Early Surgical Management of Middle Cerebral Artery Aneurysms Associated With Intracerebral Hematomas: The Uludağ University Experience

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Abstract: In this case series study, the surgical outcomes of 29 patients with intracerebral hematomas resulting from the rupture of middle cerebral artery aneurysms that were operated on within the first 12 hours after rupture were retrospectively analyzed. Preoperative cerebral angiography could be obtained in 12 (41.3%) of our patients. Outcome was assessed according to the Glasgow Outcome Scale at 6 months after surgery. Overall mortality was 48%. Of 12 patients in good preoperative condition, 6 (50%) had a favorable outcome (Glasgow Outcome Scale, 4 to 5), whereas of the 17 patients in poor preoperative condition only 1 (5.8%) had a favorable outcome ($P = 0.042$). Our results suggest that despite early surgical treatment of patients with ruptured middle cerebral artery aneurysms associated with massive intracerebral hematoma, mortality continues to be high in patients with poor preoperative grades.

Key Words: aneurysm, middle cerebral artery, intracerebral hematoma, clipping, sylvian fissure

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Aneurysm rupture results in an intracerebral hematoma (ICH) in 4% to 42.6% of patients and is a predictor of unfavorable outcome.[1–6] Middle cerebral artery (MCA) aneurysms are the most common source of ICH and early surgical evacuation of large ICH is believed to improve the outcome.[2,5–16] Earlier studies report over 80% mortality with conservative treatment,[10,17] whereas evacuation of hematoma without aneurysm clipping has been reported to be associated with 75% to 100% mortality.[16] Even with aneurysm clipping and hematoma aspiration, the reported mortality rate ranges from 21% to 85%.[3,5,8,10,14,17] Owing to the technical difficulties of coiling the usually complex MCA aneurysms, microsurgical clipping continues to be a valid alternative, especially for patients having MCA aneurysms with associated large ICH.[3,8,14,18]

We report here on our experiences in a series of 29 patients diagnosed with MCA aneurysms associated with an ICH $\geq 30\,cm^3$ who were operated on within the first 12 hours after rupture.

MATERIALS AND METHODS

Patient Population

Between 1990 and 2006, 852 patients with cerebral aneurysms were surgically treated at the neurosurgery department of Uludağ, University Hospital, Bursa, Turkey. Of these, 29 (3.4%) were diagnosed with MCA aneurysms that caused an ICH with a volume of $\geq 30\,cm^3$. Inclusion criteria included patients between 18 and 65 years of age, presentation within the first 12 hours, and computed tomography (CT) evidence of subarachnoid hemorrhage (SAH) associated with an ICH $\geq 30\,cm^3$. Patients were excluded if they were on therapeutic anticoagulation or had a Glasgow Coma Scale score of 3 without spontaneous respirations. The clinical status of each patient at admission was graded according to Hunt and Hess (H-H) classification.[19] We considered patients to have a good preoperative condition if their H-H grade was I-III, whereas patients with grade IV or V were considered as poor grade. The volume of the ICH was estimated from the CT using the ABC/2 method.[20] The types of ICH were classified into 2 groups according to CT findings on admission: (1) intratemporal ICH and (2) intrasylvian ICH. Microsurgical clipping was the only treatment modality used for the patients in this study. During the study period, CT angiography (CTA) was not available at our institution and endovascular intervention was not an option because of lack of equipment and operators. Preoperative cerebral angiography could be obtained in 12 (41.3%) of our patients. In all cases, aneurysm clipping and ICH evacuation was performed through a frontotemporal craniotomy. Acute hydrocephalus was treated by external cerebrospinal fluid diversion.

Surgical Technique and Postoperative Care

Our surgical technique involved a frontotemporal craniotomy with sufficient dural opening followed by partial removal of the clot distant to the aneurysm. After

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brain relaxation was provided, proximal control was achieved and aneurysm clipping was performed followed by as much ICH evacuation as possible. Decompressive craniectomy was performed in cases with persistent brain swelling and an expectation of intracranial hypertension. All comatose patients (Glasgow Coma Scale score of ≤ 8) were mechanically ventilated and also underwent intracranial pressure monitoring with an intraparenchymal device; they were followed in our neurointensive care unit according to a standardized protocol for SAH. Patients were kept euvolemic and symptomatic vasospasm was treated with hypervolemia and induced hypertension. The Glasgow Outcome Scale (GOS) was used to classify each patient as having either a good recovery, including normal neurologic function and moderate disability (a favorable outcome), or a poor recovery, including severe disability, a vegetative state, or death (an unfavorable outcome); all living patients were evaluated at 6 months postoperatively.[21]

Statistical Analysis

The data are expressed as the values ± mean SD. For comparison, the χ^2 test was used, and P values less than 0.05 were considered to be statistically significant.

RESULTS

Clinical Characteristics and Outcomes

The characteristics of the patient population (mean age 48.27 ± 12.52 y and male to female ratio of 1.07) are detailed in Table 1. Overall mortality was 48% (14 cases, 7 of which were H-H grade V). Evaluation of outcomes according to GOS at 6 months after surgery were as follows: of 12 patients in good preoperative condition (H-H, I to III), 6 (50%) had GOS 4 to 5 and 3 (25%) had GOS 3. Of 17 patients in poor preoperative condition (H-H, IV and V), one had GOS 5, two had GOS 3, three had GOS 2, and 11 (64%) were dead at 6 months postsurgery (Table 1). Of the 29 total patients, 12 (41.3%) did not have preoperative angiography. The rate of favorable outcomes in patients who had had a preoperative angiography was 35.2% (6 of the 17) whereas it was 0.8% (1 of the 12) in patients who had not had it; however, this difference was not statistically significant ($P = 0.187$) (Table 1). Fifteen (51.7%) of the ICHs were of the intratemporal type and 14 (48.3%) was of the intrasylvian type. Mortality was 40% (6 of the 15) for patients with an intratemporal type ICH and 64.2% (9 of the 14) for the intrasylvian type ICH. Overall, only 1 (7.1%) patient with an intrasylvian ICH had a favorable outcome whereas 6 (40%) patients with intratemporal hematomas had a favorable outcome ($P = 0.080$) (Table 1). Of 12 patients with an ICH volume less than 50 cm^3, 5 had a favorable outcome whereas only 2 of 17 patients with an ICH volume of greater than 50 cm^3 did ($P = 0.092$) (Table 1).

Illustrative Cases

Case 1 (Intratemporal Type ICH)

This 34-year-old female patient presented with a sudden onset headache accompanied by speech difficulties and right hemiparesis. A CT scan showed a typical temporal lobe ICH with a midline shift and a SAH. On neurologic examination, she was alert, dysphasic, and had flexor responses to pain on her right side. Angiography revealed a left MCA bifurcation aneurysm with elevation of the MCA by the clot (Fig. 1). The patient underwent an emergency craniotomy for clipping of the aneurysm and evacuation of the ICH. She was neurologically intact at the 6-month follow-up.

Case 2

This 55-year-old male was transferred to our facility from an outside hospital where he was admitted with loss of consciousness. On arrival, he was noted to have bilateral fixed and dilated pupils and extensor responses to pain. His CT scan showed a large left temporal lobe ICH accompanied by an acute subdural hematoma (Fig. 2). Evacuation of the subdural hematoma was followed by dissection of the left sylvian fissure, which revealed a 12×10 mm MCA bifurcation aneurysm. The aneurysm was clipped and the temporal lobe ICH was evacuated, but the patient died 6 days after the operation because of vasospasm.

Case 3 (Intrasylvian Type ICH)

This 61-year-old male patient presented with a sudden onset of headache accompanied by loss of consciousness. A CT scan showed a left intrasylvian ICH and a SAH. On neurologic examination, he was alert, dysphasic, and had flexor responses to pain on his right side. Angiography revealed a left multilobulated MCA bifurcation aneurysm (Fig. 3). The patient underwent an emergency craniotomy for clipping of the aneurysm and evacuation of the ICH. He was hemiparetic and dysphasic at the 6-month follow-up.

DISCUSSION

Surgical Treatment

The incidence of ICH from rupture of MCA aneurysms has been reported to be from 35% to 71.1% and the outcome of patients with ruptured MCA aneurysms has been suggested to be worse than that of patients with other anterior circulation aneurysms.[3,4,13,22]

However, the mortality rates are still high, varying from 21% to 85%, and the proportion of patients with favorable outcomes is as low as 13% to 48%, which is worse than that for the cases of SAH without ICH.[3,5,14,17] In addition to the initial effect of the ICH, other possible causes of this unfavorable outcome can be linked to the associated severe brain edema, excessive retraction injury, rebleeding during surgery, use of temporary clips, and prolonged operative time.[3,14,23] Yoshimoto et al[6] reported their experience on 92 patients with ruptured MCA aneurysms, where they grouped the patients according

TABLE 1. Clinical Characteristics of 29 Patients With Middle Cerebral Artery Aneurysms With Intracerebral Hematoma

Clinical Feature	Total No. Cases	Favorable Outcome (at 6 mo)	Unfavorable Outcome (at 6 mo)	*P*
No. cases	29	7	22	
Mean age (y)	48.27 ± 12.52			
Sex				
Female	14	4	10	0.681
Male	15	3	12	
Hunt-Hess grade				
2	3	2	1	
3	7	3	4	
4	7	2	5	
5	12	0	12	0.042
Anisocoria				
Yes	7	0	7	0.147
No	22	7	15	
Glasgow Coma Scale				
3-5	7	0	7	0.052
6-8	10	1	9	
9-13	4	2	2	
14-15	8	4	4	
Aneurysm size (mm)				
< 7	9	0	9	0.056
7-12	11	5	6	
13-24	4	0	4	
≥ 25	5	2	3	
Bleeding location				
Intrasylvian	14	1	13	0.080
Intratemporal	15	6	9	
Dominant hemisphere bleeding				
Yes	9	1	8	0.381
No	20	6	14	
Intraventricular hemorrhage				
Absent	24	7	17	0.296
Present	5	0	5	
Acute hydrocephalus				
Absent	26	6	20	1
Present	3	1	2	
Hematoma size (cm^3)				
< 50	12	5	7	0.092
≥ 50	17	2	15	
Midline shift				
Absent	12	3	9	1
Present	17	4	13	
Angiography				
With	17	6	11	0.187
Without	12	1	11	
Vasospasm				
Yes	7	1	6	0.645
No	22	6	16	
Surgical complication				
Yes	8	0	8	0.142
No	21	7	14	
Rebleeding				
Yes	1	0	1	1
No	28	7	21	
Glasgow Outcome Scale score (6 mo)		7	22	
GR (5)	3			
MD (4)	4			
SD (3)	4			
VS (2)	3			
D (1)	15			

D indicates death; GR, good recovery; MD, moderate disability; SD, severe disability; VS, vegetative state.

to the location and distribution of the hemorrhage on CT scan: group A comprised 17 patients who had intraparenchymal hematomas larger than 30 mm (largest diameter) with or without SAH, group B comprised 24 patients with hematomas located in the sylvian fissure larger than 30 mm (largest diameter), and group C consisted of 52 patients having only diffuse SAH without a localized dense hematoma. Groups A and B had, on average, a more severe clinical grade on admission than those in group C did, and the patients in these groups had a poorer outcome. Delayed ischemic neurologic deficits occurred in 7% and 50% of the patients in groups A and B, respectively. The authors concluded that the accurate assessment of bleeding patterns could help the treating physician to predict the clinical course and thus determine the appropriate treatment.

Shimoda et al[14] reported on 47 patients who underwent early aneurysm surgery and hematoma evacuation within 24 hours after the onset of ICH. They classified the types of ICH as temporal, intrasylvian, and ICH with diffuse SAH. In patients with temporal ICH, they suggested aggressive surgical management irrespective of the hematoma volume or neurologic status, whereas they advocated the same management for patients with an intrasylvian type ICH if the patient presented within the first 6 hours. For patients with ICH and SAH, surgery was indicated if the hematoma volume was 25 mL or less.

Başkaya et al[8] reported on 10 patients with ruptured aneurysms (9 involving the MCA and 1 in the posterior communicating artery) associated with ICH with a mean clot volume of 28 ± 4 mL. They performed clipping and hematoma evacuation within 12 hours after the ictus and reported good outcomes (GOS 4 and 5) in 70% of their patients. They advocated early surgical treatment in patients with intrasylvian ICH regardless of the neurologic grade on admission.

Prat and Galeano[24] reported their experience with 12 poor-grade patients with ruptured MCA aneurysms associated with ICH (> 20 cm^3 in volume) who underwent surgery within the first 8 hours of bleeding. Five of their patients had a good prognosis 1 year postoperatively and the predictors of good outcome were defined as good clinical status upon admission, temporal lobe versus sylvian location of the hematoma, right hemisphere involvement, and a midline deviation of less than 2 cm. Our findings were similar with more patients who had an intratemporal ICH having a favorable outcome, although this result was not statistically significant.

In a series of 585 SAH patients, Güreşir et al[3] quantified the relationships between ICH and poor outcomes and showed that 126 patients (21.5%) with SAH and ICH had poorer presenting grades, larger aneurysms, more rebleeding, and poorer outcomes than patients with SAH alone.

Endovascular Treatment

Endovascular technique may not be possible because of the complexity of the MCA aneurysms and

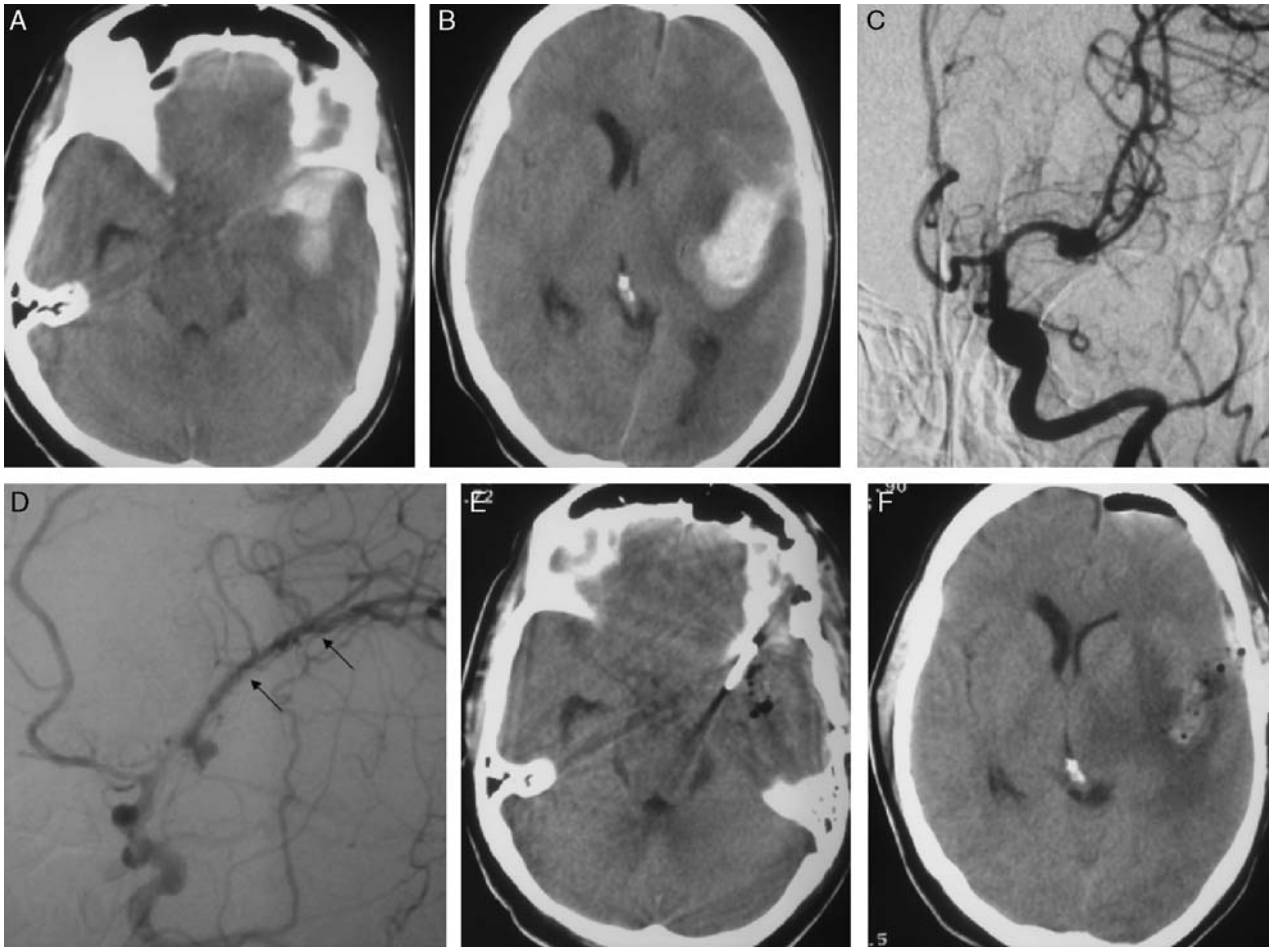

FIGURE 1. This 34-year-old female patient presented with a sudden onset headache accompanied by speech difficulties and right hemiparesis. A and B, A CT scan showed a typical left temporal lobe ICH with a midline shift and a subarachnoid hemorrhage. C and D, Angiography revealed a left MCA bifurcation aneurysm with elevation of the MCA by the ICH. E and F, Postoperative CT scan shows evacuation of the ICH and clips. CT indicates computed tomography; ICH, intracerebral hematoma; MCA, middle cerebral artery.

inherent technical difficulties such as difficult-to-pass arterial curves, wide necks, requirement of stenting, and so on. However, parallel to the developments and increased use of the endovascular technique, experience is also accumulating in the use of this treatment modality for patients who have aneurysms associated with massive ICH.[23,25,26]

Niemann et al[26] reported their experience with treating ruptured aneurysms associated with ICH, which includes external ventriculostomy, angiography, and coil obliteration of the aneurysm followed by hematoma evacuation. Despite admission grades of 4 to 5 in 25 patients (92%), 13 recovered well with GOS scores of 1 or 2, and 6 patients (21%) died. In their study, the time from rupture to admission was within 12 hours in 19 (70.4%) of 27 patients and the time to treatment after admission was within a further 12 hours in 16 (59.3%) of the 27 patients for coiling and 15 (55.6%) of 27 patients for hematoma evacuation. For 4 patients who had unilaterally fixed pupils, mortality and outcome data are not available. The authors concluded that their treatment algorithm represents a valuable alternative to surgery.

Jeong et al[23] reported their experience with 9 patients (7 MCA and 2 ICA aneurysms) who were treated by coiling followed by surgery for clot evacuation. They reported zero mortality and good recovery and moderate disability in 66.7% of their patients. The authors concluded that coil embolization followed by clot evacuation might be a less-invasive alternative for this group of patients.

Notwithstanding these good outcomes with endovascular aneurysm occlusion followed by clot evacuation in patients who have ruptured intracranial aneurysms associated with ICH, some factors need careful consideration. For example, coiling may not be the best choice for patients who rapidly deteriorate because of the mass effect of the hematoma; in addition, the morphology of

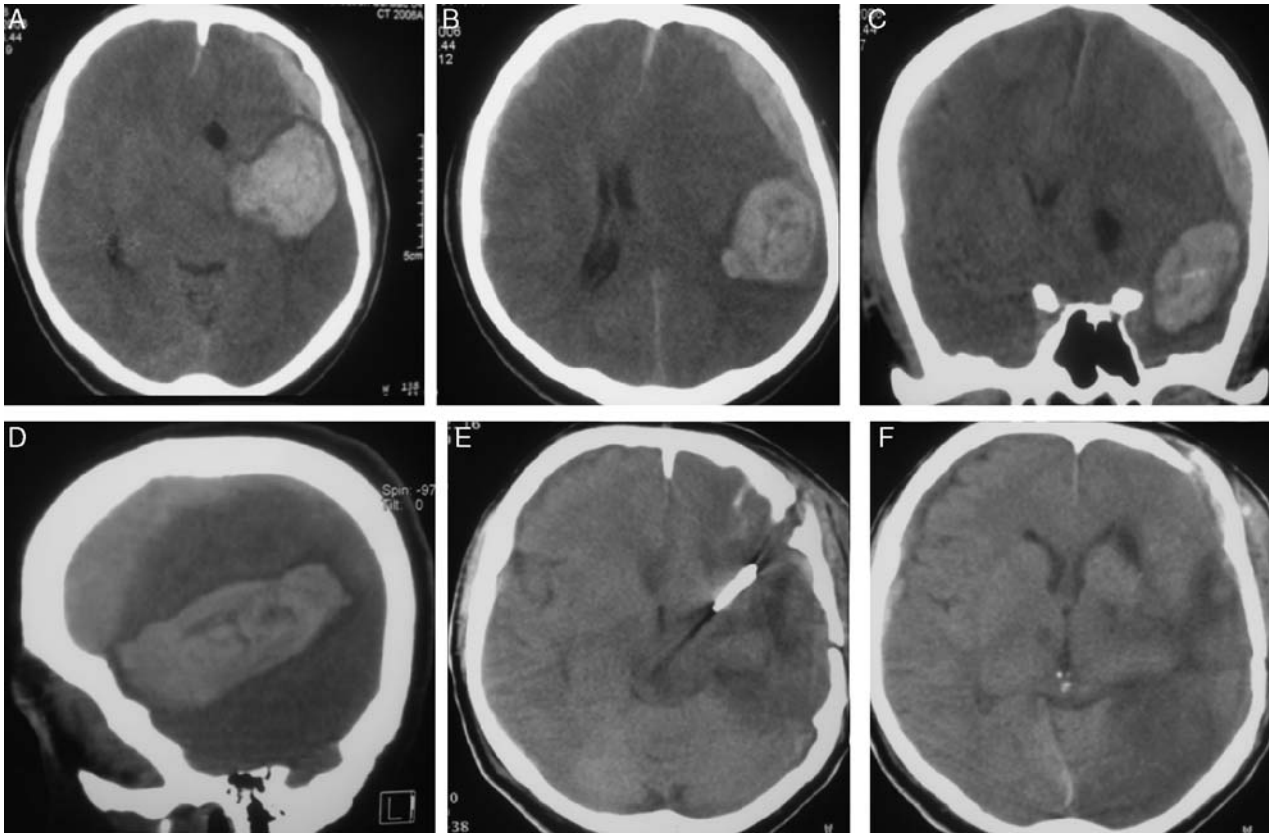

FIGURE 2. This 55-year-old man was transferred to our facility from an outside hospital. On admission, he had extensor posturing. A to D, Admission CT scan shows a large left temporal lobe intracerebral hematoma accompanied by an acute subdural hematoma. He was operated on promptly without angiography where a ruptured left middle cerebral artery bifurcation aneurysm was found. E and F, Postoperative CT scan shows complete evacuation of the clot. CT indicates computed tomography.

the aneurysm is a critical factor in its successful obliteration and the usual complex morphology of MCA aneurysms makes them difficult lesions for complete obliteration.[23,26,27]

Preoperative Imaging

Although digital subtraction angiography has been considered the gold standard for detection of aneurysms, CTA with 3-dimensional reconstruction is increasingly being used for this purpose.[28] CTA can eliminate the need for an angiogram in patients who deteriorate rapidly and can shorten the time interval to surgery. During the study period, CTA was not available at our institution and endovascular intervention was not possible because of the lack of equipment and operators. Furthermore, 17 of the 29 patients (58.6%) underwent surgery without preoperative angiography. Aneurysm surgery without preoperative angiography poses several technical challenges such as lack of knowledge of the size and shape (lobulation) of the aneurysm as well as unknown course and branching pattern of the MCA. These factors may cause premature rupture and untoward consequences.[29]

In terms of our surgical technique, proximal control was attempted by opening the sylvian fissure whenever it was possible. When the brain was extremely swollen, an initial cortisectomy was performed over the superior temporal gyrus and part of the hematoma was evacuated for relaxation followed by clipping of the aneurysm either through the cortisectomy or more often after splitting the fissure.[30]

Location and Size of the ICH

Shimoda et al[14] reported a correlation between the locations of the ICH caused by ruptured MCA aneurysms, such that patients with temporal type ICH had favorable outcomes when compared with patients with intrasylvian type ICH. This finding has been corroborated by other studies as well.[6,8] Our study also showed similar findings; there was a trend toward a better outcome in patients with a temporal type ICH (where 40% of patients had a favorable outcome) as compared with patients with an intrasylvian type ICH (where only 7.1% of patients had a favorable outcome). The reason for this difference may be related to manipulation of the MCA branches during evacuation of the intrasylvian type ICH wherein the clot usually tends to adhere to insular branches of the MCA. In contrast, a temporal type ICH usually abuts the temporal cortex lending itself to easy evacuation through a small cortisectomy.

The size of the clot is an important factor that affects the outcome.[3,14] In our study, the mean size of the

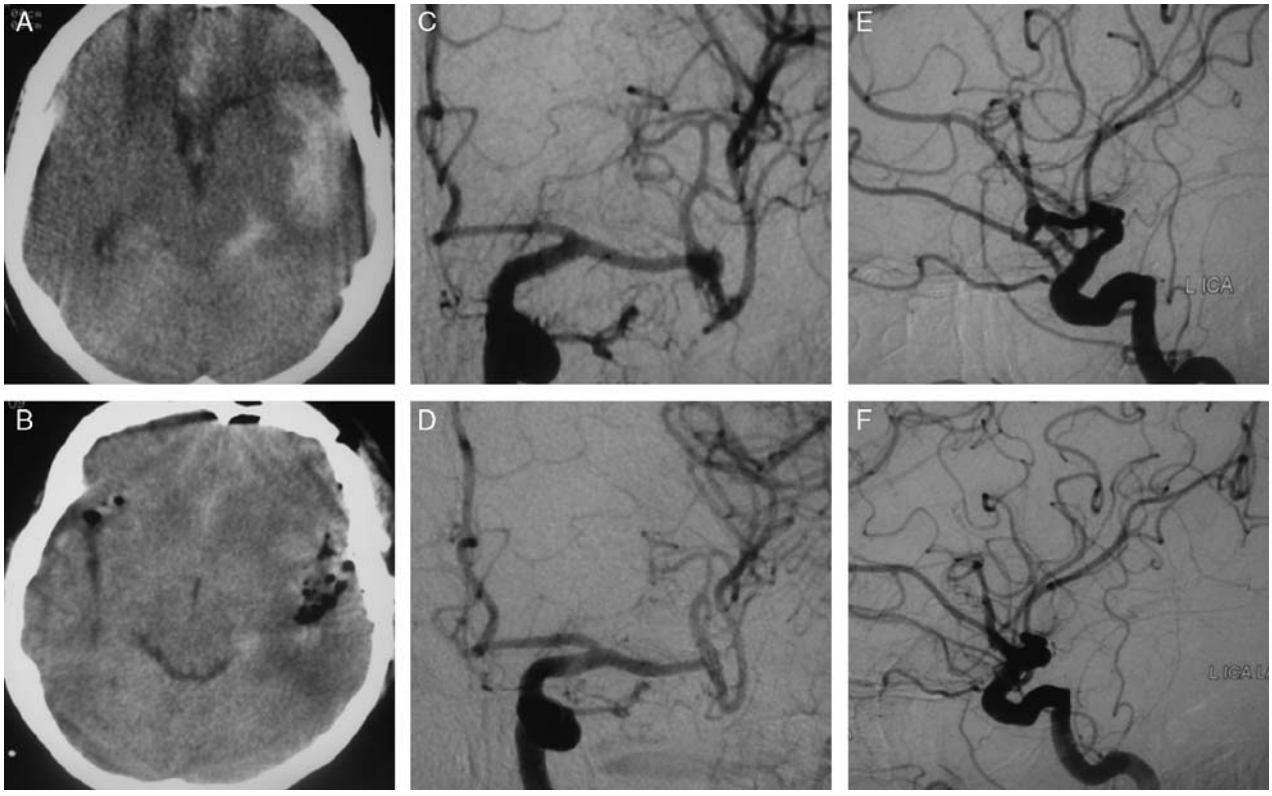

FIGURE 3. This 61-year-old male patient presented with a sudden onset of headache accompanied by loss of consciousness. A and B, A CT scan showed a left intrasylvian ICH and a subarachnoid hemorrhage. C and D, Angiography revealed a left multilobulated middle cerebral artery bifurcation aneurysm. E and F, Postoperative CT and angiography are shown after an emergency craniotomy for clipping of the aneurysm and evacuation of the ICH. He was hemiparetic and dysphasic at 6-month follow-up. CT indicates computed tomography; ICH, intracerebral hematoma.

ICH was 59 cm^3, which is larger than that in other studies of same type.[6,8,14,24]

Mortality

The reported mortality rate in patients with ruptured aneurysms associated with massive ICH after aneurysm clipping and hematoma aspiration ranges between 21% and 85%.[3,5,8,10,14,17]

In this study, the overall mortality rate (48%) seems relatively high, although 59% of our patients were in poor grade at admission. When the patients with poor-admission grade alone were assessed, mortality in this group was 64%. The high percentages of patients with a poor preoperative grade, large mean volume of ICH, intrasylvian location of ICH, and no preoperative angiography are the possible factors that might have contributed to the outcome in our study.

Not all intrasylvian or temporal hematomas result from MCA aneurysms Although an intrasylvian or temporal lobe ICH is suggestive of a MCA aneurysm, a posterior communicating or an anterior choroidal artery aneurysm can also cause a clot at these same locations.[8] This fact is an important nuance as in the absence of a preoperative angiography, as with most of the patients in our study, operative manipulations directed at proximal control and release of cerebrospinal fluid from the basal cisterns may lead to premature rupture of such an aneurysm leading to catastrophic consequences.

Limitations of Our Study

Our study has the inherent flaws related to its retrospective nature. The study spans a relatively long period, during which considerable improvements in the diagnostic techniques, instrumentation, and anesthesia took place. Although general principles of aneurysm surgery like partial hematoma evacuation and proximal control were used, the fact that the operations were performed by different surgeons combined with the relatively small number of patients in our case series makes it difficult to draw strong conclusions.

CONCLUSIONS

Our study shows that despite early surgical treatment of patients with ICH caused by ruptured MCA aneurysms, mortality continues to be high in poor-grade patients. Training of dedicated cerebrovascular neurosurgeons skilled in microsurgery of aneurysms is crucial to guarantee a high level of treatment when endovascular techniques may not be an alternative.

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