Bull. Tokyo Med. Dent. Univ., 20: 81–91, 1973.

DYNAMIC STUDY ON CEREBROSPINAL FLUID CIRCULATION AFTER SUBARACHNOID HEMORRHAGE

BY

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ABSTRACT

Alterations in the cerebrospinal fluid (CSF) circulation after subarachnoid hemorrhage (SAH) were examined in 19 patients. Sources of hemorrhage were aneurysm in 17 cases, arteriovenous aneurysm in one and unknown in one. Cistenography was performed using 1 mCi of ^{169}Yb diethyltriaminepentaacetic acid which was given intrathecally by lumbar injection. Persistent ventricular filling was seen in 48% of the cases and transient ventricular filling in 33%. The radioactivity in serial blood samples was measured by a well-type scintillation counter. The relationship of cisternogram to classification of patient's condition by Hunt was found to be closely related to the degree of abnormality of CSF circulation. The patient's history of rebleeding was also found to influence the degree of abnormality in CSF circulation. In regard to the site of aneurysms, those in the circle of Willis appeared to cause normal pressure hydrocephalus more frequently. Shunt operation was performed on 6 cases, 4 of whom showed improvement. Indications for shunt were determined according to clinical syndrome and diagnostic tests such as angiography, pneumoencephalography and cisternography. In addition to these, test for radioactivity in the peripheral blood was found useful for evaluation of the condition in CSF circulation.

INTRODUCTION

Recent increase of the incidence of ruptured intracranial aneurysm in Japan[1] offers several complex problems for its management. Persistent neurological deficits or clinical deterioration after subarachnoid hemorrhage (SAH) can result from subsequent communicating hydrocephalus which can be treated by surgical shunting[2]. We have studied alterations in the cerebrospinal fluid (CSF) circulation after SAH and relationship between SAH and obstructing communicating hydrocephalus or normal pressure hydrocephalus in clinical materials.

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Received for publication, December 1, 1972.

Table 1. Summary of patient data and result

Case No.	Age	Diagnosis	Neurological status	Isotope cisternography	Tracer activity in blood
1.	62	ACCA aneurysm	Akinetic mutism	Persistent ventricular filling	A
2.	55	ACCA aneurysm	Akinetic mutism	Persistent ventricular filling	
3.	57	l-MCA aneurysm	Disorientation, Gerstmann	Persistent ventricular filling	A
4.	49	ACCA aneurysm	Amnesia, disoriented confabulation	Transient ventricular filling	C
5.	37	ACCA aneurysm	Euphoria	Transient ventricular filling	C
6.	40	ACCA aneurysm	Deep coma	Persistent ventricular filling	A
7.	52	ACCA aneurysm	Disoriented, memory disturbance	Transient ventricular filling	B
8.	57	l-ICPC & A_1 aneurysm	Dementia, memory & gait disturbance	Persistent ventricular filling	B
9.	26	l-ACA & AICA aneurysm	Disorientation	Persistent ventricular filling	A
10.	57	r-ACA aneurysm	Symptom-free	No ventricular filling	C
11.	21	AVM	Symptom-free	No ventricular filling	C
12.	25	l-IC aneurysm	Symptom-free	No ventricular filling	C
13.	26	l-ACA & AICA aneurysm	Emotional disturbance	Persistent ventricular filling	A
14.	37	r-ICPC aneurysm	Lethargic	Transient ventricular filling	C
15.	39	ACCA aneurysm	Disorientation, amnesia	Persistent ventricular filling	A
16.	23	l-ICPC aneurysm	Slowness of mental activity	Transient ventricular filling	B
17.	41	SAH, unknown	Amnesia	Persistent ventricular filling	A
18.	48	l-ICPC	Memory impairement	Transient ventricular filling	
19.	63	SAH, unknown	Alert	No ventricular filling	C

ACCA=anterior communicating artery
AICA=anterior inferior cerebellar artery
ACA=anterior cerebral artery
MCA=middle cerebral artery
IC=internal carotid artery
A, B, and C indicate delayed type, medium type, and normal type, respectively.

Fig. 1. ^{169}Yb-DTPA cisternogram showing persistent ventricular filling with absence of convexity flow. 1a: 3 hr, anterior view. 1b: 3 hr, left lateral view. 2a: 24 hr, anterior view. 2b: 24 hr, left lateral view. 3a: 48 hr, anterior view. 3b: 48 hr, left lateral view.

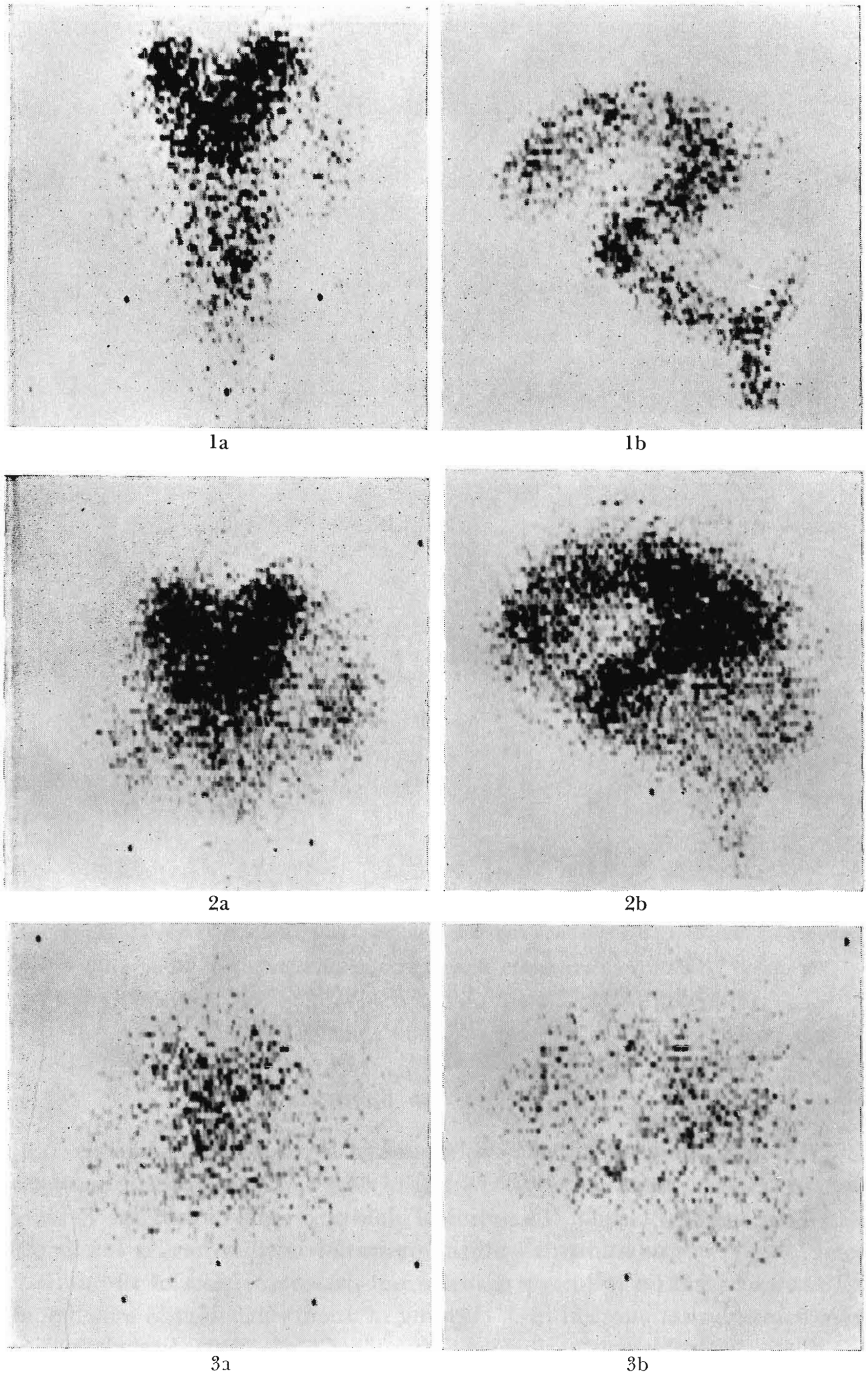

Fig. 1

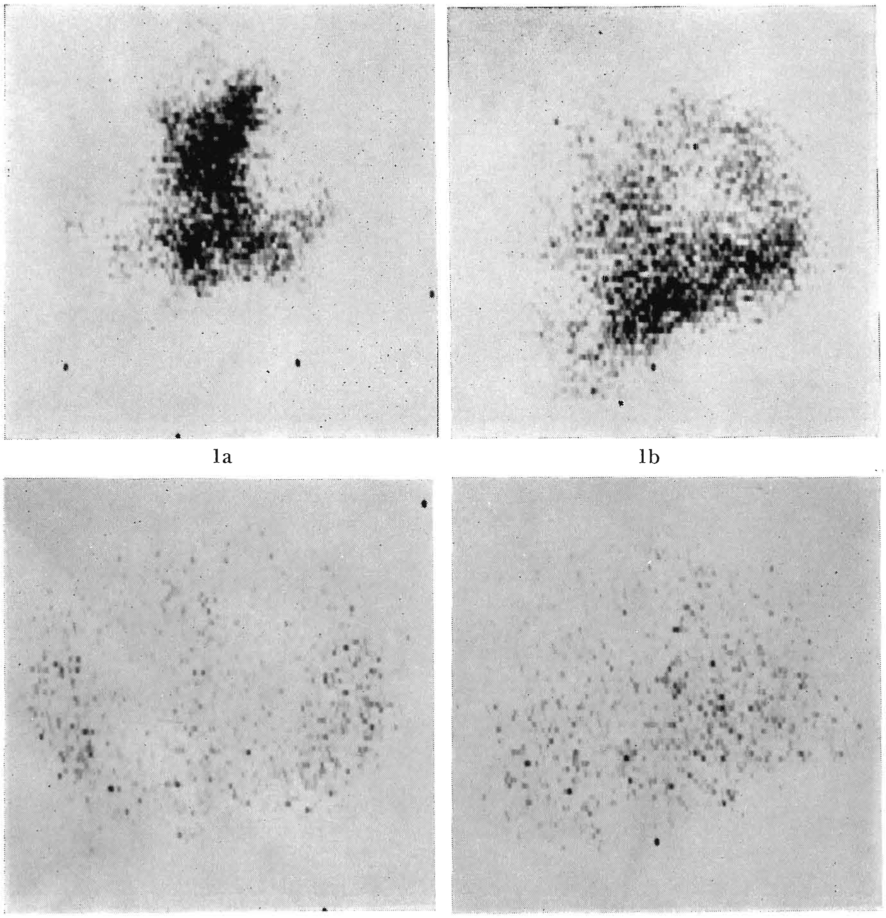

Fig. 2. ^{169}Yb-DTPA cisternogram showing transient ventricular filling with delayed convexity flow. 1a: 3 hr, anterior view. 1b: 3 hr, right lateral view. 2a: 24 hr, anterior view. 2b: 24 hr, right lateral view.

Materials and Methods

Nineteen cases with SAH were studied in our neurosurgical clinic. Sites of bleeding were confirmed by angiography with the exception of one case with unknown site. The clinical data are summarized in Table 1. Some patients were studied during their initial hospitalization for hemorrhage and others on follow-up visits as out-patients. Most of the patients were scanned after surgical neck clipping of aneurysm.

Cisternography was performed using 1 mCi of ^{169}Yb diethyltriaminepentaacetic acid (^{169}Yb-DTPA) which was given intrathecally by lumbar in-

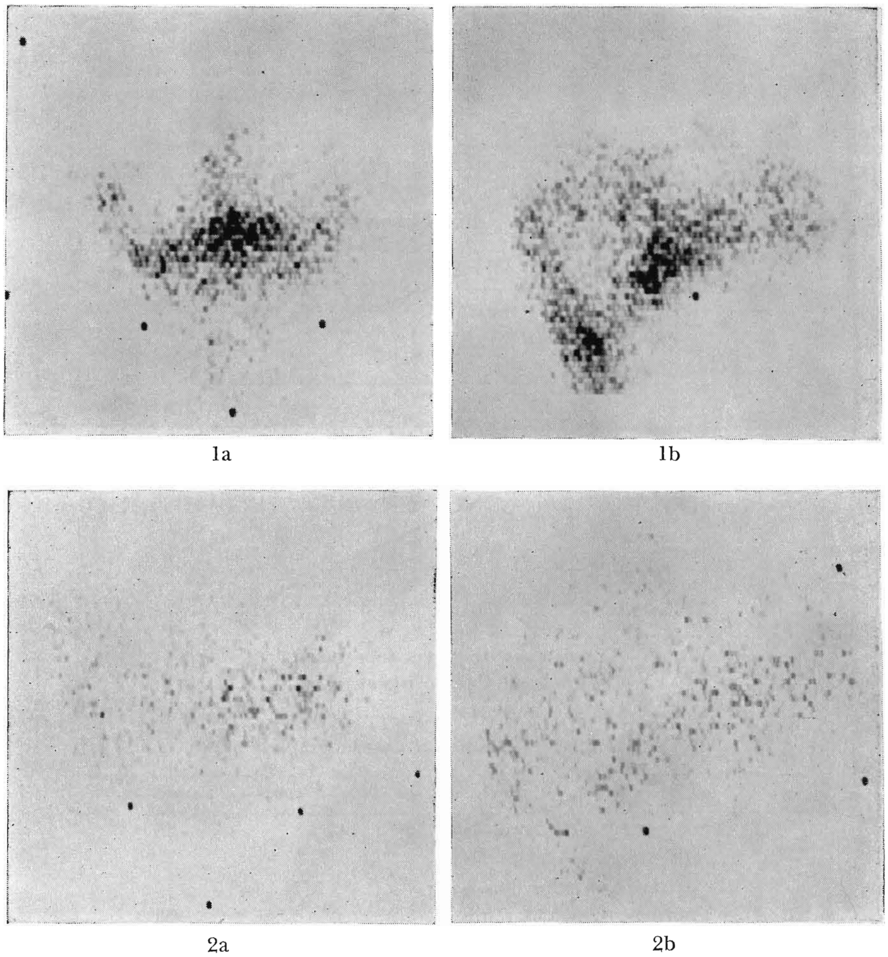

Fig. 3. ^{169}Yb-DTPA cisternogram showing delayed convexity flow with no ventricular filling. 1a: 3 hr, anterior view. 1b: 3 hr, right lateral view. 2a: 24 hr, anterior view. 2b: 24 hr, right lateral view.

jection[3,4]. Scans or camera images of the lateral and anterior views were obtained after 3, 6, 24, and 48 hr, if necessary. In two patients, cisternography was repeated to follow up the course. The radioactivity in serial blood was measured by a well-type scintillation counter at 30 min, and 1, 2, 3, 6, and 24 hr after injection. Transfer curves of ^{169}Yb-DTPA from CSF to blood were obtained.

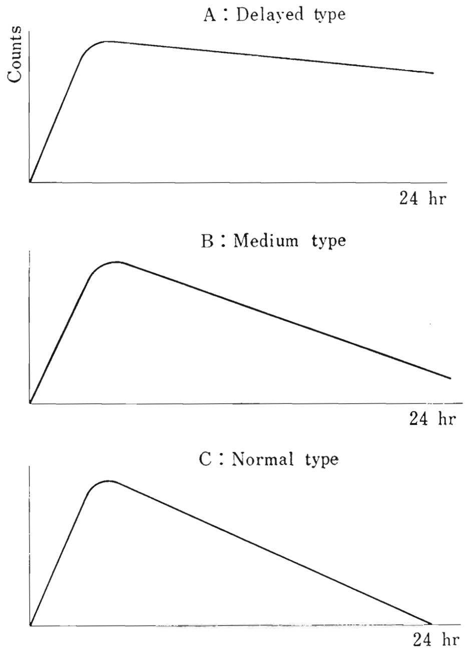

Fig. 4. Three types of curves for transfer of ^{169}Yb-DTPA from CSF to blood.

Table 2. Results of cisternography

	No. of cases		Percentage
I. Persistent ventricular filling	10		48
a. absence of convexity flow		6	
b. partial convexity flow		4	
II. Transient ventricular filling	7		33
a. delayed convexity flow		5	
b. normal convexity flow		2	
III. No ventricular filling	4		19
a. delayed convexity flow		2	
b. normal convexity		2	
Total	21		100%

Results

Results of cisternogram were classified into 3 groups and 6 subgroups as shown in Table 2. In 48% of the cases, persistent ventricular filling with delayed clearance and reduction or absence of flow in the cerebral subarachnoid space was demonstrated (Fig. 1). In 33% of the cases, transient ventricular filling with delayed or normal convexity flow was observed (Fig. 2).

Table 3. Results of isotope activity in blood

	No. of cases	Percentage
A. Delayed type	8	42
B. Medium type	4	21
C. Normal type	7	37
Total	19	100%

Table 4. Relationship of cisternogram to isotope activity in blood

	Isotope activity in blood		
	delayed	medium	normal
Persistent ventricular filling	8	1	0
Transient ventricular filling	0	3	3
No ventricular filling	0	0	4

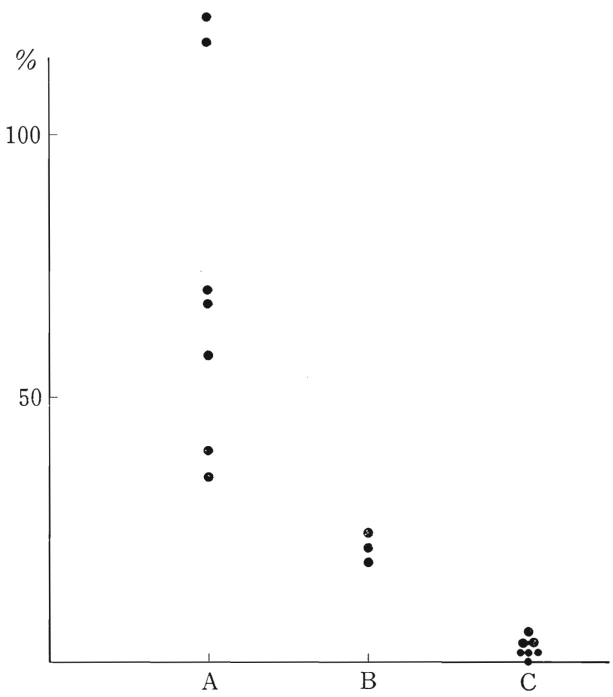

Fig. 5. Count ratio of blood activity at 24 hr to that at 3 hr.

Only in 2 cases, cisternography showed normal convexity flow without ventricular filling (Fig. 3).

Three types of curves for transfer of ^{169}Yb-DTPA from CSF to blood were classified; delayed type, medium type, and normal type (Fig. 4). In delayed type, the count ratio of blood activity at 24 hr to that at 3 hr is over

Table 5. Relationship of cisternogram to classification of patient by Hunt

	I	II	III	IV	V
Persistent ventricular filling	0	0	3	4	1
Transient ventricular filling	2	2	1	1	0
No ventricular filling	2	2	0	0	0

Table 6. Relationship of cisternogram to rebleeding

	Rebleeding	
	(+)	(−)
Persistent ventricular filling	5	3
Transient ventricular filling	2	4
No ventricular filling	1	3

Table 7. Results of surgical treatment

Case No.	Age	Bleeding site	Isotope cisternography	Tracer activity in blood	Surgical results
1.	62	Anterior communicating	Persistent ventricular filling	Delayed	Improved
2.	55	Anterior communicating	Persistent ventricular filling	Delayed	Improved
3.	57	Left middle cerebral	Persistent ventricular filling	Delayed	?
4.	40	Anterior communicating	Persistent ventricular filling	Delayed	?
5.	57	Left internal carotid & anterior cerebral	Persistent ventricular filling	Medium	Improved
6.	37	Right internal carotid	Transient ventricular filling	Normal	Improved

30%. In medium type, it is between 10 and 30%. In normal type, it is below 10% (Fig. 5 and Table 3). There was a close correlation between cisternogram and transfer curve (Table 4). In most cases with persistent ventricular filling the transfer curve showed a delayed type. The relationship of cisternogram to classification of patient's condition by Hunt and Hess[5] was studied. The grade of patient's condition was found to be closely related to the degree of abnormality in CSF circulation (Table 5). The existence of rebleeding in the patient's history was also found to influence the degree of abnormality in CSF circulation. However, single bleeding may also cause abnormality, such as persistent ventricular filling on cisternogram (Table 6). Shunt operation was performed on 6 cases according to the results of cisternography, transfer curve, and angiography. Four patients improved postoperatively, although 2 patients died of other complications soon after the shunt, and the effect of the procedure cannot be evaluated (Table 7).

Discussion

Foltz and Ward[2)] described in 1956 of patients with hydrocephalus after SAH and without increased CSF pressure, who improved after a CSF shunt procedure. In 1965, Adams *et al.*[6)] reported the clinical details of 3 cases of "normal-pressure hydrocephalus" with greatly enlarged ventricles who were successfully treated by a surgical shunt procedure. Since the subarachnoid hemorrhage has been shown to be one of the most frequent known etiologies for the normal pressure hydrocephalus[2,7,8,9)], it is important to screen the patients with a certain safe and relatively simple test, in order to detect the significant subarachnoid obstruction before the permanent damage has occurred on the brain. It is also important for the management of patients to find the overall incidence of communicating hydrocephalus after SAH. Radioisotope cisternography, first described by DiChiro[10)], offers the best physiological assessment of the CSF dynamics and is of primary importance in establishing the diagnosis[11–14)]. We performed cisternography 21 times with ^{169}Yb-DTPA in 19 patients with SAH. In our neurosurgical clinic, high incidence of abnormal CSF circulation was found to be present from this study, after the surgical clipping of aneurysm. The usefulness of isotope cisternography can be enhanced by concomitant monitoring of blood activity after the intrathecal injection of isotope[15–17)]. The three types of ^{169}Yb-DTPA transfer curve were observed in this study. Since a good correlation of cisternogram and transfer curve was demonstrated, it is suggested that this test for investigation provides a supplementary method for the diagnosis of normal pressure hydrocephalus. Because the shunting procedure for the communicating hydrocephalus is one of the most important problems and at times might be followed by various complications, the criteria for the selection of the patient must be rigid. When patients with SAH show a typical clinical syndrome, a combination of enlarged ventricles on the angiogram and a definitely abnormal isotope test is a sufficient indication to proceed with a ventriculo-atrial shunt[8)]. McCullough *et al.*[18)] reported the most favorable outcome in those patients with prolonged retention of the radioisotope in the ventricles. On the other hand, patients showing isotope clearance from the ventricles in 24 to 48 hr seldom responded to surgical therapy. A higher incidence of communicating hydrocephalus in patients with aneurysms about the circle of Willis than in those with middle cerebral or posterior cerebral artery aneurysms has been reported[19)]. In our series, however, the patient with the middle cerebral artery aneurysm showed communicating hydrocephalus. It is also of interest that the patient with aneurysm of anterior inferior cerebellar artery showed communicating hydrocephalus.

A preliminary report on canine experiment suggests that the volume of blood in subarachnoid space is an important factor for the development of the communicating hydrocephalus[20]. Further study should be made to clarify the mechanism of the development of the normal pressure hydrocephalus by experimental and clinical investigations.

ACKNOWLEDGEMENT

This study was carried out with the assistance of Takeo Okuyama, M.D., of the Department of Radiology, Tokyo Medical and Dental University.

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