Comparison Between Intrasylvian and Intracerebral Hematoma Associated with Ruptured Middle Cerebral Artery Aneurysms: Clinical Implications, Technical Considerations, and Outcome Evaluation

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BACKGROUND: **Subarachnoid hemorrhage (SAH) due to a middle cerebral artery (MCA) aneurysm rupture is often associated with an intracerebral hematoma (ICH) or intrasylvian hematoma (ISH).**

METHODS: **We reviewed 163 patients with ruptured MCA aneurysms associated with pure SAH or SAH plus ICH or ISH. The patients were first dichotomized according to the presence of a hematoma (ICH or ISH). Next, we performed a subgroup analysis comparing ICH versus ISH to explore their relationship with the most relevant demographic, clinical, and angioarchitectural features.**

RESULTS: **Overall, 85 patients (52%) had a pure SAH, and 78 (48%) had presented with an associated ICH or ISH. No significant differences were observed in the demographics or angioarchitectural features between the 2 groups. However, the Fisher grade and Hunt-Hess score were higher for the patients with hematomas. A good outcome was observed in a higher percentage of patients with pure SAH compared with those with an associated hematoma (76% vs. 44%), although the mortality rates were comparable. Age, Hunt-Hess score, and treatment-related complications were the main outcome predictors on multivariate analysis. Patients with ICH appeared worse clinically compared with those with ISH. We also found that older age, a higher Hunt-Hess score, larger aneurysms, decompressive craniectomy, and treatment-related complications were associated with poor outcomes among the patients with an ISH, but not an ICH, which appeared, per se, as a more severe clinical condition.**

CONCLUSIONS: **Our study has confirmed that age, Hunt-Hess score, and treatment-related complications influence the outcome of patients with ruptured MCA aneurysms. However, in the subgroup analysis of patients with SAH associated with an ICH or ISH, only the Hunt-Hess score at onset appeared as an independent predictor of the outcome.**

INTRODUCTION

Subarachnoid hemorrhage (SAH) due to middle cerebral artery (MCA) aneurysm rupture can be associated with other hemorrhagic patterns that can significantly influence the clinical status at onset and the prognosis. These are mainly

Key words
- Hematoma
- ICH
- Intracerebral
- Intrasylvian
- Middle cerebral artery
- SAH
- Subarachnoid hemorrhage

Abbreviations and Acronyms
eGOS: Extended Glasgow outcome scale
ICH: Intracerebral hematoma
ISH: Intrasylvian hematoma
MCA: Middle cerebral artery

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represented by intracerebral hematomas (ICHs) and intrasylvian hematomas (ISHs) or sometimes by a mixed pattern.

In certain circumstances, the presence of space-occupying hematomas can also affect the treatment strategy, favoring upfront open surgery instead of an endovascular approach, followed by surgical hematoma evacuation with the main aim of obtaining rapid internal decompression rather than for aneurysm angioarchitectural reasons.

Although data regarding the risk factors for ICH and ISH formation remain controversial, the presence of these secondary hemorrhagic patterns has been associated with MCA aneurysm rupture as frequently as about one third of cases.[1-3] Furthermore, although in the case of a pure ICH, its evacuation will be desirable to obtain rapid brain decompression and improve brain perfusion, the removal of a large hematoma located in the sylvian fissure (i.e. , ISH) can result in the risk of vascular damage. Most investigators have usually reported its partial removal concurrent with aneurysm dissection and clipping.

In the present study, we retrospectively analyzed a consecutive multicenter series of patients with ruptured MCA aneurysms and the presence of a concomitant ICH or ISH at onset to investigate the possible different prognoses compared with ruptured MCA aneurysms associated with a pure SAH pattern and compared with each other.

METHODS

The institutional review board waived the requirement for ethical approval because of the retrospective collection of anonymous data. All the patients participating in the present study had provided written informed consent before inclusion.

Population

We retrospectively reviewed 163 consecutive patients who had been admitted to 5 Italian tertiary referral cerebrovascular centers between 2015 and 2019 with a diagnosis of a ruptured MCA aneurysm. Of these 163 patients, 78 (48%) had had a diffuse SAH associated with an ICH or ISH. For the patients with a mixed ISH and ICH pattern, the patients were assigned to the ISH group or ICH group according to the prevalent location of the bleeding. All the patients had undergone aneurysm treatment via microsurgical clipping or endovascular coiling after the multidisciplinary cerebrovascular board had reached a consensus.

The selection of treatment for each case was determined by the characteristics of the individual patients and aneurysms and the presence of large ICH or ISH amenable to surgical evacuation. The indication for hematoma evacuation was usually determined by the clinical and neuroradiological criteria, including the presence of a significant mass effect and loss of consciousness. All the patients who had undergone a clipping procedure had unavoidably received a certain amount of hematoma evacuation during this open procedure. For those who had undergone endovascular treatment, the decision to evacuate the hematoma after securing the aneurysm was determined by the relationship between a radiological evident mass effect and corresponding hemiparesis or loss of consciousness, although we could not exclude a possible role for the associated SAH, except in the case of a pure ICH pattern.

Inclusion and Exclusion Criteria

An ISH was defined as a subarachnoid collection of blood entirely located within the sylvian fissure, and an ICH was defined as a hematoma with extension into the subpial space. The inclusion criteria were age ≥18 years and the availability of complete clinical and radiological reports. The exclusion criteria were giant MCA aneurysms (size >25 mm) and thrombosed MCA aneurysms because these were very rare in our multicenter series. Also, they were considered special cases because we could not determine the mass effect independently of the effects from the associated hematoma after their rupture.

We retrieved the following data from the clinical and radiological reports:

1. Patient characteristics
   a. Demographics: age, sex, and ethnicity
   b. Modified Hunt-Hess score after SAH
   c. Extended Glasgow outcome scale (eGOS) at discharge
   d. eGOS at last follow-up
2. Radiological features
   a. Evidence of intracerebral (ICH) or intrasylvian (ISH) hemorrhage or a mixed pattern
   b. Aneurysms size, morphology, and aspect ratio
   c. Modified Fisher grade
   d. Hydrocephalus requiring active treatment
3. Treatment-related characteristics
   a. Type of treatment (surgical clipping or endovascular coiling)
   b. Amount of hematoma removed
   d. Decompressive craniectomy

Outcomes Analysis

The demographic, clinical, and radiological data were retrieved from the patients' medical records. The radiological data were reassessed for each patient with the help of expert neuroradiologists. All available computed tomography angiography, magnetic resonance angiography, and digital subtraction angiography scans archived in the 5 institutional PACSs (picture archiving and communication systems) were analyzed.

The clinical outcome was assessed at discharge and using the eGOS (upper good recovery, lower good recovery, upper moderate disability, lower moderate disability, upper severe disability, lower severe disability, vegetative state, death). For patients with SAH, a good outcome was considered an eGOS score of upper or lower good recovery or upper or lower moderate disability.

The patients were first dichotomized according to the presence or absence of a hematoma (ICH or ISH) associated with SAH. Next, we performed a subgroup analysis of the patients with an ICH versus an ISH component to compare the most relevant demographic, clinical, and angioarchitectural parameters between the 2 groups. The patients with a mixed hemorrhagic pattern were alternatively assigned to 1 of the 2 groups by the prevalence of parenchymal or sylvian hemorrhage to make the analysis easier for

Table 1. Comparison Between Patients with Pure SAH and Those with SAH Plus a Hematoma

Variable	Pure SAH (*n* = 85; 52%)	SAH + Hematoma (*n* = 78; 48%)	Total (*n* = 163; 100%)	*P* Value
Age (years)	57 ± 13.4	56.6 ± 13.7	56.8 ± 13.5	NS
Female sex	61 (72)	60 (77)	121 (74)	NS
Left side	35 (41)	30 (38)	65 (40)	NS
Aneurism size (mm)	7.2 ± 3.9	8.1 ± 4.9	7.6 ± 4.4	NS
Aspect ratio	2.1 ± 1	2 ± 0.7	2 ± 0.8	NS
Collateral branches from aneurysm dome/neck	15 (18)	13 (17)	28 (17)	NS
Modified Hunt-Hess score	2.5 ± 1.3	3.7 ± 1.4	3 ± 1.5	<0.001*
Modified Fisher scale score	2.7 ± 1	3.7 ± 0.6	3.2 ± 1	<0.001*
Hydrocephalus at presentation	22 (26)	19 (24)	41 (25)	NS
Treatment				
Clipping	56 (66)	59 (64)	106 (65)	NS
Coiling	29 (34)	28 (36)	57 (35)	NS
Treatment-related complications	5 (6)	19 (24)	24 (15)	<0.001*
Death during hospitalization	7 (8)	12 (15)	19 (11.6)	NS
Good outcome at discharge	65 (76)	34 (44)	99 (61)	<0.001*
eGOS at discharge				
Upper, good recovery	44 (51.8)	11 (14.1)	55 (33.7)	<0.001*
Lower, good recovery	1 (1.2)	0 (0)	1 (0.6)	NS
Upper, mild disability	16 (18.8)	16 (20.5)	32 (19.6)	NS
Lower, mild disability	4 (4.7)	7 (9)	11 (6.7)	NS
Upper, severe disability	5 (5.9)	13 (16.7)	18 (11)	0.03*
Lower, severe disability	7 (8.2)	10 (12.8)	17 (10.4)	NS
Vegetative state	1 (1.2)	9 (11.5)	10 (6.1)	0.006*
Death	7 (8.2)	12 (15.4)	19 (11.7)	NS
Mean follow-up (months)	23.6 ± 15.3	23 ± 20.1	23.3 ± 17.5	NS
Good outcome at follow-up	66 (77.6)	34 (43.6)	100 (61.3)	<0.001*
eGOS at follow-up				
Upper, good recovery	44 (51.8)	16 (20.5)	60 (36.8)	<0.001*
Lower, good recovery	11 (12.9)	8 (10.3)	19 (11.7)	NS
Upper, mild disability	11 (12.9)	10 (12.8)	21 (12.9)	NS
Lower, mild disability	0 (0)	0 (0)	0 (0)	NS
Upper, severe disability	7 (8.2)	19 (24.4)	26 (16)	0.005*
Lower, severe disability	2 (2.4)	2 (2.6)	4 (2.5)	NS
Vegetative state	0 (0.0)	9 (11.5)	9 (5.5)	0.001*
Death	10 (11.8)	14 (17.9)	24 (14.7)	NS

Data presented as mean ± standard deviation or *n* (%).
SAH, subarachnoid hemorrhage; NS, not statistically significant; eGOS, extended Glasgow outcome scale.
*Statistically significant.

Table 2. Binomial Logistic Regression*: Outcomes Stratified by Glasgow Outcome Scale Score

Covariate†	OR	*P* Value	95% CI
Age	1.052	0.006‡	1.015—1.092
Aneurysm size	1.040	0.441	0.942—1.148
Modified Hunt-Hess score	2.048	<0.001‡	1.437—2.919
Modified Fischer scale score	1.439	0.274	0.749—2.763
SAH + hematoma	1.394	0.498	0.534—3.637
Clipping	1.349	0.521	0.541—3.363
Treatment-related complications	12.152	<0.001‡	2.813—52.493

OR, odds ratio; CI, confidence interval; SAH, subarachnoid hemorrhage.
*A poor outcome was coded as class 1 and included severe disability, vegetative state, and death.
†The dependent variable was the outcome at discharge.
‡Statistically significant.

clinical interpretation. The patients were also stratified by the treatment type and percentage of hematoma evacuation to measure their effects on the clinical outcome at discharge. The patients who had undergone clipping had invariably also received a certain percentage of concomitant hematoma evacuation. In contrast, the patients who had undergone endovascular treatment could have received concurrent or delayed hematoma evacuation as determined by clinical judgment.

Statistical Analysis

First, we compared the patients with pure SAH with those with SAH plus ICH or ISH and then performed a subgroup analysis to compare the patients with ICH versus ISH.

Quantitative variables are presented as the mean ± standard deviation, and the Student t test was used for comparison. If the equal variance assumption was violated, a Welch test was used instead of the Student t test. The χ^2 test or, when more appropriate, the Fisher exact test (2-sided) was used to compare the categorical variables. Multivariate analyses were performed through binomial logistic regression models, assuming the clinical outcome at discharge as the dependent variable. The variables significant on univariate analysis were considered independent variable for the entire ruptured MCA aneurysm group and the subgroup of patients with an ICH or ISH. The significance level was set at $P \leq 0.05$. Statistical analysis was performed using JASP, version 0.16.3 (available at: https://jasp-stats.org/).

RESULTS

We included 163 consecutive patients who had been admitted for a ruptured MCA aneurysm. Of the 163 patients, 85 (52%) had had a pure SAH, and 78 (48%) had presented with an associated ICH or ISH. No significant differences were observed in age, sex, or aneurysm size, angioarchitecture, or aspect ratio (Table 1). The neuroradiological assessment at admission revealed a significantly higher Fisher grade for the patients with an associated hematoma (3.7 vs. 2.7), although the incidence of acute hydrocephalus was similar. In addition, the clinical severity, expressed as the Hunt-Hess score, was, on average, >1 point higher for those with an associated hematoma (3.7 vs. 2.5). Also, although the choice between endovascular and surgical treatment was comparable between the 2 groups, the rate of complications appeared significantly higher for the patients with a hematoma (24% vs. 6%). Finally, a good outcome at discharge was observed for a significantly higher percentage of patients with pure SAH compared with those with an associated hematoma (76% vs. 44%), although mortality remained comparable. A multivariate binomial logistic regression model confirmed that age, Hunt-Hess score at onset, and the incidence of treatment-related complications were the main variables influencing the outcomes at discharge in our multicenter series (Table 2).

Next, we compared the 2 subgroups of patients who had presented with SAH and an associated hematoma (ICH vs. ISH; Table 3). We found that, in general, the clinical status at admission was significantly worse for the patients with an ICH (mean Hunt-Hess score, 4.2) than for those with an ISH (mean Hunt-Hess score, 3.2). Moreover, the incidence of ICH was higher for the patients with larger MCA aneurysms than for those with smaller aneurysms. No other demographic, angioarchitectural, or clinical features appeared different between the 2 groups, including the treatment choice and final outcomes.

Finally, we performed a further subgroup analysis between the patients with ICH versus ISH to search for different outcome predictors. We found that older age, a higher Hunt-Hess score at clinical onset, a larger aneurysm size, the need for decompressive craniectomy, and treatment-related complications were associated with a poor outcome for patients with ISH but not for those with ICH, which had appeared, per se, as a more severe clinical condition because only 5% of ICH patients had presented with a good clinical status (Table 4). However, the role of an ICH did not appear independent from the other covariates in influencing the outcomes in the multivariate model (Table 5).

DISCUSSION

In the present study, we found that the presence of an associated intracranial hematoma significantly influenced the clinical severity after SAH in our series (Table 1). Although its influence as an independent predictive factor of the final outcome was not confirmed on multivariate analysis (Table 2), specifically for MCA aneurysms, this aspect has important epidemiological value because an ICH or ISH occurred in association with SAH from MCA aneurysm rupture in almost 44% of reported cases[1-3] and was 48% in our series.

In general, a linear relationship will be observed between the severity at onset and the hematoma size, because patients with a larger ICH or ISH have also had worse clinical status at admission.[4-6] However, we did not observe a significant change in the outcome when stratified by the percentage of hematoma evacuation (Table 4).

Locksley[7] found that 90% of the patients who had died within 3 days after the onset of an aneurysmal SAH had had an ICH. In contrast, in our series, the difference in the mortality rate was not statistically significant between those with and without a hematoma, although the percentage of deaths for patients with

Table 3. Comparison Between Patients with ISH and ICH

Variable	ISH (n = 40)	ICH (n = 38)	Total (n = 78)	P Value
Age (years)	57.5 ± 14	55.7 ± 13.5	56.6 ± 13.7	NS
Female sex	30 (75)	30 (79)	60 (77)	NS
Left side	15 (37.5)	15 (39)	30 (38)	NS
Aneurysm size (mm)	7 ± 3.9	9.3 ± 5.6	8.1 ± 4.9	0.04*
Aspect ratio	2 ± 0.7	1.9 ± 9.3	2 ± 0.7	NS
Collateral branches from aneurysm dome/neck	5 (12.5)	8 (21)	13 (17)	NS
Modified Hunt-Hess score	3.2 ± 1.5	4.2 ± 1	3.7 ± 1.4	<0.001*
Modified Fisher scale score	3.6 ± 0.7	3.7 ± 0.4	3.7 ± 0.6	NS
Hydrocephalus at presentation	12 (30)	7 (18)	19 (24)	NS
Treatment				
Clipping	25 (62.5)	25 (66)	59 (64)	NS
Coiling	15 (37.5)	13 (34)	28 (36)	NS
Early aneurysm occlusion				NS
Complete	32 (80)	29 (76.3)	61 (78.2)	
Partial	8 (20)	9 (23.7)	17 (21.8)	
Hematoma evacuation rate				NS
100%	6 (15)	7 (18.4)	13 (16.7)	
50%—99%	18 (45)	16 (42.1)	34 (43.6)	
<50%	14 (35)	10 (26.3)	24 (30.8)	
No evacuation	2 (5)	5 (13.2)	7 (9)	
Decompressive craniectomy	6 (15)	4 (10.5)	10 (12.8)	NS
Treatment-related complications	10 (25)	9 (24)	19 (24.4)	NS
Death during hospitalization	9 (22.5)	3 (8)	12 (15)	NS
Good outcome at discharge	21 (52.5)	13 (34)	34 (43.6)	NS
eGOS at discharge				
Upper, good recovery	8 (20)	3 (7.9)	11 (14.1)	NS
Lower, good recovery	0 (0)	0 (0)	0 (0)	NS
Upper, mild disability	11 (27.5)	5 (13.2)	16 (20.5)	NS
Lower, mild disability	2 (5)	5 (13.2)	7 (9)	NS
Upper, severe disability	2 (5)	11 (28.9)	13 (16.7)	0.005*
Lower, severe disability	5 (12.5)	5 (13.2)	10 (12.8)	NS
Vegetative state	3 (7.5)	6 (15.8)	9 (11.5)	NS
Death	9 (22.5)	3 (7.9)	12 (15.4)	NS
Mean follow-up (months)	29 ± 26.6	17.8 ± 10.6	22.9 ± 20.1	NS
Good outcome at follow-up	18 (45)	16 (42)	34 (44)	NS
eGOS at follow-up				
Upper, good recovery	11 (27.5)	5 (13.2)	16 (20.5)	NS
Lower, good recovery	6 (15)	2 (5.3)	8 (10.3)	NS

Data presented as mean ± standard deviation or n (%).
ISH, intrasylvian hematoma; ICH, intracerebral hematoma; NS, not statistically significant; eGOS, extended Glasgow outcome scale.
*Statistically significant.

Continues

Table 3. Continued

Variable	ISH (n = 40)	ICH (n = 38)	Total (n = 78)	P Value
Upper, mild disability	1 (2.5)	9 (23.7)	10 (12.8)	0.005*
Lower, mild disability	0 (0)	0 (0)	0 (0)	NS
Upper, severe disability	8 (20)	11 (28.9)	19 (24.4)	NS
Lower, severe disability	1 (2.5)	1 (2.6)	2 (2.6)	NS
Vegetative state	3 (7.5)	6 (15.8)	9 (11.5)	NS
Death	10 (25)	4 (10.5)	14 (17.9)	NS

Data presented as mean ± standard deviation or n (%).
ISH, intrasylvian hematoma; ICH, intracerebral hematoma; NS, not statistically significant; eGOS, extended Glasgow outcome scale.
*Statistically significant.

a hematoma was almost double compared with those with pure SAH (Table 1).

Although exploration of the different prognostic factors for these patients is important for choosing the optimal management strategy, in general, early surgical management has been advocated for patients with larger ICHs or ISHs.[8-10] Nevertheless, in agreement with previous reports,[11] we also found a significantly higher rate of treatment-related complications for patients with SAH and an associated intracranial hematoma. At present, consistent evidence indicating the different clinical effects of ISH and ICH on patients' clinical status at admission and outcomes are still lacking in literature.

Therefore, radiological discrimination between ICH and ISH from the first computed tomography and/or computed tomography angiography scans is important (Figure 1). van der Zande et al.[12] proposed the presence of intra-hematoma contrast-enhancing vessels as the diagnostic criterion for ISH. However, in their series, they did not find a direct relationship between the presence of intra-hematoma vessel enhancement and the patients' clinical condition or functional outcome.[12] Similarly, no significant differences in clinical condition at admission and outcome were reported by Yoshimoto et al.[13] or Saito et al.[14] between those with ICH and ISH. In contrast to these findings, in our series, patients with an ICH had had a significantly worse Hunt-Hess score at admission compared with those with ISH (Tables 3 and 4). Moreover, only 5% of ICH patients had had a good Hunt-Hess score at arrival (Hunt-Hess score, 1 or 2) compared with 43% of those with ISH. A good Hunt-Hess score at onset was associated with a good outcome in both groups, and the Hunt-Hess score was the only independent outcome predictor for patients with SAH associated with a hematoma on multivariate analysis (Table 5). The low frequency of patients with a good Hunt-Hess score in the ICH subgroup probably explains the lack of significance for the mean Hunt-Hess score in this subgroup on univariate analysis.

Other investigators have focused their attention on the angioarchitecture of the aneurysm and its association with either type of hematoma. Zhang et al.[3] assumed that the angle between the pointing direction of the aneurysm and the M1 trunk could indicate the hematoma type. In particular, an angle between 109° and 216° would indicate an ISH, and aneurysms with a greater angle would have ultimately led to an ICH.[3] In our series, we found that the larger the size of the aneurysm, rather than its pointing direction, was associated with the risk of an ICH (Table 3). Also, although an ISH is a voluminous accumulation of subarachnoid blood in a cisternal space, the formation of an ICH requires a greater breaking force to overcome the resistance of the pia mater and dissect the fibers of the white matter.

A different pathogenetic theory between the 2 hemorrhagic patterns was proposed by Suzuki et al.[15] They observed that the characteristics of extravasation in sylvian hematomas indicated cotton-like multiple bleeding points, and these findings differed markedly from those of previously reported extravasation from aneurysms. From their experience, Suzuki et al.[15] described multiple extravasations from small vessels that differed from ruptured aneurysms, hypothesizing that these extravasations are the specific bleeding sources of ISHs.

In agreement with some investigators,[3,16] in our multicenter series, we found that the occurrence of an ICH was associated with a worse Hunt-Hess score at admission compared with the presence of an ISH. In contrast, other investigators found that an ISH resulted in a worse prognosis than an ICH.[17] Several reasons are possible for the worse outcomes in the ISH group. First, early surgical evacuation will generally be easier for ICHs and significant postoperative clinical improvement can be expected from the immediate internal decompression.[3,18] Second, a thorough evacuation of an ISH can be a demanding and risky procedure owing to the subarachnoid location of fibroadhesive clots to the branches of the MCA and its small perforating vessels.[13,14] Finally, an aggressive attempt at intrasylvian clot evacuation can result in the risk of vascular lesions and the excessive vessel manipulation can increase the risk of vasospasm. However, the presence of a large residual ISH represents one of the most important risk factors for the development of a postoperative brain swelling, with the risk of a secondary decompressive craniotomy.

Early open surgery still represents the treatment of choice in many neurosurgical units for almost all cases of MCA aneurysms, especially when associated with a larger ICH or ISH.[19] However, different treatment paradigms have become prevalent at other centers where vascular neurosurgery expertise has been

Table 4. Outcome Predictors for Ruptured MCA Aneurysms Causing SAH with Associated ISH or ICH

Variable	Outcome											
	ISH				ICH				Total (ISH + ICH)			
	Good (*n* = 21)	Poor (*n* = 19)	Total (*n* = 40)	*P* Value	Good (*n* = 13)	Poor (*n* = 25)	Total (*n* = 38)	*P* Value	Good (*n* = 34)	Poor (*n* = 44)	Total (*n* = 78)	*P* Value
Age (years)	51.8 ± 14	63.8 ± 11.2	57.5 ± 14	0.006*	55.8 ± 15.5	55.7 ± 12.7	55.7 ± 13.5	NS	53.4 ± 14.6	59.2 ± 12.6	56.6 ± 13.7	NS
Female sex	16 (76)	14 (74)	30 (75)	NS	11 (8)	19 (76)	30 (79)	NS	27 (79)	33 (75)	60 (77)	NS
Left side	9 (43)	6 (32)	15 (38)	NS	3 (23)	12 (48)	15 (39)	NS	12 (35)	18 (41)	30 (38)	NS
Mean modified Hunt-Hess score	2.4 ± 1.3	4 ± 1.2	3.2 ± 1.5	<0.001*	3.8 ± 1.2	4.4 ± 0.8	4.2 ± 1	NS	2.9 ± 1.5	4.3 ± 1	3.7 ± 1.4	<0.001*
Clinical status at admission				0.002*				0.04*				<0.001*
Good (H-H score, 1–2)	14 (67)	3 (16)	17 (43)		2 (15)	0 (0)	2 (5)		16 (47)	3 (7)	19 (24)	
Poor (H-H score, 3–5)	7 (33)	16 (84)	23 (57)		11 (85)	25 (100)	36 (95%)		18 (53)	41 (93)	59 (76)	
Mean modified Fisher score	3.4 ± 0.9	3.8 ± 0.4	3.6 ± 0.7	NS	3.8 ± 0.4	3.7 ± 0.5	3.7±0.4	NS	3.6 ± 0.7	3.7 ± 0.4	3.2 ± 1	NS
Mean aneurysm size (mm)	5.9 ± 2.6	8.4 ± 4.8	7±3.9	0.04*	8.5 ± 6.6	9.7 ± 5.2	9.3±5.6	NS	6.9 ± 4.6	9.2 ± 5	7.6 ± 4.4	0.04*
Aneurysms size (mm)				NS				NS				NS
≤5	7 (33)	5 (26)	12 (30)		5 (38)	5 (20)	10 (26)		12 (35)	10 (23)	22 (28)	
>5 but ≤10	13 (62)	10 (53)	23 (57)		5 (38)	14 (56)	19 (50)		18 (53)	24 (55)	42 (54)	
>10	1 (5)	4 (21)	5 (13)		3 (23)	6 (24)	9 (24)		4 (12)	10 (23)	14 (18)	
Hydrocephalus at presentation	6 (29)	6 (32)	12 (30)	NS	3 (23)	4 (16)	7 (18)	NS	9 (26)	10 (23)	19 (24)	NS
Aneurysm treatment				NS				NS				NS
Surgery	12 (57)	13 (68)	25 (63)		7 (54)	18 (72)	25 (66)		19 (56)	31 (70)	50 (64)	
Endovascular	9 (43)	6 (32)	15 (38)		6 (46)	7 (28)	13 (34)		15 (44)	13 (30)	28 (36)	
Hematoma evacuation rate				NS				NS				NS
100%	2 (10)	4 (21)	6 (15)		1 (8)	6 (24)	7 (18)		3 (9)	10 (23)	13 (17)	
50%–99%	9 (43)	9 (47)	18 (45)		7 (54)	9 (36)	16 (42)		16 (47)	18 (41)	34 (44)	
<50%	8 (38)	6 (32)	14 (35)		3 (23)	7 (28)	10 (26)		11 (32)	13 (30)	24 (31)	
No evacuation	2 (10)	0 (0)	2 (5)		2 (15)	3 (12)	5 (13)		4 (12)	3 (7)	7 (9)	
Early aneurysm occlusion				NS				NS				NS
Complete	14 (66.6)	17 (89.5)	31 (77.5)		9 (69.2)	20 (80)	29 (76.3)		23 (67.6)	37 (84.1)	60 (76.9)	
Partial	7 (33.4)	2 (20.5)	9 (22.5)		4 (30.8)	5 (20)	9 (23.7)		11 (32.4)	7 (15.9)	18 (23.1)	
Decompressive craniectomy	0 (0)	6 (32)	6 (15)	0.005*	1 (8)	3 (12)	4 (11)	NS	1 (3)	9 (20)	10 (13)	0.03*
Treatment-related complications	0 (0)	10 (53)	10 (25)	<0.001*	1 (8)	8 (32)	9 (24)	NS	1 (3)	18 (41)	19 (24)	<0.001*

Data presented as mean ± standard deviation or *n* (%).
MCA, middle cerebral artery; SAH, subarachnoid hemorrhage; ISH, intrasylvian hematoma; ICH, intracerebral hematoma; NS, not statistically significant; H-H, Hunt-Hess.
*Statistically significant.

Table 5. Binomial Logistic Regression*: Outcomes Stratified by Glasgow Outcome Scale for SAH + Hematoma

Covariate†	OR	*P* Value	95% CI
Age	1.049	0.060	0.998—1.102
Aneurysm size	1.070	0.304	0.940—1.218
Modified Hunt-Hess score	1.993	0.006‡	1.214—3.271
Hematoma characteristics (mainly intracerebral)	1.205	0.796	0.293—4.955
ICH evacuation <50%	0.961	0.948	0.287—3.221
Decompressive craniectomy	8.757e-8	0.994	0.000— ∞
Treatment-related complications	1.272e+8	0.993	0.000— ∞

OR, odds ratio; CI, confidence interval; ICH, intracerebral hemorrhage.
*A poor outcome was coded as class 1 and included severe disability, vegetative state, and death.
†The dependent variable was the outcome at discharge.
‡Statistically significant.

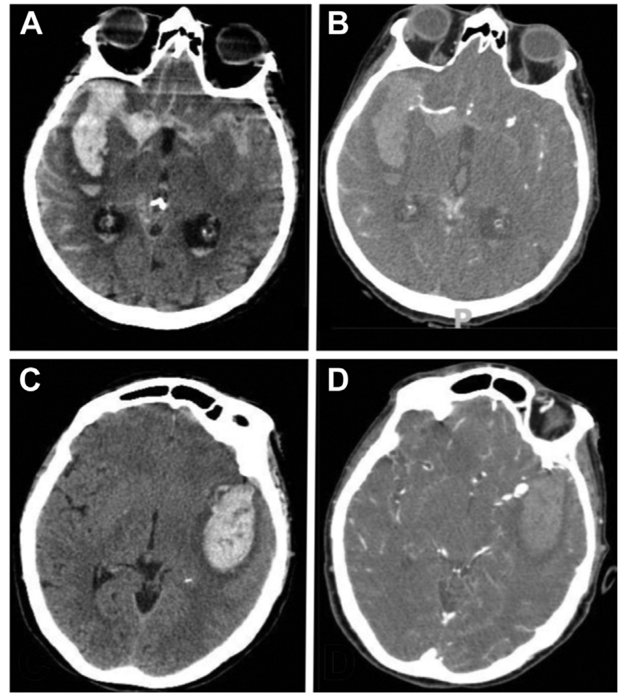

Figure 1. (**A**) Basal computed tomography (CT) scan and (**B**) corresponding CT angiogram showing a subarachnoid hemorrhage due to right middle cerebral artery aneurysm rupture associated with an intrasylvian hematoma. (**C**) Basal CT scan and (**D**) corresponding CT angiogram showing a subarachnoid hemorrhage due to a left middle cerebral artery aneurysm rupture associated with an intraparenchymal hematoma.

progressively declining. Thus, endovascular obliteration has emerged as the first approach for all ruptured aneurysms,[20-22] including those associated with hematomas whose evacuation will, therefore, be delayed after the aneurysm has been secured. Nevertheless, the combination of endovascular obliteration, followed by hematoma evacuation, has been advocated by teams with strong expertise in vascular neurosurgery as a reasonable option for selected patients with SAH and an associated ICH because it can transform a complex surgery to easier and quicker decompression.[23] It is possible that, in the future, a new generation of cerebrovascular surgeons with both vascular and endovascular expertise and dedicated hybrid operating rooms will be able to shorten the time between the 2 procedures and make this mixed option preferable for some patients. However, preserving open neurovascular surgery expertise is still mandatory, because a high percentage of MCA aneurysms will have irregular morphology and full embolization often requires stent assistance and double antiplatelet therapy, even for patients with acute conditions after bleeding.[19] Thus, the use of a hybrid procedure could not only delay evacuation of the blood clot but also increase the risk of a new hemorrhagic infarction after the second surgery owing to the antiplatelet therapy required the endovascular procedure.

Study Limitations

The present study had some limitations. First, owing to the retrospective study design, the treatment choice was determined at the treating centers in accordance with local experience and expertise. Second, because of the low number of cases, we did not evaluate the influence of the hematoma volume on the clinical presentation and outcomes. However, this could be more relevant for those with ICH than for those with pure ISH, because larger hematoma volumes are more common with a mixed pattern with ICH prevalence. Moreover, for the patients who had presented with mixed ISH and ICH patterns, we limited the dichotomization to ISH and ICH according to the prevalent bleeding pattern to avoid a redundant analysis that would not show significant clinical value. From a clinical viewpoint, it is the main bleeding component that strongly influences the management and outcome of these cases. Third, we did not evaluate the role of the timing of hematoma evacuation from accident and emergency arrival, which, intuitively, will be longer for cases in which coiling was performed before hematoma evacuation. However, an indirect answer to this question is the similar outcomes after endovascular treatment versus clipping.

CONCLUSIONS

Our study showed that age, clinical status at admission, and the occurrence of treatment-related complications influence the outcome of patients with SAH due to a ruptured MCA aneurysm. However, in the subgroup analysis of patients affected by SAH associated with an ICH or ISH, only the clinical severity at admission appeared as an independent predictor of the outcome. However, the patients with ICH had had significantly worse clinical status at admission compared with the patients with ISH.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Carmelo Lucio Sturiale: Conceptualization, Methodology, Investigation, Formal analysis, Writing — original draft, Approval of final version. **Alba Scerrati:** Helping with drafting. **Luca Ricciardi:** Investigation. **Oriela Rustemi:** Investigation. **Anna Maria Auricchio:** Investigation. **Nicolò Norri:** Investigation. **Amedeo Piazza:** Investigation. **Fabio Ranieri:** Investigation. **Alberto Tomatis:** Investigation. **Alessio Albanese:** Helping with drafting. **Annunziato Mangiola:** Helping with drafting, Approval of final version. **Vincenzo Di Egidio:** Approval of final version. **Donato Carlo Zotta:** Approval of final version. **Marco Farneti:** Approval of final version. **Enrico Marchese:** Approval of final version. **Antonino Raco:** Approval of final version. **Lorenzo Volpin:** Approval of final version. **Gianluca Trevisi:** Conceptualization, Methodology, Investigation, Formal analysis, Writing — original draft, Approval of final version.

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