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Positive sharp waves and fibrillation potentials in polio survivors with sequelae: Are they due to late deterioration or radiculopathy?

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Abstract

Background & Objective: Needle electromyography (EMG) abnormalities can be observed in clinically affected or unaffected muscles in polio survivors. The primary aim of this study is to evaluate the positive sharp waves (PSWs) and fibrillation potentials (FPs) that can be observed in polio survivors. In addition, the presence of post-polio syndrome and radiculopathy was investigated in patients with PSWs/FPs. *Methods:* Clinical features and needle EMG findings of polio survivors with sequelae who applied to our neurophysiology laboratory between August 2018 and January 2021 were analyzed retrospectively. Cervical and lumbosacral magnetic resonance imaging (MRI) of polio survivors with PSWs/FPs were included in the analyses. In addition, polio survivors were divided into groups with and without post-polio syndrome. *Results:* Fifty-one polio survivors (33 male, 18 female) were included in the study. The mean age of the patients was 49.5±7.5 years. There were 13 (25.5%) polio survivors with post-polio syndrome. Needle EMG findings of 590 muscles were analyzed. PSWs/FPs were found in 11 medial gastrocnemius, four iliopsoas, four tibialis anterior, two vastus lateralis muscles, and one deltoid muscle. PSWs or FPs were present in 12 (23.5%) of patients. PSWs/FPs were present in three (23.1%) and nine (23.7%) polio survivors with and without post-polio syndrome, respectively ($p>0.05$). Of the 12 patients with PSWs/FPs, 11 had cervical and lumbosacral MRIs. In eight (72.7%) of these 11 patients with PSWs/FPs, the nerve segment of the muscle with PSWs/FPs and the segment of radiculopathy detected by MRI were compatible with each other.
Conclusions: This study indicated that PSWs/FPs may be present in polio survivors. PSWs/FPs may be due to radiculopathy and/or late deterioration. It was concluded that PSWs/FPs are not a parameter that can be used to differentiate polio survivors with and without post-polio syndrome.

Keywords: Fibrillation potentials, positive sharp waves, poliomyelitis, radiculopathy

INTRODUCTION

Poliomyelitis is an infectious disease caused by an enterovirus. Due to this infectious disease, motor neurons in the spinal cord and brain stem may be affected, and muscle weakness and atrophy may develop.[1,2] Fortunately, with the invention of the vaccine, this infectious disease has been eradicated in developed countries. However, there are still few cases with neurological deficits, and poliomyelitis can be seen in some countries due to the ineffective use of the vaccine. Moreover, disorders such as orthopedic problems or post-polio syndrome (PPS) that may occur over years after the acute infection. These late deteriorations continue to cause problems for patients, and daily activities of the patients may be restricted due to these late disorders.[3,4] Therefore, poliomyelitis still maintains its importance in the world due to these late deteriorations and the fact that poliomyelitis can still be seen in some countries.[1]

Electrodiagnostic tests including nerve conduction study and needle electromyography (EMG) are useful for both the diagnosis of poliomyelitis and the differential diagnosis. If there is no additional condition that may cause neuropathy, sensory nerve conduction studies are expected to be normal.[3,5,6] By examining the muscles with needle EMG, information about the physiology of motor units can be obtained. In the acute phase of poliomyelitis, positive sharp

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waves (PSWs) and fibrillation potentials (FPs) are observed, and then neurogenic motor unit action potentials (MUAPs) develop within weeks.[5-7] In polio survivors, these needle EMG abnormalities can be observed in clinically affected extremity muscles, as well as in extremity muscles without weakness.[3,5] Finding the characteristics of PSWs/FPs in polio survivors was the main goal of the study. Moreover, finding the presence of active denervation separately in polio survivors with and without PPS, and evaluation of radiculopathy in polio survivors with PSWs/FPs were other aims of this current study.

METHODS

Subjects

Polio survivors with sequelae older than 18 years of age who applied to Adana City Training and Research Hospital (ACTRH) Clinical Neurophysiology Laboratory between August 2018 and January 2021 were included in this study. Ethical approval was obtained from the Ethics Committee of ACTRH (number:1747/98). Polio survivors should have the following characteristics[1]: 1) History of poliomyelitis in childhood 2) Muscle weakness and atrophy in at least one extremity after poliomyelitis. Patients were excluded from the study if they had a disease that would cause polyneuropathy such as diabetes mellitus, or if they had polyneuropathy or a neurodegenerative disease or a plexopathy. In addition, patients were divided into those with and without PPS as previously suggested.[3] Patients with PPS should have the following features[3]: 1) Prior history of poliomyelitis 2) Muscle weakness and atrophy after poliomyelitis 3) Stability of neurological functions for at least 15 years after poliomyelitis 4) Newly developed muscle weakness or fatigue and symptoms of these complaints lasts at least one year 5) Exclusion of another disease that may cause newly developed muscle weakness. Cervical or lumbosacral MRI findings of patients with PSWs/FPs were also analyzed.

Electrodiagnostic tests

Electrodiagnostic tests were performed with the Cadwell Sierra Summit EMG unit (Cadwell Laboratories, Kennewick, Washington, USA). Nerve conduction studies were performed using previously suggested methods.[8,9] The normal values of our laboratory were used for the normal values of the nerve conduction study.[8,9] Needle EMG study was performed with concentric needle electrodes (length=50mm, diameter=0.46mm, Bionen Medical Devices, Florence, Italy). The band filter range for needle EMG was 10 Hz-10kHz. The sweep speed/sensitivity during rest, during mild muscle contraction, and for interference pattern analysis were 10 ms/100 uV, 10 ms/500-1000 uV, and 100 ms/500-1000 uV, respectively. Needle EMG was applied visually. PSWs, FPs, and fasciculations were carefully analyzed. If PSWs / FPs were present, they were classified as: +: If single PSW / FP was observed in at least two areas; ++: If moderate numbers of PSWs / FPs were observed in three or four areas; +++: If PSWs / FPs were observed in all areas; ++++: If PSWs / FPs filled the entire screen.[10] For the analysis of fasciculation potentials, it was waited for 10 to 20 seconds without moving the concentric electrode. Ten to 20 MUAPs were evaluated semiquantitatively during mild muscle contraction. If the MUAP amplitude was > 4 mV and the MUAP duration > 15 ms, this MUAP was considered neurogenic. In addition, if MUAPs were difficult to obtain and rapid-firing MUAPs were present (reduced recruitment: recruitment frequency > 10 Hz), these MUAPs were considered neurogenic.[10,11] According to the needle EMG findings, the affected regions were determined. If needle EMG abnormality was present in two muscles with different nerve and segment innervation in the lower extremity, it was accepted that the lumbosacral region was affected. If needle EMG abnormality was present in two muscles with different nerve and segment innervation in the upper extremity, the cervical region was considered to be affected.

Statistical analysis

Variables were expressed as numbers and percentages (%). The Pearson chi square test and Fisher's exact test were used to compare categorical variables between groups. If $p < 0.05$, it was considered statistically significant. SPSS 22.0 program was used for statistical analysis.

RESULTS

Fifty-one polio survivors were included in the study. Thirty-three (64.7%) of the patients were male. The mean age of the polio survivors was 49.5±7.5 (min-max 35-71) years. The numbers of patients with weakness in one lower extremity, bilateral lower extremities, one upper extremity, both one upper and one lower extremity, both bilateral lower extremities and one upper extremity, and all extremities were 20 (39.2%),

24 (47.1%), 1 (2.0%), 1 (2.0 %), 4 (7.8%) and 1 (2.0%), respectively. According to needle EMG findings, lumbosacral region was affected in 29 (56.9%) patients. Both cervical and lumbosacral regions were affected in 22 (43.1%) patients. There were 13 (25.5%) patients with PPS. The clinical features and the affected segments according to needle EMG findings of patients with and without PPS are shown in Table 1.

Five hundred and ninety muscles were examined with needle EMG. The characteristics of MUAPs in polio survivors are shown in Table 2. PSWs or FPs were observed in 12(23.5%) of the patients. The numbers of patients with PSWs / FPs in at least one muscle in patients with and without PPS were three (23.1%) and nine (23.7%), respectively, and this difference was not significant (p=1.000). According to needle EMG findings, lumbosacral region was affected in 5, both cervical and lumbosacral regions in 7 of 12 patients with PSWs/FPs, while lumbosacral region was affected in 24, both cervical and lumbosacral regions in 15 patients without PSWs/FPs (p=0.224). Fasciculation potentials were observed in the tibialis anterior muscle of one patient without PSWs/FPs. Table 3 shows the characteristics of clinical, electrodiagnostic and imaging tests of patients with PSWs/FPs in at least one muscle. MRI of one patient with PSWs/FPs was not available. In eight (72.7%) of 11 patients with PSWs/FPs, the segments innervating the muscles with these signs of active denervation were consistent with the radiculopathy segments found on MRI. Muscles with PSWs/FPs are shown in Figure 1.

DISCUSSION

Nerve conduction study and needle EMG in polio survivors may be useful when the diagnosis is uncertain or in the differential diagnosis of entrapment mononeuropathy or polyneuropathy.[3,5,6] If there is no accompanying neuropathy, sensory nerve conduction studies are expected to be normal, while compound muscle action potential amplitudes of the nerves may

Table 1: The clinical features and affected segments according to needle EMG findings of patients with and without post-polio syndrome

Clinical features	Polio survivors without post-polio syndrome n=38	Polio survivors with post-polio syndrome n=13	P value
Number of male patients (%)	25 (65.8%)	8 (61.5%)	0.782
Age – years mean SD (min-max)	49.2±7.3 (35-67)	50.5±8.4 (40-71)	0.829
Number of patients with weakness in extremities			
One lower extremity (%)	17 (44.7%)	3 (23.1%)	
Bilateral lower extremities (%)	16 (42.1%)	8 (61.5%)	
One upper extremity (%)	1 (2.6%)	0 (0%)	
One upper and one lower extremity (%)	1 (2.6%)	0 (0%)	
One upper extremity and bilateral lower extremities (%)	2 (5.2%)	2 (15.4%)	
All of the extremities (%)	1 (2.6%)	0 (%)	
Number of patients according to affected regions determined by needle EMG findings			
Lumbosacral region	21 (55.3)	8 (61.5%)	
Lumbosacral and Cervical regions	17 (44.7%)	5 (38.5%)	0.693

Table 2: MUAP characteristics in polio survivors

Muscles	Right- MUAP			Left- MUAP			Total- MUAP (%)		
	Amp↑ Dur↑	Ø	Norm	Amp↑ Dur↑	Ø	Norm	Amp↑ Dur↑	Ø	Norm
FDI (n=57)	16	1	32	5	0	3	21 (37)	1 (2)	35 (61)
APB (n=11)	3	1	3	2	0	2	5 (46)	1 (9)	5 (46)
BB (n=54)	9	2	38	2	1	2	11 (20)	3 (6)	40 (74)
TR (n=15)	5	0	6	3	0	1	8 (53)	0 (0)	7 (47)
DEL (n=22)	10	1	6	3	1	1	13 (59)	2 (9)	7 (32)
TA (n=115)	36	10	8	39	16	6	75 (65)	26 (23)	14 (12)
MG (n=133)	37	19	10	34	23	10	71 (53)	42 (32)	20 (15)
PL (n=19)	7	1	2	4	1	4	11 (58)	2 (11)	6 (32)
VL (n=115)	41	14	3	40	17	0	81 (70)	31 (27)	3 (3)
IP (n=45)	16	1	3	18	5	2	34 (76)	6 (13)	5 (11)
AD (n=4)	2	0	0	2	0	0	4 (100)	0 (0)	0 (0)

Ø : absent; AD: adductor magnus; Amp: amplitude; APB: abductor pollicis brevis; BB: biceps brachii; DEL: deltoid; Dur: duration; FDI: first dorsal interosseous; IP: iliopsoas; MG: medial gastrocnemius muscle; MUAP: motor unit action potential; TA: tibialis anterior muscle; TR: triceps brachii; VL: vastus lateralis muscle.

reduce. Neurogenic MUAPs can be observed in needle EMG examination. In addition, active denervation findings such as PSWs/FPs may be present even after years of poliomyelitis.[5-7] In this current study, PSWs/FPs were investigated in polio survivors with sequelae.

In the study by Şenol *et al*., PSWs and FPs were found in 25.2% and 17.9% of patients, respectively. In our study, PSWs or FPs were present in 23.5% of the patients.[7] However, unlike our study, patients with radiculopathy were not included in the study of Şenol *et al*. Only one patient with PSWs/FPs did not have a lumbosacral MRI, and most of the remaining patients with PSWs/FPs had concordant nerve segments of muscles with these active denervation findings and radiculopathy segments found on MRI. Considering that patients with radiculopathy were not included in the study by Şenol *et al*., a higher rate of PSWs/FPs was observed compared to our study. We find it difficult to explain these findings, but the low number of patients in our study may be one of the reasons. However, the presence of PSWs/FPs in some patients in the current study and in that study without a cause such as radiculopathy or polyneuropathy may mean that denervation continues or has just developed in some patients. There are some considerations that may explain late complications and subsequent or ongoing PSWs/FPs. The fact that motor neurons die faster in polio survivors than during the normal aging process may be an explanation for these active denervation findings.[12,13]

Moreover, conditions such as excessive efforts, excessive weight gain, or chronic infection are also blamed for increasing damage to motor neurons.[3,14,15] In addition, the findings in this current study showed that lumbosacral radiculopathy is also one of the causes of PSWs/FPs. It has been shown in other studies, as in our study, that the lower extremities are more affected in polio patients.[16] Therefore, weakness of the lower extremities, excessive work of the healthy extremity, excessive load on the lower back and obesity due to sedentary lifestyle may have caused lumbosacral radiculopathy.[17-19] Therefore, radiculopathy may also be one of the late deteriorations like scoliosis. Active denervation findings due to radiculopathy may have developed in polio survivors, but the cause may not be just radiculopathy. We think that PSWs/FPs may have developed as a result of the combined effect of radiculopathy and the aforementioned conditions such as the death of motor neurons in polio survivors faster compared to the normal aging process.[12,13] In the current study, fasciculation potentials were present in only one patient. In the study of Şenol *et al*., fasciculation potentials were observed in approximately 24% of the patients. This may be related to the expected time at rest for fasciculation potentials. It is recommended to wait 90 seconds for fasciculation potentials

Table 3. The findings of clinical, electrodiagnostic and imaging tests of patients with PSWs/FPs in at least one muscle

Patients	Age (years) / Gender	PP syndrome	Weakness	Affected region*	Muscle with PSWs/FPs	MRI finding
Patient#9**	51 / F	-	One LE	CR+LS	R-MG+	R-L5/S1 radiculopathy
Patient#11**	45 / F	+	One LE	LS	L-TA++++	Bilateral L4/L5/ S1radiculopathy***
Patient#12**	45 / F	+	Bilateral LEs	LS	L-VL+	Bilateral neural foraminal narrowing L4/L5
Patient#14	40 / M	+	Bilateral LEs	CR+LS	R-MG+	L neural foraminal narrowing L4
Patient#17	49 / M	-	One UE	CR+LS	R-TA++/ MG++	LS-Normal
Patient#18	57 / M	-	One UE and one LE	CR+LS	R-DEL+	CR/LS-Normal
Patient#23**	51 / M	-	Bilateral LEs	CR+LS	R-MG+++ L-MG++	Bilateral neural foraminal narrowing L3/L4/L5/ S1***
Patient#24**	38 / M	-	One LE	LS	R-TA+/ MG++/ IP+ L-TA+	Bilateral L2/L3/L4/L5/ S1 polyradiculopathy*** (R- L3/L4 laminectomy defect)
Patient#25**	60 / M	-	Bilateral LEs	LS	L-VL+	Neural foraminal narrowing L4/L5
Patient#29	38 / M	-	Bilateral LEs	LS	R-MG++/ IP++ L-MG++ / IP++	NA
Patient#35**	37 / M	-	Bilateral LEs	CR+LS	R-TA++/ MG++/ IP++ L-MG+	Scoliosis (thoracic and lumbar vertebrae) and bilateral L3/L4/L5/S1 polyradiculopathy
Patient#39**	37 / M	-	Bilateral LEs	CR+LS	R-MG++	Scoliosis (lumbar vertebra), bilateral L4/ L5/S1 polyradiculopathy

*:According to needle EMG findings. **: The segment providing the innervation of the muscle with PSWs/FPs was consistent with the segment with radiculopathy on MRI. ***: History of surgery in the lumbar region. +: severity of PSWs/FPs, mentioned in the method section. CR: cervical region; F: female; FP: fibrillation potential; IP: iliopsoas muscle; L: left; LE: lower extremity; LS: lumbosacral region; M: male; MG: medial gastrocnemius muscle; MRI: magnetic resonance imaging; NA: not available; PP: post-polio; PSW: positive sharp wave; R: right; TA: tibialis anterior muscle; UE: upper extremity; VL: vastus lateralis muscle.

to make a more precise decision.[20] However, the fact that fasciculation potentials and PSWs/FPs were seen in a minority of patients in the current study indicates that polio survivors do not have widespread denervation findings unlike amyotrophic lateral sclerosis patients.[21] Similarly, the areas and muscles involved between these two diseases may be different. While the early involvement of the C8-T1 segments is important for the diagnosis of ALS[22-24], the higher rate of lower extremity involvement in polio survivors, as the current study and other studies have shown, indicates that the areas affected by the two diseases may be different. The lower rate of needle EMG abnormality in the first dorsal interosseous muscle compared to the vastus lateralis muscle may support this situation.

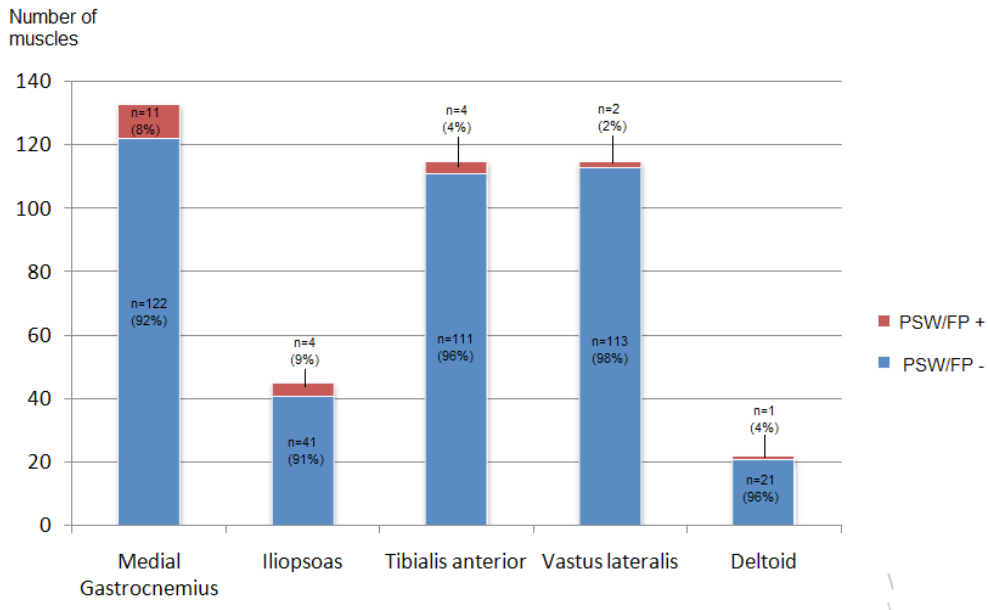

Figure 1. Muscles with PSWs/FPs
FP: fibrillation potential; n: number; PSW: positive sharp wave.

PSWs/FPs were observed in the medial gastrocnemius muscle. This may be related to the higher incidence of L5, S1 radiculopathy.[25,26] Another explanation may be the high number of medial gastrocnemius muscles examined with needle EMG. It should be kept in mind that the peroneus longus muscle, which is more innervated by the L5 nerve, is examined with needle EMG in fewer patients.

Post-polio syndrome is a late deterioration and may limit the physical activities of the patients. The prevalence of post-polio syndrome in polio survivors ranges from 20% to 80%.[27-30] In our study, this rate was approximately 25%. The numbers of patients with PSWs/FPs were not different between polio survivors with and without PPS. This finding may indicate that electrodiagnostic tests and denervation will not be useful in distinguishing polio survivors with PPS from those without PPS.[12,31,32] However, it should be kept in mind that most of the patients with PSWs/FPs in this study had lumbosacral radiculopathy.

There were some limitations of this study. In addition to retrospective nature of the study, the number of polio survivors was low. Second, the same muscles could not be examined by needle electromyography in all patients. Third, follow-up of these patients was not available. Further studies, including whether these signs of active denervation disappear during follow-up, may clarify the pathophysiology of neuromuscular deterioration in polio survivors. Finally, the paraspinal muscles were not examined with needle EMG, which was a limitation.

In conclusion, this study showed that PSWs/FPs can be seen in polio survivors. PSWs/FPs were present in patients without radiculopathy as seen in patients with radiculopathy. Therefore, it was concluded that PSWs/FPs may be due to radiculopathy and/or to late neuromuscular deterioration. In addition, this study showed that PSWs/FPs are not useful in distinguishing patients with and without PPS.

DISCLOSURE

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Ethics approval: Approval for the study was obtained from the Ethics Committee of University of Health Sciences Adana City Training and Research Hospital (number:1747/98).

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