A study on clinical characteristics, computed tomography brain imaging, causes and complications of subarachnoid hemorrhage

Le Xuan Duong, Vu Duy Minh,
Ngo Chi Cong, Do Thanh Hoa

108 Military Central Hospital

Summary

Backgroud: Subarachnoid hemorrhage (SAH) is sudden bleeding into the subarachnoid space. The most common cause of spontaneous SAH is a ruptured aneurysm. Symptoms include sudden, severe headache, usually with loss or impairment of consciousness. It has a lot of dangerous complications especially re-bleeding and vasospasm which are the major causes of death and disability. *Objective:* To study on clinical characteristics, computed tomography brain imaging, causes and complications of subarachnoid hemorrhage. *Subject and method:* A cross-sectional prospective study on 202 patients who suffered from subarachnoid hemorrhage admitted to the Stroke Center, 108 Military Central Hospital from June 2018 to January 2020. *Result and conclusion:* The average age was 60.5 years. The most common age group was among the aged 45-64 years (71.2%). The most common symptoms of SAH was sudden severe headache (98%); neck stiff (86.1%), followed by consciousness disorders (56.9%), systolic blood pressure above 160mmHg (50.5%), focal neurologic deficits (20.3%). The Fisher classification: Grade 1 (4.5%), grade 2 (17.3%), grade 3 (19.3%), grade 4 (58.9%). The ruptured cerebral aneurysm accounted for 89.6% of the causes of SAH. The most common site of aneurysm was in the anterior communicating artery (34.8%), followed by the middle cerebral artery (21.5%) and in the internal carotid artery (16.6%). Posterior cerebral circulation accounted for 12.7%; 4.4% of patients had multiple aneurysms. The most common complications of SAH was cerebral vasospasm (26.2%) and typically occurred between 5 and 7 days after SAH, followed by rebleeding accounted for 7.9%, the most cases occurred within the first 24 hours, acute and subacute hydrocephalus (10.4%), hyponatremia (11.4%) and seizures (5.4%).

Keywords: Subarachnoid hemorrhage, ruptured aneurysm, tomography brain imaging.

1. Background

Subarachnoid hemorrhage (SAH) occurs when blood flows from the intracranial vascular bed and onto the surface of the brain to mix with cerebrospinal fluid in the subarachnoid space [13]. Although head trauma causes some cases of SAH, up to 85% is the result of a ruptured cerebral aneurysm [3].

Patients typically present complaining of a severe headache; however, only 10% of patients presenting to the Stroke center complaining of a thunderclap headache end up having a SAH. Associated symptoms may include neck stiffness, nausea/vomiting, and photophobia [12].

Computed tomography angiography (CTA) is noninvasive test that is useful for screening and treatment planning. CTA can identify aneurysms

Correspondence to: Le Xuan Duong - Department of Emergency Medicine, 108 Military Central Hospital
Email: duongicu108@gmail.com

≥ 3mm with a high degree of sensitivity. According to Donmez H. et al., pooled sensitivity and specificity of CTA in the diagnosis of cerebral artery aneurysm were 95.1% and 94.1%, respectively [3].

Spontaneous SAH happens in about one per 10,000 people per year [5], despite advances in medical and surgical management, SAH remains a major cause of premature mortality. Well-established risk factors for mortality included poor clinical grade at presentation, older age, aneurysm rebleeding, large aneurysm size, and cerebral infarction from vasospasm [5].

The aim of this study was to identify clinical features, computed tomography images, causes and complications of subarachnoid hemorrhage.

2. Subject and method

2.1. Subject

A cross-sectional study was conducted on 202 patients with SAH hospitalized at the Stroke Center, 108 Military Central Hospital from June 2018 to January 2020.

Selection criteria: All patients diagnosed with non-traumatic subarachnoid hemorrhage based on clinical characteristics and brain CT or lumbar puncture in the face of a negative CT, with above 16 years of age.

Exclusion criteria: Patient arrived in hospital after 72 hours from onset. Patient or representative disagreeing to participate in the study.

Criteria for removal from the study: Patients died within 48 hours of admission.

2.2. Variable and data processing

When a clinical suspicion for SAH exists based on history and physical exam, non-contrast computed tomography (CT) is the first diagnostic tool. Information and exploitation filled in the research records includes:

General characteristics, main symptoms at the time of admission, clinical diagnosis, clinical classification according to Hunt-Hess scale.

Brain CTA: Lesion location, Fisher score, bleeding complications, cause of SAH.

Lumbar spinal puncture in case of no SAH in brain CT.

Treatment: Complications of re-bleeding, vasospasm, hydrocephalus, hyponatremia, seizures.

2.3. Process of data analysis

Descriptive statistics were reported as means and standard deviations, minimium, maximum or percentage. Data analysis was done by SPSS 22.0 software (IBM Inc, USA).

3. Result

Table 1. Characteristics of age and gender of patient population

Parameter		number	Percentage %
Age $\bar{X}$ ± SD (min-max)		60.5 ± 12.8 (25 - 90)	
Age groups (years)	< 25	0	0
	25 - 34	3	1.5
	35 - 44	23	11.4
	45 - 54	72	35.6
	55 - 64	72	35.6
	> 64	32	15.9
Female		105	52

The mean age of the patients was 60.5 years, in which the common age group was from 45 - 64 years old, accounting for 71.2%. The age group from 25 to 44 accounted for 12.9% and 52% were women.

Table 2. Main symptoms at the time of admission

Symptoms	Number (n = 202)	Percentage %
Sudden, severe headache	198	98.0
Nausea / vomiting	130	64.4

Neck stiffness	174	86.1
Reduce consciousness	115	56.9
Dizziness	8	4.0
Seizures	8	4.0
Unilateral pupil dilation	9	4.5
Focal neurologic deficits	41	20.3
Systolic blood pressure > 160mmHg	102	50.5

The most common symptoms of SAH were sudden severe headache, accounted for 98%; neck stiffness accounted for 86.1%, followed by consciousness disorders (56.9%), insystolic blood pressure above 160mmHg (50.5%), focal neurologic deficits (20.3%). The other symptoms of dizziness, seizures, unilateral dilated pupils accounted for 4 to 5%.

Table 3. Distribution of the Hunt-Hess grade before intervention

Grade of Hunt-Hess	No. of patients (n = 202)	Percentage %
I	11	5.4
II	90	44.6
III	46	22.8
IV	55	27.2
V	0	0.0

Most of Hunt-Hess grade was II (accounting for 44.6%), Hunt-Hess grade IV (accounting for 27.2%), no patients had Hunt-Hess grade V.

Table 4. Distribution of the Fisher scale in brain non-contrast CT

Fisher	Number (n = 202)	Percentage %
1	9	4.5
2	35	17.3
3	39	19.3
4	119	58.9

The highest percentage was fisher 4 accounted for 58.9%. The lowest was fisher 1 accounted for 4.5%.

Table 5. Distribution of causes of subarachnoid hemorrhage

Causes of SAH	Number (n = 202)	Percentage %
Ruptured cerebral aneurysm	181	89.6
Brain tumor	0	0.0
Cerebral arteriovenous malformation	6	3.0
Coagular disorder	1	0.5
No cause determination	14	6.9

Cerebral aneurysm accounted for the highest rate of 89.6%, no cause determination accounted for 6.9%, cerebral arteriovenous malformation accounted for 3.0%.

Table 6. Classification of the sites of the aneurysms on brain CT angiography

Sites of the aneurysms		Number (n= 181)	Percentage %	Total n (%)
Anterior cerebral circulation	Anterior cerebral artery	6	3.4	150 (82.9%)
	Anterior communicating artery	63	34.8	
	Middle cerebral artery	39	21.5	
	Posterior communicating artery	12	6.6	
	Internal carotid artery	30	16.6	

Posterior cerebral circulation	Basilar artery	10	5.5	23 (12.7%)
	Posterior cerebral artery	3	1.7	
	Vertebral artery	10	5.5	
Multiple aneurysms		8	4.4	8 (4.4%)

The most common site of aneurysm was in the anterior communicating artery accounts for 34.8%, then the middle cerebral artery (21.5%) and in the internal carotid artery (16.6%). Posterior cerebral circulation accounted for: 12.7%, 4.4% of patients had multiple aneurysms.

Table 7. Complications of subarachnoid hemorrhage

Time / Complications	< 3 days	3 - 4 days	7 days	> 7 days	Total	Percentage %
Re-bleeding	9	2	3	2	16	7.9
Vasospasm	1	16	30	6	53	26.2
Hydrocephalus	1	3	5	3	23	11.4
Hyponatremia	4	4	7	6	21	10.4
Seizures	0	1	2	8	11	5.4

The most common complications of SAH was cerebral vasospasm (26.2%) and typically occurred between 5 and 7 days after SAH, followed by rebleeding accounted for 7.9% the most cases occurred within the first 24 hours, acute and subacute hydrocephalus (10.4%), hyponatremia (11.4%) and seizures (5.4%).

4. Discussion

4.1. Age and gender characteristics

The study was conducted on 202 patients hospitalized at the Stroke Center, 108 Military Central Hospital from June 2018 to January 2020. According to our study, the average age of patients with SAH was 60.5 years old (among 25 to 90 years old). The most common age group was among the aged 45 - 64 years (accounted for 71.2%). This result is in agreement with that of the study of de Rooij, SAH was also common in middle-aged and old people, while SAH at the age of under 55 only accounts for about 55% [5]. The rate of female enlightenment was higher than that of men (52% compared to 48%). The results are consistent with the research of Robert JS and et al (2020) revealed 60% of patients with SAH were female [10].

4.2. Symptoms of subarachnoid hemorrhage

The most common symptoms of SAH were sudden severe headache, accounted for 98%; neck stiffness accounted for 86.1%, followed by consciousness disorders (56.9%), systolic blood pressure above 160mmHg (50.5%), focal neurologic deficits (20.3%) and seizures (4.0%). According to medical literature, classic characterizes the headache of SAH as a “thunderclap headache,” which is defined as a sudden, severe headache often described as the worst of the patient’s life. The headache is typically a sudden onset, which is commonly characterized as occurring within a few minutes, although research parameters include headache that reaches maximum intensity within one hour. Headache is a common symptom in patients in the emergency room. But the rate of headache due to SAH is low, according to the studies with a total of 5283 patients found that 329 patients (6%) had SAH [10].

In addition to headache, common associated symptoms of SAH include a brief loss of consciousness, vomiting, and neck stiffness. Seizures are more common if an aneurysm causes the SAH, and a SAH in a patient with a history of seizures is often diagnostis of a cerebral arteriovenous malformation. Seizures occurs less than 10% of patients with SAH during the first 24 hours but it is a predictor of poor outcomes [9], [12].

Neck stiffness typically does not occur until about 6 hours after the onset of a SAH. Asymmetrical pupil size and loss of the pupillary light reflex may indicate brain herniation caused by rising intracranial pressure. Increased intracranial pressure can lead to a sympathetic surge due to activation of the descending sympathetic nervous system at the medulla, which causes a local release of inflammatory mediators that activate the sympathetic system in the peripheral circulation. This sympathetic surge may lead to an increase in blood pressure, cardiac arrhythmias, and/or cardiac arrest.

Most of Hunt-Hess grade was II (accounted for 44.6%), followed by grade IV (accounted for 27.2%). No patients (0%) presented with grade V. This result is in agreement with the reseach of Pham Dinh Dai et al. the rate of Hunt-Hess grade I, II and III accounted for about 80.7% [1].

4.3. Site of aneurysm in computed tomography, the classification and causes of subarachnoid hemorrhage.

Arcoding to our research results, 94.6% patients with SAH was diagnosed by brain CT. Fisher classification of SAH on brain CT: The highest percentage was Fisher grade 4, accounted for 58.9%. The lowest was Fisher grade 1, accounted for 4.5%.

When a clinical suspicion for SAH exists based on history and physical exam, CT is the first diagnostic tool. It is also valuable in excluding other pathologies such as intracranial hemorrhage, malignancy, or abscess. At the onset of the bleed, subarachnoid blood is the most readily visible on CT, but it becomes more difficult to appreciate as red blood cell degradation progresses. Advances in neuroimaging have increased the sensitivity of non-contrast CT, raising questions regarding the need for lumbar puncture (LP) in the face of a negative CT [10]. In our study, 5.4% patients with SAH and negative initial CT (Hunt-Hess degree I) were diagnosed by lumbar spinal puncture. There are rare instances in which the clinical scenario so strongly suggests SAH that even an adequate negative CT completed within six hours is unable to rule out SAH and should be followed by LP. If the imaging is completed after the six-hour timeframe, the sensitivity of CT drops to 85.7%. In these cases, the diagnostic utility of LP increases as the probability of SAH after negative CT also increases [3]. A meta-analysis found that less than 1.5 in 1000 patients with SAH would be missed if no LP was done in patients who met the following conditions: a normal head CT using a modern scanner within six hours of headache onset (with a clear time of onset) [11].

The cerebral aneurysm accounted for 89.6% of the causes of SAH, this result is in agreement with other studies such as Donmez H. with the rate of 85%, Le Van Tin with the rate of 80% the causes of SAH [3]. Other causes include: Cerebral arteriovenous malformation (3.0%) and coagular disorder (0.5%) and no cause determined (6.9%), this result is similar to the literature about 15 - 20% SAH due to other causes such as: Cerebral vascular malformation, dissection of intracranial arteries, brain tumors and no cause determined [11]. CTA is noninvasive test that is useful for screening and presurgical planning. CTA can identify aneurysms ≥ 3mm with a high degree of sensitivity, but they do not achieve the resolution of conventional angiography. The sensitivity of CTA for the detection of ruptured aneurysms, using DSA as the gold standard, is 83 to 98 percent. Small aneurysms (especially ≤ 2mm)

may not be reliably identified. Although small aneurysms rupture less frequently than large aneurysms, they are more common, and rupture of small aneurysms (approximately 5 mm or less) accounts for nearly one-half of SAH cases. Therefore, DSA should be performed if CTA does not reveal an aneurysm in a patient with SAH. DSA is definitely required in patients with SAH and negative initial CTA. In this specific situation, DSA should be performed to rule out small aneurysms and may be repeated within 2 to 6 weeks if the initial DSA is negative [10].

The most common site of aneurysm was in the anterior communicating artery (34.8%), followed by the middle cerebral artery (21.5%) and in the internal carotid artery (16.6%). Posterior cerebral circulation accounted for: 12.7%; 4.4% of patients had multiple aneurysms. This result is in agreement with that of previous studies as follows, Pham Dinh Dai et al Showed that the most common aneurysm in the anterior communicating artery (34.5%), followed by the posterior communicating artery (20.7%), the internal carotid artery 19.0% [1]. In the study cohort of 1993 patients (61% women) with saccular ruptured intracranial aneurysms the 4 most common locations of ruptured intracranial aneurysms were the middle cerebral (32%), anterior communicating (32%), posterior communicating (14%), and pericallosal arteries (5%). anterior circulation ruptured intracranial aneurysms accounted for 90% of all ruptured intracranial aneurysms, and 30% of the patients had multiple intracranial aneurysms [1].

4.4. Common complications of subarachnoid hemorrhage

A variety of early complications can occur with SAH, including rebleeding, hydrocephalus, brain edema, vasospasm and delayed cerebral ischemia, seizures, hyponatremia, cardiopulmonary abnormalities, and neuroendocrine dysfunction.

In our study, rebleeding is the most dangerous complication, occurred in 7.9 percent of patients within the first 24 hours of admission and heralded the onset of complications and poor outcomes. This result is in agreement with that of previous studies as follows, after aneurysmal SAH, the patient is at substantial risk of early rebleeding (4 to 14 percent in the first 24 hours, with maximal risk in the first 2 to 12 hours) [4]. Some factors identified as predictors of rebleeding include: longer time to aneurysm treatment, worse neurologic status on admission, larger aneurysm size, high systolic blood pressure, presence of intracerebral or intraventricular blood, acute hydrocephalus [11]. Aneurysm treatment is the only effective treatment for the prevention of rebleeding. Therefore, patients with rebleeding should have emergency aneurysm repaire. In addition, some therapies can reduce the rate of rebleeding include: Blood pressure control, sedatives, pain relief, absolute rest, avoid constipation...

Vasospasm is a frequent complication of SAH; it contributes substantially to morbidity and mortality after SAH. Accoding to our study, vasospasm occurred in 26.2% of patients in between 5 and 7 days from the onset of SAH. These findings are in agreement with data in literature, vasospasm typically begins no earlier than day 3 after hemorrhage, reaching a peak at days 7 to 8. Vasospasm is believed to be produced by spasmogenic substances generated during the lysis of subarachnoid blood [6]. Clinical manifestations of cerebral vasospasm include: Focal neurologic impairment (such as hemiparesis, aphasia, apraxia, hemianopia, or neglect) or a decrease of at least two points on the Glasgow Coma Scale that lasts for at least one hour, was not apparent immediately after aneurysm occlusion, and cannot be attributed to other causes after appropriate clinical assessment, brain imaging, and laboratory studies. CTA is used to identify patients with symptomatic vasospasm. However, even

symptomatic vasospasm may not be identifiable on cerebral angiography as spasm in small arteries defies the resolution of even state-of-the-art angiography.

If vasospasm does occur, it can be treated with intravenous fluids to achieve a state of hypertension, hypervolemia, and hemodilution. This triad is often referred to as “Triple H”. However, to date, no randomized controlled trials have been conducted to support its utility. If vasospasm continues despite this medical management, angiography may be attempted to identify the site of spasms and administer intra-arterial vasodilator medication or angioplasty with balloon stenting [11]. Cerebral vasospasm typically occurs after the third day of onset and typically reaches its peak on the fifth to the seventh day, with 30/53 cases of vasospasm (56.6%). This result is in agreement with that of previous studies as Vo Hong Khoi et al [2], Frontera JA et al [6].

Acute and subacute hydrocephalus after SAH is thought to be caused by obstruction of cerebrospinal fluid (CSF) flow by blood products or adhesions or by a reduction of CSF absorption at the arachnoid granulations. The former occurs as an acute complication; the latter tends to occur two weeks after or later and is more likely to be associated with shunt dependence. Hydrocephalus affects 20 to 30% of patients with SAH. The percentage of hydrocephalus in my study was 10.4%. What is the difference between literature review because hydrocephalus usually appears in the second week or later [12], whereas most of the patients stayed at our hospital in 2 or 3 weeks before transfering to other hospitals.

In our research, hyponatremia is seen in 10.4 percent of patients with SAH. This finding is in agreement with data in literature, the rate of hyponatremia accounts for 5% to 30% of patients with SAH and is probably mediated by hypothalamic injury. The water retention that leads to hyponatremia following SAH may result from either the syndrome of inappropriate secretion of antidiuretic hormone (SIADH) or from cerebral salt wasting [5].

Acute seizures occured in 5.4 percent of patients with SAH. This finding is in different with data in research of Natha SK et al. seizures occured in up to a third of SAH hospitalizations [8]. Risk factors include thick subarachnoid clot, intracerebral hemorrhage, delayed infarction, and aneurysm in the middle cerebral artery [11].

In addition to the above complications, cardiovascular complications such as arrhythmia, acute pulmonary edema, heart failure due to an increase in catecholamine reaction. There are also common complications for patients with stroke such as hospital infections (respiratory infections, urinary infections ...), deep vein thrombosis, stomach ulcers, pressure pressure ulcers...

5. Conclusion

The study was conducted on 202 patients with subarachnoid hemorrhage. The average age was 60.5 years. The most common age group was among the aged 45 - 64 years (71.2%). Females were more commonly affected than males. The most common symptoms of SAH were sudden severe headache, accounted for 98%; neck stiffness accounted for 86.1%, followed by consciousness disorders (56.9%), systolic blood pressure above 160mmHg (50.5%), focal neurologic deficits (20.3%) and seizures (4.0%).

The classification of SAH on brain CTA, Fisher grade 4 accounted for 58.9%. Fisher grade 1 accounted for 4.5%. The cerebral aneurysm accounted for 89.6% of the causes of SAH. The most common site of aneurysm was in the anterior communicating artery accounted for 34.8%, followed by the middle cerebral artery (21.5%) and in the internal carotid artery (16.6%). Posterior cerebral circulation accounted for: 12.7%; 4.4% of patients had multiple aneurysms.

The most common complications of SAH was cerebral vasospasm (26.2%) and typically

occurred between 5 and 7 days after SAH, followed by rebleeding accounted for 7.9% the most cases occurred within the first 24 hours, acute and subacute hydrocephalus (10.4%), hyponatremia (11.4%) and seizures (5.4%).

References

1. Phạm Đình Đài, Đỗ Đức Thuần, Đặng Phúc Đức (2016) *Nghiên cứu đặc điểm lâm sàng, hình ảnh và kết quả điều trị can thiệp nội mạch phình động mạch não đã vỡ ở Bệnh viện 103.* http://www. benhvien103.vn/vietnamese/bai-bao-y-hoc/ nghien-cuu-dac-diem-lam-sang-hinh-anh-va-ket-qua-dieu-tri-can-thiep-noi-mach-phinh-dong-mach-nao-da-vo-o-benh-vien-103/1495/.
2. Võ Hồng Khôi, Lê Văn Thính, and Nguyễn Chương (2010) *Nghiên cứu đặc điểm lâm sàng, cận lâm sàng, nguyên nhân và hướng xử trí một số biến chứng của chảy máu dưới nhện.* Tạp chí Thần kinh học, http://hoithankinhhocvietnam.com.vn/ nghien-cuu-dac-diem-lam-sang-can-lam-sang-nguyen-nhan-va-huong-xu-tri-mot-so-bien-chung-cua-chay-mau-duoi-nhen/.
3. Donmez H., Serifov E., Kahriman G et al (2011) *Comparison of 16-row multislice CT angiography with conventional angiography for detection and evaluation of intracranial aneurysms.* Eur J Radiol 80(2): 455-461.
4. Connolly ES Jr, Rabinstein AA, Carhuapoma JR, et al (2012) *Guidelines for the management of aneurysmal subarachnoid hemorrhage: A guideline for healthcare professionals from the American Heart Association/american Stroke Association.* Stroke 43: 1711.
5. De Rooij NK, Linn FH, van der Plas JA et al (2007) *Incidence of subarachnoid haemorrhage: A systematic review with emphasis on region, age, gender and time trends.* J. Neurol. Neurosurg. Psychiatry 78(12): 1365-1372.
6. Frontera JA, Claassen J, Schmidt JM et al (2006) *Prediction of symptomatic vasospasm after subarachnoid hemorrhage: The modified fisher scale.* Neurosurgery 59(1): 21-27.
7. Miikka K, Riku K, and Behnam A (1993) Size and *location of ruptured intracranial aneurysms: Consecutive series of 1993 hospital-admitted patients.* Journal of Neurosurgery 127: 709-964.
8. Nathan SK, Brahme IS, Kashkoush AI et al (2018) *Risk factors for in-hospital seizures and new-onset epilepsy in coil embolization of aneurysmal subarachnoid hemorrhage*. World Neurosurg 115: 523-531.
9. Perry JJ, Sivilotti MLA, Sutherland J et al (2017) *Validation of the ottawa subarachnoid* hemorrhage *rule in patients with acute headache.* CMAJ 189: 1379.
10. Robert JS, Christopher SO, and Guy R (2020) *Aneurysmal subarachnoid hemorrhage: Clinical manifestations and diagnosis.* Uptodate.com.
11. Robert JS, Christopher SO, and Guy R (2020) *Aneurysmal subarachnoid hemorrhage: Treatment and prognosis.* Uptodate.com.
12. Shea AM, Reed SD, Curtis LH et al (2007) *Characteristics of nontraumatic subarachnoid hemorrhage in the United States in 2003.* Neurosurgery 61(6): 1131-1137.
13. Toth G and Cerejo R (2018) *Intracranial aneurysms: Review of current science and management.* Vasc Med 23(3): 276-288.