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CLINICAL APPLICATION OF THE F-WAVE
II. FREQUENCY OF THE F-WAVE

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Abstract

After the observation of F-wave frequency, the following results were obtained.

1. In normal control F-wave frequency of 24-64% was observed, and no significant difference was recognized between the left and right side.

2. In Parkinson's disease there was observed a significant correlationship between the degree of rigidity and F-wave frequency. In addition, as the objective evaluation method of therapeutic effect F-wave frequency is useful.

3. In cerebrovascular disease irrespective of acute stage or chronic stage, the observation of F-wave is useful for the detection of subclinical lesion and the determination of the recovery process of central nervous system. Especially in the case of complete paralysis the appearance of F-wave coincided with the appearance of associated reaction in the stage.

4. In motor neuron disease it was possible to determine the involvement of upper and lower motor neurones from quite early stage.

INTRODUCTION

The origin of F-wave is considered to be due to the backfiring of motoneuron[1-6], and F-wave conduction velocity with F-wave as its parameter is recently being used clinically as the method to reflect the condition of peripheral motor nerve, especially the radicular portion[7-11]. Now, F-wave, stimulated even under a certain fixed condition, shows a considerable variability in its appearance, but recently even in a spastic state there is report indicating the increase of frequency and amplitude of F-wave, suggesting that F-wave reflects to a certain extent the excitability of alpha motor neuron system[12,13]. However, the report concerning the frequency of F-wave is rare, and its clinical application has not been done sufficiently. This time I studied the frequency of F-wave

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in neurological disease of various kinds, especially centering around its laterality, and also studied its relationship to the disease course and therapeutic effect.

SUBJECTS AND METHODS

Subjects : The investigation was done with 45 patients of neurological disease of various kinds, consisting of 16 cases of Parkinson's disease, 14 of cerebrovascular disease (CVD) and 3 cases of amyotrophic lateral sclerosis (ALS), 2 cases having only the upper motor neuron sign, 2 cases of spinal progressive muscular atrophy (SPMA), one of Hirayama's disease, 2 of brain stem lesion, 2 of Guillain-Barre syndrome (GBS), and 2 of polymyositis (PM). As the normal control group 15 healthy persons in the age range of 19 to 24 years consisting of 5 males and 10 females were used.

Methods : The method was the same as in measuring F-wave conduction velocity, and the stimulation was given to the ulnar nerve trunk of the wrist. For electromyography the Modular Electrophysiological System MS 6 of Medelec Company was used, and for the recording it was arranged so that at least 100 M waves could be caught. Moreover, it was set the calibration on the right and left to be the same, in other words, it was set to have the magnification on the right and left to become equal, and as a rule the analytical time was 45 msec, in some instances it was 90 msec. For the purpose to examine the effect of grip on the F-wave frequency 100 M waves were elicited at rest, then subject was asked to make a fist by grasping the second and third fingers of the examiner as hard as possible to obtain at least over 20 M waves and changes in the F-wave frequency were observed. With some cases the vibration of 50-60 Hz was applied on the anterior surface of the elbow joint to be tested and the change of F-wave frequency was observed, at the same time it served to distinguish it from H wave. F-wave frequency at rest was taken as the number of F-wave for 100 M waves, and as to grip effect the number of F-wave appearance per 20 M waves. In addition, on deciphering F-wave by its size, for convenience the waves with the amplitude over 300 μV and with shape similar to M wave were placed in large group (L), and those waves that could be clearly recognized as F-wave but with very small amplitude as 50-300 μV in small group (S), and the waves of amplitude less than 50 μV were excluded from the appearance number because they are difficult to identify as F-wave. This time precise study on the amplitude was omitted.

RESULTS

(1) Normal control (Table 1)

F-wave frequency at rest on the right side proved to be L 10.0 per

TABLE 1. F-wave frequency in normal control

No	Sex	Age	R/L	Frequency/100			During Grip/20		
				La	Sm	Total	La	Sm	Total
1	M	22	R	18	46	64	7	7	14
			L	15	43	58	6	6	12
2	M	22	R	9	50	59	7	11	18
			L	6	47	53	6	14	20
3	F	20	R	7	36	43	1	9	10
			L	10	29	39	3	6	9
4	F	21	R	2	23	25	4	6	10
			L	2	22	24	1	7	8
5	F	19	R	18	46	64	9	9	18
			L	10	50	60	7	7	14
6	F	19	R	9	39	48	7	9	16
			L	9	45	54	4	12	16
7	M	20	R	10	40	50	3	12	15
			L	18	32	50	6	8	14
8	F	19	R	8	16	24	1	15	16
			L	9	15	24	3	2	5
9	F	20	R	5	25	30	2	11	13
			L	4	29	33	2	9	11
10	F	20	R	7	32	39	4	11	15
			L	4	31	35	1	11	12
11	F	20	R	13	25	38	2	11	13
			L	17	21	38	2	8	10
12	M	24	R	2	24	26	2	7	9
			L	3	26	29	1	10	11
13	F	21	R	17	38	55	7	8	15
			L	13	45	58	9	6	15
14	F	23	R	11	36	47	6	6	12
			L	14	36	50	4	7	11
15	M	21	R	14	10	24	8	8	16
			L	9	19	28	4	10	14
Mean	/	/	R	10	32.4	42.4	4.7	9.3	13.9
			L	9.5	32.7	42.2	3.9	8.2	12.1

100 M, S 32.4 per 100 M, total 42.4 per 100 M, on left side L 9.5 per 100 M, S 32.7 per 100 M, total 42.2 per 100 M, showing no significant difference between the right and left side. F-wave frequency during the grip on the right side proved to be L 4.7 per 20 M, S 8.3 per 20 M, total 13.9 per 20 M, on the left side L 3.9 per 20 M, S 8.2 per 20 M, total 12.1 per 20 M. %-F-wave frequency calculated as the ratio of the frequency during grip against 100 M waves showed a sigificant increase as compared to that at rest ($p<0.001$, Fig. 1-A).

(2) Parkinson's disease (Table 2)

Following the severity classification of Yahr's Stage I comprised 6 persons, Stage II 4, Stage III one, and Stage IV 5. As to the correlationship between the triad of Parkinsonism and F-wave frequency, there could be observed a significant correlation in rigidity, L and total frequency ($P<0.05$). However, no correlationship could be seen with tremor, and as to the laterality of F-wave frequency on the side with marked symptoms centering the rigidity, L and total

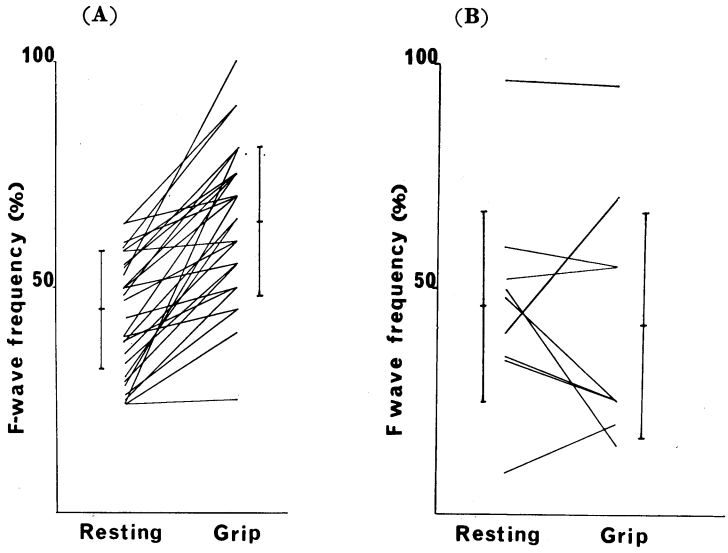

Fig. 1. Influence of grip on F-wave frequency
A. Grip activation in normal control
B. Grip effect in Parkinson's disease

frequency proved to be significantly higher ($P<0.01$). As to the relationship to Yahr's severity classification these cases, not necessarily show a significant correlationship, but it is not definitive as there would be the influence of the presence or absence of treatment. Now, 6 patients of hemiparkinson's disease, Stage I of Yahr, excepting one case, showed significantly high L frequency on the affected side, but no significant difference could be observed in the total frequency. Moreover, as to the influence of grip a decrease of %-frequency was observed in 7 limbs out of 10, but statistically no significance was recognized (Fig. 1-B). With 5 patients investigation was conducted on the correlationship of therapeutic effect to F-wave frequency. With these 5 cases treatment was carried out over one month with Levodopa or Carbidopa, and changes in F-wave frequency was observed before and after the treatment. As for the severity there were 2 cases of Stage I and one case each of Stage II, III and IV of Yahr's classification. After the treatment the alleviation of rigidity was observed in every case, but on the severity classifiication ones in Stage III and IV turned to Stage II, but otherwise the remaining 3 cases showed no change.

Nonetheless, the F-wave frequency showed a signifiicant fall in L and total frequency in parallel with the decrease of rigidity ($p<0.001$, Fig. 2).

TABLE 2. F-wave frequency in Parkinson's disease

No	Pt	Sex	Age	R/L	Rigidity	Reflex	Tremor	Frequency/100 L	S	Total	Yahr's stage
1	M.K.	F	47	R	N	++	−	17	37	54	I
				L	+	++	+	28	36	64	
2	T.M.	F	47	R	N	+	−	7	36	43	I
				L	+	+	+	20	29	49	
3	T.I.	F	64	R	++	+	+	34	43	77	I
				L	N	+	−	9	69	78	
4	M.K.	F	55	R	+	+	+	20	30	50	I
				L	N	+	−	14	32	46	
5	T.T.	F	68	R	N	+	−	7	42	49	I
				L	++	++	++	19	39	58	
6	T.I.	F	70	R	±	+	±	13	39	52	I
				L	N	+	−	8	1	9	
7	K.T.	F	60	R	±	+	±	7	27	34	II
				L	±	+	±	5	35	40	
8	S.M.	F	62	R	+	+	−	36	32	68	II
				L	+	+	+	28	46	74	
9	T.T.	F	47	R	±	+	−	30	28	58	II
				L	±	++	−	15	38	53	
10	K.W.	F	57	R	+	+	+	19	29	48	II
				L	±	+	−	21	13	34	
11	K.N.	F	66	R	+	+	+	18	17	35	III
				L	++	+	+	31	28	59	
12	M.M.	F	61	R	+	+	−	28	32	60	IV
				L	+++	+	−	60	34	94	
13	S.S.	F	74	R	++	+	+	22	64	86	IV
				L	+	+	−	20	35	55	
14	K.F.	M	55	R	++	+	±	41	9	50	IV
				L	+++	+	++	58	38	96	
15	T.O.	F	72	R	±	+	+	19	19	38	IV
				L	±	+	−	10	26	36	
16	M.Y.	F	52	R	+++	+	++	34	54	88	IV
				L	++	+	++	33	26	59	

Rigidity N : normal, ± : trace, + : mild, ++ : moderate, +++ : marked

Tremor − : none, ± : trace, + : mild, ++ : moderate

(3) CVD (Table 3 and 4)

The initial examination was conducted 2 weeks after the onset of disease with all 11 cases of cerebral infarction group, and within two days of the onset with all 3 cases of cerebral bleeding group. Of 11 cases of the infarction group there were 5 cases showing higher frequency on the affected side, two cases were bilaterally involved, and both showed higher frequency on the older affected side. There were 3 cases who showed higher frequency clinically on the non-affected side, of them one case after the close examination showed a silent small meningioma near the central gyrus on the opposite side (Fig. 3).

By physical examination on the non-affected side not any abnormality such as paralysis, abnormal muscle tone nor the abnormality of deep reflex could be recognized. Another case several days after the examination began

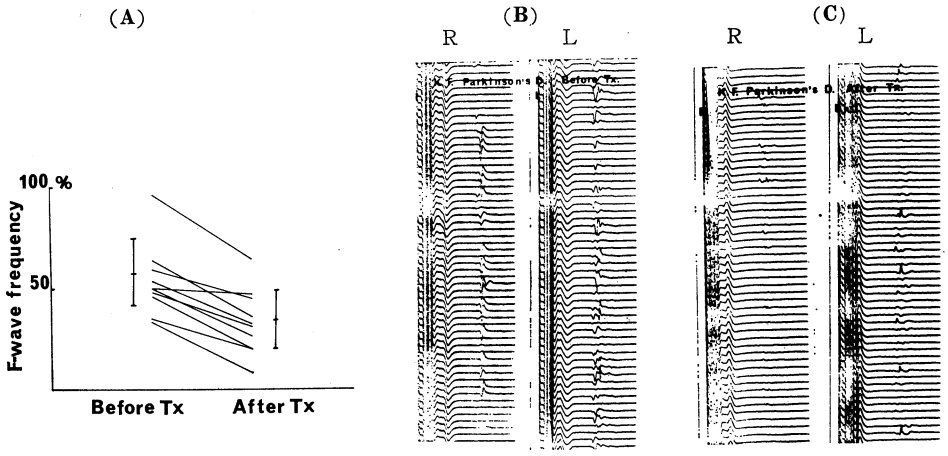

Fig. 2. Effect of treatment on F-wave frequency in Parkinson's disease
A. The changes of F-wave frequency after treatment
B. Recording of F-waves before treatment
C. Recording of F-waves after treatment

TABLE 3. F-wave frequency in CVD

No.	Pt.	Bleeding Infarction	Sex	Age	Involved side	R/L	Tonus	Reflex	Weakness	Pathologic Reflex	frequency L	S	Total
1	T.K.	Bleeding	F	74	R	R	F	-	-4	-	2	0	2
						L	N	+	0	-	14	13	17
2	S.M.	"	F	65	R	R	F	-	-4	-	0	2	2
						L	N	+	0	-	5	30	35
3	R.F.	"	F	80	R	R	F	-	-4	-	0	0	0
						L	N	+	0	-	0	70	70
4	T.F.	Infarction	M	50	L	R	N	+	0	-	6	14	20
						L	N	+	-1	-	18	13	31
5	S.T.	"	F	72	R	R	++	++	-2	+	16	57	73
						L	N	+	0	-	20	15	35
6	T.M.	"	M	40	R	R	N	+	-1	-	47	32	79
						L	N	+	0	-	28	32	60
7	Y.O.	"	F	60	R	R	N	++	-1	+	9	8	17
						L	N	++	0	-	1	16	17
8	I.M.	"	F	72	R	R	N	±	-2	-	11	18	29
						L	N	±	0	-	9	15	24
9	K.K.	"	M	41	R	R	N	+	-0.5	-	27	33	60
						L	N	+	0	-	31	25	56
10	T.U.	"	M	50	R&L	R	±	+	-0.5	-	71	8	79
						L	++	++	-1	-	30	41	71
11	T.Y.	"	M	57	R&L	R	N	+	-0.5	-	10	55	65
						L	S	++	-2	+	15	45	60
12	K.O.	"	M	74	L	R	N	±	0	-	42	12	54
						L	N	+	-2	-	3	31	34
13	K.Y.	"	M	65	L	R	N	+	0	-	7	24	31
						L	++	++	-2	+	4	21	25
14	J.Y.	"	M	75	L	R	N	+	0	-	33	20	53
						L	S	++	-3	+	10	10	20

(Tonus) F:flaccid, ±:decreased, N:normal, ++:increased, S:spastic
(Reflex) -:absent, ±:trace, +:normal, ++:increased
(Weakness) -4:complete paralysis, 0:normal

TABLE 4. Relationship between disease course and F-wave frequency

No	Disease	Pt	Sex	Age	R/L	I st Tonus	I st Deep Reflex	I st Pathologic Reflex	I st frequency L	I st frequency S	I st frequency Total	II nd Tonus	II nd Deep Reflex	II nd Pathologic Reflex	II nd frequency L	II nd frequency S	II nd frequency Total	Duration (week)
1	CVD (Bleeding)	T.K.	F	74	R	F	−	−	2	0	2	F	+	−	31	5	36	6
					L	N	+	−	14	13	27	N	+	−	18	19	37	
2	"	S.M.	F	65	R	F	−	−	0	2	2	F	−	−	0	42	42	4
					L	N	+	−	5	30	35	N	+	−	5	46	51	
3	"	R.F.	F	80	R	F	−	−	0	0	0	F	−	−	0	50	50	9
					L	N	+	−	0	70	70	N	+	−	0	100	100	
4	CVD (Infarction)	K.O.	M	74	R	N	±	−	42	12	54	N	±	±	29	15	44	4
					L	N	+	−	3	31	34	N	+	−	5	12	17	
5	"	K.Y.	M	65	R	N	+	−	7	24	31	N	+	−	1	11	12	5
					L	↑	++	+	4	21	25	↑	++	±	4	4	8	
6	GBS	A.I.	M	25	R	F	−	−	0	0	0	F	−	−	1	0	1	12
					L	F	−	−	0	0	0	F	−	−	5	1	6	
7	"	T.I.	M	18	R	F	−	−	0	0	0	↓	±	−	0	14	14	10
					L	F	−	−	0	0	0	↓	±	−	0	25	25	
8	MND	K.F.	M	45	R	S	+++	−	83	17	100	⇑	++	−	48	22	70	7
					L	S	++	−	0	0	0	↑	+	−	0	0	0	
9	Brain stem Tumor	H.H.	M	46	R	⇑	++	±	12	48	60	↑	+	−	11	17	28	14
					L	S	+++	+	100	0	100	⇑	++	+	28	4	32	

CVD: Cerebrovascular disease GBS: Guillain - Barre Syndrome MND: Motor neuron disease

F: flaccid S: spastic

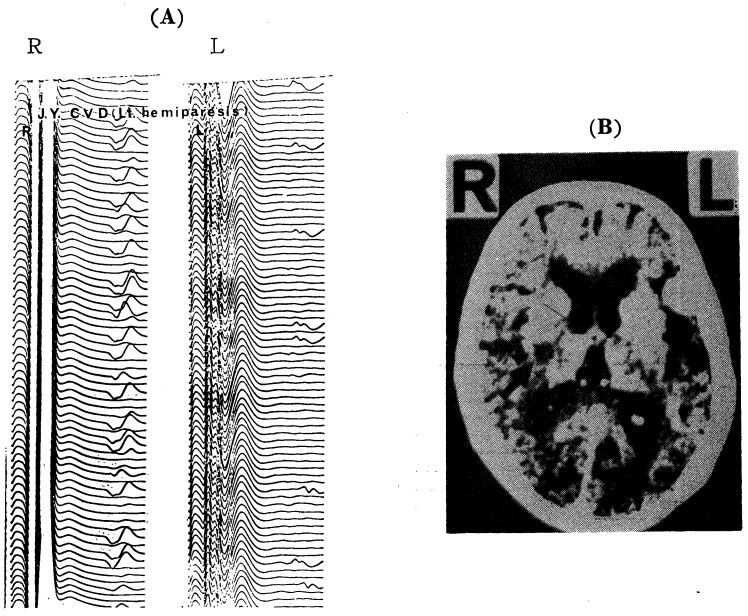

Fig. 3. A. Recording of F-waves in patient with cerebral infarction, showing higher frequency on the non-affected side (right side)
B. CTscan, showing a small meningioma on the left convexity and small low density area at the right internal capsule (arrow)

to show pathological reflex on the non-affected side, and the case was assumed to be of both hemispheric lesion. The remaining one case did not reveal any distinct lesion on the non-affected side, but on the CT film there was observed a moderate cortical atrophy. Of 3 cases in bleeding group there were 2 cases of subcortical bleeding and one case of thalamic hemorrhage with ventricular perforation, and all of them were in the state of an early stage, complete paralysis, flaccid tone, areflexia, and hardly any F-wave appearing on the affected side. In the one case who showed the appearance of deep reflex and an improvement of weakness by the results of the follow-up study 6 weeks later the total frequency did not have laterality and L frequency was higher than that on the non-affected side (Fig. 4). The other two cases were still in the state of complete paralysis, flaccid tone, and areflexia, but total frequency all belonged to S group, reaching over 40 per 100 M. An important point to be borne in mind is that both two cases began to show the appearance of associated reaction at this stage. Now coming to the correlationship of F-wave frequency to muscle tone, weakness and deep reflex, in the case of complete paralysis and flaccid state F-wave disappeared or decreased, but in the other state there could be observed not necessarily any significant correlationship.

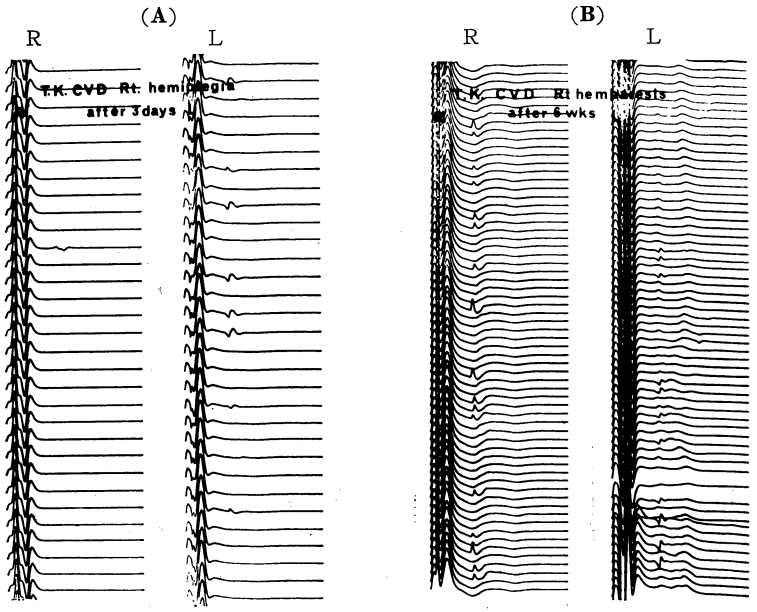

Fig. 4. Recordings of F-waves in patient with cerebral bleeding (analytical time of 90 msec)
A. Recording 3 days after onset, showing hardly any F-wave on the right side.
B. Recording 6 weeks after onset, showing increased F-wave frequency on the right side.

(4) MND (Table 5)

Two cases out of 3 ALS cases, despite a very mild muscular atrophy, showed F-wave frequency of almost zero and also no grip activation could be recognized (Fig. 5-A). Clinically, in one of the two cases having only upper motor neuron sign despite the F-wave frequency of the right upper limb being 100 per 100 M, F-wave did not appear on the left side, and also grip activation could not be observed. Of the two cases with SPMA one showed a marked muscular atrophy and F-wave also hardly appeared. Howevr, another case had muscular atrophy of scapuloperoneal type without any muscular atrophy of distal portion of limbs, and showed F-wave at a relatively high frequency. Hirayama's disease comprised only one case, but there could be observed F-wave of high amplitude (about a third of M wave) and about the same shape could be observed quite frequently on the involved side (Fig. 5-B).

TABLE 5. F-wave frequency in MND and other neurological disease

No	Disease	Pt.	Age	Sex	R/L	Upper limb			Frequency		
						Tonus	Reflex	Atrophy	L	S	Total
1	ALS	S.I.	34	M	R	N	+	+	0	0	0
					L	N	+	+	0	2	2
2	"	J.H.	50	M	R	N	+	+	0	0	0
					L	N	+	+	0	0	0
3	"	H.K.	50	M	R	++	++	±	40	34	74
					L	++	++	±	50	9	59
4	Upper MND	K.F.	46	M	R	S	+++	−	83	17	100
					L	S	++	−	0	0	0
5	"	T.N.	39	M	R	++	+	−	37	32	69
					L	++	+	−	7	80	87
6	SPMA	S.K.	50	M	R	N	+	−	32	30	62
					L	N	+	+	33	44	77
7	"	H.K.	71	M	R	N	+	++	0	0	0
					L	N	+	++	2	0	2
8	Hirayama disease	H.K.	18	M	R	N	+	++	33	41	74
					L	N	+	−	3	20	23
9	GBS	T.I.	18	M	R	F	−	±	0	0	0
					L	F	−	±	0	0	0
10	"	A.I.	25	M	R	F	−	±	0	0	0
					L	F	−	±	0	0	0
11	PM	J.S.	53	F	R	±	−	+	7	31	38
					L	±	−	+	0	40	40
12	"	Y.M.	25	M	R	±	±	+	2	26	28
					L	±	±	+	2	29	31
13	Brain etem lesion	H.H.	46	M	R	++	++	−	12	48	60
					L	S	+++	−	100	0	100
14	"	M.K.	27	F	R	N	+	−	8	29	37
					L	N	+	−	27	48	75

ALS : Amyotrophic lateral sclerosis MND : Motor neuron disease
SPMA : Spinal progressive muscular atrophy PM : Poly myositis
GBS : Guillain-Barre syndrome
Tonus F : flaccid, ± : decreased, N : normal, ++ : increased, S : spastic
Reflex − : absent, + : trace, + : normal, ++ : hyperreflexia (mild)
+++ : moderate

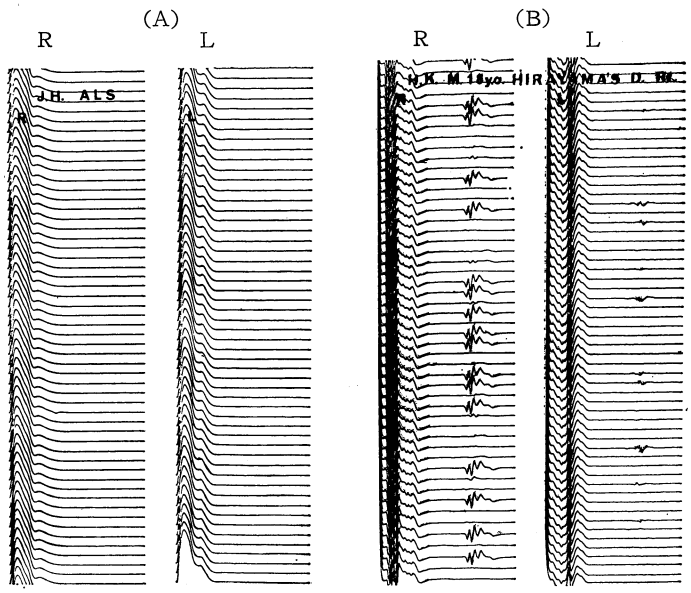

Fig. 5. Recordings of F-waves
A. ALS, showing complete loss of F-wave
B. Hirayama's disease, showing high frequency of the large F-wave on involved side (right side)

(5) Other neurological diseases (Table 4 and 5)

In 2 cases of GBS F-wave frequency was zero in early stage but by the re-examination 10 weeks later, though frequency itself was low, there was the appearance of F-wave, and clinically an improvement of muscular power though slight, could be recognized. In 2 cases of PM change of F-wave frequency was less and no laterality was observed in spite of the presence of a decrease of muscle tone and muscular atrophy. Two cases with brain stem lesion showed high frequency coinciding with laterality clinically observable. Especially one case who received radiation therapy on suspicion of tumor was spastic and whose frequency was 100 per 100 M before the treatment, but after the treatment showed a marked fall of F-wave frequency accompanying the decrease of muscle tone.

DISCUSSION

(1) Normal control

Concerning F-wave frequency Yate et al. reported that in their single motor unit study using a single fiber they obtained the maximum frequency of 10%[14], but by the conventional needle electrode study not using single fiber still higher frequency of 24-64% was recognized. This seems to be due to the

difference in the number of the neuromuscular units elicitable. In any event by the routine needle electrode method F-wave frequency will differ considerably according to individuals, hence it is difficult to consider as abnormal necessarily only by a deviation of frequency. However, the important point is the presence or absence of laterality, and by the result of present study in the normal control no significant laterality could be observed in any case. In other words, when a significant laterality is observed in F-wave frequency, it is necessary to pay a close attention and to conduct precise examinations.

Moreover, F-wave frequency is affected by various factors and it can change by changes of consciousness level and mental activity. Furthermore, it is altered also by gripping of contralateral fist, and Schiller et al. state that in the case of low frequency at rest the frequency increases by gripping while in the case of high frequency on the contrary it decreases[12]. However this is based on long term data, and there is a chance of being accustomed to the gripping effect.

Actually by my experience by over 30 stimuli (over 30 sec) often the effect decreased in some instances. Taking these points into consideration, I observed %-frequency by gripping with 20 stimuli, namely, within 20 sec, as a result I recognized a significant activation. The observation of changes in the frequency by gripping does not mean necessarily to detect abnormality, but in the event of low frequency the performance of gripping activation might also have some meaning. The amplitude of F-wave also is quite variable, and in the comparison of two groups of L and S, the average ratio was 1 to 3.

(2) Parkinson's disease

Kinukawa et al. studied 10 cases of Parkinsonism and observed for the first time the appearance of F-wave, and reported that the F-wave frequency was high and the amplitude change is great, taking an undullation pattern and the severity and the degree of undullation coincides[15]. By my results there was observed a significant correlation between the degree of rigidity and F-wave frequency, and also it coincided well with its laterality. As for the amplitude change in most of mild cases the change was less, and in severe cases undullation pattern was observed, moreover, in such cases the change of latency was also marked. As for the F-wave frequency, the presence or absence of tremor, and its degree, no correlation at all was recognized. Investigation of effect of vibration was conducted with several cases, but no significant change was observed. It is known that in Parkinson's disease micrographia is often recognized and this is increased by vibration, but in the present observation there was no effect on F-wave frequency.

Taking these into consideration, it is suggested that micrographia in

Parkinson's disease is not due solely to rigidity. As to the laterality of F-wave frequency it is correlated to the laterality of rigidity as already mentioned, but what is interesting in relation this is the result of 6 cases of hemiparkinson's disease. Hemiparkinson's disease belongs to Stage I of Yahr's classification, and clinically it is the case whose symptoms are limited to one side. Total frequency, with exception of one case, is located somewhat predominantly on the involved side, but there is hardly any difference, but L group only somewhat on the involved side predominantly.

In early stage of Parkinson's disease it is mostly hemiparkinson's disease which turns to bilateral as the disease advances, but judging from the results of F-wave frequency, at the stage of hemiparkinson's disease there can be seen the sign of bilateral disorders. Moreover, it has been suggested that as symptoms advance from unilateral to bilateral, there is a possibility of S group predominance turning to L group predominance. So far there is not any report dealing with relationship of therapeutic effect to F-wave frequency. In the five cases that I could follow up after treatment I found a significant decrease of frequency being accompanied by decrease of rigidity. As the objective evaluation method of therapeutic effects in Parkinson's disease has not been established so far in the past, the method using F-wave as its parameter might be considered useful in the point that it can evaluate objectively to a certain degree changes of rigidity.

(3) CVD

Concerning CVD Fisher reported that F-wave frequency decreases in parallel with severe weakness, decreasing of reflex and tone after the onset of stroke in his paper entitled "Assessing segmental excitability after acute rostal lesions". He further states that the frequency increases along with the improvement of clinical symptoms[16]. However, he studied F-wave frequency against 10 M waves so that in taking the variable nature of F-wave into consideration his data cannot be said to be sufficiently reliable. The author studied at least over 100 M waves for F-wave frequency. As the result in cerebral infarction cases with symptoms fixed higher frequency was observed on the involved side in every case. Moreover, in the bilaterally involved cases a higher frequency was found on the side with older lesion. In the hemiplegic patients due to CVD higher frequency is shown on the involved side as recognized by Liberson et al.[17], and they stated that averaged amplitude is also greater on the involved side than non-involved side.

However, an interesting point in this study of 3 cases is the fact that higher frequency was shown on non-involved side. These 3 cases clinically all showed not any abnormality on non-involved side, whereas one case showed

silent meningioma and another case showed the appearance of pathologic reflex though paralysis was not so severe several days later. The remaining one case showed no abnormality other than cortical atrophy. This fact indicates that F-wave can detect subclinical lesion, namely, the lesion that cannot be detected by physical examination, especially in CVA it can be said to be a useful examination method including prognosis decision. Now, in 3 cerebral bleeding cases who fell into the state of acute paralysis, flaccid tone, and areflexia F-wave frequency was almost zero. However, in one case 6 weeks later F-wave frequency no longer showed laterality, and clinically muscle tone itself was flaccid but deep reflex appeared, that is, in the so-called quasi-flaccid state, and thereafter paralysis was improved rapidly. The rest two cases were still in the state of complete paralysis and areflexia on the re-examination 4 and 9 weeks later, but F-wave frequency was increased, and objectively the so-called associated reaction was recognized. Of these 2 cases one case had a rapid recovery of her paralysis, and the other had the movement of fingers possible. Associated reaction is the reaction that in hemiplegic patient even the intentional movement is impossible on the involved side, when the strong power of healthy side is made to work, its effect reaching the involved side elicits the contraction of the muscle on the involved side, and it is considered to be a positive sign of the movement unification originally existing in spinal cord to appear on the surface. In other words, as the result of the control from the central nervous system has weakened, the primitive phenomenon that is only latently present has appeared on the surface by escaping the control. The coincidence of the time of appearance of this reaction with time of F-wave appearacne strongly indicates the possibility of assuming the changes of the central control, in other words, the recovery process of the central nervous system. These findings seem to suggest that in CVA irrespective of acute stage or chronic stage the examination of F-wave should be conducted at least once, and it would be a powerful and useful examination method for the detection of subclinical lesion, or for grasping its pathological condition as well as for judging its recovery processes.

(4) MND

Even in the ALS patient of quite early stage with mild muscular atrophy the appearance of F-wave could hardly be observed. The loss of F-wave suggests a marked damage of motoneuron, but by electromyographic examination no typical giant potential can be recognized, so that rather than a complete damage of anterior horn cell it would be the damage of the passage of antidromic impulse for the better understanding.

Recently Inoue et al. reported the entire 10 month course of autopsied

case in the paper entitled "Early pathological changes of ALS" indicating the presence of numerous spheroids in the anterior horn of the spinal cord[18] According to Carpenter[19] this spheroid is the swollen proximal axon, and by such a series of changes it is sufficiently possible the passage of antidromic impulse is impeded. Kinoshita et al. reported the decrease of central conduction velocity in some case of ALS[20]. From electrophysiological observation in ALS degenerative process such as the decrease of conduction velocity in the proximal segment of motor neuron at first and then the disturbance of the central pass (namely, loss of F-wave) and finally a complete damage of anterior horn cell can be assumed.

In addition, the fact that in the patient showing only upper motor neuron sign F-wave did not appear, while on the contrary in the case clinically considered to be SPMA showing only lower motor neuron sign high F-wave frequency was observed, is the finding suggestive of the involvement of lower and upper motor neuron in each respective group. Such findings are interesting from its relationship to ALS. Hirayama's disease[21] shows muscular atrophy of upper limb unilaterally, but electromyographically giant potential can often be observed even in healthy upper limb, suggesting intramedullary lesion also to be located at the site other than brachial plexus and root[22,23]. By the observation of F-wave clearly higher frequency with greater amplitude as well as F-wave of less change were observed. Since such F-wave can most often be observed in so-called spastic state, in other words, they can be considered as findings suggesting of involvement of upper motor neuron. As the case is only one, no conclusion can be drawn, but there is a few report indicating the involvement of upper motor neuron[22], if that is the case, the case can be said as a benign type of ALS, and it requires further study on more numerous cases.

(5) Other neurological diseases

In GBS by the severity of radicular involvement it is only natural that F-wave may disappear aside from the decrease of F-wave conduction velocity. In the case that the measurement of F-wave conduction velocity is impossible, the recovery process can be assumed by the presence or absence of F-wave appearance. Of the two cases with brain stem lesion the one presented at first typical spasticity, and F-wave frequency was 100 per 100M with hardly any changes in the amplitude and shape, after radiation therapy F-wave frequency also markedly decreased in parallel with decreasing of muscle tone. The other case was clinically suspected of a very slight upper motor neuron sign but from the observation of F-wave of significantly higher frequency the confirmation was obtained. In any event there is no question of doubt that in typical spastic

state large and persistent F-wave can be obtained.

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