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ORIGINAL ARTICLE

Survival, neurological recovery and morbidity after spinal cord injuries following road accidents in Israel

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Design: A retrospective cohort study.
Objective: Assess outcomes in patients with spinal cord injuries (SCI) following road accidents, and factors that affect them.
Setting: Loewenstein Rehabilitation Hospital, Raanana, Israel.
Subjects: A total of 143 patients admitted for rehabilitation between 1962 and 2004.
Methods: Survival rates were estimated using the product limit (Kaplan–Meyer) method and their association with risk factors was analyzed with the Cox model. Neurological recovery was determined by comparing the Frankel grade at admission to rehabilitation and at discharge. The relation between recovery and various factors was tested with logistic regression.
Results: The risk of SCI in road accidents is higher among car drivers and motorcycle or bicycle riders. Median survival was 43 years. Survival was negatively associated with age at injury ($P<0.0002$) and with diagnosis of pressure sores ($P=0.0065$). Recovery of at least one Frankel grade occurred in 29.1% of patients. Useful recovery (upgrade to Frankel grade D or E) occurred in 23.1% of all patients. Neurological recovery was negatively associated with the severity of neurological deficit ($P<0.001$) and with thoracic injuries ($P=0.046$). The most common complications were pressure sores and those of the urinary and respiratory systems.
Conclusions: In SCI following road accidents, survival rates were higher and recovery rates lower than in mixed types of trauma. This may be related to better compensation followed by better nursing for road accident victims in Israel, which may prevent life-shortening complications, and to more severe injuries caused by road accidents.
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Keywords: road accidents; SCI; survival; risk factors; neurological recovery; morbidity

Introduction

Spinal cord injury (SCI) was associated with poor survival until attempts to repair the damaged spinal cord were replaced with the systematic prevention and treatment of complications. Today, in western counties life expectancy after SCI is over 30 years.[1] In Israel, survival of SCI patients is close to that of the general population,[2] and many of them achieve considerable neurological recovery.[3]

Road accident injuries are frequent in Israel.[4] During the year 1999, 4328 people were registered as having been wounded by road accidents according to the Israeli Trauma Registration.[5] Only a minority of the injured had SCI, but 64.3% of the SCI were of medium or high severity. Severe injuries were more frequent among SCI than in other injury groups.[5] Although SCI are rare among road accident victims, road accidents are the major cause of spinal injury worldwide and in Israel.[3,6,7] Road accidents caused 42.1% of the SCI in patients admitted to rehabilitation at Lowenstein Rehabilitation Hospital between 1992 and 2003.[7]

As road accidents are numerous among the SCI etiologies, examination of outcomes in patients with SCI following road accidents may encourage treatment strategies aimed to optimize outcomes in these patients.[1–3,8–10]

In the present study, survival, morbidity and neurological recovery are described in 143 SCI patients following road accidents in Israel.

Methods

The study sample included patients with SCI after a road accident, injured between 1962 and 2004, and treated at Lowenstein Rehabilitation Hospital, the major referral center for rehabilitation medicine in Israel. Only patients with SCI at or above the L_1 level were included.

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Clinical and demographic data such as age at injury, gender, level and severity of the injury, the interval between injury and first admission to rehabilitation, additional injuries other than the SCI and complications were collected from the hospital charts. The severity of neurological deficit was graded according to Frankel *et al*.[11] The degree of neurological recovery or regression in each patient was determined by comparing the Frankel grade at admission for rehabilitation and before discharge. Recovery was assessed either as 'any recovery' (recovery of at least one Frankel grade from A, B, C or D), or as 'useful recovery' (from Frankel grade A, B or C at admission to grade D or E at discharge). In most cases, Frankel grades had not been assigned during hospitalization, so for purposes of the study, they were assigned retrospectively on the basis of the examination protocols. Mortality data were collected from the Population Registry of the Israel Ministry of Internal Affairs.

Survival rates were estimated using the product limit (Kaplan–Meyer)[12] method and the long-rank test for comparing survival in subgroups. The comparison demonstrated the relationship between survival and affecting factors. Logistic regression was used to examine associations between affecting factors and recovery. The effect of Frankel grade on recovery was not included in the logistic regression because no patient with Frankel grade D showed neurological improvement. This effect was analyzed using the χ^2 test.[12] Data were analyzed by the SPSS for Windows, version 12 (SPSS Inc., Chicago, IL, USA).

Results

Demographic and clinical data

One hundred and forty-three patients were included in the study. Age at injury was 14–81 years (mean 37.8 years) (Table 1). Male:female ratio was 4.95:1.

Forty-three percent of the lesions were cervical, 49.3% thoracic and 7.7% lumbar. Forty-one percent of the injuries were complete at first admission to rehabilitation (Frankel grade A), and 59% were incomplete (Table 1). The mean interval between injury and first admission to rehabilitation was 113 days (s.d.: 227 days), and the median was 35.9 days. Data about patient involvement in the accident were found in the hospital charts of 63 patients and are presented in Table 1.

Outcomes

Survival. One hundred and twenty-seven of the 143 patients survived at the end of the study and 16 died. Maximum survival was 43.3 years after injury. Survival rates are detailed in Table 2.

Survival was negatively associated with age at injury ($P<0.001$), and with the presence of pressure sores ($P=0.006$) (Table 3). Survival also showed a tendency to be negatively associated with the severity of neurological deficit, but this association did not reach statistical significance ($P=0.66$). The overall SCI level effect on the survival was also nonsignificant ($P=0.62$). The effect of other injuries that occurred in addition to the SCI, such as brain damage, damage to internal organs, or limb fractures, or the effects of urinary tract infection and overall complications (Table 6), was not found significant ($P>0.2$).

Neurological recovery. Sufficient data to assess neurological recovery were found for 134 patients. Thirty-nine of them (29.1%) showed recovery of at least one Frankel grade (any recovery). In patients with Frankel grade A, B or C on admission, any recovery was inversely related to the severity of the original deficit. None of the patients with Frankel grade D showed recovery (Table 4). Useful recovery (from Frankel grade A, B or C to D or E) occurred in 31 patients (23.1%). Useful recovery did not occur in patients with Frankel grade A on admission, and was more common among patients with Frankel grade C than B (Table 4).

Neurological recovery was significantly affected by lesion severity and level. It was better in patients with Frankel grade C on admission than in patients with Frankel grades A, B and D ($P<0.001$, Table 4). The odds of recovery in patients with thoracic lesions were 0.233 of those with lumbar lesions ($P=0.046$), but the difference in recovery between cervical and lumbar lesions was not statistically significant (Table 5).

Age at injury, gender, the presence of pressure sores, overall complications during hospitalization and the interval between injury and first administration to rehabilitation did not affect recovery significantly (Tables 5 and 6).

Morbidity. In the hospital charts of 74 of 143 patients, we found reports on complications following SCI. The most frequent complications were urinary tract infections and pressure sores (Table 6).

Discussion

Although only a minority of road accident victims suffers from SCI (9.6% in a report from Greece and 1.4% in Israel),[5,13] road accidents are a major cause of SCI. In the USA, GB and Israel,[5,6] about 43% of SCIs are due to road

Table 1 Patient distribution by age at injury, Frankel grade on first admission to rehabilitation and patient involvement in the accident

Age (years)	n	%	*Frankel grade*	n	%	*Patient involvement*	n	%
<25	46	32.2	A	55	41.0	Car driver	22	34.9
25–35	28	19.6	B	15	11.2	Car passenger	9	14.3
35–45	24	16.8	C	43	32.1	Bicycle/motorcycle rider	18	28.6
>45	45	31.4	D	21	15.7	Pedestrian	14	22.2
Total	143	100	Total	134	100	Total	63	100

accidents. In Thailand and Australia, they cause about 50% of SCIs.[14,15] An Australian study showed an increase in SCI following road accidents, probably because of the increased rate of seat belts usage, which prevented death but not SCI.[14]

Nevertheless, only a few of the many studies on survival and recovery in SCI patients were dedicated to SCI after road accidents.[1–3,6–11] The present study demonstrates, for the first time, specific characteristics of this group in Israel. We found that the survival of road accident victims with SCI was long, probably longer and their recovery rate lower than has been described in previous studies on SCI. The presence of pressure sores was the only complication affecting survival in these SCI patients.

Survival

Median survival in the present study was 43 years. In our previous study on patients with SCI of multiple causes, in which the mean age was younger (34.5 years), median survival was 36.5 years.[2] Survival in the present study was also longer than reported by Whiteneck *et al*.[6]

Table 2 Survival rates at various periods after injury

Time after injury (years)	*Survival rate (%)*
5	95.6
10	92.9
20	86.3
30	74.2
40	74.2

Table 3 Factors affecting survival

Affecting factor	*Estimated survival (years)*	*s.e.*	P
Age at injury			<0.001
<25	38.2	0.8	
25–35	34.7	3.6	
35–45	38.9	5.5	
>45	22.5	3.1	
Pressure sores			0.006
Yes	28.5	4.1	
No	38.2	1.4	

Abbreviation: s.e., standard error.

Age at injury and pressure sores were the only factors that significantly affected survival in the studied group.

It seems that most of the factors that are known to affect mortality following SCI cannot be responsible for the longer survival in this study. Age at injury in this study was older than in our previous study,[2] and older age at injury is known to have a negative effect on survival.[1,2,6,16] The lesions in this study were not milder than in our previous study,[2] and lesion severity was shown to be negatively associated with survival[1] or at least to show such a tendency, both in this and our previous study.[2] Lesion level was represented by a higher proportion of thoracic injures in this study than in our previous one,[2] and thoracic injuries are not associated with longer survival in SCI. Concomitant injuries and complications were not significantly related to survival in this study.

The longer survival in this study may be attributed to the later time of injury. Whiteneck *et al*.[6] showed that median survival was prolonged by 7 years after a two decades interval. But in many of the patients studied here, the time of injury overlaps that of previous studies,[2,7] and it is therefore questionable that time at injury alone can explain the longer survival in the road accident patients.

Other factors, which are not often considered as mortality risks, may be responsible for the difference in survival. In our previous study on survival after SCI, about 14% were injured in suicide attempts;[2] in the present study, this group is not represented. People who had tried to commit suicide are likely to do less to prevent complications and their survival may be shorter. Financial condition may also affect survival after SCI. Road accident victims in Israel are better compensated than other SCI patients in our groups, which may contribute to better care for longer periods and to the prevention of complications.[16]

The significant negative effect of pressure sores on survival in this study supports the role of economic factors on survival in the present group. Sores are potentially lethal but can be prevented by good nursing, and in Israel the availability of nursing depends on financial resources. At the same time, the medical treatment required for other complications is usually available through the public health system.

The lack of significant influence of injury level and severity, of additional injuries, and of overall complications on survival in road injured patients in this study may be related to the success of primary care and rehabilitation that prevented complications.

Table 4 Relationship between severity of neurological damage and any recovery[a]: Frankel grades on admission for rehabilitation and on discharge from hospitalization

Frankel grade on admission (n)	*Frankel grade at discharge*					*Recovery rate (%)*[b]
	A (%)	*B (%)*	*C (%)*	*D (%)*	*E (%)*	
A (55)	92.7	5.6	1.8	0	0	7.4
B (15)	0	66.7	20.0	13.3	0	33.3
C (43)	0	0	32.6	65.1	2.3	67.4
D (21)	0	0	0	100	0	0

[a]Recovery of at least one Frankel grade.
[b]In percentages of the initial number of patients with each grade.

Table 5 Odds of any neurological recovery during rehabilitation, controlling for affecting factors

Affecting factor	*Odds*	*95% CI*		P
		Lower	*Upper*	
Age	0.995	0.971	1.018	0.655
SCI complications	1.342	0.581	3.096	0.491
Interval from injury to rehabilitation	0.998	0.995	1.001	0.213
Gender	0.925	0.301	2.838	0.891
SCI level				
Lumbar	1.0	—	—	—
Thoracic	0.233	0.055	0.0976	0.046
Cervical	0.736	0.178	3.039	0.672

Abbreviations: CI, confidence interval; SCI, spinal cord injury.
Odds, odds of any neurological recovery (of at least one Frankel grade).
P, significance of the odds.
Affecting factors: age at injury (years); complication (vs no complications); interval from the accident to first admission to rehabilitation (months); gender; SCI level: cervical or thoracic vs lumbar.

Table 6 Distribution of complications diagnosed during rehabilitation

Complication	*Frequency (%)*
Urinary tract infection	37.1
Pressure sores	26.6
Vesicourinary reflux	6.3
Pneumonia	4.2
Deep vein thrombosis	3.5
PNBF	3.5
Pulmonary embolus	2.8
Uro-lithiasis	2.8
High blood pressure	2.8
Orchio-epididimitis	2.1
Sepsis	1.4
Osteomyelitis	1.4
Autonomic dysreflexia	1.4
Hydronephrosis	0.7

Abbreviation: PNBF, periarticular new bone formation.

Recovery

Neurological recovery was not better after SCI due to road accidents than due to other causes. Any recovery occurred in 29.1% of road accident victims in this study and in 32% of the SCI population in our previous study; useful recovery occurred in 23.1 and 27%, respectively.[3] The difference is probably related to somewhat higher severity grade and injury level in the present study. Among the road accident SCI patients, Frankel grade A was found in 41 vs 29.6% in the previously studied group with SCI of various causes.[3] Thoracic injuries were present in 49.3% of the patients in this study and in 32.4% in our previous study.[3]

The better recovery of the Frankel grade C group than of the Frankel grades A and B groups[3,17–19] is probably due to the less severe neurological deficit. The fact that in this study no patient with Frankel grade D on admission showed recovery may be related to a 'ceiling effect'.[19]

The lower odds of recovery in thoracic vs lumbar injuries are probably related to the more severe lesions in thoracic injuries, the result of the relative anatomical and biochemical stability of the thoracic spine, which succumbs only to severe trauma.

The fact that age at injury and interval between injury and first admission to rehabilitation had no effect on recovery in this study, in contrast to previous studies,[17,18] can be explained by relatively good nursing after road accidents, which prevents age-related complications, and by the high variance of the interval between injury and admission.

Morbidity

Morbidity events in this study resemble those in our previous studies of spinal cord lesions treated between 1959 and 2000 (unpublished data). Comparison of morbidity with other studies was not possible because of differences in definitions and follow-up periods between studies.

Patient involvement in the accident

More car drivers were found among patients with SCI than among the general road accident victims population, both in the present study and in the research on the Israeli Trauma Registration from 1999.[5] In the present study (but not in the 1999 study),[5] the proportion of bicycle and motorcycle riders among the SCI patients was higher than their proportion among the wounded with any injury. The opposite (low proportion of SCI in this study and high proportion in the 1999 study) was found for vehicle passengers. In both studies, the proportion of SCI among pedestrians is lower than their share in the general population of people wounded in road accidents.[5]

Similar to the present study, a Greek study found that pedestrians involved in road accidents were less likely to have SCI than did motorcycle riders and car drivers.[13]

An Australian study, which did not include pedestrians, showed similar SCI involvement in road accident patients to this study.[14] In the Australian study, the risk of SCI was higher among motorcycle riders than among car drivers and passengers.

The difference between the 1999 study (based on trauma registration) and the other studies (performed on patients in special SCI rehabilitation units) may be due to the fact that more motorcycle riders are referred to SCI rehabilitation units because of the more severe injuries that characterize this group. The difference can also be explained by reduced trauma registration of motorcycle drivers who suffer from mild SCI.

Gender

The high male:female ratio found in the present study was also described in previous studies on SCI[2,3,14,18] as well as in the Israeli Trauma Registration of people injured in road accidents. The gender ratio was higher in SCI than in other road accident victims, probably because of the higher proportion of car and motorcycle riders (who are mainly men) in the first group.[14]

Study limitations

Only 143 cases fit the inclusion criteria of the study, and for only 63 patients we found data about patient involvement in

the accident, which limits the generalizability of conclusions about SCI patients following road accidents. A potential methodological drawback of the study was the retrospective assignment of Frankel grades, but the information that the original examiners of the patients would have used to grade them was recorded in the hospital charts. Therefore, the retrospective grading of the neurological deficit was most likely as valid as it would have been had it been performed at the original recording. Morbidity data were scarce and we could not draw conclusions in this area.

Conclusion

The risk of SCI in road accidents is higher in men than in women, and among car drivers and motorcycle or bicycle riders.

We found that road accident victims with SCI have a somewhat higher survival rate but lower neurological recovery than the general SCI population. On one hand, a higher proportion of patients with complete spinal lesions reduced the recovery in the studied group, and on the other hand financial advantages probably enabled better nursing, which prevented life-shortening complications. Factors reducing survival were higher age at injury and pressure sores. Severe neurological damage on admission to rehabilitation and injuries of the thoracic spinal cord reduced recovery rates. The non-sufficient neurological recovery in SCI patients after road accidents calls for emphasis on rehabilitation efforts to maximize functional ability.

Despite the relatively higher recovery rates among multiple-cause SCI patients, recovery rates in the present study were good and outcomes suggest that rehabilitation enables substantial recovery of the spinal cord, reduces morbidity and contributes to longer survival.

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