The Utility of Paraspinal Mapping Technique in the Diagnosis of Lumbar Spinal Canal Stenosis

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Summary:

Background: Lumbar spinal canal stenosis (LSCS) is a disorder that causes neurologic deficit, pain and disability. It is common in the elderly, and increasingly encountered as the population ages. Because other causes of back pain are common and difficult to prove, it is possible that mechanical backache, in conjunction with coincident neuropathy or other unrelated leg complaint, might lead to inappropriate treatment including surgery. Thus, accurate diagnosis of the clinical syndrome of spinal stenosis using paraspinal mapping technique may be of critical importance.

Objectives: Asses the utility of paraspinal mapping technique in detecting the level of lumbar radiculopathies in patients with lumbar spinal canal stenosis.

Subjects and methods: Ninety seven (97) patients with LSCS with a mean age of (46.3±11.2) years and thirty four (34) healthy control subjects with a mean age of (42.8±8.8) years involved in the study. Needle EMG of lumbar paraspinal muscles in addition to eight lower limbs muscles were performed.

Results: Paraspinal muscles scores greater than 4 significantly differentiate the patients with LSCS from the control groups. The percentages of each level of lumbar radiculopathy by using paraspinal mapping technique differ from those by using lower limbs electromyography (EMG) for example right and left L5 radiculopathy 19.6%, 18.6% using EMG of PSM when compared with 78.2%, 79.4% using EMG of lower limbs muscles, and the percentages will increase by combination of both tests in such a way that RT and LT L5 radiculopathy increase to 84.5%, 82.5%.

Conclusion: Paraspinal mapping technique is a sensitive, useful, quantifiable and quite effective method in the diagnosis of lumbar spinal canal stenosis when compared with lower limbs EMG.

Keywords: LSCS lumbar spinal canal stenosis, PSM paraspinal muscles, PM paraspinal mapping technique, R radiculopathy.

J Fac Med Baghdad 2014; Vol.56, No .1
Received Oct .2013
Accepted Jan. 2014

Introduction:

Lumbar spinal canal stenosis (LSCS) has been defined as any type of narrowing of the central spinal canal (vertebral canal), nerve root canals (lateral recess), or the intervertebral foramina through which the spinal cord root(s) enter and exit. This narrowing can be caused by bone, soft tissue or both. The resultant nerve root compression leads to nerve roots ischemia and a clinical syndrome associated with variable degrees of low back, buttock and leg pain (1). LSCS is a disorder that causes neurologic deficit, pain and disability. It is common in the elderly and increasingly encountered as the population ages (2). Some clinicians use the term stenosis to describe statistical deviation from average size of the spinal canal or the neural foramen regardless of symptoms, while others use it to describe a clinical syndrome that presents classically with neurogenic claudication pain in the back or legs with ambulation (3). Because other causes of back pain are both common and difficult to prove, it is possible that mechanical backache, in conjunction with coincident neuropathy or other unrelated leg complaint, might lead to inappropriate treatment including surgery (4).Thus accurate diagnosis of the clinical syndrome of spinal stenosis is of critical importance. Despite the increasing socioeconomic impact of LSCS, with its associated disabilities and costs, it remains difficult to make an accurate diagnosis. Recently electrodiagnostic testing, especially the quantified paraspinal mapping needle electromyographic protocol for examination of the paraspinal muscles, has been shown to be effective in diagnosing LSCS. Paraspinal muscles (PSM) involvement in various spinal and generalized disease processes is well known. Documentation of electromyographic abnormalities in this region identifies a radicular lesion that affects the spinal nerve at a point proximal to its bifurcation into the posterior and anterior rami. Recent advances in the knowledge of the PSM in health and disease allow physiologist to obtain sensitive, specific, quantifiable, and reproducible data about disease through the needle examination. The paraspinal mapping technique is an important way to gather this information. To our

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knowledge, this is the first time where paraspinal mapping technique is used in Iraq. The main aim of the study is to highlight the importance of this technique in the diagnosis of LSCS and to build practical experiences on this topic with experiences elsewhere comparison.

Patients and methods:

The study had been conducted at the department of neurophysiology in the Neurosciences Teaching Hospital, during the period from November 2012 to July 2013. Ninety seven (97) patients with lumbar spinal canal stenosis with a mean age of (46.3±11.2) years and thirty four (34) healthy control subjects with a mean age of (42.8±8.8) years were involved in the study. All the patients were diagnosed and referred by neurosurgeons and neurologists in the neurosurgery and neuromedicine departments. Electrophysiological study was performed, using NIHONKOHDEN MEB – 9400 A/ K EMG/ EP measuring system. Needle EMG of lumbar paraspinal muscles was performed according to standard protocol (paraspinal mapping technique). In addition to, needle EMG of the right and left lower limbs muscles were done by the conventional method.

1. The Paraspinal Mapping Technique:

Paraspinal mapping (PM) is performed by placing needles in the lumbar paraspinal muscles in carefully selected different locations. while the patient was in prone position, palpation of 2.5 cm lateral and 1.0 cm cranial to the inferior edge of the spinous processes of L3, L4, and L5 (the inferior edge is the gap between L3-L4, L4-L5 and L5-S1). Whereas, the fourth location was 2.5 cm lateral to the midline between the tips of the posterior superior iliac spines. These locations was labeled as L2, L3, L4, and L5 on the paraspinal mapping score sheet to indicate the innervation of the multifidus muscle found next to midline at each level. At each insertion site, a 50 mm concentric needle is directed at a 45-degree angle toward the midline and is inserted in approximately 5 mm intervals until it contacts the spinous process. On contact with the spinous process the needle is withdrawn to the surface and redirected 45 degrees cranially, then on contact with bone again withdrawn and redirected 45 degrees caudally. This results in 4 skin punctures, 12 insertions to the bone, and 24 scores of 0-4, with a total possible score of 96 on one side. A score is calculated from each individual needle and then all are added to determine a total PM sensitivity score.

A finding at each level was scored as follows (score meaning):

0 mean: No reliable data obtained. (0 - M, 0 - B, and 0 - A might be used to specify that muscle activity, bone, or adipose tissue was the cause of unreliable data).

- mean: No reproducible spontaneous activity.

+ mean A single, reproducible train of fibrillation potentials.

++ mean: More than one train of fibrillation potentials, at different configurations or depths.

+++ mean: Numerous fibrillation potentials at more than one depth.

++++ mean: Fibrillation potentials fill the screen.

Scoring: Spontaneous activity scored separately for insertions within the first 4 cm of needle insertion (placed in the mixed" M" column on the score sheet) and in the last 1 cm of needle insertion (placed in the specific "S" column of the score sheet).

The data for each of the 12 locations was recorded on the paraspinal score sheet. Individual "S" column scores used to suggest which nerve root involved in a radiculopathy. A total score was obtained by adding together all of the pluses. Total scores on one side of 0 to 2 were considered normal in younger persons and 0-4 in persons over age 55.

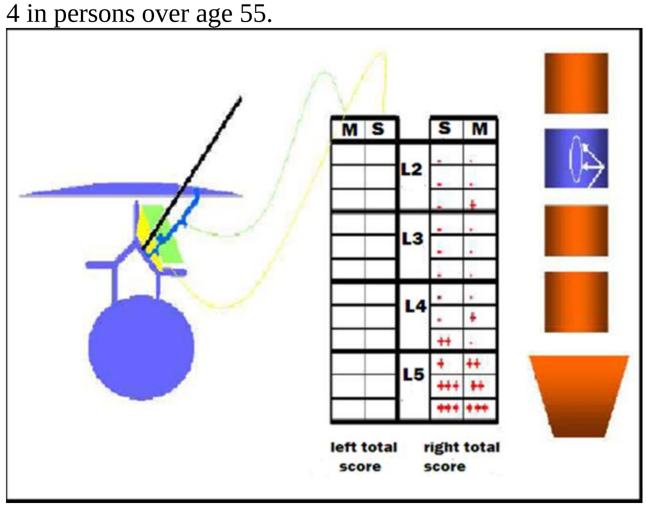

Figure (1): Needle insertion viewed from a cross section, along with paraspinal mapping score sheet.

The S (specific) column scores come from findings in the last centimeter before contacting midline. The M (mixed) column scores come from any lateral insertions.

2. The needle examination of the lower limbs muscles was performed in five steps:

Step one: identification of the muscle, the muscle was palpated during contraction to identify its location.

Step two: the needle was inserted when the muscle at rest in order to study the insertional activity.

Step three: the muscles examined at rest to detect the spontaneous activity if present. The gain setting was 50 microvolt / cm and sweep speed 5-10 msec/ cm. the gain has been increased, so the sensitivity is increased to ensure the visualization of fibrillation potentials that may be remote and therefore quite small.

Step four: minimal or mild muscle contraction to assess the motor units potential. Twenty or more single motor unit potentials were isolated, and two parameters were studied; duration and polyphasia.

Step five: maximal contraction was ordered to study the recruitment pattern. However, The EMG of the lower limbs designated as abnormal when it show one or more of the following

characteristics:

Abnormal spontaneous activity (FP and/or positive sharp wave); reduced (neurogenic) recruitment of motor-unit firing and features of chronic motor unit action potential (MUAP) reinnervation (increased duration and polyphasia) in which the MUAP was assessed by isolation of 20 motor units or more with assessment of duration and phases of each MU. The individual motor units were polyphasic when it has five or more phases. However, the MUAP was defined as abnormal (neurogenic motor units) when the polyphasia more than 20% and the summation of the duration of the collected motor units divided by their numbers was higher than the normal value of the same age.

Statistical analysis:

Analysis of data was carried out using the available statistical package of SPSS-20 (Statistical Packages for Social Sciences- version 20).

Data were presented in simple measures of frequency, percentage, mean and standard deviation.

The significance of difference of different means (quantitative data) was tested using independent student-t-test for difference between two means,

Statistical significance was considered whenever the P value was equal or less than 0.05.

Results:

Paraspinal muscles scores:

As illustrated in table1, there are significant differences in the mean of paraspinal muscles score at the right and left sides of each level of paraspinal muscles between the patients with LSCS and the control group; in such a way that the mean of abnormal paraspinal muscles scores at right L2 level 12.5 which is higher than the corresponding level 1.5 in the control group (P<0.05).

Table (1): Comparison of paraspinal muscles scores between the patient and the control groups.

The paraspinal muscles	Patients		Controls		P value
	Number	Mean±SD (Range)	Number	Mean±SD (Range)	
L2 PSM RT	8	12.5±5.2	2	1.5±0.7	0.0004*
LT	8	11.1±3.2	2	1.5±0.7	0.0001*
L3 PSM RT	12	8.9±5.1	4	1.3±0.5	0.0002*
LT	13	10.7±5.8	3	1.7±0.8	0.0001*
L4 PSM RT	17	9.1±4.5	5	1.2±0.4	0.0001*
LT	15	8.9±3.7	4	1.3 ±0.5	0.0001*
L5 PSM RT	19	11.8±4.4	5	1.6±0.5	0.0001*
LT	18	11.7±4.7	6	1.7±0.5	0.0001*

*Significant using Students-t-test for difference between two independent means at 0.05 level

EMG of lumbar paraspinal muscles:

Figure 3 demonstrates the differences in the percentage of each level of lumbar radiculopathy in patients with LSCS while using the EMG of PSM alone and when using the EMG of the lower limbs muscle alone. As it is clear that L2 and L3 radiculopathy achieve higher percentage when it diagnosed by the EMG of PSM.

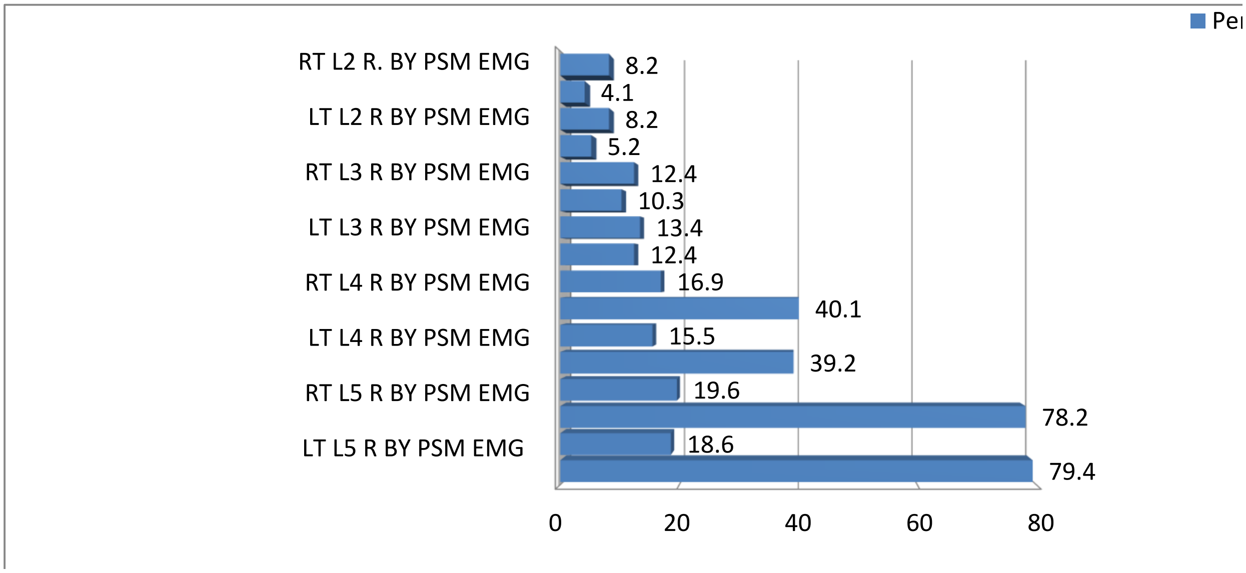

Figure (3): Bar chart showing the comparison of percentage of each level of lumbar radiculopathy when diagnosed by EMG of PSM alone and when diagnosed by EMG of lower limbs muscles alone.

The EMG of paraspinal muscles and/or lower limbs muscles:

Figure 4 explore the percentage of each level of lumbar radiculopathies when diagnosed by combination of the EMG of paraspinal muscles (paraspinal mapping technique) with that of the lower limbs EMG. However, comparison of the percentages of lumbar radiculopathies in this figure with those that are demonstrated in figures 2 and 3, reveal that the percentage of each level of lumbar radiculopathy increase. As for RT L5 radiculopathy 19.6% using EMG of PSM, 78.2% while using EMG of lower limbs and 84.5 by combination of both tests.

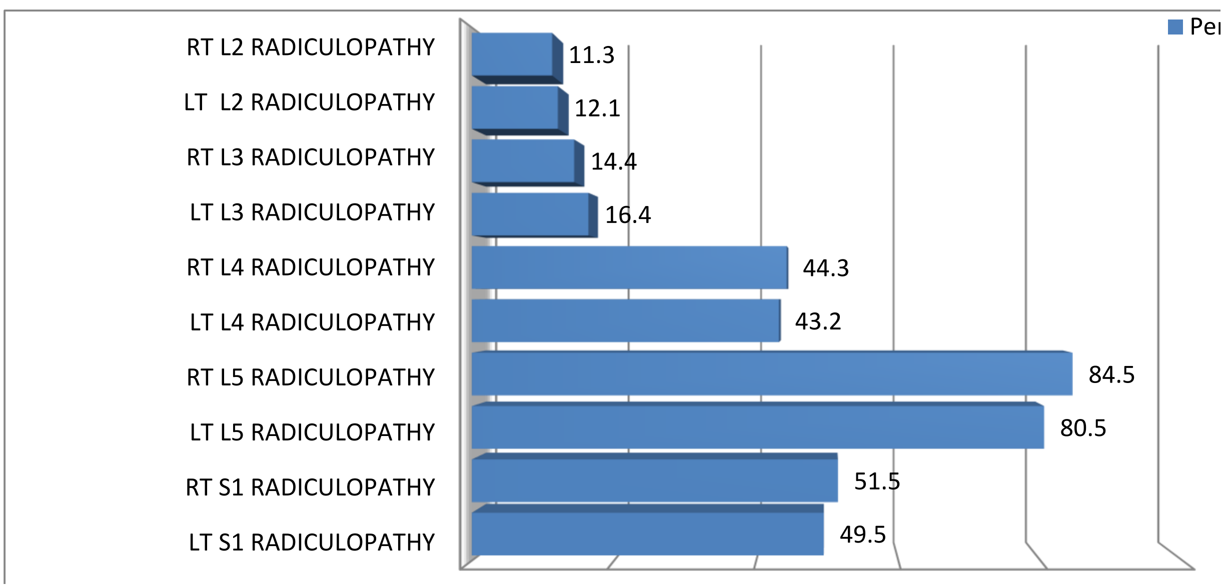

Figure (4): Bar chart shows percentage of each level of radiculopathy when diagnosed by the combination of EMG of PSM the EMG of the lower limbs muscles.

Discussion:

The paraspinal muscles (PSM) are physiologically similar to the limb muscles in their innervation and response to pathologic changes. The diagnosis of radiculopathies is dependent upon finding evidence for denervation in a specific segmental pattern (5). Paraspinal mapping is a way to objectify and quantify the needle examination of the paraspinal muscles (6). Paraspinal mapping (PM) is a relatively new technique that can be done with standard EMG equipment. Haig, et al., conducted 50 studies to ultimately show that PM sensitivity scores had higher sensitivity than that either peripheral EMG or imaging alone (7).The PM score provides a quantitative means of deriving the degree of paraspinal muscle denervation. It distinguishes normal persons from those patients with radiculopathy. This novel and quantitative technique may prove to identify subtle radiculopathies or spinal stenosis with greater precision (8). In the present study the PM technique was applied on 97 patients with LSCS and 34 healthy subjects; detection of abnormal score in 45 patients (41%) was nearly similar the study of Kerry, 2002 (9) who found clear evidence of paraspinal denervation in approximately 50% of cases of lumbosacral radiculopathies. Whereas 41% is higher than what was found by Henry, 2012 (10) in which the PM test alone with a cutoff of greater than 4 was positive for radiculopathy in 16 (33.3%) of 48 subjects. Examination of eight levels of PSM (four on the right and four on the left) was considered in the patients and the control groups. Different percentages of lumbar radiculopathy from L2 to L5 levels were diagnosed in the patients (fig. 3). The comparisons of the patients paraspinal score at each level with the corresponding level in the control (table 1) yield a statistical results of a significant difference ($p < 0.05$), these results agree with study of Haig, et al., 2006 (11) who reported a paraspinal mapping score greater than 4 significantly differentiates persons with stenosis from the control group. Most patients with LSCS have abnormal PM that could indicate denervation and possible atrophy of the paraspinal muscles (13). What was noticed in this study is that the percentage of right and left L2 radiculopathy and that of L3 radiculopathy through PM technique were higher than that the percentage of L2, L3 radiculopathy diagnosed by the EMG of lower limbs muscles (figure 3). High lumbar disk herniation is an important sub-category and most problematic in the electrodiagnosing medicine, because they are uncommon, their presentation does not involve the classic radiation below the knee, the neurologic examination is not sensitive, nor is the MRI. However, in this study; PM was very useful in the diagnosis of such high lumbar root lesions which are even not reliably distinguished from each other by application of the conventional lower limbs muscles EMG because of the overlap of innervation of the anterior thigh muscles. Consequently, the benefit of PM that is obtained in this study in the diagnosis of high lumbar disk herniation was correlated with other studies (12, 13, 14). On the other hand, using of the abnormalities of the lower limbs EMG as a marker for lumbar radiculopathies give different percentages (figure 3). Consequently, combination of the abnormalities obtained from the EMG of the lower limbs with that of the paraspinal muscles results in percentages of lumbar radiculopathies (figure 4) higher than that obtained from the EMG of paraspinal muscles alone or lower limbs muscles alone (figure 3).

Conclusion:

Paraspinal mapping technique is a sensitive, quantifiable and quite effective method in the diagnosis of lumbar spinal canal stenosis and the detection of the uncommon and difficult to diagnose high lumbar root lesions (L2, L3).

The combination of the EMG of the PSM with that of the lower limbs for the diagnosis of lumbosacral radiculopathy is better than the use of the EMG of the lower limbs alone or the use of the EMG of the PSM alone.

Authors Contributor:

Study conception: Prof. Dr. Najeeb Hassan Mohammed (supervisor).

Study design: Prof. Dr. Najeeb Hassan Mohammed (supervisor).

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