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The cavernous sinus meningiomas' dilemma: Surgery or stereotactic radiosurgery?

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ABSTRACT

Despite the advances in techniques and technologies, the management of cavernous sinus (CS) meningiomas still remains a challenge for both neurosurgeons and radiation oncologists.

On the other hand, the improvement of the anatomical knowledge and the microsurgical techniques together with diffusion of radiosurgery are currently changing the treatment strategy, opening new perspectives to the patients which are suffering from such lesions.

The authors reviewed here the literature data. A multidisciplinary treatment algorithm is also proposed.

1. Introduction and historical remarks

The cavernous sinus (CS) region, due to its complex anatomy and its particular position in the antero-lateral skull base, has always been a challenge for neurosurgeons. The treatment of malignant diseases has presented over the past few decades a number of developments, particularly with the progress of the techniques of radiotherapy and radiosurgery. Even today however, it is still a controversial and debatable subject, and the best multimodal treatment is yet to be defined.

In 1965 Parkinson[1] was the first to realize an anatomical study and to propose a surgical approach to the CS. Despite the development of the microsurgical technique in the seventies, it was thought that microneurosurgery was reaching its furthest limits in the approach of lesions in and around the CS. The extremely high risk of damaging nervous structures, as well as causing uncontrollable haemorrhage or postoperative CSF leak seemed to be an unavoidable and insuperable obstacle. Thanks to the anatomical work of Dolenc and his surgical experiences, a rational surgical approach was eventually developed and the different relations between the lesion and the neurovascular structures were defined. In Dolenc's book preface, Yasargyl states that "there is no doubt that this type of microsurgical anatomical study is a new step in the 100 year history of neurosurgery".[2]

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Once this frontier was opened the experiences of other groups of skull base surgeons were added and we started to develop different approaches and new techniques to address these tumours.[3,4] More recently, new and less invasive endoscopic routes started to flourish. These approaches are less invasive and allow to address the tumour combining two complementary corridors, one antero-lateral and one transsphenoidal.

Still, a complete radical removal or the attempt of near total excision with anatomo-functional preservation is a very arduous exercise or even an illusion. The intimacy between tumour, nerves and vessels can be hardly overcome and represents the main unfavourable prognostic factor.

The role of both radiotherapy and radiosurgery to treat the recurrent tumours of the skull base is well known.[5]

However, it was with the gradual evolution of stereotactic radiosurgery that the method of dealing with the CS pathology has really changed. A multimodal treatment strategy combining surgery with radiotherapy, as well as radiotherapy alone in selected cases, have become the main practice to handle these tumours.

2. Anatomy

Cavernous sinus is constituted of paired venous structures located in the middle cranial fossa.[2,6]

These structures are surrounded by dural layers, which contain neurovascular structures, and face the sella turcica, the pituitary gland, the sphenoid bone on the medial side and the temporal lobe on the lateral side.

A cavernous sinus is roughly arranged in four walls, the lateral, medial, anterior and posterior walls, and a roof.

The lateral wall faces the temporal lobe. The medial wall is mainly arranged by the sella turcica and the pituitary gland together with the sphenoid bone. The posterior margin is limited by the posterior cranial fossa. Anteriorly the cavernous sinus reaches the superior optic fissure and the near inferior surface of the anterior clinoid process. The roof faces the basal cisterns, extending anteriorly from the anterior clinoid process to the posterior clinoid process posteriorly.

The dura completely surrounds the cavernous sinus. From the floor of the medial cranial fossa the dura curves rostrally along the lateral edge of the sella and then it turns laterally to shape the lateral wall of the cavernous sinus.

The lateral dural wall of the cavernous sinus is composed of two layers, the outer dural layer (dura propria) and the inner membranous layer. The inner layer of the lateral edge of the cavernous sinus contains the critical structures, it separates the lateral wall and its contents form the venous spaces. The outer layer faces the mesial temporal lobe.

The lateral wall meningiomas usually grow between the inner and the outer layer. In this sense these lesions are substantially extra cavernous tumours. This particular condition has to be considered in surgical planning and an accurate dissection of these layers has to be performed in order to obtain a total removal of these tumours.

The cavernous sinus contains vascular and nervous structures.

The vascular structures include the cavernous segment of the internal carotid artery (ICA) and multiple venous tributaries (superior and inferior petrosal sinuses, the basilar sinus, the intercavernous sinus) as well as various draining veins of the skull base, sylvian fissure, and middle cerebral vein.

The nervous structures include the sympathetic plexus, the oculomotor nerves (III, IV, VI) and the first and second branch of the trigeminal nerve (V1, V2). According to a craniocaudal direction, the cranial nerves III and IV as like as V1 and V2 travel inside the lateral wall of the cavernous sinus. The cranial nerve VI occupies a more medial position, behind and lateral the ICA.

According to their anatomy it is possible to identify meningiomas which arise from cavernous sinus dura itself (the strictly speaking cavernous sinus meningiomas) and meningiomas arising from the dura of the sphenoid ridge, clinoid processes and petroclival region extending to or infiltrating the cavernous sinus.

3. General considerations

In CS tumours management histological type, biological behaviour, location, extent of dural attachment and particularly relationship and encasement of neurovascular structures have to be considered. Biological behaviour can be schematically categorized into three groups: benign, intermediate malignancy and high malignancy. This subdivision is probably too simplistic, but it may facilitate decision making and the most appropriate treatment strategy. Among the most common benign oncotype, we find meningiomas, pituitary adenomas and schwannomas. These tumours may invade and encase nearby structures. Tumours of intermediate malignancy include chordomas, chondrosarcomas, adenoid cystic carcinomas and low grade esthesioneuroblastomas. Highly malignant tumours include cranial base carcinomas, sarcomas, high grade esthesioneuroblastomas and lymphomas.[7]

Meningiomas represent 41% of all CS tumours. They can either start in areas outside the CS and subsequently invade it, or start into CS and then spread to the surrounding structures. The CS is frequently invaded by tumours (meningiomas) of the orbital apex, sella, medial sphenoid wing, middle fossa, Meckel's cave, petrous apex and tentorium. This behaviour is mostly to be found in en plaque meningiomas. On the other hand, meningiomas arising within the CS can extend and involve the same above mentioned areas, infiltrating extra or subdural spaces and bone.

Sekhar in order to assess the surgical technical difficulties and risks, and to compare different patients' series, created a classification based on the CS areas involved by the tumour, on its volume and on carotid artery involvement.[3,8] According to this point, the most important variable influencing risks and patients outcome in the management of such lesions is the grade of involvement-encasement of nerves and vessels.

The natural history of meningiomas is still partially unknown. Although the growth rate is estimated to be between 2 and 24 mm per year, some authors found that about 23% of the meningiomas (particularly the calcified ones) did not grow.[9]