Prediction of the site of the aneurysms in the region of the circle of Willis and the vicinity by CT scan

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Abstract:

Retrospective study of the proved aneurysms, detected by i.v. contrast CT study in 21 cases, relating with the angiographic and surgical results. The aneurysms were mapped on the "pentagon" which was assumed to represent the circle of Willis. Paramedian anterior pentagon represented the site of anterior communicating artery aneurysm and the opposite posterior paramedian or median area was the site of basilar tip aneurysm. The lateral anterior corner was for the aneurysm of the horizontal portion (rare) of the middle cerebral a. or supraclinoid internal carotid a. The lateral posterior corner would be for aneurysm of the posterior communicating a, or distal internal carotid artery. Most of the aneurysms at the genu of the middle cerebral a. (more common than at the horizontal portion) were outside the petagon and were at the region posterior to the anterior middle cranial fossa. Rarer case of the anterior communicating a. was above the pentagon, seen between the floor of both frontal horns.

Key words: Aneurysms, circle of Willis, CT scan

Intracranial aneurysms represent the most common atraumatic cause of subarachnoid hemorrhage (7). The vast majority of saccular aneurysms are isolated lesions without any underlying predisposing factor. In less than 5 percent of cases, aneurysms are associated with septic emboli, head trauma, or neoplasia. Approximately 90 percent of saccular aneurysms occur in the anterior circulation in the region of the circle of Willis. Most commonly, specific sites of occurrence are the anterior communicating artery, posterior communicating origin, and middle cerebral artery bifurcation/trifurcation. Traditional methods of identifying the origin of aneurysms have rested upon either CT correlation of the site of the hemorrhage (8, 9) or angiographic morphologic changes in ruptured aneurysms. For instance, anterior interhemispheric blood correlated to ruptured anterior communicating aneurysms, whereas Sylvian fissure hemorrhage often indicates middle cerebral artery bifurcation aneurysm rupture.

Direct detection of the aneurysm by i.v. contrast CT scan is possible in the absent or faint subarachnoid blood. We study the possibility of accurate localization of the origin of these CT detected aneurysms.

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Materials and methods:

Retrospective study of the aneurysms in the region of the circle of Willis detected by enhanced axial CT scan of the brains was performed in 21 patients. Correlation of the sites of the aneurysms detected by CT scans with the angiographic and operative findings was done. The suprasellar cistern where the circle of Willis located was viewed as the "Pentagon". The enhanced aneurysms seen were mapped on this pentagon. The levels of the CT cuts where the enhanced aneurysms were visualized, were labelled as levels 1, 2, or 3.

The axial cuts at the posterior fossa were 4 mm in some cases and 10 mm in another cases. The level 1 was the cut that the sellar turcica, dorsum sella or the posterior clinoid process was visualized. The level 2 was the level that the suprasellar cistern was seen. The level 3 was the level that the 3rd ventricle was shown.

Results

Twenty-one patients studied were 11 males and 10 females. The age ranged from 29 to 71 yrs old. Subarachnoid hemorrhage was present in 18 cases and the focal neurological sign without subarachnoid hemorrhage in 3 cases. The size of the aneurysms were 4-14 mm, according to the CT findings and all were saccular type.

The detailed findings in the cases of the anterior communicating artery, basilar tips, internal carotid artery, posterior communicating artery and the middle cerebral artery were shown in Table 1, 2, 3, 4 and 5 respectively. The illustrated cases of the anterior communicating artery were shown in Fig. 1, of the basilar tip in Fig 2, of the internal carotid artery in Fig 3 and 4, of the posterior communicating artery in the Fig. 5 and of the middle cerebral artery in the Fig. 6 and 7.

The anatomic diagram of the circle of Willis is shown in Fig. 8. The summarized diagram of the aneurysms on the Pentagon and the labeled site of the aneurysm was seen in Fig. 9. The aneurysms outside the pentagon was illustrated in the diagrams of Fig. 10 and Fig. 11.

Table 1. Detailed analysis of the 9 aneurysms at the anterior communicating artery by CT scan

No.	Age	Sex	Aneurysm's size (mm)	Level	DMM(mm)	Side	Location on the pentagon
1.	55	M	10	2	5	Lt	
2.	55	M	6	2	2	Lt	
3.	71	M	10	1	5	Rt	
4.	52	M	8	1	4	Rt	
5.	49	F	8	2	0	Midline	
6.	45	M	4	2	2	Lt	
7.	58	M	14	2	0	Midline	
8.	53	F	8	2	4	Lt	
9.	62	M	5	3	2	Rt	

Note; DDM = distance from midline to the middle part of the aneurysm
* the aneurysm was at between floor of both frontal horns, cut level 3

Table 2. Detailed analysis of the 2 aneurysms at the basilar tip by CT scan

No.	Age	Sex	Aneurysm's size (mm)	Level	DDM(mm)	Side	Location on the pentagon
1.	67	F	12	1,2,3	0	midline	
2.	55	F	17	2	0	midline	

Table 3. Detailed analysis of the 2 aneurysms at the internal carotid artery by CT scan

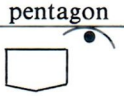
No.	Age	Sex	Aneurysm's size (mm)	Level	DDM,DPC (mm)	Side	Location on the pentagon
1.	40	M	7	2	12, 9	Rt	
	the aneurysm was at the distal ICA bifurcation						
2.	60	F	6	2	10, 18	Lt	
	the aneurysm is at the supraclinoid portion						

Note; DPC = distance from prepontine cistern to mid part of the aneurysm

Table 4. Detailed analysis of the 3 aneurysms at the posterior communicating artery by CT scan

No.	Age.	Sex	Aneurysm's size (mm)	Level	DDM,DPC (mm)	Side	Location on the pentagon
1.	55	F	5	1	11, 8		
2.	68	F	11	2	10, 5		
3.	67	M	6	2	8, 7		

Table 5. Detailed analysis of the 5 aneurysms at the middle cerebral artery by CT scan

No.	Age	Sex	Aneurysm's size (mm)	Level	DDM (mm)	Side	Location on the pentagon
1.	29	M	10	2	36	Lt	
2. *	53	F	6	1	10	Rt	
3.	50	F	5	2	28	Rt	
4.	59	F	8	1	28	Lt	
5.	55	M	2	2	30	Rt	

* the aneurysm arose from the mid horizontal portion of rt MCA
Other aneurysms were from the region of the trifurcation/bifurcation of the MCA

Discussion

The circle of Willis is an interconnecting arterial polygon that surrounds the ventral surface of the diencephalon adjacent to the optic nerves and tracts (1). The normal circle of Willis is shown diagramatically in Figure 8. The following vessels comprise the circle of Willis: 1. the two ICAs 2. the horizontal (A l) segments of both anterior cerebral arteries 3. the anterior communicating artery 4. the two posterior communicating arteries 5. the horizontal (P1) segments of both posterior cerebral arteries 6. the basilary artery. (2). The ICAs, ACAs, ACoA, and their branches are sometimes termed the anterior circulation; the basilar bifurcation, PCAs, and PCoAs are collectively termed the posterior circulation (3). In normal patients the entire circle of Willis is only occasionally visualized on a single injection during cerebral angiography. Contrast enhanced spiral CT with maximum intensity projection can be used to obtain angiographic images of the circle and its major branches (4, 5, 6). Other noninvasive techniques for visualizing these vessels include magnetic resonance angiography (MRA) and transcranial doppler ultrasound.

The circle of Willis is actually "the Septagon", however, for simplicity, we drew "the Pentagon" to represent it. From this study, we could see from Fig. 9, that there were 5 locations where aneurysms sit on the Pentagon. The anterior communicating a. aneurysm would be at midline or paramedian part of the anterior Pentagon. The opposite midline posterior pentagon was the site of basilar tip aneurysm. The posterior right or left corner would be for aneurysm of the posterior communicating a. or distal ICA. The anterior corner of both sides would be for aneurysm of the horizontal portion of the middle cerebral a. or supraclinoid internal carotid a. The regions on the lateral wall of the pentagon anywhere between the anterior and posterior corners would be for aneurysm of the posterior communicating a. or distal internal carotid artery. These aneurysms which could be related to the circle of Willis (or the pentagon) must be seen at the cut levels 1 or 2.

There were aneurysms seen outside the pentagon. One case of the anterior communicating a. aneurysm that was located high (seen at cut level 3) between the floor of the frontal horns. The aneurysms of the genu of the middle cerebral a. would be posterior to the anterior wall of the middle cranial fossa.

By mapping the visualized enhanced aneurysm by CT scan on the pentagon, it help to locate the origin of the aneurysm.

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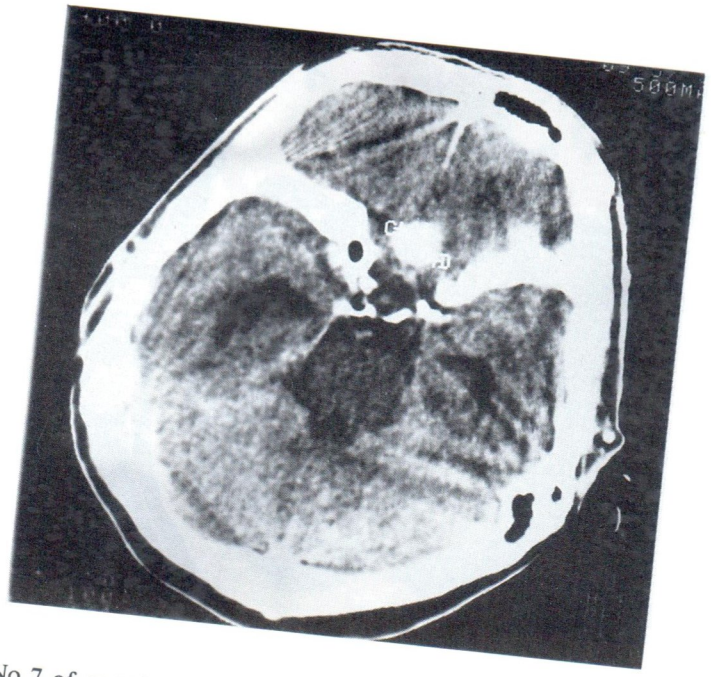

Fig.1a Case No.7 of anterior communicating a. aneurysm by i.v. enhanced CT scan

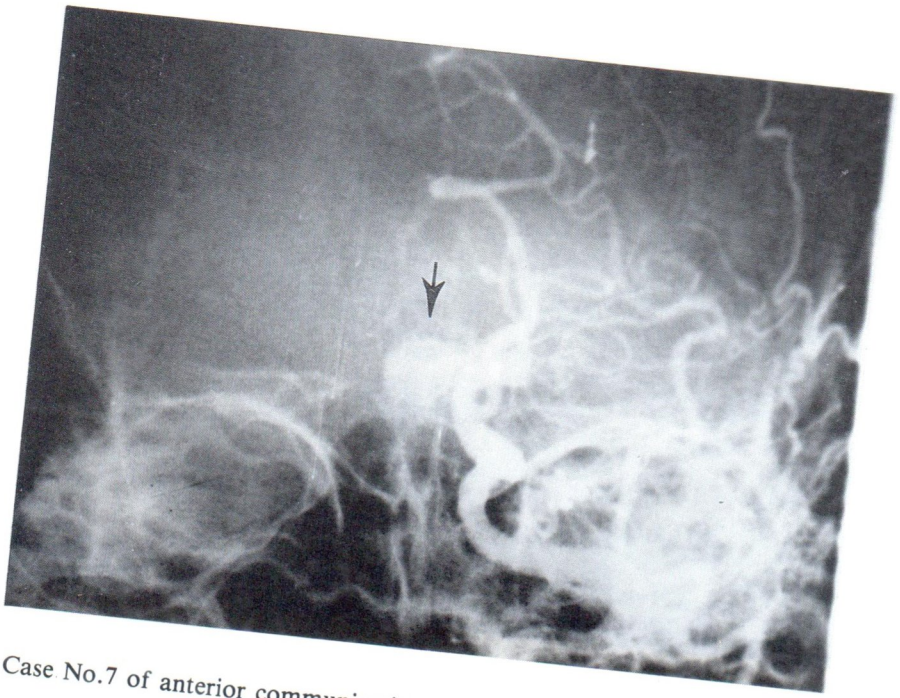

Fig.1b Case No.7 of anterior communicating a.aneurysm by conventional angiography

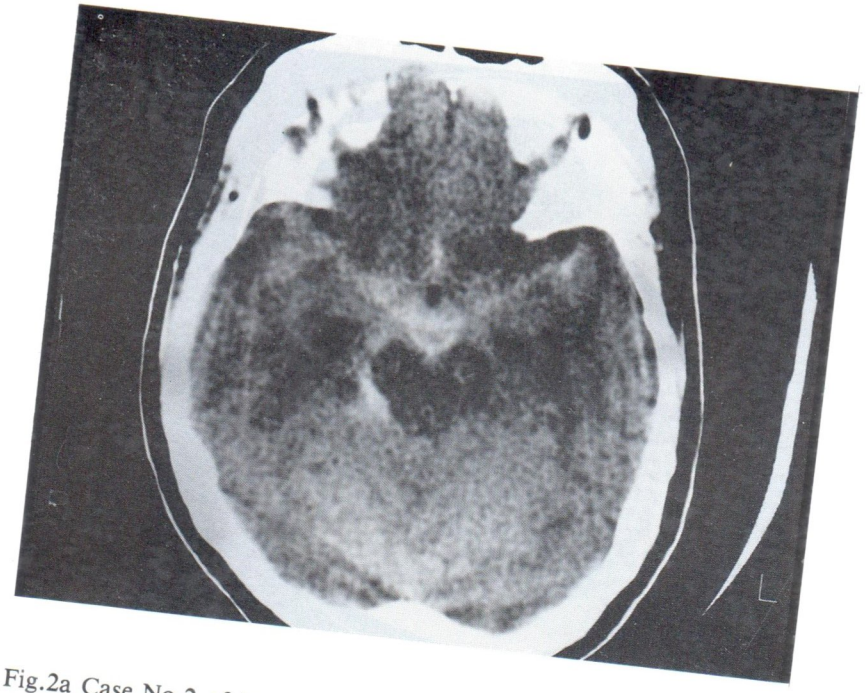

Fig.2a Case No.2 of basilar tip aneurysm by i.v. contrast study

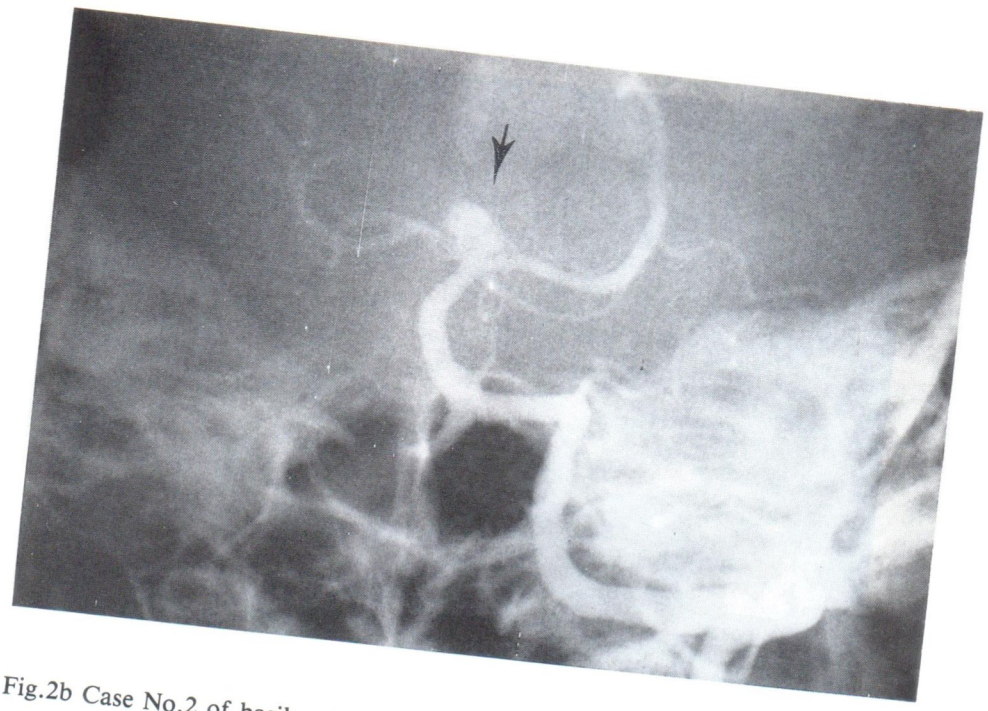

Fig.2b Case No.2 of basilar tip aneurysm by conventional angiography

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Fig.3a Case No.1of aneurysm at distal ICA by i.v. enhanced study

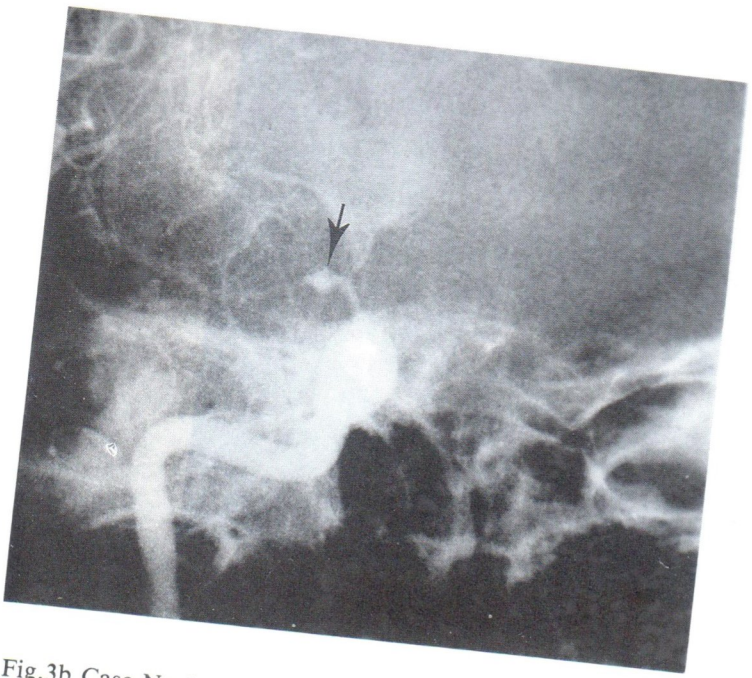

Fig.3b Case No.1 of aneurysm at distal ICA by conventional angiography

Fig.4a Case No.2 of aneurysm at supraclinoid internal carotid a. by i.v. enhanced CT scan

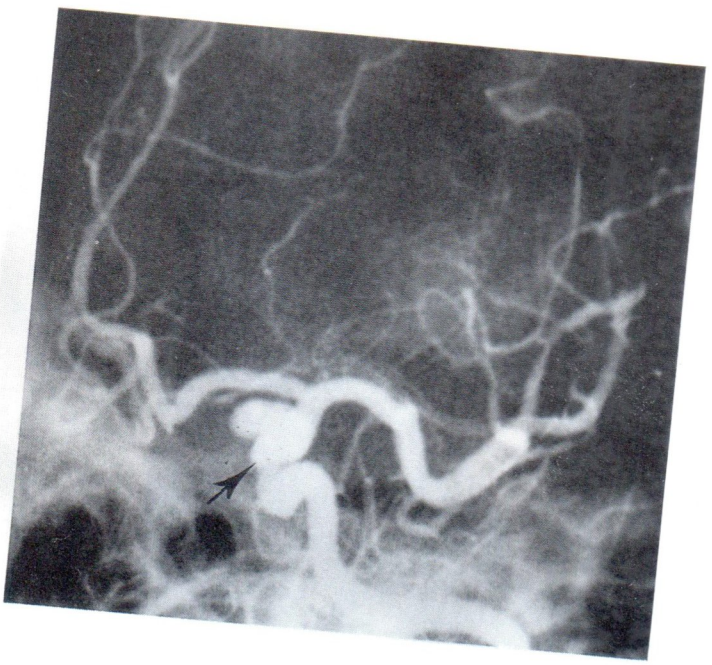

Fig.4b Case No.2 of aneurysm at supraclinoid internal carotid a. by conventional angiography

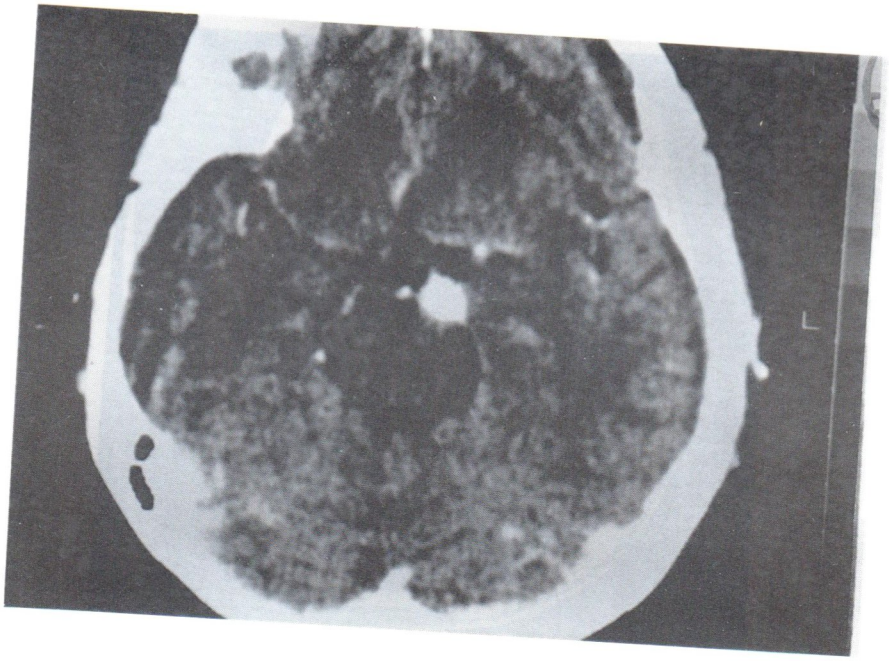

Fig.5a Case No.2 of posterior communicating a. aneurysm by i.v. enhanced CT scan

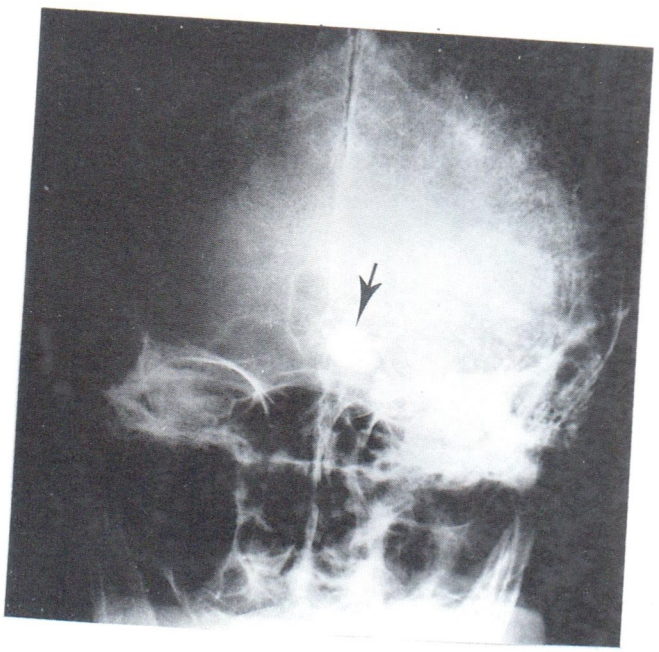

Fig.5b Case No.2 of posterior communicating a. aneurysm by conventional angiography

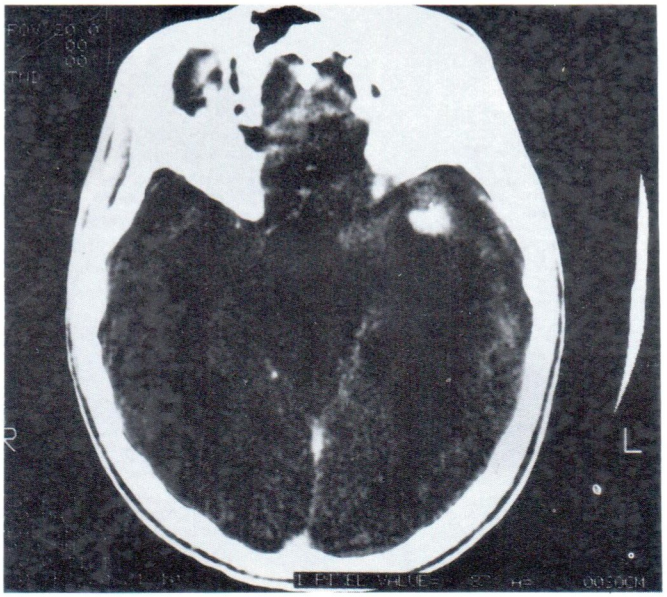

Fig.6a Case No.1 of middle cerebral a.aneurysm by i.v. enhanced CT scan

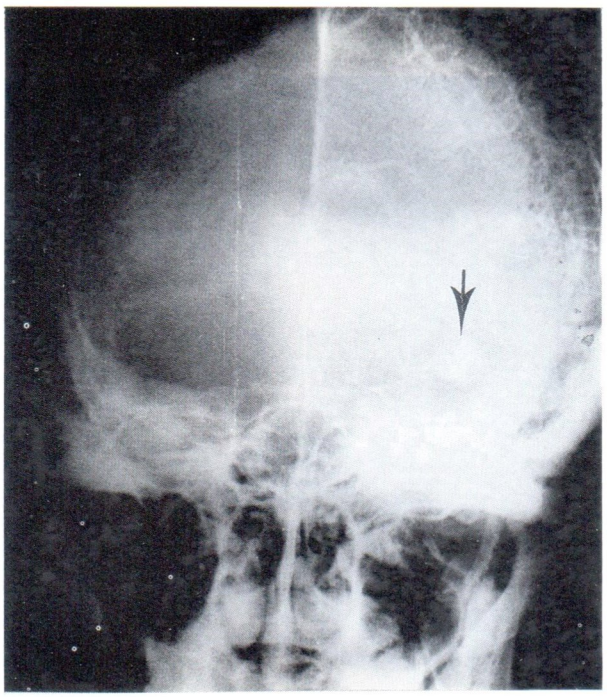

Fig.6b Case No.1of middle cerebral a. aneurysm by conventional angiography

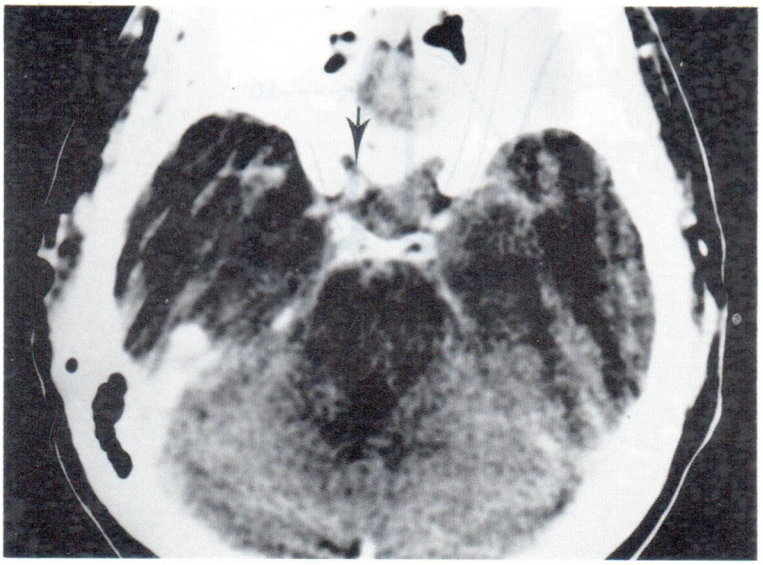

Fig.7a Case No.2 of middle cerebral a. by i.v. enhanced CT scan

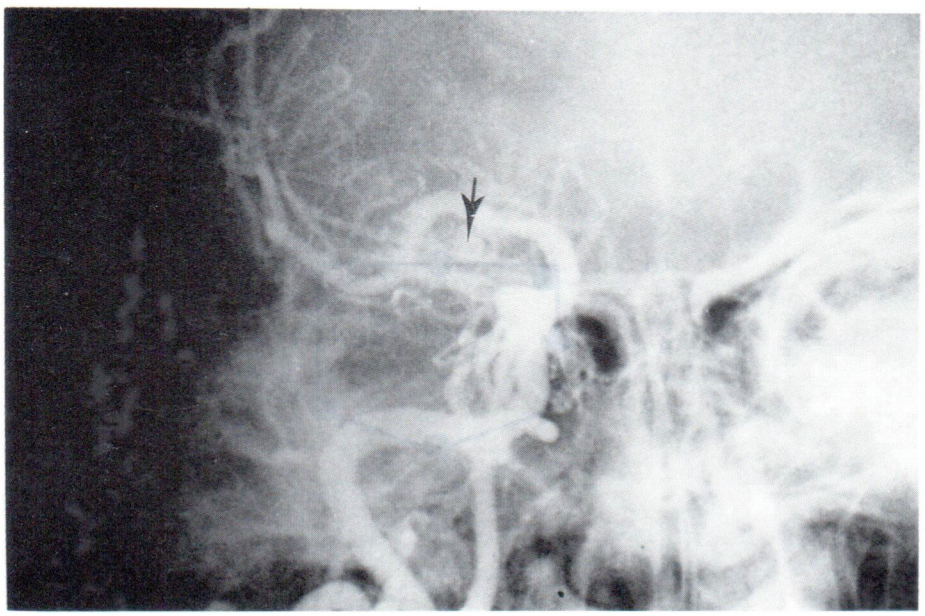

Fig.7b Case No.2 ofmiddle cerebral a. by conventional angiography

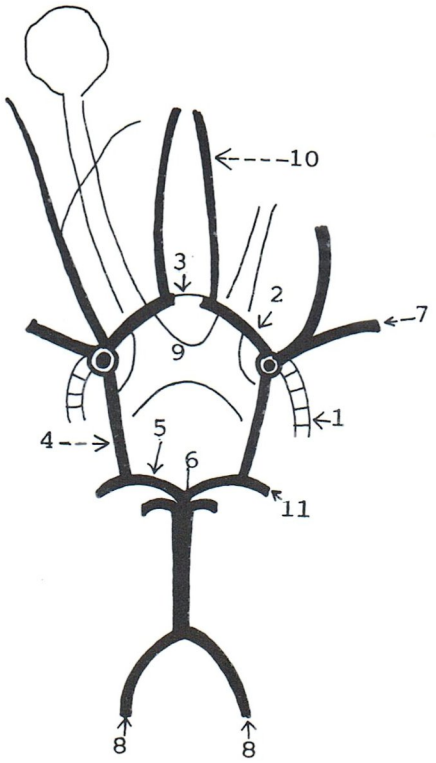

Fig.8 Anatomic diagram depict the circle of Willis. 1, Internal carotid artery (ICA). 2, Horizontal (A1) anterior cerebral artery segment. 3, Anterior communicating artery (ACoA). 4, Posterior communicating artery (PCoA). 5, P1 segment of posterior cerebral artery (PCA). 6, Basilar artery (BA) bifurcation. 7, Middle cerebral artery (MCA; not part of the circle of Willis). 8, Vertebral arteries (VAs; also not part of the circle of Willis). 9. Optic chiasm. 10, A2 (post communicating) ACA segment. 11, P2 (post communicating) PCA segment. (Modified from Osborn AG: Handbook of Neuroradiology, Mosby-Year Book 1991)

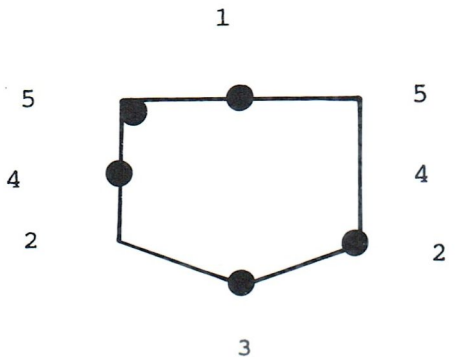

Fig.9 Summarized diagram of the aneurysms of thecircle of Willis, according to the locations on the "pentagon"
1 = aneurysm of anterior communicating artery
2 = aneurysm of posterior communicating artery vs distal ICA
3 = aneurysm of the tip of the basilar artery
4 = aneurysm of posterior communicating artery vs distal ICA
5 = aneurysm of horizontal portion of middle cerebral a. vs of supraclinoid ICA.

Fig.10 Aneurysm outside the circle of willis, at the genu of middle cerebral artery, approximately at the region posterior to mid curve of the anterior middle cranial fossa wall

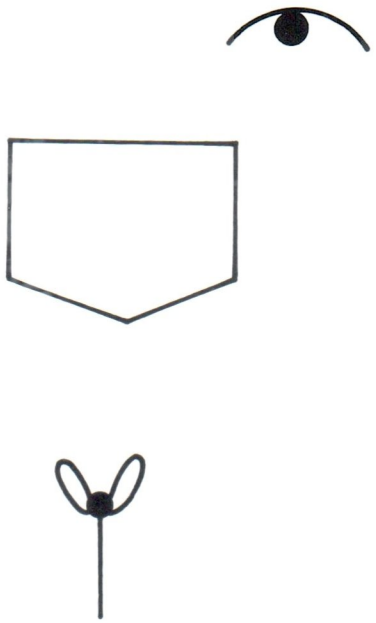

Fig.11 Aneurysm was shown at area 3, of anterior communicating a. between the floor of the frontal horns