Surgical Anatomy of the Subcallosal Artery: Implications for Transcranial and Endoscopic Endonasal Surgery in the Suprachiasmatic Region

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BACKGROUND: Suprachiasmatic subcallosal lesions may have an intimate relationship with the anterior communicating artery (AcomA); injury to AcomA branches can result in basal forebrain infarction and cognitive dysfunction.

OBJECTIVE: To evaluate anatomic variations of the AcomA basal perforating branches, especially the subcallosal artery (ScA), for clinical implications when approaching the suprachiasmatic subcallosal region from endonasal and transcranial routes.

METHODS: The origin, course, diameter, and branching pattern of the AcomA's perforating branches were studied in 33 specimens from transcranial and endonasal perspectives.

RESULTS: The ScA was present in 79% of the specimens as a single dominant artery arising from the posterior/posterosuperior surface of the AcomA, along with hypothalamic arteries (55%), or as a single artery (24%). It coursed posteriorly towards the lamina terminalis region, curving superiorly to the subcallosal area. The ScA gave off many branches to provide the main blood supply to the subcallosal region. Importantly, it supplies the septal/subcallosal region bilaterally. The ScA can be found posterior, superior, or inferior to the AcomA when using a transylvian, interhemispheric, or endonasal approach, respectively. In specimens with no ScA (21%), the median callosal artery (MdCA) was the dominant artery arising from the AcomA. It followed an identical course to the ScA, providing supply to the same structures bilaterally, but its distal extension reached the body/splenium of the corpus callosum. The MdCA is a ScA variant.

CONCLUSION: The ScA is a unique vessel because it supplies the septal/subcallosal region bilaterally; preservation of this vessel during surgery is crucial for successful outcomes.

KEY WORDS: Anterior communicating artery, Subcallosal artery, Surgical anatomy, Endoscopic endonasal approach, Interhemispheric approach, Pterional approach

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The basal perforating branches of the anterior communicating artery (AcomA) were first studied by Senior[1] in 1923 and Rubinstein[2] in 1944, although their clinical relevance was not completely understood at the time. Yasargil later stressed their surgical importance, and named them "hypothalamic arteries" in 1984.[3] More recently, Serizawa et al[4] classified the perforating branches of the AcomA based on their vascular territories, describing three groups: hypothalamic, chiasmatic, and subcallosal.

ABBREVIATIONS: AcomA, anterior communicating artery; **DWI,** diffusion-weighted imaging; **EEA,** endoscopic endonasal approach; **MdCA,** median callosal artery; **MRI,** magnetic resonance imaging; **ScA,** subcallosal artery

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The AcomA is a common site of intracranial aneurysms, and the suprachiasmatic subcallosal space, where the AcomA is located, may be occupied by different pathologies, including anterior skull base meningiomas, pituitary adenomas, and craniopharyngiomas. Thus, understanding the surgical anatomy of the perforating branches of the AcomA, both from transcranial and endoscopic endonasal perspectives, is essential when approaching the suprachiasmatic subcallosal region. Injury to the AcomA branches, specifically the subcallosal artery (ScA), can result in severe cognitive and memory dysfunction due to infarction of the associated basal forebrain.[5]

In this study, we aim to evaluate the anatomic variations of the basal perforating branches of the AcomA, with an emphasis on the ScA; we discuss the clinical implications of the findings when approaching the suprachiasmatic subcallosal region from endoscopic endonasal and transcranial routes.

METHODS

Thirty-three adult head specimens were lightly fixed in a formalin solution and prepared for dissection after the intravascular injection of colored silicone. The research was approved by the Research Ethics Board at our University. Cadaver heads were dissected using an endoscope (Karl Storz, 4 mm, 18 cm, Hopkins II, 0 and 45°; Karl Storz Gmbh & Co, Tuttlingen, Germany) attached to a high-definition camera and an operating microscope with 6 to 24× magnification (Olympus OME 8000 surgical microscope). An endoscopic endonasal approach (EEA) to the anterior cranial base (transtubercular-transplanum and transcribriform) and a transcranial approach (pterional and interhemispheric) were performed simultaneously on all heads. The origin, course, diameter, and branching pattern of the basal perforating branches of the AcomA were studied in all 33 specimens, from both transcranial and endonasal perspectives. A total of 20 of the 33 specimens were sectioned in the coronal and/or sagittal planes after dissection to follow the subarachnoid course of the perforating branches, and to identify the points at which they penetrated the neural tissue. We divided the basal perforating arteries of the AcomA into three groups according to their vascular territories: subcallosal, hypothalamic, and chiasmatic.[4] The diameters of these vessels were measured with digital micrometer calipers.

The data were analyzed using ANOVA and Wilcoxon signed-rank tests. Statistical analyses were performed using SPSS 16.0 (IBM, Armonk, New York) and SAS 9.3 (SAS Institute, Cary, North Carolina).

RESULTS

The AcomA Complex

A normal AcomA is defined as an anastomosis between the left and right anterior cerebral arteries through a single lumen. Normal AcomAs were present in 16 specimens (48.4%); in the remaining 17 specimens, there was fenestration in 10 (30.3%), duplication in 3 (9%), fusion in 2 (6%), and hypoplasia in 2 (6%).

Basal Perforating Arteries

The ScA

The ScA was present in 26 specimens (79%) as a single dominant artery, arising from the posterior or posterosuperior surface of the AcomA. It arose from the AcomA, either along with the hypothalamic arteries (in 54% of the cases) or as a single artery (in 25% of the cases). Its mean diameter was 0.5 ± 0.1 mm, and it coursed first posteriorly towards the region of the lamina terminalis, and then curved superiorly to reach the subcallosal area (Figures 1A, 1B, 2A, and 2B; Table 1). The ScA gave off many terminal branches to provide the main blood supply to the subcallosal region, including the anterior commissure, paraolfactory gyri, paraterminal gyri, fornice columns, anterior cingulate gyri, and rostrum and genu of the corpus callosum. Importantly, a single ScA supplied the septal/subcallosal region bilaterally in all cases (Figure 2A-2D). Regardless of any AcomA variations, the ScA can arise either from the side of the artery or from the mid-portion of the artery (Figure 2A, 2B, and 2D).

In the remaining 7 specimens (21%) with no ScA, the median callosal artery (MdCA) was present as the dominant artery arising from the AcomA, either along with the hypothalamic arteries (in 15% of the cases) or as a single artery (in 6% of the cases). Its mean diameter was 1.1 ± 0.6 mm. The ScA and the MdCA never occurred together. The MdCA followed a course identical to that of the ScA, and provided supply to the same structures bilaterally. However, the MdCA distal extension reached the body and splenium of the corpus callosum; therefore, the MdCA can be considered a variant of the ScA with a longer trajectory (Figure 3A-3D; Table 1).

Since the ScA originates from the posterior or posterosuperior aspect of the AcomA, the intraoperative identification of this artery is different, depending on the surgical approach selected (Figure 4A-4D; Table 2). From a pterional perspective, using the transylvian-subfrontal route, the subcallosal region is approached from lateral to medial, and therefore the ScA is identified medial and posterior to the ipsilateral A1 and A2 segments (Figure 4A). From the anterior interhemispheric route, the subcallosal space is accessed from superior to inferior, and once the interhemispheric and chiasmatic cisterns are opened, the ScA will be identified superior to the AcomA and in between both A2 segments (Figure 4 B). On the other hand, an EEA provides access to the infra and suprachiasmatic space with an inferior-to-superior approach; in general, access to the suprachiasmatic space from the endonasal route is facilitated by the inferior and posterior displacement of the optic chiasm by the mass lesion. Surgical exploration of the suprachiasmatic space allows identification of the ScA below the AcomA and above the optic chiasm; further dissection above the AcomA will expose the ScA as it runs towards the subcallosal region (Figure 4C and 4D).

The Hypothalamic Arteries

The hypothalamic arteries were found in all cases, with an average of 4 ± 1.7 branches (range: 2-11 branches), and a mean diameter of 0.2 ± 0.1 mm. These arteries arose from the posterior or posteroinferior surface of the AcomA in 18 specimens (54.5%), from the A1-AcomA junction in 11 specimens (33.3%), and from the posterior wall of the distal half of the A1 segment in 4 specimens (12.1%). The hypothalamic arteries ascended first along the lamina terminalis cisterns and then penetrate immediately below the level of the anterior commissure to supply the anterior hypothalamus; they frequently anastomosed with branches of the ScA (Figures 1A, 1B, and 2B-2D; Table 1). The hypothalamic arteries did not supply the corpus callosum in any of the specimens.

The Chiasmatic Arteries

The chiasmatic arteries were present in 28 specimens (85%), with an average of 3 ± 1.63 branches (range: 0-8 branches) and

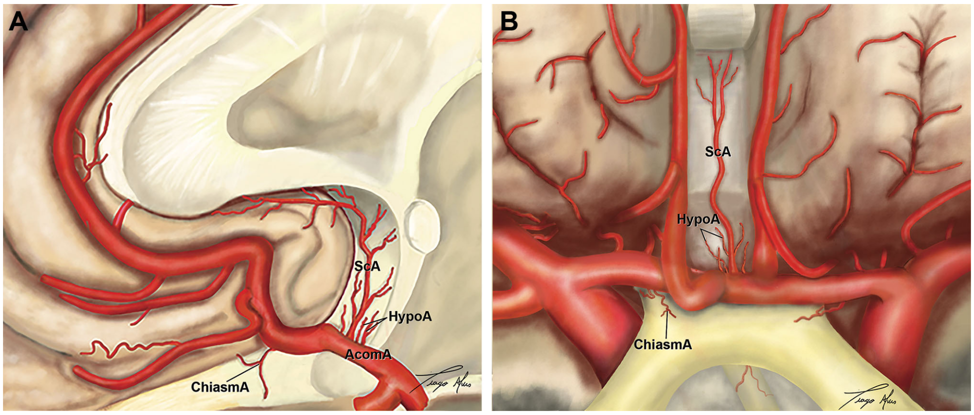

FIGURE 1. *An illustration of the vasa perforator of the anterior communicating artery (AcomA) complex. From* **A***, sagittal and* **B***, coronal views, the ScA, hypothalamic arteries, and chiasmatic arteries originate from the AcomA complex.*

TABLE 1. Characteristics of Perforating Branches From the AcomA in 33 Cadaveric Specimens

Arterial branches	Origen	Diameter, mm	Number range	Occurrence (brains) number (%)	Vascular territory
ScA	AcomA	0.5 ± 0.1	0-1	26 (79)	Subcallosal/septal area
MdCA[a]	AcomA	1.1 ± 0.6	0-1	7 (21)	Septal area and corpus callosum
Hypothalamic arteries	A1,AcomA	0.2 ± 0.1	2-11	33 (100)	Anterior hypothalamus
Chiasmatic arteries	A1,AcomA	0.1	0-8	28 (85)	Optic chiasm and optic tract

[a]The MdCA is considered a variant of the ScA with a longer trajectory.

a mean diameter of 0.1 mm. Of the 84 total chiasmatic arteries, 53 (63%) originated from the A1 segment, and 31 (37%) originated from the AcomA. These arteries supplied the upper surface of the optic chiasm and optic tract (Figures 1A, 1B, and 2B; Table 1).

There were no cases in which the A2 segment provided terminal branches to supply the subcallosal or hypothalamic area. In addition, there was no relationship between the anatomic variations of the AcomA complex and the number of its basal perforating branches.

Case Illustrations

Case 1: Tubercullum Sella Meningioma

A 53-yr-old female presented symptoms of right optic neuropathy; a brain magnetic resonance imaging (MRI) with gadolinium revealed a tuberculum sella meningioma with suprasellar-suprachiasmatic, subcallosal extension, as well as an optic canal invasion on the right side. The MRI also showed engulfment of both A1 segments, both proximal A2 segments, and the AcomA, which could be associated with ScA engulfment (Figure 5A-5C). The patient underwent an endonasal endoscopic transsellar-transplanum with right optic canal decompression. Involvement of the AcomA complex, and the subcallosal and hypothalamic arteries was confirmed intraoperatively. Both the chiasm and the AcomA were displaced posteroinferiorly by the tumor; therefore, the ScA was identified above the AcomA and optic chiasm. Postoperatively, the patient had improved vision, and an MRI revealed a gross total resection of the tumor (Figure 5D and 5E; **Video**, **Supplemental Digital Content**).

Case 2: Recurrent Invasive Pituitary Adenoma

A 35-yr-old male presented a history of invasive pituitary adenoma and tumor progression after two surgical tumor removal attempts at outside institutions, including with transsphenoidal and pterional approaches. The patient had developed complete left third nerve palsy and hypocortisolism after the second surgery. An MRI showed a large residual tumor with suprasellar extension and left cavernous sinus invasion (Figure 6A and 6B). An EEA treatment was proposed, but the surgery faced difficulties from the previous interventions. In the suprasellar region, the tumor was adherent to the adjacent structures, and it extended between the optic chiasm and AcomA. During the dissection of the suprachiasmatic subcallosal area, below the

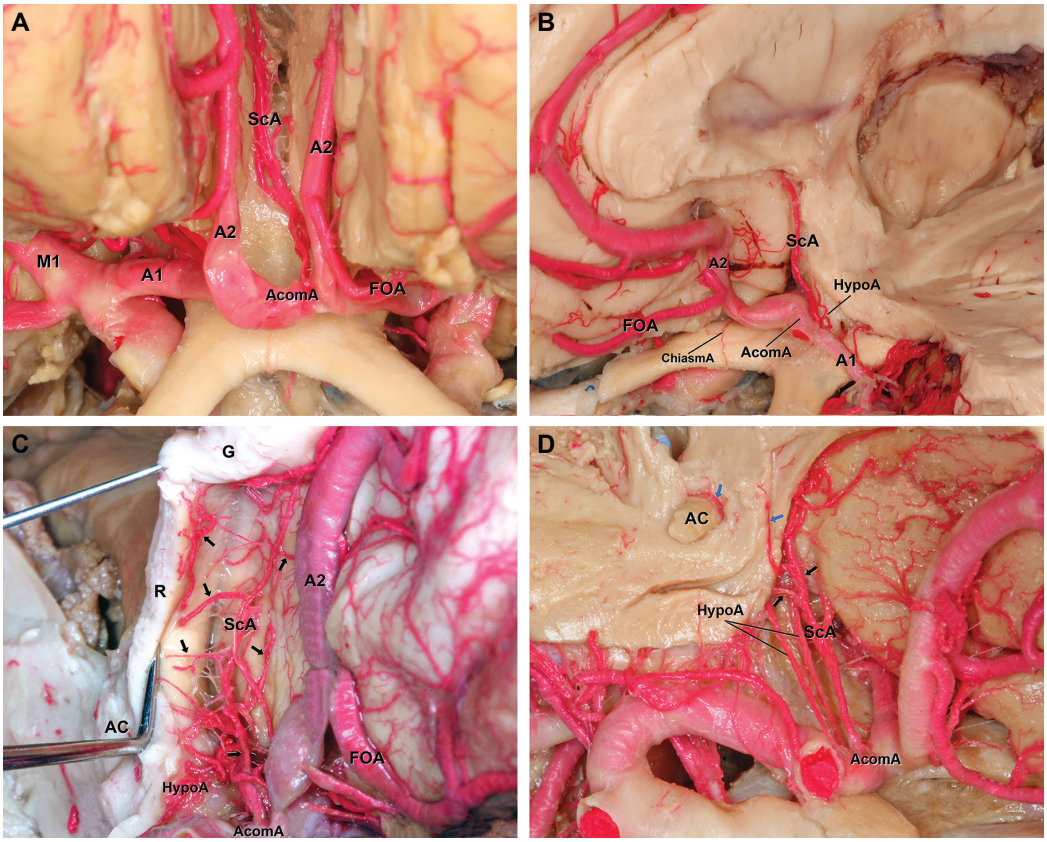

FIGURE 2. *The anatomic relationship of the subcallosal artery (ScA) and the perforating arteries of the anterior communicating artery (AcomA) complex.* **A**, *From a coronal view, the ScA can be identified arising from the posterior surface of the AcomA on the left side of the artery. The ScA runs toward the subcallosal/septal area, crossing over the lamina terminalis.* **B**, *From a sagittal view, the ScA can be seen ending at the level of the rostrum of the corpus callosum. The hypothalamic (HypoA) and chiasmatic arteries (ChiasmA) arising from the A1 segment are also visible.* **C**, *In another specimen, with a closer coronal view, the ScA arises from the mid-portion of the AcomA, then penetrates immediately above the level of the anterior commissure to supply the septal/subcallosal area bilaterally (black arrows). The ScA is frequently anastomosed with branches of the HypoA. AC***:** *Anterior commissure.* **D**, *A close, midsagittal view of the ScA and the HypoA; the ScA branches to the septal/subcallosal area bilaterally (black arrows). The fornix (precommissural and postcommissural fibers) is supplied by the branches of the ScA (blue arrows).*

AcomA, arterial bleeding was noticed, although no obvious vascular injury could be identified. The bleeding was controlled with bipolar coagulation and warm saline. Despite all technical difficulties, a gross total resection was achieved (Figure 6C and 6D). In the first postoperative day, the patient was confused with intermittent agitation and short-term memory dysfunction; an MRI demonstrated complete tumor resection but in the diffusion-weighted imaging (DWI) sequence there was a signal alteration on both fornices, the septum pellucid, and the posterior hypothalamus, consistent with ScA infarction (Figure 6E and 6F). At 6-mo follow-up, the patient has had significant cognitive recovery, with remaining mild short-term memory difficulties.

DISCUSSION

Lesions occupying the suprachiasmatic subcallosal space, including aneurysms and tumors, may have an intimate relationship with the AcomA complex.[3,4,6] Here, we have investigated the surgical anatomy of the basal perforating branches of the AcomA from endoscopic endonasal and transcranial perspective in order to provide relevant information when approaching the suprachiasmatic subcallosal space.

The ScA is the single largest branch of the AcomA complex and supplies the subcallosal/septal region bilaterally. Therefore, disruption of this single vessel could lead to bilateral vascular compromise of the septal area, and result in a potentially

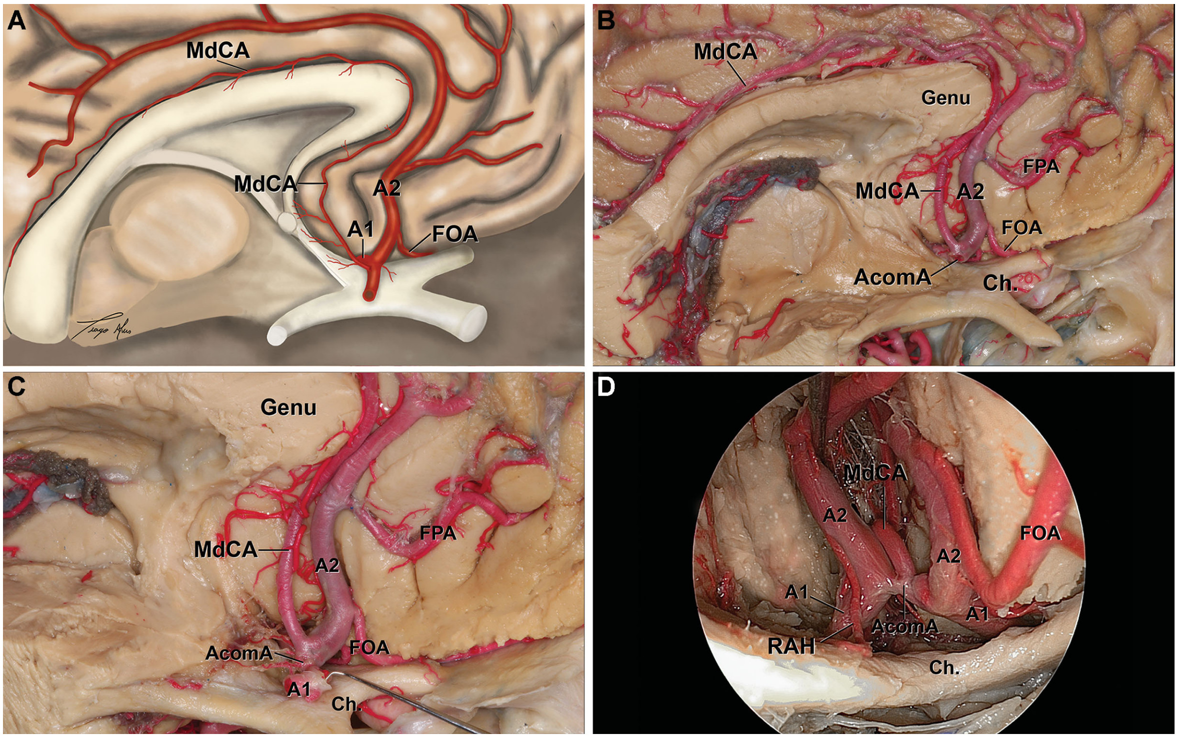

FIGURE 3. *The MdCA.* **A**, *Illustration of a medial view of a brain hemisphere demonstrating the course of the median callosal artery (MdCA). The MdCA originates from the anterior communicating artery (AcomA) and projects superior and posteriorly following the corpus callosum. In its course, the MdCA sends branches to the septal area and the corpus callosum and finishes at the level of the splenium of the corpus callosum.* **B**, *Anatomic dissection demonstrating a typical MdCA from its origin, in the AcomA, and its end, at the level of the splenium of the corpus callosum.* **C**, *Closer view of the subcallosal area. The MdCA originates from the AcomA and has a superior course sending branches to the septal area and genu of the corpus callosum.* **D**, *Endoscopic view of the MdCA. Under endoscopic visualization, the MdCA is located in the posterosuperior aspect of the AcomA and projecting posterosuperiorly in between the two A2 segments of the anterior cerebral artery.*

devastating neurological deficit.[3,4,7] The deficits associated with injury to the ScA include incapacitating memory deficits and personality changes, as observed in our illustrative case 2. Our findings are in concordance with the study conducted by Serizawa et al,[4] but the study presented here incorporates the findings not just from the AcomA branches, but also from the A1 and A2 segments and their branches. Moreover, this study is the first to provide a detailed description of the AcomA basal perforating arteries from an endoscopic endonasal perspective, and we also provide details of surgical anatomy and landmarks for the ScA from pterional, anterior interhemispheric, and endoscopic endonasal perspectives. Specifically, the ScA is identified posterior to AcomA and ipsilateral A2 segment when approached from lateral (pterional-transylvian approach), superior to the AcomA and between both A2 segments when accessed from anterior and superior (via the anterior interhemispheric approach), and inferior to the AcomA and superior to the optic chiasm when approached from anterior and inferior (endonasal endoscopic route), except when the tumor displaces the AcomA and chiasm inferiorly, in which case the ScA will be find superior to the AcomA and between both A2.

Based on the results presented here, we can conclude that the ScA is the most important perforator arising from the AcomA. Consequently, intraoperative identification and preservation of the ScA is crucial when approaching lesions located in the suprachiasmatic subcallosal space. It is important to note that the ScA arises from the posterior surface of the AcomA, which explains the increased risk of poor neuropsychological outcomes associated with posteroinferiorly projecting AcomA aneurysms after surgical or endovascular treatment.[5,7,8] Furthermore, one should be aware of variations of the ScA related to the site from which it arises, as it does not always arise from the midsite of the AcomA (Figure 2A, 2B, and 2D). The subcallosal region is one of the most eloquent areas of the brain because it includes the septal area, the anterior hypothalamus, and the fornix, which are critical for memory and cognition. A variety

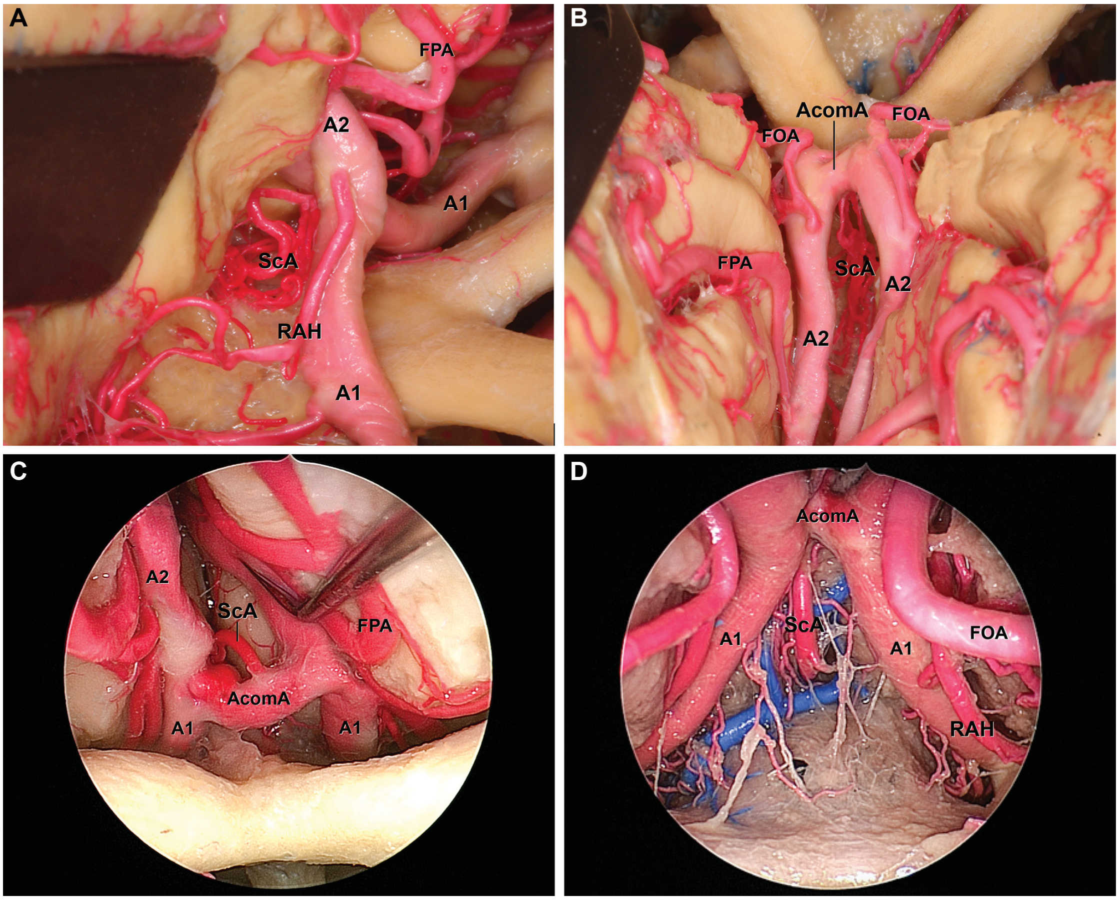

FIGURE 4. *Surgical visualization of the subcallosal artery (ScA) using transcranial and EEA.* **A**, *In a right side pterional craniotomy, the ScA can be identified emerging from the posterior surface of the anterior communicating artery (AcomA) and moving to the interhemispheric fissure. In this specimen, the recurrent artery of Heubner (RAH) originates from the A2 segment, which is located lateral to the ScA.* **B,** *With an anterior interhemispheric approach, the ScA can be identified in the midline, emerging from the posterosuperior surface of the AcomA between the two A2 segments. Both fronto-orbital arteries (FOA) are visualized coming from the A2 segment as well as the frontopolar artery (FPA) on the left side.* **C**, *Using an endoscopic endonasal transplanum approach, the ScA is easily identified originating from the posterosuperior aspect of the AcomA and moving to the septal area.* **D**, *The AcomA complex has been retracted superiorly; the ScA is visualized, and its course to the lamina terminalis can be seen.*

of different skull base approaches can be used to access the subcallosal region, each with distinct advantages and limitations. Inferior-lateral routes, such as the fronto-orbitozygomatic transsylvian approach, or anterior routes, such as the anterior interhemispheric approach, are most commonly used to access lesions located in the subcallosal region.[9-12] More recently, an EEA via the transplanum transtuberculum provides an anterior midline approach and a direct caudocranial angle to the suprasellar cistern.[13,14]

Waldron and Lawton[11] reported transient neurological deficits in 2 out of 5 patients with cavernous malformations in the anteroinferior part of basal ganglia resected by using the supracarotid-infrafrontal approach. Similarly, Shirane et al[15] reported transient memory disturbances (due to infarction of the perforating vessel) in 1 out of 31 patients with craniopharyngiomas resected by using the frontobasal interhemispheric approach. Lesions with retrochiasmatic and lamina terminalis extension can adhere to the ScA or hypothalamic arteries, and care should be taken so as to not pull the tumor, thereby preventing vessel avulsion.[16]

Before surgically approaching the subcallosal region in the case of a tumor or aneurysm, the surgeon must be aware of the possible anatomic variations of the ScA. A careful preoperative study of this artery using MRI/magnetic resonance angiography, and cerebral angiography, is strongly recommended. Detailed knowledge of the normal and variant anatomy of this artery

TABLE 2. ScA: Microsurgical and Endoscopic Perspectives, and Surgical Landmarks

	View perspective	Key landmarks	Position of the ScA
Pterional-transylvian approach	Lateral to medial	AcomA	Posterior
		A2 ipsilateral	Posterior
Anterior interhemispheric approach	Superior to inferior	AcomA	Superior
		Both A2	Between
Endonasal endoscopic approach	Inferior to superior	AcomA	Inferior
		Optic chiasm	Superior

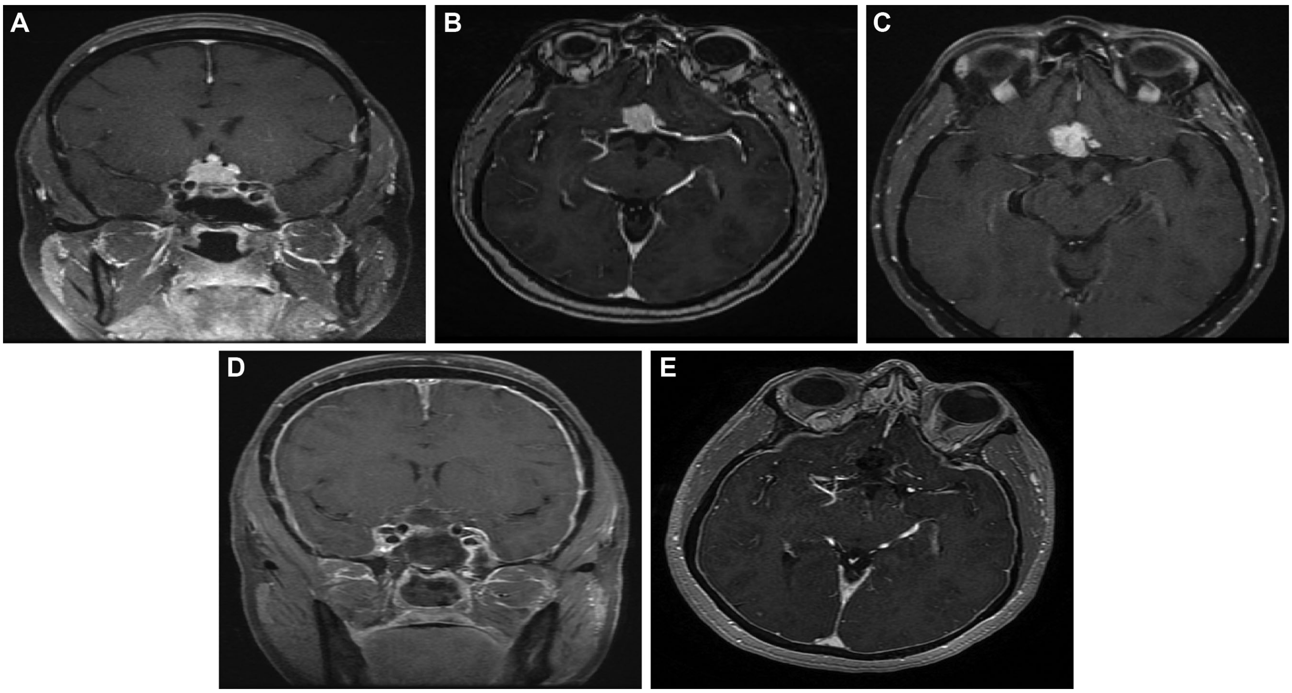

FIGURE 5. *Tuberculum sella meningioma.* **A** *to* **C***, Preoperative T1 postcontrast MRI images show a small tuberculum sella meningioma with clear engulfment of both A1 segments, both proximal A2 segments, and the AcomA, which could be associated with ScA engulfment.* **D** *and* **E***, The postoperative MRI showed gross total resection.*

applies in neuroradiological studies, which can be a valuable resource to the neurosurgeon when planning an approach in this region. In addition, it can better enable one to recognize important anatomic landmarks during surgery, and therefore proceed with precision and accuracy when exploring this complex region.

From a surgical viewpoint, the basal perforating arteries can be identified and preserved with both transcranial and endoscopic approaches. However, we believe that the transcranial approaches (pterional or anterior interhemispheric) are more advantageous than the endoscopic approach in cases when vascular encasement of the AcomA is present, specifically when there is tumor extension behind the AcomA complex. Fortunately, when using an EEA, there is a very low risk of injuring these vessels, as the pathology is typically ventral to the AcomA, but lesions such as complex adenomas with subarachnoid invasion and meningiomas may occupy the space behind the AcomA, thereby placing the subcallosal perforating arteries at risk.

Familiarity with the details of the vascular anatomy of the perforating branches of the AcomA, both from transcranial and endoscopic endonasal perspectives, is crucial to performing surgery in this region.

CONCLUSION

The ScA is a unique vessel because it supplies the septal/subcallosal region bilaterally. It can be found posterior, superior, or inferior to the AcomA when using a transylvian,

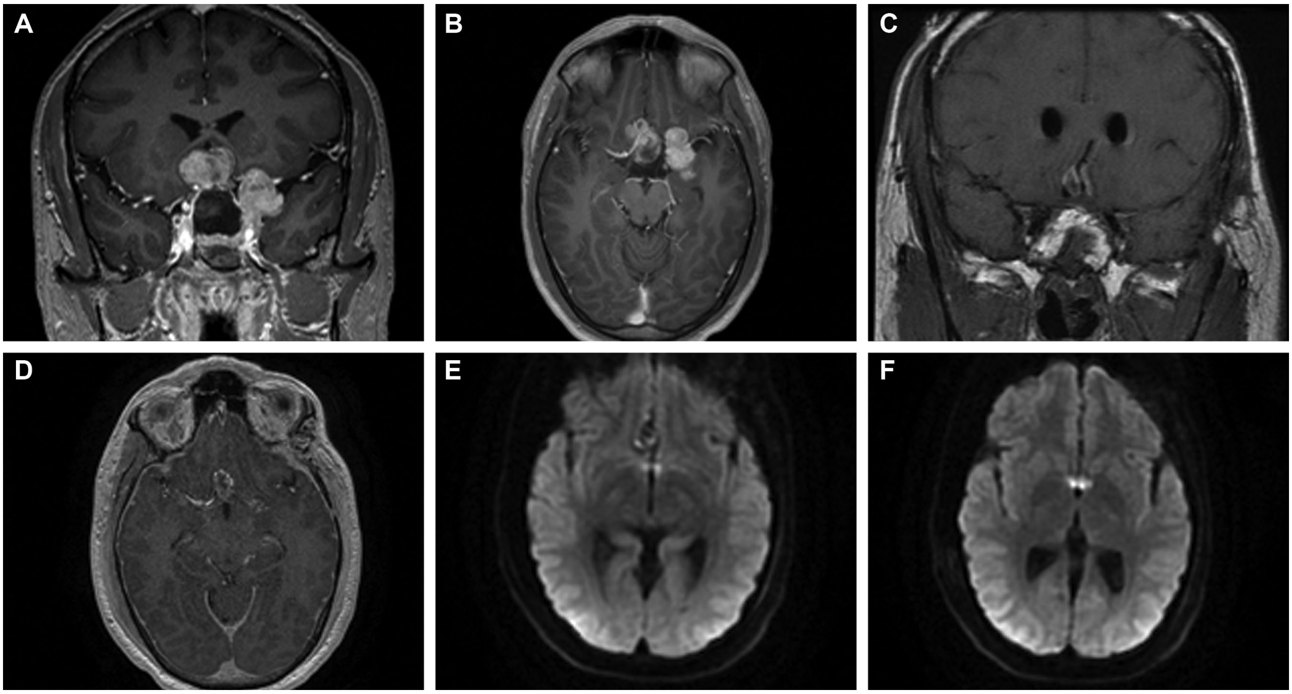

FIGURE 6. *Recurrent invasive pituitary adenoma. Preoperative T1 postcontrast MR1 from* **A**, *coronal and* **B**, *axial views demonstrate a sizeable recurrent tumor with significant compromising of the suprasellar space and left cavernous sinus invasion.* **C** *and* **D**, *The postoperative MRI showed gross total resection, and* **E** *and* **F**, *the DWI sequence showed signal alterations on the septum pellucid, fornix, and posterior hypothalamus, bilaterally suggesting a ScA infarct.*

interhemispheric, or endonasal approach, respectively. Preservation of the ScA and other basal perforating vessels during surgery to treat suprachiasmatic tumors or aneurysms is crucial for successful outcomes.

Disclosure

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

REFERENCES

1. Senior HD. The blood vascular system. In: Morris H (ed). *Human anatomy Philadelphia: Blakiston's Son*. 1923; 562-563.
2. Rubinstein HS. The anterior communicating artery in man. *J Nerv Ment Dis*. 1944;100(5):533.
3. Yasargil MG. Microneurosurgery: Microsurgical Anatomy of the Basal Cistern and Vessels of the Brain, Diagnostic Studies, General Operative Techniques and Pathological Considerations of the Intracranial Aneurysms. 1984.
4. Serizawa T, Saeki N, Yamaura A. Microsurgical anatomy and clinical significance of the anterior communicating artery and its perforating branches. *Neurosurgery*. 1997;40(6):1211-1218.
5. Mugikura S, Kikuchi H, Fujii T, et al. MR imaging of subcallosal artery infarct causing amnesia after surgery for anterior communicating artery aneurysm. *AJNR Am J Neuroradiol*. 2014;35(12):2293-2301.
6. Marinković S, Milisavljević M, Marinković Z. Branches of the anterior communicating artery. *Acta Neurochir*. 1990;106(1-2):78-85.
7. Meila D, Saliou G, Krings T. Subcallosal artery stroke: infarction of the fornix and the genu of the corpus callosum. The importance of the anterior communicating artery complex. Case series and review of the literature. *Neuroradiology*. 2015;57(1):41-47.
8. Kamble RB, Sheshadri V, Jayaraman A, Chandramouli BA. Rare complication of anterior communicating artery aneurysm coiling: Transient retrograde amnesia. *Neuroradiol J*. 2015;28(3):325-328.
9. Chang EF, Gabriel RA, Potts MB, Berger MS, Lawton MT. Supratentorial cavernous malformations in eloquent and deep locations: surgical approaches and outcomes. *J Neurosurg*. 2011;114(3):814-827.
10. Rangel-Castilla L, Spetzler RF. The 6 thalamic regions: surgical approaches to thalamic cavernous malformations, operative results, and clinical outcomes. *J Neurosurg*. 2015;123(3):676-685.
11. Waldron JS, Lawton MT. The supracarotid-infrafrontal approach: surgical technique and clinical application to cavernous malformations in the anteroinferior Basal Ganglia. *Operative Neurosurgery*. 2009;64(3 suppl):ons86-ons95.
12. Ehni G. Interhemispheric and percallosal (transcallosal) approach to the cingulate gyri, intraventricular shunt tubes, and certain deeply placed brain lesions. *Neurosurgery*. 1984;14(1):99-110.
13. Kassam A, Snyderman CH, Mintz A, Gardner P, Carrau RL. Expanded endonasal approach: the rostrocaudal axis. Part I. Crista galli to the sella turcica. *Neurosurgical Focus*. 2005;19(1):E3.
14. Kassam AB, Gardner PA, Snyderman CH, Carrau RL, Mintz AH, Prevedello DM. Expanded endonasal approach, a fully endoscopic transnasal approach for the resection of midline suprasellar craniopharyngiomas: a new classification based on the infundibulum. *J Neurosurg*. 2008;108(4):715-728.
15. Shirane R, Ching-Chan S, Kusaka Y, Jokura H, Yoshimoto T. Surgical outcomes in 31 patients with craniopharyngiomas extending outside the suprasellar cistern: an evaluation of the frontobasal interhemispheric approach. *J Neurosurg*. 2002;96(4):704-712.
16. Yaşargil MG. Microsurgery: Microneurosurgery of CNS Tumors. *Georg Thieme Verlag*. 1996.

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Supplemental Digital Content. Video. Tuberculum Sella Meningioma.

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COMMENT

The complexity of the skull base and its inhabitant structures demands more study to better define this region's anatomy. This article focuses on the anterior communicating artery complex and its perforators. The authors should be commended on their meticulous cadaveric dissections and assessment of findings. The subcallosal artery is an important perforator stemming from this region as it perfuses highly eloquent regions and can easily be damaged during surgery. There are few prior studies that define the subcallosal artery and its variants; however, knowledge of this anatomy is highly relevant to the endoscopic skull base surgeon.

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