Spinal Cord (2004) 42, 621–626

www.nature.com/sc

Original Article

Outcomes in patients admitted for rehabilitation with spinal neurological lesions following intervertebral disc herniation

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Background: Little information is available about the survival, neurological recovery, and length of stay in hospital for rehabilitation (LOS) of patients with spinal neurological deficit following disc herniation (DH).
Study design: Retrospective cohort study.
Objective: To report on outcomes and factors affecting these.
Setting: The Spinal Research Laboratory, Loewenstein Rehabilitation Hospital, Israel.
Subjects: A total of 158 patients with DH spinal neurological lesions (DHSNL).
Method: Data were collected retrospectively. Survival was assessed using the Kaplan–Meier method; relative mortality risk by the Cox proportional hazard model. Neurological recovery was evaluated by calculating the change in Frankel grades, and factors that affect it were assessed by logistic regression. LOS associations were analyzed with ANOVA.
Results: The median age at lesion onset was 48 years, and the median survival 29 years. Age and gender had a significant effect on survival, but not so lesion severity, level, or decade of onset. Of the 69 patients who had Frankel grades A, B, or C on admission, 72% achieved useful recovery to grades D or E. The severity and level of the spinal neurological lesion (SNL) had a significant effect on recovery. The mean LOS was 87 days; it was significantly affected by lesion severity and level and by the decade of admission to rehabilitation, and decreased with time.
Conclusions: Patients with DHSNL who were admitted for rehabilitation have favorable survival and recovery rates compared with previously studied patients with other types of SNL. Their LOS is probably a function of medical requirements, but is decreasing with time.
Spinal Cord (2004) **42,** 621–626. doi:10.1038/sj.sc.3101642; Published online 3 August 2004

Keywords: spinal cord lesion; disc herniation; survival; recovery; length of stay in hospital

Introduction

Disc herniation (DH) is usually related to degenerative disc disease, which is believed to develop owing to the combined effects of several factors, including genetic factors and changes in collagen hydration. Decreased hydration of the disc can reduce its cushioning effect, thus transmitting a greater portion of the load to the annulus fibrosus, which may tear, which in turn could allow extrusion of the nucleus pulposus and lead to injury to the spinal cord and nerve roots.[1,2]

DH is most common in the lumbar region, mainly at the L_4–L_5 and L_5–S_1 levels. When it causes neurological damage, it is usually by injury to nerve roots, but higher lumbar discs may also herniate and injure the cauda equina or the conus medullaries.[3] Lumbar DH usually presents with symptoms of low back pain (LBP) and sharp burning leg pain, and is often associated with numbness and tingling. In more advanced cases, sensory or motor deficit may occur, sometimes with bladder and bowel difficulties.

DH also occurs frequently in the cervical spine. Cervical DH usually presents with cervical radiculopathy; patients complain of radiating arm pain with numbness and paresthesia and/or weakness in the muscles supplied by that nerve root. If the DH is severe and compresses the spinal cord, patients may present with signs and symptoms of myelopathy: finger numbness, weakness of the upper limbs, and difficulty in walking due to spasticity and impaired sense of position.

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In more severe cases, bowel and bladder control dysfunction may appear.

DH is less common in the thoracic spine, but herniation of the thoracic disc has been diagnosed more frequently since the introduction of new imaging techniques,[4] and it frequently results in myelopathy.[5]

Treatment can be conservative or surgical. Many studies have assessed the management of DH,[6–15] but have included patients without neurological deficit, and outcomes frequently describe reduction of pain or are concentrated on surgical results. Only scant information is available about DH outcomes that are important for patients with SNL in rehabilitation, such as survival, neurological recovery, and length of stay as in-patients in rehabilitation.[5,16–19] However, DH is a relatively frequent cause of nontraumatic spinal neurological lesions (SNL) among in-patients in rehabilitation, and the etiology of almost 15% of a studied group with nontraumatic SNL in Israel.[20] In other series, it appears as an underlying cause of SNL, but its prevalence is not separated from that of other conditions of degenerative spine disease.[16,17,21] The present study reports on the most relevant outcome measures in patients admitted to rehabilitation with spinal neurological deficit following DH (DHSNL). The information obtained by this study can serve as a basis for comparisons with future outcomes to help evaluate the effect of rehabilitation and improve patient care.

Methods

The study included 158 patients with DHSNL, admitted between 1962 and 2000 to the spinal department of Loewenstein Rehabilitation Hospital, in Israel. The patients had disabilities that required hospitalization; many had myelopathy, and most of them were admitted to rehabilitation following spinal surgery.

Demographic and clinical data were retrospectively collected by reviewing the hospital charts. Mortality data were collected from the Population Registry of the Israel Ministry of Internal Affairs. Survival rates were estimated using the product limit (Kaplan–Meier) method, and differences between subgroups were analyzed by logrank test (univariate analysis). The Cox proportional hazard model was used to determine the probability of mortality ('hazard') in the presence of specific risk factors (multivariate analysis).[22] The time of SNL onset was defined as the earliest time of DHSNL symptoms and signs mentioned in the hospital records.

The severity of neurological deficit below the spinal level of injury was graded according to Frankel,[23] as described in a previous publication on traumatic SNL recovery.[24] In most cases, Frankel grades had not been assigned during hospitalization, so for purposes of the study, they were assigned retroactively on the basis of the examination protocols. The degree of neurological recovery or regression in each patient was determined by comparing the Frankel grade of neurological deficit at first admission for rehabilitation (initial Frankel grade) with the grade at discharge from the same hospitalization. Recovery rate was assessed either as *any recovery*, namely a recovery of at least one Frankel grade from a grade of A, B, C, or D, or as *useful recovery*, namely a recovery from Frankel grades A, B, or C at admission to grades D or E at discharge. The assessment of useful recovery did not include patients with an initial Frankel grade of D or E. Logistic regressions were used to examine the association between various affecting factors and recovery.[22]

Analyses of the length of stay in hospital for rehabilitation (LOS) due to DHSNL were performed after a square root transformation to approach a normal distribution. The associations of LOS with potentially affecting factors were analyzed by ANOVA: three-way ANOVA for age, gender, and Frankel grade, and one-way ANOVA, followed by Tukey's *post hoc* test, for comparisons between decade of admission and SNL severity.

Statistical significance was defined by $P<0.05$. Data were analyzed by SPSS for Windows, version 11 (SPSS Inc., USA).

Results

Demographic and clinical data

Included in the study were 104 male (66%) and 54 female (34%) patients, with a median age of 48 years and a mean age of 48. 2 years (SD = 12.7 years) at lesion onset. SNL was cervical in 38 patients (24%), thoracic in 25 (16%), and lumbar in 93 (60%). The mean time from SNL onset to rehabilitation was 18.4 months (SD = 29.4 months). The initial Frankel grade was A in one patient (0.6%), B in 15 patients (9.5%), C in 53 patients (33.5%), and D in 89 patients (56.3%). In all, 14 patients were admitted before 1970, 34 between 1971 and 1980, 34 between 1981 and 1990, and 76 between 1991 and 2000.

Outcome: survival

Mortality data were available for 156 of the 158 patients. Of them, 123 (79%) survived at the end of the follow-up period (May 2001). The longest survival up to that time was 40.5 years. The accumulated survival was 96.5% (SE = 1.6%) 5 years after the SNL onset, 88.3% (SE = 2.9%) 10 years after the SNL onset, 78.7% (SE = 4.3%) 15 years after the SNL onset, 73% (SE = 5.1%) 20 years after the SNL onset, 62.9% (SE = 6.5%) 25 years after the SNL onset, and 41.8% (SE = 11.8%) 30 years after the SNL onset (Figure 1). The median survival time was 29 years.

Univariate analysis showed that age at SNL onset, gender, and decade of SNL onset, but not Frankel grade or lesion level, had a significant effect on survival ($P<0.05$). After controlling for gender, initial Frankel grade, SNL level, and decade of SNL onset, the mortality risk was 1.1 times higher for every additional year of age at SNL onset. After controlling for age, initial Frankel grade, SNL level, and decade of SNL onset, the mortality risk was 3.4 times higher for men

than for women. The effects on the risk of mortality of initial Frankel grade, SNL level, and decade of SNL onset were not statistically significant when controlling for the other affecting factors (Table 1).

Outcome: neurological recovery

Of the 69 patients who had initial Frankel grades of A, B, or C (72.5%, or 31.6% of all DHSNL patients), 50 achieved useful recovery and showed an improvement during the course of rehabilitation to grades D or E (Table 2). Of these, 53 (76.8% or 34% of all patients with DHSNL) showed any recovery (improvement of at least one Frankel grade).

The frequency of any recovery in patients who had initial Frankel grades of A, B, or C was inversely related to the severity of the original deficit: grade A: 0, grade B: 73.3%, and grade C: 79.2%. Of the grade B patients, 20% achieved grade C and 53.3% grade D. Of the grade C patients, 77.4% achieved grade D and 1.9% grade E. Of the grade D patients, 37.1% achieved grade E (Table 3).

When controlling each initial Frankel grade, age at admission to rehabilitation, gender, SCL level, and decade of admission to rehabilitation, for all the other listed variables, only initial Frankel grade had a significant effect on any recovery, and only SNL level had a significant effect on useful recovery ($P<0.05$; Tables 4 and 5).

The odds of any or useful recovery during rehabilitation were not significantly different for initial Frankel grade C *versus* A and B, but the odds of recovery for initial grade D were 19% of those for A and B ($P=0.014$; Tables 4 and 5). The odds of useful recovery during rehabilitation were not significantly different for cervical *versus* either thoracic or lumbar lesions, but the odds of recovery for thoracic lesions were 20% of those for lumbar lesions ($P=0.025$; Table 5).

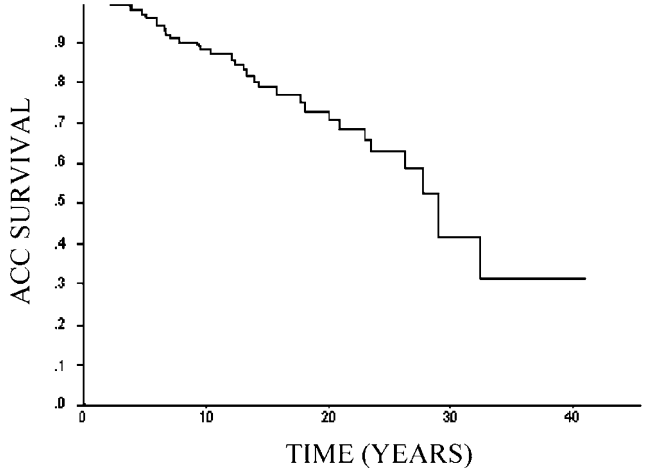

Figure 1 Survival following SNL due to DH. Acc survival = Accumulated survival rate. Time = Time from lesion onset to death or end of follow-up

Table 2 Neurological recovery in DHSNL

Frankel grade	*Relative proportion of the grade on admission (%)*	*Relative proportion of the grade at discharge (%)*	*Change in the relative proportion of the grade (%)*
A	0.6	0.6	0
B	9.5	2.5	−7
C	33.5	8.9	−24.6
D	56.3	66.5	10.2
E	0	21.4	21.4

Changes in the severity of neurological damage by Frankel grades between admission for rehabilitation and discharge from hospitalization, in percent of patients ($N=262$). Total of A, B, and C grades at admission (56.5%) minus total at discharge (23.7%) = 32.8%, representing 58% of 56.5%

Table 1 Hazard (relative risk of mortality) in DHSNL, considering factors with potentially concomitant effects

			95% confidence interval	
Affecting factor	*Hazard*	*P*	*Lower*	*Upper*
Age	1.10	0.001	1.06	1.15
Male gender	3.44	0.033	1.11	10.70
SNL severity	0.91	0.826	0.38	2.16
SNL level		0.910		
Cervical	1.01	0.981	0.38	2.69
Thoracic	1.26	0.668	0.44	3.55
Decade		0.247		
1961–1970	8.27	0.07	.860	79.78
1971–1980	4.74	0.148	0.58	38.88
1981–1990	7.35	0.07	0.87	62.28

Age and decade at lesion onset. The hazard is compared with that for lumbar lesions (level) and that for 1991–2000 (decade)

Table 3 Relationship between severity of neurological damage and recovery

Frankel grade on admission (N)	*Frankel grade at discharge*				
	A (%)	*B (%)*	*C (%)*	*D (%)*	*E (%)*
A (1)	100	0	0	0	0
B (15)	0	26.7	20	53.3	0
C (53)	0	0	20.8	77.4	1.9
D (89)	0	0	0	62.9	37.1

Changes in Frankel grades between admission for rehabilitation and discharge from hospitalization, in percent of initial number of patients for each grade (N)

Table 4 Any recovery in DHSNL

			95% confidence interval	
Affecting factor	*Odds*	*P*	*Lower*	*Upper*
SCL severity		0.001		
FC *versus* FA + FB	1.84	0.386	0.460	7.32
FD *versus* FA + FB	0.19	0.014	0.051	0.72
Age	0.99	0.384	0.96	1.02
SCL level		0.26		
T *versus* C	0.36	0.111	0.10	1.26
L *versus* C	0.59	0.246	0.24	1.44
Male gender	1.26	0.552	0.59	2.70
Decade		0.759		
1961–1970	0.44	0.280	0.10	1.94
1971–1980	0.92	0.860	0.35	2.37
1981–1990	0.92	0.863	0.37	2.29

Odds of any recovery during rehabilitation, controlling for affecting factors. SNL severity by Frankel grading. Age and decade at admission to rehabilitation. For age, odds are for each additional year. Each decade is compared to 1991–2000. FA, FB, FC, FD = Frankel grades. C = Cervical SNL; T = Thoracic SNL; L = Lumbar SNL

Outcome: LOS

The mean LOS was 87.2. days (SD = 65.1 days; range = 15–343 days). When controlling for two age groups at rehabilitation ($\leqslant 50$ or $\geqslant 51$ years), gender, and initial Frankel grade (A, B, and C or D), only Frankel grade had a significant effect on LOS ($P<0.001$), while the effects of age and gender were not significant ($P=0.833$ and 0.569). LOS was 296 days for the single patient with Frankel grade A; mean LOS was 159 days (SD = 88 days) for patients with Frankel grade B, 107 days (SD = 68 days) for C, and 61 days (SD = 37 days) for D.

The mean LOS was 108 days (SD = 79 days) before 1970, 113 days (SD = 73 days) for 1971–1980, 82 days (SD = 55 days) for 1981–1990, and 74 days (SD = 59 days) for 1991–2000. The change in LOS over the decades was found statistically significant ($P=0.013$). In the last decade, LOS was significantly shorter than before 1980 ($P<0.05$), but the difference in LOS between the last two decades did not reach statistical significance. The mean LOS was 76 days (SD = 58 days) for cervical SNL, 116 days (SD = 88 days) for thoracic SNL, and 84 days (SD = 59 days) for lumbar SNL. The difference in LOS between cervical and thoracic SNL levels was also found significant ($P<0.05$), but the difference between the lumbar and the other SNL levels was not significant.

Table 5 Useful recovery in DHSNL

			95% confidence interval	
Affecting factor	*Odds*	*P*	*Lower*	*Upper*
SCL severity	3.45	0.095	0.81	14.72
Age	0.96	0.170	0.91	1.02
SCL level		0.041		
T *versus* C	0.10	0.060	0.01	1.10
L *versus* C	0.48	0.537	0.05	4.99
Male gender	1.02	0.979	0.26	3.92
Decade		0.705		
1961–1970	0.97	0.976	0.13	7.04
1971–1980	0.82	0.800	0.18	3.78
1981–1990	4.19	0.281	0.31	56.70

Odds of useful recovery during rehabilitation, controlling for affecting factors. SNL severity by Frankel grading. Age and decade at admission to rehabilitation. For age, the odds are for each additional year. Each decade is compared to 1991–2000. C = Cervical SNL; T = Thoracic SNL; L = Lumbar SNL

Outcome: main SNL complications

Of the 158 patients included in this study, 26 (16.4%). had urinary complications (of them, six had vesicoureteral reflux), four (2.5%) had respiratory complications, and six (3.8%) had pressure sores.

Discussion

DHSNL may cause morbidity and death and require long hospitalization, but the orthopedic and rehabilitation literature lacks attention to survival, recovery, and LOS in series of DHSNL patients. This study has been conducted to add information to what is already available about outcomes for this patient group and to contribute to the assessment of the role of rehabilitation medicine in their care.

This DHSNL patient group is too small for actuarial calculation, but a rough comparison with data from the central bureau of statistics in Israel, given a median age of 48 years at lesion onset and a median survival of 29 years, reveals that the survival of these patients is close

to that of the general population in Israel during the same period. Comparisons with various SNL etiologies indicate that the mortality risk in SSSNL is the lowest.[20] These, and the fact that survival was not significantly affected by the severity or level of the lesion, may indicate that the complications of spinal neurological damage are not life-threatening in this group, as they are in patients with other SNL, including traumatic spinal cord lesions (TSCL).[20,24,25] The significant effect of decade of onset on survival, demonstrated by univariate analysis, may be misleading, as this effect did not reach statistical significance when controlling for other affecting factors.

Recovery rate over the course of rehabilitation was high: 72.5% progressed from a nonfunctional to a functional condition, as compared to 23–27% in patients with TSCL studied earlier.[25,26] The significance of this finding is emphasized by the independence of useful recovery of age, gender, SNL level, and decade of admission to rehabilitation. Useful recovery was also independent of the SNL severity, but this finding indicates only that recovery rate is not significantly different between patients with Frankel grades of either B or C, and that grade B lesions also had a high tendency to recover. Inference about recovery rates in DHSNL with complete lesions is impossible, as the group included only one patient with Frankel grade A. The significantly lower recovery from a grade D lesion to normal neurological status indicates that although relatively mild, these DHSNL tend to cause a persistent neurological damage, which may have clinical implications despite the excellent functional recovery.

Despite the incomplete DHSNL in the vast majority of cases and the encouraging survival and recovery, DHSNL patients can develop serious medical complications. In the present study, these complications were represented in 2.5–16.4% of patients by urinary impairments including vesico-ureteral reflux, respiratory disorders, and pressure sores. Therefore, favorable final outcomes cannot be taken for granted and they probably depend partly on the quality of care during rehabilitation and partly on ongoing care, socioeconomic conditions, and health-related behaviors.

LOS was longer for the studied DHSNL patients than for patients with TSCL in the USA or Australia,[16,17,27–29] but shorter than for patients with TSCL in Europe.[5,22,30] The longer LOS in Europe may be related to the different population in the European studies (TSCL *versus* DHSNL). Lesions are more severe in TSCL studied than in the DHSNL in the present study, and therefore this finding is compatible with the major impact of lesion severity on LOS found in the present study. The longer LOS in patients with more severe lesions is probably related to the greater amount of functional problems, which require therapeutic attention, and implies that the patient's medical condition has a significant impact on LOS. The shorter LOS of TSCL patients in the US and Australia, and the decrease in LOS over the decades in the present series, which is approaching US levels of LOS, might have been related to lower or decreasing lesion severity or to improvements in medical procedure, outpatient services, and rehabilitation practices. The authors believe, however, that the trends in LOS reflect mainly financial limitations and the increasing demand for rehabilitation services.

The increasing demand is reflected by admissions to rehabilitation of patients with DHSNL. In our population, it doubled in the 1991–2000 decade compared with the previous one and increased five-fold compared with the 1961–1970 decade. This may be explained partly by some increase in the need for postoperative rehabilitation as a consequence of an increase in spinal surgical procedures in Israel, which is likely to follow a similar trend reported in the US.[31] Shortening of LOS and the consequent increase in the availability of rehabilitation beds may also be a contributing factor. However, our impression is that the main reasons for this tendency is the increasing awareness of the importance of rehabilitation in the care of these patients and the improved accessibility of these patients to rehabilitation services.

DH in the thoracic spine is rare according to previous publications, and its incidence was noted as 1% or less of all herniated discs.[4] In the present series, however, 16% of patients had thoracic DH, which probably indicates that it is more frequent among patients with DHSNL than in patients with DH without neurological compromise. This implies that the chance of a significant neurological damage may be higher in thoracic than in other herniated discs, which is consistent with the finding that thoracic DHSNL recovered less than lumbar or cervical, and required longer LOS. The more severe and less reversible nature of thoracic DHSNL may be related to differences in the mechanisms that create the neurological damage owing to the excess mobility of the cervical and lumbar spine.

The retrospective nature of the research, and the size of the patient group imposed certain limitations on this study: additional factors that might have influenced outcome, such as the effect of myelopathy *versus* root lesion or surgery *versus* rehabilitation, could not be analyzed; only limited information could be obtained on medical SNL complications, and the paucity of complications did not allow their further breakdown by influencing factors; the hazard analysis may not have a sufficient power to allow for conclusions to be drawn about the lack of relationship between survival and other variables. However, the hazard for SNL severity and level is 0.91–1.26, and its *P*-values are 0.66–0.98, so relationship between survival and these variables is unlikely.

In conclusion, the present study shows that patients with DHSNL admitted for rehabilitation have favorable survival and neurological recovery, better than in previously studied patients with other types of SNL. This may be related to a combination of mostly incomplete lesions, care in the rehabilitation system, and ongoing care. LOS in DHSNL patients is related to lesion severity and it is probably adapted to patient requirements, but has been decreasing over the decades,

reflecting mainly an increased demand for rehabilitation services under the increasing influence of economic factors on medical decisions. Further study with larger patient groups may clarify LOS impact on rehabilitation outcomes, help define the optimal LOS, obtain additional information on outcomes and factors that affect them, and improve the medical and economic aspects of the rehabilitation services for these patients.

Acknowledgements

This study was supported by the Unit of Medical Services, Rehabilitation Department, Israel Ministry of Defense.

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