Original Article

Assessment of Thoracolumbar Spinal Injury with Nerve Conduction Study: Correlation with Neurological Deficit and Recovery Assessed by ASIA Score

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ABSTRACT

Introduction: The present study aimed to investigate the association between findings of nerve conduction study of lower limb in acute thoracolumbar spinal cord injury (SCI) and its correlation with neurological deficit and subsequent recovery as assessed by American Spinal Injury Association (ASIA) score.

Methodology: A hospital based longitudinal study was conducted at a government tertiary care teaching hospital Jaipur, India. Sixty patients with acute thoracolumbar SCI presenting within 15 days of injury were clinically evaluated for level, extent, and severity according to ASIA impairment scale. Nerve conduction studies (NCS) of bilateral tibial, peroneal, and sural nerve were conducted at baseline and on follow up after 3 months ASIA score and NCS was repeated.

Results: There was a statistically significant improvement in ASIA motor and ASIA total score in all study subjects and better conversion of ASIA scale on follow up. Also, there was a statistically significant difference between mean amplitude and conduction velocity of bilateral tibial, peroneal, and left sural nerve of study population at baseline and at 3 month follow up and for right sural nerve changes in mean amplitude was significant. There was a statistically significant negative Kappa agreement for ASIA score and right tibial nerve compound motor action potential (CMAP) and bilateral peroneal nerve CMAP among D1-L1 patients and positive kappa agreement of bilateral sural nerve sensory nerve action potential (SNAP) for all patients.

Conclusions: ASIA score with NCS of peripheral nerve can help to assess and predict neurological recovery in acute SCI and can contribute to selection of appropriate treatment and rehabilitation program on follow up.

Keywords: Nerve conduction, Neurological deficit, Spinal cord.

INTRODUCTION

Acute spinal cord injury (SCI) as a result of trauma is a common scenario seen in any health care setting. The clinical manifestation of SCI can range from minor neurological loss to partial or total paralysis with or without bowel or bladder incontinence, depending on the severity and level of SCI. It alters the previous lifestyle of the person, causing a high social and economic impact, both in the short and long term, on a young person during their productive age.[1,2,3]

The fact that central nervous system function cannot fully recover after such catastrophic damage is a key concern with SCI. Clinicians and researchers have been striving to uncover several potential techniques to improve neuronal function based on the pathophysiology of SCI.[4]

ASIA impairment scale is a standardized test that consists of a myotomal based motor examination, a dermatomal-based sensory examination, and an anorectal examination. These test results are used to determine the extent and severity of the injury. Clinical assessment predicts the level, severity, and numerous neurological components which are supported by investigations such as X-ray, computed tomography, and magnetic resonance imaging.[5,6]

Nerve conduction study (NCS) is a test for examining how signals move across a nerve and reveals the health of the best remaining nerve fibres. NCS is the most accurate diagnostic method for evaluating lesions of peripheral motor nerves which originate from the anterior horn cells in conus medullaris and the peripheral motor nerve fibres of cauda equina. This tool can proficiently identify the different neurological conditions and also establish more objective metrics which improves compliance in individuals who are unwilling to cooperate.[6,7] It is used to augment clinical and radiological evaluations and distinguish between spinal (ascending and descending fibre tract) and peripheral nervous system abnormalities (e.g., radicular lesions, plexus, peripheral nerves).[6] NCS is made up of three components: nerve conduction velocity (NCV), compound muscle action potential (CMAP), and sensory nerve action potential (SNAP).[8]

As the number of SCI patients grow, there is a greater need to investigate diagnostic techniques that can predict the neurological outcome.[9] This study aimed to determine the relationship between the findings of a nerve conduction study of the lower limb in patients with acute thora-columbar spinal cord injury, as well as their correlation with neurological deficit and subsequent recovery as measured by the ASIA score. The information gathered from these will aid in counselling worried families, forecasting the duration of stay, hospital spending, and tailoring rehabilitation.[10,11]

METHODS

The study was conducted on clinically and radiologically diagnosed acute thora-columbar SCI cases between the age group of 18-60 years in the IPD of Physical Medicine and Rehabilitation department of a government tertiary care teaching hospital. Written and informed consent were taken between November 2021 to September 2022. Persons with history of any other comorbid medical or surgical conditions causing direct effect on spinal cord or peripheral nerves, neuromusculo-skeletal disorders e.g.- chronic cervical myelopathy, cerebral palsy, sensory motor neuropathy and peripheral nerve lesions, history of head injury or spinal cord injury other than thoracolumbar spine, congenital spine mal-formations, non-cooperative patients or cognitive impaired patients, previously implanted metallic devices, pace-maker, and pregnant patients were excluded. The present study was approved by ethics committee with reference number 986/MC/EC/2021 dated 30/10/21 and is in accordance with the declaration of Helsinki.

This was a hospital based longitudinal study. All the individuals were explained about the nature and purpose of the study, a written informed consent was obtained, and all required demographic data was recorded.

Sample size was calculated at 80% study power and alpha error of 0.05 assuming mean difference of 0.39 mv in amplitude at the time of injury and at 3 month follow up, 52 patients were required as sample size which was further enhanced and rounded off to 60 patients as final sample size for present study expecting 10 percent dropout/ loss of follow up/ attrition.

A detailed history was obtained from the individuals followed by complete neurological examination and radiological evaluation for the level, extent, and severity of SCI according to the ASIA standards. NCS of bilateral two motor (tibial and peroneal) and one sensory (sural) nerve was conducted and at 3 months, neurological recovery was documented as per ASIA impairment scale and NCS was repeated and parameters were assessed.

NCS was performed with the subject lying comfortably in supine position using machine model- SALUS/1603003/ ADB Recorder and Medicare System Private Limited. Room temperature was maintained between 21-23ºC. A standardized technique was used to obtain and record action potential of the motor and sensory nerve. Compound muscle action potential, sensory nerve action potential and from this motor nerve conduction velocity and sensory nerve conduction velocity were calculated.[12]

Bilateral peroneal nerve and the tibial nerve were used to analyze motor nerve conduction and bilateral sural nerve was used to analyze sensory nerve conduction. CMAP and SNAP onset latencies were measured at the initial point of the negative phase of the potential. The CMAP amplitude was measured from baseline to the negative peak and the SNAP amplitude was measured from the first negative peak to the following positive peak. The settings for the recordings of the motor studies were as follows: sensitivity, 35 mV/division; low-frequency filter, 10 Hz; high-frequency filter, 10 kHz; and sweep speed, 5 ms/division. The settings for the recordings of the sensory study were as follows: sensitivity, 20 mV/division; low-frequency filter, 10 Hz; high-frequency filter, 2 kHz; and sweep speed, 2 ms/division.[13]

Data was entered into Microsoft Excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of frequencies and proportions. Chi-square test was used as a test of significance for qualitative data. Continuous data was represented as mean and standard deviation. Independent t test was used as a test of significance to identify the mean difference between two quantitative variables.[14] Paired t test or Friedman test was the test of significance for paired data. Agreement between two or more observers/methods or instruments and equipment was assessed by using Kappa statistics and a p value of <0.05 was considered as statistically significant.[15]

RESULTS

Out of 60 study subjects, 52% of the patients were between 51-60 years age group with mean age 46.22±14.42 years. 38 were males and 22 were females. Sixty percent of the people belonged to the lower middle class. Most common mode of spinal injury was fall from height (52%) (Table 1).

Dorsal spine injuries were observed in 67% of patients. Among these, the most common level was D6-D10 (33%). 52% subjects were neurologically incomplete (ASIA B to D), 38% were neurologically complete (ASIA A), and remaining 10% subjects were intact (ASIA E) (Table 2).

The mean ASIA motor score and ASIA total score among the study population with D1 to L5 level of vertebral injury showing significant improvement with statistical difference is depicted in the figure.

Table 2 depicts there was statistically significant improvement in ASIA motor and ASIA total score in all study

Table 1: Distribution of study population according to age, sex, socio-economic status, and mode of injury

	No. of patients (n)	Percentage (%)
Age distribution of patients in study population		
≤20 years	5	8.33%
21-30 years	8	13.33%
31-40 years	4	6.67%
41-50 years	12	20%
51-60 years	31	51.67%
Grand Total	60	100%
Gender distribution		
Gender		
Female	22	36.67%
Male	38	63.33%
Grand Total	60	100%
Socioeconomic status		
Socioeconomic status		
Lower middle class	36	60%
Middle class	19	31.67%
Upper middle class	5	8.33%
Grand Total	60	100%
Mode of spinal injury		
Mode of injury		
Fall of heavy objects on back	8	13.33%
Fall from height	31	51.66%
Road traffic accident	14	23.33%
Others	7	11.66%
Grand Total	60	100%

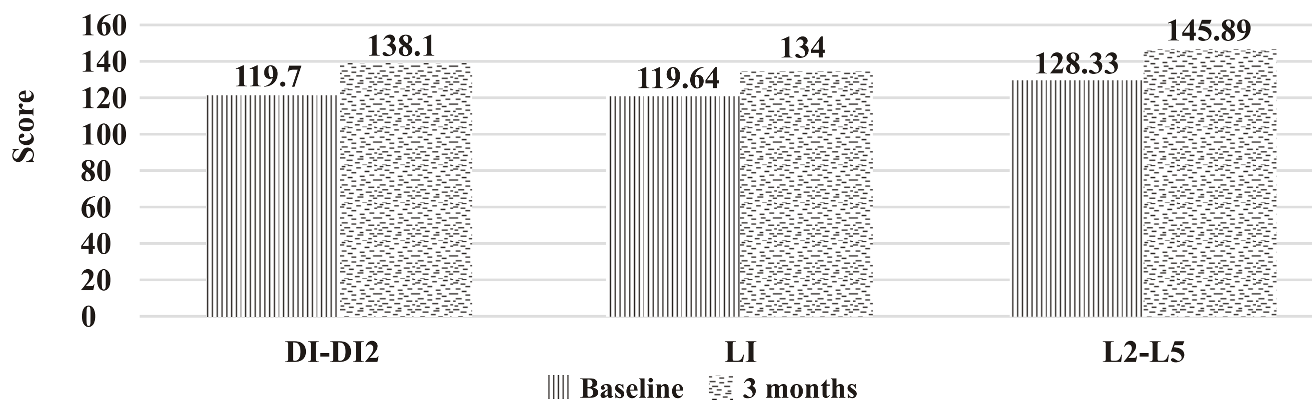

Figure: Change in ASIA total score with respect to vertebral level spinal cord injury in study population.

Table 2: Changes in the ASIA scale in study population on follow up

ASIA impairment scale	Baseline (No. of patients)		3 months (No. of patients)		p value (Fisher's exact test)
A	23	38.33%	17	28.33%	0.02*
B	12	20.00%	10	16.66%	
C	9	15.00%	14	23.33%	
D	10	16.66%	11	18.33%	
E	6	10.00%	8	13.33%	

* Statistically significant

Table 3: Change of mean values of tibial, peroneal and sural nerve's amplitude and conduction velocity over the period of follow-up

		Timeline Baseline Mean	Baseline SD	3 months Mean	3 months SD	Mean Difference	p value #
Amplitude (mV)							
Tibial Nerve	Right	7.21	2.37	7.97	2.36	0.76	<0.001*
	Left	7.30	2.41	7.90	2.36	0.6	<0.001*
Peroneal Nerve	Right	2.79	0.56	3.39	0.56	0.6	<0.001*
	Left	2.90	0.58	3.54	0.54	0.64	<0.001*
Sural Nerve	Right	12.32	11.73	16.66	10.42	4.34	<0.001*
	Left	12.31	10.78	16.50	10.24	4.19	<0.001*
Conduction velocity (m/s)							
Tibial Nerve	Right	41.95	9.57	46.54	3.61	4.59	<0.001*
	Left	42.03	8.11	47.83	3.88	5.8	<0.001*
Peroneal Nerve	Right	47.92	4.36	49.36	3.88	1.44	<0.001*
	Left	46.39	4.28	49.12	5.26	2.73	<0.001*
Sural Nerve	Right	54.11	5.74	55.60	9.91	1.49	0.055
	Left	53.33	6.56	56.94	9.25	3.61	0.013*

*# Paired t-test, * Statistically significant*

subjects and better conversion of ASIA scale on follow up.

Table 3 depicts that on comparison of mean values of amplitude and conduction velocities of bilateral tibial, peroneal, and left sural nerve of study population over the period of 3 months there was a statistically significant difference both in terms of amplitude and conduction velocity. For right sural nerve, changes in mean amplitude were significant while change in mean conduction velocity was not significant (p value = 0.055) over the period of 3 months.

Table 4 depicts that there was negative agreement in assessing the neurological recovery status between ASIA score and CMAP of bilateral tibial nerves in all study subjects while statistically significant relation only with respect to right tibial nerve among the subjects with D1 to L1 injury, where fairer agreement was evident.

There was positive agreement in assessing the neurological recovery status between ASIA score and CMAP of peroneal nerve in all study subjects with D1 to L1 vertebral level of injury, remaining subjects showed negative agreement with no statistical significance. There was a statistically significant positive agreement in assessing the neurological recovery status between ASIA score and SNAP of bilateral sural nerves.

Table 5 depicts a positive agreement in assessing the neurological recovery status between the ASIA scores and NCV of tibial and sural nerve, except with respect to left tibial nerve among D1-D12 SCI patients. Overall, the study found no significant relation in these aspects. There was negative agreement in assessing the neurological recovery status between the ASIA scores and NCV of bilateral peroneal nerves with statistical significance only with respect to bilateral peroneal nerves among the subjects with D1-D12 injury, where fairer to moderate agreement was evident.

DISCUSSION

The rehabilitation goal is towards achievement of a higher

Table 4: Agreement in neurological recovery according to ASIA score and CMAP of tibial and peroneal nerve and SNAP of sural nerve at 3 months

	Vertebral level	Kappa agreement	p value
Tibial nerve (CMAP)			
Right	D1-D12	-0.368	0.028*
	L1	-0.311	0.026*
	L2-L5	-0.250	0.285
Left	D1-D12	-0.036	0.826
	L1	-0.211	0.344
	L2-L5	-0.250	0.285
Peroneal nerve (CMAP)			
Right	D1-D12	0.026	0.873
	L1	0.248	0.455
	L2-L5	-0.250	0.285
Left	D1-D12	-0.029	0.858
	L1	0.219	0.373
	L2-L5	-0.250	0.285
Sural nerve (SNAP)			
Right	D1-D12	0.375	0.018*
	L1	0.667	0.019*
	L2-L5	0.727	0.023*
Left	D1-D12	0.468	0.003*
	L1	0.680	0.024*
	L2-L5	0.727	0.023*

** Statistically significant*

Table 5: Agreement in neurological recovery according to ASIA scale and nerve conduction velocity of tibial, peroneal, and sural nerve findings at 3 months

	Vertebral level	Kappa agreement	p value
Tibial nerve (NCV)			
Right	D1-D12	0.047	0.388
	L1	0.117	0.378
	L2-L5	0.158	0.408
Left	D1-D12	-0.018	0.811
	L1	0.257	0.478
	L2-L5	0.158	0.408
Peroneal nerve (NCV)			
Right	D1-D12	-0.359	0.024*
	L1	-0.363	0.223
	L2-L5	-0.231	0.408
Left	D1-D12	-0.423	0.011*
	L1	-0.337	0.127
	L2-L5	-0.250	0.285
Sural nerve (NCV)			
Right	D1-D12	0.020	0.897
	L1	0.045	0.878
	L2-L5	0.053	0.858
Left	D1-D12	0.078	0601
	L1	0.378	0.422
	L2-L5	0.357	0.284

** Statistically significant*

possible neurological and functional recovery, to the treatment of concurrent spinal cord injury, and the prevention of long term complications along with instructions to patient and care givers for care after discharge and preparation of suitable home environment and promotion of social reintegration.[16] This study was conducted to investigate the association between findings of NCS lower limb in acute thoraco-lumbar SCI and its correlation with neurological deficit and subsequent recovery assessment by ASIA score.

In this study, the majority of the participants belonged to the age group of 51 to 60 years (52%), with mean age of 46.22 ± 14.42 years and male to female ratio of 1.72:1. Nirmala et al[3] and Karacan I et al[16] conducted a study on clinical and socio demographic profile in spinal cord injury which reported a similar male to female gender ratio of 1.5: 1.

In this study, a major number of cases were male (63%), as in India male population are engaged in various high-risk occupations compared to females and females are less exposed as they are mostly engaged in household works. In the current study, a major group of subjects belonged to the lower middle class (60%) as per Kuppuswamy scale of socio-economic status, which is similar to study done by Nirmala et al.[3] Because of illiteracy and lesser resources of income as per WHO, this population is probably less aware or uneducated about safety measurements and precautions that should be followed during transportation, moving to workplaces, and while working hence having higher incidence for trauma and fall from height. Similar to the studies of Mathur et al[17] and Kumar Satyendra et al[18] reporting that the major cause for the SCI is occupational hazards like fall from heights (53% to79%) and road traffic accidents (17% to 26%), our results also report that the most common mode of injury was fall from height (52%) followed by RTA and others.

In the current study, the impairment among the subjects was assessed by American Spinal Cord Injury Association (ASIA) scale and most of the study subjects were in ASIA grade A (38%) at baseline, followed by grade B subsequently. After 3 months of trauma, study subjects in ASIA grade A and B decreased and ASIA B, C, and D cases increased, this conversion showed statistically significant improvement in the neurological condition of the patients. Khorasanizadeh et al[19] reported that neurological recovery was significantly different between all grades of SCI severity in the following order: C > B > D > A. After rehabilitation, 21% patients improved from ASIA/B to ASIA C (greater recovery), while the rest remained at ASIA/B (lesser recovery). Kirshblum et al[20] and Allison et al[21] also found significant improvement in ASIA scale over the period of follow up in SCI.

We assessed lower limbs ASIA score including motor, sensory (light touch and pin prick), and ASIA total score. Further analysis of the study showed mean ASIA motor score and total ASIA score improvement among the study population with D1 to L5 level of vertebral injury, which was found to be statistically significant. Curt et al[6] and Van Middendorp et al[22] also reported that ASIA score was improved significantly on 6 months follow up.

There was a statistically significant difference between the mean values of tibial, peroneal, and left sural nerves over a period of 3 months both in terms of amplitude and conduction velocity. For right sural nerve, changes in mean amplitude were significant while change in mean conduction velocity was not significant (p value 0.055) over the period of 3 months. A study on thirty-five SCI patients reported that increment in mean conduction velocity and mean amplitude of bilateral peroneal and sural nerve was statistically significant[1]. For bilateral tibial nerve increment was seen in mean conduction velocity with follow up but was non-significant while mean amp-litude increment for bilateral tibial, nerve, was statistically significant. Statistically significant differences between the groups (study subjects versus normative data) for sural amplitude, peroneal CMAP, peroneal NCV, tibial CMAP, and tibial NCV ($p<0.0001$) have been reported.[20] Allison et al[21] observed an insignificant recovery in CMAP levels after 3 months of SCI despite an appreciable clinical recovery.

In the present study, analysis of Kappa agreement of ASIA scores at three months with CMAP for both tibial and peroneal nerve, SNAP of sural nerve, and NCV for all three nerves was done. There was statistically significant negative Kappa agreement for right tibial nerve CMAP and NCV of bilateral peroneal nerve among D1-L1 patients and positive agreement of bilateral sural nerve SNAP for all patients. Singh et al[1] found statistically significant Kappa agreement between ASIA scores and NCV of the right tibial nerve. Extensive literature review did not reveal any other study reporting agreement between ASIA score and NCS parameters.

CONCLUSION

This study concluded that ASIA score with NCS of peripheral nerves can help to assess and predict neurological recovery in acute SCI and can contribute to selection of appropriate treatment and rehabilitation programs on follow up.

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