**Meningiomas: always an easy diagnose?**

**Poster No.:** C-1279  
**Congress:** ECR 2013  
**Type:** Educational Exhibit  
**Authors:** M. V. Trujillo Ariza¹, A. Coessens¹, A. Martínez de Alegría¹, J. A. Castiñeira¹, A. Banuero Gutierrez¹, P. Gómez Martínez¹, M. C. Ageitos Casais², A. Arango¹, J. M. Pumar¹, J. M. Pumar¹; ¹Santiago de Compostela/ES, ²Ribeira, A Coruña/ES  
**Keywords:** Image verification, Normal variants, Diagnostic procedure, MR, CT, Neuroradiology brain  
**DOI:** 10.1594/ecr2013/C-1279

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR’s endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method is strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys’ fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Learning objectives

- To correlate the histological origin of meningiomas with their location and anatomopathologic features.
- To describe the typical and atypical imaging characteristics of meningiomas using CT and MRI.
- To emphasize imaging features in atypical meningiomas and facilitate their differential diagnosis with other intracranial neoplasms.
Background

Meningiomas are the most common non-glial primary tumours of the central nervous system and the most common extra axial neoplasms, accounting for approximately 15% of all intracranial tumours. Meningiomas were first described in 1614 by Felix Paster.

They are typically defined as an extra axial mass with broad-based dural attachment and a homogeneous and intense enhancement.

They represent approximately 15% of all symptomatic and about 33% of all incidental (asymptomatic) intracranial neoplasms.

Meningiomas are generally benign, slow growing tumours that may produce neurological symptoms and signs due to compression of adjacent structures.

They are, however, a tumour entity with fickle clinical presentations, a heterogeneous histological picture, and an inherent tendency for recurrence.

Etiology

Meningiomas are neoplasms thought to derive from arachnoidal cap cells in the meningeal coverings of the spinal cord and brain.

The peak incidence is in the sixth and seventh decades of life.

They have a 2:1 female predilection and may be related to female sex hormones (correlated with breast cancer, may increase in pregnancy, progesterone receptors have been identified in tumours).

They often occur in multiples, especially when associated with neurofibromatosis type 2 or when hereditary.

Meningiomas may also occur in children; one group reported that 1.3% of 1397 patients with meningiomas were under 16. Intraventricular location, peritumoral cysts, and a lack of dural attachment are more common in children than in adults.

Meningiomas have also been associated with radiation exposure and head trauma: radiation may be responsible for a chromosomal deletion that causes the cell to lose a suppressor sequence. The role of trauma in causing meningiomas is unclear; the possibility of a correlation remains intriguing; Schiffer recently reported three cases developing precisely at the site of an old fracture, and patients with meningiomas often recall head trauma. This may, in some way, represent induction of tumours by the process of wound healing.
Location

Meningiomas are typically intracranial in origin, but can be found within the orbit and spinal canal. They have been reported in almost every organ, although extracranial localizations are very rare.

Intracranially, meningiomas occur most frequently along the cerebral convexities, especially along the falx cerebri. Intracranial origin in order of decreasing frequency of occurrence includes the parafalcine location, the falx, the sphenoid ridges and the posterior fossa (including petroclival location and foramen magnum). In addition, they are found at the tuberculum sella, olfactory grooves, the tentorium, optic nerves, petrous ridges and, rarely, intraventricular or even extracranial origin. Fig. 3 on page 7

Unusual locations Fig. 4 on page 8

Cerebellopontine angle meningioma: The meningioma is the second most common mass lesion of the cerebellopontine angle, with 13%-18% of all neoplastic lesions in this location being meningioma. Must be distinguished from acoustic schwannoma.

Orbital meningioma: Account for less than 2% of cranial meningiomas but constitute 10% of all intraorbital neoplasms. They may produce diffuse thickening of the optic nerve, a well-defined and rounded mass, or even an eccentric lesion with an irregular border. It may contain calcifications.

En Plaque Meningioma: This type of meningiomas cloak the inner table of the skull, where they may infiltrate both the dura mater and underlying bone. On CT scans, especially those obtained without contrast material, it may be difficult to distinguish the tumor itself from the associated hyperostosis. The extent of radiographic hyperostosis has little relation to the degree or presence of bone invasion and may occur secondary to local hypervascularity. Peritumoral edema is less common with en plaque tumors. MR images obtained with gadolinium enhancement enable this type of meningioma to be easily distinguished from the associated bone changes.

Intraventricular Meningiomas: They arise from the tela choroidea or the stroma of the choroid plexus itself. Approximately 80% arise in the lateral ventricles with a preference for the left trigone, 15% occur in the third ventricle, and about 5% within the fourth ventricle. Meningioma is the most common trigonal intraventricular mass in an adult.

Ectopic Meningioma: Less than 1% of meningiomas develop extradurally. These ectopic meningiomas may arise within the intradiploic space, from the outer table of the
skull, in the overlying skin, inside the pananasal sinuses, in the parotid gland, and from the parapharyngeal space. Meningiomas have also rarely been discovered in locations at distance from the neural axis including the mediastinum, lung, and adrenal glands. Possible explanations include ectopic arachnoid cell and meningothelial differentiation from pluripotential mesenchymal cells.

**Symptoms and signs**

Symptoms vary according to size and location. Less than 10% of meningiomas are asymptomatic.

Patients present with headache in 36% of cases, whereas other symptoms may be the result of compression of adjacent structures such as cranial nerves or obstruction of the ventricles. Fig. 5 on page 9

**Differential diagnosis**

The differential diagnosis needs to be made with other extra-axial soft-tissue lesions, as well as some superficial intra-axial tumours. For example, haematologic neoplasms such as leukaemia or central nervous system Hodgkin lymphoma, dural and calvarial metastases from breast cancer or metastatic neuroblastoma; granulomatous diseases like tuberculosis or sarcoidosis, etc. Fig. 6 on page 10 Fig. 7 on page 13

**Histopathological characteristics**

There is no single pathological marker for a meningioma cell. Whorls and psammoma bodies are characteristic of groups of cells. Epithelial membrane antigen may be useful, as it is positive in 80% of these tumors, and tests for glial fibrillary acidic protein are almost always negative. Vimentin staining is positive and anti-leu-7, often positive in a schwannoma, is virtually never found in meningiomas. In the ultrastructure, exuberant infolding and interdigitation of the plasma membrane, intermediate astroskeletal filaments, hemidesmosomes, and basal lamina characterize meningotheliomatous, transitional, and fibroblastic types.

There are several classification schemes for meningiomas:

Cushing and Eisenhardt divided them into mesenchymatous, angioblastic, meningotheliomatous, psammomatous, osteoblastic, chondroblastic, fibroblastic, melanoblastic, and lipomatous types.

The currently used classification is Russell and Rubenstein's, which consists of meningotheliomatous (syncytial), fibrous, transitional, and angioblastic types. Unusual features, including fatty degeneration, hemorrhage, calcification, and cyst formation, may
occur. In this system, there is still controversy as to whether an angioblastic meningioma is the same as a hemangioepicytoma.

Meningiomas have historically been divided into many subtypes of which meningothelial, fibrous and transitional are the most common, however, the World Health Organization (WHO) classification scheme is independent of subtypes.

*The WHO classification of meningiomas includes three grades:*

*Grade I* meningiomas are considered benign.

*Grade II and grade III meningiomas* are termed atypical, comprising 4.7-7.2% of all meningiomas, and anaplastic, comprising 1.0-2.8% of all meningiomas.

WHO grade II and III meningiomas occur more frequently in children and males. Anaplastic meningiomas have been known to metastasize to the lung, pleura, bone and liver.

Atypical imaging features do not imply atypical histology. *Fig. 8* on page 11 *Fig. 9* on page 12
Fig. 2

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 3

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Unusual locations

- Cerebellopontine angle meningioma
- Orbital meningioma
- En Plaque Meningioma
- Intraventricular Meningioma
- Ectopic Meningioma

Fig. 4

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 5

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 6

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 8

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 9: Grade I Meningioma: (4x) psamoma bodies(arrow), low cell density no mitosis or necrosis. Same image 10x. Grade II Meningioma:(20X)higher cell density and mitosis than in grade I meningiomas (arrow), CNS infiltration del SNC (arrow) Grade III Meningioma:(20x)high cell density and necrosis (arrow).

© Courtesy of Dr. Romy Reyes and Juan José Carrera. Pathology Service, Hospital Clínico Universitario Santiago de Compostela, Santiago de Compostela-Spain.
Fig. 7: 9 year-old girl with Neuroblastoma stage IV, with dural metastatic disease.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Imaging findings OR Procedure details

Typical Imaging findings Fig. 10 on page 18

**NECT:**

CT imaging of meningiomas demonstrates isodense or slightly hyperdense tumours with a 15-20% incidence of tumoral calcifications. Calcifications are more common in fibroblastic or transitional subtypes with dense calcifications occurring in psammomatous subtypes.

On unenhanced CT scans they are sharply circumscribed and tend to be hyperdense or isodense relative to gray matter. Meningiomas that are isodense relative to gray matter may be difficult to identify on non-contrast CT. Fig. 11 on page 18

They demonstrate bony changes, usually in the form of hyperostosis in 20% of cases, with more benign varieties. Hyperostosis associated with meningiomas has not been shown to be associated with either tumor size or grade. Abnormal enlargement of the paranasal sinuses has been associated with meningiomas as well.

**CECT:**

Meningiomas enhance uniformly following contrast administration. Fig. 12 on page 19

**MRI:**

On MR images obtained without contrast material enhancement, meningiomas are characteristically hypointense to isointense with T1-weighted pulse sequences and isointense to hyperintense with T2-weighted pulse sequences and FLAIR sequences. FLAIR sequences are the best to see the peritumoral edema. Fig. 13 on page 20 Fig. 14 on page 21 Fig. 15 on page 22

After Gadolinium administration the mass enhances homogeneously. Fig. 16 on page 23

MRI better differentiates enhancing tumor from dura, however, one should be aware of dural reaction to the tumor in the form of an enhancing "dural tail" which does not contain tumor cells. The "dural tail", however, is not specific for meningiomas and has been shown also to occur with lymphoma, peripheral gliomas and schwannomas. Fig. 17 on page 24

The presence of adjacent osseous changes may help differentiate dural reaction from neoplastic dural thickening.
Dynamic contrast MRI may be useful in separating typical from atypical meningiomas; of the parameters tested, the "volume transfer constant", a measure of capillary permeability, appears to be able to distinguish typical from atypical meningiomas.

On diffusion weighted imaging, malignant meningiomas tend to display higher signal intensities. Lower diffusion constants on diffusion-weighted MRI have been shown to be predictive of higher tumor grades. Fig. 18 on page 25

Another important point to evaluate is vascular compromise, we need to make sure if there is or not dural sinus involvement by the tumor. Angio 3D reconstructions are a good method to determinate it. Fig. 19 on page 26

MR spectra are dominated by choline signal, reduced signal from creatinine and phosphocreatinine and lack N-acetylaspartate. Fig. 20 on page 27

**Atypical Imaging findings Fig. 21 on page 28**

**Peritumoral Edema:**

Peritumoral brain edema is found in more than half of all meningioma cases. It is a common feature of intra-axial masses like glioma, metastatic disease, and abscesses, so this finding can be problematic, since its presence may suggest incorrectly that the lesion is intra-axial.

Various degrees and shapes of edema have been reported, ranging from barely noticeable to up to 2-3 times the volume of the tumor. It increases intracranial pressure and induces neurological impairment.

A number of papers have reported that there is no statistical correlation between meningioma volume and peritumoral edema. However, a larger tumor is more likely to cause vascular, ischemic, and secondary brain edema, and some studies have claimed that venous compression of meningioma is a major factor in peritumoral brain edema development. Fig. 22 on page 29

Meningiomas with irregular margins more frequently have peritumoral brain edema than meningiomas with smooth margins.

The arachnoid plane around the tumor represents a physiological barrier of the adjacent normal brain tissues from tumors such as meningioma. The arachnoid plane is a non water-permeable cerebrospinal barrier. The pia mater is permeable for water and electrolytes, but is not for polymers, such as plasma proteins, and the cerebral cortex is not water-permeable. Therefore, vascular edema may occur from plasma proteins and blood plasma flowing into the white matter because of increased vascular permeability. This may occur by edema fluid produced by meningioma and substances that contribute to the development of edema.
A high SI in T2WI of the tumour indicates a high water content and a high level of vascularity in the tumor. Tumours with high water content can easily spread to adjacent organs because of differences in osmotic pressure. Fig. 23 on page 30

Atypical and anaplastic meningiomas (GII/GIII) have been reported to show higher cell proliferation rates than benign meningiomas (GI). Peritumoral brain edema in intracranial meningiomas has been reported to be associated with histological grade.

**Ring enhancement:** Meningiomas are usually fairly homogeneous masses, with homogeneous enhancement, although they may have an atypical ringed appearance. The peripheral enhancement represents the normal pattern for viable meningeal neoplasms and the center is an avascular or necrotic region. The causes of this feature include bland tumor infarction, necrosis in aggressive histological variants, and true cyst formation from benign fluid accumulation. Fig. 24 on page 31

**Cystic meningioma:** The cysts can be located within the tumour mass, either centrally or eccentrically, outside and adjacent to the edge of the tumor, and occasionally inside the adjacent brain parenchyma. A large cystic meningioma may have an atypical clinical presentation and contribute to misdiagnosis of a cystic or necrotic glioma. Fig. 25 on page 32

**Lipoblastic meningioma:** There is a metaplastic change of meningothelial cells into adipocytes, through the accumulation of fat within their cytoplasm. It may have an imaging appearance of a fatty tumor.

**Other findings:**

More aggressive varieties may demonstrate destructive changes. Lytic changes have been associated with intraosseous meningiomas.

Hemorrhage and necrosis within the tumor bed may also result in a heterogeneous appearance on both noncontrast and contrast-enhanced CT. Fig. 26 on page 33
Fig. 10

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 11: Typical meningioma in NECT image: extra-axial mass with calcifications and associated hyperostosis.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 12: Typical meningioma in CECT images: the mass homogeneously enhances after contrast administration.
Fig. 13: T1-weighted images: Mass typically iso to slightly hypointense with cerebral cortex.
**Fig. 14:** T2 weighted images: mass isointense to hyperintense. This is the best sequence for visualizing the cerebrospinal fluid (CSF)/vascular cleft between tumor and the brain.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 15: On FLAIR images we can see the peritumoral edema and the dural tail sign.
Fig. 16: After administration Gadolinium contrast the mass homogeneously enhances.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Typical Imaging findings: MRI

DURAL TAIL: What does it mean?

• It's a curvilinear region of dural enhancement adjacent to the bulky hemispheric tumor.
• Originally thought to represent dural infiltration by tumor.
• Most of the linear enhancement especially when more than 1 cm away from the tumor bulk, is probably caused by a REACTIVE PROCESS.

Fig. 17

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 18: Diffusion weighted images at different B values.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
**Fig. 19:** Infiltration of the longitudinal superior sinus by the parafacial meningioma.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 20

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 21

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 22: NECT, CECT, T1 and T1+C MRI of the same patient showing important vasogenic peritumoral edema. After surgery the diagnose was Meningioma Grade I (WHO).

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
**Fig. 23:** NECT, CECT, axial FLAIR and T2-weighted images, coronal T2-weighted images, T1 + Gd images in a patient with a right anterior parafalcine mass that causes mass effect over the mid-line and important peritumoral edema. After surgery was diagnose as an Atypical Meningioma, a year later showed recidive (same image characteristics), after surgery, the pathology results were: High grade glioma.

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
**Fig. 24:** MRI T2 weighted and T1 and T1 + Gd images show a mass in the right cerebellar hemisphere, with ring enhancement and peritumoral edema. After surgery was diagnosed as a grade II meningioma (WHO).

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 25: NECT, CECT, T2 and T1-weighted images and T1+Gd. In this case we see an extraaxial frontal left mass that shows peritumoral edema and cystic degeneration. After surgery was diagnose as grade I meningioma (WHO).

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Fig. 26: Cranial x-ray and T1+Gd MRI. In the x-ray we can see the bony destruction by the extra-intracranial meningioma. After surgery was diagnose as grade III meningioma (WHO).

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
Conclusion

After this review we will be able to:

- Correlate the histological origin of meningiomas with their imaging features.
- Make a brilliant imaging description of meningiomas.
- Remind that meningiomas could have atypical imaging features that can lead us to misdiagnose.
Images for this section:

Fig. 27

© Radiodiagnóstico, Clínico Universitario Santiago de Compostela, Clínico Universitario Santiago de Compostela - Santiago de Compostela/ES
References


