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Clinical Article

Acute Aneurysmal Subdural Hematoma : Clinical and Radiological Characteristics

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Objective : Acute spontaneous subdural hematoma(SDH) secondary to a ruptured intracranial aneurysm is a rare event. The authors present nine cases with aneurysmal SDH.

Methods : We analyzed nine cases of aneurysmal SDH from 337 patients who underwent treatment for a ruptured aneurysm between January 1998 and May 2004. Clinical and radiological characteristics and postoperative course were evaluated by reviewing medical records, surgical charts and intraoperative videos.

Results : The nine patients comprised four males and five females with a mean age of 53years (range 15-67years). The World Federation of Neurosurgical Societies grades on admission were I in one patient, II in two patients, III in five patients and V in one patient. With respect to location, there were four internal carotid-posterior communicating artery(ICA-Pcom) aneurysms, one distal anterior cerebral artery(DACA) aneurysm, one anterior communicating artery and three middle cerebral artery aneurysms. CT scans obtained from the four patients with ICA-Pcom aneurysms revealed SDH over the convexity and along the tentorium, and two of these patients presented with pure SDH without subarachnoid hemorrhage(SAH). In three patients with ICA-Pcom aneurysm, the ruptured aneurysm domes adhered to the petroclinoid fold. In the patient with the DACA aneurysm, the domes adhered tightiy to the pia mater and the falx.

Conclusion : Ruptured intracranial aneurysm may cause SDH with or without SAH. In the absence of trauma, the possibility of aneurysmal SDH should be considered.

KEY WORDS : Cerebral aneurysm · Subdural hematoma.

Introduction

Acute subdural hematoma(SDH) usually occurs after head trauma. However, it may also be an uncommon manifestation of a ruptured intracranial artery aneurysm[1-3,5-7,11-14,17-24]. The reported incidence of acute aneurysmal SDH varies from 0.5% to 7.9%[5,6,15,20]. It may lead clinicians to misdiagnosis and inappropriate management, especially in cases of pure aneurysmal SDH without subarachnoid hemorrhage(SAH). To our knowledge, fewer than 45 patients of pure aneurysmal SDH have been reported[5,11,12,18,20,24]. Here we report our experience with nine cases of aneurysmal SDH and describe their clinical and radiological characteristics.

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Materials and Methods

We retrospectively reviewed medical records of 337 patients who were treated for intracranial aneurysm between January 1998 and May 2004. Nine patients had acute SDH secondary to the rupture of an intracranial aneurysm. All patients underwent surgical intervention. Clinical characteristics and postoperative course were evaluated by reviewing medical records, surgical charts and intraoperative videos. Postoperative outcome was evaluated based on the Glasgow Outcome Scale (GOS). We reviewed radiological examinations, including computed tomography(CT), three-dimensional(3D) CT angiography and conventional angiography, with an emphasis on differential diagnosis of SDH from other etiologies, for example, trauma and other vascular malformations.

Table 1. Clinical data from patients with aneurysmal subdural hematoma

Case	Age(yrs)/Sex	WFNS grade	Presence of SAH	Location of aneurysm	Treatment	GOS
1	45/F	II	−	Right ICA−Pcom	Craniotomy & clipping	SD
2	15/M	V	−	Right ICA−Pcom	Craniectomy & clipping	Death
3	58/F	III	+	Left DACA	Craniectomy & clipping	Good
4	63/F	I	−	Left MCA	Craniectomy & clipping	MD
5	63/F	III	+	Left ICA−Pcom	Craniotomy & clipping	MD
6	58/M	III	+	Right ICA− Pcom	Craniotomy & clipping	MD
7	67/M	II	+	Acom	Craniotomy & clipping	Good
8	45/F	III	+	Right MCA	Craniectomy & clipping	Good
9	66/M	III	+	Right MCA	Craniotomy & clipping	Good

ICA : internal carotid artery, Pcom : posterior communicating artery, DACA : distal anterior cerebral artery, Acom : anterior communicating artery, MCA : middle cerebral artery, PCA : posterior cerebral artery, SD : severe disability, MD : Moderate disability, WFNS : World Federation of Neurosurgical Societies, GOS : Glasgow Outcome Score

Results

The medical records of five female and four male patients with a mean age of 52years (range 15~67years) were reviewed. The World Federation of Neurosurgical Societies (WFNS) grade on admission was I in one patient, II in two patients, III in five patients and V in one patient. The aneurysms that caused SDH were located on the internal carotid-posterior communicating artery(ICA-Pcom) junction in four patients, the distal anterior cerebral artery and anterior communicating artery (Acom) in one patient each, and the middle cerebral artery(MCA) in three patients. ICA-Pcom was the most common site. The aneurysms ranged in size from 5 to 12mm (median 7mm and mean 6.57mm). In all patients with ICA-Pcom aneurysms, CT scans demonstrated an acute aneurysmal SDH over the cerebral convexity and along the tentorium. In the patient with DACA aneurysm, CT scan revealed SDH over the convexity, tentorium cerebelli and along the falx. Six patients had SDH in combination with SAH or intracerebral hemorrhage, and three patients had pure SDH. In three patients with ICA-Pcom aneurysm, the ruptured domes adhered to the petroclinoid fold.

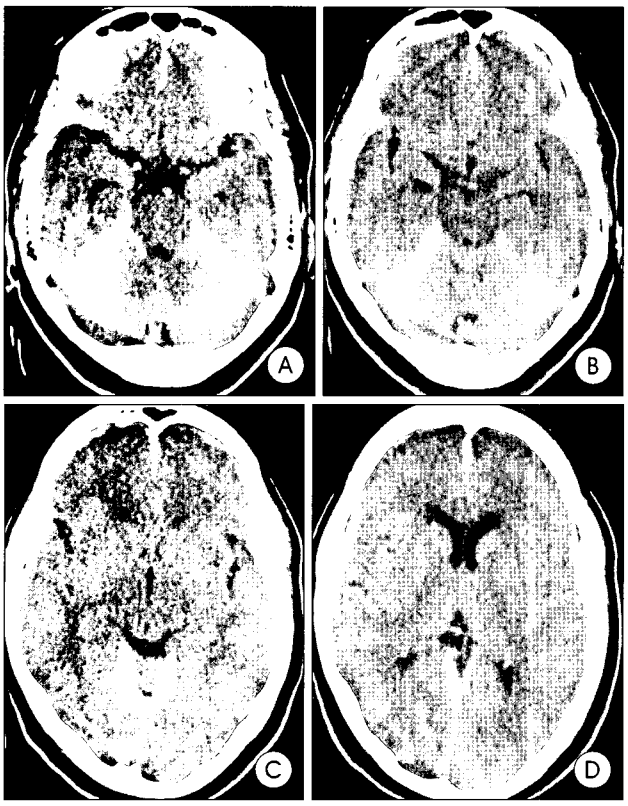

Fig. 1. A−D : Brain computed tomography scans of patient 1, taken immediately after arrival in the emergency room, showing a subdural hematoma along the tentorium, and over both cerebral convexities. There is no evidence of subarachnoid hemorrhage.

In the patient with the DACA aneurysm, the dome adhered tightly to the pia mater and the falx. The outcomes were good recovery in four patients, moderate disability in three patients, severe disability in one patient, and death in one patient. Early rebleeding occurred in the latter two patients (Patients 1 and 2 respectively). These two patients showed poor outcomes. The clinical characteristics and treatment-related data are summarized in Table 1.

Illustrative Cases

Patient 1

A 45-year-old woman presented with a history of sudden bursting headache and a transient episode of loss of consciousness. There was no history of head trauma. Neurological examination revealed no neurological deficits except mild confused mentality. Laboratory data, including coagulation parameters did not show abnormalities. A CT scan revealed an acute SDH over both cerebral convexities and along the tentorium, but no evidence of SAH (Fig. 1). The patient was treated conservatively; however, her neurological status suddenly deteriorated two days after admission. A repeat CT scan showed SAH in the basal and sylvian cisterns (Fig. 2). Conventional angiography revealed an ICA-Pcom aneurysm that projected postero-laterally (Fig. 3). Emergency pterional craniotomy was performed and the aneurysm successfully clipped. The dome was located on the anterior petroclinoid fold and was adhered tightly to the tentorial surface. She was discharged with severe disability.

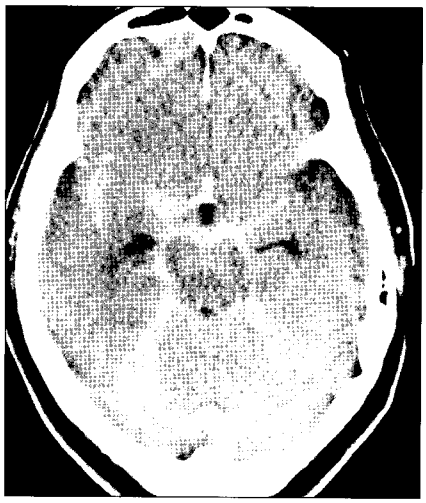

Fig. 2. Brain computed tomography scan of patient 1 obtained after neurological deterioration showing a thick subarachnoid hemorrhage in the basal, perimesencephalic and sylvian cisterns.

Fig. 3. Right oblique carotid angiogram of patient 1 showing a saccular aneurysm (arrow) at the right internal carotid-posterior communicating artery junction, with the aneurysmal dome projecting posterolaterally.

Patient 2

A 15-year-old boy with no history of head trauma was referred with comatose mentality to our institution. Six hours before arrival, he had presented at a local clinic with severe haedache, but was conscious, oriented and obeyed all commands. A CT scan obtained at that time showed an acute SDH over the right cerebral hemisphere and along the tentorium, which caused mass effect with ventricular compression and displacement (Fig. 4). However, the CT revealed no recognizable SAH. Four hours later, he suddenly became comatose and was referred to our emergency room. A CT scan taken immediately after arrival demonstrated intraventricular hemorrhage and SDH with a marked midline shift (Fig. 5). Three-dimensional CT angiography showed an ICA-Pcom aneurysm (Fig. 6). Emergency craniectomy was performed, the SDH was evacuated, an extraventricular drain catether was inserted through the Painne's point and the aneurysm was clipped. The dome was adherent to the petroclinoid folds. The patient died from severe brain swelling 10 days later.

Patient 3

A 58-year-old woman presented with severe headache and paraparesis (Grade III). She was referred to the emergency room with a Glasgow Coma Scale(GCS) of 13. A CT scan revealed SDH over the right convexity and along the tentorium, interhemispheric SDH and intraparenchymal hematoma (Fig. 7). Conventional angiography showed a DACA aneurysm that projected posterolaterally (Fig. 8). Bifrontal craniectomy was performed, the SDH was evacuated and the aneurysm was successfully clipped. The aneurysm was buried in the right frontal lobe and a portion of the aneurysmal dome adhered to the falx. Postoperative course was uneventful. Two months later, the patient recovered fully and was discharged without neurological deficits.

Patient 4

A 63-year-old woman suffered headache seven days before admission. Brain CT scan and MRI demonstrated a thin SDH over the left cerebral hemisphere and the tentorium (Fig. 9). There were no evidences of SAH. Five hours later, she suddenly became comatose (Glasgow Coma Scale : eye opening 1, verbal response 1, motor response 1, total score 4). Brain CT scan obtained at that time revealed a thick SDH (Fig. 10). Emergency craniotomy was performed and the SDH evacuated. Postoperatively, she showed a rapid neurological recovery (Glasgow Coma Scale: eye opening 3, verbal response 3, motor response 5, total score 11) .

One day later, however, she became comatose. Brain CT scan obtained after neurological deterioration showed a thick SDH with a marked midline shift (Fig. 10). Emergency craniectomy was performed and the SDH was removed. MCA bifurcation aneurysm was identified. The dome was tightly adhered to the sphenoid ridge and the adjacent sylvian arachnoid was noticed to be torn. The aneurysm was clipped. One month later, she was discharged with moderate disability.

Discussion

Acute SDH is usually caused by traumatic disruption of superficial cerebral veins such as the bridging veins draining into the sinus. However, intracranial aneurysmal rupture may cause acute SDH with or without radiological evedences of SAH[1-3,5-7,11-15,16-20,22,24]. The reported incidence of spontaneous SDH due to aneurysmal rupture varies from 0.5% to 7.9%[5,14,15,18-20,22]. In our series of 337 patients, 2.7% presented with aneurysmal SDH. Pure SDH secondary to aneurysmal rupture is extremely rare. To our knowledge, fewer than 45 patients with pure aneurysmal SDH have been reported since 1855[1,5,6,11,13,18-20,24]. In this report, we have added another three patients and described their clinical and neurological characteristics. Furthermore, we have reported six patients

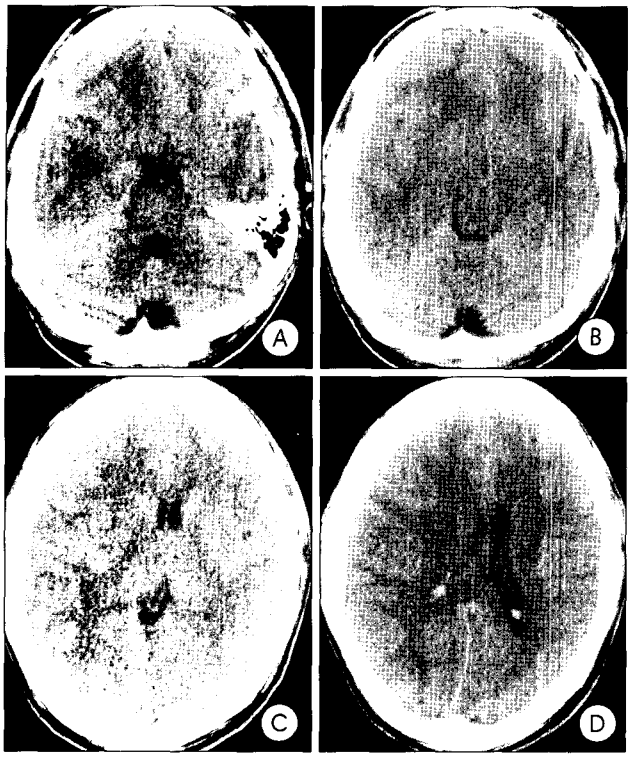

Fig. 4. A–D : Brain computed tomography scans of patient 2 taken before neurological deterioration, showing a thin subdural hematoma over the right cerebral hemisphere and along the tentorium with midline shift.

who presented with aneurysmal SDH combined with SAH. Three mechanisms have been proposed to explain the causes of SDH after rupture of saccular aneurysms[5,12,13,16,18,19,24]: (1) successive small hemorrhages (sentinel hemorrhages) result in adhesions forming between the aneurysm and the arachnoid, which create a path from the dome to the subdural space and the final rupture occurs in the subdural space; (2) the high pressure emanating from the ruptured aneurysm causes tearing of the arachnoid membrane through which blood extravasates into the subdural space; and (3) a massive hemorrhage results in rupture of the cortex and arachnoid membrane. Usually, evidence of sentinel bleeding is suspected from the patient's history[8,9], however, it is difficult to prove that headache before SAH is associated with a warning leak.

Four of our patients (Patients 1-4) had a history of probable warning headache one to three weeks before presentation, which suggested sentinel bleeding. Many patients reported previously also had a history of warning headache[5,19,20], supporting the theory that small successive bleeds and subsequent adhesion cause aneurysmal SDH. Other patients have presented with SDH in combination with SAH, which supports the theory that high pressure from the ruptured aneurysm causes SDH with or without SAH. Patients with

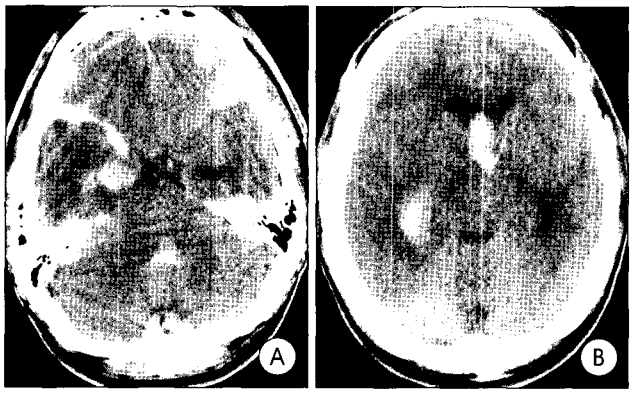

Fig. 5. A, B : Brain computed tomography scans of patient 2 taken after neurological deterioration, showing intraventricular hemorrhage and subdural hematoma with significant mass effect.

aneurysmal SDH generally show poor pre-operative clinical characteristics and have poor post-operative outcomes[5,6,17,18,20], the two may be directly related. However, in our patients, pre-operative characteristics were not as poor and poor outcomes were directly related to the occurrence of rebleeding; for example, rebleeding occurred in Patients 1 and 2 before surgical or endovascular intervention.

Early rebleeding may be partly attributable to the physician's lack of knowledge of aneurysmal SDH. Accurate diagnosis is difficult, especially in cases of pure aneurysmal SDH. Differential diagnosis between traumatic SDH and aneurysmal SDH may be almost impossible. Thus, acute SDH in the absence of head trauma requires further evaluation to define its cause[3,5]. It may be essential to consider other probable causes in situations where the severity of head injury seems disproportionately mild compared with radiological evidence showing massive SDH with or without SAH[5]. About 170 patients with aneurysmal SDH with or without SAH have been reported[1-3,5-7,11-15,17-24], and ICA aneurysms were most common, followed by MCA and ACA aneurysms. In our patients, ICA-Pcom aneurysms were most frequent. The CT scans of patients with ICA-Pcom aneurysms showed

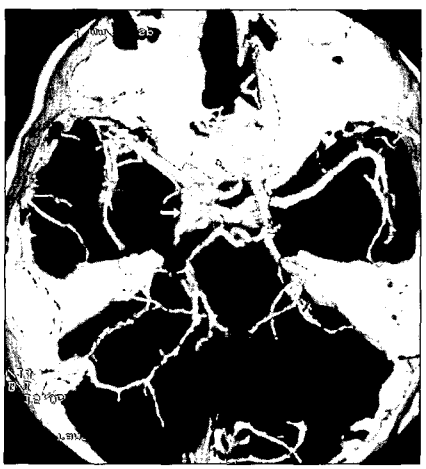

Fig. 6. Three-dimensional computed tomographic angiography of patient 2 showing a saccular aneurysm (arrow) at the right internal carotid-posterior communicating artery junction.

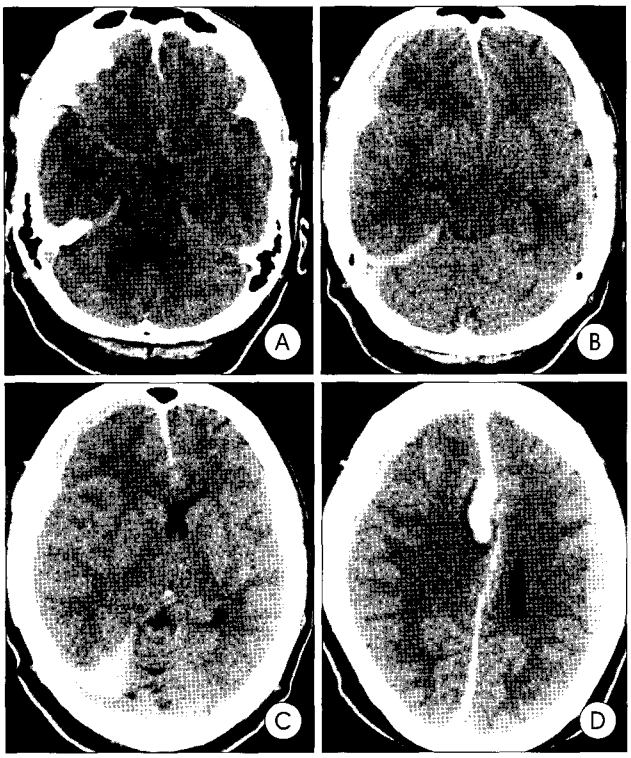

Fig. 7. A–D : Computed tomography scans of patient 3 showing a subdural hematoma in the right convexity, interhemispheric fissure and on the tentorium, and a small amount of subarachnoid hemorrhage in the basal cistern.

SDH both over the convexity and along the tentorium. During surgery, the anatomical features of the aneurysm were confirmed. The dome of the aneurysm was located in the anterior petroclinoid fold and adhered to adjacent structures in the patients with ICA-Pcom aneurysm. In the patient with the DACA aneurysm, the bleeding point adhered to the pia mater and the falx. Yu et al reported a case of pure aneurysmal SDH. They said that abnormally elongated artery might be related to the adhesion and rupture of aneurysm to the subdural space. In our case, the aneurysm itself is elongated and in contact with the falx. In the patients with DACA aneurysm, elongated artery and/or aneurysm may be the causative factor for aneurysmal SDH. Continuity of SDH between the convexity and tentorium was demonstrated in patients with ICA-Pcom aneurysms and continuity of SDH between the convexity and interhemispheric fissure was noted in the patient with a DACA aneurysm. The falx and tentorium is in continuity with the dura mater. The locations of aneurysm causing SDH are near the falx and tentorium. Nonaka et al[18] suggested that these characteristic CT findings might be an indicator for differentiation of aneurysmal SDH from traumatic SDH. Four patients with pure tentorial SDH secondary to aneurysmal rupture have been reported[14]. Therefore, SDH along the tentorium without a history of head trauma requires further neuroradiological investigation, for example, by 3D CT angiography, magnetic resonance angiogram(MRA) and conventional angiography. Several authors recommend angiographic examination if the blood clot is present in more than one of the subdural, subarachnoid, or intracerebral compartments[3,5,17,18].

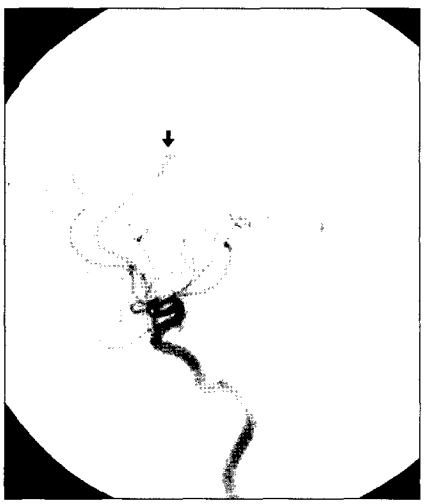

Fig. 8. Left lateral carotid angiogram of patient 3 showing an aneurysm at the distal anterior cerebral artery with the aneurysmal dome projecting posteriorly.

Multicompartmental hemorrhage may support the theories that high pressure emanating from the ruptured aneurysm or massive hemorrhage causes an aneurysmal SDH. Three-dimensional CT angiography is regarded as the best investigative technique for differntiating aneurysmal SDH if the patient is in poor clinical condition[4,10,16,22]. Conventional four vessel angiography is the gold standard for detecting the presence of an aneurysm; however, it is time consuming and not safer than 3D CT angiography, particularly in poor grade patients[4,10,16,22]. Recent studies have suggested that 3D CT angiography is equal or superior to the conventional angiography in characterizing aneurysms for surgical planning[10,14,16]. Whether angiography should be performed before surgery for SDH is somewhat controversial.

Rengachary and Szymanski[21] insisted that it is unnecessary because of the low incidence of SDH secondary to an aneurysmal rupture. However, some authors recommend angiography in patients with SDH that is suspected to be arterial in origin[5,17,18,20]. Based on the previous reports and our clinical experiences, we recommend 3D CT angiography in patients with (1) acute SDH and no history of head trauma, (2) SDH and a history of probable sentinel bleeding, (3) rapidly progressing symptoms and sings that suggest bleeding of arterial origin, or (4) mild head trauma whose CT findings show disproportionately massive SDH with or without SAH. We also recommend 3D CT angiography in patients with spontaneous, nontraumatic SDH whose CT scan shows (1) SDH over the convexity and along the tentorium or the falx,

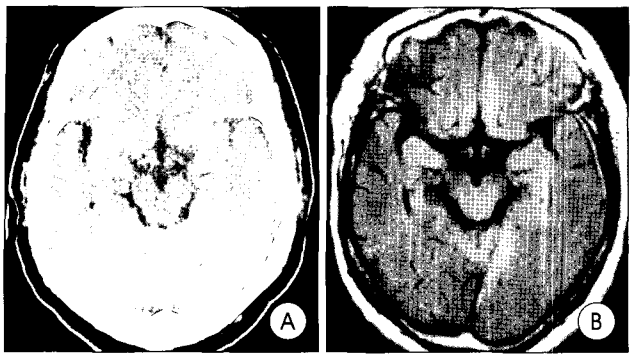

Fig. 9. A : Brain computed tomography scan of patient 4 showing a thin subdural hematoma over the left temporal convexity and the tentorium. B : Fluid attenuated inversion recovery magnetic resonance image showing a thin subdural hematoma over the left temporal convexity and along the left tentorium. There was no evidence of subarachnoid hemorrhage.

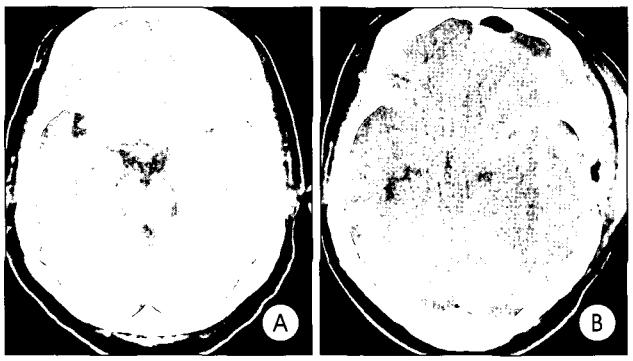

Fig. 10. A : Brain computed tomography scan of patient 4 obtained after neurological deterioration showing a thick subdural hematoma over the left convexity and the tentorium. B : Post-operative computed tomography scan showing a thick subdural hematoma with a marked midline shift.

(2) multicompartmental hematoma, (3) pure SDH over the tentorium, or (4) pure SDH in the interhemispheric fissure. In this study, we performed surgical intervention in all patients and confirmed the presence of the aneurysm. The patients showed relatively good outcomes except two in whom early rebleeding occurred. Early detection using 3D CT angiography and appropriate surgical intervention are mandatory to achieve good outcomes in patients with aneurysmal SDH.

Conclusion

The authors present nine patients with aneurysmal SDH. Rupture of an aneurysm may cause a SDH with or without SAH. Therefore, clinicians should be aware of the possibility of aneurysmal SDH to avoid misdiagnosis and mismanagement. Characteristic CT findings and clinical history may be helpful for differential diagnosis. Three dimensional CT angiography is a very useful tool for early detection of aneurysm even in the patient with poor clinical grade.

References

1. Barton B, Tudor J : Subdural haematoma in association with intracranial aneurysm. **Neuroradiology 23** : 157-160, 2000
2. Han YH, Kang SD, Kim JM : Two cases of posterior communicating artery aneurysm complicated by massive subdural hematoma. **J Korean Neurosurg Soc 25** : 1036-1046, 1996
3. Hatayama T, Shima T, Okada Y : Ruptured distal anterior cerebral artery aneurysm presenting with acute subdural hematoma : report of two cases. **Neurol Surg 22** : 577-582, 1994
4. Hsiang JNK, Liang EY, Lam JMK, Zhu XL, Poon WS : The role of computed tomographic angiography in the diagnosis of intracranial aneurysms and emergent aneurysm clipping. **Neurosurgery 38** : 481-487, 1996
5. Inamasu J, Saito R, Nakamura Y, Ichikizaki K, Suga S, Kawase T, et al : Acute subdural hematoma caused by ruptured cerebral aneurysms : diagnostic and therapeutic pitfalls. **Resuscitation 52** : 71-76, 2002
6. Ishibashi A, Yokokura Y, Sakamoto M : Acute subdural hematoma without subarachnoid hemorrhage due to ruptured intracranial aneurysm-case report. **Neurol Med Chir (Tokyo) 37** : 533-537, 1997
7. Ishikawa E, Sugimoto K, Yanaka K, Ayuzawa S, Iguchi M, Moritake T, et al : Interhemispheric subdural hematoma caused by a ruptured internal carotid artery aneurysm. **Case report. Surg Neurol 54** : 82-86, 2000
8. Jakobsson KE, Saveland H, Hillman J, Edner G, Zygmunt S, Brandt L, et al : Warning leak and management outcome in aneurysmal subarachnoid haemorrhage. **J Neurosurg 85** : 995-999, 1996
9. Juvela S : Minor leak before rupture of an intracranial aneurysm and subarachnoid haemorrhage of unknown aetiology. **Neurosurgery 30** : 7-11, 1992
10. Kaminogo M, Hayashi H, Ishimaru H, Morikawa M, Kitagawa N, Matsuo Y, et al : Depicting Cerebral Veins by Three-Dimensional CT Angiography before Surgical Clipping of Aneurysms. **AJNR Am J Neuroradiol 23** : 85-91, 2001
11. Katsuno M, Murai Y, Teramoto A : Acute subdural hematoma without subarachnoid hemorrhage following rupture of a distal anterior cerebral artery aneurysm : a case report. **No To Shinkei 55** : 435-438, 2003
12. Kondziolka D, Bernstein M, Brugge K, Schutz H : Acute subdural hematoma from ruptured posterior communicating artery aneurysm. **Neurosurgery 22** : 151-154, 1988
13. Kong HJ, Choi SK, Byun BJ, Lee IS : Subdural hematoma due to ruptured intracerebral aneurysm. **J Korean Neurosurg Soc 14** : 211-216, 1985
14. Krishnaney AA, Rasmussen PA, Masaryk T : Bilateral tentorial subdural hematoma without subarachnoid hemorrhage secondary to anterior communicating artery aneurysm rupture : A case report and review of the literature. **AJNR Am J Neuroradiol 25** : 1006-1007, 2004
15. Lee KC, Lee HK, Chu JW, Kim CS, Choi YI : Hematoma as a consequence of ruptured intracranial aneurysms. **J Korean Neurosurg Soc 11** : 7-15, 1982
16. Liang EY, Chan M, Hsiang JH : Detection and assessment of intracranial aneurysms : value of CT angiography with shaded surface display. **AJR Am J Roentgenol 165** : 1497-1502, 1995
17. McLaughlin MR, Jho H-D, Kwon Y : Acute subdural hematoma caused by a ruptured giant intracavernous aneurysm : case report. **Neurosurgery 38** : 388-392, 1996
18. Nonaka Y, Kusumoto M, Mori K, Maeda M : Pure acute subdural haematoma without subarachnoid haemorrhage caused by rupture of internal carotid artery aneurysm. **Acta Neurochir (Wien) 142** : 941-944, 2000
19. Nowak G, Schwachenwald S, Kehler U, Muller H, Arnold H : Acute subdural haematoma from ruptured intracranial aneurysms. **Acta Neurochir (Wien) 136** : 163-167, 1995
20. O'Sullivan MG, Whyman M, Steers JW, Whittle IR, Miller JD : Acute

subdural haematoma secondary to ruptured intracranial aneurysm : diagnosis and management. **Br J Neurosurg 8** : 439-445, 1994
21. Rengachary SS, Szymanski DC : Subdural hematomas of arterial origin. **Neurosurgery 8** : 166-172, 1981
22. Shenoy SN, Kumar MG, Raja A : Intracranial aneurysms causing spontaneous acute subdural hematoma. **Neurol India 51** : 422-424, 2003
23. Stephenson G, Gibson M : Acute spontaneous subdural hematoma of arterial origin. **Br J Neurosurg 3** : 225-228, 1989
24. Yu JC, Kim YD, Kang YK, Kim DH, Yeo HT : Pure acute subdural hematoma without subarachnoid haemorrhage caused by rupture of distal anterior cerebral artery aneurysm. **Korean J Cerebrovasc Surg 5** : 147-149, 2003