Correlation of Electrodiagnostic and Clinical Findings in Unilateral S1 Radiculopathy

Seyed Mansoor Rayegani[1,2], Seyed Ahmad Raeissadat[1,3], Elham Loni[4], Navid Rahimi[1,2], Shahram Rahimi-Dehgolan[5], Leyla Sedighipour[1,2]

[1] *Department of Physical Medicine and Rehabilitation, Physical Medicine and Rehabilitation Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[2] *Shohada Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran*

[3] *Clinical Development Research Center, Shahid Modarres Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran.*

[4] *Department of Physical Medicine and Rehabilitation, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran*

[5]*Department of Physical Medicine and Rehabilitation, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran*

Received: 20 Jan. 2018; Accepted: 15 Dec. 2018

Abstract- Lumbosacral radiculopathy is a challenging diagnosis, and Electrodiagnostic study (EDX) is a good complementary test for Magnetic Resonance Imaging (MRI). Physical examination, MRI and electrodiagnosis have different diagnostic values in this regard. MRI can provide anatomical evidence and is useful in choosing a treatment process, but it could also have false positive results. In this study, we assessed the correlation of clinical and electrodiagnostic findings in patients with positive MRI findings for S1 radiculopathy. EDX was performed for 87 patients referred with clinical and MRI diagnosis of S1 radiculopathy. The consistency between EDX results, MRI, and clinical findings were evaluated by Pearson chi 2 and odds ratio. Fifty-eight percent of patients had disc protrusion, and 42% had extrusion. Physical examination revealed absent Achilles reflex in 83% and decreased S1 dermatome sensation in 65%. In this study, EDX sensitivity was about 92%. The highest consistency among EDX parameters and physical examination findings was between absent H-reflex and decreased Achilles reflex (OR=6.20, *P*=0.014), but there was no significant consistency between H-reflex and neither muscular weakness nor SLR test result (*P*>0.05). There was also no relationship between type of disc herniation in MRI and H reflex. There was correlation between H-reflex abnormalities and absent ankle reflex in patients with unilateral L5-S1 disc herniation in MRI. Results of this study showed that in patients with positive MRI for L5-S1 disc protrusion and S1 nerve root compression, it is still beneficial to perform EDX for selected patients.

Acta Med Iran 2019;57(4):229-234.

Keywords: Consistency; EMG-NCS; H reflex; Lumbosacral; MRI; S1 radiculopathy

Introduction

Lumbosacral discopathy is one of the most common causes of low back pain. Estimated lifetime prevalence of lumbosacral radiculopathy is about 3-5 % of the general population (1). The intervertebral disc between fifth lumbar and first sacral vertebrae (L5-S1) is the most susceptible point to herniation accounting for 42% of all lumbar disc herniation (2). Lumbosacral radiculopathy is a challenging diagnosis. EDX is a useful way to help diagnosis because the test is very specific and is, therefore, a good complement to lumbosacral MRI, which is a very sensitive, but not specific test. In addition, it is the unique test to evaluate the physiologic function of the spinal nerves to see if they are damaged or not. A comprehensive study can also help excluding differential diagnoses that cause pain or neurologic changes in the lower extremity as well as a rule in the diagnosis of radiculopathy. In the hands of a skilled examiner, EDX is very specific and can help us to rule out some differential diagnoses that are very common (3). In some studies, two limb muscles plus associated lumbar paraspinal muscle

Corresponding Author: L. Sedighipour*, S. Rahimi-Dehgolan**
* Department of Physical Medicine and Rehabilitation, Physical Medicine and Rehabilitation Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
Tel: +98 21 22731112, Fax: +98 21 22731112, E-mail address: lsedighy@yahoo.com
** Department of Physical Medicine and Rehabilitation, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 21 61190, Fax: +98 21 61190, E-mail address: shahram.rahimi.dehgolan@gmail.com

abnormality, two limb muscles abnormality, or one limb muscle plus associated lumbar paraspinal muscle abnormality in EMG had 97%, 96%, and 92% specificity, respectively for radiculopathy (4). The specificity of 0.85% was reported for EDX in another study (5). There are other studies that showed EDX couldn`t be replaced by MRI (6), but there is not any systematic review regarding this comparison. Therefore as lumbosacral radiculopathy has no golden standard test, in both research and the clinic, a combination of history, physical examination, imaging, and EDX are used to confirm the diagnosis (3).

There are multiple clinical, imaging, and electrodiagnostic tests to detect S1 radiculopathy (2,7). As we know lumbar radiculopathy has various presentations. Some patients are vague historians, and physical exam is neither high sensitive nor specific in these patients. Because of this and because there is no gold standard test for diagnosis it is common for patients to undergo further testing. From an evidence-based medicine perspective, it can be difficult to assess the value of these tests (3).

Imaging (especially MRI) can well depict disc degeneration and herniation. However, there is very poor consistency between imaging findings of disc herniation and the clinical presentation or course. In another word, MRI is more sensitive than clinical findings and consequentially has a large amount of false positive (8). For example, lumbar disc protrusions can be seen as high as 67% of asymptomatic patients older than age 60, and more than 20% have lumbar central stenosis (3).

Electro-diagnostic studies including electromyography and nerve conduction study, when performed by an expert physician is a very valuable method to diagnose root involvement. It is especially valuable in patients whose physical examination is not reliable (7) and also in highly suspicious patients who have negative MRI, so we suspect to non-compressive radiculopathy such as infective or immune-mediated. EDX is very helpful in the workup of patients who have multiple level involvements and also in patients who are at the risk of neuropathy (3). One study found that needle EMG is very specific in the diagnosis of lumbar radiculopathy when the appropriate EDX criteria are used (92 % specificity). Electrodiagnostic study for radiculopathy has low number of false positive result (6).

Among EDX findings, H waves are very helpful in the diagnosis of S1 radiculopathy. In some studies, it has been mentioned to be definite sign of S1 radiculopathy even without the need to accomplish needle electromyography (9-12). This wave has several strengths, including the ability to detect injury to sensory fibers and they are not dependent on a window of opportunity to discover abnormalities as is the needle examination, because they become abnormal as soon as compression occurs and the deficit can last indefinitely (12). The aim of the present study was to describe the utility of electro-diagnostic studies in confirming clinically suspected diagnosis and investigate the consistency between clinical and para-clinical findings (EDX) in a high suspected patient of S1 radiculopathy with positive MRI result.

Materials and Methods

This study was conducted prospectively in Shohada-e-Tajrish Hospital of Shahid Beheshti University in 2016 in Tehran, Iran. Our patients were referred from neurosurgery department with a high clinically suspicion of S1 radiculopathy and positive results of MRI through 3 weeks ago. All 87 patients referred between 2014 Oct and 2016 April which their diagnosis was suspicious or needed more evaluation to make better decision for treatment were included in this study consecutively. None of our patients had local soft tissue infection or other contraindication to do EDX. All patients who were included in this study signed informed consent. The inclusion criteria were:

1. Low-back pain radicular to one lower limb
2. The onset of symptoms between 3 weeks to 3 months ago.

Individuals with bilateral radicular symptoms, previous spine surgeries, polyneuropathies, focal neuropathies in the lower limb, myopathies and known motor neuron diseases were excluded from the study.

In physical examination, the ankle reflex, SLR (straight leg raise) test, plantar flexion strength and sensory loss in S1 territory were examined. Manual muscle testing was recorded in the grading system of the Medical Research Council Scale; full available Range of Motion (ROM) is achieved against gravity and is able to demonstrate maximal resistance (5/5). Full available ROM is achieved against gravity and is able to demonstrate moderate resistance (4/5). Full available ROM is achieved against gravity but is not able to demonstrate resistance (3/5). Full available ROM is achieved only with gravity eliminated (2/5). A visible or palpable contraction is noted, with no joint movement (1/5). No contraction is identified (0/5) (14). Achilles reflex was determined by taping Achilles tendon with a reflex hammer in the prone position and assessed as 0 (no response), 1+ (diminished but present and might require

facilitation), 2+ (usual response), 3+ (more brisk than usual), 4+ (hyperactive with clonus).

We performed EDX studies to confirm the diagnosis and also to determine the severity or progressive axonal loss.

Para clinic evaluation

Electrodiagnostic (EDX) test was performed by a two-channel synergy electro-diagnostic instrument (Medelec™ Synergy T-EP). Needle EMG with a concentric needle electrode was performed by an experienced physiatrist who was full professor of physical and rehabilitation medicine.

Multiple muscles within the appropriate myotome and adjacent myotomes (above and below) were examined (13-14).

Nerve conduction studies (NCS)

Standard EDX techniques (13) were used for sural, saphenous and superficial peroneal nerves' sensory conduction studies. Sensory Action Potentials (SNAPs) and Nerve Conduction Velocities (NCVs) of above nerves were calculated. Surface electrodes were used for NCS.

Motor conduction studies were also performed for tibial and deep peroneal nerves, and Compound Motor Nerve Action Potentials (CMAPs) were recorded from Abductor Hallucis and Extensor Digitorum Brevis muscles. Nerve Conduction Velocities (NCVs) of both tibial and deep peroneal nerves were also measured.

Patients with impaired nerve conduction studies including patients with peripheral nerve injury, lumbosacral plexopathy or polyneuropathy were excluded from the study.

Also patients with history of radiation, immune or infectious diseases which could induce post irradiational radiculitis, plexopathy, infective or immune-mediated radiculopathy were excluded.

Standard electromyography techniques were followed for six muscles in S1 myotome (gastrocnemius, soleus, abductor hallucis, gluteus maximus, peroneus longus, flexorhallucis longus) and paraspinal muscles. Also, muscles innervated by L4 and L5 were examined for diagnosing S1 radiculopathy and ruling out differential diagnoses. The criteria for neurogenic EMG included: membrane instability; defined as fibrillation potentials and/or positive sharp waves, polyphasic (>4 phases) and/or long-duration motor unit action potentials (MUAPs) (≥13 ms), reduced recruitment and/or reduction in interference pattern (14).

H-reflex was recorded from gastro-soleus muscle using Braddom's technique by submaximal stimulation over the tibial nerve (14). We also adjusted these values for patients' leg length and age. All these electro-diagnostic tests were done in both limbs.

Statistical methods

Statistical analysis was conducted using SPSS version 20. Association between EDX parameters and clinical findings were calculated by odds ratios with observed level of significance determined by Pearson chi2 test. Also paired T-test was used to assess changes in continuous variables. $P<0.05$ was considered as the significance level.

Results

During this 18-month-study, 87 patients with high suspicion of clinical and imaging findings for unilateral S1 radiculopathy were referred to our EDX lab. Demographic and clinical characteristics of the patients are shown in table 1.

Table 1. Demographic and clinical characteristics of patients

Sex	Male	Female
Male/female	48 (55%)	39 (45%)
Age **Mean**	41.2 year	
Range	19-65 year	
Duration of patients symptoms Chronicity	6-24 months	
Physical exam findings:	Positive	Negative
SLR test	41(47%)	46 (53%)
Ankle reflexes	Absent or Decreased	Normal
	73 (84%)	14 (16%)
Sensation in S1 dermatome	Decreased	Normal
	47 (65.5%)	30 (34.5%)
Plantar flexor muscles strength	Weak	Normal
	2 (2%)	85 (98%)

Abbreviations: SLR: Straight Leg Rising test

According to patients' MRI results, 51 patients had protruded, and 36 patients had extruded herniation of disc (59% and 41%, respectively). Physical examination revealed absent Achilles reflex in 83%, decreased S1 dermatome sensation in 65%, positive SLR test in 47%, and prominent muscular weakness in only 2.3% of patients. In this study, EDX sensitivity was high (92%, positive result in 80 patients). There was no association between the type of disc herniation and Achilles tendon reflex (*P*=0.47, OR=0.65, 95% CI [0.2-2.0]), also there was no association between type of disc herniation and neither H-reflex (*P*=0.769, OR= 0.82, 95% CI [0.23-2.94]) nor EMG result (*P*=0.13).

Calculated sensitivity for H-reflex to diagnose S1 radiculopathy was 87.4% (76 patients had decreased or absent H reflex) and only 11 subjects (12.6%) had normal H-reflex. There was no association between H-reflex and SLR test results (*P*=0.58, OR=1.08, 95% CI [0.3-3.8]), not between H-reflex and plantar flexor muscle weakness (*P*=0.23, OR= 0.133, 95% CI [0.008-2.30]) or H-reflex and decreased sensation in S1 dermatome (*P*=0.12, OR=2.6, 95% CI [0.7-9.3]) but H-reflex and ankle jerk were strongly associated (*P*=0.014, OR=6.2, 95% CI [1.5-24.5]) and were seen together in 77 % of all patients and 91% of patients who had decreased Achilles reflex (Table 2).

Table 2. H-reflex findings in patients with S1 radiculopathy

	Ankle reflex		SLR		Sensory examination	
Normal H-reflex	**Normal**	**Decreased**	**Negative**	**Positive**	**Normal**	**Decreased**
	5 (45.5%)	**6 (54.5%)**	**6 (54.5%)**	**5 (45.5%)**	**5 (45.5%)**	**6 (54.5%)**
Abnormal H-reflex	**9 (11.8%)**	**67 (88.2%)**	**40 (52.6%)**	**36 (47.4%)**	**9 (11.8%)**	**67 (88.2%)**
Sig	***P*=0.014/OR=6.20**		***P*=0.582/OR=1.08**		***P*=0.124/OR=2.60**	

Electromyography showed neurogenic pattern (neurogenic MUAPs or active denervation) in 92% of subjects. Only 7 patients were normal on EMG exam, and 80 patients had positive findings as showed in Table-3 (Total Sensitivity=92%). The highest sensitivity was for active denervation (37.9%) and then chronic neurogenic pattern (27.6%) (Table 3). There was no correlation between the type of disc herniation in MRI and type of EMG abnormalities in the electro-diagnostic study (*P*=0.13).

Table 3. Electromyographic findings

EMG finding	Percentage
Normal	7 (8%)
Denervation pattern	33 (38%)
Chronic neurogenic process	24 (26%)
Decreased interference	17 (18%)
Denervation and neurogenic pattern	6 (7%)
Total abnormal EMG	80 (92%)

Discussion

Low back pain with radiating pain to the lower limb is the most common reason for the reference to EDX lab. EDX has been used to assess for lumbosacral radiculopathy diagnosis, determine the involved roots, physiologic function of nerve and severity of the lesion. They also can serve as extensions of the clinical history and physical examination, and confirm neuro-imaging result (15). In our study, EMG and H-reflex sensitivities in diagnosing lumbosacral radiculopathy were 92% and 87%, respectively and the two most common physical examinations were decreased Achilles reflex and S1 dermatome abnormality. In another investigation, sensory loss in the painful dermatome was the most frequent finding at physical examination (56% of cases), and EMG was abnormal in at least one myotome in 42% of cases (16).

Recently there are some evidence about the role of EDX before surgery to know which patients have better prognosis, but this is beyond the scope of this article. H-reflex is routinely used to evaluate S1 radiculopathy diagnosis. The H-reflex diagnostic criteria are latency difference between two sides, prolonged latency, and absence of H-reflex (12-13). The diagnostic sensitivity and specificity varies widely in studies. The sensitivity and specificity of 50% and 91% are reported for H reflex, respectively (8). In the present study, ankle jerk reflex

abnormalities were followed by H-reflex latency abnormality in 91% of patients. In similar investigations, H-reflex study was abnormal in 88% of subjects (17). Bobinac reported that EMG abnormalities indicating S1 radiculopathy were followed by H or F wave latencies abnormality in 63% of patients. The rest of patients (37%) showed mild EMG abnormalities followed by normal H or F wave (11). Our study revealed similar results: there was significant association between EMG findings and H reflex (P=0.066). Normal EMG finding was followed by normal H or F wave in 64% of patients. In a study performed by Katirji, the maximal H-reflex amplitude and the maximal H/maximal M amplitudes associated in a positive slope with the ankle jerk (18). In most of the previous studies, H-reflex abnormalities including H-reflex latency or its absence were strongly associated with ankle reflex.

In a study conducted by Lauder to determine the extent to which the history and physical examination predict the outcome of the electro-diagnostic (EDX) evaluation in patients with suspected lumbosacral radiculopathy, the history, and physical examination couldn't reliably predict the electro-diagnostic outcome (2). But there was a strong association between the presence of an abnormality in the respective reflex and radiculopathy at that level. For example, subjects with an abnormal Achilles reflex were more than eight times more likely to have S1 radiculopathy than those with a normal Achilles reflex (19). These findings are almost consistent with the results of our study.

Finally, we should say imaging can be considered complementary to electro-diagnostic medicine. It depicts disc degeneration and disc herniation and also can suggest the presence of discogenic abnormality, but the lack of a gold standard obviates any definitive conclusions. As we know, there is very poor correlation between imaging findings of disc herniation and the clinical presentation or course (9). In our study, EDX findings were applied for confirming the diagnosis of disc herniation, but there was no significant correlation between the pattern of disc herniation (extrusion vs. protrusion) and electro-diagnostic results including EMG findings, H-reflex latency, etc.

In conclusion, in the population of patients with suspected lumbosacral radiculopathy referred for an EDX study, generally physical examination may not be reliable at predicting EDX outcome. However, ankle reflex can be assessed and considered as H-reflex study in electro-diagnostic testing. This study also showed that in a patient with positive MRI findings for S1 radiculopathy, at the presence of an expert EMG man, it is still beneficial to perform EDX study in particular for patients who are candidate for surgery intervention or those with negative MRI results. However, MRI and EDX are complementary to each other. MRI investigates the anatomical change of discovertebral complex, and electrodiagnostic studies provide physiologic information. EDX could reveal nerve root compression its progress, its stage: being acute or chronic lesion, but imaging and other investigations may be necessary to determine the exact cause of spinal nerve damage other than disc herniation.

References

1. Velázquez-Pérez L, Sánchez-Cruz G, Pérez-González RM. Neurophysiological diagnosis of lumbosacral radicular compression syndrome from late responses. Rev Neurol 2002;34:819-23.
2. Lauder TD, Dillingham TR, Andary M, Kumar S, Pezzin LE, Stephens RT, et al. Effect of history and exam in predicting electrodiagnostic outcome among patients with suspected lumbosacral radiculopathy. Am J Phys Med Rehabil 2000;79:60-8.
3. Barr K. Electrodiagnosis of lumbar radiculopathy. Phys Med Rehabil Clin N Am 2013;24:79-91.
4. Tong HC. Specificity of needle electromyography for lumbar radiculopathy in 55- to 79-yr-old subjects with low back pain and sciatica without stenosis. Am J Phys Med Rehabil 2011;90:233-8.
5. Hasankhani EG, Omidi-Kashani F. Magnetic Resonance Imaging versus Electrophysiologic Tests in Clinical Diagnosis of Lower Extremity Radicular Pain. ISRN Neurosci 2013;4:4.
6. Coster S, De Bruijn S. Tavy D. Diagnostic value of history, physical examination and needle electromyography in diagnosing lumbosacral radiculopathy. J Neurol 2010;257:332-7.
7. Dillingham TR, Lauder TD, Andary M, et al. Identifying lumbosacral radiculopathies: an optimal electromyographicscreen.Am J Phys Med Rehabil 2000;79:496-503.
8. Charles Cho S, Ferrante MA, Levin KH, Harmon RL, So YT. Utility of electrodiagnostic testing in evaluating patients with lumbosacral radiculopathy: An evidence-based review. Muscle Nerve 2010;42:276-82.
9. Maus T. Imaging the back pain patient. Phys Med Rehabil Clin N Am 2010;21:725-66.
10. Makovec M, Benedicic M, Bosnjak R. Hwave and spinal root potentials in neuromonitoring of S1 root function during evacuation of herniated disc:preliminary results. Croat Med J 2006;47:298-304.
11. Bobinac-Georgijevski A, Sokolovic-Matejcic B, Graberski

M. The H or F wave latencies in medial gastrocnemius in the electrodiagnostic study of sciatica patients with suspected S1 radiculopathy. Neurol Croat 1991;40:85-91.
12. Braune HJ, Wunderlich MT. Diagnostic value and different neurophysiological methods in the assessment of lumbar nerve root lesions. Arch Phys Med Rehabil 1997;78:518-20.
13. Tarulli AW, Raynor EM. Lumbosacral radiculopathy. Neurol Clin 2007;25:387-90.
14. Dumitru D, Zwarts M. Focal peripheral neuropathies. In: Dumitru D, Amato A, Zwarts M, eds. Electrodiagnostic Medicine.4th edition. Philadelphia, PA: Hanley and BelfusInc, 2002:1043-126.
15. Sandoval AE. Electrodiagnostics for low back pain. Phys Med Rehabil Clin N Am 2010;2:767-76.
16. Mondelli M, Aretini A, Arrigucci U, Ginanneschi F, Greco G, Sicurelli F. Clinical findings and electrodiagnostic testing in 108 consecutive cases of lumbosacral radiculopathy due to herniated disc. Neurophysiol Clin 2013;43:205-15.
17. Ghugare BW, Singh RK, Patond KR, Joshi MU. Assessment of nerve conduction study to establish most common electrophysiological predictor of lumbosacral radiculopathy among radiologically diagnosed L5-S1 neural foramina compression cases. Indian J Physiol Pharmacol 2013;57:209-13.
18. Katirji B, Weissman JD. The ankle jerk and the tibial H-reflex: a clinical and electrophysiological correlation. Electromyogr Clin Neurophysiol 1994;34:331-4.
19. Lee JH, Lee SH. Physical examination, magnetic resonance image and electrodiagnostic study in patients with lumbosacral disc herniation or spinal stenosis. J Rehabil Med 2012;44:845-50.