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Original Article

Evaluation of Role of Electrophysiological Studies in Patients with Lumbar Disc Disease

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Abstract

Background: The role of the electrophysiologic studies in peripheral nerves and muscles of lower limbs (including paraspinal muscles) in prolapsed lumbar intervertebral discs has been studied with equivocal results. Pre- and post-operative electrodiagnostic studies have not been compared much. **Aims and Objectives:** To study the role of the electrophysiologic studies in prolapsed lumbar/lumbosacral intervertebral discs for finding the association between clinical findings and electrophysiological changes and to compare the electrophysiologic studies pre- and post-operatively. **Materials and Methods:** The study was conducted from July 2014 to June 2016 on fifty patients who were admitted in the department of neurological surgery with lumbar disc prolapse and all these patients were subjected to surgery. Both pre- and post-operative (from 1 to 6 months after surgery) electrophysiological studies were conducted and compared. **Results:** As per the electromyographic (EMG) abnormalities, the most common levels of intervertebral disc prolapse were L4–L5 and L5–S1 accounting for 32% of cases each followed by L5–S1 level which was seen in 28% of patients with L2–L3, L3–L4, and L4–L5 prolapsed intervertebral disc (PIVD) and L3–L4 and L4–L5 PIVD were seen in 4% of cases each. Of the 50 patients, EMG findings correlated with operative findings in 37 (74%) patients, however operative findings did not correlate with EMG findings in 13 (26%) patients. **Conclusion:** In compressive lesions of nerve roots (due to disc prolapsed), the EMG method has a high degree of accuracy in determining not only the presence of such lesions but also their exact location. EMG is accurate when correlated with the operative findings.

Keywords: *Disc, electromyography, lumbar, prolapse*

Introduction

Electrophysiological studies are efficacious methods in the diagnosis and predicting the prognosis of radiculopathies. An electrical abnormality represents the involved root in the form of fibrillation potentials and neurogenic motor unit action potentials (MUAPs) in a segment or a myotome. These studies are proper for differentiating the diagnosis of the lumbosacral radiculopathy from mimics such as plexopathies, polyneuropathies, and so on.[1]

Materials and Methods

This study was conducted in the Department of Neurological Surgery at Sher-I-Kashmir Institute of Medical Sciences, Kashmir, which is the only referral neurosurgical center in Jammu and Kashmir state catering 8 million people. It was conducted prospectively with the aim of evaluating patients with lumbar disc prolapse by means of electrophysiological studies, electromyography (EMG), and nerve conduction velocity. The study was conducted from July 2014 to June 2016 on fifty patients (after taking a proper informed consent from the patient and approval from the Institutional Ethics Committee) with lumbar disc prolapse, and all these patients were subjected to surgery. Both pre- and post-operative (from 1 to 6 months after surgery) electrophysiological studies were conducted and compared. A detailed history, complete physical and neurological examinations were carried in all patients. Magnetic resonance imaging scan of the lumbosacral region was used to confirm the diagnosis, and it showed prolapsed disc, theca, nerve root etc., very clearly. Electrophysiological studies including EMG and nerve conduction study (NCS) were carried out both preoperatively and 1–6 months after surgery. NCS was performed on common peroneal, tibialis, and sural nerves, and H-reflexes were

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obtained from soleus muscles bilaterally. EMG study was performed by recording active and resting potentials in five muscle groups comprised iliopsoas, quadriceps femoris, gastrocnemius, anterior tibialis, and extensor hallucis longus muscles. In addition, lumbar paraspinal muscles were evaluated in all patients. Other muscles were also tested if clinically or electrophysiologically indicated.

The basis of the EMG localization of a single nerve root lesions is the finding of denervation fibrillation in those muscle supplied specifically by the nerve root involved and is no other muscles.

In performing postoperative EMG, the level and length of the operation scar were noted, and the skin was marked 3 cm lateral to the scar. The locations of the spinous processes were determined, and at each spinous process, the EMG electrode was inserted to a depth of 4–5 cm at both locations lateral to scar. Each lumbar root level was explored bilaterally in this fashion. Clinical NCSs were performed with the EMG apparatus that incorporates built in nerve conduction equipment. NCSs require the addition of a nerve stimulator to standard EMG apparatus. The nerve stimulator delivers stimuli of various durations from a minimum of 0.1 ms to at least 1 ms and the frequency stimulation from 0.5 to 50 Hz.

Both motor and sensory NCSs were carried out. Motor NCS required stimulation of a peripheral nerve while recording from a muscle innervated by that nerve. Sensory NCSs were performed by stimulating a mixed nerve while recording from a cutaneous nerve or by stimulating a cutaneous nerve while recording from a mixed or cutaneous nerve. Studies were conducted on common peroneal, tibial, and sural nerves. Following parameters were measured latency, compound muscle action potentials: conduction velocity, and amplitude H-reflex: Hoffman's reflex. it is considered to be a monosynaptic reflex. H-reflex can most easily and consistently elicited in the muscles innervated by the S1 roots and the tibial nerve.

The amplitude of H-wave and H-latency is determined. The active electrode was placed over the median gastrocnemius half way between the popliteal crease and the proximal medial malleolus. The reference electrode is placed over the Achilles tendon with the ground electrode being lateral to the active electrode. The tibial nerve is stimulated at the popliteal crease with the cathode proximal.

H-latency value can be predicted from the following formula:

$$\text{H-latency (ms)} = 9.14 + 0.46 \text{ leg length (cm)} + 0.1 \text{ age (years)} + 5.5$$

When the study was performed, stimulus of short duration (0.05 ms) was given at a frequency no greater than once every 2 s. The H-reflex appeared and became maximal with a stimulus that is submaximal; the amplitude decreased as the strength increases to supramaximal. The measurement of latency was to the first deflection from the baseline when a maximal response was noted. H-reflex latency was used as an objective evidence of S1 radiculopathy. As little as 1.5 ms difference in the H-reflex latency of both legs of the same patients was found to be objective evidence of S1 radiculopathy. There is either prolongation or absence of H-reflex on the affected side in patients with unilateral S1 radiculopathy. In normal participants, the difference between two sides is <1.2 ms.

F-wave: The F-wave was most easily elicited by placing the recording electrode over an intrinsic muscle of foot and supramaxillary stimulating the appropriate motor nerve. Stimulation frequency of 1/s was recommended. F-wave has a latency that is approximately the same as the H-reflex over the same segment.

Results

Of the fifty patients, 76% were males and 24% were females in the ratio of 3.16:1. Low back pain was the most common symptoms seen in 96% of patients, followed by the leg pain seen in 76% in patients, numbness of lower limbs in 28% of patients, and loss bowel and bladder control was least and was present in 4% of patients. All the patients in our study presented with more than one symptoms. As per the EMG abnormalities, most common levels of intervertebral disc prolapse were L4–L5 and L5–S1 accounting for 32% of cases each followed by L5–S1 level which was seen in 28% of patients with L2–L3, L3–L4, and L4–L5 prolapsed intervertebral disc (PIVD), and L3–L4 and L4–L5 PIVDs were seen in 4% of cases each. Of the 50 patients, EMG findings correlated with operative findings in 37 (74%) patients, however operative findings did not correlate with EMG findings in 13 (26%) patients. Of the 50 patients with preoperative evidence of fibrillation potentials suggestive of root lesions (disc prolapse), 64% (32 patients) showed normal EMG after surgery (postoperative EMG was done 1–6 months after surgery). Thirty-six percent (18 patients) continued to show EMG abnormalities. Thirty patients had L5–S1 lesion, all these thirty patients had prolonged H-reflex latency before surgery, i.e. difference in H-reflex latencies between the right (R) and left (L) lower limb was greater than 1.5 ms. After surgery, twenty patients showed normal H-reflex latency, while ten continued with prolonged H-reflex, so improvement was noted in 66.6% of patients after surgery. A total of twenty patients (40%) were having delayed tibial nerve velocity after surgery. After surgery, tibial nerve velocity was delayed in 8 (40%) patients and improvement was noted in 60% (12 patients). Ten patients (20%) had delayed preoperative peroneal nerve conduction velocity. After surgery, improvement was noted in six patients (60%), whereas four (40%) patients had delayed peroneal conduction velocity. Eight patients (16%) had delayed sural nerve conduction before surgery. After surgery, three (37.5%) patients improved,

whereas five patients, i.e. (63%) continued with delayed sural nerve conduction velocity. A total of twenty (40%) patients had delayed F-wave in the preoperative period. After surgery, improvement was noted in 12 (60%) patients, while 8 patients, i.e., (40%) continued with delayed F-wave latency. Significant improvement in NCV parameters after surgery can be observed. Observations are summarized in Tables 1-5.

Discussion

Refinements in the neuroradiological imaging procedures have permitted better definition of structural lesions involving the lumbosacral roots. However, imaging techniques do not indicate the severity of root lesions or the prognosis for reversal of neurologic abnormalities caused by them; the radiologic changes may sometimes have no relevance to the clinical complaints of individual patients. Electrophysiological studies can help to determine the presence, severity, and prognosis of a radiculopathy and the functional relevance of an anatomic lesion. They are also noninvasive and can be performed on outpatients. It was found that in majority of patients, the clinical diagnosis of a compressive lumbosacral radiculopathy was confirmed by electrophysiologic studies.[2-4]

In our study, the youngest patient was 20 years and the oldest was 60 years. About 76% of the patients were males and 24% were female patient. Most common complaints were low back ache, seen in 48 (96%) patients. This was followed by leg pain in 38 (76%) patients, numbness of lower limbs in 14 (28%) patients, and loss of bowel and bladder control were seen in two (4%) patients. As per the EMG abnormalities, most common spinal levels were L4–L5 and L4–5, L5–SI accounting for 32% of cases each, followed by L5–SI level which was seen in 28% of patients. Several studies have noted greater incidence of EMG abnormalities in L5–SI disc herniations. Of the 50 patients, EMG findings correlated with operative findings in 37 (74%) patients, however operative findings did not correlate with EMG findings in 13 (26%) patients. In 22 patients with intervertebral disc prolapse between L5–SI, it was found that EMG correlated with operative findings in 17 patients. In 12 patients with intervertebral disc prolapse between L4–L5, EMG correlated with operative findings in 9 patients. Of the eight patients with intervertebral disc herniation between L4–L5 and L5–SI EMG correlated with operative findings in six patients. In two patients with intervertebral disc herniation between L2–L3 and L4–L5, EMG correlated with operative findings in one patient. In six patients with intervertebral disc herniation between L3–L4 and L4–L5, EMG correlated with operative findings in four and did not correlative in two patients. Hence, out of 50 patients, EMG findings correlated with operative findings in 37 patients, i.e., 74%, however EMG findings did not correlate with operative findings in 13 patients, i.e., 26%.

Table 1: Clinical presentation with electromyographic abnormalities

	Number of patients (%)
Clinical symptoms	
Low back ache	48 (96)
Leg pain/radiculopathy	38 (76)
Numbness	14 (28)
Loss of bowel and bladder control	2 (4)
Level of PIVD as per electromyographic abnormalities	
L2-L3, L3-L4, L4-L5	2 (4)
L3-L4, L4-L5	2 (4)
L4-L5	16 (32)
L4-L5, L5-S1	16 (32)
L5-S1	14 (28)

PIVD – Prolapsed intervertebral disc

Table 2: Comparison of electromyographic and operative findings

Herniated or PIVD found at surgery	Number of patients	EMG	
		Correlated (%)	Not correlated (%)
L5-S1	22	17 (77.27)	5 (22.73)
L4-L5	12	9 (75)	3 (25)
L4-L5, L5-S1	8	6 (75)	2 (25)
L2-L3, L4-L5	2	1 (50)	1 (50)
L3-L4, L4-L5	6	4 (66.7)	2 (33.3)
Total	50	37 (74)	13 (26)

EMG – Electromyography; PIVD – Prolapsed intervertebral disc

Table 3: Comparison of preoperative nerve conduction velocity parameters with the postoperative changes

NCV parameters	Preoperative (%)	Postoperative	
		Improved (%)	Not improved (%)
Prolonged H-reflex latency	30 (60)	20 (66.7)	10 (33)
Delayed tibial NCV	20 (40)	12 (60)	8 (40)
Delayed peroneal conduction velocity	10 (20)	6 (60)	4 (40)
Delayed F-wave latency	20 (40)	12 (60)	8 (40)

NCV – Nerve conduction velocity

Table 4: Age- and gender-wise distribution

Age (years)	Number of patients (%)	Males (%)	Females (%)
20-30	10 (20)	7 (14)	3 (6)
31-40	24 (48)	19 (38)	5 (10)
41-50	14 (24)	10 (20)	4 (8)
51-60	2 (4)	2 (4)	0
Total	50	38 (76)	12 (24)

Table 5: Comparison between pre- and post-operative electrodiagnostic studies

	Preoperative EMG		**Postoperative EMG**	
Test	Normal	Abnormal	Normal	Abnormal
Number of patients (%)	Nil	50 (100)	32 (64)	18 (36)
	Preoperative H-reflex latency		**Postoperative H-reflex latency**	
Test	Normal	Abnormal	Normal	Abnormal
Number of patients (%)	Nil	30 (60)	20 (66.6)	10 (33.3)
	Preoperative tibial nerve velocity		**Postoperative tibial nerve velocity**	
Test	Normal	Abnormal	Normal	Abnormal
Number of patients	30 (60)	20 (40)	12 (60)	8 (40)
	Preoperative peroneal nerve velocity		**Postoperative peroneal nerve velocity**	
Test	Normal	Abnormal	Normal	Abnormal
Number of patients (%)	40 (80)	10 (20)	6 (60)	4 (40)
	Preoperative sural nerve velocity		**Postoperative sural nerve velocity**	
Test	Normal	Delayed	Normal	Delayed
Number of patients (%)	42 (84)	8 (16)	3 (37.5)	5 (63)
	Preoperative F-wave latency		**Postoperative F-wave latency**	
Test	Normal	Delayed	Normal	Delayed
Number of patients (%)	30 (60)	20 (40)	12 (60)	8 (40)

EMG – Electromyography

Comparing the results of our study with the available literature, we found that the results of our study matched with the available literature. In our study, EMG was correct in 74% of patients and correlated with operative findings. In the year 1950, Shea *et al*.[5] showed that EMG was correct in 90% of patients and correlated with operative findings. Marinacci[6] reported 71 cases with lumbosacral herniation of the intervertebral disc in which the EMG findings agreed with the operative findings in 94.3%. A study by Knutsson[7] revealed that EMG correlated correctly with operative findings in 55 out of 60 patients, i.e., 91.6%.

Aiello *et al*.[8] evaluated the accuracy of EMG for detecting and localizing nerve root compromise in patients with surgical findings of a single lumbar disc at L3–L4 level and found 100% true positive rate with disc herniation at L4–L5 (96% true positive rate) and with disc herniation L5–SI (71% true positive rate). Of the 50 patients with preoperative EMG evidence of fibrillation potentials suggestive of nerve of root lesions (disc prolapse), 32 (64%) patients showed normal EMG after surgery (laminectomy). Postoperative EMG was done 1–6 months after surgery. Eighteen (36%) patients continued to show EMG abnormalities. When we compare our results with the published in western literature we find that EMG abnormalities in postlaminectomy patients persist in roughly one-third of the patients, i.e., 33% which matches the results of our study.

Johnson *et al*. in the year 1972[9] found persistence of preoperative abnormalities to be present as long as a 3–4 years after surgery when the nerve root compromise by the herniated disc was served. Wedell *et al*.[10] found that fibrillations and lack of MUAP were consistent finding up to 3 cm from scar; 3 weeks after surgery, Mack[11] evaluated 18 patients with recurrence of low back pain 15–30 days following surgery. One-third of the patients had fibrillation potentials. Blom and Lemperg[12] reported that at 6 weeks, all the 51 patients, who were operated for lumbar disc prolapse, had fibrillations; at 6 months, 40 of the 50 patients were examined. Seventeen (42.5%) patients showed fibrillation potential, while twenty (50%) patients showed improvement. See and Kraft[13] described postlaminectomy EMG in twenty asymptomatic patients. The studies were carried out 3½ to 41 months postoperatively 17 (85%) patients showed abnormalities. Johnson *et al*.[9] found significant postoperative electroperative abnormalities in twenty out of sixty patients, i.e., one-third of patients.

Of the fifty patients, L5–SI PIVD was noted in thirty patients; in these patients, H-reflex latency was prolonged (mean H-latency was 29.8 ms), i.e., difference in H-reflex latencies between right and left lower limb was 1.5 ms or more. In the postoperative study, H-reflex latency improved in twenty (66.6%) patients. In ten patients, no improvement was noted. Comparing our results with the western literature we found that our results matched with the western studies. In our study, H-reflex tests were positive in 100% of patients with L5–SI disc herniation. Aiello *et al*.[8] evaluated H-reflex tests and EMGs for fifty patients in whom a single disc prolapse was found at surgery. H-reflex tests were positive in 100% patients with L5–SI disc herniation.

Braddom and Johnson[14] evaluated H-reflex tests in 25 patients with clinically suspected SI radiculopathy. All 25 patients had H-reflex latencies greater than 2 standard deviations above the mean for the control group. Of the fifty patients, F-wave latency was prolonged in twenty (40%) patients. Postoperatively, F-wave latency improved in

12 (60%). Western literature[15] reveals diagnostic yield with F-wave between 18% and 65%. Of the fifty patients, twenty (40%) patients demonstrated delayed tribal nerve conduction velocity. Postoperative tribal nerve conduction was carried out 1 to 6 months after surgery. Nerve conduction improved in 12 (60%) patients, while 8 patients continued tribal nerve conduction. Similarly, peroneal nerve conduction velocity was delayed in ten patients before surgery; after surgery, improvement was noted in six (60%) patients, whereas four (40%) patients continued to have delayed peroneal nerve conduction. Similarly, sural nerve conduction velocity was delayed in twenty (40%) patients before surgery; after surgery, improvement in sural nerve conduction velocity was noted in 12 (60%) patients, while 8 (40%) patients continued with delayed sural nerve conduction velocity.

Conclusion

In compressive lesions of nerve roots (due to disc prolapsed), the EMG method has a high degree of accuracy in determining not only the presence of such lesions but also their exact location. EMG is accurate when correlated with the operative findings.

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Conflicts of interest

There are no conflicts of interest.

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