Cerebral Angiography and Electroencephalography in Cerebrovascular Disease

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YOSHII, N. *Cerebral Angiography and Electroencephalography in Cerebrovascular Disease.* Tohoku J. exp. Med., 1970, 102(1), 13-21 — The continuous EEG recording was performed on 48 patients with cerebrovascular diseases before, during and after the injection of the contrast medium into the common carotid artery. The contrast medium was conditioned as equally as used in the cerebral angiography. Injections of Ringer's solution were made to the 48 cases in order to compare the results. The same examinations were performed also on 5 normal persons. 1) Significant changes in EEG were not observed in the normal persons. 2) EEG changes appeared in few cases with cerebrovascular diseases by injecting the Ringer's solution. 3) EEG alterations appeared in 33% of the cases with the cerebrovascular diseases during and/or after the injection of contrast medium. 4) Focal abnormality in EEG which was most frequently seen, appeared in 13 cases. It must be noted that the focal abnormality which had not been seen before, appeared after the injections, and that the extent of the appearance of the focal abnormality was considerably enlarged in some cases. Changes in frequency and amplitude of the basic waves were found in 4 cases. Bilateral spike appeared in one case. 5) The kinds and degrees of the clinical symptoms were not associated with the appearance of EEG abnormality. As to the relationship between the appearance rate of abnormal EEG and the kinds of the diseases, the rate in the cerebral hemorrhage showed insignificant differences from that in cerebrovascular disease, though the former was slightly lower. The local disturbance in the brain existed in most of the patients with the cerebrovascular diseases, though its symptom did not always appear. It is presumed in such instances that the metabolic disturbance becomes apparent and that EEG change is induced by the injection of the contrast medium in the cerebral angiography. ——— cerebral angiography; electroencephalography; cerebrovascular disease

The cerebral angiography has been used actively in patients suffering from the head injuries and cerebrovascular diseases, owing to its technical improvement. As to changes in the brain function due to the cerebral angiography, however, most of the experimental and clinical studies hitherto reported have shown absence of insignificant change in the normal brain function.^{1-7,9} A few investigators have noticed encephalopathy, when angiography was performed on patients with cerebrovascular diseases.¹ Some reported the occurrence of the side-effects like

hemiplegia and so forth by the cerebral angiography. Continuous recordings of EEG were used in the present study for the evaluation of the influence of the cerebral angiography on the brain function before, during and after injection of the contrast medium to the normal persons and patients with the cerebrovascular diseases. In this paper clinical findings and details of EEG changes are reported.

CASES AND METHODS

Records were taken from the patients who were admitted to Shizuoka Red Cross Hospital and Mihara Memorial Hospital, including 5 normal persons, aged below 30 years, and 48 patients who had cerebrovascular diseases diagnosed by clinical examinations and cerebral angiography. The latter consisted of 12 cases of the age below 49 years and 36 cases of the age above 50 years (Table 1). As to their clinical symptoms, 36 cases had hemiplegia or hemiparesis and 15 cases speech disturbance. The remainings consisted of patients with convulsion, headache, visual disturbance, ataxia and so on (Table 2).

TABLE 1. *Age distribution of patients*

Age	Number of cases
10-19	1
20-29	4
30-39	2
40-49	5
50-59	14
60-69	14
70-	8

TABLE 2. *Clinical signs and symptoms of patients*

Clinical sign	Number of cases
Hemiplegia or hemiparesis	36
Aphasia (and speech disturbance)	15
Convulsion	5
Headache	5
Others	5

The patients examined included 21 cases with cerebrovascular disease, 14 cases with cerebral artery occlusion or stenosis (including 11 cases with middle cerebral artery, 2 cases with anterior cerebral artery and one case with posterior cerebral artery disturbance), 6 cases with cerebral hemorrhage and 3 cases with cerebral aneurysm (including a case with internal carotid artery aneurysm and 2 cases with anterior communicating artery aneurysm (Table 3).

Atropine sulfate in a dose of 0.5 mg was injected intramuscularly 30 minutes before the angiography and common carotid artery was punctured percutaneously under local anesthesia with 1% procaine, using 18 gauge Conade needle.

Ten ml of Ringer's solution and then, 10 ml of a contrast medium were injected through a puncture needle. The contrast media used were 60% Urografin (sodium 3,5-diacetamido 2,4,6-triiodobenzoate + methylglucamine 3,5-diacetamido 2,4,6-triiodobenzoate) in 23 cases,

TABLE 3. *Clinical and angiographical diagnosis of patients*

Clinical sign	Clinical diagnosis	Angiographical diagnosis
Intracerebral hemorrhage	13	6
Cerebral artery occlusion	19	14
Cerebrovascular accident	8	0
Cerebrovascular sclerosis	1	21
Cerebral aneurysm	4	3
Cerebral tumor	2	0
Cerebral atrophy	1	1
Normal	0	3

or 60% Conery (methylglucamine 5-acetamide-2,4,6 triiodo-isophthalamate) in 25 cases. The injection was accomplished within 1-2 sec. The contrast medium was injected bilaterally in 42 cases and unilaterally in the others, including 6 cases in which the injection was done on the affected side. Recording was made by placing 16 disc type electrodes on the scalp using electroencephalographic machines of 9 channels (Nihon Kohden Co.) and 8 channels (Sanei Sokki Co.). Both earlobes were used as a reference electrode and an earth, respectively. EEG tracings for 5 minutes before and for 10 minutes or more during and after injection of the contrast medium and Ringer's solution were compared. The time interval between their injections was at least 10 minutes. The time of the EEG examination ranged from a week to several years after the appearance of initial symptoms.

RESULTS

Any symptoms or signs were not observed during and after the injection of the contrast media. No change in EEG was observed in 4 out of 5 normal cases, and no abnormal sign in cerebral angiograms was observed in all normal persons, except one case; the basic rhythm decreased by 0.5 cycle for several sec after the injection and then, it soon recovered to the former frequency. In 48 cases with the cerebrovascular diseases, there were 4 cases which showed changes in EEG after injection of the Ringer's solution. In them similar changes were obtained by injecting the contrast medium. Three of the 4 cases had occlusions or stenosis of the left middle cerebral artery and the remaining one had occlusion of the posterior cerebral artery.

Sixteen (33%) out of 48 cases showed EEG changes by injecting the contrast medium, and they included 3 (25%) of 12 cases of the age below 49 years and 13 (36%) of 36 cases of the age above 50 years. EEG changes were more frequently observed in older age groups (Table 4).

TABLE 4. *Age distribution of patients with EEG abnormality*

Age	Abnormal EEG	
10-19	0	} 3(12) 25%
20-29	1	
30-39	1	
40-49	1	
50-59	4	} 13(36) 36%
60-69	5	
70-	4	

Numerals in parentheses indicate total number of cases.

Sixteen cases in which EEG change was found after injection of the contrast medium were divided into three groups according to their EEG findings: Group I, change in basic wave; Group II, change in focal abnormality, and Group III, nonfocal and intermittent change.

The basic rhythm frequency was decreased by more than 1.0 cps in 2 of 4 cases of Group I, and in one amplitude of basic wave was increased by more than 50%, and in one, the amplitude was decreased by more than 50%. In Group I, 2 cases showed changes in only basic waves, and in the other two, changes in the basic waves and focal abnormality occurred simultaneously.

Focal abnormality which had not been noted before the injection appeared after the injection in 5 of 13 cases of Group II (Fig. 1). In the remaining 8 cases, focal

Fig. 1. A 51-year-old male with complaints of headache and difficulty in walking. Clinical and angiographical diagnosis was cerebrovascular sclerosis. After the admission EEG examinations were performed twice and no focal abnormality was found. Both EEG records during and after the injection of Ringer's solution and dye revealed single or double theta waves in the left anterior and middle temporal regions one-dozen times during 100 seconds after the injection. Figure revealed left anterior and middle temporal theta waves 10 seconds after the injection of dye.

abnormality which had existed before the injection was exaggerated (Fig. 2). As to the localization of focus, unilateral focal change was observed in 10 cases; bilateral change (Fig. 3) in one case; and shifting type in 2 cases. Increase in number of times of appearances was found in 11 cases by a precise analysis of EEG findings of 16 cases. In 6 cases an increased amplitude was found. The frequency of the focal wave did not increase in any case and decreased in 3 of 13 cases. The extent

Fig. 2. A 69-year-old male with left-sided hemiparesis for 3 years. Clinical diagnosis was cerebral hemorrhage but angiographical diagnosis was right middle cerebral artery stenosis. EEG findings of preangiography revealed right temporal delta waves intermittently. Injections of Ringer's solution into the bilateral carotid arteries caused no change of focal waves. After the left and right carotid angiographies bilateral delta theta waves with alpha range waves appeared several times with or without left-sided amplitude emphasis. Figure showed bilateral delta theta waves 7 seconds after the injection of dye through the right internal carotid artery.

TABLE 5. *EEG changes after the angiography*

EEG changes	Number of cases	
I. Changes in posterior background activity		
a) Frequency } Decrease	2	4
} Increase	0	
b) Amplitude } Decrease	1	
} Increase	1	
II. Changes of focal abnormality		
Unilateral focal changes	10	13
Bilateral focal changes	1	
Shifting focal changes	2	
a) Number of appearance		
Slight increase	5	11
Marked increase	6	
b) Changes in focal wave frequency		
Decrease	3	:
Increase	0	
c) Changes in focal wave amplitude		
Decrease	0	6
Increase	6	
d) Enlargement of focal abnormality		1
III. Bilateral burst and sharp wave		1

Fig. 3. A 50-year-old female with right-sided hemiparesis and speech disturbance occurring 20 days before the EEG study. EEG tracing of preangiography revealed random theta delta waves in the left anterior and middle temporal regions occasionally. Injections of Ringer's solution into left and right carotid arteries and injection of dye into the right carotid artery revealed the same findings as preangiographical EEG. However injection of dye into the left carotid artery caused almost continuous theta delta waves with alpha in the middle and anterior temporal regions for 75 seconds following the injection of dye.

of the appearance of focal abnormal wave was enlarged in one case. Focal changes in temporal region appeared in most of the cases and those in temporo-central regions in one case. Irregular alpha and sharp waves in bilateral regions were found in one case with stenosis of the right middle cerebral artery of Group III. Relationships between cerebral angiography and EEG changes were as follows: in Group I, 2 cases were of occlusion or stenosis of the cerebral artery and 2 cases were of severe cerebral arteriosclerosis; in Group II, 5 cases were of occlusion or stenosis of the cerebral artery, 4 cases of cerebral arteriosclerosis, one case of cerebral hemorrhage, one case of cerebral aneurysm, and 2 cases of normal appearing vessels; stenosis of the cerebral artery was an aforesaid case of Group III. It may be said from the above-mentioned findings, that in cases of cerebral arteriosclerosis and occlusion or stenosis of the cerebral artery, EEG is largely influenced by the injection of the contrast medium. EEG change appeared in 9 of 25 cases in which Urografin was used and in 7 of 25 cases in which Conrey was used.

DISCUSSION

A few investigations have dealt with an influence of angiography upon EEG, and showed no significant influence on EEG.

Ingvar³ investigated the EEG changes after cerebral angiography on 17 cases (carotid angiography in 9 cases, and vertebral angiography in 6 cases) by using about 10 ml. of 35% Umbradil and described that there were no significant alterations except for 3 cases in which delta waves already existing before the angiography increased slightly for several hours after the examination. Greitz and Weiss² performed carotid angiography by injecting 30–35% Hypaque or Miokon and found no alterations in EEG. Schiefer and Steinmann⁶ performed cerebral angiography in patients of cerebral tumors and vascular disturbance using 60% Urografin and reported that a few cases showed slight EEG changes. Maass and Lennartz⁵ concluded that EEG change by cerebral angiography scarcely appeared. Ingvar and Söderberg⁴ examined EEG before and after the injections of various concentrations of a contrast medium into the carotid artery in cats, and reported that no change was seen in EEG at doses comparable to those used clinically.

Kirstein *et al.*⁷ compared EEG tracings in 29 cases before and after cardiac angiography by mainly using Umbradil (Diodrast) under general anesthesia and found no change in 20 cases except for 9 cases in which slowing activity after the injections returned to normal during 2–14 days in six cases, and intermittent wave existing before the injections decreased in remaining 3 cases. Faris *et al.*¹ performed brachiocephalic angiography with Hypaque on 21 patients with cerebrovascular insufficiency. In two cases, 3–4 cps wave appeared in bitemporal regions immediately following the injections. They concluded that there were little differences in EEG between groups with occlusion of the carotid artery and those with normally appearing vessels. In our present study, alterations in EEG were noted in many cases of intracranial vascular disease.

Anoxia which may occur when the contrast medium passes through the brain can be considered as a factor which causes EEG change, in cases with cerebrovascular diseases, especially with sclerosis, occlusion and stenosis of the cerebral artery. However, the contrast medium runs through vessels so fast and therefore it is presumable that a very short time cerebral anoxia by contrast medium may cause neither localized nor diffuse brain dysfunction.

Next, influences of concentration and dosage of the contrast medium, pressure induced by the injection on vessels' walls and frequency of injections of the contrast medium on the brain tissue and the cerebral vessels must be considered. However, in normal cases no significant EEG change was noted in many reports including ours.

Ingvar and Söderberg⁴ reported that cerebral vasoconstriction took place and cerebral blood flow decreased, but EEG change did not appear, in the experimental animals after the injections of Umbradil (Diodrast). According to them, this cerebral vasoconstriction was due to the direct stimulation of the vascular walls by the contrast medium. Some EEG changes due to decreased cerebral circulation were noted when large amount and high concentration of the medium were used.

Thomas *et al.*¹⁰ presumed that cerebral vasoconstriction occurred in order to avoid a direct poisonous action upon nervous tissue by the injection with Diodrast into carotid artery and that EEG change was due to the delicate change in balance between vasomotor tone and cellular response. Further, they inferred that the increase in delta wave focus and levelling of rhythmic spike were due to the suppression of neural activity by the contrast medium. As to interpretation of EEG change by injecting Ringer's solution, it is presumed that acute change in pressure in vessels by the injected fluid influences the EEG and that frequent occurrence of EEG changes by the contrast medium is due to of its stimulatory and cohesive properties. The cerebrovascular diseases have chronic local or diffuse disturbance in the cerebral tissue and the cerebral circulatory insufficiency (no matter whether they are electroencephalographically latent or not). Therefore a severer metabolic change would take place at the disturbed region in the cases when decrease in the cerebral blood circulation occurs by the stimulation of the contrast medium, injection pressure and so forth. This is, we think, the cause of the appearance of EEG change. It seems to us that our view is supported by the following findings: appearance of focal abnormality which has not been found before the injections, enlargement of the focal change, the appearance of spike, and change in basic wave which have not seen before the injections.

The main clinical symptoms in 16 cases with abnormal EEG are summarized in Table 2. Some specific symptom is not associated with EEG abnormality. The incidence of the complication by the cerebral angiography varies with technical factor, the kinds of the contrast media and the age and conditions of the patients. The incidence of the side effects was high when Diodrast and Thorotrast were used, being 9.5 and 19.9%, respectively. When Hypaque, Urografin, and Conrey were used, the ratio decreased; incidence of the side effects were ranging from 0.7 to 7.5%. We used the contrast media which belonged to the latter and found no side-effects. It must be noted that the focal abnormality (newly appeared focus or increase focal abnormality) appeared in 27% of cases in which the contrast medium was injected into the artery of the lesional side. Therefore it is necessary to prepare emergency kit including oxygen at bed side against possible angiographical complication in patients with cerebrovascular diseases with or without EEG abnormality.

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