Venous Anatomy of the Sphenoparietal Sinus: Evaluation by MR Imaging

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Summary

The termination of the superficial middle cerebral vein (SMCV) has been described as entering or being partially equivalent to the venous sinus coursing under the lesser sphenoid wing, which has classically been called the sphenoparietal sinus. However, the recent literature reports that the SMCV is not connected to the sphenoparietal sinus. In this study, the venous anatomy was evaluated to clarify the anatomy of the sphenoparietal sinus and the termination of the SMCV. Magnetic resonance imaging (MRI) was performed on 1.5-T superconductive units using a three-dimensional fast spoiled gradient-recalled acquisition in the steady state (3-D fast SPGR) sequence with fat suppression in a total of 48 sides of 24 patients. Coronal source images and reconstructed axial images were displayed on the Advantage Window Console, and connections to the cavernous sinus were then evaluated for the venous sinus coursing under the lesser sphenoid wing (hereafter called the sinus of the lesser sphenoid wing), the middle meningeal vein, and the SMCV.

The following findings were observed bilaterally in all patients. The sinus of the lesser sphenoid wing was connected medially with the cavernous sinus and laterally with the anterior branch of the middle meningeal vein near the pterion.

The anterior branch of the middle meningeal vein entered the bony canal laterally above the junction with the sinus of the lesser sphenoid wing and coursed along the inner table of the skull or emerged into the diploic vein, indicating its parietal portion. Although the termination of the SMCV had several patterns, the SMCV was not connected with the sinus of the lesser sphenoid wing in any of the patients. The sphenoparietal sinus is considered to consist of the sinus of the lesser sphenoid wing and the parietal portion of the anterior branch of the middle meningeal vein; these were identified as venous structures distinct to the SMCV.

Introduction

The termination of the superficial middle cerebral vein (SMCV) is important in transvenous embolization of cavernous sinus dural arteriovenous fistula (AVF). This is because coil packing must be started at the junction of the cavernous sinus and the SMCV to prevent cortical venous reflux that could cause venous congestion of the brain parenchyma. However, the termination of the SMCV reveals several patterns and some authors have reported that this vein can join the sphenoparietal sinus¹⁻⁴.

In such cases, it would be important to identify the sphenoparietal sinus in order to perform treatment. The sphenoparietal sinus is

Figure 1 A 40-year-old woman with arteriovenous malformation of the left basal ganglia. The coronal source images (A-D) of the middle cranial fossa was obtained by contrast-enhanced 3-D fast SPGR. The sinus of the lesser sphenoid wing (SLSW) is identified to be connected medially with the cavernous sinus and laterally with the anterior branch of the middle meningeal vein near the pterion. The SMCV courses near the SLSW and enters the cavernous sinus independently of the SLSW. CS, cavernous sinus; diploic v, diploic vein; MCA, middle cerebral artery; MMV, anterior branch of the middle meningeal vein; MMV parietal, parietal portion of the anterior branch of the middle meningeal vein; SLSW, sinus of the lesser sphenoid wing; SMCV, superficial middle cerebral vein.

classically defined as the venous sinus under the lesser sphenoid wing¹. The purpose of this study was to clarify the venous anatomy of the sphenoparietal sinus and the termination of the SMCV in order to facilitate the transvenous embolization of cavernous sinus dural AVF.

Methods

Subjects were 24 patients (ten males and 14 females; age range, 20-75 years; mean age, 54.3 years); both sides were examined in each patient (i.e. a total of 48 sides). Conditions includ-

Figure 2 Schema of the SMCV and sphenoparietal sinus (axial view). The termination of the SMCV can be classified into the following four basic types; cavernous sinus type (Cav), paracavernous sinus type (Para), laterocavernous sinus type (Latero), and absent type (not shown). The SMCV enters the anterolateral aspect of the cavernous sinus in the cavernous sinus type. The SMCV courses outside the cavernous sinus and enters the foramen ovale or the superior petrosal sinus in the paracavernous sinus type. The SMCV enters the lateral wall of the cavernous sinus, coursing between the two layers in the laterocavernous sinus type. The sinus of the lesser sphenoid wing (SLSW) enters the anterolateral aspect of the cavernous sinus medially and connects with the anterior branch of the middle meningeal vein (MMV) laterally and continues to the parietal portion of anterior branch of the middle meningeal vein (Parietal MMV). The sphenoparietal sinus consists of the sinus of the lesser sphenoid wing and the parietal portion of the middle meningeal vein, and enters the cavernous sinus independently of the SMCV. Cav, cavernous sinus type; Latero, laterocavernous sinus type; Para, paracavernous sinus type; CS, cavernous sinus; MMV, anterior branch of the middle meningeal vein; Parietal MMV, parietal portion of the anterior branch of the middle meningeal vein; SLSW, sinus of the lesser sphenoid wing; SMCV, superficial middle cerebral vein; SOV, superior ophthalmic vein.

ed brain tumor (n=17) cerebral arteriovenous malformation (n=2), multiple sclerosis (n=1), dural AVF of the transverse sinus (n=1), ethmoid sinus tumor (n=1), old brain contusion (n=1), and hearing disturbance (n=1). After intravenous Gd-DTPA injection, magnetic resonance imaging (MRI) was performed on 1.5-T superconductive units using a three-dimensional fast spoiled gradient-recalled acquisition in the steady state (3-D fast SPGR) sequence

with fat suppression. The center of the volume slab was located on the anterior clinoid process in the sagittal localizer image, and coronal images were acquired with the following parameters: repetition time/echo time/excitations, 21-26/2-3/1; 18-cm field of view, 1.0 or 1.5 mm slice thickness, 60 slices, flip angle 15°, and 256 x 256 matrix. Coronal source images and reconstructed axial images were displayed on the Advantage Window Console within a few minutes,

and connections to the cavernous sinus were then evaluated for the venous sinus under the lesser sphenoid wing, the middle meningeal vein, and the SMCV.

Results

The major vessels were identified around the cavernous sinus and in the middle cranial fossa, and the following findings were observed bilaterally in all patients (figure 1). The venous sinus coursing under the lesser sphenoid wing was identified to be connected with the cavernous sinus medially. This venous sinus (thereafter called the sinus of the lesser sphenoid wing) was connected near the pterion with the anterior branch of the middle meningeal vein that coursed from the foramen spinosum along the vascular groove in the floor of the middle cranial fossa.

The anterior branch of the middle meningeal vein entered the bony canal laterally above the junction with the sinus of the lesser sphenoid wing and coursed along the inner table of the skull or emerged into the diploic vein. It was difficult to identify the anterior branch of the middle meningeal artery that anatomically ought to course along the anterior branch of the middle meningeal vein.

The termination of the SMCV was classified into the following four types (figure 2). In type 1 (cavernous sinus type), the SMCV entered the anterolateral aspect of the cavernous sinus; this was observed in 17 sides of 14 patients (35.4%). In type 2 (paracavernous sinus type), the SMCV coursed outside the cavernous sinus and entered the foramen ovale or the superior petrosal sinus; this was found in five sides of four patients (10.4%).

In type 3 (laterocavernous sinus type), the SMCV entered the lateral wall of the cavernous sinus; this occurred in eight sides of seven patients (16.7%). In this type, because the SMCV courses between the two layers of the lateral wall of the cavernous sinus and enters the pterygoid plexus, the diameter of the SMCV decreases within the lateral wall. Although the two layers of the lateral wall of the cavernous sinus could not be identified, the narrow SMCV diameter in the lateral edge of the cavernous sinus indicated this type. Finally, in type 4, the SMCV was absent; this was identified in 17 sides of 11 patients (35.4%). It was difficult to determine the laterocavernous sinus

type or the cavernous sinus type in one side of one patient (2.0%). The SMCV was not connected with the sinus of the lesser sphenoid wing or the middle meningeal vein in any of the patients.

Discussion

The literature contains various anatomic descriptions of the sphenoparietal sinus and termination of the SMCV¹⁻⁷. Wolf et Al¹ described the SMCV entering the dura in the region of the pterion and running along the lesser wing of the sphenoid to enter the anterior end of the cavernous sinus. They mentioned that the dural portion of this channel along the lesser sphenoid wing had been frequently referred to as the sphenoparietal sinus, and they suggested that the term "sinus of the lesser wing of the sphenoid" should be preferred. Oka et Al² reported that the SMCV could either join the sphenoparietal sinus or drain directly into the cavernous sinus. In a study of 140 cadaveric heads, Bisaria³ reported that the SMCV terminated into the sphenoparietal sinus in 67.1%. Similarly, in an MRI study of 100 patients using 3-D contrast-enhanced magnetization-prepared rapid gradient-echo (MP-RAGE), Ikushima et Al⁴ reported that the SMCV entered the sphenoparietal sinus in 57.5%. However, in a study of 15 nonfixed human specimens using the corrosion cast technique, San Millan Ruiz et Al⁵ recently clarified that SMCV was not connected to the sphenoparietal sinus in any of the specimens. They reported that the sphenoparietal sinus consists of the artificial combination of two venous structures, the parietal portion of the anterior branch of the middle meningeal vein and a sinus of the lesser sphenoid wing. They found that the SMCV drained into the paracavernous sinus, laterocavernous sinus, and the cavernous sinus⁵⁻⁷, and they proposed that the classic notion of the SMCV draining into or being partially equivalent to the sphenoparietal sinus had been erroneous⁵.

In the present study, the SMCV was not found to enter the sphenoparietal sinus, supporting the findings of San Millan Ruiz et Al⁵. Although the termination of the SMCV was very close to the sinus of the lesser sphenoid wing in some cases, these two venous structures could be distinguished from each other on MRI. The anterior branch of the middle meningeal vein entered the bony canal lateral-

Figure 3 A 62-year-old man with dural AVF of the left cavernous sinus. Right external carotid arteriograms in frontal (A) and lateral (B) projections show dural AVF of the left cavernous sinus (white arrow). The dural AVF drains into the left inferior petrosal sinus (double black arrows). Note the cortical venous reflux into the left SMCV (black arrow). Venograms of the left sinus of the lesser sphenoid wing (C) and the left SMCV (D) were performed gently by manual injection in a frontal projection via the left inferior petrosal sinus. The lateral portion of the sinus of the lesser sphenoid wing is obscure because of the remaining contrast media (C). The SMCV and the sinus of the lesser sphenoid wing connect with the cavernous sinus independently. Right external carotid arteriogram in a frontal projection (E) immediately after transvenous coil embolization of the left cavernous sinus shows disappearance of dural AVF. The venous phase of the left internal carotid arteriogram in a lateral projection (F) shows the left SMCV (black arrow), demonstrating improved venous circulation.

ly above the junction with the sinus of the lesser sphenoid wing and coursed along the inner table of the skull or emerged into the diploic vein. These findings were also compatible with those of San Millan Ruiz et Al⁵. The sphenoparietal sinus is considered to consist of the sinus of the lesser sphenoid wing and the parietal portion of the anterior branch of the middle meningeal vein (figure 2).

In transvenous coil embolization of cavernous dural AVF, it is important to identify the junction of the SMCV with the cavernous sinus in order to prevent cortical venous reflux into the SMCV (figure 3). According to the results of our study, embolization of the junction between the sphenoparietal sinus and the cavernous sinus would not be of use because the SMCV does not enter the sphenoparietal sinus. It is therefore important to assess the SMCV termination by precise evaluation of the venous phase of cerebral arteriography before treatment. MRI using contrast-enhanced 3-D fast SPGR sequence with fat suppression is also useful for evaluation of the SMCV termination. Although evaluation of the SMCV termination was difficult due to anteroposterior shortening of the volume slab when the SMCV

turned posteriorly, we selected coronal orientation rather than axial orientation in order to overcome this problem.

In this study, it was necessary to observe only the relationship among the sinus of lesser sphenoid wing, the middle meningeal vein, the SMCV, and the cavernous sinus. It takes longer to obtain information from the floor of the middle cranial fossa to the parietal calvarium in the axial orientation than in the coronal orientation. The information obtained by our method was sufficient to evaluate the venous structures around the cavernous sinus described above.

Conclusions

The sphenoparietal sinus consists of the sinus of the lesser sphenoid wing and the parietal portion of the anterior branch of the middle meningeal vein. The SMCV was not found to enter the sphenoparietal sinus; the sphenoparietal sinus and SMCV appear to be independent of each other. MRI using contrast-enhanced 3-D fast SPGR sequence with fat suppression is useful for evaluation of these venous structures.

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