

# Endovascular treatment of 306 anterior communicating artery aneurysms: overall, perioperative results

## Clinical article

**GUIDO GUGLIELMI, M.D.,<sup>1,2</sup> FERNANDO VIÑUELA, M.D.,<sup>1</sup> GARY DUCKWILER, M.D.,<sup>1</sup> REZA JAHAN, M.D.,<sup>1</sup> ENRICO COTRONEO, M.D.,<sup>2</sup> AND RENATO GIGLI, M.D.<sup>2</sup>**

<sup>1</sup>*Division of Interventional Neuroradiology, University of California at Los Angeles, California; and*

<sup>2</sup>*Division of Neuroradiology, San Camillo Hospital, Rome, Italy*

**Object.** A series of 306 consecutive patients with an anterior communicating artery (ACoA) aneurysm is presented. The goal in this study was to report the results of endovascular treatment of ACoA aneurysms in these patients.

**Methods.** The aneurysms were managed with an endovascular approach in which detachable coils were used. A brief anatomical description of the ACoA and its branches as well as a review of the surgical and endovascular literature is presented. The “ACoA Syndrome” (that is, amnesia and personality changes), which may occur after subarachnoid hemorrhage, is briefly reviewed and described. Recent technical developments that can lead to improved results are also discussed.

**Results.** Of the 306 aneurysms, 268 (87.5%) were small, 30 (10%) were large, and 8 (2.6%) were giant. One hundred ninety-three aneurysms (63%) had a small neck, whereas 113 (37%) had a wide neck. Sixty-five lesions (21%) were incidental, 5 (2%) presented with symptoms of mass effect, and 236 (77%) presented with a subarachnoid hemorrhage. A complete aneurysm occlusion was attained in 139 cases (45.5%), a neck remnant was detected in 145 (47.5%), and in 22 cases (7%) a residual filling of the aneurysm was observed. Regarding the clinical neurological outcome, 280 patients (91.5%) remained neurologically intact, improved, or unchanged from their initial clinical status. Two large, wide-necked, subtotally occluded aneurysms ruptured 3–7 months after the procedure, with subsequent death of the patients. The procedure-related morbidity and mortality rates were 3.5% (11 cases) and 1% (3 cases), respectively.

**Conclusions.** The inherently lower risk of injuring or occluding the delicate branches and perforating vessels arising from the ACoA makes the endovascular approach attractive, interesting, and elegant.  
(DOI: 10.3171/2008.10.JNS081005)

**KEY WORDS** • anterior communicating artery aneurysm • detachable coil • endovascular procedure

OF all brain aneurysms, the ACoA aneurysm is the most frequent.<sup>20</sup> Due to the deep, midline location of these aneurysms and to the number of important small branches and perforating vessels arising from the ACoA, their surgical treatment remains an arduous task. In recent years the endovascular approach to ACoA aneurysms has emerged as an inherently less traumatic alternative treatment option.<sup>7,11,12,19</sup>

We present our experience in the endovascular management of 306 consecutive patients harboring an ACoA

aneurysm. Clinical outcome, angiographic results, and complications are presented.

## Methods

### Case Material

A series of 306 consecutive patients harboring an ACoA aneurysm were treated at our institutions via the endovascular approach. In this series, 192 were females (63%) and 114 (37%) were males. The patients' ages ranged from 9 to 85 years, with an average age of 57 years.

In 12 cases, which were not included in this series, the endovascular treatment was attempted but failed, with

Abbreviations used in this paper: ACoA = anterior communicating artery; GDC = Guglielmi detachable coil.

## Endovascular treatment of 306 ACoA aneurysms: overall results

no adverse clinical consequences. Ten of the 12 failures occurred early in our experience, whereas only 2 failures occurred in the last 130 cases.

### *Aneurysm Characteristics*

Regarding the aneurysm size, 268 lesions (87.5%) were small (3–15 mm in diameter), 30 (10%) were large (15–25 mm in diameter), and 8 (2.5%) were giant (> 25 mm in diameter). Regarding the aneurysm neck size, 193 lesions (63%) had a small neck ( $\leq 4$  mm), whereas 113 (37%) had a wide neck (> 4 mm).

### *Clinical Presentation*

Sixty-five aneurysms (21%) were incidental, 5 (2%) presented with symptoms of mass effect, and 236 (77%) presented with a subarachnoid hemorrhage. Of these, 97 were categorized in Hunt and Hess Grade I, 40 in Grade II, 46 in Grade III, 33 in Grade IV, and 20 in Grade V.

### *Indications for Endovascular Treatment*

The endovascular approach rather than surgical clip application was chosen for the following reasons: poor neurological grade in 68 patients; previous failed clipping in 29; poor medical condition in 44; and anticipated surgical difficulty in 83. Surgery was refused by 82 patients.

### *Technique Used*

All procedures were performed via the transfemoral approach, after induction of general anesthesia and with the patient receiving systemic heparinization. After microcatheterization of the aneurysm, GDCs or Matrix coils (both from Boston Scientific Neurovascular) were delivered and detached until dense aneurysm packing was obtained, trying not to compromise the lumen of the ACoA–anterior cerebral artery complex and the surrounding branches. An embolization was considered to be complete when there was no contrast filling of the dome, body, base, or neck of the aneurysm. A neck remnant was defined as residual filling of the neck of the aneurysm. An incomplete embolization was indicated by contrast agent in the base and a portion of the body of the aneurysm.

## Results

### *Treatment Results*

A complete aneurysm occlusion was attained in 139 cases (45.5%) (Fig. 1). A neck remnant was detected in 145 cases (47.5%) (Fig. 2), and in 22 (7%) a residual filling of a portion of the aneurysm was observed. In 10 cases (3%) the aneurysm was perforated during the procedure. This resulted in the death of 2 patients. In the other 8 cases, the hemorrhage was immediately stopped by delivering additional coils and reversing the anticoagulation therapy.

### *Angiographic Follow-Up Studies*

In 144 cases at least 1 angiographic follow-up study was performed. In 99 cases (69%) no change in the degree of occlusion was detected. In 22 cases (15%) further

thrombosis of the aneurysm was observed. In 23 cases (16%) the angiogram showed compaction of the coils into the aneurysm: 17 of these cases required a second embolization session, whereas in 6 the residual aneurysm was surgically clipped.

### *Clinical Outcome*

Regarding the clinical neurological outcome, 280 patients (91.5%) remained neurologically intact, improved, or unchanged from initial clinical status. The posttreatment clinical examination showed a permanent new neurological motor-sensory deficit in 11 cases (3.5%). The deficit was mild in 2 cases, moderate in 6, and severe in 3.

Overall, 15 patients died (5%). Of these, 7 were originally categorized in Hunt and Hess Grade V and died of the consequences of the original hemorrhage, 2 died of severe vasospasm, and 1 of septicemia. Two large, wide-necked, subtotally occluded aneurysms ruptured 3–7 months after the procedure, with subsequent death of the patients. Regarding the procedure-related deaths, 2 patients died of aneurysm perforation, and 1 of intractable retroperitoneal hematoma. Therefore, the procedure-related morbidity and mortality rates were 3.5% (11 cases) and 1% (3 cases), respectively.

### *Additional Treatment*

In 24 cases a severe vasospasm required mechanical or chemical angioplasty (papaverine). Intraprocedural chemical thrombolysis was performed in 3 cases. In 3 cases a pericallosal artery–pericallosal artery side-to-side bypass was surgically created prior to coil occlusion of the aneurysm. In 6 cases a residual aneurysm that was present after coil insertion was surgically clipped.

## Discussion

### *Anatomy of the ACoA*

The ACoA has a diameter ranging from 0.8 to 3.4 mm, and a length of 0.8 to 4.6 mm. There are several branches arising from the artery: in autopsy studies<sup>3,13</sup> the number of these branches ranged from 3 to 13, with an average of 6. Two studies<sup>9,15</sup> showed that the ACoA branches are small and large, all arising from the posterior aspect of the artery. The small branches were 1–5 in number and 70–270  $\mu$ m in diameter, while the largest branch was the subcallosal artery. This artery had a bilateral termination in the subcallosal areas, which includes the rostrum and genu of the corpus callosum, the anterior commissure, the anterior cingulate gyri, the paraolfactory gyri, the paraterminal gyri, the anterior septum pellucidum, and the column of the fornix.<sup>6</sup> Impairment of the ACoA branches is reported to cause memory disturbances and personality changes.

### *Surgical Series*

Ljunggren et al.<sup>8</sup> reported on the surgical outcome of 69 patients with Hunt and Hess Grades I–III who harbored an ACoA aneurysm. Seven of these patients (10%)



FIG. 1. *Left:* Cerebral angiogram showing a small, narrow-necked ruptured ACoA aneurysm facing in a downward direction. *Right:* Postembolization unsubtracted angiogram showing that the aneurysm has been completely occluded with 1 "soft" GDC. This coil was 2 mm in circular memory, and 6 cm in length. Due to the small size of the lesion, the microcatheter was kept in the neck of the aneurysm while delivering the coil.

had a permanent neurological deficit that developed after surgery.

Yaşargil<sup>20</sup> correlated the preoperative Hunt and Hess grading to the postsurgical clinical outcome in 375 patients with ACoA aneurysms. The overall clinical outcome was good in 328 patients (87.5%), fair in 11 (3%), poor in 13 (3.5%), and 23 patients (6%) died. Of the 23 deaths, only 5 were procedure related. In this series, only 18 patients (5%) of 375 were categorized in Hunt and Hess Grades IV and V.

Suzuki et al.<sup>17</sup> reported on the postsurgical overall clinical outcome in 603 patients with an ACoA aneurysm. Of these patients, 367 (61%) had an excellent outcome, 107 (18%) had a good outcome, 99 (16%) had a fair/poor outcome, and 30 (5%) died. Of the 264 patients who

presented in Hunt and Hess Grades 0–III, 86% had an excellent or good outcome.

Fukushima et al.<sup>4</sup> reported on the overall clinical outcome postsurgery in 138 patients with an ACoA aneurysm. In 119 cases (86%) the outcome was excellent or good, and 8 (6%) died. Of the 83 patients presenting in Hunt and Hess Grades I–III, 92% had an excellent or good outcome.

#### Endovascular Series

In 2002 Kazekawa et al.<sup>7</sup> presented the overall clinical and angiographic evaluation in 19 consecutive patients with ACoA aneurysms who were treated with GDCs. Complete obliteration was obtained in 68% of cases,

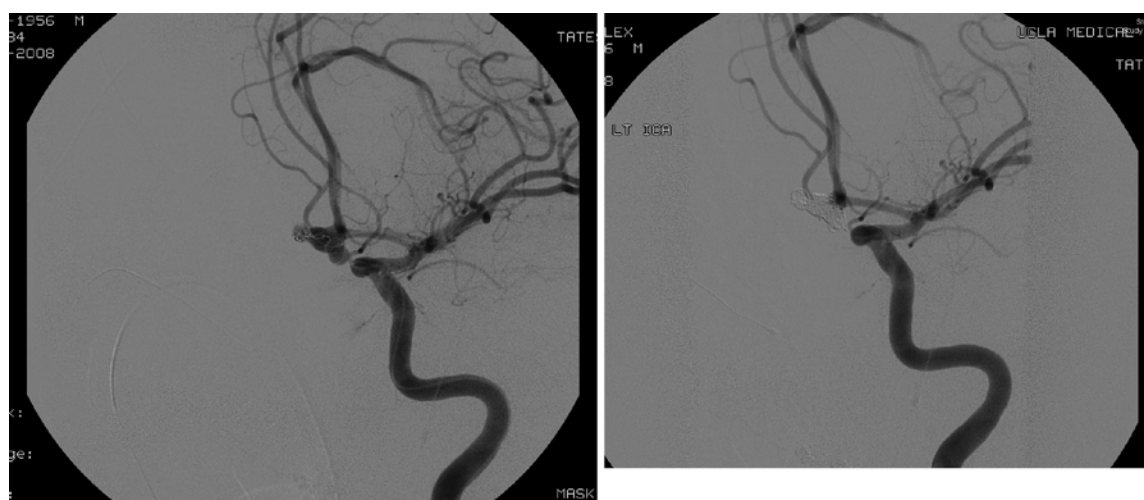


FIG. 2. *Left:* Cerebral angiogram showing a trilobulated ACoA aneurysm facing in an anterior direction. The first coil is already in the distal lobule of the aneurysm. *Right:* Postembolization angiogram showing near-total occlusion of the aneurysm. A small residual aneurysm neck is visible.

## Endovascular treatment of 306 ACoA aneurysms: overall results

whereas a neck remnant was observed in 32%. Regarding the overall clinical outcome, 3 patients (15%) who were originally categorized in Grades IV and V died, 1 (5%) was moderately disabled, and 15 (80%) had a good recovery. The authors pointed out that the patients who had a good recovery did not demonstrate significant personality or behavioral changes.

In 1996, Moret et al.<sup>11</sup> published the results of endovascular treatment in 36 ACoA aneurysms. In 7 of these cases (20%) the treatment failed. This high rate of failure can be explained because the technical armamentarium in the mid-1990s was not as advanced and sophisticated as it is today (see *Present Series*). Of the 29 treated aneurysms, it was possible to achieve a complete occlusion in 23 (79%), whereas the occlusion was only partial (neck remnant) in the remaining 6 cases (21%). These investigators observed a postprocedural temporary neurological deficit in 2 cases, and the procedure-related permanent morbidity was 3.5% (1 case). No procedure-related death was reported.

Tsutsumi et al.<sup>19</sup> reported on the overall results in 19 ruptured tiny (diameter  $\leq 3$  mm) ACoA aneurysms. Sixteen patients presented in Grades I–III, and 3 cases were categorized in Grade IV. Complete aneurysm occlusion was obtained in 84% of cases, whereas near-complete occlusion was obtained in 16% of cases. In 15 patients (79%) the outcome was good, whereas in 3 cases (16%) the clinical follow-up showed severe disability, and 1 patient (5%) died of severe vasospasm. None of the 18 patients who were followed clinically for a median period of 39.5 months showed rebleeding.

Proust et al.<sup>12</sup> conducted a study in which the ACoA aneurysms were divided into 3 groups. In Group A, clip application was performed regardless of whether the aneurysm fundus was directed anteriorly or posteriorly. In Group B, clip application was performed only in aneurysms that were anteriorly directed. In Group C (37 cases), the aneurysms were treated endovascularly with coil occlusion. In this latter group the investigators observed identical morbidity and mortality rates (8%). These rates compare unfavorably with the results of our and others' series (see above). Proust et al. concluded that anteriorly directed ACoA aneurysms should be surgically clipped, whereas posteriorly directed ACoA aneurysms should be treated with coils. This was recommended because all the ACoA branches and perforating vessels arise from the posterior aspect of the artery.

### *Present Series*

In our endovascular series the treatment was attempted and failed in 12 cases (4% failure rate). With recent technical advancements, such as rotational angiography, new microcatheters and microguidewires, small and supersoft coils, and compliant balloons for the balloon-assisted technique, the failure rate is diminishing. This is demonstrated in our series: 10 of the 12 failures occurred early in our experience, while only 2 failures (1.5%) occurred in the last 130 cases.

Regarding the occlusion rates of the aneurysms, a complete occlusion was achieved in 139 cases (45.5%). A neck remnant was detected in 145 aneurysms (47.5%),

and in 22 cases (7%) a residual filling of the aneurysm was observed. A detailed analysis of the significance of a residual aneurysm neck was reported by Hayakawa et al.<sup>5</sup>

Regarding the clinical neurological outcome, 280 patients (91.5%) remained neurologically intact, improved, or unchanged from their initial clinical status. Two large, wide-necked, subtotally occluded aneurysms ruptured 3–7 months after the procedure, with subsequent death of the patients. The procedure-related morbidity and mortality rates were 3.5% (11 cases) and 1% (3 cases), respectively.

### *Technical Developments*

A number of recent technical developments have ameliorated the results and the feasibility of endovascular treatment of ACoA aneurysms. The improved coatings in microcatheters and guidewires improved the efficacy and safety in the catheterization of brain aneurysms.

The development of tridimensional coils improved the device's anchoring and produced a more homogeneous aneurysm embolization in small and large wide-necked aneurysms. The introduction of rotational digital angiography improved the anatomical and geometrical information, the catheter localization, the coil selection, the angle of embolization, and the anatomical outcome. As a consequence, it also decreased technical and clinical complications. The use of the balloon-assisted technology in ruptured and unruptured aneurysms, and the use of stents in unruptured aneurysms are particularly effective in large and wide-necked lesions, with a very low rate of iatrogenic complications.

### *Aneurysm Recanalization*

We observed a 16% rate of recanalization of the aneurysms on the follow-up angiograms, mainly in large, wide-necked lesions. The most important factors related to aneurysm recanalizations were as follows: acutely ruptured aneurysms, use of soft and smaller coils, large size of the aneurysm, and large size of the neck of the aneurysm.

Another factor that predisposes to recanalization is the spatial direction of the ACoA aneurysm: lesions that point upward and posteriorly are more difficult to treat. In this type of aneurysm the difficulty of safe catheterization increases. It is important to steam-shape the microcatheter properly to improve its positioning and anchoring (Fig. 3). In fact, the microcatheter may lose position within the aneurysm relatively easily, with consequently less dense aneurysm packing with coils.

A second session of embolization was performed in the majority of recanalized aneurysms, with a very low rate of iatrogenic complications. In a minority of cases, surgical clipping was the preferred therapeutic option.

### *Presence of Vasospasm*

The presence of symptomatic moderate or severe vasospasm was not a contraindication for endovascular embolization of ACoA aneurysms. If necessary, it is possible to perform pharmacological manipulation of the spasm

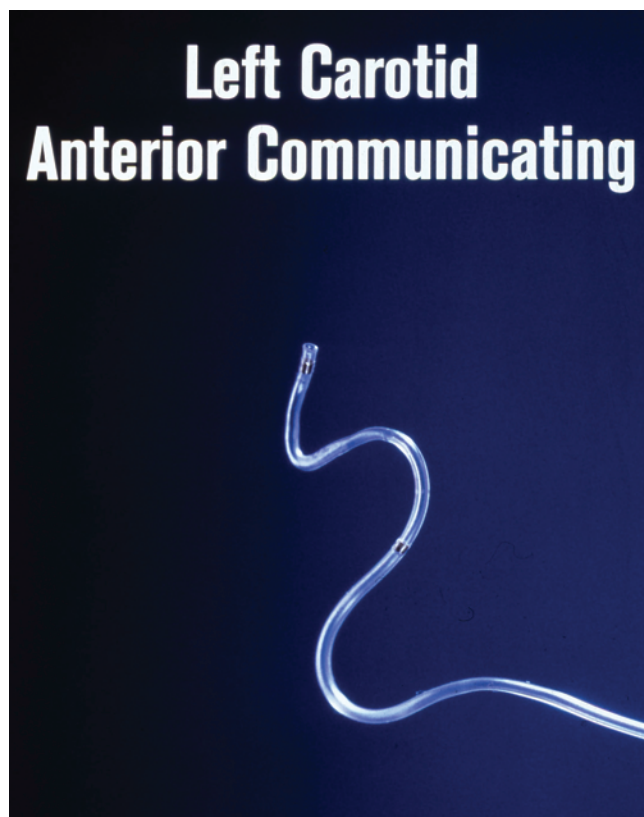


FIG. 3. Photograph of a steam-shaped microcatheter for the catheterization of upward-directed ACoA aneurysms. The first (proximal) curve is for the carotid siphon, the second curve is for the left A<sub>1</sub> segment, and the third curve is for the aneurysm neck.

to be able to block the aneurysm with coils. The immediate occlusion of the aneurysm allows intense medical or endovascular therapy for the arterial vasospasm. A significant advantage over surgery is that there is no need for any kind of manipulation or resection of an “angry,” “swollen” brain to reach the aneurysm.

#### *The “ACoA Syndrome”*

Rupture alone, or surgical repair of an ACoA aneurysm may result in cognitive deficits such as memory impairment and personality changes, which are usually referred to as the “ACoA syndrome.”<sup>1,10,14,18</sup> Even patients with a postoperative Glasgow Outcome Scale score of 4 or 5 may still exhibit significant cognitive deficits.<sup>10</sup> One study<sup>16</sup> evaluated the quality of life and the degree of cognitive dysfunction in 93 patients 4.5 years after surgery of a ruptured brain aneurysm; patients with an ACoA aneurysm were more likely to suffer cognitive dysfunctions than patients who had a ruptured aneurysm elsewhere in the intracranial vasculature. The only study that compares the cognitive outcome between surgically and endovascularly treated patients was published by Chan et al.<sup>2</sup> In this study, neuropsychological tests were used to assess the cognitive function in 18 patients with a ruptured ACoA aneurysm. Half of them had undergone sur-

gical clip application and the other half had endovascular embolization. The patients treated with coil embolization showed significantly fewer severe cognitive deficits than those who had undergone surgical clip application.

### Conclusions

From the results of this series and from the review of the literature it is possible to infer that the endovascular treatment of ACoA aneurysms has a definite place in the treatment of these complex lesions. Recent technical developments have improved the safety and efficacy of endovascular treatment. From the data of the literature it is possible to deduce that postsurgical personality and memory disturbances seem less likely to occur in patients treated using the endovascular procedure. The inherently lower risk of injuring the delicate branches and perforating vessels arising from the ACoA makes the endovascular approach attractive, interesting, and elegant.

### Disclosure

Dr. Guglielmi is the inventor of the GDC system, and Dr. Viñuela is the inventor of the Matrix coil system. The authors report no other potential conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

### References

- Alexander MP, Freedman M: Amnesia after anterior communicating artery aneurysm rupture. *Neurology* **34**:752–757, 1984
- Chan A, Ho S, Poon W: Neuropsychological sequelae of patients treated with microsurgical clipping or endovascular embolization for anterior communicating artery aneurysms. *Eur Neurol* **47**:37–44, 2002
- Crowell RM, Morawetz RB: The anterior communicating artery has significant branches. *Stroke* **8**:272–273, 1977
- Fukushima T, Miyazaki S, Takusagawa Y, Reichman M: Unilateral interhemispheric keyhole approach for anterior cerebral artery aneurysms. *Acta Neurochir Suppl (Wien)* **53**:42–47, 1991
- Hayakawa M, Murayama Y, Duckwiler GR, Gobin YP, Guglielmi G, Viñuela F: Natural history of the neck remnant of a cerebral aneurysm treated with the Guglielmi detachable coil system. *J Neurosurg* **93**:561–568, 2000
- Heros R: Comment in: Serizawa T, Saeki N, Yamaura A: Microsurgical anatomy and clinical significance of the anterior communicating artery and its perforating branches. *Neurosurgery* **40**:1211–1218, 1997
- Kazekawa K, Tsutsumi M, Aikawa H, Iko M, Tanaka A, Go Y, et al: Endovascular treatment of anterior cerebral artery aneurysms using Guglielmi detachable coils: mid-term clinical evaluation. *Radiat Med* **20**:291–297, 2002
- Ljunggren B, Saveland H, Brandt L: Causes of unfavorable outcome after early aneurysm operation. *Neurosurgery* **13**:629–633, 1983
- Marinkovic S, Milisavijevic M, Marinkovic Z: Branches of the anterior communicating artery. Microsurgical anatomy. *Acta Neurochir (Wien)* **106**:78–85, 1990
- Mavaddat N, Sahakian B, Hutchinson P, Kirkpatrick P: Cognition following subarachnoid hemorrhage from anterior communicating artery aneurysm: relation to timing of surgery. *J Neurosurg* **91**:402–407, 1999
- Moret J, Pierot L, Boulin A, Castaings L, Rey A: Endovas-

## Endovascular treatment of 306 ACoA aneurysms: overall results

- cular treatment of anterior communicating artery aneurysms using Guglielmi detachable coils. **Neuroradiology** **38**:800–805, 1996
12. Proust F, Debono B, Hannequin D, Gerardin E, Clavier E, Langlois O, et al: Treatment of anterior communicating artery aneurysms: complementary aspects of microsurgical and endovascular procedures. **J Neurosurg** **99**:3–14, 2003
  13. Rhoton A: Aneurysms. **Neurosurgery** **51** (1 Suppl):S121–S158, 2002
  14. Sekhar L, Natarajan S, Britz G, Ghodke B: Microsurgical management of anterior communicating artery aneurysms. **Neurosurgery** **61** (5 Suppl):273–292, 2007
  15. Serizawa T, Saeki N, Yamaura A: Microsurgical anatomy and clinical significance of the anterior communicating artery and its perforating branches. **Neurosurgery** **40**:1211–1218, 1997
  16. Sonesson B, Ljunggren B, Saveland H, Brandt L: Cognition and adjustment after late and early operation for ruptured aneurysm. **Neurosurgery** **21**:279–287, 1987
  17. Suzuki J, Mizoi K, Yoshimoto T: Bifrontal interhemispheric approach to aneurysms of the anterior communicating artery. **J Neurosurg** **64**:183–190, 1986
  18. Tidswell P, Dias P, Sagar H, Mayes A, Battersby R: Cognitive outcome after aneurysm rupture: relationship to aneurysm site and postoperative complications. **Neurology** **45**:875–882, 1995
  19. Tsutsumi M, Aikawa H, Onizuka M, Kodama T, Nii K, Matsubara S, et al: Endovascular treatment of tiny ruptured anterior communicating artery aneurysms. **Neuroradiology** **50**:509–515, 2008
  20. Yaşargil G: Anterior communicating artery aneurysms, in Yaşargil G (ed): **Microneurosurgery, Vol II**. New York: Thieme-Verlag, 1984, pp 169–223

---

Manuscript submitted August 10, 2008.

Accepted October 27, 2008.

Please include this information when citing this paper: published online January 30, 2009; DOI: 10.3171/2008.10.JNS081005

Address correspondence to: Guido Guglielmi, M.D., Piazza Mazzini, 27 00195 Rome, Italy. email: guidogdc@yahoo.com.