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Original Article

Impact of age on the injury pattern and survival of people with cervical cord injuries

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Study design: A retrospective, follow-up study.
Objectives: To differentiate the injury pattern and survival of people with cervical cord injuries with onset at different ages.
Setting: Rehabilitation wards of a university hospital that is a tertiary referral center in Taipei, Taiwan.
Methods: The records of acute and traumatic cervical cord injury patients hospitalized from 1989 to 1997 were reviewed. All subjects received comprehensive rehabilitation programs during hospitalization. Their survival status at the end of follow-up was studied.
Results: Forty-seven of 109 (43.1%) people with cervical cord injuries were 50 years or older at onset. Older patients were more frequently injured by minor falls, resulting in more incomplete quadriplegia. They also showed fewer spinal fractures, and more demonstrated associated spondylosis and ossification of the posterior longitudinal ligament. Eleven (10.2%) subjects were deceased, found by a linkage to a death registration database at the end of follow-up. The significant predictor of survival status at follow-up was older age at injury using Cox proportional hazards model.
Conclusion: Spinal cord injured patients had different injury patterns, demanding different preventative strategies. Those injured at older ages were at higher risk of mortality according to our study.
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Keywords: spinal cord injury; elderly; survival

Introduction

Spinal cord injury (SCI) occurs predominantly in a younger population with the peak age of onset at 20–40 years. However, a trend of increasing proportion of SCI onset at older age was observed as the life span is prolonged.[1,2] The average age of onset of traumatic SCI ranged from 24.0 to 48.6 years in different surveys.[3,4] The oldest average age of onset was reported by Japanese researchers, which showed a mean age of 51 years in those with cervical cord injuries.[3]

As people with SCI in the older population usually occurred with more complications, they deserved special attention.[5,6] Prior studies observed some clinical characteristics of older people with SCI, including a higher female sex ratio, more cervical cord injuries, more incomplete lesions, and more frequently injured by minor falls.[1,7–10] The differences in neurological level and extent of injuries were believed to be the result of the differences in causes noted among older patients.[11] Underlying degenerative changes of the spine and stenosed canal also contributed to the high risk of cervical injuries by even a minor fall in the elderly.[7,8] Other researchers reported a high proportion of odontoid fracture in the elderly with cervical injuries.[10,12] The strategy for prevention and care for the growing number of elderly people with SCI is thus becoming more important.

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Age at onset of SCI plays an important role in both survival and functional outcome. The survival of people with SCI has generally improved significantly in recent decades, although they are still unable to achieve the life expectancy of the general population, especially in certain subgroups.[13–15] Older patients with complete quadriplegia have the poorest prognosis. Other important predictors of mortality among people with SCI include year of injury, neurological severity, and some psychosocial factors.[13,16–18] Comparatively, age effect on rehabilitative outcome is in debate. Age was not a significant factor to predict the independent living or rehabilitative outcome in some studies, supporting the practice of providing comprehensive rehabilitation service to all patients regardless of age.[19,20] However, some other researchers observed a negative influence of age on either short-term functional recovery or long term health outcome.[21,22]

A recent nationwide survey of people with SCI in Taiwan disclosed an annual incidence of 18.8 per million population and an average onset age of 46.1 years. Older people had an extraordinarily high annual incidence up to 47.5 per million population, urging more studies on this subgroup of people with SCI.[4] They demonstrated a higher female to male ratio, different distribution of neurological deficits and injuries more likely caused by level falls, similar to previous studies. But no difference was found in the aspects of severity of injuries, complications, hospitalization days and outcome. However, there has been no follow-up study of people with SCI in Taiwan yet.

Since different types of neurological impairment, paraplegic or quadriplegic, posed a heterogeneous distribution of age, sex, external causes of injuries and even prognosis,[3,18,23] we chose cervical cord injured patients in the present study. Our goal is to study the mortality and the predictors of survival.

Methods

We conducted this study at rehabilitation wards of the National Taiwan University Hospital, which served as a major referral center of SCI in northern Taiwan. There were two patient sources in the rehabilitation wards, either from acute care or emergency service of the same hospital, or from other acute hospitals after patients were stable. Patients transferred from the other hospitals were included only if they arrived within 6 months after injuries and were admitted for the purpose of more aggressive rehabilitative programs. Those with non-traumatic spinal cord lesions were excluded. Under these criteria, there was a total of 191 people with traumatic, acute SCI admitted from 1 January 1989 to 31 December 1997.

A thorough chart review was made to obtain the following information: (1) demographic data, including age, sex, and identification number, (2) variables of injury, including causes of injury, associated injuries, roentgenographic findings, and neurological classification, (3) variables of treatment, including the conditions of acute care and rehabilitation management, (4) variables of discharge outcome, including the locomotion, bladder management and discharge destination. American Spinal Cord Injury Association (ASIA) 1982 standard[24] was used to define the neurological severity. Roentgenographic findings were recorded according to the formal reports of radiologists on the charts.

Follow-up of survival was done by linking the data to the death registration system of the Bureau of Vital Statistics of the Taiwan Provincial Department of Health, which is in charge of the death registration system in Taiwan. Every citizen in Taiwan is assigned to a unique identification number at birth, which makes the linkage possible. For each death, detailed demographic information, including sex, date of birth, date of death, cause of death, place of death, and residential district (municipality) is recorded. The International Classification of Disease, Injury, and Causes of Death, 9th Revision, Clinical Modification is used to code the cause of death. The system has been completely computerized since 1971. In order to improve the accuracy, we used both the identification number and birth date for linkage.

Data analysis was done by dividing all eligible subjects into two subgroups on the basis of age at injury, using 50 years as a cut point. Differences in categorical data were determined using Chi-square analysis. Student's *t*-test was used for continuous data. Estimation of survival was done using life table analysis. Cox proportional hazards model was chosen to assess the influence of predictor variables on survival as was similarly conducted in some follow up studies of people with SCI.[17,18,25] Deceased or alive was used as the dependent variable. The independent variables entering the model included age at injury, gender, and completeness of quadriplegia on discharge. A P value less than 0.05 was used as the significant level. The assumption of proportional hazards, that the ratio of the hazard rates remains constant over time, was tested using the 'log(−log)' plot for each factors studied. All the statistics were analyzed using the SAS® package.

Results

Demographic and injury variables

The male/female ratio was 4 : 1. The average age was 39.5 ± 16.2 years (range: 11–75) with the peak age distribution at 20–29 years (23.0%), followed by 30–39 years (20.4%). One hundred and nine quadriplegics, about 57.1% of all patients with SCI hospitalized during this period, were included in the present study.

The average age at onset of 109 cervical cord injured patients was 45.1 ± 16.3 years (range 11–75). Male patients accounted for 86.2% of the sample. Forty-seven (43.1%) subjects were 50 years or older. Information on the demographic and injury variables

Table 1 Comparison of demographic characteristics and other determinants of outcome in cervical cord injury patients stratified by age

	Age (years old)		
	>50	*⩾50*	P *value*
Number of cases	62	47	
Percentage of males	87%	85%	>0.1
Causes of injury			<0.001
Traffic accident	62.9%	44.7%	
Minor falls	4.8%	38.3%	
Fall from heights	12.9%	10.6%	
Others*	19.4%	6.4%	
Associated injuries			
Traumatic brain injuries	9.7%	0%	
Limb fractures	17.7%	2.2%	
Other injuries	6.5%	6.4%	
Roentgenographic findings			
Spinal injury			
Fracture with/without dislocation	62.9%	34.0%	0.003
Herniation of intervertebral disc	24.2%	27.7%	>0.1
Associated findings			
Spondylosis	17.7%	70.2%	0.001
OPLL**	11.3%	31.9%	0.008
Ankylosing spondylitis	1.6%	4.3%	>0.1
Duration from onset to admission to rehabilitation ward (months)	1.6 ± 1.5	1.3 ± 1.0	>0.1
Surgical intervention	72.6%	57.5%	>0.1
Completing rehabilitation	96.8%	85.1%	0.04
Average rehabilitation stay for completion cases (days)	79.6 ± 38.0	75.8 ± 41.1	>0.1

*Including diving injuries, penetrating injuries and act of violence. **OPLL indicates ossification of posterior longitudinal ligament. ***Including only those completing rehabilitation

are summarized and stratified by age in Table 1. Motor vehicle accident was the most frequent cause of cervical cord injuries in both groups. The older group had significantly more incomplete quadriplegia, more frequently caused by minor falls, and had less associated injuries. No older subjects incurred diving or penetrating injuries. Central cord syndrome was observed in 14.5% and 21.3% of younger and older patients, respectively. Two younger subjects presented with Brown-Sequard syndrome, which were due to penetrating injuries.

Acute and rehabilitative care

More older patients received acute care in the same university hospital (46.8% *vs* 53.2%) but the difference was not statistically significant. A higher proportion of younger patients received surgery for their cervical cord injuries. There was no difference in length of stay in rehabilitation wards for the different age groups. A significantly smaller proportion of the older group completed the course of rehabilitation. The length of stay for those completing rehabilitation was similar between the two groups, as shown in Table 1.

Roentgenographic findings

Computed tomography (CT) and/or magnetic resonance image (MRI) examination for cervical injuries was received by 69.4% in the younger group and 87.2% in the older group, and results of radiological findings are also shown in Table 1. Spinal fracture with or without dislocation was more common in younger patients (62.9% *vs* 34.0%). Fracture sites most frequently observed were between C5 to T1, occurring in 82.0% of younger patients and 70.51% of older patients. Fracture at C1-2 was noted in two younger and one older patient. Injuries in older patients were more frequently associated with spondylosis and ossification of the posterior longitudinal ligament. Injuries in one younger and two older patients were associated with ankylosing spondylitis.

Outcome on discharge

A similar proportion of patients classified as Frankel D could achieve functional ambulation with or without a device in both groups (73.9% *vs* 63.6%). Regarding bladder control, five younger patients and five older ones had indwelling catheterization or permanent cystostomy upon discharge. The majority of these patients were discharged to home.

Follow up of mortality

All except one subject with a missing identification number were linked to the death registration database from 1989 to 1998. Eleven (10.2%) were deceased

accordingly. The overall mortality was 3.2% for younger patients and 19.6% for older individuals with an average follow-up of 5.3±2.5 years (range: 1.1–9.9). Using life table analysis, the estimate of survival is shown in Figure 1. The results are based on stratification of age at onset. The causes of death, as shown in Table 2, are most frequently from neoplasm.

Cox regression

The results are summarized in Table 3. Only age at injury was found to be a significant factor with a risk ratio of 6.27 for older subjects in comparison with those injured at the age less than 50 years.

Table 3 Cox proportional hazards model for mortality with all the following factors entering the model simultaneously

	Risk ratio	*95% Confidence interval*	P value
Gender			
Female	1.00	–	
Male	0.64	0.13–3.07	0.64
Completeness of quadriplegia			
Incomplete	1.00	–	
Complete	1.17	0.14–9.54	0.88
Age at onset			
Younger than 50 years	1.00	–	
50 years or older	6.27	1.33–29.5	0.02

Discussion

This was a rehabilitation-ward-based study, focusing on follow-up of cervical cord injured patients. In the sampled population, the clinical pictures were not quite the same as previous reports.[4,8,10] First, the ratio of male patients was similar in both younger and older groups (87% *vs* 85%). In contrast, most other researchers reported a predominance of females in the elderly.[1,7–10] Second, traffic accidents, rather than falling, were the most frequent external cause of injury in older people. The major reason might be the bias of a sample from hospital-based study. This study collected cases from a rehabilitation unit, while previous studies usually sampled cases in spinal centers or acute care units. In the present study, all the patients were either from acute wards of the same university hospital or from other acute care hospitals. Patients who died in the acute phase or who had very mild neurological deficits would not be recruited. In addition, only patients with the motivation to receive further rehabilitative programs would be here. Therefore, caution should be taken when generalizing the results of our data to all the cervical cord injuries.

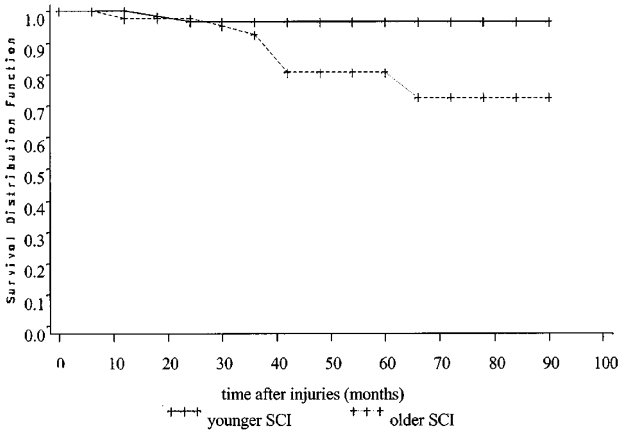

Figure 1 Survival estimates by life table analysis of 108 cervical cord injuries stratified by age

Table 2 Numbers and causes of death followed up by linkage to death registration system

*ICD-9 Code**	*Cause*	*Younger group*	*Older group*
001-139	Infectious and parasitic diseases	–	1
140-239	Neoplasm	–	3
240-279	Endocrine/nutritional/metabolic and immunity diseases	–	1
460-519	Diseases of the respiratory system	–	1
520-579	Diseases of the digestive system	1	1
780-799	Symptoms, signs and ill-defined conditions	–	1
800-999	Injury and poisoning	1	1

*ICD-9 Code indicates *International Classification of Diseases, 9th revision, Clinical Modification*

Falls on level surfaces were the second leading cause of injuries among the elderly in our study. It was well demonstrated by several studies that a minor fall was the most frequent cause of injuries in the aged with SCI.[3,4,8] Quadriplegia resulting from minor falls in the elderly were frequently incomplete and could be easily overlooked.[26] Central cord syndrome was quite common among these individuals. Weingarden and Graham reported that 64.9% cases presented with central cord syndrome in older people with SCI caused by falls.[26] In the study of Penrod *et al*,[21] 30% of their patients with central cord injuries resulted from falls. We had 21.3% of older patients present with central cord syndrome. The high risk of falling in this group may be due to subclinical proprioceptive impairment, poor eyesight, cardiac disease, consumption of alcohol or usage of medication.[26] This implied that a different strategy in the prevention of SCI should be advocated in the older population.

Some researchers reported high incidences of upper cervical injuries, especially odontoid fracture, in the older group.[10,12] Such a finding was not observed by other studies or ours, however.[9,27] Only two younger and one older patient had C1-2 fracture according to

our results. A relatively high proportion of older patients (66.0%) could not be identified with any significant bony destruction. Similarly, Subbarao *et al*[7] reported 60% patients without X-ray evidence of fracture or dislocation. However, herniation of intervertebral disc, a finding unable to be identified by plain X-ray, occurred in about one quarter of patients in both groups of our subjects. In such cases, MRI and CT could help by providing more detailed radiological findings. MRI could be more effective in demonstrating spinal cord pathology and intervertebral disc herniation, while CT was superior in demonstrating osseous injury.[28]

How can such a minor fall causing no bony destruction result in cervical cord injuries? A possible contribution might come from the preexisting degenerative change of cervical spine, which renders the spinal cord vulnerable to minor injuries in an already stenosed canal.[8,10] Spondylosis, ankylosing spondylitis and ossification of the posterior longitudinal ligament (OPLL) were relatively prevalent in elderly patients of our study, which was also found in other SCI series.[8,10] OPLL is a prevalent spinal pathology in oriental people,[29] with a reported prevalence of 2.8% in Taiwan based on a review of cervical spine radiographs.[30] Minor trauma may cause quadriplegia or quadriparesis in these patients.[29,31] It occurred in 31.9% of older patients and 11.3% in the younger group according to our study, which was higher than the 6.5% reported by Endo *et al*.[32] Although OPLL might be silent, it has been suggested that such patients must be educated to avoid even minor injuries at any cost.[33]

We used the death registration system to follow up the survival status. Since it is mandatory to register death certificates at local household registration offices and the household registration information is verified annually through a door-to-door survey, the death registration in Taiwan is extremely complete. Although causes of death may be misdiagnosed and/or misclassified, the problem has been minimized through the improvement in the verification and classification of causes of death in Taiwan from 1971. One subject in our database was lost to follow-up due to incomplete ID on chart. To further minimize errors in linkage, we linked the data by both ID and birth date. As the annual emigration rate for people in Taiwan (an island) is low, the incompleteness of follow-up would be minimal.

The overall majority was significantly higher in older patients (19.6% *vs* 3.2%) after an average follow-up period of 5.3 years. In the studies of Alander,[27,34] who followed cervical injured patients older than 50 years, the early mortality (less than 4 months) was 23%; while the intermediate mortality (5.5 years on average) was 100% for complete cord injuries and 50% for incomplete injuries. Comparatively, DeVivo *et al*[11] reported the 2-year survival rate to be 59% among people with SCI of 60 years or older. The difference in mortality should be interpreted bearing in mind differing study population characteristics, research designs and analytical methods.[15] We conducted the studies in rehabilitation wards, where patients had survived the acute phase of high mortality. Thus it would make survival appear more favorable. However, it also implied that cervical cord injured patients discharged from rehabilitative wards had a relatively good survival and deserved more effort on follow-up care. Improving the quality of life is important while setting goals of treatment for those surviving in both age groups.[25]

According to the results of the Cox proportional hazards analysis in the present study, age at onset was the only significant determinant of mortality on follow-up, and neurological completeness of quadriplegia did not reach a significant level for prediction of survival. Similarly, Samsa *et al*[35] reported that the contribution of age might even overcome that of neurological severity. However, the limitation of small sample size in the present study, especially in the group of complete quadriplegia, was one possible reason. In addition, we included only cervical cord injured patients, which might lead to different results in comparison with the other SCI cohorts.

Conclusion

The clinical pictures were different between people with cervical cord injury onset at different ages in our rehabilitation wards. The older patients sustained more falls on level ground, and more incomplete quadriplegia. A smaller proportion of spinal bony destruction was observed in older individuals. Coexisting spinal pathology, such as spondylosis or OPLL, was common in the elderly, which might contribute to their cervical cord injuries. These two groups showed significantly different survival curves on follow-up and age at onset was found to be the only significant predictor according to the proportional hazards model. Future preventive strategies should take these factors into consideration.

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