Basal Cistern Effacement and Pseudo−Subarachnoid Hemorrhage on Computed Tomography Images of Chronic Subdural Hematoma

Hideki Atsumi, Takatoshi Sorimachi, Yoichi Nonaka, Mitsunori Matsumae

■ OBJECTIVE: **Computed tomography images of patients with chronic subdural hematoma (CSDH) sometimes show obliteration of the basal cistern with high density in an obliterated Sylvian cistern, termed pseudo−subarachnoid hemorrhage (SAH). The present study aimed to clarify the characteristics and outcomes of these conditions.**

■ METHODS: **We retrospectively investigated 669 consecutive patients who were surgically treated for CSDH between January 2006 and May 2019.**

■ RESULTS: **Basal cistern effacement and pseudo-SAH were found in 24 (3.6%) and 11 (1.6%) patients, respectively. Predictors of basal cistern effacement in patients with CSDH were younger age, cerebrospinal fluid leak, and bilateral CSDH ($P < 0.05$). In patients with basal and Sylvian cistern effacement, the significantly different main features to differentiate patients with and without pseudo-SAH were younger age, cerebrospinal fluid leak, and thick small hematomas on computed tomography slices of the Sylvian cistern ($P < 0.05$). Magnetic resonance imaging showed that high-density areas in the Sylvian cistern of pseudo-SAH on precontrast computed tomography images corresponded to the M1 segment of the middle cerebral artery. The outcomes of patients with basal cistern effacement and of patients with pseudo-SAH did not differ from other patients with CSDH, although rates of surgical complications were significantly higher among patients with basal cistern effacement.**

■ CONCLUSIONS: **Although the outcomes of patients with basal cistern effacement and pseudo-SAH were similar to outcomes of other patients with CSDH, problematic post-surgical complications and cerebrospinal fluid leaks were more likely to arise in such patients.**

INTRODUCTION

The basal cistern is compressed and effaced on computed tomography (CT) images of some patients with chronic subdural hematoma (CSDH) because of the mass effect of the hematoma. The characteristics of basal cistern effacement, including prognosis, have never been reported, whereas several studies of acute head injury have indicated that basal cistern effacement on CT predicts an unfavorable prognosis.[1,2] Pseudo−subarachnoid hemorrhage (SAH) and SAH appear similar on CT images in the absence of blood in the subarachnoid space, which is evident in hypoxic brain injury, meningoencephalitis, or intracerebral mass lesions, with frequent unfavorable outcomes.[3-5] Several patients with CSDH and pseudo-SAH in the Sylvian cistern on CT have been described,[6-13] but neither the characteristics nor the mechanisms of pseudo-SAH have been analyzed. In this study, we clarified the characteristics of basal cistern effacement in patients with CSDH, including frequency, clinical predictors, and outcomes. We then evaluated the CT imaging features of pseudo-SAH among patients with basal cistern effacement and discuss its mechanisms.

MATERIALS AND METHODS

Patient Population

The Review Board for Clinical Research of Tokai University Hospital approved this retrospective study (Approval No.

Key words
- Chronic subdural hematoma
- Computed tomography
- Prognosis
- Subarachnoid hemorrhage
- Surgical complication

Abbreviations and Acronyms
CSDH: Chronic subdural hematoma
CSF: Cerebrospinal fluid
CT: Computed tomography
MCA: Middle cerebral artery
MRI: Magnetic resonance imaging
mRS: Modified Rankin Scale
RBC: Red blood cell
SAH: Subarachnoid hemorrhage

Department of Neurosurgery, Tokai University, Isehara, Kanagawa, Japan

To whom correspondence should be addressed: Takatoshi Sorimachi, M.D., Ph.D. [E-mail: sorimachi@tokai-u.jp]

Citation: World Neurosurg. (2019) 132:e109-e115.
https://doi.org/10.1016/j.wneu.2019.08.249

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

13R-069). We retrospectively assessed data from 669 consecutive patients (mean age ± SD 74.0 ± 12.7 years; 473 [70.7%] men and 196 [29.3%] women) in whom CSDHs were diagnosed and treated between January 2006 and May 2019 at our hospital. Patients who underwent surgery for CSDH were included. Patients who were treated conservatively, were <20 years of age, or had undergone a second surgery for recurrent CSDH were excluded. All patients were evaluated by neurosurgeons.

Clinical Evaluation

We extracted the following information about the patients from reviews of clinical charts: age; sex; extant comorbidities, including cerebrospinal fluid (CSF) leak, dementia, malignancy, and liver disease; use of anticoagulant or antiplatelet agents; daily alcohol consumption; hematoma laterality; history of apparent trauma ≥3 weeks earlier or ≤7 days before admission; (Glasgow Coma Scale) score on admission; surgical complications; modified Rankin Scale (mRS) score at discharge; and recurrent CSDH requiring surgery. Glasgow Coma Scale scores ≤12 and ≤8 were regarded as indicating mildly and extremely disturbed consciousness, respectively.[14] Clinical outcomes were assessed using mRS scores at discharge, with good outcomes being defined as mRS score 0. We investigated the laboratory parameters of red blood cell (RBC) count, platelet count, activated partial thromboplastin time, and prothrombin time/international normalized ratio. Surgery for CSDH was generally burr hole craniotomy under local anesthesia.

Image Acquisition and Imaging Analysis and Interpretation

We acquired CT images using a Brilliance 40-slice CT system (Philips Medical Systems, Best, The Netherlands) or a SOMATOM Definition AS 128-slice CT system (Siemens Healthcare, Erlangen, Germany). Noncontrast head images were acquired from the skull base to the vertex, with 5-mm axial reformats parallel to the orbitomeatal line. The imaging parameters were 120 kVp, 350 or 360 mA, and 0.5 or 1 second/rotation. The status of the basal and Sylvian cisterns, distance of midline shift, presence of bilateral CSDH, and subdural hematoma thickness on CT images at the level of the Sylvian cistern were analyzed. The appearance of the basal cistern was defined as patent or effaced. When the basal cistern was effaced, the Sylvian cistern was then assessed. Based on the appearance of the Sylvian cistern, basal cistern effacement was classified as effacement with pseudo-SAH (Figure 1A), effacement without pseudo-SAH (Figure 1B), or patent (Figure 1C). Maximum densities were measured on regions of interest of an effaced Sylvian cistern (Figure 1A, dotted circle) and of the brain adjacent to it (Figure 1A, circle) on CT slices. The window was the same in all studies (approximate width, 100/window level 40). Two board-certified neurosurgeons (H.A. and T.S.) with >20 years of experience in their specialties evaluated the CT images. The thickness of the subdural hematoma was measured on CT slices at the level of the Sylvian cistern (Figure 1B and C, double arrows). Magnetic resonance imaging (MRI) and/or CT angiography axial images of basal cistern effacement were also evaluated if available.

Statistical Analysis

Categorical variables were assessed using χ^2 or Fisher exact probability tests, and continuous variables were analyzed using Student *t* tests or Mann-Whitney *U* tests. Significant predictors were identified using univariate analyses that included these variables. Multiple comparisons were corrected using the Holm method. Variables that were significant at the < 0.05 level in univariate analyses were included in multivariate logistic regression models and reduced by successive removal of the least significant variables from the model. Values of < 0.05 were considered significant. All data were statistically analyzed using JMP 10 software (SAS Institute Inc., Cary, North Carolina, USA).

RESULTS

Basal Cistern Effacement

CT images demonstrated basal cistern effacement in 24 patients. Table 1 shows comparisons of clinical factors between patients with and without basal cistern effacement. Multivariate analysis selected younger age, bilateral hematomas, and CSF leak as predictors. Three patients with basal cistern effacement developed surgical complications, which were more frequent than in patients without basal cistern effacement ($P < 0.05$). One patient with CSF leak developed bilateral posterior cerebral artery infarcts on postoperative day 4. Two patients without CSF leaks developed acute subdural hematoma immediately after surgery and on postoperative day 2, respectively. Both patients were treated by emergency craniotomy surgery and completely recovered.

Pseudo-SAH

Of the 24 patients with basal cistern effacement, 5 had Sylvian cistern patency, and 19 had Sylvian cistern effacement. Of the 19 patients with Sylvian cistern effacement, pseudo-SAH was found in 12 (Figure 1A and B). Patients with a patent Sylvian cistern did not demonstrate pseudo-SAH because the density in the Sylvian cistern was low (Figure 1C). Table 2 shows comparisons of clinical factors between 12 and 7 patients with and without pseudo-SAH, respectively, among 19 patients with basal and Sylvian cistern effacement. Monovariate analyses selected younger age, low mean hematoma thickness at the Sylvian cistern level on CT slices, CSF leak, less frequent dementia, high RBC count, and high serum albumin ($P < 0.05$). The maximal density adjacent to the Sylvian cistern on CT images was significantly lower in patients with pseudo-SAH, although the density of the Sylvian cistern itself was similar. All 6 patients with basal cistern effacement and CSF leak had pseudo-SAH. However, outcomes, including mRS score at discharge, occurrence of surgical complications, and recurrence, did not significantly differ.

Seven and 3 patients with pseudo-SAH were assessed by MRI and CT angiography axial images, respectively. Both MRI and CT angiography demonstrated that the M1 segments of the middle cerebral artery (MCA) corresponded to areas of high density on precontrast CT images of these patients (Figure 1D and E). In 24 patients with basal cistern effacement, mean bilateral subdural hematoma thickness on CT images at the level of the Sylvian cistern was compared among patients with Sylvian cistern effacement with and without pseudo-SAH and patients with a patent Sylvian cistern (Figure 2). Mean ± SD subdural hematoma thickness in patients with pseudo-SAH, without pseudo-SAH, and with a patent Sylvian cistern were 0.4 ± 0.7 mm, 6.1 ± 5.6 mm,

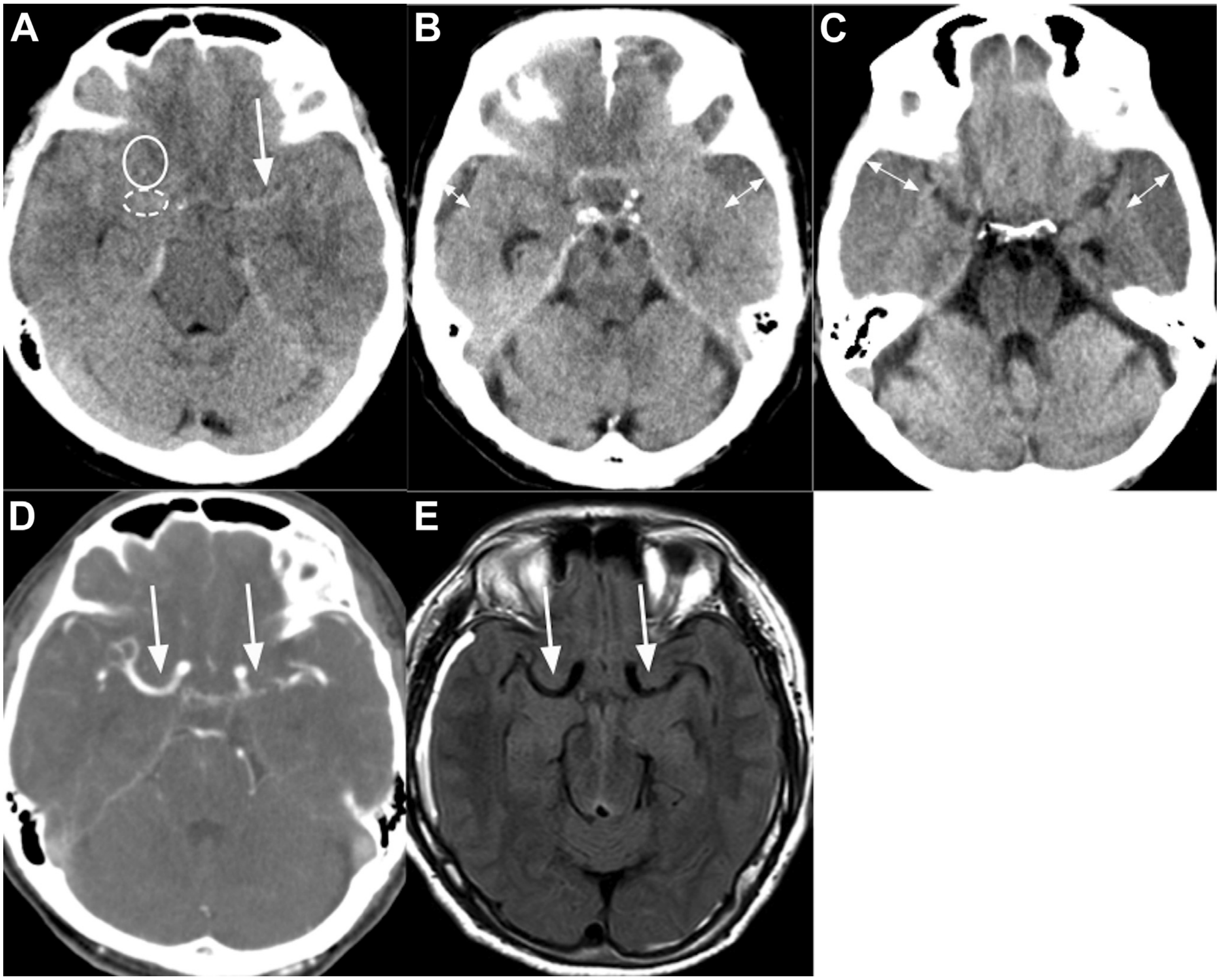

Figure 1. Images of 3 types of chronic subdural hematoma with basal cistern effacement. (**A**) Computed tomography (CT) image of pseudo–subarachnoid hemorrhage (SAH) with high density in the Sylvian cistern (*arrow*). Maximum densities are measured in regions of interest on (*dotted circle*) and adjacent to (*circle*) the Sylvian cistern. Subdural hematoma is not evident on the CT slice at the Sylvian cistern level. (**B**) CT image of negative pseudo-SAH in chronic subdural hematoma with effacement of the basal and Sylvian cisterns. Bilateral subdural hematomas are demonstrated on a slice at the level of the Sylvian cistern (*double arrows*). (**C**) CT image of Sylvian cistern patency. A slice at the level of the Sylvian cistern shows the largest hematomas among 3 types of basal cistern effacement (*double arrows*). (**D**) CT angiography axial image of pseudo-SAH shows the M1 segment of the middle cerebral artery in flattened Sylvian cisterns (*arrows*). (**E**) Magnetic resonance imaging fluid attenuated inversion recovery sequence of pseudo-SAH shows linear low intensities caused by flow void in M1 (*arrows*).

and 11.3 ± 4.1 mm. Multiple comparisons corrected using the Holm method demonstrated that subdural hematoma thickness significantly differed among the 3 types of basal cistern effacement ($P < 0.05$).

DISCUSSION

Basal Cistern Effacement in CSDH

Predictors of basal cistern effacement were younger age, bilateral hematomas, and CSF leak. The predictors seemed to be associated with basal cistern effacement for the following reasons. Younger patients tended to have a larger brain volume, which could more easily cause obliteration of the basal cistern. Both bilateral CSDH and CSF leak cause a caudal shift of the brain, which results in obliteration of the basal cistern. Postoperative complications that might have been related to caudal displacement of the brain occurred more frequently in patients with basal cistern effacement than in other patients. Therefore, postoperative causes of basal cistern effacement should be carefully assessed. The present study found that outcomes at discharge did not differ between patients with and without basal cistern effacement, in contrast to patients with acute brain injury and basal cistern effacement.[1,2]

Table 1. Comparisons Between Patients with Chronic Subdural Hematoma Accompanied or Not by Basal Cistern Effacement on Computed Tomography

	Basal Cistern Effacement			Multivariate Analysis	
	Yes (n = 24)	No (n = 645)	Univariate Analysis, P	P	OR (95% CI)
Age, years	62.6 ± 18.7	74.4 ± 12.2	<0.0001*	0.0086*	0.95 (0.93—0.99)
Male sex	14 (58.3%)	459 (71.2%)	0.1751		
CT findings					
Bilateral hematoma	21 (87.5%)	218 (33.8%)	<0.0001*	<0.0001*	11.9 (3.7—55.0)
Midline shift, mm	4.4 ± 4.5	7.2 ± 4.2	0.0014*		
Previous status					
CSF leak	7 (29.2%)	1 (0.2%)	<0.0001*	0.0002*	41.5 (5.9—847.6)
Dementia	6 (25%)	70 (10.9%)	0.0323*		
Malignancy	0 (0%)	61 (9.5%)	0.0966		
Liver disease	2 (8.3%)	41 (6.4%)	0.6982		
Alcohol consumption	10 (41.7%)	136 (21.2%)	0.0170*		
Previous trauma ≥3 weeks	8 (33.3%)	336 (52.1%)	0.0710		
Antiplatelet use	0 (0%)	118 (18.3%)	0.0087*		
Anticoagulant use	1 (4.2%)	62 (9.6%)	0.3203		
Interval from onset to admission, days	15.1±16.2	9.2±12.8	0.0352*		
Status					
GCS score ≤12	6 (25%)	76 (11.8%)	0.0525		
GCS score ≤8	4 (16.7%)	32 (5.0%)	0.0347*		
Headache	13 (54.2%)	159 (24.7%)	0.0012*		
Pupillary abnormality	1 (4.2%)	11 (1.7%)	0.9346		
Paresis	10 (41.5%)	494 (76.8%)	0.0004*		
Outcome					
Surgical complications	3 (12.5%)	20 (3.1%)	0.0448*		
Good outcome	18 (75%)	449 (69.6%)	0.5724		
Recurrence	7 (29.2%)	89 (13.8%)	0.0976		

Values are reported as mean ± SD or number (%).
OR, odds ratio; CI, confidence interval; CT, computed tomography; CSF, cerebrospinal fluid; GCS, Glasgow Coma Scale.
*Significant difference.

Pseudo-SAH in CSDH

Among the patients with effaced basal and Sylvian cisterns, the representative characteristics of pseudo-SAH were younger age, CSF leak, and thin subdural hematoma on CT slices at the level of the Sylvian cistern. Relationships between these characteristics and other significantly different clinical factors between patients with and without pseudo-SAH were suspected for the following reasons. Younger patients usually have a relatively large brain volume in the calvaria. Thus, if a hematoma compresses the brain, the basal and Sylvian cisterns will tend to be obliterated in younger, rather than in older, patients. Younger patients have other relevant factors, such as more RBCs and less dementia. Sylvian cistern densities were not different between patients with and without pseudo-SAH; therefore, a higher RBC count was insufficient to cause hyperdensity in the M1 segment of the MCA on CT. Half of the patients with pseudo-SAH in our series had CSDH associated with CSF leaks. Pseudo-SAH in patients with CSF leaks has been reported.[6,15-17] Outcomes, including mRS score at discharge and recurrence after discharge, significantly differed between patients with an effaced basal cistern accompanied or not by pseudo-SAH. In several patients with CSDH and pseudo-SAH on CT, SAH has been misdiagnosed, and the patients have undergone angiography[9,13] and/or clipping of an unruptured incidental aneurysm.[12] Confirmation using MRI fluid attenuated inversion recovery sequence and measuring Sylvian cistern density on CT might help to prevent such misdiagnosis in

Table 2. Comparisons Between Patients with and without Pseudo—Subarachnoid Hemorrhage on Computed Tomography of Patients with Basal and Sylvian Cistern Effacement

	Pseudo-SAH		
	Yes (n = 12)	No (n = 7)	Univariate Analysis, P
Age, years	49.1 ± 11.9	68.9 ± 13.2	0.0037*
Male sex	9 (75%)	4 (57.1%)	0.3785
CT findings			
Hematoma thickness on Sylvian cistern slice, mm	0.3 ± 0.7	6.1 ± 5.6	0.0024*
Maximum density of Sylvian fissure, HU	53.3 ± 3.9	51.3 ± 3.9	0.3054
Maximum density adjacent to Sylvian fissure, HU	42.7 ± 2.4	48.6 ± 4.0	0.0008*
Previous status			
CSF leak	6 (50%)	0 (0%)	0.0341*
Dementia	0 (0%)	3 (42.9%)	0.0361*
Previous trauma ≥3 weeks	6 (50%)	1 (14.3%)	0.1441
Interval from onset to admission, days	21.6 ± 15.9	13.8 ± 18.3	0.3722
Status			
GCS score ≤12	2 (16.7%)	2 (28.6%)	0.4750
Headache	9 (75%)	3 (42.9%)	0.1820
Paresis	2 (16.7%)	3 (42.9%)	0.2366
Blood tests			
RBC count, $\times 10^4$/mm^3	472 ± 33	393 ± 39	0.0002*
Albumin, g/dL	4.3 ± 0.3	3.8 ± 0.5	0.0176*
Outcome			
Surgical complications	1 (8.3%)	2 (28.6%)	0.2962
Good outcome	11 (91.7%)	5 (71.4%)	0.2962
Recurrence	4 (33.3%)	2 (28.6%)	0.7616

Values are reported as mean ± SD or number (%).
SAH, subarachnoid hemorrhage; CT, computed tomography; HU, Hounsfield units; CSF, cerebrospinal fluid; GCS, Glasgow Coma Scale; RBC, red blood cell.
*Significant difference.

patients with CSDH and a Sylvian fissure with apparently high density.[5]

Mechanisms of Pseudo-SAH in CSDH

Reported causes of pseudo-SAH in various diseases, including hypoxic brain injury, meningoencephalitis, and mass lesions, include decreased brain density surrounding the cistern[3-5,18] and/or an increase of subarachnoid space density[5,18,19] associated with subarachnoid space disappearance.[6,9,11] In the present comparison of densities on CT between basal and Sylvian cistern effacement with and without pseudo-SAH, the density adjacent to the Sylvian cistern was lower in patients with pseudo-SAH, whereas the Sylvian cistern density did not differ. Based on MRI and CT angiography axial images, the appearance of pseudo-SAH was partly due to high density in the M1 segment of the MCA.[11]

The occurrence of pseudo-SAH might be related to the thickness of a subdural hematoma on CT slices at the level of the Sylvian cistern. The anterior perforating substance located just above M1 in the Sylvian cistern belongs to the paleocortex. Because the paleocortex is thinner than the neocortex, white matter dominates this area.[20] When the brain was mainly compressed by vertically located hematomas, caudal displacement of the brain obliterated the Sylvian cistern, which was surrounded by the white matter with relatively low density (Figure 3A). Hematomas on CT slices at the level of the Sylvian cistern were thinner in patients with hematomas restricted to the vertex area. Caudally extending subdural hematomas appeared thicker on CT slices at the level of the Sylvian cistern, and the frontal and temporal lobes that were compressed by the hematoma from the front and temporally moved in the occipital-medial direction. Thereafter, cortical gray matter with relative high density surrounded the Sylvian cistern because both the orbitofrontal cortex in the frontal base and the temporal pole cortex were displaced, which covered the Sylvian cistern

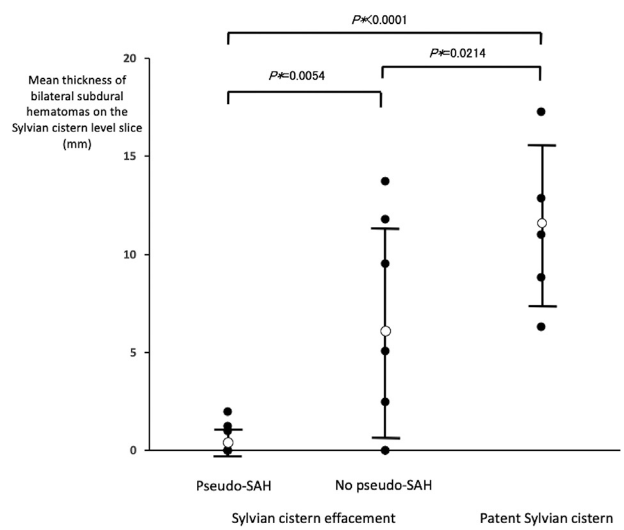

Figure 2. Relationships between types of basal cistern effacement and mean thickness of bilateral hematomas on a computed tomography slice at the level of the Sylvian cistern. Multiple comparisons using Holm correction show that hematoma thickness significantly differs among 3 types of basal cistern effacement. *Significant difference ($P < 0.05$). SAH, subarachnoid hemorrhage.

(Figure 3B). The hematomas on CT slices at the level of the Sylvian cistern were thickest among patients with an effaced basal cistern and a patent Sylvian cistern. Caudal displacement of the brain caused by pressure from a vertex hematoma was buffered by a shift of liquescent hematoma blood into the caudal region. This type of brain displacement would not be sufficient to obliterate the Sylvian cistern.

Limitations

This study has limitations associated with the nature of the retrospective design. Because CT imaging proceeded with 5-mm thickness, when the basal and/or Sylvian cisterns were not completely obliterated, they could appear to be effaced on CT images. We defined mRS score 0 as a good outcome because most patients with CSDH usually completely recovered after surgery. When a patient had premorbid impairment with mRS score ≤1, the effect of CSDH was overestimated.

CONCLUSIONS

Approximately 1 in 30 patients with CSDH showed basal cistern effacement on CT, and half of the basal cistern effacement was associated with pseudo-SAH. Characteristics associated with basal cistern effacement and pseudo-SAH included younger age, CSF leak, bilateral hematomas, and a thin hematoma on

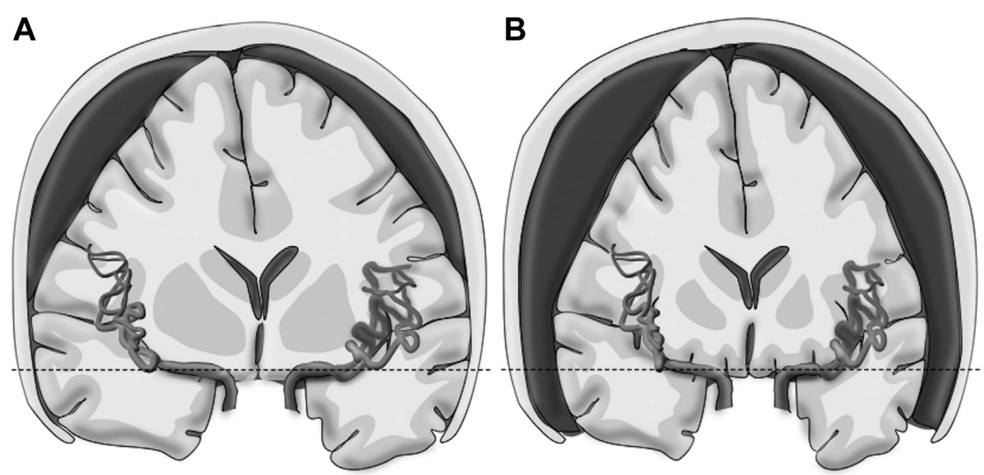

Figure 3. Mechanism of pseudo–subarachnoid hemorrhage (SAH) in chronic subdural hematoma with basal and Sylvian cistern effacement. (**A**) Coronal brain schema of pseudo-SAH. Subdural hematoma is not visible on a computed tomography (CT) slice at the Sylvian cistern level (*dotted line*). Bilateral hematomas restricted to the vertex displace the entire brain in the caudal direction. Thereafter, the compressed and obliterated cistern becomes surrounded by caudally displaced white matter. On CT, the relatively high density of the M1 segment of the middle cerebral artery is enhanced by the relatively low density of the surrounding white matter, which results in the appearance of high density in the Sylvian cistern, termed pseudo-SAH. (**B**) Coronal brain schema of non–pseudo-SAH. Subdural hematomas extend caudally beyond the Sylvian cistern level (*dotted line*). Frontal and temporal lobes that are compressed by the hematoma from the vertex and the front have moved in the occipital-medial direction, and cortical gray matter of the orbitofrontal and temporal pole cortices surround M1. The density of gray matter is relatively higher than the density of white matter on the CT image. Therefore, the high density of M1 becomes inconspicuous, and pseudo-SAH does not appear.

CT slices at the level of the Sylvian cistern. The main mechanism of a pseudo-SAH was the relatively high density of the M1 segment of the MCA in an obliterated Sylvian cistern, which is surrounded by white matter with relative low density, thus resembling a true SAH. Although outcomes and recurrence rates of patients with an effaced basal cistern were not worse than those of any other patients assessed, more frequent surgical complications among the patients with basal cistern effacement required extremely vigilant postoperative observation.

REFERENCES

1. Toutant SM, Klauber MR, Marshall LF, et al. Absent or compressed basal cisterns on first CT scan: ominous predictors of outcome in severe head injury. *J Neurosurg*. 1984;61:691-694.

2. Aarabi B, Tofighi B, Kufera JA, et al. Predictors of outcome in civilian gunshot wounds to the head. *J Neurosurg*. 2014;120:1138-1146.

3. Hasan TF, Duarte W, Akinduro OO, et al. Nonaneurysmal "pseudo-subarachnoid hemorrhage" computed tomography patterns: challenges in an acute decision-making heuristics. *J Stroke Cerebrovasc Dis*. 2018;27:2319-2326.

4. Lee BK, Kim YJ, Ryoo SM, et al. "Pseudo-subarachnoid hemorrhage sign" on early brain computed tomography in out-of-hospital cardiac arrest survivors receiving targeted temperature management. *J Crit Care*. 2017;40:36-40.

5. Given CA 2nd, Burdette JH, Elster AD, Williams DW 3rd. Pseudo-subarachnoid hemorrhage: a potential imaging pitfall associated with diffuse cerebral edema. *AJNR Am J Neuroradiol*. 2003;24:254-256.

6. Ferrante E, Regna-Gladin C, Arpino I, et al. Pseudo-subarachnoid hemorrhage: a potential imaging pitfall associated with spontaneous intracranial hypotension. *Clin Neurol Neurosurg*. 2013;115:2324-2328.

7. Huang D, Abe T, Ochiai S, et al. False positive appearance of subarachnoid hemorrhage on CT with bilateral subdural hematomas. *Radiat Med*. 1999;17:439-442.

8. Ohno S, Ikeda Y, Onitsuka T, Nakajima S, Haraoka J. Bilateral chronic subdural hematoma in a young adult mimicking subarachnoid hemorrhage [in Japanese]. *No To Shinkei*. 2004;56:701-704.

9. Rabinstein AA, Pittock SJ, Miller GM, Schindler JJ, Wijdicks EF. Pseudosubarachnoid haemorrhage in subdural haematoma. *J Neurol Neurosurg Psychiatry*. 2003;74:1131-1132.

10. Shima H, Shirokane K, Baba E, Tsuchiya A, Nomura M. Bilateral chronic subdural hematoma presenting with pseudo-subarachnoid hemorrhage sign on computed tomography. *Asian J Neurosurg*. 2019;14:510-512.

11. Shimizu S, Endo M, Kan S, Kitahara T, Ohwada T, Fujii K. Tight Sylvian cisterns associated with hyperdense areas mimicking subarachnoid hemorrhage on computed tomography—four case reports. *Neurol Med Chir (Tokyo)*. 2001;41:536-540.

12. Son D, Kim Y, Kim C, Lee S. Pseudo-subarachnoid hemorrhage: chronic subdural hematoma with an unruptured aneurysm mistaken for subarachnoid hemorrhage. *Korean J Neurotrauma*. 2019;15:28-33.

13. Tokuno T, Sato S, Kawakami Y, Yamamoto T. Bilateral chronic subdural hematomas presented with subarachnoid hemorrhage: report of two cases [in Japanese]. *No Shinkei Geka*. 1996;24:573-576.

14. Honda Y, Sorimachi T, Momose H, Takizawa K, Inokuchi S, Matsumae M. Chronic subdural haematoma associated with disturbance of consciousness: significance of acute-on-chronic subdural haematoma. *Neurol Res*. 2015;37:985-992.

15. Schievink WI, Maya MM, Tourje J, Moser FG. Pseudo-subarachnoid hemorrhage: a CT-finding in spontaneous intracranial hypotension. *Neurology*. 2005;65:135-137.

16. Koh E, Huang SH, Lai YJ, Hong CT. Spontaneous intracranial hypotension presenting as pseudo-subarachnoid hemorrhage on CT scan. *J Clin Neurosci*. 2011;18:1264-1265.

17. Yokota H, Yokoyama K, Nakase H. Spontaneous intracranial hypotension with pseudo-subarachnoid hemorrhage. *Acta Neurol Belg*. 2016;116:643-644.

18. Cucchiara B, Sinson G, Kasner SE, Chalela JA. Pseudo-subarachnoid hemorrhage: report of three cases and review of the literature. *Neurocrit Care*. 2004;1:371-374.

19. Ho AL, Sussman ES, Pendharkar AV, et al. Practical Pearl: use of MRI to differentiate pseudo-subarachnoid hemorrhage from true subarachnoid hemorrhage. *Neurocrit Care*. 2018;29:113-118.

20. Serra C, Akeret K, Maldaner N, et al. A white matter fiber microdissection study of the anterior perforated substance and the basal forebrain: a gateway to the basal ganglia? *Oper Neurosurg (Hagerstown)*. 2019;17:311-320.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 7 August 2019; accepted 30 August 2019

Citation: World Neurosurg. (2019) 132:e109-e115.
https://doi.org/10.1016/j.wneu.2019.08.249

Journal homepage: ***www.journals.elsevier.com/world-neurosurgery***

Available online: ***www.sciencedirect.com***