Original Article

Ambulation following spinal cord injury and its correlates

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Abstract

Objectives: To assess walking ability of spinal cord injury (SCI) patients and observe its correlation with functional and neurological outcomes. **Patients and Methods:** The present prospective, observational study was conducted in a tertiary research hospital in India with 66 patients (46 males) between January 2012 and December 2013. Mean age was 32.62 ± 11.85 years (range 16-65 years), mean duration of injury was 85.3 ± 97.6 days (range 14-365 days) and mean length of stay in the rehabilitation unit was 38.08 ± 21.66 days (range 14-97 days) in the study. Walking Index for spinal cord injury (WISCI II) was used to assess ambulation of the SCI patients. Functional recovery was assessed using Barthel Index (BI) and Spinal Cord Independence Measures (SCIM). Neurological recovery was assessed using ASIA impairment scale (AIS). We tried to correlate ambulatory ability of the patients with functional and neurological recovery. **Results:** Ambulatory ability of the patients improved significantly using WISCI II ($P < 0.001$) when admission and discharge scores were compared (1.4 ± 3.5 vs 7.6 ± 6.03). Similarly, functional (BI: 31.7 ± 20.5 vs 58.4 ± 23.7 and SCIM: 29.9 ± 15.1 vs 56.2 ± 20.6) and neurological recovery were found to be very significant ($P < 0.001$) when admission vs discharge scores were compared. Improvement in WISCI II scores was significantly correlated with improvement in neurological (using AIS scores) and functional status (using BI and SCIM scores) ($P < 0.001$). **Conclusions:** Significant improvement was seen in WISCI II, BI, and SCIM scores after in-patient rehabilitation. Improvement in WISCI II scores also significantly correlated with functional and neurological recovery.

Key Words

Ambulation, functional and neurological recovery, spinal cord injury

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Introduction

Spinal cord injuries (SCI) are a devastating group of afflictions of the spinal cord which may be traumatic or otherwise in nature. Limiting the personal mobility of an affected individual is one among its many serious consequences. As a result, retraining the affected individual to attain some form of ambulation is an important part of the rehabilitation program of these patients and is a felt need of the affected individual.

The main determinants of normal gait are:

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1. balance and posture,
2. Range of motion,
3. Muscle strength,
4. Co-ordinated motor control,
5. Muscle tone,
6. Proprioception,
7. Vision,
8. Cognition, and
9. aerobic capacity out of which the first six factors are impaired in spinal cord injured individuals.[1]

Depending on the nature of the spinal cord insult and recovery from the same, an individual may be non-ambulatory, wheel-chair ambulatory, therapeutic ambulatory, or community ambulatory. Functional ambulation may be defined as "the ability to walk, with or without the aid of appropriate assistive devices (such as prostheses, orthoses, canes, or walkers), safely and sufficiently to carry out mobility-related activities of daily living."[2]

Various outcome measures are used to quantify ambulation during rehabilitation of SCI. Some of them include Walking

Index for Spinal Cord Injury II (WISCI II), 50-Foot Walk Test (50FTWT), 6-Minute Walk Test (6MWT), 10-Meter Walk Test (10MWT), and Functional Independence Measure-Locomotor (FIM-L).[3]

WISCI II is a 21-level hierarchical scale where the levels are scored from 0 (patient is unable to walk) to 20 (patient can walk without braces and/or devices and without physical assistance for at least 10 meters). It is considered as a reliable measure of walking ability in spinal cord injured patients.[4] It is more sensitive than 6-minutes or 10-meter walk test in this group of patients.[5] It is well-validated and more sensitive to walking recovery as compared to other scales.[6,7] The WISCI II has high inter-rater and intrarater reliability and good reproducibility in the acute and subacute phase of spinal cord injury.[8] It has a unique characteristic as a "capacity measure of walking function" of spinal cord injury patients.[9] The objective of the present prospective study was to observe the ambulatory capacity of SCI patients at admission in rehabilitation unit and improvement in ambulation with rehabilitation. We also wanted to observe its correlation with functional and neurological recovery as well as length of stay (LOS) in rehabilitation unit.

Patients and Methods

The study included patients with SCI (both traumatic and non-traumatic) admitted in neurological rehabilitation department between January 2012 and December 2013 in a tertiary university research hospital in India. Approval for the study was taken from the institute's ethics committee. SCI subjects aged between 15 and 65 years with duration of spinal cord insult between 2 weeks and 1 year admitted for in-patient rehabilitation were included in the study. Patients with confirmed spinal cord lesion (who had undergone computed tomography (CT) or magnetic resonance imaging (MRI) scan imaging) of traumatic and non-traumatic origin with monophasic insult and medically fit to participate in rehabilitation program were included in the study. Patients, whose admission and discharge ambulatory ability was recorded using WISCI II scale, were included in the study. Patients with multiple sclerosis, patients with cardio-vascular or pulmonary illness or other medical conditions like unstable vertebral injuries were excluded. Demographic data, detailed neurological examination, functional status, ASIA impairment scale (AIS) scores, and WISCI II scores were recorded at admission and discharge and compared.

Patients were enrolled for standard rehabilitation programs. Gait training was imparted trained therapists. Preparatory phase would involve improving trunk and pelvic balance and strengthening upper limbs and training in technique of donning and doffing appropriate orthosis. Following this, the individual was trained in the parallel bars in sit to stand technique, walking using support of bars and turning technique. After accomplishing reasonable control in the parallel bars, over-ground training with walker, axillary/elbow crutches was provided first using 4-point and then 2-point technique, depending upon level/severity of injury and skills attained by the patients. If neurological status would improve, then trial of reducing or eliminating orthosis would be given and patient made to ambulate accordingly. Once patient deemed to have achieved a safe and efficient gait for his/her neurological level, he/she would be deemed fit for discharge from rehabilitation unit.

Statistical Analysis

Data was managed and analysed using statistical package of social sciences (SPSS) 15 software. For comparison of Barthel Index (BI) and Spinal Cord Independence Measures (SCIM) at admission and discharge, paired t-test was used. For finding correlation between WISCI II and functional improvement, length of stay and duration of injury, Spearman's rho was used. For comparison between AIS scores at admission and discharge, McNemar-Bowker test was used and for comparing AIS improvement and WISCI II, Mann-Whitney test was used. Statistical significance was considered at P value < 0.05.

Results

Forty-six out of 66 SCI patients (69.7%) were male. Mean age was 32.62 ± 11.85 years, (range 16-65 years) mean duration of neurological insult was 85.3 ± 97.6 days (range 14-365 days) and mean LOS in rehabilitation was 38.08 ± 21.66 days (range14-97 days). Thirty-one patients (47%) had traumatic etiology, 11 patients (25.5%) had transverse (long segment) myelitis, 10 had primary spinal tumors (16.6%), 7 had prolapsed intervertebral disc lesion (10.6%), 2 had degenerative spinal disease-ossified posterior longitudinal ligament (3%), 4 had tuberculosis of the spine (6%), and 1 patient had spinal vascular disease (1.5%).

Out of total 66 patients, 13 had cervical level injury, (19.7%), 31 (47%) dorsal level injury, and 22 patients (33.3%) had lumbosacral level of injury [Tables 1-3].

Table 1: Functional outcomes

Parameters	At admission	At discharge	*P*-value
Barthel index (n = 65)	31.7±20.5	58.4±23.7	<0.001
Spinal cord independence measure (n = 56)	29.9±15.1	56.2±20.6	<0.001
Walking index for spinal cord Injury (n = 65)	1.4±3.5	7.6±6.03	<0.001

Table 2: ASIA impairment scale (AIS) scores at admission and discharge

		AIS at discharge				
		A	B	C	D	Total
AIS at admission	A	22	2	1	1	26
	B	0	6	1	4	11
	C	0	0	15	9	24
	D	0	0	0	5	5
	Total	22	8	17	19	66

There was significant difference between the AIS scores at admission and discharge (P = 0.006).

Table 3: Results of the WISCI II data thatcorrelated with demographic data, functional and neurological improvement

Parameters	WISCI II (at admission)	Change in WISCI II scores at admission and discharge
Age	r=−0.185	r=−0.044
	P=0.136	*P*=0.729
Length of stay in rehabilitation	r=−0.252	r=0.033
	P=0.041	*P*=0.796
Duration of injury	r=0.135	r=−0.322
	P=0.279	*P*=0.009
Change in BI scores	r=−0.095	r=0.633
	P=0.451	*P* < 0.001
Change in SCIM scores	r=−0.121	r=0.607
	P=0.374	*P*<0.001
Improvement in AIS status	z=−0.536	z=−4.064
	P=0.592	*P*=< 0.001

r = Spearman's rho, z = Mann-Whitney U Test co-efficient, WISCI II = Walking index for Spinal Cord Injury, BI = Barthel Index, SCIM = Spinal Cord Independence Measure, AIS = ASIA impairment scale, Results of the analysis show that patients who stay longer for in-patient rehabilitation tend to have lower initial WISCI II scores and patients with lesser duration of injury tend to have better outcomes as regards to ambulation at discharge. Improvement in ambulation is correlated with improvement in functional status and neurological improvement, When WISCI II outcomes were compared between traumatic and non-traumatic groups, no significant difference was observed ($P > 0.05$).

Discussion

Gait training in SCI patients may be conventional over-ground training, body-weight supported training, or robot-assisted gait training. Central pattern generators are neural circuits that can produce rhythmic patterns of activity without receiving rhythmic inputs and for which feedback from proprioceptive receptors is not needed. The brain sends signals to the central pattern generator in the lumbar spinal cord to trigger and modulate the complex, rhythmical pattern of muscle activation in the lower limbs that make walking possible.[10] Training of this circuit in spinal cord injured patients is responsible for improvement in ambulatory function. Locomotor training depends on therapies to generate activity-dependent plasticity so as to activate the neuromuscular system below the lesion by providing sensory input to stimulate remaining spinal cord networks even when supra-spinal input is compromised.[11]

Various approaches for gait training in SCI patients show potential for improvement but no one approach has been shown to be superior.[12] Pharmacological agents have limited role to play in facilitating recovery of walking after SCI.[13] Functional electrical stimulation and robotic gait training has been shown to be of benefit in improving mobility scores in some patients with chronic SCI.[14,15]

Approximately, one-quarter to one-third of patients with SCI and about half of all non-traumatic SCI in rehabilitation regain some ability to walk.[16,17] If we consider a WISCI II score of 12 as an independent ambulator, (ambulates with two crutches, with braces and no physical assistance, 10 meters) in the present study, there were two patients who had already achieved that score at admission and 12 (18%) achieved that score by the time of discharge from the rehabilitation unit. Improvement in ambulation even after discharge from rehabilitation unit for up to 1 year has been reported.[18]

Criterion validity of the WISCI for examining people with SCI has been estimated by comparing it to the Barthel Index of Activities of Daily Living (r = 0.67) and the Spinal Cord Independence Measure (r = 0.97)[19] In our study, we found positive correlation between change in BI scores and change in SCIM and change in WISCI II scores at admission and discharge, which indicates that functional improvement was associated with acquisition of better ambulatory capacity with rehabilitation.

Dramatic recovery with extensity conventional locomotor training for up to 8 weeks has been reported in incomplete cervical level injury with WISCI II scores improving from 6 to 20.[19] In a study with 18 SCI patients, who were provided with 6-week Lokomat training (robot assisted training) significant change in the WISCI II scores were recorded, which means that functional walking ability improved with training.[20] A study with AIS D tetraplegic patients showed that WISCI II cut-off score of 17.5 indicated adequate community ambulation in this group of patients.[21]

When WISCI II scores and functional improvement was compared between traumatic and non-traumatic spinal cord injuries, it was found that there was no difference between the groups regarding functional or neurological improvement. This is in agreement with an earlier study done by Scivoletto *et al*., which showed that patients with traumatic or ischemic SCIs experience the same functional and neurologic outcomes.[22] Similar results were found when functional outcomes (BI, WISCI) were compared between neoplastic, inflammatory and traumatic myelopathies and generally between traumatic and non-traumatic myelopathies.[23-26]

In a large study of 273 patients with traumatic SCI when AIS conversion was compared with walking indices like timed up and go test and 10 meter walk test, it was found that AIS conversion was poorly correlated with the ability to walk.[27] In our study, patients who had AIS conversion tended to show significant improvement in the WISCI II scores. This could be due to the fact that we had a large number of non-traumatic myelopathies, younger age of patients, lesser tetraplegics. and a larger proportion of patients who were not AIS A at discharge. Studies have shown that some sparing of corticospinal tract is necessary for gain of locomotor function in spinal cord injury patients, which explains better WISCI II scores in higher AIS grade patients in our study.[28] Another study on 343 patients with traumatic SCI showed that higher AIS grade patients tend to walk at discharge and higher age is negatively correlated to walking.[29]

Conclusions

Patients show significant improvement in their ambulatory ability with in-patient rehabilitation, as measured by specific ambulatory scales like WISCI II. This improvement in ambulatory ability is significantly correlated with functional and neurological recovery in SCI patients.

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