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Original article

Computed tomographic findings in ruptured basilar tip aneurysms

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Background: Computed tomography (CT) plays an important role in the evaluation of acute non- traumatic subarachnoid hemorrhage (SAH), mostly due to ruptured aneurysms. Knowledge of the common CT pattern of hemorrhage in ruptured basilar tip aneurysms would be beneficial for diagnostic evaluation and treatment planning.
Objective: To characterize the common CT findings pattern of patients who had ruptured basilar tip aneurysms at King Chulalongkorn Memorial Hospital (KCMH) between January 1, 2011, and December 31, 2015.
Methods: Sixteen patients diagnosed with ruptured basilar tip aneurysm were recruited in this study. The CT findings, demographic data, clinical signs and symptoms, as well as cerebral angiographic findings associated with ruptured basilar tip aneurysms were retrospectively reviewed from the Hospital Information System (HIS) and Picture Archiving and Communication Systems (PACS).
Results: The most common CT findings in ruptured basilar tips aneurysms were subarachnoid hemorrhage (SAH) in the interpeduncular cistern (88%) followed by a prepontine cistern and Sylvian cistern (81%) and cerebral convexities (75%). More than half of the patients (56%) were classified as grade 4 according to modified Fisher's SAH grading system. Intraventricular hemorrhage (IVH) was noted in 9 of 16 patients (56%). IVH was observed in the lateral, third and fourth ventricles in 78%, 67%, and 67%, respectively. Hydrocephalus was demonstrated in 14 of 16 patients (88%).
Conclusion: Our study reveals the common CT findings together with the demographic data, clinical presentation and cerebral angiographic findings in ruptured basilar tip aneurysms in 16 patients. The results can be used to predict ruptured basilar tip aneurysms in common CT findings for proper management in order to reduce mortality rate and disability.

Keywords: Subarachnoid hemorrhage, basilar tip aneurysm, computed tomographic findings.

Ruptured saccular aneurysms are the most common cause of non-traumatic subarachnoid hemorrhage, accounting for approximately 85% of the cases. The overall incidence is about 9 per 100,000 with a wide range, in Japan and Finland up to 20 per 100,000. [1] In the past, Bunyaratavej S. [2] noted that there is a low incidence of intracranial aneurysms in Thailand owing to poor awareness as well as an underdeveloped neurological and neurosurgical services. Nowadays, there are innovative medical equipment and accessible health services to improve more precise diagnosis of ruptured intracranial aneurysm. The mortality rate of aneurysmal subarachnoid hemorrhage is about 60% within 6 months.[3] Approximately 12% of the patients died before reaching the medical health care.[3]

Computed tomography (CT) plays an important role in the evaluation of subarachnoid hemorrhage caused by ruptured cerebral aneurysms.[2] Many studies have been published regarding its use in the identification of location of the ruptured aneurysms.[3-5] However, these studies have described mostly with supratentorial aneurysms, and findings in ruptured posterior fossa aneurysms have been less described.[6-8]

Because of complex vascular anatomy of the basilar artery bifurcation, the intimate relationship of an aneurysm with the skull base and vital structures around the interpeduncular fossa, and the difficulty of obtaining proximal control, surgical treatment for basilar tip aneurysm is technically challenging.[8-9] Since the morbidity and mortality rate for surgically treated basilar tip aneurysms remain high, selective endovascular intervention is the treatment of choice.[10]

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Knowledge of CT pattern of hemorrhage in ruptured basilar tip aneurysms would be beneficial for diagnostic evaluation and proper treatment planning. When encountering a pattern highly typical for ruptured basilar tip aneurysms, careful evaluation of the vertebrobasilar anatomy is required, especially in case of other documented co-incidental aneurysms. Finally, the knowledge of typical and atypical patterns of hemorrhage seen in ruptured basilar tip aneurysms might guide to determine which one of multiple aneurysms has ruptured.

Materials and methods

Subjects

This was a descriptive, single-center retrospective study of patients with ruptured basilar tip aneurysms admitted to King Chulalongkorn Memorial Hospital (KCMH), Faculty of Medicine, Chulalongkorn University, between January 1, 2011 and December 31, 2015. As per the Helsinki Declaration, the confidentiality of the patients was protected and the experimental design and protocol reviewed and approved by the Institutional Review Board (IRB) of the Faculty of Medicine, Chulalongkorn University. The authors reviewed non-enhanced computed tomography (NECT) brain study and cerebral angiography by using the Hospital Information System and Picture Archiving and Communication Systems (PACS).

Inclusion criteria for the present study were: The patients who 1) were admitted and diagnosed ruptured basilar tip as aneurysm by ICD-10 in KCMH since January 1, 2011, until December 31, 2015; 2) They underwent both NECT brain performed at KCMH or other hospitals with equivalent quality image and cerebral angiography performed at KCMH; 3) were confirmed diagnosis by an operative note or cerebral angiography. The exclusion criteria were: 1) Ruptured aneurysms more than one aneurysm sites; 2) Poor quality image of the NECT brain; and 3) Onset of symptom to the time of NECT brain longer than 72 hours.

Forty patients who were admitted and diagnosed with ruptured basilar tip aneurysm in KCMH between January 1, 2011 and December 31, 2015, by using ICD-10 in the patient medical records were retrospecitvely reviewed. After reviewing the NECT brain and the cerebral angiography, 11 patients were excluded because there were NECT brain performed before cerebral angiogram was not available; 2 patients were excluded due to poor image quality; 3 patients were excluded because the wrong diagnosis on ICD-10; and 8 patients were excluded by other location of the aneurysms. Finally, there were 16 patients enrolled in the present study.

The demographic data, clinical, and hospitalization information were assembled. The demographic data included age and sex. The clinical data included: 1) Comorbidity (i.e. hypertension, Ehlers-Danlos syndrome type IV, autosomal dominant polycystic kidney disease, neurofibromatosis type I); 2) Risk factors (smoking, alcohol drinking, family history of a cerebral aneurysm); 3) Clinical signs and symptoms (presenting symptom and the onset of symptom to the time at NECT brain); 4) Initial neurological status (Modified World Federation of Neurosurgical Societies subarachnoid haemorrhage grading system; modified WFNS). [11]

Imaging techniques

NECT of the brain was performed on 16 patients; 4 patients were performed at KCMH and the rest were done from the other hospitals with an equivalent quality image. The NECT interventions were performed at KCMH with 4 CT scanners (Siemens SOMATOM Force CT scan; GE discovery CT750HD; Philips Brilliance CT 64 channel; Toshiba Aquilion one) with a 5-mm axial slice thickness in the posterior fossa and suprasellar region.

Each patient underwent 3 - 4 vessels cerebral angiography (Siemens Neurostar Bi-plane and Philips Allura Xper FD20 Single plane), according to the institutional protocol. The cerebral angiogram was obtained in at least two projections of each vessel: anteroposterior view and lateral view. The technique used to obtain the images was 3 frames per seconds for 7 - 10 seconds. Additionally, rotational angiography with 3D reconstruction was performed in the selected case.

Imaging analysis

A researcher under a board-certificated radiologist supervisor and interventional neuroradiologist reviewed NECT brains and cerebral angiography images independently and achieved a determination on the definite interpretations by consensus. All of the images were reviewed on a PACS workstation.

NECT images were analyzed first apart from the cerebral angiography images. NECT images were assessed for the location of subarachnoid hemorrhage

(SAH), modified Fisher's grading [12], intraventricular hemorrhage, intraparenchymal hematoma, and hydrocephalus.

Subarachnoid hemorrhage would be defined as the extravasation of blood into the cerebrospinal fluid-filled subarachnoid spaces around the brain. The appearance of hemorrhage will be classified using the modified Fisher's grading scale. Hydrocephalus will be recorded as present when the Evans index, that is, the ratio of the largest width of the frontal horns to the maximal biparietal diameter, is greater than 30%.

The cerebral angiographic images would be assessed for presence of an aneurysm, the location, size, and neck dimension of an aneurysm, direction of an aneurysmal tip and any presence of vasospasm. Angiographic vasospasm would be defined as moderate-to-severe arterial narrowing on the cerebral angiography.

Statistical analysis

The categorical data were analyzed for number and percentages while the continuous data were assessed for mean and standard deviation (SD).

Results

Forty patients who were admitted and diagnosed as ruptured basilar tip aneurysm at KCMH between January 1, 2011 and December 31, 2015:16 patients were enrolled in this study, the age of them ranged from 16 to 84 years (mean ± SD = 50.5 ± 18.87 years). There were six men (38%) and ten women (62%). The most common symptom at the presentation was a headache (81%). Alteration of consciousness was another presenting symptom (19%). Hypertension was found in more than half of the patients (56%). The onset of the symptom to the time at the NECT brain ranged from 2 to 72 hours (mean ± SD = 31.1 ± 24.1 hours). The most initial neurological status according to the modified WFNS was grade 1 (63%). The demographic data including sex, age, comorbidities, risk factors, the onset of the symptom to time at NECT brain, clinical presentation and initial neurological status (modified WFNS grading) are presented in Table 1.

Most common CT findings in ruptured basilar tips aneurysms were SAH in the interpeduncular cistern (88%) (Figure 1), followed by a prepontine cistern and Sylvian cistern (81%) (Figure 1), and cerebral convexities (75%). More than half of patients (56%) were classified in grade 4 according to modified Fisher's grading system (Figure 2). Intraventricular hemorrhage (IVH) was noted in 9 of 16 patients (56%). IVH was observed in the lateral, third and fourth ventricles in 44%, 38%, and 38%, respectively. Hydrocephalus was demonstrated in 14 of 16 patients (88%)(Figure 2). No associated intraparenchymal hemorrhage was presented in this study. The NECT findings in ruptured basilar tip aneurysms are presented in Table 2.

Table 1. Demographic data.

Demographic data		
Age	Mean age ± SD (years)	50.5 ± 18.9
	Sex Female	10 (62%)
	Male	6 (38%)
Comorbidities	Hypertension	9 (56%)
Onset of the symptom to the time at NECT brain	Mean onset ± SD (hours)	31.1 ± 24.1
Clinical Presentation	Headache 13 (81%)	
	Alteration of the consciousness	3 (19%)
Modified WFNS grading	Grade 1	10 (63%)
	Grade 2	0
	Grade 3	1 (6%)
	Grade 4	3 (19%)
	Grade 5	2 (12%)

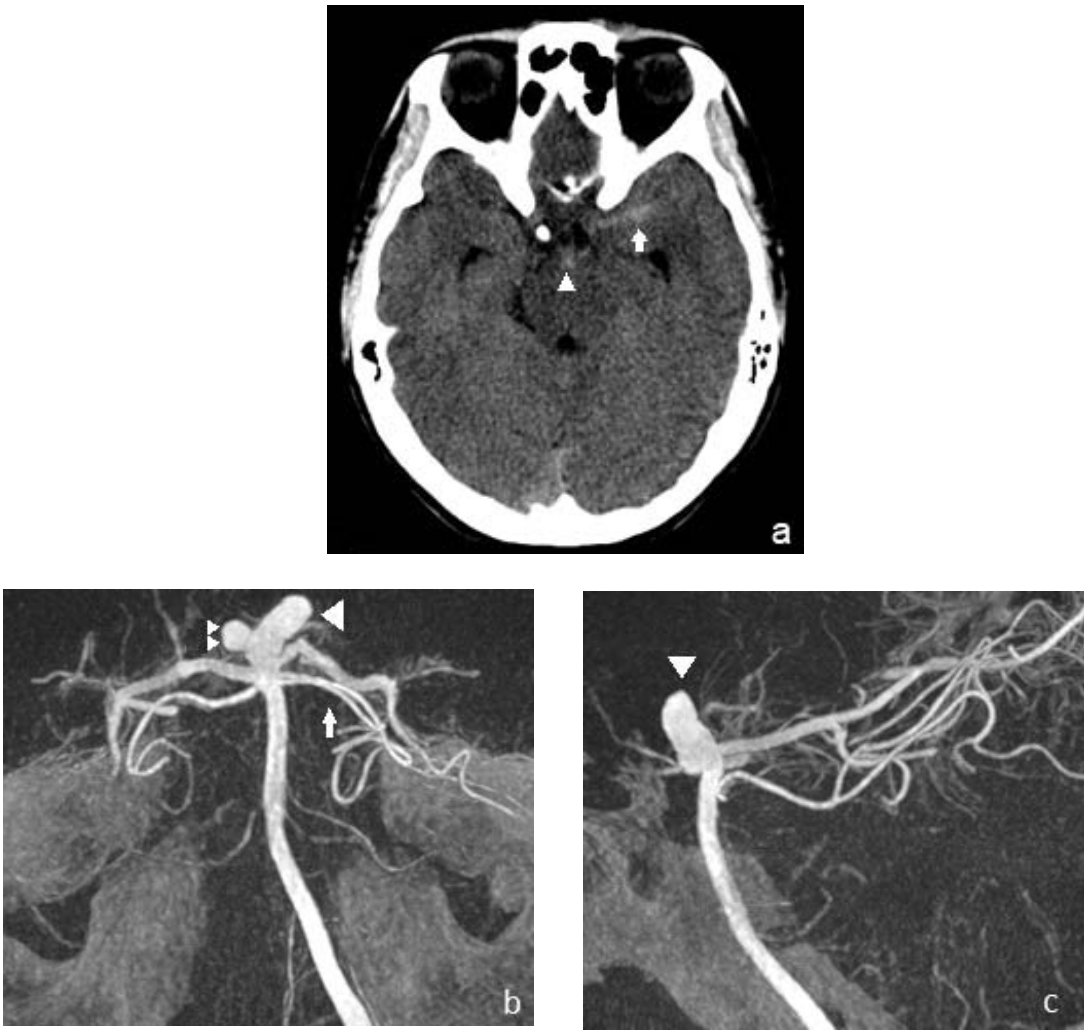

Figure 1. **a)** Axial NECT brain of a 27-year-old male presented with headache shows focal SAH in interpeduncular cistern (arrow head) and left Sylvian fissure (arrow) without IVH, compatible with grade 1 SAH according to Modified Fisher Grading scale. Associated hydrocephalus is observed. **b)** and **c)** Rotational 3D angiography in AP and lateral projections, respectively, of the same patient demonstrate a bi-lobulated basilar tip aneurysm pointed anterosuperiorly (arrow head) with a daughter sac projected to the right (double arrow head). Double left superior cerebellar arteries are also noted (arrow).

Angiographic findings of the ruptured basilar tip aneurysms, the mean height ± SD, mean width ± SD and mean neck ± SD as 7.4 ± 5.4 mm, 5.5 ± 3.3 mm and 4.1 ± 2.5 mm, respectively. Most of the basilar tip aneurysms were point anterosuperiorly in 7 of 16 patients (44%). Associated cerebral vasospasm was found in 7 of 16 patients (44%). More than half of the patients (56%) with grade 4 SAH according to modified Fisher's grading system had associated cerebral vasospasm (Figure 3). Grade 1 and grade 3 SAH according to modified Fisher's grading system with associated cerebral vasospasm were presented in 33% and 25%, respectively. Cerebral angiographic findings in ruptured basilar tip aneurysm patients are shown in Table 3. Five of sixteen patients (31%) showed other aneurysms in the different locations, however, all of them were angiographically confirmed that basilar tip aneurysm was the ruptured site.

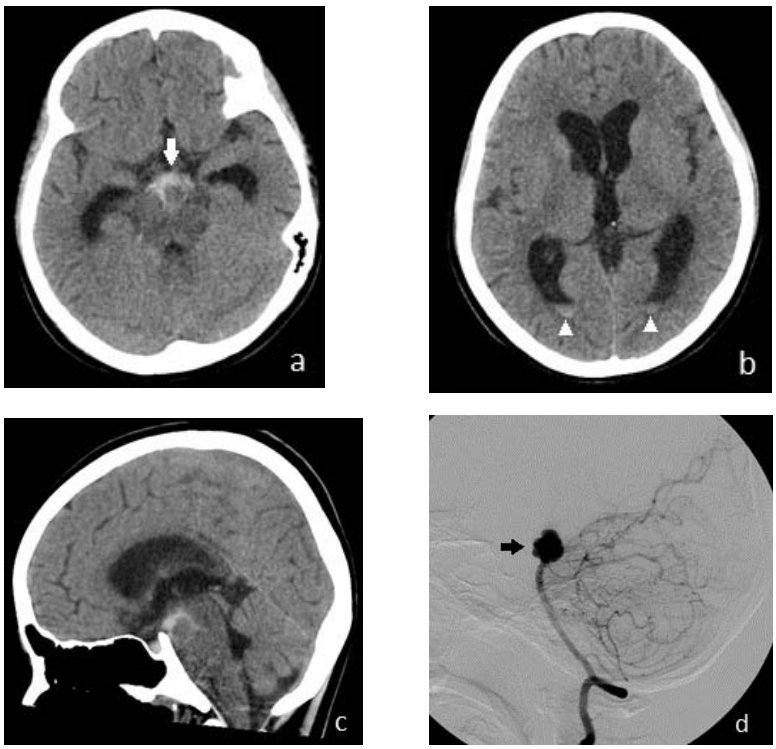

Figure 2. **a)** and **b)** axial images, **c)** sagittal image of CT brain of a 16-year-old female presented with headache show thick SAH at the interpeduncular cistern (arrow) as well as IVH in bilateral lateral ventricles (arrow heads), compatible with grade 4 SAH according to Modified Fisher Grading scale. Associated hydrocephalus is noted, **d)** digital subtraction angiography in lateral projection reveals a lobulated aneurysm at the basilar tip, projecting superiorly (arrow).

Table 2. CT findings of the ruptured basilar tip aneurysm**.**

Location of SAH on NECT		**Number (%)**
	Interpeducular cistern	14 (88%)
	Prepontine cistern	13 (81%)
	Sylvian cistern	13 (81%)
	Cerebral convexities	12 (75%)
	Crural cistern	10 (62%)
	Chiasmatic cistern	10 (62%)
	Anterior interhemispheric fissure	10(62%)
	Posterior interhemispheric fissure	9 (56%)
	Superior cerebellopontine cistern	9 (56%)
	Laminar terminalis	9 (56%)
	Quadrigerminal cistern	9 (56%)
	Ambient cistern	9 (56%)
	Inferior cerebellopontine cistern	8 (50%)
	Superior cerebellar cistern	8 (50%)
	Vellum interpositum	8 (50%)
	Pre medullary cistern	7 (44%)
	Pericollasal cistern	7 (44%)
	Cisterna magna	5 (31%)
Modified Fisher Grading	Grade 1	3 (19%)
	Grade 2	0
	Grade 3	4 (25%)
	Grade 4	9 (56%)
Intraventricular Hemorrhage (IVH)	No IVH	7 (44%)
	IVH	9 (56%)
	Lateral ventricle	7 (44%)
	Third ventricle	6 (38%)
	Fourth ventricle	6 (38%)
Intraparenchymal Hematoma		0
Hydrocephalus		14 (88%)

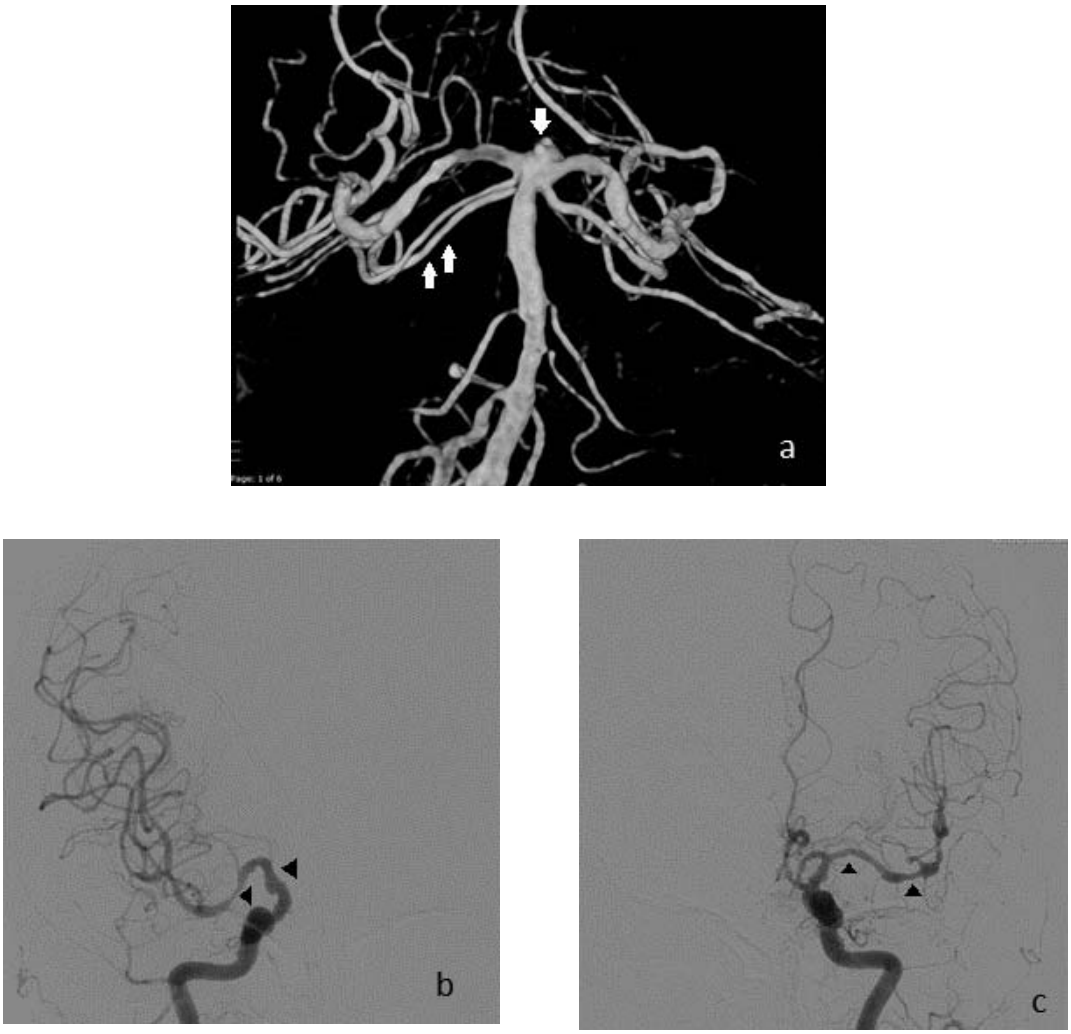

Figure 3. **a)** rotational angiography with 3D reconstruction in AP projection of an 84-year-old female shows a relatively wide neck aneurysm at the tip of the basilar artery (arrow). The neck of an aneurysm is partially involved the proximal P1 segment of the left posterior cerebral artery. Dome of an aneurysm projects posteriorly. There are few small spikes projecting from dorsal aspect of the aneurysm sac. Double left superior cerebellar arteries are also noted (double arrows), **b)** and **c)** digital subtraction angiography of the right and the left internal carotid arteries show several scattered segmental vasospasms (arrow heads).

Table 3. The cerebral angiographic findings of ruptured basilar tip aneurysm.

Size of aneurysm			
	Mean height ± SD (mm) (min-max)		7.5 ± 5.4 (2.6 - 23.4)
	Mean width ± SD (mm) (min-max)		5.5 ± 3.3 (1.9 - 12.9)
	Mean neck ± SD (mm) (min-max)		4.1 ± 2.5 (1.8 - 11.7)
Direction of aneurysm			Number (%)
	Anterosuperior		7 (44%)
	Superior		6 (38%)
	Posteriorsuperior		3 (18%)
Vasospasm	Modified Fisher's grading	Gr 1	1 (33%)
		Gr 3	1 (25%)
		Gr 4	5 (56%)

Discussion

In this study, we found that ruptured basilar tip aneurysm is uncommon with only 16 cases during 5 years period in our institution. Most patients presented with headache (81%). Hypertension was noted in more than half of the patients (56%). Most common CT findings in ruptured basilar tips aneurysms were SAH in the interpeduncular cistern (88%), followed by prepontine cistern and the Sylvian cistern (81%) and cerebral convexities (75%). More than half of patients (56%) were classified as grade 4 SAH according to modified Fisher's grading system. These would imply that although basilar tip aneurysm is located in the posterior fossa, the common pattern of SAH in ruptured basilar tip aneurysm is diffuse subarachnoid hemorrhage along both infratentorial and supratentorial regions.

Norihiro S, *et al.* [8] studied CT brain in 20 patients with acute ruptured posterior fossa aneurysms, which showed two cases of ruptured basilar aneurysm as diffuse subarachnoid hemorrhage in the supratentorial region and interpeduncular cistern and one of them had IVH in the lateral, third and fourth ventricle. Davis KF, *et al.* [9] studied CT pattern of hemorrhage associated with ruptured posterior inferior cerebellar artery aneurysms in 44 patients, demonstrated extensive supratentorial SAH in conjunction with posterior fossa hemorrhage were the common findings which were compatible with our findings in this study. Davis KF, *et al.* [9] also noted high frequency of IVH and hydrocephalus, both findings being present in 95% of cases. Although we found less frequency of IVH in 9 of 16 patients (56%) in our study, hydrocephalus was relatively common findings in 14 of 16 patients (88%). No associated intraparenchymal hemorrhage was presented in our study.

In our cerebral angiographic findings, we found associated cerebral vasospasm in 56% of the patients with grade 4 SAH according to modified Fisher's grading system. Grade 1 and grade 3 SAH according to modified Fisher's grading system with associated cerebral vasospasm were presented in 33% and 25%, respectively. The similarly, Frontera JA, *et al.*[12] found that higher scores of modified Fisher's grading were highly associated cerebral vasospasm also influenced the patient's prognosis.

Owing to retrospective descriptive study in the single center, there are small target population and limited clinical data including comorbidities (i.e. Ehlers-Danlos syndrome type IV, autosomal dominant polycystic kidney disease, neurofibromatosis type I) and risk factors (e.g. smoking history, alcohol drinking and family history of a cerebral aneurysm). Eleven patients were referred from the rural hospital without film or CD of the NECT brain from their hospital, therefore, they were excluded in our study due to incomplete data.

In the future study, we suggested the prospective study design should be performed in multicenter to gather more clinical data and increase target population for improvement with statistical significance.

Conclusion

Our study documents the common CT findings together with the demographic data, clinical presentation and cerebral angiographic findings in ruptured basilar tip aneurysms in 16 patients. The results can be used to predict the ruptured basilar tip aneurysms in the common CT findings for proper management to reduce mortality and disability.

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