CLINICAL ARTICLE

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Comparison of Computed Tomography Findings between Aneurysmal and Traumatic Subarachnoid Hemorrhage

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Objective : The purpose of this study is to identify any differential point in computerized tomographic(CT) findings between aneurysmal subarachnoid hemorrhage(ASAH) and traumatic subarachnoid hemorrhage(TSAH), which sometimes make us not confident in differentiation.

Methods : CT of 142 ASAH and 82 TSAH patients over the last 2 years were retrospectively reviewed. We evaluated the thickness of SAH, the laterality of sylvian cisternal hemorrhage, the location, the number of involved cisterns, and the associated other lesions between two types of SAH.

Results : Suprasellar cisterns and sylvian cisterns were most prominently and frequently involved cisterns in ASAH but cortical sulci and sylvian cisterns were most frequently involved in TSAH. Intraventricular and intracerebral hemorrhage were frequently seen in ASAH. Thickness of SAH over 1mm, bilateral sylvian SAH, multiple cisternal SAH were in favor of ASAH. The number of involved cisterns were more frequently seen in ASAH than in TSAH. In ASAH, bilateral sylvian hemorrhages were more frequently seen than in TSAH. Skull fracture, subdural hematoma, subgaleal hematoma, and hemorrhagic contusion were frequently associated with TSAH.

Conclusion : As a result of our study, the authors conclude that when IVH, hydrocephalus, thick SAH > 1mm bilateral sylvian SAH, and multiple cisternal SAH are seen in CT, immediate angiography should be performed to rule out cerebral aneurysms whether associated with other traumatic lesions or not.

KEY WORDS : Aneurysmal subarachnoid hemorrhage · Traumatic subarachnoid hemorrhage · Computerized tomography · Differential diagnosis.

Introduction

When a patient with subarachnoid hemorrhage(SAH) is found without a witness, it is sometimes difficult to distinguish by computed tomography(CT) whether the SAH is spontaneous or traumatic. Aneurysmal SAH(ASAH) may cause the patient to collapse resulting in head injury or head injury may rupture a pre-existing aneurysm by its traumatic impact force. It is said that traumatic SAH(TSAH) occurs in about 30~60% of all traumatic head injuries[3,4,14] and there is a report that 8% of TSAH patients[1] have cerebral aneurysms.

When SAH combines with other intracranial injuries on CT, it is diagnosed as TSAH but we cannot completely rule out ASAH without angiography.

In the CT diagnosis of the emergent patients with head injury, the authors compared the CT findings of ASAH and TSAH to find out any differential points in CT between them.

Materials and Methods

We analyzed 142 ASAH and 82 TSAH patients who had been hospitalized from January 2003 to December 2004. The mean age of ASAH patients was 51 (from 26 to 81) and the mean age of TSAH patients was 46.5 (from 5 to 84).

The CT records were reviewed by a neurosurgeon who conducted the treatment and also by a neuroradiologist. We studied the presence of combined injuries, such as skull fracture, subgaleal hematoma, intracerebral hemorrhage(ICH), subdural

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hematoma(SDH), epidural hematoma(EDH), hemorrhagic contusion, pneumocephalus, intraventricular hemorrhage (IVH), and hydrocephalus.

The subarachnoid spaces were divided into suprasellar cistern, sylvian cistern, quadrigeminal cistern, interhemispheric cistern, and cortical sulci. We studied the number of visible involved cisterns. We also measured the thickness hemorrhage in the vertical cisterns in TSAH and ASAH. In the cases involving sylvian cisterns, we divided them into two groups, unilateral and bilateral. We took student t-test, chi-square test, Mantel-Haenszel test for analysis by applying SPSS (ver. 12.0) program. We considered the data significant if p-values were under 0.05.

Results

Patient population

Of the 224 patients, 114 (50.9%) patients were men, and 110 (49.1%) patients were women. Of the 82 TSAH patients, men (59) were 2.7 times more than women (23) and the distribution of the age was peaked in their forties. Of the 142 ASAH patients, women (87) were 1.6 times more than men (55) and the distribution of the age was peaked in their forties (Fig. 1).

Location of SAH

ASAH was found to have hemorrhage at suprasellar cisterns in 127, sylvian cisterns in 132, interhemispheric cisterns in 95, quadrigeminal cisterns in 95, and cortical sulci in 95 cases. In the cases of TSAH, hemorrhage was found at suprasellar cisterns in 7, sylvian cisterns in 53, interhemispheric cisterns in 18, quadrigeminal cisterns in 22, and cortical sulci in 62 (Table 1). SAH was found most frequently at sylvian cisterns in both ASAH and TSAH. But hemorrhage was found second most frequently at suprasellar cisterns in ASAH and at cortical sulci in TSAH. In the cases of ASAH, visible hemorrhage was found more frequently at suprasellar cisterns, sylvian cisterns, interhemispheric cisterns, quadrigeminal cisterns than TSAH ($p<0.001$) but visible hemorrhage at cortical sulci was not statistically different ($p=0.177$) between two groups.

Simultaneous involvement of suprasellar cisterns and sylvian cisterns was more frequent in ASAH than TSAH($p<0.001$). Besides, quadrigeminal and interhemispheric cisterns were also involved significantly ($p<0.001$) (Table 2).

Combined lesions

Of 142 ASAH cases, combined lesions were found in 70 cases. IVH and hydrocephalus were the most common lesions (38 cases respectively; 26.8%) followed by ICH (32 cases; 22.5%) and SDH (2 cases; 1.4%).

Among 82 TSAH cases, combined lesions were found in 66 cases. Skull fractures were the most common injuries (33 cases; 40.2%) followed by SDH (27 cases; 32.9%), subgaleal hematoma(25 cases; 30.5%), hemorrhagic contusion (24 cases; 29.3%), ICH (9 cases; 11.0%), EDH (6 cases; 7.3%), pneumocephalus (6 cases; 7.3%), and IVH (2 cases; 7.3%) (Table 3).

IVH, hydrocephalus and ICH were frequently associated with ASAH, but other injuries were more frequently associated with TSAH ($p<0.001$) (Table 3).

Thickness of SAH

Thickness of SAH was analyzed by classifying into small group, which is thinner than 1mm in vertical cisterns and large group, which is thicker than 1mm. In ASAH, small group included 37 cases and large group included 105 cases. TSAH included 47 cases of small group and 35 cases of large group (Table 4). The large group was dominant in ASAH ($p<0.001$).

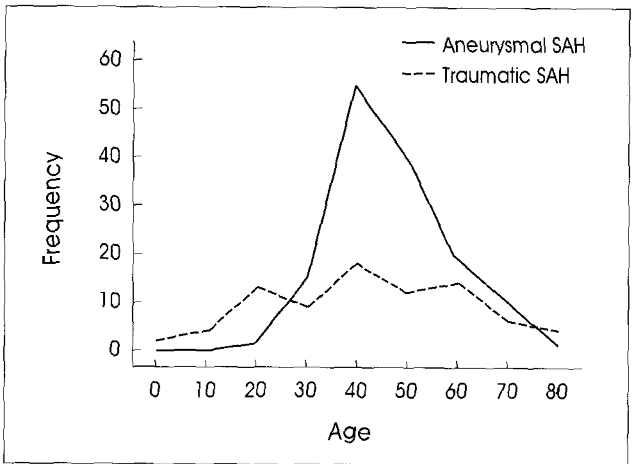

Fig. 1. Distribution of age.

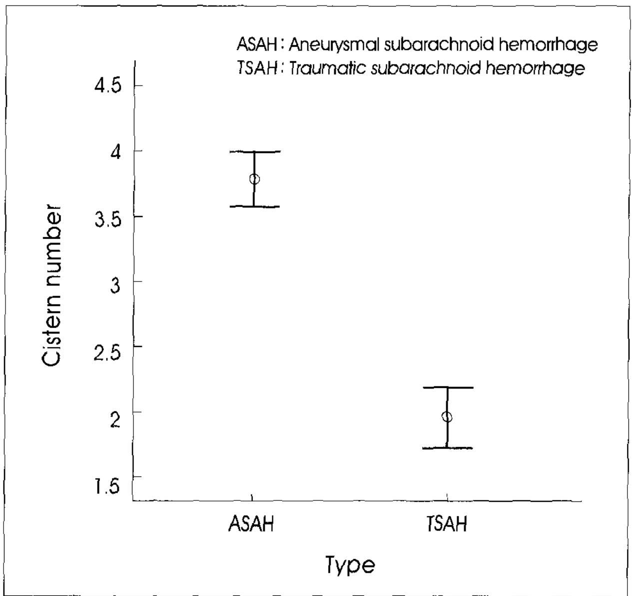

Fig. 2. Distribution of involved number of cisterns.

Table 1. Location of subarachnoid hemorrhage

Location of SAH	Type of SAH		No. of patient (N=224)	χ2 test
	ASAH(N=142)	TSAH(N=82)		
Suprasellar cistern*				p<0.001
present	127	7	134	
absent	15	75	90	
Sylvian cistern*				p<0.001
present	132	53	185	
absent	10	29	39	
Interhemispheric cistern*				p<0.001
present	95	18	113	
absent	47	64	111	
Quadrigeminal cistern*				p<0.001
present	90	22	112	
absent	52	60	112	
Cortical sulci				p=0.177
present	95	62	157	
absent	47	20	67	

*Statistically significant

Table 2. Location of multicisternal subarachnoid hemorrhage

Location of SAH	Type of SAH		M-H test
	ASAH	TSAH	
Su+Sy*	67	5	p<0.001
Su+Sy+In*	28	2	p=0.012
Su+Sy+Q*	24	0	p=0.005
Su+Sy+In+Q	7	0	p=0.308

M-H test : Mantel-Haenszel test, Su : Suprasellar cistern, Sy : Sylvian cistern, In : Interhemispheric cistern, Q : Quadrigeminal cistern, *Statistically significant

Laterality of SAH in sylvian cistern

Of 224 SAH cases, 185 cases had hemorrhage in sylvian cisterns. ASAH had 7 cases of unilateral and 125 cases of bilateral sylvian hemorrhage. In TSAH, 17 cases had unilateral and 36 cases had bilateral involvement (Table 4). TSAH involved unilateral sylvian cisterns more frequently than bilateral sylvian cisterns ($p<0.001$).

Extent of SAH

The number of involved cisterns in ASAH were counted. Nine cases had 1, 14 cases had 2, 32 cases had 3, 29 cases had 4, 58 cases had 5 cisterns involved respectively. In TSAH, 33 cases had 1, 30 cases had 2, 9 cases had 3, 8 cases had 4, 2 cases had 5 involved cisterns respectively (Table 4). The mean number of cisterns involved by ASAH and TSAH were 3.80 ($\pm$1.25) and 1.98 ($\pm$1.07) respectively. The extent of SAH was larger in ASAH than TSAH ($p<0.001$). When SAH were divided into two groups, involving 1 or 2 cisterns (group A) and involving more than 3 cisterns (group B), ASAH had 23 cases of group A and 119 cases of group B. TSAH had 63 cases of group A and 19 cases of group B. SAH involving more than 3 cisterns were more frequently found in ASAH than in TSAH ($p<0.001$).

Table 3. Associated lesions

Associated lesion	ASAH	TSAH	χ2 test
Skull fracture*	0 (0%)	33 (40.2%)	p<0.001
Subgaleal hematoma*	0 (0%)	25 (30.5%)	p<0.001
Intracerebral hemorrhage*	32 (22.5%)	9 (11.0%)	p=0.033
Intraventricular hemorrhage*	38 (26.8%)	2 (2.4%)	p<0.001
Subdural hematoma*	2 (1.4%)	27 (32.9%)	p<0.001
Epidural hematoma*	0 (0%)	6 (7.3%)	p=0.002
Hemorrhagic contusion*	0 (0%)	24 (29.3%)	p=0.001
Pneumocephalus*	0 (0%)	6 (7.3%)	p=0.002
Hydrocephalus*	38 (26.8%)	0 (0%)	p<0.001

*Statistically significant, ASAH : aneurysmal subarachnoid hemorrhage, TSAH : traumatic subarachnoid hemorrhage

Table 4. Comparison of radiologic features

Radiologic feature	Type of SAH		No. of patients (N=224)	χ2 test
	ASAH(N=142)	TSAH(N=82)		
Thickness of clot*				p<0.001
<1mm	37	47	84	
>1mm	105	35	140	
Laterality of clot in Sylvian cistern*				p<0.001
unilateral	7	36	43	
bilateral	125	17	132	
No. of involved cisterns*				p<0.001
1	9	33	42	
2	14	30	44	
3	32	9	41	
4	29	8	37	
5	58	2	60	

*Statistically significant, ASAH : aneurysmal subarachnoid hemorrhage, TSAH : traumatic subarachnoid hemorrhage

Discussion

Contrary to arterial rupture in ASAH, TSAH is usually caused by the burst of the bridging veins by shearing force at the moment of trauma[19,20]. Because of low venous pressure, TSAH would be different from ASAH in the severity, amount, and extension of hemorrhage.

That can explain why clinical vasospasm in TSAH is not so significant as ASAH or negligible[6]. However there are some reports that existence of TSAH in head injured patients has certain influence on the prognosis[3,9,10,12-14,20] and requires calcium channel blockers to prevent vasospasm and delayed ischemic damage[4,11,12,15,16].

When a patient with SAH presented with decreased consciousness level, it is crucial to differentiate it into ASAH or TSAH. Sometimes, aneurysmal rupture can cause head injury and vice versa. ASAH requires immediate angiography to find out aneurysms but TSAH may not require urgent vascular study. Because pathogenesis and bleeding vessels are different in ASAH and TSAH, CT features of ASAH and TSAH will be different. As the name implies, TSAH is associate with various cerebral injuries including skull fracture[7]. As head injury occurs more commonly for the outdoor workers, men were affected much more frequently than women contrary to ASAH in this study. In ASAH, most frequently involved cisterns were suprasellar and sylvian cisterns. This can be explained by the location of the circle of Willis and middle cerebral artery bifurcation which are the most prevalent aneurysmal location. In TSAH, sylvian cistern was the most frequently involved cistern. Sylvian cistern is in close contact with sphenoid ridge that the vessels in the cistern can easily be injured by this sharp bony edge at the moment of head trauma. Cortical sulci are widely dispersed on the cerebral cortex and in contact with inner calvarium.

These anatomical relationship can explain why these sites are easily injured in head trauma. In ASAH, IVH and hydrocephalus were common associate lesions. Aneurysmal rupture through the lamina terminalis, rupture of the ventricular wall or retrograde flow into the ventricles results in IVH. Blood in the ventricles, cisterns, and cortical sulci obstruct CSF flow and produces acute hydrocephalus[18]. But in TSAH, IVH was rare and hydrocephalus was not associated. Breakage of tela choroidea seems to produce IVH[2]. Increased intracranial pressure and relatively small amount of blood in the cisterns may interrupt CSF production but not be enough to obstruct CSF outflow and absorption. If hemorrhagic contusion, multiple ICH, SDH, EDH, pneumocephalus, and/or skull fracture are associated with SAH, TSAH is easily diagnosed.

The majority of the ASAH showed bilateral sylvian SAH compared with TSAH involving unilateral sylvian cistern. In ASAH, high arterial pressure thrust blood into both sides of sylvian cisterns but in TSAH, ruptured venous pressure is not high enough to thrust blood into both sides. In autopsy series, venous hemorrhage was largely seen in the cisterns of TSAH[5].

The thickness of SAH is another important differential point between ASAH and TSAH. Undoubtedly arterial bleeding in ASAH would result in more blood in the cisterns than venous bleeding in TSAH as shown in this study. Before the CT era, nearly all of the head injured patients had taken cerebral angiography, so coexisted vascular lesions could hardly be missed in diagnosis. But in the era of CT, brain CT became a primary diagnostic study for the intracranial lesions, skipping cerebral angiography. As a result, cerebral aneurysmal rupture, that might cause the patient to collapse resulting in head injury or might be the result of head injury which caused the pre-existing aneurysm to rupture by traumatic impact. When a patient has SAH with or without other intracranial lesions, it seems to be necessary to do the angiography if IVH, hydrocephalus, thick SAH, bilateral sylvian SAH, and multicisternal SAH are shown on CT to rule out cerebral aneurysms.

Conclusion

As a result of our study, the authors conclude that IVH and hydrocephalus are highly suggestive of ASAH that required immediate angiography.

Besides, suprasellar hemorrhage, bilateral sylvian hemorrhage, multicisternal hemorrhage, and thick hemorrhage are in favor of ASAH that necessitated immediate angiography whether they are associated with other intracranial traumatic lesions or not.

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Commentary

Authors have provided important informations about CT findings of patients with altered consciousness how to differentiate them into aSAH or tSAH.

Over the past decade, significant advances have been made in the field of subarachnoid haemorrhage. Prompt diagnosis with high-resolution CT and intensive critical care support remain key aspects of good patient management. Early identification and definitive treatment of underlying ruptured aneurysms is generally advocated to reduce the risk of re-bleeding, a complication with high mortality and morbidity.

Traumatic subarachnoid hemorrhage(tSAH) is a frequent finding after closed-head injuries, and its presence is a powerful factor associated with poor outcome. tSAH is caused by bleeding of cortical arteries, veins, and capillaries from brain surface cerebral contusion. Rarely, tSAH can be caused by rupture of bridging veins or traumatic aneusyms.

tSAH is associated with various cerebral injuries including skull fracture or cerebral contusion. Men were affected more frequently in tSAH. In tSAH sylvian cistern and cortical sulci were frequently involved unilaterally.

Aneurysmal subarachnoid hemorrhage(aSAH) is caused by rupture of cerebral aneurysm and there were more blood in the cisterns due to arteral bleeding. In aSAH women were more frequently affected, suprasellar and sylvian cisterns were frequently involved bilaterally and IVH and hydrocephalus were common associated lesions.

It is reasonabaly accepted that When a patient has SAH with or without other intracranial lesions, it sees to be necessary to do the angiography if IVH, hydrocephalus, thick SAH, bilateral sylvian SAH, and multicisternal SAH are shown on CT to rule out cerebral aneurysm.

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