



# **Analysis of Electrophysiological Parameters as an Early Indicator for Nerve Root Involvement among the Patients with Acute Lumbar Radiculopathy**

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## **Authors' contributions**

*This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/JPRI/2021/v33i35B31908

### Editor(s):

(1) Dr. Rafik Karaman, Al-Quds University, Palestine.

### Reviewers:

(1) Krishnangshu Bhanja Choudhury, West Bengal University of Health Sciences, India.

(2) Maria Alexandra Fenandes Rodrigues, Universidade Eduardo Mondlane, Mozambique.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/69564>

**Original Research Article**

**Received 02 May 2021**

**Accepted 06 July 2021**

**Published 07 July 2021**

## **ABSTRACT**

Electrophysiological parameters especially the late responses which include H reflex analysis are of great significance and importance in diagnosing and predicting the level of nerve root involvement radiculopathy patients. The main objective of the present study was to analyse the electrophysiological parameters like amplitude and latency for prediction of nerve root involvement in lumbar radiculopathy patients. The present research project study was undertaken on 50 diagnosed patients of lumbar radiculopathy. The study participants were between the age group of 30-60 years and were having the low back pain ranging from 30-60 days. The bilateral nerve conduction studies were performed for posterior tibial nerve, sural nerve, and late responses like H waves were studied and analysed for amplitude and latency for all the patients. Patients with radiculopathy showed significant reduction in the amplitude of sural sensory nerve, the latencies were prolonged among the patients with L5-S1 root involvement based on the MRI findings. H wave's amplitude asymmetry was significantly noted among the patients with L5-S1 root involvement suggesting the axonal compression at nerve root level earlier than the changes in the latencies for H waves. Prolonged latencies is reduction in the amplitude of sural nerve as well as, the amplitude asymmetry for late responses like H waves can be considered as one of the earlier signs of compression of the nerve roots in lumbosacral radiculopathy.

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*Keywords: Amplitude; H reflex; electrophysiology; nerve; radiculopathy.*

## 1. INTRODUCTION

Low back pain is considered to be one of the most common complaints of adulthood and occurs among 40- 80% of population for at least once in their lifetime [1]. There are multiple etiologies which include hernia ion of lumbosacral segments and disc related pathologies, there are other causes too which includes degenerative and inflammatory bone disorders, overweight and obesity which may also cause low back pain [2,3]. Literature is suggestive that the chronic pain can last for more than a month, or few of them consider it as chronic when it lasts for more than six to seven weeks, and few consider it as more than six months. Late responses can be effectively utilized for the assessment of proximal nerve root disorders. The proximal segment of the nerves involving both pathways can be effectively screened using electrophysiological parameters like H-reflex, tibial nerve conduction velocity and latencies of F-waves which are highly inaccessible by routine surface stimulating as well as recording techniques. It is recommended by The American Association of Neuromuscular and Electro Diagnostic Medicine that the accurate diagnosis of poly neuropathy can be done by using clinical signs and symptoms and highly specific electro diagnostic test [1]. The most effective of these nerve conduction parameters to diagnose the radiculopathy at lumbosacral level is H-reflex analysis [2]. There are certain diagnostic criteria's on which the utility of H reflex is assessed, which includes, prolonged latency and amplitude reduction on the affected side, absence of H reflex on the affected side, differences in the side to side latencies [3] Significant demyelisation of nerves especially the larger diameter axons among patients suffering from radiculopathy can be diagnosed based on prolong latency or difference in side-to-side latency [4]. The nerve conduction block with excessive demyelisation can be well understood when the amplitude for H reflex is decreased or there is no response on the affected side due to reduction in the recruitment of fast conducting spinal motor neurons [5]. The varying degree of conduction block and demyelisation can occur simultaneously among patients having radiculopathy [6]. The changes that occur in the H reflex latency are occasionally detected during the acute stage as the as the severity of damage is less both structurally as well as functionally,

but due to continuous nerve compression it may progress to a full-fledged pathological condition [7]. The changes pertaining to the amplitude of H-reflex which includes reduction, absence of H reflex or bilateral asymmetry, amplitude changes (e.g., asymmetry, absence, reduction) are more common in the early stages of radiculopathy. The H-reflex amplitude asymmetry usually occurs earlier as compared to the changes in the latencies among patients suffering from acute form of radiculopathy where the duration of the symptoms ranges between 31 to 57 days [8]. Due to continuous faulty posture, severe compression of nerve at the root level may happen, during the progression of radiculopathy, this result in changes of both amplitude as well as latency, changes pertaining to the amplitude are more evident due to nerve compression among the patients suffering with radiculopathy [9]. However, there is paucity of information regarding the stipulated changes in the late response parameters, the present study will help in analyzing the changes in the sural sensory nerve action potentials as well sole us H-reflex latency as well as amplitude among the patients suffering from radiculopathy at L5-S1 level.

## 2. METHODOLOGY

The present cross sectional comparative study was undertaken in a tertiary care hospital of Pondicherry during February- August 2018 among 50 patients who were attending the neurology OPD. Same number of control population volunteers from the hospital and college were recruited as controls for the present study (n=50).The study subjects were attending the neurology OPD with low back pain referred for lumbar MRI from spine and neurology clinic.

### 2.1 Inclusion Criteria

Age Group: 30-60 years, those with complaints of low back pain

### 2.2 Exclusion Criteria

- Patients with pre-existing neurological disorder
- History of systemic and metabolic disorders which could affect electro diagnostic results (diabetes, hypertension)
- Patients having history of specific injury have undergone any kind of operative procedure at lumbar or sacral region [10],

- Diagnosed cases of lumbar radiculopathy associated with any disorder of metabolism or history of any medications [11].
- Patients whose NCS reports showed involvement bilateral peripheral nerve.

patients with unilateral denervation of the nerves [12].

### 3. SAMPLING TECHNIQUE

Calculation of the sample size was done based on the derived formula,  $n = 4pq/d^2$  where

$n$  = Sample size

$p$  = Proportion of individuals with lumbar radiculopathy being the cause of LBP

Since lifetime prevalence of LBP is 84%. 80% of LBP is due to lumbar radiculopathy. So, 80% of 84% is,  $80 \times 84 / 100 = 67.2\%$

$$q = 100 - 67.2 = 32.8\%$$

$$d = \text{precision. (20\% of 67.2\%)} = 67.2 \times 20 / 100 = 13.4$$

$$\text{Therefore, } n = \frac{4 \times 67.2 \times 32.8}{13.4 \times 13.4} = 8816.64 / 179.56 = 49.10$$

This is approximately equal to 50.

To confirm the radiculopathy leading history was also obtained from the patient, detail clinical examination was performed, patient with lumbar radiculopathy presented with complain of pain usually unilateral in nature and parenthesis in the affected lower limb. On examination the deep tendon reflexes were also reduced. The second important criteria were MRI findings criteria include patients having findings of annular disc bulging as well as disc hernia ion. The third most important criteria used for analysis of electrophysiological parameters is inclusion of

### 4. RECORDING OF H REFLEX AND SURAL SENSORY NERVE ACTION POTENTIAL (SNAP)

Recording of H reflex and SNAP was performed using Medtronic Key point @ 2EMG EP software Inc Germany. For recording the SNAP, the setting of the filters was done between the values of 20 Hz and 2 kHz, sensitivity was set at  $10 \mu\text{V/div}$  while the duration of sweep was around 20ms, temperature of around  $25^\circ\text{C}$  was maintained at lateral alveolus and the response was recorded using surface electrodes [13]. The excitability of the motor neurons was controlled by making the subject comfortable in lying relaxed position. The adjustment of the stimulator was done in such a way that the response obtained will be of best expected as well as possible amplitude. Taking into an account of the standardized method, response for sole us H waves was recorded, by setting a gain of (1-5mv) and was recorded by stimulating the tibial nerve where the site of stimulation was at popliteal fosse [14]. Use of surface electrodes was done in order to record the needed response. The response was recorded using the surface electrodes in Fig. 2. The intensity of stimulation was maintained with verification of consistency in the amplitude of M wave. The recording and stimulating electrodes were placed at a required and prefixed distance. Fig. 1 shows the Site for the placement of stimulation and the recording electrodes for recording the SNAP. Fig. 2 shows the position of electrodes required for eliciting the response of H-waves where S = point of stimulus, R= Point of response recording, and G = Placement of the ground electrodes.

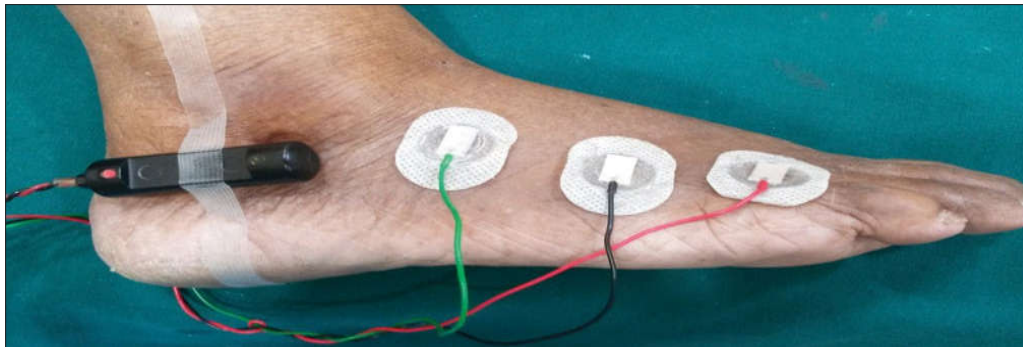
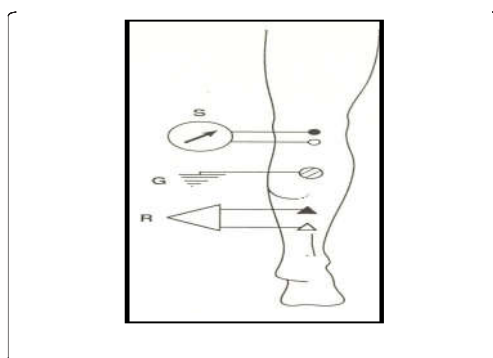


Fig. 1. Site for the placement of stimulation and the recording electrodes for recording the SNAP



**Fig. 2.** Figure shows the position of electrodes required for eliciting the response of H-waves where S = point of stimulus, R= Point of response recording, and G = Placement of the ground electrodes

The average of 5 recordings latency as well as average of peak amplitude for H waves was considered for both the patients as well as control subjects. Based on the reference values derived the side to side amplitude for H reflex was calculated [11] H/H ratio was calculated using Han et al's method and based on the difference of side to side latency the patients were categorized into two groups. Group A (N=22) (12 males and 10 females) having the normal latency or without difference in the side-to-side latency and if present will be less than 1.0 ms, while group B (N=28) (20 males and 8 females) having abnormal latency with difference in the side- to-side latency of more than 1.0ms.

Statistical analysis Mean and standard deviation values were derived for gage groups for latencies and amplitude as well as H/H ratio [12]. One-way ANOVA analysis was performed in order to compare the differences between the controls, patients with and without normal latencies, in order to adjust the difference between the age groups among the two sets of study population; covariance analysis was performed. Pearson's correlation coefficient was used to analyze the relationship between the study parameters for H-reflex, nerve conduction parameters, as well as the clinical findings. Post hoc analysis was performed using Bonferroni's correction method.

## 5. RESULTS

MRI findings among the patient's group is suggestive that out of 50 diagnosed radiculopathy patients n=38 patients had annular disc bulging and hernia ion, n=12 patients had disc prolapsed and degeneration. Among the control group of subjects, the average mean amplitude of sural sensory nerve was 8.8 $\mu$ V;

average value for latency was 4.2ms; while the average conduction velocity for sural nerve was 33.7m/while among the patients with radiculopathy, the amplitude of SNAP was 4.6 $\mu$ V; latency was 6.9 ms (optimal range 6.2–7.8 ms), while the average velocity of nerve conduction for sural nerve was 20.03m/s (optimal range 19–23 m/s) (p value  $\leq$  0.05) (Table 1). The recording of H reflex was obtained for all the study participants. As compared with the healthy controls the patients having lumbosacral level radiculopathy showed highly significant variations in the amplitude of H wave asymmetry however, significant asymmetrical patterns for amplitude of H waves was observed among radiculopathy patients in comparison with the healthy subjects (p value $\leq$  0.05) in Table 1. The average values for H/H ratios were 0.89 in normal control subjects, 0.62 among patients with normal latencies and 0.55 among radiculopathy patients with prolonged latency, and among the control study groups respectively. We performed the Bonferroni's post hoc correction analysis and the results obtained showed that the values for H/H ratio was significantly different for the control group of study population and among the patients having radiculopathy but normal latency, while the H/H ratio was significantly different among the normal control group subjects and the radiculopathy patients having the abnormal or prolonged latencies (p value 0.0005)Significantly, latencies were prolonged among the patients suffering with radiculopathy. (p value $\leq$  0.05). Analysis of correlation coefficient showed significant correlation ship between the occurrence (r value 0.83), and duration of clinical symptoms (r value 0.7) and the asymmetries of the amplitudes among the patients having the prolonged latencies in Table 1. The values of corrected Bonferroni's analysis showed

significant difference among healthy controls and among the radiculopathy patients having prolonged latencies (28.89 ms and 33.98 ms respectively) and that of patients with normal latencies (32.10 ms) while the correlation between clinical symptoms, duration of symptoms and asymmetries of the amplitudes among patients having normal latencies was certainly not significant. ( $r$  value 0.03,  $r = 0.5$ ). Table 1 shows the Comparative table for different electrophysiological parameters pertaining to the different categories of the patients.

Significant differences ( $p < 0.05$ ) of sural sensory nerve action potentials (SNAP) was denoted with \* Significant differences for sole us H-reflex ( $p < 0.0005$ ) was denoted by \*\*; Significant differences between patients having normal latencies and controls using the Bonferroni's correction is denoted by #; Significant differences ( $p < 0.05$ ) between patients having abnormal latencies and controls using the Bonferroni's correction is denoted by @; Significant differences ( $p < 0.05$ ) between patients having abnormal latencies and controls using the Bonferroni's correction for latency parameter is denoted by \$; Relationship between the amplitude asymmetries and duration of symptoms is denoted by \$\$.

## 6. DISCUSSION

As already discussed about the role of electrophysiological studies in assessment of the disorders of the nerve roots which is known and is being the area of interest since decades, the present study was undertaken to assess the role of sural sensory nerve action potentials and late responses such as sole us H reflex in assessment of progression of the proximal nerve root disorders. The results for our study showed that there was reduction in the amplitude, prolongation of the latencies and reduction in the conduction velocities of sural sensory nerve on the affected side of the patients. The changes related to the asymmetry of the H reflex were more prominent as compared to the differences in the latencies among the patients suffering from radiculopathy in comparison with the control subjects. We tried to correlate the MRI finding with the electrophysiological findings by categorizing the patients based on disc bulging and degeneration. Changes pertaining to latencies and amplitude were more profound among patients having severe or chronic radiculopathy. The cause for asymmetry in the amplitude is blockage in the axonal conduction of larger diameter nerve fibres, this may result in

**Table 1. Comparative table for different electrophysiological parameters pertaining to the different categories of the patients**

Parameters	Category	Control subjects (n=50) Mean SD	Patients group with normal latencies(n=22)	Patients group with abnormal latencies(n=28)	P value
Age		42.9±22.8)	45.3±19.1	48.3±23.1	-----
SNAP (Sural sensory nerve action potential) ( $\mu$ V)					
Amplitude (mV)		8.8±4.3	6.8±2.9	3.8±1.9	$\leq 0.05^*$
Latency (ms)		4.0±2.92	4.9±3.12	5.7±2.9	$\leq 0.05^*$
Conduction Velocity(m/s)		33.7±6.8	20.03±13.2	19.2±10.6	$\leq 0.05^*$
Amplitude (mV)	Symptomatic	5.79±2.23	3.83± 2.83	2.49±1.74	
	Asymptomatic	6.04±2.09	5.14±2.78	3.9±2.29	
Latency (ms)	Symptomatic	28.79±3.1 \$	32.41±2.19	32.12±2.14\$	$\leq 0.0005^*$
	Asymptomatic	31.09±2.9	32.45±2.23	31.43±2.79	*
Amplitude for H/H reflex ratio		0.89±0.12#@	0.62± 0.13#	0.55±0.12@	$\leq 0.0005^*$
Difference in the latency		0.13±0.04	0.32±0.2	1.390.69	
Duration of low back pain		Not applicable	32±5.7	58±8.4 \$\$	

signal input desynchronization, and this may also result in reduction of speed of neuronal signals transmission, which leads to reduction in the recruitment of motor neurons and H reflex amplitude. As the progression of radiculopathy occurs which includes tingling numbness, weakness in the lower limbs, pain on the affected side, the prolonged latencies as well as changes in the amplitude symmetry are more profound. Our results also showed that based on the duration of the symptoms, the values for variations in the H/H reflex ratio was 0.62, when normal range of latency was observed (duration 32 days) and as the duration of radiculopathy was prolonged (58 days) there was significant reduction in the H/H ratio with prolonged latencies. This is due to involvement of more number of axonal neurons which results in reduction of H reflex amplitude. Though the latencies are normal, our results are suggesting that the asymmetry in H reflex can be utilized as an early marker suggesting the neuronal compression. Neuronal encroachment and low back pain is often associated with delayed or prolonged latencies and is commonly reported in the previous studies or literature. As the chronicity of the radiculopathy increases due to associated neuronal demyelisation and axonal damage, the latency related changes are not so prominent. Due to variations in the amplitude reflex, the neurologists are always in a state of dilemma for using preferred diagnostic parameter in the form of either latency or amplitude. The changes pertaining to the amplitude may be the result of either variation in cognition, activity of the muscles or excitation of the vestibular apparatus. The possibility of increasing the stability in the reflex is possible only when the standard testing procedure / protocols are followed. The stability of H reflex can be acquired using tape on the electrodes for sticking, maintain the head in proper position, the more repeatedly the tibial nerve is stimulated before the actual test the more stability of the reflex can be assured. The use of repetitive trace recordings is important for taking any diagnostic decision, previous literature is suggestive that the use of minimum 4 tracings are needed to determine H wave amplitude reduction or asymmetry, and it has been also proven that among radiculopathy patients, the changes in the amplitude asymmetry of H reflex are useful in assessment of patho physiological changes in the nerve root segment. Our results and conclusions are based on the fact proven by Jin et al who had utilized two different ways for recording the late responses for H waves, first

method is at foramen of S1 was recorded by stimulating the s1 root at level of neural foramen, while the other method was traditional one were the H reflex was recorded with the stimulation of tibial nerve at the level of the popliteal fossa. In our study we used the traditional method for assessment of H reflex for reporting of radiculopathy. Several studies have shown the changes related to the H reflex amplitudes and H/M ratio is utilized in diagnosing the lumbosacral radiculopathy few studies have also recommended that the smaller the H/H ratio there is lesser latency difference among the patients having S1 nerve root involved. Our study results have shown that the H/H ratio was lesser than 0.62 when latencies were not prolonged, and were also indicative of involvement of S1 nerve root. Our study results also proved the feasibility and convenience of recording the response from the affected limb rather than recording response for both limbs which may cause physical discomfort to the patient too.

## 7. CONCLUSION

Although a variable parameter the amplitude of H reflex can be used as one of the reliable and preferred test to diagnose radiculopathy at lumbosacral level. The H/H ratio focusing on the amplitude can be utilized more as compared with the latency as one of the dependent test parameters. Asymmetry in the amplitude of H reflex in comparison with the changes in the latency can be considered to be an important parameter for diagnosing the radiculopathy. The author feels that the number of sample size would have been more to validate the findings; however our results were based on assumptions of the clinical knowledge regarding radiculopathy. We tried to correlate the MRI finding with the electrophysiological findings by categorizing the patients based on disc bulging and degeneration, but did not correlate the nerve conduction changes with MRI findings which would have helped in validating the results. It would have been more practical to correlate the changes in the MRI, clinical symptoms as well as the H-reflex analysis as this is a part of a research project. It would have been more specific if equal number of male and female subjects of same age group would have been included in the study which would have increased the validity and reliability of the study. However, we fulfilled our desired objective for the assessment of the most perfect nerve conduction parameter for the diagnosis of radiculopathy.

## CONSENT AND ETHICS APPROVAL

Prior clearance from the ethical committee of the institution was obtained, from Sri Balaji vidyapeeth MGMCRI, IHEC (Ref: FACULTY PROJECT/2018/06/06). Written consent for participation in the study was taken from all the study participants.

## ACKNOWLEDGEMENTS

The author would like to thank the management of Sri Balaji Vidyapeeth's Mahatma Gandhi Medical College Hospital and Research Institute for their permission and extended cooperation effective conduct of the study. The authors also thank the faculty members of department of physiology, for supporting throughout the study. Last but not the least a big thanks to the study participants who heard patiently and participated actively in the study.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:

The peer review history for this paper can be accessed here:  
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