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Motor recovery following spinal cord injury associated with cervical spondylosis: a collaborative study

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A prospective multicenter study was conducted within the National Model Spinal Cord Injury System program to examine neurological deficits and recovery patterns following spinal cord injury (SCI) in individuals with cervical spondylosis and without a spinal fracture. Nineteen patients were evaluated. Sixty-eight percent presented intially with motor incomplete lesions. Of those who presented with motor incomplete injuries at their initial examination, 69 percent had less deficit in the lower than in the upper extremities, indicative of a central cord syndrome. At follow-up, 12 subjects were unable to ambulate, four required assistance and three were able to ambulate independently. On the average, subjects doubled their initial Asia Motor Score (AMS) scores by one year following injury. Residual upper extremity weakness, however, limited the ability to ambulate. Recovery of motor strength in this group is comparable to that of individuals with incomplete tetraplegia in general but the proportion who regain ambulatory function is less.

Keywords: motor recovery; cervical spondylosis; tetraplegia

Introduction

Spinal cord injury (SCI) is one of the most devastating injuries an individual can sustain. Although the majority of individuals who sustain such an injury are relatively young males injured due to high impact trauma or violence, there is a proportion of the SCI population who do not fit this pattern.[1] These are individuals with SCI associated with cervical spondylosis without evidence of a spinal fracture or dislocation. Typically these individuals are older and their injuries are commonly precipitated by relatively minor trauma.

The purpose of this report was to determine the characteristics of the neurological deficit and quantify motor recovery in individuals who sustained tetraplegia associated with cervical spondylosis. Since it is difficult for any one center to collect a sufficient number of patients for data analysis in a reasonable period of time, a collaborative investigation among the Regional Model Spinal Cord Injury Systems was undertaken.

Methods

Detailed motor examinations were performed prospectively according to the American Spinal Injury Association Standards for Neurological and Functional Classification of Spinal Cord Injury.[2] Examinations were performed at admission and approximately one year following injury. If patients did not return for an examintion one year following injury, the most recent examination was recorded as the follow-up.

The ASIA Motor Score uses a standard six point manual muscle testing system to assess strength in five key upper extremity muscles representing the five consecutive neural segments between C5 and T1, and in five key lower extremity muscles representing neural segments between L2 and S1. The total possible upper extremity motor score (UEMS) is 50 points, and the total lower extremity motor score (LEMS) is 50 points. Thus, an individual with no neurological deficit would have an ASIA Motor Score (AMS) of 100 points.

Recovery was determined by calculating the differences between the initial and the follow-up examination scores for the UEMS, LEMS and AMS. Another measure of recovery, percent recovery, was also determined. To determine the percent recovery, the initial AMS was subtracted from the total possible of 100 points. This number, representing the total possible recovery, is then divided into the actual number of points recovered and multiplied by 100 to express the percent recovery.

Bladder control status and ambulatory status were also assessed. Ambulation status was graded on a three point scale (1: non-walker, 2: assisted walker, 3: independent walker). Patients who were able to ambulate at least 150 feet without physical assistance from a helper were classified as 'independent'. Patients requiring physical assistance from a helper were classified as 'assisted'. Bladder control status was assessed as absent or present.

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Because data collection for this sample of patients commenced prior to ASIA's acceptance of the sacral sparing definition of completeness, and since no sensory examination was conducted, patients could only be classified according to motor completeness.[2,3] A motor complete injury was defined as one in which there was no preserved sacral motor function. A motor incomplete injury was one in which some sacral motor function was present.

Various analyses comparing group differences were done by analysis of variance.

Results

The locations of the six regional centers who participated in this study are shown in Table 1. There was a total of 19 patients (14 male, five female) who had spondylosis and sustained SCI without evidence of a spinal fracture or pre-existing myelopathy. Six sustained motor complete injuries while 13 were motor incomplete. The ages of subjects ranged from 31 to 85, while the average age of the sample was 52 years. The most common etiology of injury was a fall (11 patients), followed by motor vehicle accidents (six). One patient had been assaulted, and one had a motorcycle accident.

The initial examination was conducted an average of 19 days following injury, and the follow-up examination was performed an average of 364 days (S.D. = 153.5 days) following injury. Spinal surgery was performed an average of 66 days following injury in the six individuals who received surgical treatment.

Table 1 Locations of participating model spinal cord injury systems

Downey, California
San Jose, California
Atlanta, Georgia
New York, New York
Ann Arbor, Michigan
Chicago, Illinois

The average initial UEMS, LEMS, and total AMS for all individuals are shown in Table 2. Data for each case is shown in Table 3. There was an average increase in UEMS of 13.2 points at follow-up. Individuals with motor complete injuries recovered an average of 6.5 UEMS points while those with incomplete injuries recovered an average of 16.3 points ($P = 0.04$).

As expected, there was a significant difference in the lower extremity motor score (LEMS) between subjects with motor complete injuries and those with motor incomplete lesions. At the initial examination, all of the subjects with motor complete injuries had no lower extremity motor function while those with motor incomplete injuries had an average LEMS of 19.6 points ($P = 0.002$). At follow-up, LEMS had increased an average of 8.5 points for motor complete injuries and 14.6 for those with motor incomplete injuries. This difference, however, was not significant. There was, however, a significant difference in the absolute LEMS at follow-up. The average LEMS for individuals with complete injuries was 8.5 points while the average for the subjects with incomplete injuries was 34.2 points ($P = 0.001$).

There were significant differences between the two groups for both the initial and the follow-up total AMS scores. At the initial examination the subjects with motor complete injuries had an average AMS of 5.3 while those with motor incomplete injuries had an average AMS of 32.1 points ($P = 0.01$). At follow-up, those with motor complete injuries had an average AMS of 20.3 points while those with motor incomplete injuries had an average AMS of 63.0 ($P = 0.002$).

The percent recovery ranged from 0 to 95% with an average of 34.4% recovery. There was a significant correlation between the initial AMS and the percent recovery, with individuals with higher initial AMS demonstrating greater percent recovery ($r = 0.7553$, $P = 0.001$).

Table 2 Motor scores

	Motor comp	*Motor inc*	*All*	
UEMS:				
Initial	5.3±6.2	12.5±11.6	10.2±10.6	NS
Follow-up	11.8±8.8	28.8±13.3	23.4±14.3	$P = 0.01$
Recovery	6.5±5.3	16.3±10.4	13.2±10.1	$P = 0.04$
LEMS:				
Initial	0	19.6±13.1	13.4±14.2	$P = 0.002$
Follow-up	8.5±16.0	34.2±12.6	26.1±18.1	$P = 0.001$
Recovery	8.5±16.0	14.6±7.1	12.7±10.7	NS
AMS:				
Initial	5.3±6.2	32.1±21.8	23.6±22.1	$P = 0.,01$
Follow-up	20.3±19.8	63.0±25.5	49.5±31.0	$P = 0.002$
Recovery	15.0±20.3	30.9±12.6	25.9±16.7	$P = 0.05$

UEMS- upper extremity motor score; LEMS- lower extremity motor score; AMS- asia motor score

Table 3 The data for each patient

Case#	*DTE1*	*DTE2*	*UEMS1*	*UEMS2*	*LEMS1*	*LEMS2*	*AMB1*	*AMB2*	*BLAD1*	*BLAD2*	*%Recovery*
1	1	613	16	41	48	48	2	3	1	1	69
2	14	100	34	45	34	44	1	2	0	0	66
3	1	135	2	4	3	11	1	1	0	0	11
4	27	384	19	39	18	43	1	2	0	1	71
5	4	420	7	16	0	0	1	1	0	0	10
6	1	238	17	25	0	0	1	1	0	0	10
7	7	440	5	4	0	0	1	1	0	0	0
8	47	215	0	3	0	0	1	1	0	0	3
9	4	261	2	47	33	50	1	3	0	1	95
10	0	386	35	45	30	50	2	3	1	1	86
11	46	319	0	18	11	20	1	1	0	0	30
12	11	296	2	17	0	40	1	1	0	0	56
13	59	364	11	27	17	32	–	2	0	0	43
14	31	364	8	23	7	31	1	1	0	0	46
15	29	455	7	21	8	24	1	2	0	0	35
16	21	771	18	24	20	40	–	1	1	1	42
17	32	392	2	18	11	28	1	1	0	0	38
18	35	364	8	22	15	24	1	1	0	0	30
19	13	381	2	6	0	11	1	1	0	0	15

1: Initial exam, 2: follow-up exam; DTE- days to exam; UEMS- upper extremity motor score; LEMS- lower extremity motor score; AMB- ambulation status (1- unable, 2- assisted, 3- independent); BLAD-voluntary bladder function (0- absent, 1- present)

Of the six subjects who were motor complete at initial examination, four remained motor complete at follow-up. One individual progressed from having absent lower extremity function to a LEMS score of 40 at follow-up at 9 months. The other patient gained 11 LEMS points at follow-up.

Of the 13 patients with motor incomplete injuries at the initial examination, 9 (69 percent) demonstrated less deficit in the lower extremities compared to the upper extremities (ie, LEMS > UEMS). There were no differences in motor recovery between subjects who were treated non-operatively and those who received operative treatment.

Nine subjects had received methylprednisolone treatment as advocated by Bracken *et al.*[4] There were no significant differences in the initial, follow-up or change in UEMS, LEMS or AMS between those who had received methylprednisolone and those who had not.

No subject was able to ambulate independently at the initial examination. At follow-up, 12 were unable to ambulate, four required assistance with ambulation and three subjects were able to ambulate independently. Of the three subjects who were able to ambulate independently at follow-up, two had been assisted with ambulation initially and one had been unable to ambulate at the initial examination. No subject who was motor complete at the initial examination regained any ambulatory function. Since patients lacking lower extremity function are unable to ambulate, the four subjects who remained motor complete at follow-up were excluded from the analyses of upper and lower extremity motor scores in Table 4. There were significant differences in the average initial LEMS, follow-up LEMS, and follow-up UEMS of the 15 subjects with lower extremity function at follow-up based upon ambulation status at follow-up (Table 4). The average initial LEMS of those who were independent ambulators, assisted ambulators, or unable to ambulate were 37.0±9.6, 19.3±10.8 and 8.4±7.2 respectively ($P=0.001$). Individuals who were independent or were assisted with ambulation had higher average upper extremity motor scores at follow-up than those who were unable to ambulate (44.3±3.1, 33.0±11.0, 16.5±7.6 respectively, $P=0.0006$).

At the initial examination, only three of 19 subjects had volitional bladder function. At the follow-up examination five subjects had volitional bladder function. There was no deterioration of either ambulation status or bladder function in any of the patients.

Conclusions

Although the majority of SCIs occur in young males, there is a group of older individuals with SCI who present with a characteristically different clinical

Table 4 Follow-up ambulation status*

	Independent (n=3)	*Assisted* (n=4)	*Unable* (n=8)
LEMS1[1]	37.0±9.6	19.3±10.8	8.4±7.2
LEMS2[2]	49.3±1.2	35.8±9.5	25.6±11.4
UEMS2[3]	44.3±3.1	33.0±11.0	16.5±7.6

*Ambulation status for only subjects with lower extremity function at follow-up. [1] $P=0.001$; [2] $P=0.013$; [3] $P=0.0006$

picture. These are individuals with cervical spondylosis. Typically, the spondylotic process with resultant spinal canal stenosis and chronic cord ischemia renders the spinal cord less resistant to minor trauma.[5,6] Thus minor trauma that may have no effect on an uninvolved spine can result in neurological injury in an older individual.

The National Spinal Cord Injury Database estimates that 84.1% of all injuries occur in individuals aged 45 years or younger.[1] Approximately 10% occur in individuals between the ages of 46 and 60, and only 6% occur in people over the age of 60. Furthermore, the causes of SCI change as the ages of the individuals increases. In individuals less than 45 years of age, the primary etiologies are vehicular accidents and violence. After the age of 45, the leading cause of SCI is falls.[1]

Although the Database reports on the etiology of injury, it does not report on the pathology of trauma (eg, spinal fracture or dislocation, cord infarct, etc.) It does, however, report that cervical spondylosis is a pre-existing major medical condition in 4.4% of all persons enrolled in the Database.[1] While this is a relatively low prevalence it is second only to hypertension as reported in the Database. Furthermore, although 4.4% seems to indicate that spondylosis is relatively rare, it must be remembered that this is 4.4% of all people in the Database. As previously stated, the majority of individuals with SCI are relatively young. Spondylosis, however, is a degenerative condition of the spine seen primarily in middle-aged and elderly individuals. Therefore, it would be unusual to see a high prevalence of spondylosis among the patients in the Database.

Although there are reports in the literature documenting SCI due to falls[7] or SCI in older individuals,[8–11] reports restricted to outcomes in individuals with SCI due to spondylosis were rare.[5,6,12]

The demographics of this study support those reported previously.[1,7–9] Our subjects were older than the typical individual with SCI, falls were the primary etiology of injury and there was a greater proportion of females compared to the SCI population as a whole. Also, as previously reported, the majority of subjects sustained motor incomplete injuries.

Patients with spondylosis resulting in SCI often demonstrate a pattern of deficit known as the central cord syndrome.[5–7,12] In these patients the deficit is more pronounced in the upper extremities than in the lower extremities. Thirteen of the nineteen individuals (68%) with motor incomplete injuries in our study also demonstrated a greater neurological deficit in the upper extremities compared to that in the lower extremities. In some instances, the difference was minimal (cases 3 and 15) while in others the difference was substantial (cases 1 and 9). This pattern of deficit is attributed to compression of the central grey matter of the cord due to hyperextension of the neck in an individual with a stenotic spinal canal.

The increase in UEMS reported for this group of subjects when categorized based upon motor completeness is comparable to that previously reported for both individuals with complete tetraplegia and those with incomplete tetraplegia.[13,14] Recovery of LEMS averaged 12.7 points which was also comparable to LEMS recovery which was noted among individuals with incomplete tetraplegia.

Two patients who were initially motor complete had converted to incomplete status at follow-up. Patient number 19 recovered 11 points and number 12 recovered 40 points. Previous studies have documented late conversions but with substantially less recovery.[13] Since only motor completeness was determined in this study, it is possible that these two patients were in fact neurologically incomplete according to the sacral sparing definition although initially motor complete. Case number 19 was a patient from our center and further review of his medical records revealed he was in fact neurologically incomplete. Given the significant LEMS recovery demonstrated in case number 12 it is highly likely that this individual was also neurologically incomplete.

Use of percent recovery allows some compensation for the 'ceiling effect'. The ceiling effect refers to the situation whereby an individual with a relatively high initial AMS has fewer points to potentially recover compared to a subject with a low initial AMS. An individual with a low initial AMS may regain more absolute points but remain more impaired than another subject with a higher initial AMS. For example, a subject with an initial AMS of 10 and a final AMS of 30 has recovered 20 points but since he had a potential of 90 points to regain his percent recovery is 22%. In contrast, an individual with an initial AMS of 95 and a final AMS of 99 has recovered only 4 points but since he only had a potential of five points to recover, his percent recovery is 80%. The first subject regained a greater number of absolute points but the second subject recovered a much greater percentage of what was possible to recover. Our data revealed that individuals with less initial deficit demonstrated a greater percent recovery.

Seven subjects (37%) in our study were able to ambulate at follow-up. Other investigators have reported that approximately fifty percent of subjects with central cord type injuries are able to ambulate.[15,16] Crawford and Shepherd reported on seven individuals with cervical cord injury due to spondylosis and found that all were able to ambulate at discharge.[6] Previous studies have determined that all subjects with an initial LEMS of 20 or greater are able to ambulate in the community at one year follow-up.[14] In patients with incomplete tetraplegia residual upper extremity weakness restricted the use of assistive devices such as canes or crutches thereby limiting ambulation. The present study does not distinguish community versus household ambulation but rather categorizes patients based upon the level of assistance/ independence. In our study there was one subject (number 22) with an initial LEMS of 20 who remained unable to ambulate at follow-up. This individual, however, had an UEMS at follow-up of only 24 points. This is well below the average UEMS for both assisted and independent ambulators.

Spivak and associates contrasted SCI in individuals less than 40 years and 65 years and older.[9] The demographics of their older subjects are similar to that of our study. They did not, however, restrict their study to individuals with spondylosis while our study was not restricted on the basis of age. Neurological status was categorized by Frankel grades and by motor index scores (MIS). They reported a higher average initial MIS (33 points) compared to our subjects but less recovery.

DeVivo and associates also compared outcomes in individuals based on age at the time of injury.[10] They reported that among older individuals, falls were the most common cause of injury. They also categorized the neurological status by the Frankel grade and reported that in general Frankel grades did not change from the initial assessment to discharge.

Our results indicate that individuals with SCI associated with spondylosis can, on average, expect to double their initial AMS scores by one year following injury. Their residual upper extremity weakness, however, limits their ability to ambulate. Recovery of motor strength in this group is comparable to that of all patients with incomplete tetraplegia but the proportion of individuals who regain ambulatory function is less.

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