Cavernomas and Arteriovenous Malformations in the Mesial Temporal Region: Microsurgical Anatomy and Approaches

**BACKGROUND:** The mesial temporal region (MTR) is located deep in the temporal lobe and it is surrounded by important vascular and nervous structures that should be preserved during surgery.

**OBJECTIVE:** To describe microsurgical anatomy and approaches to the MTR in relation to cavernomas and arteriovenous malformations (AVMs).

**METHODS:** Five formalin-fixed and red silicone-embedded heads of adult cadavers were used for this study. Between January 2003 and June 2014, 7 patients with cavernomas and 6 patients with AVMs in the MTR underwent surgery.

**RESULTS:** The MTR of the cadavers was divided into 3 areas: anterior, middle, and posterior. Of the 7 patients with MTR cavernomas, 4 were located anteriorly, 2 were located medially, and 1 was located posteriorly. Of the 6 patients with MTR AVMs, 3 were located in the anterior sector, 2 in the middle sector, and 1 in the posterior sector. For the anterior portion of the MTR, a transsylvian-transinsular approach was used; for the middle portion of the MTR, a transtemporal approach was used (anterior temporal lobectomy); and for the posterior portion of the MTR, a supracerebellar-transtentorial approach was used.

**CONCLUSION:** Dividing the MTR into 3 regions allows us to adapt the approach to lesion location. Thus, the anterior sector can be approached via the sylvian fissure, the middle sector can be approached transtemporally, and the posterior sector can be approached via the supracerebellar approach.

**KEY WORDS:** Anatomy, Approach, Arteriovenous malformations, Cavernoma, Cavernous malformations and related lesions, Deep arteriovenous malformations, Temporal horn, Temporal lobe

The mesial temporal region (MTR) is located deep in the temporal lobe, medial to the temporal horn. On the margins of the basal cisterns, it is surrounded by important vascular and nervous structures that should be preserved during surgery. From an anatomic and surgical standpoint, the MTR is divided into 3 regions: anterior, middle, and posterior.

The MTR is a frequent location for neurosurgically resectable lesions to develop, such as tumors, cavernomas, and arteriovenous malformations (AVMs). Approximately 20% of supratentorial cavernomas and 16% of AVMs are located in the temporal lobe.

We aimed to describe the microsurgical anatomy and approaches to cavernomas and AVMs located in the MTR.

**METHODS**

Five formalin-fixed and red silicone-embedded heads of adult cadavers were used for this study. Between January 2003 and June 2014, 7 patients with cavernomas and 6 patients with AVMs in the MTR underwent surgery by the authors. A retrospective chart review was performed to assess patient age, sex, diagnosis, lesion location, and postoperative outcome. Herein, we illustrated an example of a lesion in each MTR sector (anterior, middle, and posterior).
FIGURE 1. **A**, medial surface of the left cerebral hemisphere. The medial surface of the temporal lobe is the most complex of the medial cortical areas. It is composed of 3 longitudinal strips of neural tissue, one located above the other. The most inferior strip is formed by the parahippocampal gyrus, the middle strip is formed by the dentate gyrus, and the superior strip is formed by the fimbria of the fornix. The choroid fissure in the temporal horn is located between the fimbriae and the lower surface of the thalamus. The parahippocampal gyrus forms most of the medial surface of the temporal lobe. Anteriorly, the parahippocampal gyrus deviates medially to form the uncus. Posteriorly, it is intersected by the calcarine sulcus, which divides the posterior portion of the parahippocampal gyrus into an upper part that is continuous with the isthmus of the cingulate gyrus and a lower part that is continuous with the lingula. **B**, the medial temporal region is divided into 3 parts: anterior, middle, and posterior. The anterior part (A) extends posteriorly from the anterior end of the rhinal sulcus and uncus to a transverse line at the level of the inferior choroidal point. The middle part (M) extends posteriorly from the inferior choroidal point to a transverse line passing at the level of the quadrigeminal plate. The posterior part (P) extends from the quadrigeminal plate to the level of the basal parietotemporal line, which connects the preoccipital notch to the lower end of the parieto-occipital sulcus. **C**, superior view of the right temporal lobe. The upper surface of the temporal lobe forms the floor of the sylvian fissure and presents 2 distinct parts: the planum polare anteriorly and the planum temporale posteriorly. The planum polare is free of gyri, and its lateral edge is formed by the superior temporal gyrus. The inferior choroidal point, or the lower end of the choroidal fissure, is located just behind the uncus and head of the hippocampus, the posterior limit of the anterior mesiotemporal region. The choroid plexus and the fimbria, the dentate, parahippocampal gyrus, uncus, and amygdala are demarcated.
FIGURE 1. Continued.  
D. The sylvian fissure is opened widely and the limiting sulcus of the insula is exposed. The dashed line shows the corticotomy site, of no more than 8 mm. The uncinate fasciculus (pink), optic radiations (green), and the projection of the temporal horn (gray) are demarcated.  
E. Inferior view of the basal surface of the brainstem and temporal lobe. The floor of the right temporal lobe, except for the anterior part of the uncus, has been removed. The anterior choroidal artery is demarcated; the preoptic part of the AChA extends from its origin at the inferomedial side of the carotid artery to the artery’s genu along the carotid cistern. The postoptic part of the efferent segment courses within the crural cistern and extends from the genu to the inferior choroidal point. This segment is hidden behind the uncal apex. The choroid plexus, the thalamus, the basal vein, and the posterior cerebral artery are also demarcated. A., artery; Ant., anterior; Car., carotid; Ch., choroidal; Chor., choroid; Inf., inferior; Parahippo., parahippocampal; PCA., posterior cerebral artery; Pl., plexus; V., vein. Color version available online only.

RESULTS

Anatomy

The MTR was divided into 3 regions, as previously described1–6: (1) the anterior part extends posteriorly from the anterior end of the rhinal sulcus and uncus to a transverse line at the level of the inferior choroidal point; (2) the middle part extends posteriorly from the inferior choroidal point to a transverse line passing at the level of the quadrigeminal plate; and (3) the posterior part extends from the quadrigeminal plate to the level of the basal parietotemporal line, which connects the preoccipital notch to the lower end of the parieto-occipital sulcus (Figure 1).

Patients

Seven patients underwent surgery for cavernomas (4 male and 3 female; average age, 40 years) (Table). Four cavernomas were located in the anterior part of the MTR (3 left-sided, 1 right-sided), 2 in the middle region of the MTR (both left-sided), and 1 in the posterior sector (right-sided). The diagnosis was refractory epilepsy in 4 cases (57%) and bleeding in 3 cases (43%). One patient required 2 surgeries because of a persistent cavernoma on postoperative imaging. Four patients became seizure-free after surgery. Postoperative complications included 3 patients (42%) with a mild visual deficit (homonymous quadrantanopia); this visual deficit was objectivated by the visual field, but only slightly noticed by the patient. One patient (14%) demonstrated transitory memory alteration for 2 months. Complications connected to the approach were not observed.

Six patients underwent surgery for AVMs (3 male and 3 female; average age, 44 years). Three AVMs were located in the anterior region of the MTR (2 right-sided and 1 left-sided), 2 in the medium sector of the MTR (1 right-sided and 1 left-sided), and 1 in the posterior region of the MTR (right-sided). The diagnosis was bleeding in 4 cases (66%) and seizures in 2 cases (34%). Complete AVM resection was achieved in all patients. Post-operatively, 2 patients (33%) demonstrated a mild visual deficit (homonymous quadrantanopia). One patient (16%) demonstrated severe language alteration, which partially improved over time. Complications connected to the approach were not observed.

With regard to anterior MTR lesions, the transsylvian-transinsular approach was used in all patients. For medium portion MTR lesions, the transtemporal (anterior temporal

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*AVM, arteriovenous malformation.*

TABLE. Patients

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lobectomy) approach was used. For lesions in the posterior portion of the MTR, a supracerebellar transtentorial approach was performed in all cases.

**Transsylvian-Transinsular Approach**

The patient was placed in the dorsal decubitus position, with the head slightly lateralized to the contralateral side and deflexed\(^1\)\(^,\)\(^9\) (Figure 2). The incision began at the upper edge level of the zygomatic arch near the tragus, and continued behind the hair’s insertion line to the midline. A subgaleal dissection was performed to expose the fat pad above the temporal fascia. At this level, the incision was cut through the superficial fascial layer and the fatty tissue between the superior and inferior fascial layers to advance along the inferior fascial layer to protect the frontal branch of the facial nerve. The orbital rim was exposed. The temporal muscle was elevated from the bone starting at the superior temporal line by means of retrograde dissection to prevent postoperative atrophy.

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**FIGURE 2.** A, medial surface of the left cerebral hemisphere. The anterior part (demarcated in green) extends posteriorly from the anterior end of the rhinal sulcus and uncus to a transverse line at the level of the inferior choroidal point. B, the coronal view shows the relationship between the hippocampus, insula lobe, and the temporal horn. The yellow arrow points out the direction of the approach, through the temporal horn. C, classic pterional approach. The incision starts at the level of the upper margin of the zygomatic arch, 1 cm anterior to the tragus, and extends behind the hairline up to the midline. Subgaleal dissection is performed until the fat pad above the temporal fascia is seen. The interfascial dissection allows preservation of the frontal branch of the facial nerve. The temporal muscle is incised and elevated from the bone, exposing the pterion and the squamous suture, while part of the muscle is left attached to the bone allowing a more cosmetic reconstruction. After the craniotomy, the dura covering the upper temporal and lower frontal surfaces can be seen. D, the sylvian fissure and the branches of the middle cerebral artery are exposed. The dashed line shows the corticotomy site. E, the anterior part of the temporal horn with the hippocampal head was exposed. Also, the choroid was opened. F, the hippocampal head was resected. Color version available online only.
A 19-year-old man was evaluated by the emergency service for an acute headache. CT demonstrated a hematoma at the uncal level of left temporal lobe. Axial and coronal T1-weighted MRI revealed a subtle area of increased density at the uncal level. Postoperative axial T2- and T1-weighted MRI after resection of the lesion.

After that was completed, a pterional craniotomy centered at the sylvian fissure was performed. The dura mater was opened in 2 flaps (frontal and temporal), with the central incision along the sylvian fissure. The sylvian fissure was widely opened from distal to proximal, starting at the level of the pars opercularis of the inferior frontal gyrus. It was necessary to medially displace the temporal branch of the sylvian artery to accurately visualize the anterior and inferior parts of the limiting sulcus of the insula. In addition, small vessels entering the insula required division. Then, a small (approximately 8 mm) corticotomy was performed at the level of the limiting sulcus of the insula, just behind the limen insulae. This approach deepens through the white matter to access the anterior temporal horn. Once the ventricular anatomy (hippocampus, choroid plexus, etc) was recognized, lesion resection was performed.

A clinical case illustrating this approach follows. A 19-year-old male patient presented with a severe headache. Brain computed tomography (CT) confirmed a hematoma at the left MTR sector (uncus temporal lobe). Cerebral angiography was negative. Magnetic resonance imaging (MRI) revealed a cavernoma that bled. Surgery was performed according to the technique described above. On pathology, a cavernoma was reported. Postoperative MRI showed complete resection of the lesion with preservation of the lateral and basal temporal cortex. The patient recovered without neurological sequelae (Figure 3).
Transtemporal Approach: Anterior Temporal Lobectomy

The patient was placed in the supine position, with the head slightly lateralized to the contralateral side and deflected1–10 (Figure 4). The incision began at the upper edge level of the zygomatic arch, near the tragus and continued behind the hair’s insertion line to the midline. A subgaleal and interfascial dissection was performed to expose the orbital rim and temporalis muscle. After the upper sector curettage of the temporal muscle, apterional craniotomy centered at the sylvian fissure was performed to fully expose the floor and anterior wall of the temporal fossa. In cases in which the patient has a very large temporal muscle, the zygomatic arch can be cut to completely manage the muscle (transzygomatic approach). The dura mater was opened in 2 flaps (frontal and temporal), with the central incision along the sylvian fissure. Next, a small, temporal lobectomy (approximately 2–3 cm long) was performed, preserving the superior temporal gyrus. This approach deepens through the white matter to access the anterior temporal horn. Once the ventricular anatomy (hippocampus,
choroid plexus, etc) was recognized, the lesion resection was performed.

This approach is illustrated with the following case. A 22-year-old female patient was referred for headache and seizures. Brain CT confirmed a hematoma at the middle portion of the left MTR (lateral midbrain). Cerebral angiography was negative; MRI confirmed a cavernoma that bled. Surgery was performed according to the technique described above. Pathological examination confirmed a cavernoma. On postoperative MRI, a portion of the lesion persisted; the same approach was repeated, with complete resection of the lesion. Postoperatively, the patient recovered without neurological sequelae, with the exception of a right homonymous quadrantanopia (Figure 5).

**Supracerebellar-Transtentorial Approach**

The patient was placed in a semisedated position, with the head flexed and without rotation. A paramedian incision was performed 2 cm above the superior nuchal line and continued to the level of C2. Soft tissue dissection was performed to access the flat bone (occipital flake). After subperiosteal curettage, a suboccipital craniotomy or craniectomy was performed, which amply revealed the transverse sinus. The dura was opened with a horizontal incision parallel to the sinus and within 3 mm of its lower edge, which in a circular way is directed downward, near the bottom of the craniotomy. After opening the magna cistern and evacuating the cerebrospinal fluid (CSF), dissection between the upper face of the cerebellum and the tentorium was performed until the free edge of the tentorium and the posterior portion of the ambient cistern were visualized. Then, the tentorium was opened in the anteroposterior direction to expose the posterior portion of the MTR. At that level, by making a small corticectomy, the posterior-most portion of the temporal horn can be entered; once the ventricular anatomy (hippocampus, choroid plexus, etc) was recognized, lesion resection was performed.
The following clinical case illustrates this approach. A 58-year-old female patient presented with a headache and sensory deterioration. Brain CT showed a subarachnoid hemorrhage and a small hematoma in the posterior region of the MTR (right) and blood in the ventricular cavities. Cerebral angiography confirmed an AVM in the posterior portion of the MTR. Surgery was performed according to the technique described above; AVM was confirmed on pathology. The patient recovered without neurological sequelae (Figure 7).
FIGURE 7. **A** and **B**, a 58-year-old woman was evaluated by the emergency service for acute headache and subsequent neurological deterioration. CT demonstrated subarachnoid hemorrhage, with a small hematoma in the posterior mesiotemporal region, and ventricular hemorrhage. **C** and **D**, T1- and T2-weighted MRI demonstrated areas of parenchymal AVM involvement, showing dilated feeding arteries. **E** and **F**, cerebral angiography shows enlarged feeding artery, the nidus, and an enlarged draining vein, related with the posterior cerebral artery. **G** and **H**, postoperative cerebral angiography with complete resection of the malformation by a supracerebellar transtentorial approach.
DISCUSSION

The MTR is a region of extremely complex cortical anatomy; it is hidden deep within the temporal lobe on the basal cistern margin and is surrounded by neurovascular structures that must be preserved during surgery. When treating an MTR injury, we find additional structures including the Wernicke area, optic radiations, the midbrain, the carotid artery, the anterior choroidal artery, the middle cerebral and posterior arteries, the basal vein of Rosenthal and Labbé, and the third and fourth cranial nerves. Determining the right approach to treat them is a challenge because the complex and deep anatomy of the MTR. Many approaches have been described over the past 30 years to treat MTR injuries; we aimed to demonstrate the best approach, according to diagnosis and anatomic location within the MTR.

The transsylvian-transinsular approach was first described by Yasargil et al in 1985 to surgically treat refractory epilepsy. Over time, this approach was standardized as a way to access the MTR without damaging the lateral or basal temporal cortex. Although this approach is very anatomical, the main disadvantage is the potential damage to the optic radiations, given that those fibers are closely related to the roof and side wall of the temporal horn. It is a good approach to access the anterior portion of the MTR, especially in the dominant hemisphere. To avoid damaging the Meyer loop, it is important to remember that corticotomy at the limiting sulcus of the insula should be done just behind the limen. Of the 4 patients with cavernomas and the 3 patients with AVMs in the anterior portion of the MTR, 1 patient presented with postoperative quadrananopia, possibly because of a more posterior opening in the limiting sulcus of the insula.

Anterior temporal lobectomy was popularized by Spencer for refractory epilepsy. Later, Spencer et al described this approach in more detail, arguing that it was accessible even to the posterior portion of the MTR.

We thought that, for lesions located in the middle portion of the MTR, this approach is best suited. However, the main disadvantage is injury to optic radiations. Of the 4 patients who underwent surgery in the middle portion of the MTR, all developed postoperative quadrantanopia. To minimize visual injury, resection should be limited to the anterior portion of the temporal lobe (about 2 cm), and obliquely enter the temporal horn.

The supracerebellar-transtentorial approach was first described by Voigt and Yasargil in 1976 to treat a cavernoma of the parahippocampal gyrus. This was redescribed by de Oliveira et al and Ture et al. For lesions of the posterior MTR, the authors suggest supracerebellar-transtentorial. Ture et al also claim that this approach is accessible to all portions of the MTR (anterior, middle, and posterior). However, the authors agree with de Oliveira et al, arguing that it is a good approach, especially for the anterior portion of the MTR. The main disadvantage of this approach is that it must be done in a semisected position, with an increased risk for air embolism. Therefore, it is necessary to take all preventive measures to avoid this complication.

Of patients with supratentorial cavernomas, 50% to 70% have seizures, which are believed to be due to small asymptomatic microhemorrhages on the surrounding brain that produce hemosiderosis and gliosis. Temporal lobe cavernomas have a tendency to produce refractory epilepsy; this is thought to be due to the proximity to limbic structures. Kivelev et al operated on 49 of 53 temporal cavernomas. According to the authors, any symptomatic temporal lobe cavernoma, especially in a young adult, is an indication for surgery. Epilepsy is the most common diagnosis (82%) of those cases, and 77% remained seizure-free after surgery. Regarding neurolological postoperative complications, 4% demonstrated memory deficits and 4% demonstrated a visual field deficit. Kivelev et al classified cavernomas of the temporal lobe into 3 groups: (1) medial, (2) anteromedial, and (3) posterolateral; medial cavernomas had more postoperative neurolological complications than expected.

In this series of all medial cavernomas, 2 patients (28%) had a visual deficit and 1 patient (14%) had memory impairment. It is important to note that 5 of 7 patients had cavernomas in the left hemisphere. Nevertheless, language impairment was not seen in any case.

Temporal AVMs have special functional considerations regarding important anatomic structures in the region, especially in the mesial region. The most common symptoms are seizures followed by hemorrhage and focal neurolological deficit.

The challenges of surgery for temporal AVMs can be illustrated by the postoperative results of studies published in recent years. Boström et al described 44 patients who underwent surgery for temporal AVMs; 7% had a new permanent hemiparesis and 19% had a visual field disturbance.

In Ojeda's study, 29 patients underwent surgery for temporal AVMs; 24.1% showed immediate postoperative deficits, which improved after 3 months; according to the authors, this was linked to a dissecting hematoma, not a direct surgical injury.

In a larger series published by Gabarrós Canals et al, 88 patients with temporal AVMs underwent surgery; 83% of patients maintained or improved their symptoms, whereas 17% deteriorated or died. These authors described an anatomical classification of temporal AVMs into 5 types: lateral, basal medial, sylvian, and ventricular. This has no predictive value with regard to bleeding risk, but definitely in the choice of approach. It is reported that when lesions are identified in front of the anterolateral location's cerebral peduncle edge, they can be addressed by the sylvian orbitofrontal fissure via the zygomatic transsylvian approach with a tangential path, and when the location is posterior to the cerebral peduncle, the subtemporal or transcortical approach would be used. In our experience, the supracerebellar-transtentorial approach is preferable, because it provides a tangential view of the malformation. From posterior, with the afferent vessels ahead, careful dissection of the nidus can control potential bleeding, while observing anteriorly how the vein color changes as the afferents are coagulated.
CONCLUSION

Dividing the MTR into 3 sections allows us to adapt the approach according to the location of the lesion. Thus, the anterior portion is approachable through the Sylvian fissure; the middle portion is approachable transtemporally; and the posterior portion is accessible by a supracerebellar transtentorial approach.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

REFERENCES


COMMENTS

The authors present a review of the anatomy and surgical approaches to lesions of the mesial temporal lobe. Their findings are based on cadaveric dissections in 5 specimens and on clinical experience with 13 cases, 7 cavernomas and 6 AVMs. They divide the mesial temporal region into an anterior, middle, and posterior region on an anatomical basis. The paper discusses surgical approaches to the area in the context of these anatomical distinctions. The anterior and middle portions are demarcated by the inferior choroidal point; the middle and posterior portions are divided at the level of the quadrigeminal plate. The authors recommend a transylvian-transinsular approach for lesions located in the anterior region, a transtemporal approach for lesions of the middle region, and a supracerebellar transtentorial approach for lesions of the posterior region. The authors describe the basic technique for each approach, and offer tips for complication avoidance particularly with regard to the visual fibers. The article includes representative cadaveric dissections and case examples to support the discussion. While the design of this study does not allow for any claims regarding what is the best, safest, or most efficacious approach to the MTR, the article does provide a useful anatomical paradigm for thinking about lesions of the mesial temporal region. This is a succinct review of relevant surgical anatomy that the readership is likely to find useful.

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