidence of vascular obliteration in histopathological samples of CMs that were previously treated with radiation (either conventional radiotherapy or stereotactic radiosurgery), af-

ter a mean follow-up period of 3.5 years. There is a report of a cerebellar CM treated with radiosurgery in which the lesion showed reduction without hemorrhage after a mean follow-up duration of 34 months.²⁸ The lack of evidence for the effectiveness of radiosurgery for intracranial CMs, along with the risk of a higher rate of radiation-induced complications, justifies prospective randomized studies on this subject.^{26,35,42}

Surgical Treatment. Cerebellar hemorrhage from CMs has a wide range of clinical presentations, from minimal symptoms to sudden death caused by massive hemorrhage.¹² Thus, each patient must be analyzed individually. Patients with symptomatic CMs, with sudden or progressive presentation (with or without radiological evidence of bleeding), and those with recurrent hemorrhage should be considered for surgical treatment.^{16,29,31} Porter and coworkers⁴³ showed that after a hemorrhage from a CM treated conservatively, only 37% of patients experienced complete recovery and 27% did not improve at all. Consequently, some authors recommend surgical treatment even for asymptomatic CMs, especially if there is evidence of growth on neuroimages.¹⁶

Surgical management of posterior fossa CMs depends on a wide number of factors such as the patient's clinical condition, age, lesion location, hemorrhage size, presence of mass effect and hydrocephalus, and the morbidity inherent to a surgical approach.⁸ Lesions located in highly eloquent areas such the brainstem, the CPA, and the cranial nerves in the posterior fossa usually present with higher morbidity and mortality rates compared with cerebellar CMs, not only as the consequence of bleeding but also because these lesions frequently require a complex surgical approach.^{8,14} Among our 10 patients, all underwent a standard suboccipital approach and experienced no complications. Consequently, we recommend it as a safe and effective way to manage cerebellar CMs.

Although the eloquence of the cerebellum cannot be compared with the brainstem, cerebellar CMs can reach giant size²² or even cause massive hemorrhage.¹² This may not be well tolerated in the restricted posterior fossa space, causing brainstem compression⁵⁴ or hydrocephalus.¹⁵ Among our 10 patients, all presented with large lesions in which there was considerable hemorrhage, which caused

Fig. 7. Case 2. A: Intraoperative photograph obtained after opening the dura via a suboccipital approach, showing a large, hemorrhagic, mulberry-like lesion. B: Photomicrograph of a histological specimen of the resected CM. H & E, original magnification $\times 100$.

Fig. 8. Case 2. Postoperative axial (A), coronal (B), and sagittal (C) MR images demonstrating complete removal of the CM.

acute or sudden presentation and were responsible for hydrocephalus in two cases. Based on this kind of presentation, some authors recommend surgical treatment for cerebellar CMs, even in patients with asymptomatic lesions, because a hemorrhagic event in a lesion in this location can prove fatal.^{15,54}

Pozzati and colleagues⁴⁵ reported on 18 patients among 145 whose CMs exhibited aggressive biological behavior characterized by recurrent overt bleeding, growth, or de novo appearance. Consequently, total resection must be emphasized because residual lesions may grow and cause bleeding.¹⁴ In our series, one patient underwent partial removal (Case 6). This patient remains asymptomatic 108 months after resection, and MR imaging studies showed the absence of bleeding and no increase in the size of the lesion.

Conclusions

Cerebellar CMs present separate characteristics from other CMs located in the posterior fossa. We investigated a relatively large series of purely cerebellar CMs and found no difference with respect to demographic aspects (age and sex) when compared with patients who had CMs in other locations. All of our patients had an acute or sudden clinical presentation. Probably such a presentation was the consequence of the unusually large size of these lesions, which ranged from 3 to 6 cm (mean size 4.6 cm). Surgical treatment of cerebellar CMs is a safe and effective option. No complication related to surgery occurred in our series, and complete removal was accomplished in nine of 10 cases.

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Manuscript received April 13, 2006.

Accepted in final form May 30, 2006.

During this work, Dr. de Oliveira was a grant recipient from Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) (www.capes.gov.br).

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