Section: Dermatology

Original Research Article

ELECTROPHYSIOLOGICAL EVALUATION OF PERIPHERAL NERVES IN HANSENS NEUROPATHY

Bollapu Srujan Kumar[1], Janardhan A Upadhyaya[2], Yamini Devulapally[3], (Col) G K Prasad[4]

[1]Assistant Professor: Department of Dermatology, Venereology and Leprosy: MediCiti Institute of Medical Sciences, Ghanpur, Medchal- Malkajgiri, Telangana, India.
[2]Associate Professor: Department of Dermatology, Venereology and Leprosy: MediCiti Institute of Medical Sciences, Ghanpur, Medchal- Malkajgiri, Telangana, India
[3]Associate Professor, Department of Physiology, Government Medical College, Kamareddy. Telangana, India.
[4]Professor & HOD, Department of Dermatology, Venereology and Leprosy, MediCiti Institute of Medical Sciences, Ghanpur, Medchal- Malkajgiri, Telangana, India.

Received : 31/08/2024
Received in revised form : 22/10/2024
Accepted : 06/11/2024

Keywords:
Hansen's disease, Sensory neuropathy, Sural nerve, Nerve function impairment.

Corresponding Author:
Dr. Bollapu Srujan Kumar,
Email: dsrujan.kumar72@gmail.com

DOI: 10.47009/jamp.2024.6.6.9

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2024; 6 (6); 38-44

Abstract

Background: To study the nerve conduction patterns in Hansens cases reporting to department of Dermatology Venereology and Leprology (DVL). **Materials and Methods:** The Cross sectional observational study done in patients attending the outpatient and inpatient, Department of Dermatology for a period of one and half year. A total of 100 leprosy cases were enrolled for the study. **Result:** 86 % of the cases showed NCS changes at the time of diagnosis. Sensory motor mixed type (axonal & demyelinating) was the commonest pattern of peripheral Neuropathy seen in 37.2 % cases. Sensory neuropathy was more common 61% compared to motor neuropathy 34%. Sural nerve was the most commonly affected sensory nerve seen in 36% of patients with Abnormal Sensory nerve conduction patterns. Ulnar nerve was the most commonly affected motor nerve seen in 20.1 % of patients with Abnormal Motor nerve conduction patterns. Changes in NCS patterns were more pronounced in cases with disease duration of 6 to 12 months. 90.14 % of Multi bacillary cases and 75.86 % of Pauci bacillary cases showed Impaired Nerve conduction patterns. Amplitude was the commonest affected NCS parameter seen in 98% cases with Abnormal Sensory NCS and 69 % cases with Abnormal Motor NCS respectively. In nearly 43 % of cases Nerve conduction studies showed Abnormal patterns even before the Clinical Neuritis has manifested. **Conclusion:** Along with clinical tests, nerve conduction studies should also be considered in leprosy patients for the early detection of nerve function impairment whenever feasible. Employing NCS, which when done and interpreted promptly can aid in assessement, Diagnosis and further timely management of clinical and subclinical neuropathy in Hansens patients.

INTRODUCTION

Leprosy also known as Hansen's disease is a chronic granulomatous infectious disease caused by mycobacterium leprae, primarily affecting the skin and peripheral nerves. It is one of the oldest diseases known to mankind and M.leprae, is one of the earliest micro-organisms to be associated with human disease. Leprosy is an example of bacterial disease with an immunological background. The immunological component influences the occurrence of the disease, classification and the types of reactions that can occur. Incubation period is long, ranging from 5-7 years. Leprosy remains one of the commonest preventable and treatable peripheral neuropathy. It is the only bacterium known to affect myelination and cause peripheral neuropathy.[1]

Nerve involvement may vary from involvement of intradermal nerves in a cutaneous patch to a major lesion in the peripheral nerve trunk, with a predilection for the cooler parts of the body. Patients with skin lesions overlying peripheral nerve trunks are more prone to the development of sensory or motor impairment.[2,3] Deformities and disabilities are the worst outcome of peripheral neuropathy in leprosy and the most important goal in the management of leprosy is the prevention of disability via early detection of nerve impairment. When detected and treated early, primary impairments may be reversible. So, early detection and treatment of nerve function impairment (NFI) is of paramount importance in leprosy. Visible pathological changes in the nerve are almost always preceded by a stage of functional blockade of nerve impulse conduction.[4,5]

ISSN (O): 2687-5365; ISSN (P): 2753-6556

The role of electrophysiological evaluation of nerve function in the diagnosis and assessment of different neuropathies is well established.

MATERIALS AND METHODS

This retrospective cohort study was conducted at the Maharajah's Institute of Medical Sciences in Vizianagaram. The study spanned from March 2023 to February 2024 and included patients diagnosed with tuberculosis (TB) who received treatment or follow-up care at the institution. The study was designed to assess the impact of prior antibiotic exposure on the development of multi-drug-resistant tuberculosis (MDR-TB) and examine treatment outcomes among MDR-TB and non-MDR-TB patients.

Study Population

The study included a total of 100 patients diagnosed with TB during the study period. Eligibility criteria required patients to have a confirmed TB diagnosis and documented information on prior antibiotic use. Patients with incomplete medical records or those with drug-resistant TB at initial diagnosis were excluded to ensure the study's focus on the development of MDR-TB.

Data Collection

Data were retrospectively collected from patient medical records, including demographic information (age, gender), clinical data (presence of comorbidities like diabetes and HIV), and antibiotic history. Prior antibiotic exposure was recorded, with particular attention to the use of fluoroquinolones and macrolides, which are commonly prescribed for various infections but are associated with an increased risk of resistance in TB.

Outcome Measures

The primary outcome of interest was the development of MDR-TB, defined as resistance to both isoniazid and rifampicin, which was confirmed through laboratory testing. Secondary outcomes included treatment success rates and relapse rates among MDR-TB and non-MDR-TB patients. Treatment success was defined as the absence of TB symptoms and a negative laboratory result at the end of the treatment period. Relapse was noted if symptoms reappeared or TB was confirmed again after completing treatment.

Statistical Analysis

Data were analyzed to determine the association between prior antibiotic exposure and MDR-TB development. Descriptive statistics were used to summarize demographic and clinical characteristics. Chi-square tests were employed to compare MDR-TB rates between antibiotic-exposed and non-exposed groups. Odds ratios (OR) with 95% confidence intervals (CI) were calculated to assess the likelihood of MDR-TB development among patients with prior antibiotic exposure. P-values < 0.05 were considered statistically significant. Treatment outcomes and relapse rates were compared between MDR-TB and non-MDR-TB groups using appropriate statistical tests.

RESULTS

The Cross sectional observational study done in patients attending the outpatient and inpatient, Department of Dermatology, Venereology and Leprology at Mediciti Institute of Medical Sciences for a period of one and half year from January 2023 to June 2024.

A total of 100 leprosy cases were enrolled for the study.

Inclusion Criteria

Patients of age group 16 years and above in both newly diagnosed cases and known cases of Hansens on treatment.

Exclusion Criteria

Patients below the age of 16 years, Pregnant women and Patients who are not willing to participate are excluded.

Methodology: After Obtaining clearance and approval from the instituitional ethical committee,100 cases were included for the study. Informed and written consent was taken from patients and clinical data was recorded as per proforma. Detailed history taking and complete examination was done.

Clinical photographs were taken at the same sitting. All the patients were thoroughly investigated with routine haematological and biochemical investigations. Slit skin smear examination for Acid fast bacilli(AFB) and /or Skin biopsy for Histopathological examination(HPE) were performed.

Nerve Conduction Study: The electrophysiological nerve conduction assessment was done for all the patients.

Nerve conduction study was performed at the Neuroelectrophysiology laboratory. Room temperature was maintained at the thermo neutral zone (26 -28 ·C). It was ensured that all the patients were relaxed and comfortable with the laboratory set up prior to the recording.

The parameters studied for motor nerves were distal motor latency,compound muscle action potential, and conduction velocity while for sensory nerves sensory nerve action potential (SNAP), onset latency, and conduction velocity were recorded. The nerves assessed in the Upper limb were Ulnar and median and in lower limb were Sural, Peroneal and Tibial Nerves.

Motor nerve conduction was assessed in Ulnar, Median, Peroneal and Tibial Nerves.

Sensory nerve conduction was assessed in Ulnar, Median and Sural Nerves.

The Standard Nerve Conduction Studies

In Upper Limb

1. Sensory

Median (D2 or D3) and Ulnar (D5)

ISSN (O): 2687-5365; ISSN (P): 2753-6556

2. Motor - Median (thenar) Ulnar (hypothenar)
In Lower Limb
1.Sensory - Sural
2.Motor
Peroneal (EDB)
Tibial (AH)
() = Stimulating or recording sites;
D2 - index finger; D3 - middle finger; D5 - finger;
EDB - extensor digitorum brevis; AH - abductor hallucis.

Statistical Method
The collected data was analysed using the computer programme statistical package for Social Sciences(SPSS). Microsoft Word and Microsoft Excel were used to generate graphs and tables. Descriptive analysis was used to compute percentage, to calculate Mean and
Standard deviation.

RESULT

Nerve Conduction Parameters Observed in Axonal Degeneration & Demyelination.
In the present study, the youngest patient was 17 years old and the oldest 74 years. The maximum number of patients (26) showing clinical activity in this study belonged to the 51-60 years' age group whereas the least number of patients (2) belonged to the more 70 years' age group.
In the present study, out of the total 100 cases males were 67 and females were 33. The male to female ratio was 2.03: 1.
In the present study all the patients were thoroughly examined clinically and diagnosed. Out of 100 cases, 43 were diagnosed as BT, followed by 26 pure neuritic, 16 as LL, 3 cases as BB and 3 cases as TT. 9 cases were released from treatment but were included in study for their residual neurological complaints.
In the present study, 74 patients were from low income group whereas 26 patients were from middle income group. There were no patients from high income group.
The minimum duration of the disease was less than 6 months and the maximum duration was 10 years. Maximum number of patients, 49 had disease duration of less than 6 months, it was between 1-5 years in 26 and between 6-11 months in 20 cases.
Functional impairment of the nerves was commented based on standard criteria 29. Out of the total 100 patients who were included in the study, 86 (86%) patients showed changes in their nerve conduction patterns.14 cases had normal NCS study.
When considered separately sensory neuropathy was more common 61% compared to motor neuropathy 34%. Sensory motor mixed type (axonal & demyelinating) was the commonest pattern of peripheral neuropathy in the present study.
Among the sensory nerves the sural nerve was found to be maximally affected 31 (36 %) followed by the ulnar 26 (30%) and median nerve 13 (15%).
Similarly, among the motor nerves, the ulnar was maximally affected 18 (20.1%) followed by the common peroneal 16 (18%), posterior tibial 13(15%), median 8 (9%). Patients with disease duration of 6-12 months had more abnormal NCS followed by Patients with disease activity of > 12 months and < 6 months. Out of 71 Multibacillary cases 64 (90.14%) showed abnormal NCS compared to 22 (75.86%) out of 29 paucibacillary cases.

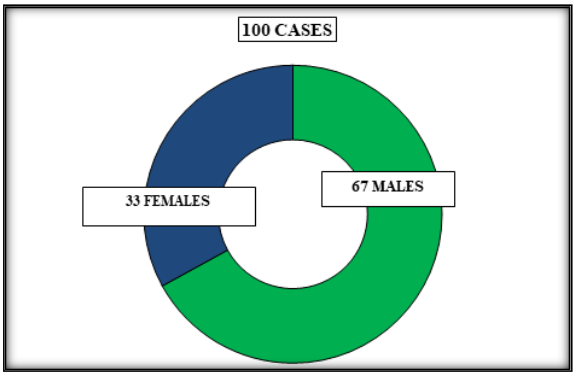

Figure 1: Sex Distribution

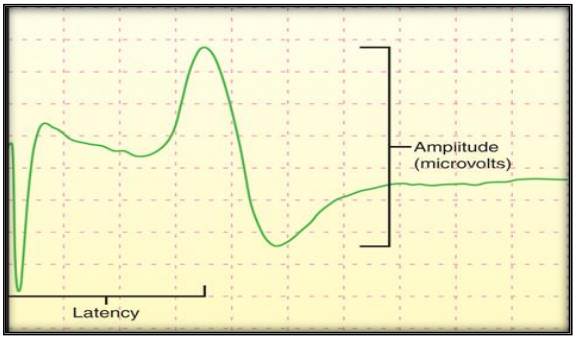

Figure 2: Latency and Amplitude

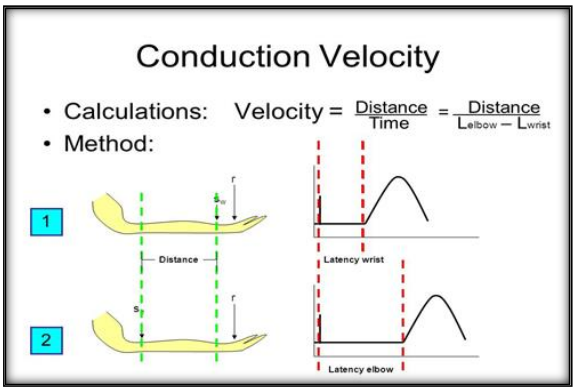

Figure 3: Conduction velocity

ISSN (O): 2687-5365; ISSN (P): 2753-6556

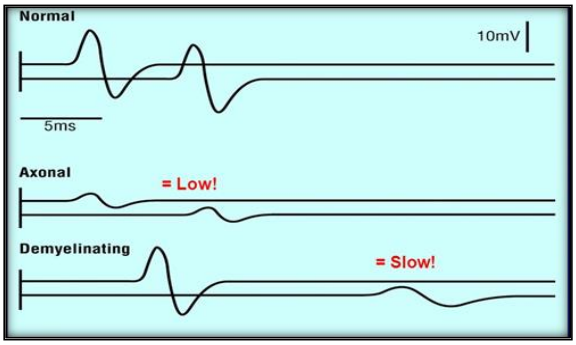

Figure 4: Axonal and demylinating neuropathy

Amplitude was the most common affected parameter for both Sensory and motor NCS. It was impaired in of 98 % of nerves having impaired NCS.

Out of 100 patients in the study 86 patients showed changes in NCS. Out of these 86 patients 75 had clinical neuritis and 11 were clinically free from neurological complaints. Out of the 75 patients who had both clinical neuritis and NCS changes, 49 patients had NCS findings that correlated well with NCS findings [Clinical Neuritis = NCS]. While in 26 out of 75 patients NCS findings were significantly greater than clinically. Manifest neuritis. [NCS Findings > Clinically manifest Neuritis]. 11 out of 86 patients who showed changes in NCS pattern were clinically free from neurological complaints [Only NCS Findings].

1. Axonal Neuropathy results in Decresed (= Low) Amplitude.
2. Demylinating Neuropathy Leads to Decreased (= Slow) Conduction Velocity.

Table 1: Axonal and demyelinating neuropathy.

	Axonal Degeneration	**Demyelination**
Sensory or Motor Amplitudes	Minimal or absent	Normal or Minimally reduced
Distal latencies	Normal	Prolonged
Conduction velocities	Normal or minimally reduced	Significant reduced
Conduction block	Absent	Present

Table 2: Demographic Results

	TT	**BT**	**BB**	**BL**	**LL**	**PN**	**RFT**	**Total**
Less than 20		5			1	2	0	8
21 - 30	1	12			1	3	1	18
31 - 40	1	8	1		3	4	2	19
41 - 50		10	1		2	6	2	21
51 - 60	1	6	1		6	10	2	26
61 - 70		1			3	1	1	6
More than 70		1					1	2
	3	43	3	0	16	26	9	100

Table 3: Clinical Diagnosis

Type	**Total**	**Percentage**
TT	3	3%
BT	43	43%
BB	3	3%
BL	-	-
LL	16	16%
PN	26	26%
RFT	9	9%

Table 4: Occupation and duration

Occupation	**Number of Patients**
Daily Wage Labours	31
Agriculture	24
House Wife	13
Students	7
Self Employed	5
Mechanic	3
Retired Employee	2
Others	4
Dependant (Unemployed)	11
Duration	
< 6 Months	49
6-11Months	20
1-5 Years	26
6-10 Years	4
>10 Years	1

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 5: Pattern of nerve conduction in leprosy patients (n = 100)

Category	No And %
Normal NCS	14(%)
Abnormal NCS	86 (%)
Sensory-motor axonal & demyelinating	32 (37.2%)
Sensory axonal	13 (15.11%)
Motor axonal	7 (8.31%)
Sensory axonal & demyelinating	15 (17.44%)
Sensory-motor axonal	19 (22.09%)

Table 6: Frequency of abnormal nerve conduction parameters (n=100)

	Parameters of Nerve Conduction		
Nerves	**Amplitude Reduced or No Response**	**Latency Increased or No Response**	**Velocity Reduced or No Response**
Sensory Nerves			
1.Ulnar	26	19	22
2.Median	13	9	10
3.Sural	31	24	28
Motor Nerves			
1.Ulnar	18	17	18
2.Median	9	8	5
3.Common Peroneal	16	16	12
4.Posterior Tibial	13	11	11

Table 7: NCS Patterns among leprosy spectrum

Disease	No of Cases	Normal NCS	Abnormal NCS	Percentage
TT	3	1	2	66.6%
BT	43	5	38	88.3%
BB	3	1	2	66.6%
LL	16	3	13	81.25%
PNL	26	2	24	92.3%
RFT	9	2	7	77.7%

Table 8: Clinical neuritis comparision with NCS changes

Clinical neuritis vs NCS changes	Number of cases (n= 86)	Percentage
NCS = Clinical	49	56.9%
NCS > Clinical	26	30.2%
Only NCS	11	12.7%

DISCUSSION

A nerve conduction study (NCS) is a medical diagnostic test commonly used to evaluate the function, especially the ability of electrical conduction, of the motor and sensory nerves of the human body. It is an invaluable tool in evaluating the peripheral neuropathies. These studies are responsible for a complete reappraisal of neuromuscular diseases as these provide vital information to confirm or alter a clinical diagnosis and prevent a serious diagnostic error.

Sensory, motor or mixed nerves can be studied. Pairs of electrodes are used – one to initiate the impulse and the other to record the response further along the path of the nerve (distally within the innervated muscle for motor nerves or proximally along sensory nerves). In peripheral neuropathy due to Leprosy segmental demyelination occurs in Lepromatous lesions and Wallerian and Axonal type of degeneration occurs in Tuberculoid type of Lesions.

In present study 86/100 patients (86%) had impaired nerve conduction study at the time of disease diagnosis. 14 patients showed normal NCS pattern. When considered separately sensory neuropathy was more common 61% compared to motor neuropathy 34%. So sensory neuropathy was found to be more common in leprosy patients. Similar was the finding in a study from western Nepal with sensory neuropathy (11.90%) more than the motor neuropathy (7.39%).[6] Brown et al,[7] also reported sensory neuropathy in 42.89% cases and motor neuropathy in 21.42% cases of the leprosy . This can be explained by the fact that in early stages of leprosy, sensory fibers undergo damage earlier than motor fibers resulting in a greater reduction of sensory conduction velocity when compared to motor. In contrast to above findings in a study by Ramadan et al,[8] motor nerve conduction was impaired more than sensory.

In the present study out of total 86% of patients with NCS changes Sensory motor mixed type (axonal & demyelinating) was the commonest pattern of peripheral neuropathy in the seen in 37.2% cases followed by sensory motor axonal type in 22.01%. A study by Chaurasia et al,[9] showed a similar finding with sensory motor mixed (axonal and demyelinating) neuropathy as the frequent neuropathy encountered in leprosy patients. However S.Marhatta et al,[10] reported sensory motor axonal as the commonest neuropathy (16%) followed by sensory motor mixed axonal & demyelinating neuropathy (9%).

ISSN (O): 2687-5365; ISSN (P): 2753-6556

In the present study out of total 86 patients with NCS changes, Among the sensory nerves the sural nerve was found to be maximally affected 31 (36 %) followed by the ulnar 26 (30%) and median 13 (15%). Similarly, among the motor nerves, the ulnar was maximally affected 18 (20.1%) followed by the common peroneal 16 (18%), posterior tibial 13(15%), median 8 (9%).Similar reports were seen in S. Marahatta et al,[10] study with the sural to be maximally affected (21.6%) followed by the ulnar (17.6%), radial (16.2%) and median (9.5%) among the sensory nerves. In the same study Among the Motor nerves, the ulnar was maximally affected (18%) followed by the common peroneal (16.2%), posterior tibial (13.5%), median (8.1%) and radial (8.1%) as detected by NCS.Van brakel et al,[11] and Khambati FA et al[12] also reported Sural nerve as the most commonly involved sensory nerve in Leprosy.

In the present study, Patients with disease duration of 6-12 months had more abnormal NCS patterns than Patients with disease activity of > 12 months and < 6 months. This can be attributed to the time needed for a minimum number of nerve fascicles to get involved in disease process before the Neuritis becomes evident in NCS.

In our study 64/71 (90.14 %) Multibacillary cases had abnormal NCS findings as compared to 22/29 (75.86%) Paucibacillary cases that showed abnormal NCS. This finding is in concordance with study reports of Ramadan et al,[8] and Chaurasia et al,[9].

In our study Sensory nerve conduction Amplitude was the most commonly affected parameter seen in 98% of Sural nerves and 77% of Ulnar nerves having abnormal nerve conduction. Decreased Sensory nerve conduction and prolonged sensory latency were the next other parameters that showed impairment in descending order. This finding correlated well with S.Marhatta et al,[10] study which showed Changes in sensory amplitude in 100% cases of abnormal Sural NC studies. In contrary NH Antia et al,[13] reported that sensory conduction velocity as the most commonly effected sensory NCS parameter than Amplitude and Latency.

In our study Amplitude was the commonest (69%) impaired Motor NCS parameter followed by Nerve conduction (60%) and latency (53%). In Case of Ulnar Nerve Motor Amplitude and Motor Conduction velocities showed a linear decrease. Whereas in other motor nerves (CPN, PTN, Median) Amplitude showed greater frequency of impairment as compared to Velocity and latency. This was in concordance with Ramadan et al,[8] study which reported changes in Motor Velocity, Amplitude, Latency in a frequency of 72%,80%, and 70% respectively.

Among the 26 cases of Pure Neuritic Leprosy 24 patients showed abnormal NCS this accounts to 92.3 %. 2 out of 3 Mid borderline leprosy cases showed impaired NCS, This accounts to 66.6%. Other forms of disease in Leprosy spectrum showed Abnormal NCS in a range between 66.6% to 92.3%.

In our present study out of 86 patients with NCS changes, 49 patients had Nerve thickening of nerves in the range of 1 -3, In these patients NCS showed changes in atleast one parameter of those thickened nerves. Clinically uninvolved nerves showed Normal Conduction velocities, Normal Latency and Normal Amplitude. 26 out of 86 (30.23%) patients had abnormal NCS showed changes both in Clinically thickened and at least one normal Nerve. 11 out of 86 (12.79%) patients had no Clinical nerve thickening (neuritis), But showed NCS impairment in atleast one parameter and atleast a single nerve. put together this accounts to 30.2 + 12.7 = 42.9 %. Which implies in nearly half (42.9 %) of the Patients, NCS showed abnormal. Patterns even before the Clinical neuritis has manifested to full extent. Similar findings were reported by Ghiglione et al.[14] in a series of 282 nerves having electrophysiological abnormalities, found 123 nerves (43.6%) to be clinically asymptomatic. Slowing of MNCV has been observed in patients without any clinical abnormality. Sajid and Malaviya,[15] found that even though clinically normal, 16% among ulnar and 20% among median nerves were electrically abnormal in leprosy. This can be explained by Reduced conduction velocities in clinically normal nerves probably represent the preclinical stage (without symptoms and signs) of damage which becomes manifest when certain defined quantum of nerve fibers becomes non-functional. This indicates that nerve thickening alone is not a reliable parameter in assessing nerve involvement in leprosy. Along with Clinical nerve assesement Nerve conduction studies should also be considered in Leprosy patients for early detection of Nerve function impairment whenever feasible.

Limitations and Recommendations: Patients included in the present study were only those who attended the Outpatient department of Dermatology, Venerology, Leprology of Medicity institute of medical sciences. Hence this study gives limited information of the epidemiology of disease. Nerve Conduction study of radial nerve and radial cutaneous nerves was not assesed due to technical limitations. Inclusion criteria was limited to patients with leprosy of age group 16 years and above, Hence the NCS patterns in children with leprosy were not assesed due to procedure related discomfort. The duration of the disease is only one and half year. So further studies are required to know the disease status better which helps in planning for Preventive measures, Early diagnosis and management

CONCLUSION

Nerve conduction studies help in demonstrating and detecting the integrity of nerve function in leprosy. Sensory-motor axonal and demyelinating (= Mixed) type is the commonest pattern of peripheral neuropathy in leprosy based on the present study. NCS as a modality is quite sensitive and subclinical changes can be picked up early even in clinically

ISSN (O): 2687-5365; ISSN (P): 2753-6556

uninvolved nerves. Out of the three components in NCS (Velocity, Amplitude and Latency), Amplitude can be considered as one of the important indicators of abnormal nerve conduction. Nerve conduction studies are reliable diagnostic and prognostic indicators useful in leprosy especially in areas that are endemic for the disease like our country. All the clinical tests i.e. monofilament testing, nerve palpation and voluntary muscle testing assessment have higher specificity, they have very low sensitivity for assessing peripheral nerve damage in leprosy. So along with clinical tests, nerve conduction studies should also be considered in leprosy patients for the early detection of nerve function impairment whenever feasible. Employing NCS, which when done and interpreted promptly can aid in assessement, Diagnosis and further timely Management of clinical and subclinical neuropathy in Hansens patients.

REFERENCES

1. Jopling WH, Mc Dougall AC. Definition, Epidemiology and World Distribution. In: Handbook of leprosy, CBSPublishers; 2000; 5: 1–9.
2. Husain S, Malaviya GN. Early nerve damage in leprosy: An electrophysiological study of ulnar and median nerves in patients with and without clinical neural deficits. Neurol India 2007;55:22-6.
3. Scollard DM, Adams LB, Gillis TP, Krahenbuhl JL, Truman RW, Williams DL. The continuing challenges of leprosy. Clin Microbiol Rev 2006;19:338-81.
4. Einar PW, Van Brakel WH. Nerve damage in leprosy. Nature Clin Pract Neurol, 2008; 4: 656–663.
5. Capadia GD, Shetty VP, Khambati FA et al. Effect of corticosteroid usage combined with multidrug therapy on nerve damage assessed using nerve conduction studies: a prospective cohort study of 365 untrated multibacillary leprosy patients. J Clin Neurophysiol, 2010; 27: 38–47.
6. van Brakel WH, Khawas IB. Nerve damage in leprosy: an epidemiological studyof 396 patients in West Nepal, part 1: definitions, methods and frequencies. Lepr Rev, 1994; 65: 204–221.
7. Brown TR, Kovindha A, Wathanadilokkol U et al. Leprosy neuropathy: correlation of clinical and electrophysiological tests. Indian J Lepr, 1996; 68: 1–14.
8. Ramadan W, Mourad B, Fadel W, Ghoraba E. Clinical, electrophysiological and immunopathological study of peripheral nerves in Hansen's disease. Lepr Rev, 2001; 72: 35–49.
9. Chaurasia RN, Garg RK, Singh MK, et al. Nerve conduction studies in paucibacillary and multibacillary leprosy: a comparative evaluation. Indian J Lepr. 2011;83(1):15-22.
10. S. Marahatta et al, Nerve conduction study in leprosy: a hearty need or a customary practice, Lepr Rev (2016) 87, 201–210.
11. Van Brakel WH, Nicholls PG, Das L et al. The INFIR Cohort Study: investigating prediction, detection and pathogenesis of neuropathy and reactions in leprosy. Methods and baseline results of a cohort of multibacillary leprosy patients in north India. Lepr Rev, 2005; 76: 14–34.
12. Khambati FA, Shetty VP, Ghate SD, Capadia GD. Sensitivity and specificity of nerve palpation, monofilament testing and voluntary muscle testing in detecting peripheral nerve abnormality, using nerve conduction studies as gold standard; A study in 357 patients. Lepr Rev, 2009; 80: 34–50.
13. Antia NH, Mehta L, Shetty V Et al. Clinical, electro-physiological, quantitative histologic and ultra-structural studies of the index branch of the radial nerve in leprosy. Preliminary Report. Int J Lepr, 1975; 43: 106–113.
14. Ghiglione E, Beronio A, Reni L, et al. Leprous neuropathy: a clinical and neurophysiological study. J Peripher Nerv Syst. 2004;9:120-1.
15. Husain S, Malaviya GN. Early nerve damage in leprosy: an electrophysiological study of ulnar and median nerves in patients with and without clinical neural deficits. Neurol India. 2007;55(1):22-6.

ISSN (O): 2687-5365; ISSN (P): 2753-6556