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Neuroanatomical Study

Surgical anatomy of the dural walls of the cavernous sinus

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ABSTRACT

The external structure of each cavernous sinus (CS) is made of four dural walls. The aim of this study was to describe the anatomy of the dural walls of the CS. We studied 42 adult cadaveric heads, fixed with formalin and injected with coloured silicon. The main findings were: (i) the lateral wall of the CS has two layers – the external, which is thick and pearly grey, and the internal, which is semi-transparent and containing the cranial nerves (CNs); (ii) the medial wall of the CS has two areas – sellar and sphenoidal, both made up of one dural layer only; and (iii) the superior wall of the CS is formed by three triangles – oculomotor, clinoid and carotid – CN III may be found in a cisternal space of the oculomotor triangle; and (iv) the posterior wall of the CS is made up of two dural layers – meningeal dura and periostic dura – and this wall is close to the vertical segment of CN VI.

1. Introduction

The cavernous sinuses (CS) are paired structures on both sides of the sella turcica, pituitary gland and sphenoid sinus.[1] The CS extends from the superior orbital fissure to the dorsum sellae, being the inferior limit of the upper border of the maxillary nerve.

The external structure of each CS is made of four walls of dura mater: the lateral, medial, superior (also called the roof of the CS), and the posterior wall. Within those walls is venous blood flow, the internal carotid artery with its branches, as well as cranial nerve VI (CN), the sympathetic plexus and adipose tissue (Fig. 1).

2. Materials and methods

The heads of 42 adult cadavers, fixed with formalin and injected with coloured silicon, were studied. In 40 of the 42 heads, the skull vault and the encephalon was removed to expose the cranial base. Twenty heads (40 CS), were studied from the outside toward the centre and 20 were studied from the top downwards. Both remaining heads (4 CS) were bisected sagittally using a high-speed electric saw (Fleetwood Food Equipment; Philadelphia, PA, USA), and the dissections proceeded medially to laterally. A Carl Zeiss surgical microscope (OPMI-1 Lab) (Oberkochen, Germany), 3× to 25× magnification, was used. A Midas Rex high-speed drill was used to remove bone tissue (Legend GoldTouch, Medtronic; Minneapolis, MN, USA).

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3. Results

3.1. Lateral wall of the cavernous sinus

The lateral wall of the CS is made of two dural layers, the outer layer (meningeal dura), and the inner one (periostic dura) (Fig. 2). Both dural layers of the lateral wall continue laterally with the dura covering the floor of the middle fossa, medially with the dura of the superior wall of the CS, anteriorly with the dura covering the concavity of the greater wing of the sphenoid bone, and posteriorly with the tentorium. The external layer is thicker with a pearly grey colour, while the internal layer is thin, transparent and containing CN III, IV and V on their way through the CS to the superior orbital fissure. There is a cleavage plane between both dural layers; which is important surgically because it permits access to the inner layer of the lateral wall without entering the venous compartment of the CS, and also allows exposure of the CN.

The limits of the lateral wall of the CS are: (i) superiorly – the anterior petroclinoid ligament; (ii) inferiorly – the superior border of the maxillary nerve; (iii) anteriorly – the superior orbital fissure; and (iv) posteriorly – an imaginary line that lies flush with the plane of the dorsum sellae.

3.2. Medial wall of the cavernous sinus

The medial wall of the CS, the only wall which cannot be observed in the skull base, is also the only wall made of only one single dural layer (Fig. 3). This dural layer makes not only the medial limit of the CS, but also the lateral limit of the pituitary fossa. The medial wall of the CS exhibits two areas: the sellar and the sphenoidal parts.[2] The sellar area is nothing but the dural

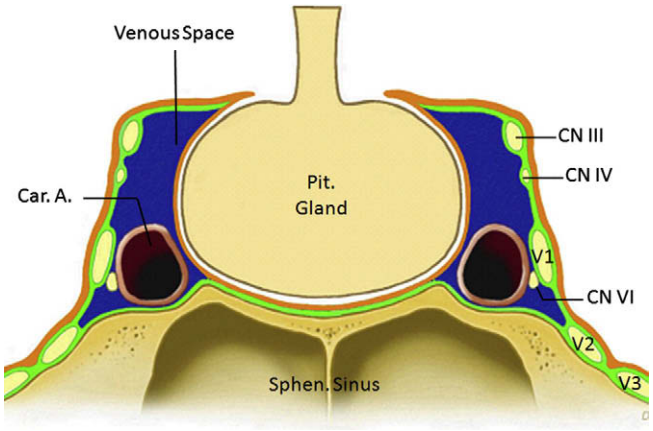

Fig. 1. Diagram of a coronal section through the cavernous sinus showing the meningeal layer (orange) and the periostic layer (green). A = artery, Car. = carotid, CN = cranial nerve, Pit. = pituitary, Sphen. = sphenoid.

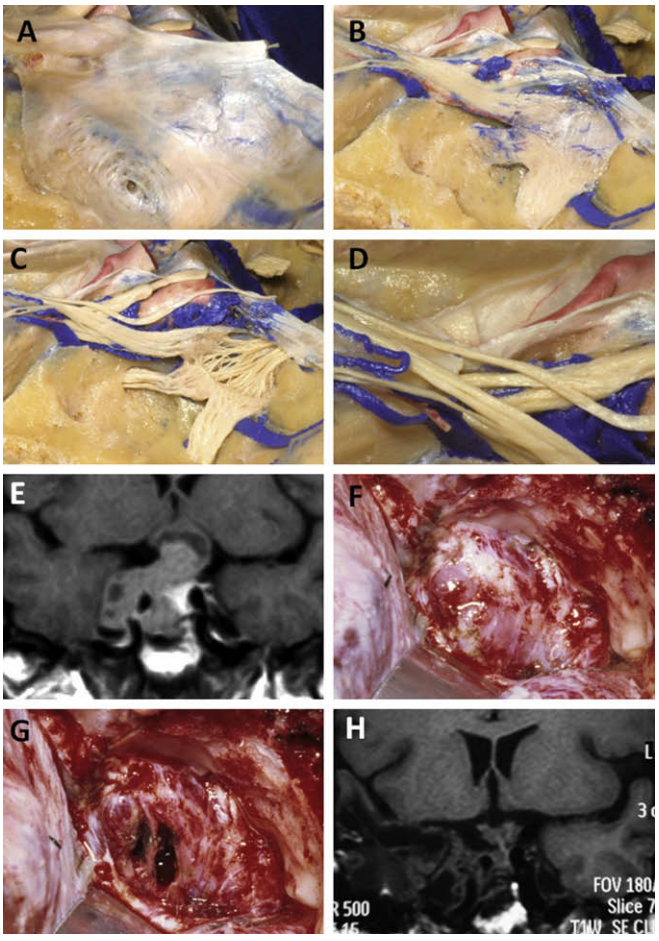

Fig. 2. (A–D) Photographs of the stepwise dissection of a lateral wall of the cavernous sinus (CS) of a formalin-fixed adult cadaverous head, injected with blue silicon (left side) showing: (A) the outer layer (meningeal layer); (B) the inner layer with cranial nerves (CN); (C) the already dissected inner layer with CN; and (D) an enlarged view of the superior orbital fissure. (E–H) Pituitary macroadenoma with extension into the right CS showing: (E) preoperative coronal T1-weighted non-enhanced MRI; (F) surgical view of the extradural approach before opening the inner layer of the lateral wall of the CS; (G) surgical view after tumor resection; and (H) postoperative coronal T1-weighted non-enhanced MRI, after an extradural approach.

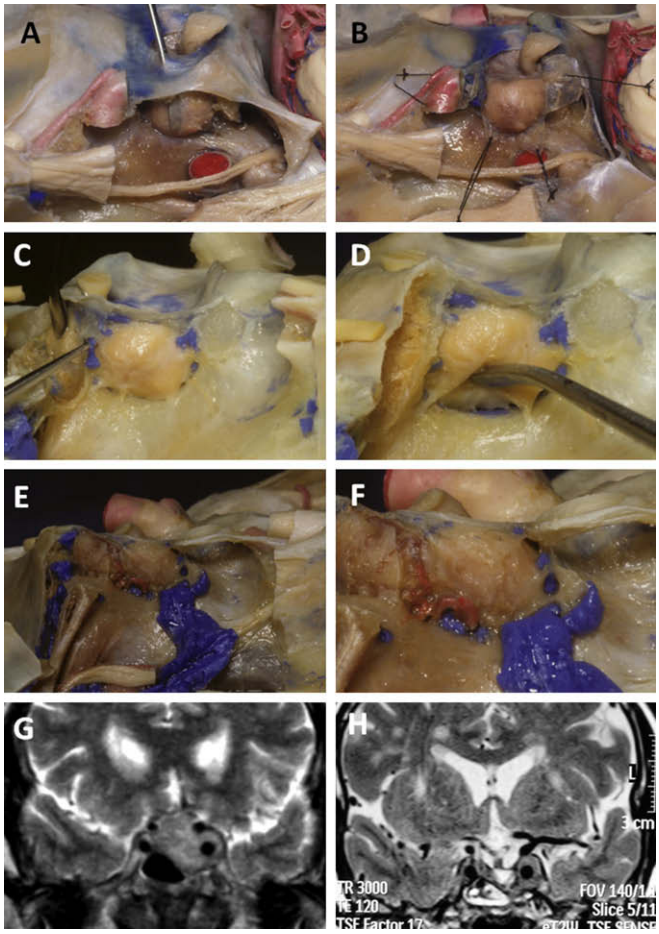

Fig. 3. (A–F) Photographs of the medial wall of the cavernous sinus (CS) showing: (A) a microdissector placed between the pituitary gland and the medial wall of the CS; (B) the opened medial wall of the CS (sellar part); (C) the medial wall of the CS; (D) a microdissector elevating the pituitary gland; and (E) the medial wall of the CS, enlarged in (F). (G) Preoperative coronal T2-weighted MRI showing a pituitary macroadenoma with extension into the left CS; and (H) postoperative coronal T2-weighted MRI, after an endonasal trans-sphenoidal approach, showing tumor resection up to the medial wall of the left CS.

membrane between the pituitary gland and the venous space of the CS, and the sphenoid area is made by the dural membrane adherent to the body of the sphenoid bone, precisely to the carotid sulcus.

The limits of the medial wall of the CS are: (i) superiorly – where the medial wall joins the superior wall of the CS; (ii) inferiorly – an imaginary line starting at the level of the foramen rotundum, passing through the inferior border of the carotid sulcus and lingula of the sphenoid bone, finally ending at the level of the upper portion of the petroclival fissure; (iii) anteriorly – an imaginary line going from the optic pillar to the foramen rotundum, passing through the medial end of the superior orbital fissure; and (iv) posteriorly – an imaginary line starting in the posterior clinoid process and reaching the superior end of the petroclival fissure.

The pituitary gland, with 6 sides, is surrounded by a very thin and transparent membrane, the pituitary capsule, firmly adherent to the gland itself. Outside this membrane, the pituitary gland is surrounded by dura. The lateral side is the only portion of the pituitary gland covered just by one dural layer.

3.3. Superior wall of the cavernous sinus

The superior wall of the CS, also called the roof of the CS, is the dural area above the CS contents, between the upper extremities of