Original Article

Foramen magnum meningioma: Series of 20 cases. Complications, risk factors for relapse, and follow-up

ABSTRACT

Introduction: Meningiomas account for 2.2% to 2.5% of all cerebral tumors, of which only 2% are located in the foramen magnum. Foramen magnum meningiomas (FMMs) are commonly found in women, with a mean age at onset of 52 years old. They generally behave more aggressively than other meningiomas.

Materials and Methods: We performed epidemiological, anatomical and surgical analyses of 20 patients diagnosed with FMMs who underwent surgical treatment from 1999 to 2019 at Santa Paula Hospital in Sao Paulo. This case series was compared with previously published ones to better understand this relatively rare disease.

Results: Twenty patients were included, with a mean follow-up of 110 months. Their mean age was 37.8 years old. The mean preoperative Karnofsky performance status scale (KPS) was 84%. We found a female (65%) and left hemisphere predominance (50%). Involvement of both hemispheres was found in 25% of patients. FMM locations were anterior, anterolateral, lateral and posterior, in 45%, 35%, 10%, and 10%, respectively. Simpson resection grades I, II, and III were achieved in 25%, 60%, and 15% of cases, respectively. Mean postoperative KPS was 79%. Three patients with anterior and bilateral located meningiomas had a worse postoperative KPS in comparison to the preoperative one.

Conclusion: Anterior and bilateral FMMs seem to be related to a worse prognosis. A gross total resection can reduce the recurrence rates. The KPS is worse in patients with recurrence.

Keywords: Foramen magnum, meningioma, skull base

INTRODUCTION

Meningiomas are central nervous system (CNS) tumors originated from arachnoid cap cells, representing 14.3% to 20% of all CNS tumors in the adult population. Those tumors have an incidence of 4.4/100.000 per year and a mean age at presentation of 63 years old.[1-3]

The first foramen magnum meningioma (FMM) was described in 1872 after an autopsy at Lariboisiere Hospital in Paris; however, the first successfully operated case was only described by Frazier and Spiller in 1922. FMMs represent 1.5% to 3.6% of all intracranial tumors; they are commonly found in women with a mean age of 52 years old. Regarding the localization, about 90% of them are anterior and anterolateral, posterior ones are the least common. An en plaque tumor can be found in rare cases.[4-8]

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In the pediatric population, meningiomas present at a mean age of 14.4–15.5 years old. The incidence varies between 1% and 4% during the first two decades of life. Meningiomas account for 2.2% to 2.5% of all cerebral tumors, of which only 2% are located in the foramen magnum.

Pediatric FMMs are usually related to genetic diseases, such as neurofibromatosis type 2. The most frequent localizations are the anterior and anterolateral ones. Vertebral artery (VA) involvement is common, as well as lesions of the IX, X, and XII cranial nerves.[3,9-11]

To better understand the natural history and presentation of this particular tumor, we retrospectively reviewed the cases operated in our service. Our main goal was to define how we should manage FMMs.

MATERIALS AND METHODS

We performed epidemiological, anatomical, and surgical analyses of 20 patients diagnosed with FMM who underwent surgical treatment from 1999 to 2019 at Santa Paula Hospital, in Sao Paulo. This case series was then compared with articles published during the same period, to identify if our results were compatible with the ones found in the literature.

We used PUBMED and LILACS databases for this review. Multiple variations of the following keywords were used: "Meningiomas," "foramen magnum," "skull base" and "skull base tumors." Case reports and other reviews were not included. The inclusion criteria focused on the following parameters: studies about FMMs, complications, and follow-up) were not included, in humans, pre- and post-operative clinical evaluation, surgical outcome, surgical results, with more than 10 patients and with a clear description of results. Studies with <10 patients, without the description of results (including tumor classification.

RESULTS

Twenty patients were analyzed [Table 1], with a mean follow-up period of 110 months (range 0–241). The mean age at presentation was 37.8 years old (range 19–53). We noticed a female (65%) and left side (50%) predominance. Both sides were affected in 25% of cases. Anterior, anterolateral, lateral, and posterior locations were, respectively, found in 45%, 35%, 10%, and 10% of patients.

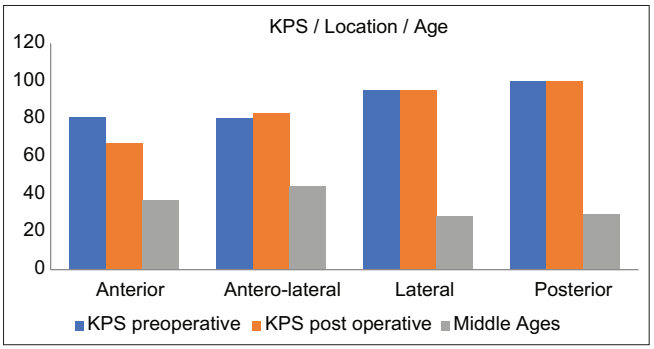
All patients underwent surgical procedure through the half-sitting position, using the transesophageal Doppler (to monitor air embolism), electrophysiologic monitoring by motor and sensory evoked potentials, and continuous electroneuromyography (for lower cranial nerves monitoring).

The incision was hockey-stick shaped, using the C2 spinous process, external occipital protuberance, and mastoid process as anatomical references, ending 1 cm below the latter. Muscles were dissected to obtain bone exposure, where a trepanation hole was done below the transverse and posterior to the sigmoid sinus. Below the foramen magnum, posterior arch, and lateral sulcus of C1 were identified where the V3 segment of VA lies before entering into the skull. This segment should be transposed carefully to avoid lesions when removing the latero-posterior arch of C1 and, if necessary, to allow removal of condyle's posterior portion for anterior tumor's access. After that, the bulbar nerves were identified, tumor's debulking and removal were performed.

Signs and symptoms at presentation were lower cranial nerves deficits (60%), pyramidal tract syndrome (50%), dizziness (40%), VIII cranial nerve lesion (40%), motor deficits (35%), gait disturbances (25%), dysesthesia (15%), headache (15%), hearing loss (10%), diplopia (10%), dysphagia (10%), hoarseness (10%), Lhermitte's sign (5%), and VII cranial nerve lesion (5%).

The extreme lateral approach was used in 90% of cases. The other 10%, corresponding to posterior FMMs, were operated through a midline suboccipital approach. Simpson resection grades I, II, and III were achieved in 25%, 60%, and 15% of cases, respectively.

The mean preoperative Karnofsky performance status scale (KPS) was 84%, while postoperative was 79% [Graph 1]. Four patients had a decrease from the preoperative value due to severe complications after surgery. Patient 5 presented meningitis, with later recurrence and death 96 months after the initial surgery. Patient 9 suffered VA lesion and further brainstem ischemia, leading to death during the hospital stay. Patient 12 presented bleeding immediately after surgery, requiring a new surgical procedure. Patient 13 presented



Graph 1: Pre- and post-operative Karnofsky performance status scale associated with age and location

Table 1: Foramen magnum meningiomas: 20 cases series

Age (years)	Gender	Side	Far lateral	Simpson	WHO grade	Recurrence	KPS (pre/post)	Radiotherapy	Follow-up (months)	Location	Associated diseases
32	Male	Left	Yes	II	Clear cell		90/90	Yes	134	A	
44	Female	Left	Yes	I	I		60/90	Yes	87	A	Neurinoma
34	Female	Right	Yes	II	I		90/100	Yes	146	A	
52	Female	Bilateral	Yes	II	I	Yes	90/70	Yes	123	A	ACoA
19	Male	Bilateral	Yes	II	I	Yes	50/10	No	96	A	
53	Female	Left	Yes	III	Atypical		90/100	Yes	63	AL	
34	Female	Left	Yes	II	I		80/90	Yes	144	A	
45	Male	Right	Yes	II	I		90/100	Yes	88	A	
40	Male	Left	Yes	III	I		90/0	No	0	A	
52	Female	Left	Yes	II	I		90/90	No	74	AL	
39	Female	Right	Yes	II	I		80/100	No	147	AL	
40	Female	Left	Yes	II	I		90/80	Yes	241	AL	
48	Male	Left	Yes	II	I	Yes	40/30	Yes	74	AL	
40	Female	Right	Yes	II	I		80/90	No	144	AL	
39	Male	Left	Yes	II	I		90/90	No	87	AL	
37	Male	Bilateral	No	I	I		100/100	No	100	P	
22	Female	Bilateral	No	I	I		100/100	No	120	P	
32	Female	Right	Yes	I	I		100/100	Yes	110	LAT	
25	Female	Left	Yes	I	I	Yes	90/90	No	108	LAT	
30	Female	Bilateral	Yes	III	I		90/60	No	123	A	

KPS - Karnofsky Performance Score Scale; A - Anterior FMM; AL - Antero-lateral FMM; P - Posterior FMM; LAT - Lateral FMM; ACoA - Anterior communicating artery aneurysm; WHO - World Health Organization; FMM - Foramen magnum meningiomas

brainstem ischemia secondary to posterior inferior cerebellar artery lesion.

Postoperative complications were: hydrocephalus (requiring shunt in four patients), gastrostomy (10%), tracheostomy (25%), cerebrospinal fluid (CSF) fistula (5%), meningitis (5%), brainstem ischemia (10%), pulmonary thromboembolism (5%), bleeding on the surgical bed (5%), and death (5%).

We could also observe that three patients with anterior and bilateral located meningiomas had a worse KPS in the follow-up period, as well as the 75% of patients that presented recurrence. All of those patients underwent total resection (one patient Simpson I and three patients Simpson III).

DISCUSSION

We performed an analysis of a case series focused on surgical treatment. We intended to provide evidence of several studies and their results, so they could be compared to our own data. Our main goal was to establish an effective surgical treatment for those rare tumors to decrease complications and recurrence rates. In Table 2, we show the studies, year of publication, number of cases, mean age, tumor location, follow-up period, pre- and post-operative clinical statuses, gross total resection rate, and main complications.

About 70% of foramen magnum tumors are meningiomas, followed by schwannomas.[12] By definition, FMMs are located between the lower third of the clivus and the posterior arch of the C2 vertebra.[13] They must be anterior, below the lower third of clivus, above the superior border of the axis, lateral to jugular tubercle, and C2 laminae. They are posteriorly limited by the edge of the squamous occipital bone and spinous process.[14]

Cranial nerves IX, X, and XI arise from postolivary sulcus, pass anteriorly to the foramen of Luschka, posteriorly to the VA and penetrate the jugular foramen. The XIIth nerve originates ventrally from preolivary sulcus, passes anteriorly to VA, and penetrates the hypoglossal canal. Those anatomic aspects explain why all lower cranial nerves can be affected by FMMs.[8]

In our series, the mean age at presentation was 37.8 years old (range 19–53). This differs from the majority of studies, which showed ages close to the sixth decade of life. However, Goel *et al*.[15] showed similar numbers to ours.

Meantime of onset to diagnosis varied between 20 and 27 months and the most common initial symptoms were chronic headache, neck pain, dysesthesia, ataxia, paresis, and difficulty using hands. Most physical findings were hyperreflexia, extremity weakness, Babinski sign, spastic gait, hypoesthesia, occipital neuralgia, cranial nerve XI deficit, C2

Table 2: Literature review: Foramen magnum meningiomas

Study	Year	Patients (*n*)	Gender	Age (years)	A	AL	*P*	Follow-up (months)	KPS (pre/ postoperative)	Simpson I/II (%)	Complications
George *et al.*[2]	1997	40	11 males 29 females	51.6	18	21	1	NA	NA	94/50**	Death (7.5%)
Arnautovic *et al.*[16]	2000	18	NA	NA	16	0	0	40	NA	75	Cranial nerve palsy (IX and X)
Goel *et al.*[15]	2001	17	6 males 11 females	39.2	0	17	0	43	NA	82.3	Lower cranial nerves lesion (5.8%)
Boulton and Cusimano[17]	2003	10	2 males 8 females	55	0	7	3	33	NA	90	CSF fistula (10%) Brown-squard syndrome (10%) Neurocognitive impairment (10%)
Pamir *et al.*[18]	2004	22	4 males 18 females	47.2	0	20	2	40	73/94	95.5	Fistula (18%) Hydrocephalus (4.5%) Lower cranial nerves paralysis (9%) Vascular injury (4.5%) Mortality (4.5%)
Bassiouni *et al.*[4]	2006	25	6 males 19 females	59.2	8	14	3	73	79/89	96	CSF fistula (16%) Lower cranial nerves lesion (4%) Mortality (4%)
Borba *et al.*[19]	2009	15	1 male 14 females	55.9	8	7	0	23.6	NA	80	XII nerve paralysis (6.6%) Fistula (6.6%) Hydrocephalus (6.6%) Transient myelopathy (6.6%)
Kandenwein *et al.*[20]	2009	16	4 males 12 females	61	3	12	1	43.5	NA	87.5	Cranial nerve palsy (31%)
Wu *et al.*[21]	2009	114	46 males 68 females	52.3	80	24	10	90.3	72.5/83.5	86	Dysphagia (55%) Tracheostomy (28.9%) hemianesthesia (2.6%) hydrocephalus (7.8%) CSF fistula (6.1%) Infection (2.6%) hypothyreoidism (2.6%) hypopituitarism (3.5%) Hyponatremia (1.8%) Diabetes insipidus (0.08%) Death (1.8%)
Kano *et al.*[14]	2010	23	8 males 15 females	56	9	14	0	42.8	83.9/89.5	62.5	Neck movement restriction and instability (39%) Hemiparesis (4.3%) Dysphagia (30%) Lower cranial nerves palsy (13%) VI palsy (17%) Hoarseness (13%)
Bruneau and George[12]	2010	107*	NA	NA	41	57	6	120	NA	86	Pulmonary thromboembolism Death (1.9%)
Pirotte *et al.*[22]	2010	26	9 males 13 females	53	7	15	0	88	NA	73	Death (4.5%) Hydrocephalus (4.5%) Fistula Hemiparesis 4.5% Lower cranial nerves paralysis (27.2%) Tracheostomy (4.5%)
Talacchi *et al.*[23]	2012	64	16 males 48 females	59	24	40	0	138	NA	81	Cranial nerves palsy IX XII (35%) Dysphagia Temporary gastrostomy

Contd...

Table 2: Contd...

Study	Year	Patients (*n*)	Gender	Age (years)	A	AL	*P*	Follow-up (months)	KPS (pre/ postoperative)	Simpson I/II (%)	Complications
Colli *et al*.[12]	2014	13	2 males 11 females	54.15	4	9	0	47.3	>80**	69.2	CSF fistula (30.8%) difficulty breathing (7.7%) Transient lower cranial nerves palsy (38.5%) Permanent lower cranial nerves palsy (7.7%)
Dobrowolski *et al*.[16]	2016	24	6 males 18 females	52	3	19	2	45.6	85/-	83.3	Hydrocephalus (4.1%) CSF fistula 4.1% Pneumonia 4.1% hemorrhage 4.1% Sinus thrombosis 4.1% dysphagia 8.3% dysesthesia 4.1%
Li *et al*.[13]	2017	185	61 males 124 females	49.4	122	49	14	110.3	80/>80	83.2	Cranial nerves palsy IX and X (21.6%), XII (10.8%) Tracheostomy (29.2%) pneumonia (11.9%) Fistula (4.3%) Intracranial hematoma (2.2%) Ischemia (0.5%) hydrocephalus (6.5%) dysphagia (15.1%)
Current case series	2018	20	7 males 13 females	37.85	9	9	2	110	84/79	85	Hydrocephalus (20%) Gastrostomy (10%) tracheostomy (25%) CSF fistula (5%) meningitis (5%) Brainstem ischemia 10% pulmonary thromboembolism (5%) Rebleeding (5%) Death (5%)

A - Anterior FMM; AL - Antero-lateral FMM; P - Posterior FMM; CSF - Cerebrospinal fluid; KPS - Karnofsky performance score scale; NA - Not available; FMM - Foramen magnum meningiomas; VI - Abducens nerve; IX - Glossopharyngeal nerve; X - Vagus nerve; XII - Hypoglossal nerve; **Intradural/extradural

hyperalgesia, neck rigidity, and Brown-Sequard syndrome. General symptoms can also be found, such as a headache and neck pain; they are explained by nervous innervation of meninges. Forty percent of patients may present a normal neurological examination.[25-28,22,29]

When analyzing location, we observed a predominance of anterolateral tumors on most studies, except for Arnautovic *et al*. series,[16] in which tumors were exclusively anterior, and Li, *et al*.,[24] and Borba *et al*.[19] series. In our series, there was no predominance, with 45% anterior and 45% anterolateral.

Surgery is the treatment of choice. The main goal is to achieve complete removal of the lesion, corresponding to Simpson I and II resection grades, which are obtained in 46% to 96% of cases. Meningiomas attached to the brainstem, venous sinuses, VA and cranial nerves or presenting malignancy, high mitotic activity, or loss of 1p36.1-p34 have been associated with incomplete resection.[30,31] Recurrence is lower in gross total resection cases. Simpson I and II resections were able to reduce recurrence rates.[32] However, surgeons should be aware that complications can be higher in those resections.

We identified three risk factors for a worse prognosis: anterior location, bilaterality, and recurrence. However, we could not analyze those parameters individually due to a lack of data. Thus, we cannot affirm that those three factors can influence prognosis individually.

Arnautovic *et al*.[16] published a case series of only anterior FMMs; curiously his results indicated a lower KPS than other studies, supporting the hypothesis of anterior location as a risk factor. We believe this is due to larger and more complex surgeries required for anterior tumors, increasing the risk of instability during surgery, cranial nerve, and brainstem lesions.

The most frequent complications after surgery were lower cranial nerves lesions (IX, X, XI, and XII cranial nerves), followed by CSF fistula. Transient or permanent damage to cranial nerves reached 38.5% and 27%, respectively. CSF fistula was cited in almost all studies, with rates of 4.1% to 30.8%. We found results compatible with this range in our case series. Another complication, hydrocephalus, appeared in our study at a considerable rate of 20%.

In the majority of studies, mortality varied between 0% and 15%. Higher mortality rates were found among patients who presented severe neurological dysfunction during the preoperative period.

CONCLUSION

Even though we had a small number of patients, we believe that anterior location, bilaterality, and recurrence are indicators of a worse prognosis. Gross total resections can reduce the recurrence rates, consisting of the main surgical goal. More aggressive tumors can be found in children, anaplastic tumors are more common in this population. The analysis of cases and studies described in this article makes us emphasize the necessity of even more studies about FMMs, with greater numbers of patients and a better exposition of pre- and post-operative KPS.

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Conflicts of interest

There are no conflicts of interest.

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