Clinical Radiology 86 (2025) 106951

Contents lists available at ScienceDirect

Clinical Radiology

journal homepage: www.clinicalradiologyonline.net

Intra-Sylvian versus intracerebral haematoma associated with ruptured middle cerebral artery aneurysm: initial and follow-up imaging features

J.I. Hwang [a], D.Y. Yoon [a,*], E.S. Kim [b], H.J. Jeon [c], J.Y. Lee [c], Y.L. Seo [a], E.J. Yun [a]

[a] Department of Radiology, Kangdong Seong-Sim Hospital, Hallym University College of Medicine, 150, Seongan-ro, Gangdong-gu, Seoul 05355, South Korea

[b] Department of Radiology, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, 22, Gwanpyeong-ro 170beon-gil, Dongan-gu, Anyang-si, Gyeonggi-do 14068, South Korea

[c] Department of Neurosurgery, Kangdong Seong-Sim Hospital, Hallym University College of Medicine, 150, Seongan-ro, Gangdong-gu, Seoul 05355, South Korea

ARTICLE INFORMATION

Article history:
Received 26 November 2024
Received in revised form
22 April 2025
Accepted 1 May 2025

AIM: The aim of this study was to evaluate and compare the initial and follow-up imaging features of intra-Sylvian haematoma (ISH) and intracerebral haematoma (ICH) from a ruptured middle cerebral artery (MCA) aneurysm.

MATERIALS AND METHODS: We retrospectively evaluated and compared the imaging features of 24 patients with ISH and 46 with ICH from ruptured MCA aneurysms. The following features in initial computed tomography, computed tomography angiography, and magnetic resonance (MR) imaging were investigated: density (Hounsfield unit) and margin of the haematoma, low density surrounding the haematoma, morphological parameters of the aneurysm, early severe vasospasm of M1 and M2 segments, active rebleeding, and high b1000 signal intensity and low apparent diffusion coefficient (ADC) surrounding the haematoma on MR diffusion-weighted imaging (DWI). Additionally, we assessed delayed severe vasospasm and the distribution of cerebromalacia on follow-up imaging examinations.

RESULTS: Compared to the ICH group, the ISH group showed a more frequent haematoma with serrated margins (100% vs 21.7%, P=0.000), absent or uniform thickness low density surrounding the haematoma (75.0% vs 15.2%, P=0.000), early severe vasospasm of M1 and M2 segments (83.3% vs 41.3%, P=0.001), thick (>5 mm) high b1000 signal intensity and low ADC surrounding the haematoma on MR DWI (100% vs 27.8%, P=0.001), delayed severe vasospasm at days 7 (±1) (100% vs 61.5%, P<0.05), and cerebromalacia involving brain surrounding the Sylvian fissure at 3 to 12 months (71.4% vs 0%, P=0.000).

CONCLUSION: Initial and follow-up imaging features can help differentiate between ISH and ICH associated with ruptured MCA aneurysm, facilitating appropriate treatment in the course of the disease.

* Guarantor and correspondent: D.Y.Yoon, Department of Radiology, Kangdong Seong-Sim Hospital, Hallym University College of Medicine, 150, Seongan-ro, Gangdong-Gu, Seoul 05355, South Korea.

E-mail address: yoon954066@naver.com (D.Y. Yoon).

https://doi.org/10.1016/j.crad.2025.106951

Introduction

Rupture of an intracranial aneurysm, as a rule, results in subarachnoid haemorrhage (SAH); however, it may also result in haematoma formation, which is associated with poor outcomes.[1] Intra-Sylvian haematoma (ISH) is a subtype of haematoma characterised by a large collection of subarachnoid blood within a Sylvian fissure. ISH has distinct features compared to parenchymal intracerebral haematoma (ICH) in patients with middle cerebral artery (MCA) aneurysm rupture[2,3]; therefore, imaging is crucial for a rapid diagnosis of ISH and disease course follow-up.

However, most previous studies on patients with ISH and ICH focussed on clinical features, such as risk factors, treatment, and outcomes.[4–7] Only a few studies have described initial computed tomography (CT) features that can help differentiate between ISH and ICH.[8–12] Computed tomography angiography (CTA) has additional value in distinguishing between ISH and ICH by identifying the location of vessels within the Sylvian fissure. van der Zande *et al.*[12] proposed the presence of enhancing vessels within haematoma on axial CTA source images as the diagnostic criterion for ISH. This sign can be used as a simple and highly specific sign for ISH; however, it may be of limited value in patients with poor cooperation or extremely severe vasospasms.

This study aimed to evaluate and compare the initial and follow-up imaging features of ISH and ICH from ruptured MCA aneurysms.

Materials and methods

Our institutional review board approved the study. The requirement for informed consent was waived due to the study's retrospective nature and anonymous data collection.

Patient selection

We conducted a cross-search of the medical record database and radiologic information system of our institution. The inclusion criteria were as follows: i) patients admitted to our hospital between January 2014 and December 2023; ii) patients diagnosed with ISH and ICH adjacent to the Sylvian fissure based on axial CTA source images; and iii) patients diagnosed with a ruptured MCA aneurysm that was responsible for ISH or ICH based on CTA and/or digital subtraction angiography.

An ISH was defined as a substantial accumulation of blood within the Sylvian fissure, marked by the presence of enhancing vessels within the haematoma when comparing non−contrast-enhanced computed tomography (NCE-CT) and axial CTA source images, following previously described criteria[12] and a transverse dimension of fissure between the temporal and insular lobes >1.5 cm. An ICH was defined as a parenchymal haematoma adjacent to a Sylvian fissure with no enhancing vessels within the haematoma and a short dimension >1.5 cm. Patients with mixed ISH and ICH patterns were assigned to the ISH or ICH group according to the predominant location of the haematoma.

Accordingly, 75 patients were identified and initially enrolled. We excluded patients with subacute or chronic haematomas (>72 h from the onset of symptoms) (n=3) and those with a delay >24 h between NCE-CT and subsequent CTA (n=2). Therefore, 70 patients were included in our final analysis, including 24 and 46 patients in the ISH and ICH groups, respectively, all resulting from MCA aneurysm rupture. Patients were treated with i) endovascular coil embolisation (n=40) and/or surgical clipping (n=37) for ruptured aneurysms; ii) surgical evacuation for haematoma (n=26); iii) extraventricular drainage (EVD) for hydrocephalus (n=29); iv) intra-arterial nimodipine infusion for severe vasospasm (n=7); and v) decompressive craniectomy (n=18).

Imaging studies

All patients underwent brain NCE-CT and subsequent CTA at the time of admission, with the longest interval between the two examinations being 6 h. Twenty-seven patients underwent brain magnetic resonance (MR) imaging at days 0 to 7 after aneurysm rupture. Forty-two patients underwent follow-up CTA at days 7 (±1) (n=39), 14 (±2) (n=29), and/or 21 (±4) (n=21), and 44 patients underwent follow-up CT and/or MR imaging 3 to 12 months after aneurysm rupture.

Brain NCE-CT and CTA were performed using a 256-detector row CT scanner (Brilliance iCT; Philips Medical Systems, Haifa, Israel). For cerebral CTA, 80 to 100 mL nonionic contrast material (iopamidol 370 mg I/mL [Pamiray 370]; DongKook Pharmaceutical, Seoul, South Korea) was injected with scanning parameters of 120 kV, 350 mAs, collimation 0.75 mm, field of view 22 cm, pixel matrix 512 × 512, pitch 0.40, and gantry rotation time 75 ms. CTA images were processed from the obtained source images using a volume-rendering algorithm with and without automatic segmentation of the precontrast images in all patients.

MR imaging was performed using a 3-T system with a 32-channel head coil or a 1.5-T system with an 8-channel head coil (Achieva X-Series, Philips Medical Systems, Bothell, WA, USA).

Analysis of imaging features

All imaging studies were independently evaluated by two blinded reviewers (D.Y.Y. and E.S.K., with more than 25 years and 15 years of experience in neuroimaging, respectively). In cases of disagreement between the two reviewers on a reading, a final decision was reached by consensus.

The following characteristics were assessed: i) Hounsfield unit of haematoma (determined by the mean value of measurements by the two reviewers), the margin of the haematoma (serrated or smooth), and low density surrounding the haematoma (absent, uniform thickness, or irregular thickness) on the initial NCE-CT; ii) morphological parameters of the aneurysm (location [MCA bifurcation, M1 or M2 segment], size [in mm, maximum dimension], shape [lobulated or non-lobulated], and direction [anterior, superior, lateral, or others]), initial severe vasospasm (>50% luminal narrowing) of M1 or M2 segment (present or absent), and active rebleeding (present or absent) on initial CTA; and iii) high b1000 signal intensity and low apparent diffusion coefficient (ADC) surrounding the haematoma (maximum thickness: >5 mm or ≤5 mm) on MR diffusion-weighted imaging (DWI) at days 0 to 7 after aneurysm rupture. T1- and T2-signal intensity of the haematoma was not assessed because many patients underwent evacuation of haematoma at the time of MR examination.

We also assessed the following characteristics on follow-up examinations: i) delayed severe vasospasm of M1 or M2 segment (present or absent) on CTA at days 7(±1), 14(±2), and 21 (±4) and ii) distribution of cerebromalacia (focal, brain surrounding the Sylvian fissure or diffuse) on the first follow-up CT 3 to 12 months after aneurysm rupture.

Statistical analysis

We performed subgroup analyses to compare ISH vs ICH, which resulted from MCA aneurysm rupture. The patient demographic and imaging characteristics were compared between groups using Student's *t*-test (for normally distributed data) or Mann-Whitney U-test (for non-normally distributed data) for continuous variables and the chi-squared or Fisher's exact test for categorical variables, as appropriate. The interobserver agreement was tested by κ test. The kappa value was interpreted as poor (<0.20), fair (0.21-0.40), moderate (0.41-0.60), substantial (0.61-0.80), or almost perfect (0.81-1.0).

All statistical analyses were performed using SPSS statistical software (version 21.0; IBM, Armonk, NY, USA). The level of statistical significance was set at a P value <0.05.

Results

Regarding patients' sex distribution, the ratio of women was significantly higher in the ISH group than in the ICH group (87.5% vs 60.9%, $P<0.05$). The maximum dimension of ruptured MCA aneurysm measured using the initial CTA had

Table 1
Comparison of patient demographics, aneurysm characteristics, and treatment between intra-Sylvian haematoma and intracerebral haematoma associated with ruptured middle cerebral artery aneurysm.

	Intra-Sylvian haematoma (24 patients)	Intracerebral haematoma (46 patients)	*P* value
Age, years (mean ± standard deviation)	67.54 ± 12.44	64.70 ± 13.34	0.389
Gender			0.028[a]
Women	21 (87.5%)	28 (60.9%)	
Men	3 (12.5%)	18 (39.1%)	
Aneurysm			
Location			0.587
Middle cerebral artery bifurcation	21 (87.5%)	41 (89.1%)	
M1 segment	3 (12.5%)	4 (8.7%)	
M2 segment	0 (0%)	1 (2.2%)	
Maximum dimension, mm			0.011[a]
Median	5.5	8.0	
25 percentile-75 percentile	4-8	5.75-13	
Direction			0.464
Anterior	8 (33.3%)	12 (26.1%)	
Superior	5 (20.8%)	5 (10.9%)	
Lateral	9 (37.5%)	21 (45.7%)	
Others	2 (8.3%)	8 (17.4%)	
Shape			0.318
Lobulated	18 (75.0%)	39 (84.8%)	
Nonlobulated	6 (25.0%)	7 (15.2%)	
Treatment[b]			
Endovascular coil embolisation of aneurysm	12 (50.0%)	28 (60.9%)	0.383
Microsurgical clipping of aneurysm	13 (54.2%)	24 (52.2%)	0.874
Haematoma evacuation	12 (50.0%)	14 (30.4%)	0.108
Extraventricular drainage	14 (58.3%)	15 (32.6%)	0.038[a]
Intra-arterial nimodipine infusion	3 (12.5%)	4 (8.7%)	0.617
Decompressive craniectomy	9 (37.5%)	9 (19.6%)	0.103

[a] The difference between the two groups was statistically significant.
[b] Percentages do not add up to 100% because some patients had more than one treatment.

a median value of 5.5 mm for the ISH group and 8 mm for the ICH group, showing a statistically significant difference ($P<0.05$). More patients in the ISH group underwent EVD therapy than those in the ICH group (58.3% vs 32.6%, $P<0.05$). Other characteristics of patient demographics, aneurysm, and treatment were not different between the two groups (Table 1).

Of the imaging features evaluated in the initial CT, CTA, and MR DWI, the ISH group showed more frequent haematoma with serrated margins (100% vs 21.7%, $P=0.000$), absent or uniform thickness low density surrounding the haematoma (75.0% vs 15.2%, $P=0.000$), early severe vasospasm (83.3% vs 41.3%, $P=0.001$), and thick (>5 mm) high b1000 signal intensity and low ADC surrounding the haematoma on MR DWI (100% vs 27.8%, $P=0.001$). In the follow-up period, patients in the ISH group were more likely to have delayed severe vasospasm at days 7 (±1) (100% vs 61.5%, $P<0.05$) and cerebromalacia involving the brain surrounding the Sylvian fissure 3 to 12 months after aneurysm rupture (71.4% vs 0%, $P=0.000$) than those in the ICH group (Table 2).

The interobserver agreement was substantial for low density surrounding the haematoma (kappa value = 0.764; 95% confidence interval [CI]: 0.620-0.907). The interobserver agreement for other categories was almost perfect, with the kappa value ranging from 0.829 (95% CI: 0.699-0.957) to 1 (95% CI: NA).

Representative cases of ISH and ICH associated with ruptured MCA aneurysms are shown in Figures 1 and 2, respectively.

Discussion

The incidence of haematoma (ISH or ICH) secondary to intracranial aneurysm rupture has been reported to be as high as 4% to 43%.[13] Ruptured MCA aneurysms cause

Table 2

Comparison of imaging features between intra-Sylvian haematoma and intracerebral haematoma associated with ruptured middle cerebral artery aneurysm.

	Intra-Sylvian haematoma (24 patients)	Intracerebral haematoma (46 patients)	*P* value	Sensitivity	Specificity
Initial CT (n=70)					
Side of haematoma			0.175		
Left	14 (58.3%)	19 (41.3%)			
Right	10 (41.7%)	27 (58.7%)			
Density of haematoma, HU (mean ± standard deviation)	62.83 ± 6.84	64.65 ± 6.99	0.301		
Margin of haematoma			0.000[a]	100%	78.3%
Serrated	24 (100%)	10 (21.7%)			
Smooth	0 (0%)	36 (78.3%)			
Low density surrounding the haematoma			0.000[a]	75.0%	84.8%
Absent	6 (25.0%)	0 (0%)			
Uniform thickness	12 (50.0%)	7 (15.2%)			
Irregular thickness	6 (25.0%)	39 (84.8%)			
Initial CTA					
Severe vasospasm			0.001[a]	83.3%	58.7%
Present	20 (83.3%)	19 (41.3%)			
Absent	4 (16.7%)	27 (58.7%)			
Active re-bleeding			1.000	8.3%	89.1%
Present	2 (8.3%)	5 (10.9%)			
Absent	22 (91.7%)	41 (89.1%)			
MR diffusion-weighted image at days 0 to 7 (n=27)					
Diffusion restriction surrounding the haematoma			0.001[a]	100%	72.2%
Thick (maximum thickness > 5 mm)	9/9 (100%)	5/18 (27.8%)			
Thin (maximum thickness ≤ 5mm)	0/9 (0%)	13/18 (72.2%)			
Follow-up CTA					
Severe vasospasm at days 7 ± 1 (n=39)			0.016[a]	100%	38.5%
Present	13/13 (100%)	16/26 (61.5%)			
Absent	0/13 (0%)	10/26 (38.5%)			
Severe vasospasm at days 14 ± 2 (n=29)			0.187	91.7%	35.3%
Present	11/12 (91.7%)	11/17 (64.7%)			
Absent	1/12 (8.3%)	6/17 (35.3%)			
Severe vasospasm at days 21 ± 4 (n=21)			0.325	84.6%	37.5%
Present	11/13 (84.6%)	5/8 (62.5%)			
Absent	2/13 (15.4%)	3/8 (37.5%)			
First follow-up CT between 3 and 12 months (n=44)					
Distribution of cerebromalacia			0.000[a]	71.4%	100%
Focal	0/14 (0%)	23/30 (76.7%)			
Brain surrounding the Sylvian fissure	10/14 (71.4%)	0/30 (0%)			
Diffuse	4/14 (28.6%)	7/30 (23.3%)			

Note. HU, Hounsfield unit; CT, computed tomography; CTA, computed tomography angiography; MR, magnetic resonance; SD, standard deviation.

[a] The difference between the two groups was statistically significant.

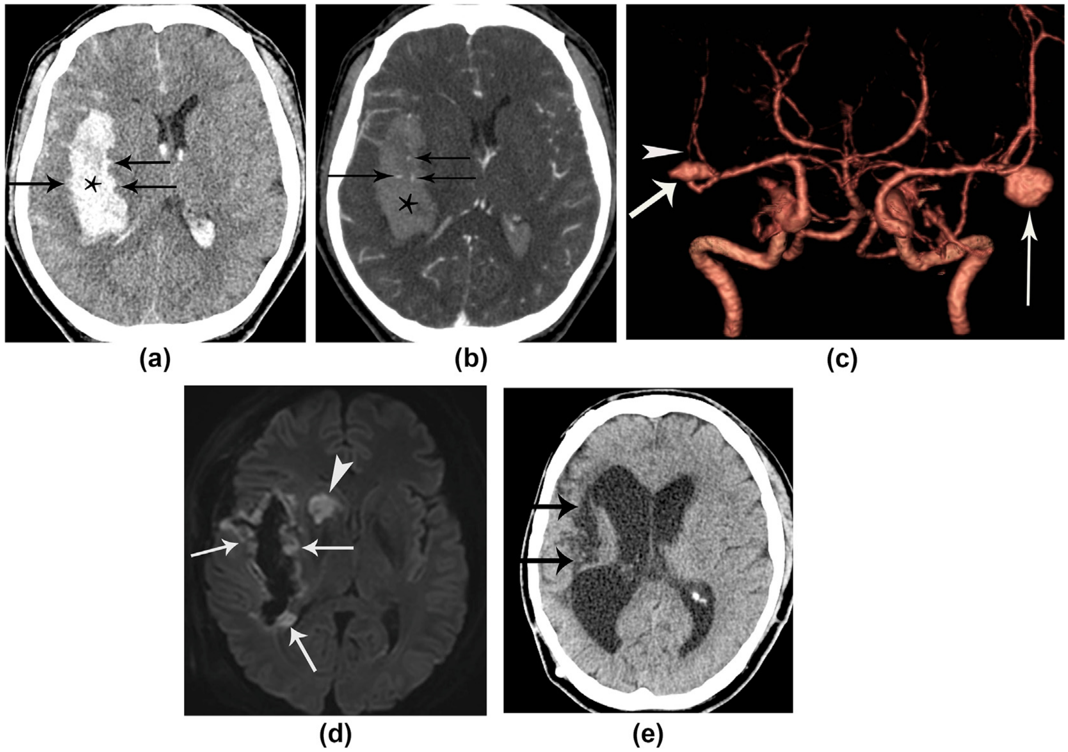

Figure 1 A 52-year-old man with intra-Sylvian haematoma due to a ruptured middle cerebral artery aneurysm.
(a) The initial non–contrast-enhanced computed tomography (CT) scan at admission shows a right intra-Sylvian haematoma (indicated by an asterisk) with subarachnoid haemorrhage and intraventricular haemorrhage. Note the serrated margin of the haematoma (arrows), with no low-density surrounding the haematoma.
(b) Axial source image of CT angiography shows contrast-enhanced vessels (arrows) within the intra-Sylvian haematoma (indicated by an asterisk).
(c) Anterior projection of volume-rendered CT angiography reveals a 9-mm lobulated aneurysm at the bifurcation of the right middle cerebral artery (arrow), with severe vasospasm in the M2 segments of the right middle cerebral artery (arrowhead). In addition, a 14-mm lobulated aneurysm at the bifurcation of the left middle cerebral artery is shown (long arrow).
(d) The patient was treated with endovascular coil embolisation of aneurysm, surgical evacuation for haematoma, and extraventricular drainage. Magnetic resonance diffusion-weighted imaging 6 days after aneurysm rupture demonstrates thick (>5 mm) high b1000 signal intensity areas surrounding the intra-Sylvian haematoma (arrows), suggesting recent ischaemia or infarction. Additionally, another recent infarction involving the right basal ganglia is shown (arrowhead).
(e) Follow-up CT 6 months after aneurysm rupture shows cerebromalacia involving the brain surrounding the Sylvian fissure (arrows).

haematoma more frequently than aneurysms in other locations, which may be attributed to the limited subarachnoid space and the close anatomical relationship between the aneurysm and cerebral cortices.[9,14] Previous studies have reported that ISH or ICH occurs in 42% to 54% of patients with subarachnoid haemorrhage (SAH) from a ruptured aneurysm of the MCA.[11,15]

Studies assessing ICHs in patients with all aneurysmal SAH[5,16,17] identified aneurysm size as the other risk factor beyond aneurysm location for ICH development. In our series, we found that the risk of an ICH was more closely associated with the size of the aneurysm than with its pointing direction. We believe that larger ruptured aneurysms are more likely to have a closer relationship with the pia mater, leading to a greater breaking force of extravasated blood to overcome the resistance of the pia mater.

Outcomes for patients with ruptured MCA aneurysms with ISH or ICH have been suggested to be worse than those for patients with SAH without haematoma.[9,11] Previous studies[16,18–20] have reported that old age, poor clinical status on admission, the large size of the ruptured aneurysm, large haematoma volume, and the presence of cerebral ischaemia/infarction significantly correlated with an unfavourable outcome in patients with ISH or ICH to be associated with MCA aneurysm rupture. In addition, early surgical management in the form of aneurysm clipping or coiling followed by haematoma evacuation has been reported to be a prognostic factor associated with a favourable outcome, particularly for patients with Hunt-Hess grade IV to V.[9,11,13,18]

Other previous studies have evaluated the difference in prognoses between ISH and ICH and reported controversial results. Several authors[3,12] reported no significant differences in prognoses when simply subdividing the haematoma into ISH and ICH. In contrast, other investigators[18,19,21] found that the ISH group had worse clinical outcomes than the ICH group. They proposed some possible reasons for the worse outcomes in the ISH group. First, early evacuation is technically more difficult for ISH than for ICH due to the tight adhesion formed by fibrin clots to subarachnoid vessels, whereas the ICH is located within the brain parenchyma and

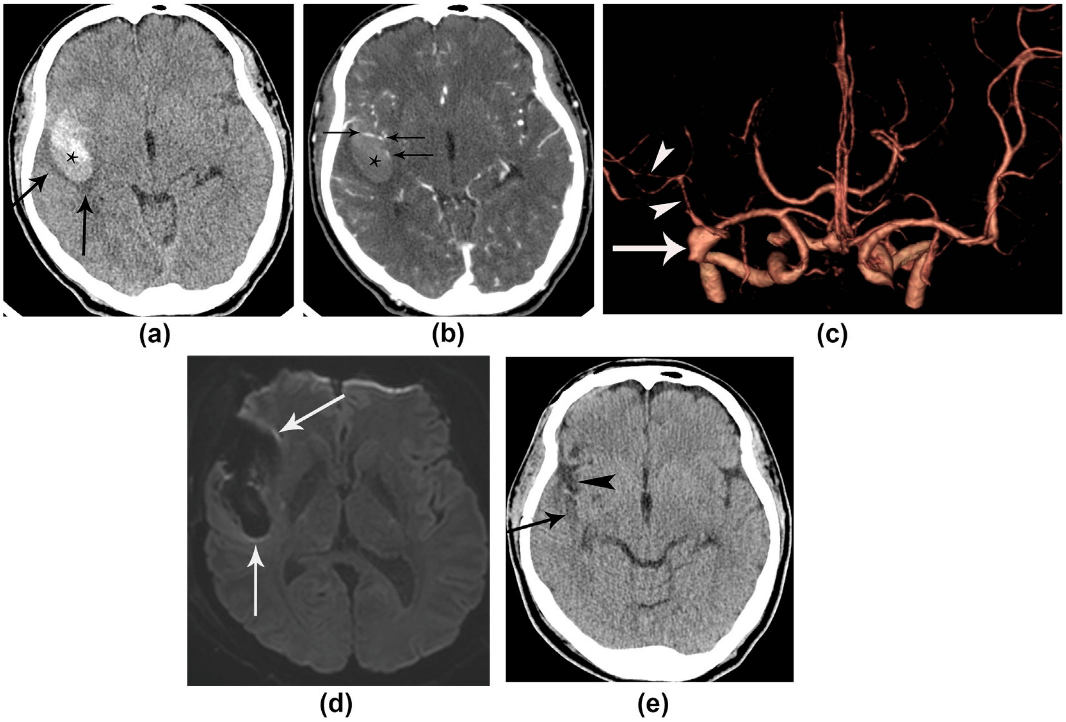

Figure 2 A 51-year-old man with intracerebral haematoma due to a ruptured middle cerebral artery aneurysm.
(a) The initial non−contrast-enhanced computed tomography (CT) scan at admission shows an intracerebral haematoma with a smooth margin (indicated by the asterisk) in the right temporal lobe, with an irregular low density surrounding the haematoma (arrows).
(b) Axial source image of CT angiography shows no contrast-enhanced vessels within the intracerebral haematoma (indicated by an asterisk), only in the compressed and displaced Sylvian fissure with subarachnoid blood (arrows).
(c) Anterior projection of volume-rendered CT angiography reveals a 10-mm lobulated aneurysm at the bifurcation of the right middle cerebral artery (arrow), with severe vasospasm in the M2 segment of the right middle cerebral artery (arrowheads).
(d) Magnetic resonance diffusion-weighted image at day 0 after aneurysm rupture demonstrates thin (≤5 mm) high b1000 signal intensity areas (arrows) surrounding the intracranial haematoma, suggesting susceptibility artifacts.
(e) The patient was treated with surgical clipping of aneurysm and surgical evacuation for haematoma. Follow-up CT 3 months after the aneurysm rupture shows focal cerebromalacia involving the right temporal lobe (arrow) posterior to the Sylvian fissure (arrowhead).

thus can be easily removed.[3,9,11,22,23] Second, aggressive attempts at ISH evacuation can increase the risk of perioperative complications and poorer outcomes due to rebleeding, cerebral oedema, and cerebral vasospasm.[3,11]

Therefore, radiological discrimination between ISH and ICH is of clinical significance as it can facilitate optimal management and satisfactory outcomes in patients. Several studies[8−11] have distinguished ISH and ICH resulting from aneurysm rupture based on NCE-CT. Niikawa S, *et al.*[10] proposed significantly thick Sylvian SAH (more than 5 ml) with or without extension into the brain as the diagnostic criteria for ISH, defined in the initial NCE-CT. Yoshimoto Y, et al [11] described that it was possible to differentiate between ISH and ICH, mainly by the shape of the haematoma and the presence of a thin fringe surrounding the haematoma corresponding to the compressed Sylvian fissure in the initial NCE-CT. However, those studies mainly focussed on different clinical courses and management strategies, which did not lead to systematic analysis of imaging features. van der Zande *et al.*[12] utilised the initial CTA source images in 71 MCA aneurysm rupture−associated haematoma patients to differentiate ISH from ICH depending on the presence of intrahaematoma contrast-enhancing vessels. They reported 90% positive predictive value and 100% negative predictive value of this CTA sign for differentiation between ISH and ICH with almost perfect interobserver agreement. In the present study, their CTA criteria were adopted as the standard of reference for comparative analysis of the initial and follow-up imaging features between ISH and ICH.

In our series, we found that MCA aneurysm rupture−associated ISH and ICH showed several differential initial and follow-up imaging features. The main clinical implication of our study is that NCE-CT can be used to discriminate between ISH and ICH resulting from a ruptured MCA aneurysm. First, the serrated margin of haematoma was found in 100% of ISH, whereas 78% of ICH showed a smooth margin in our study. The confluence of a large amount of subarachnoid clot in ISH may lead to central bulging of the Sylvian fissure bounded by a serrated margin of cerebral cortices. Second, absent or uniform-thickness low density surrounding the haematoma was seen in 75% of ISH in the initial CT, whereas irregular-thickness low-density surrounding the haematoma was seen in 85% of ICH. These differences suggest that ISH may lead to early diffused ischaemia/infarction involving the cortex around the Sylvian fissure, considering the combination of thick, high b1000 signal intensity and low ADC surrounding the haematoma on MR DWI and the presence of cerebromalacia in the brain around the Sylvian fissure during the chronic stage in the ISH group. In contrast, irregular thickness and low density surrounding the ICH were presumed to be vasogenic oedema. Several previous studies[10,11,18] reported early cerebral swelling and delayed ischaemic neurologic deficits in 50% to 88% of patients with ISH caused by ruptured MCA aneurysm, and the development of cerebral swelling has a significant effect on outcomes in these patients. However, those studies did not mention the mechanism and reason for their results.

Another concern in predicting outcomes of aneurysm rupture is cerebral infarction caused by severe vasospasm. In this study, the ISH group showed significantly more frequent early severe vasospasm in the initial CTA and delayed severe vasospasm at day 7 (±1) than the ICH group. However, differentiation between ISH and ICH by vasospasm alone was not reliable because the overall frequency of vasospasm in both groups was >50%.

The present study had some limitations. First, this study was based on a single-centre database, introducing an inherent bias that may limit its applicability to the general population. Second, due to the retrospective study design, a rather low number of patients were examined for MR and follow-up CT/CTA studies. Moreover, the follow-up interval varied depending on the patient's condition and treatment method. Third, our series included a small number of patients with mixed ISH and ICH, which may result in an inaccurate analysis.

Conclusion

Initial and follow-up imaging features can help differentiate between ISH and ICH associated with ruptured MCA aneurysm, facilitating appropriate treatment in the course of the disease.

Author contribution

1. Guarantor of integrity of the entire study: Dae Young Yoon.
2. Study concepts and design: All authors (Jeong In Hwang, Dae Young Yoon, Eun Soo Kim, Hong Jun Jeon, Jong Young Lee, Young Lan Seo, and Eun Joo Yun).
3. Literature research: Jeong In Hwang, Dae Young Yoon, and Eun Soo Kim.
4. Clinical studies: Jeong In Hwang, Dae Young Yoon, Hong Jun Jeon, and Jong Young Lee.
5. Experimental studies/data analysis: Jeong In Hwang, Dae Young Yoon, Hong Jun Jeon, and Jong Young Lee.
6. Statistical analysis: Jeong In Hwang, Dae Young Yoon, Hong Jun Jeon, and Jong Young Lee.
7. Manuscript preparation: Jeong In Hwang, Dae Young Yoon, Hong Jun Jeon, and Jong Young Lee.
8. Manuscript editing: Jeong In Hwang, Dae Young Yoon, Young Lan Seo, and Eun Joo Yun.

Ethics

Our institutional review board (Kangdong Seong-Sim Hospital Institutional Review Board) approved the study.

Funding

This research received no funding.

Informed consent

The requirement for informed consent was waived due to the study's retrospective nature and anonymous data collection.

References

1. Güresir E, Beck J, Vatter H, *et al.* Subarachnoid hemorrhage and intracerebral hematoma: incidence, prognostic factors, and outcome. *Neurosurgery* 2008;**63**:1088–93. https://doi.org/10.1227/01.NEU.0000335170.76722.B9. ; discussion 1093.
2. Başkaya MK, Menendez JA, Yüceer N, *et al.* Results of surgical treatment of intrasylvian hematomas due to ruptured intracranial aneurysms. *Clin Neurol Neurosurg* 2001;**103**:23–8. https://doi.org/10.1016/s0303-8467(01)00104-4.
3. Saito A, Akamatsu Y, Mikawa S, *et al.* Comparison of large intrasylvian and subpial hematomas caused by rupture of middle cerebral artery aneurysm. *Neurol Med Chir (Tokyo)* 2010;**50**:281–5. https://doi.org/10.2176/nmc.50.281.
4. LoPresti MA, Bruce SS, Camacho E, *et al.* Hematoma volume as the major determinant of outcomes after intracerebral hemorrhage. *J Neurol Sci* 2014;**345**:3–7. https://doi.org/10.1016/j.jns.2014.06.057.
5. Jabbarli R, Reinhard M, Roelz R, *et al.* Intracerebral hematoma due to aneurysm rupture: are there risk factors beyond aneurysm location? *Neurosurgery* 2016;**78**:813–20. https://doi.org/10.1227/NEU.0000000000001136.
6. Navratil O, Duris K, Juran V, *et al.* Middle cerebral artery aneurysms with intracerebral hematoma – the impact of side and volume on final outcome. *Acta Neurochir* 2017;**159**:543–7. https://doi.org/10.1007/s00701-016-3070-3.
7. Ryu DS, Shim YS. Importance of hematoma removal ratio in ruptured middle cerebral artery aneurysm surgery with intrasylvian hematoma. *J Cerebrovasc Endovasc Neurosurg* 2017;**19**:5–11. https://doi.org/10.7461/jcen.2017.19.1.5.
8. Silver AJ, Pederson Jr ME, Ganti SR, *et al.* CT of subarachnoid hemorrhage due to ruptured aneurysm. *AJNR Am J Neuroradiol* 1981;**2**:13–22.
9. Shimoda M, Oda S, Mamata Y, *et al.* Surgical indications in patients with an intracerebral hemorrhage due to ruptured middle cerebral artery aneurysm. *J Neurosurg* 1997;**87**:170–5. https://doi.org/10.3171/jns.1997.87.2.0170.
10. Niikawa S, Kitajima H, Ohe N, *et al.* Significance of acute cerebral swelling in patients with sylvian hematoma due to ruptured middle cerebral artery aneurysm, and its management. *Neurol Med Chir (Tokyo)* 1998;**38**:844–8. https://doi.org/10.2176/nmc.38.844. ; discussion 849.
11. Yoshimoto Y, Wakai S, Satoh A, *et al.* Intraparenchymal and intrasylvian haematomas secondary to ruptured middle cerebral artery aneurysms: prognostic factors and therapeutic considerations. *Br J Neurosurg* 1999;**13**:18–24. https://doi.org/10.1080/02688699944131.
12. van der Zande JJ, Hendrikse J, Rinkel GJ. CT angiography for differentiation between intracerebral and intra-sylvian hematoma in patients with ruptured middle cerebral artery aneurysms. *AJNR Am J Neuroradiol* 2011;**32**:271–5. https://doi.org/10.3174/ajnr.A2287.
13. Niemann DB, Wills AD, Maartens NF, *et al.* Treatment of intracerebral hematomas caused by aneurysm rupture: coil placement followed by clot evacuation. *J Neurosurg* 2003;**99**:843–7. https://doi.org/10.3171/jns.2003.99.5.0843.

14. Bohnstedt BN, Nguyen HS, Kulwin CG, *et al*. Outcomes for clip ligation and hematoma evacuation associated with 102 patients with ruptured middle cerebral artery aneurysms. *World Neurosurg* 2013;**80**:335–41. https://doi.org/10.1016/j.wneu.2012.03.008.
15. Rinne J, Hernesniemi J, Niskanen M, *et al*. Analysis of 561 patients with 690 middle cerebral artery aneurysms: anatomic and clinical features as correlated to management outcome. *Neurosurgery* 1996;**38**:2–11. https://doi.org/10.1097/00006123-199601000-00002.
16. Nemoto M, Masuda H, Sakaeyama Y, *et al*. Clinical characteristics of subarachnoid hemorrhage with an intracerebral hematoma and prognostic factors. *J Stroke Cerebrovasc Dis* 2018;**27**:1160–6. https://doi.org/10.1016/j.jstrokecerebrovasdis.2017.11.034.
17. Darkwah Oppong MD, Skowronek V, Pierscianek D, *et al*. Aneurysmal intracerebral hematoma: risk factors and surgical treatment decisions. *Clin Neurol Neurosurg* 2018;**173**:1–7. https://doi.org/10.1016/j.clineuro.2018.07.014.
18. Prat R, Galeano I. Early surgical treatment of middle cerebral artery aneurysms associated with intracerebral haematoma. *Clin Neurol Neurosurg* 2007;**109**:431–5. https://doi.org/10.1016/j.clineuro.2007.03.005.
19. Oh JW, Lee JY, Lee MS, *et al*, Brain Research Group. The meaning of the prognostic factors in ruptured middle cerebral artery aneurysm with intracerebral hemorrhage. *J Korean Neurosurg Soc* 2012;**52**:80–4. https://doi.org/10.3340/jkns.2012.52.2.80.
20. Lee CS, Park JU, Kang JG, *et al*. The clinical characteristics and treatment outcomes of patients with ruptured middle cerebral artery aneurysms associated with intracerebral hematoma. *J Cerebrovasc Endovasc Neurosurg* 2012;**14**:181–5. https://doi.org/10.7461/jcen.2012.14.3.181.
21. Kazumata K, Kamiyama H, Yokoyama Y, *et al*. Poor-grade ruptured middle cerebral artery aneurysm with intracerebral hematoma: bleeding characteristics and management. *Neurol Med Chir (Tokyo)* 2010;**50**:884–92. https://doi.org/10.2176/nmc.50.884.
22. Lee JG, Moon CT, Chun YI, *et al*. Comparative results of the patients with intracerebral and intra-sylvian hematoma in ruptured middle cerebral artery aneurysms. *J Cerebrovasc Endovasc Neurosurg* 2013;**15**:200–5. https://doi.org/10.7461/jcen.2013.15.3.200.
23. Zhang Y, Hu Q, Xue H, *et al*. Intrasylvian/intracerebral hematomas associated with ruptured middle cerebral artery aneurysms: a single-center series and literature review. *World Neurosurg* 2017;**98**:432–7. https://doi.org/10.1016/j.wneu.2016.11.022.