Obstruction of the superior sagittal sinus caused by parasagittal meningiomas: the role of collateral venous pathways

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The authors present studies of eight patients who had obstruction of the superior sagittal sinus caused by parasagittal meningioma. The results indicate that meningeal veins and end-to-end anastomoses of the superficial veins of the cerebrum play important roles as collateral venous pathways. This assessment suggests that, in patients with obstruction of the superior sagittal sinus, venous phase angiography should be carefully interpreted before surgery is attempted for parasagittal meningiomas.

KEY WORDS - superior sagittal sinus · parasagittal meningioma · collateral venous pathway · superficial cortical vein · meningeal vein

PARASAGITTAL meningioma is a tumor that arises at the convexity just off the midline adjacent to the sagittal sinus and is characterized by involvement of the superior sagittal sinus (SSS). Those parasagittal meningiomas arising in the middle and posterior third of the SSS present a difficult technical problem;\(^1\)\(^-\)\(^2\)\(^,\)\(^6\)\(^-\)\(^8\)\) namely, the superficial veins of the cerebrum entering the SSS must be spared during exposure and excision of these meningiomas if possible.

There have been very few reports emphasizing the importance of collateral venous pathways in patients with occlusion of the SSS caused by parasagittal meningiomas;\(^1\)\(^-\)\(^2\)\(^,\)\(^6\)\(^-\)\(^8\)\) however, radical treatment of parasagittal meningioma by excision only or excision and reconstruction of the SSS by duraplasty or vein grafting may depend on preoperative assessment of the patency of the SSS and on the development of collateral venous channels to the other sinuses.

Clinical Material and Methods

Magnetic resonance (MR) imaging was obtained in eight patients who had surgically verified parasagittal meningiomas between 1989 and 1992; the tumors' location, size, and anatomical relationship were noted. Anteroposterior, lateral, and lateral oblique (30°) views were obtained using digital subtraction angiography (DSA) for each patient; this method was utilized with selective bilateral injection of the internal and external carotid arteries. During the early-to-late venous phases of DSA, the venous pathways of each hemisphere were analyzed for the following findings:\(^5\) 1) nonvisualization of a segment of the SSS; 2) end-to-end anastomoses of the superficial veins of the cerebrum at a site distal to the obstruction of the SSS; 3) reversal of the normal venous flow, with collateral vessels connecting the anterior SSS with the sphenoparietal sinus, the transverse sinus, and/or the cavernous sinus at a site distal to the obstruction of the SSS; and 4) collateral venous pathways making a detour around the area of obstruction of the SSS.

One hemisphere (Case 8) was excluded from analysis because no DSA with selective injection was performed.

Results

Clinical Findings

There was no cerebral venous infarction in the eight patients. The eight parasagittal meningiomas detected on MR images were divided into three groups: attached to the anterior (one), middle (four), or posterior (three) segment of the SSS. The anterior third of the SSS extends from the crista galli to the coronal suture, the middle third from the coronal suture to the lambdoid suture, and the posterior third from the lambdoid suture to the torcular herophili.

According to Oka, et al.,\(^7\) the superficial veins of the cerebrum are divided into four groups based on their site of termination: the superior sagittal group, which drains into the SSS; the tentorial group, which drains into the transverse or lateral tentorial sinuses; the sphenoidal group, which drains into the sphenoparietal or cavernous sinus; and the falxine group, which drains...
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into the inferior sagittal sinus. End-to-end anastomoses of the superficial cortical veins created collateral pathways between the superior sagittal group and the sphenoidal group, the superior sagittal group and the tentorial group, and the superior sagittal group and the falcine group.

On the basis of the early-to-late venous phases of the DSA, a schema of the collateral venous pathways was developed for all eight patients (Fig. 1). In 13 of 15 hemispheres, occlusion of the SSS contributed to end-to-end anastomoses from the superficial cortical veins through collateral pathways to the sphenoidal and tentorial venous channels. In five of 15 hemispheres, anastomoses of the superficial cortical veins were confirmed as either the vein of Trolard or the vein of Labbé. In one hemisphere, a collateral pathway developed between the superior sagittal venous channels and the falcing venous channels. In three of the 15 hemispheres, the frontal marginal vein replaced the anterior part of the SSS and was joined by the superficial veins of the frontal lobe (Fig. 2); it then coursed caudally from the frontal poles of the frontal lobes in the parasagittal areas, was joined by tributaries along its course from the

![Fig. 1. Diagrams of digital subtraction angiography (DSA) (lateral views) illustrating the collateral venous pathways in patients with obstructed superior sagittal sinus (SSS). Dural sinuses are indicated by thick black curves. No shading indicates nonvisualization of the SSS. Superficial cortical veins are illustrated by winding, branching thinner black curves and the meningeal veins by gray line.](image)

**Fig. 2. Case 3.** A: Magnetic resonance T₁-weighted image of the sagittal view after contrast administration showing enhancement of a meningioma involving the superior sagittal sinus (SSS).  B: Left lateral view on digital subtraction angiography (DSA) demonstrating nonvisualization (arrows) of the SSS and anastomoses between the superior sagittal and falcing group (arrowheads). No end-to-end anastomoses are found between the superior sagittal group and the tentorial and sphenoidal groups.  C: Right lateral view on DSA demonstrating nonvisualization of the anterior half of the SSS and anastomoses between the superior sagittal and falcing groups (arrowheads). The frontal marginal vein (small arrows) courses caudally from the frontal pole of the frontal lobe in the parasagittal areas.  D: Left oblique view on DSA demonstrating small nonvisualized area of the SSS (large arrows).  E: Right oblique view on DSA demonstrating nonvisualization of the anterior SSS (large arrow) and the frontal marginal vein (small arrows).
frontal lobe, and entered the SSS posteriorly at the level of the Rolandic area.

In one patient, no end-to-end anastomosis could be found in either hemisphere; however, the superior sagittal and tentorial venous channels were well developed.

In seven of the 15 hemispheres, the meningeal veins acted as a collateral pathway from the SSS to the sphenoparietal sinus and/or to the transverse sinus (Fig. 3). In all seven hemispheres, end-to-end anastomoses of the superficial cortical veins were also confirmed; however, these anastomoses were slender and tortuous. In six of the seven hemispheres, the meningeal veins coursed along the anterior branch of the middle meningeal artery and joined the SSS to the sphenoparietal and cavernous sinuses. In three of the seven hemispheres, the meningeal veins originated in the foramen cecum and flowed into the cavernous sinus or the pterygoid plexus. The scalp vein constituted an important collateral channel in only one hemisphere (Case 8), as confirmed by the selective internal carotid angiogram.

The slow progressive occlusion of the SSS may allow the development of end-to-end anastomoses of the superficial veins of the cerebrum and the meningeal veins to other venous channels, thereby preserving a functioning vascular drainage system. This concept was best exemplified by Case 5. In this patient (Fig. 4), a two-stage operation was performed 5 years ago. In the first stage, the tumor was subtotally resected because the SSS was still patent. The patient was followed regularly, and when the SSS became completely occluded and the collateral venous circulation fully developed, the tumor was totally resected in the second stage of the surgery without any neurological compromise.

Discussion

Clinical signs are frequently absent in parasagittal meningioma with obstruction of the SSS. The SSS may receive venous blood from the superficial veins of the cerebrum, the meningeal veins, and the diploic veins. Oka, et al., described the abundant anastomoses between the cortical veins draining adjacent cortical areas and between the superficial cortical veins and the deep ventricular and cisternal veins. Reversal of the normal
Obstruction of the superior sagittal sinus

![Image of MRI scans](image)

**Fig. 4. Case 5.** A: Enhanced coronal computerized tomography scan showing parasagittal meningioma before the first operation. B and C: Magnetic resonance T₁-weighted images of the sagittal and axial views demonstrating growth of the tumor in the middle superior sagittal sinus (SSS). D: Left lateral view on digital subtraction angiography (DSA) demonstrating nonvisualization of the SSS (large arrows) and well-developed end-to-end anastomoses among the superior sagittal, tentorial (median arrows), and sphenoidal (small arrowheads) groups. E: Right lateral view on DSA demonstrating nonvisualization of the anterior half of the SSS. The frontal marginal veins (small arrows) anastomosed to the vein of Labbe (median arrows) and the superficial sylvian vein (arrowheads). The tumor occupies the SSS (large arrows) proximal to entrance of the frontal marginal vein. F: Left oblique view on DSA showing the anterior SSS (arrowheads) and nonvisualization of the middle SSS (large arrows). The frontopolar vein (short arrow) enters backward into the SSS (arrowheads) and the posterior frontal vein (long arrow) enters forward into it. G: Right oblique view on DSA demonstrating nonvisualization of the anterior SSS (large arrow) and the frontal marginal vein (small arrows) coursing caudally from the frontal pole of the frontal lobe in the parasagittal area.

Venous flow of the anterior SSS depends for collateral circulation mainly on the end-to-end anastomoses of the superficial cortical veins. These end-to-end anastomoses are slender and tortuous except for the vein of Trolard and the vein of Labbe. It is believed that, under normal circumstances, each end-to-end anastomosis among the superficial cortical veins is part of the collateral circulation. These end-to-end anastomoses may function as anastomotic pathways when the SSS is occluded. Intraoperative management plays an important role in preventing venous infarction. The patient must be positioned so that there is good venous return and no careless brain retraction.

In our cases, approximately half the hemispheres contributed meningeal veins as collateral pathways between the SSS and the other sinuses. In six hemispheres, the meningeal veins coursed along the middle meningeal artery; in three, the meningeal veins flowed from the foramen cecum to the cavernous sinus. Oka, et al., noted that the largest meningeal veins accompany the middle meningeal artery. The meningeal veins drain into the large dural sinuses along the cranial base at their lower margin and into the venous lacunae and the SSS at their upper margin. These veins also receive diploic veins from the calvaria. In patients with complete occlusion of the SSS, the surgeon must be careful to preserve these meningeal veins when opening the dura, because they constitute an important part of the collateral circulation.

Magnetic resonance imaging and DSA are performed as part of the preoperative evaluation of patients with parasagittal meningiomas. Magnetic resonance imaging can determine the location, size, and anatomical relationship of the parasagittal meningioma and the patency of the SSS. Digital subtraction angiography is more sensitive than MR imaging in establishing both a complete sinus occlusion and the venous circulation. However, it is difficult to get an exact preoperative delineation of the extent of the meningioma’s involvement of the wall and the lumen of the SSS. When a patent sinus is present, surgical exploration of the involved wall must be performed carefully, with the possibility of opening and reconstructing the SSS. In our experience, progressive gradual obstruction of the SSS may lead to a well-developed collateral venous pathway. If a parasagittal meningioma invades the walls of a still patent SSS and the location of the sinus makes it difficult to resect or reconstruct, a two-stage opera-
tion is recommended, limiting the first stage to the removal of the mass and delaying the resection of the SSS until it is completely occluded.²

Oka, et al.,⁷ noted abundant anastomoses between the cortical veins draining adjacent cortical areas and between the superficial cortical veins and the deep venous system. Other anastomoses also existed along the borders of the hemisphere between the veins draining the adjacent parts of the lateral, medial, and basal surfaces. These anastomoses were located at the terminal ends of the veins just proximal to the bridging veins’ entrance to the dural sinuses. In our experience, the sacrifice of a bridging vein formed by the confluence of several cortical veins is preferred to sacrifice of the veins on the cortical surfaces, because there are many opportunities to preserve anastomoses among the superficial cortical veins.

The so-called “frontal marginal” vein courses caudally from the frontal pole in the parasagittal area, receiving tributaries from the frontal lobe, and sweeps posteriorly to enter the SSS in the Rolandic area. The frontal marginal vein was observed in Cases 2, 3, and 5. Marc and Schechter⁶ thought that this vein was an intradural channel that was usually unilateral and considered it a compensatory lumen of the SSS. Krayenbühl and Yaşargil⁴,⁵ described a large frontal marginal vein in 2.1% of their cases; the anterior third of the SSS up to the central sulcus was either hypoplastic or absent. In our cases, the frontal marginal vein is considered a unilateral superficial cortical vein. Atresia of the anterior portion of the SSS was not confirmed on internal carotid angiograms.³ Previous authors⁵,⁶ misunderstood the relationship between the SSS and the frontal marginal vein. We believe that the nonvisualization of the SSS was caused by a lack of bridging veins on the frontal lobe. Bilateral internal carotid angiography should be performed to determine whether nonvisualization of the anterior third of the SSS should be attributed to atresia, hypoplasia, or a technical factor.

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