Standardized Indices of Mortality among Persons with Spinal Cord Injury: Accelerated Aging Process

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Abstract: We conducted this study to compare survival rates and morbidity of persons with spinal cord injury (SCI) versus general population, and to clarify the risk of SCI persons. The subjects of this study were 960 men with SCI who had been accommodated in the eight Labor Accident Rehabilitation Centers in Japan during the period of 1965–1995. The surveyed items were the year of birth, the year of injury, level of spinal cord injury and survival status. The classification of cause of death was taken from ICD-10. The cumulative survival rate by life table method was calculated. In order to compare the risks of each cause of death in SCI persons with general population, cause-specific standardized mortality ratio (SMR) was examined. The leading cause of death was malignant neoplasms at 28 persons, and SMR (general population=100) was 184, followed by the circulatory system disease, external cause (including suicide) and the genitourinary system disease. In the subgroups of malignant neoplasms, the SMR was 6,619 for cutaneous carcinomas and 1,482 for bladder carcinomas ($p<0.01$). Thus aging-related diseases which had close correlation with life-style and environment were the major cause of deaths in SCI persons.

Key words: Spinal cord injury, Mortality, Cutaneous carcinoma, Bladder carcinoma, Heart disease, Suicide

Introduction

Health management of persons with spinal cord injury (SCI) improved dramatically in the last several decades. In the past, representative complications of the spinal cord injury were decubitus and urinary tract infection, and death by renal failure was the primary cause of death in paraplegics. The improvement of bladder control such as intermittent aseptic catheterization in acute phase, and self-catheterization in chronic phase^{1–4)} had resulted in a decrease of such complications as urinary tract infections, hydronephrosis and renal failure. Recently, it is suggested that circulatory diseases caused by arteriosclerosis and diabetes mellitus have been increasing among paraplegics^{5–12)}. Also though data collected during clinical case studies suggested that SCI persons were at higher risk of contracting bladder and

cutaneous carcinoma¹³⁾, there were no established studies which compared the mortality rate of the SCI persons with the general population. We conducted this study in order to compare the survival rates and the mortality of long-term SCI persons versus general population, and to clarify the risks of complicated diseases on SCI.

Methods

Subjects: The subjects of this study were 960 men with SCI from labor accidents, who were accommodated in eight Labor Accident Rehabilitation Centers in Japan during the period of 1965–1995. The objective of the centers is to help persons resume their works and social life, and to find a new work. Subjects are provided with some income for work (2–5 h/d) from the centers. Many live in dormitories where meals are provided, although some live at home. In the time of investigation, residents in the centers were 247

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persons. They can carry on their daily lives, using wheel chairs at and away from work. The number of females with SCI by labor accident was too small for accurate statistical analysis, so females were excluded from the study.

Survey Procedure

Survival data analysis

The year of birth, the year of injury, period of residency in the Workshops, level of spinal cord injury and survival status were investigated. In cases of death, the date and cause of deaths were surveyed from the charts of the Workshops. The classification of cause of death was used according to the 10th International Classification of Disease (ICD-10)⁽¹⁴⁾.

Calculation

The survival rate analysis was determined for 960 persons with SCI. The cumulative survival rate by life table method was calculated using PC SAS version 6.11 (Proc Lifetest). Comparison was made with normal population statistics using the 1995 life table of the general population in Japan⁽¹⁵⁾. The start of the observation of each subject with SCI was the initial time of residency in the Workshops. The effects of age at time of injury and severity of injury were examined as the affecting factors on survival time. Proportional-hazards regression analysis was used to identify items having a statistically significant effect⁽¹⁶⁾. Additional stratified life-table analysis was carried out based on the proportional-hazards regression analysis findings. Significance was calculated using a log rank test.

Cause-specific standardized mortality ratio

In order to compare the risks of each cause of death on SCI persons with general population, standardized mortality ratio (SMR) was examined. SMR was calculated to divide actual mortalities of persons with SCI by the expected mortality of the general population. The standard death rates were based on the vital statistics 1995 of general population of Japan⁽¹⁷⁾. The significance of SMR was examined by applying normal distribution, but in case of a subject group with less than 10 persons, a probability test based on the Poisson distribution was carried out.

Results

Background of the subjects

The distribution of type of SCI and age at injury was presented in Table 1. The average age of injury was 30.1

Table 1. The distribution of type of spinal cord injury and age at injury

level of injury	number of subjects	percent (%)
C-T5	93	9.7
T6-T10	112	11.7
T11-L1	637	66.3
L2-	72	7.5
Undetermined	46	4.8
Total	960	100

C: cervical vertebra, T: thoracic vertebra, L: lumbar vertebra.

age at injury	number of subjects	percent (%)
15–19 years old	91	9.5
20–29	422	44.0
30–39	284	29.6
40–49	131	13.6
50–59	33	3.4
Total	960	100

and standard deviation (SD) was 9.2 yr old, the average age of initial entry into the centers was 36.9 (SD=10.1) yr old. Total fatalities were 118, and average age of death was 54.6 (SD=10) yr old. Average duration from the time of injury to entrance into the centers was 6.8 yr, so the cumulative survival rate of persons with SCI who exceeded the average of 6.8 yr after injury was calculated.

Cumulative survival analysis

The age at injury was classified by 10 yr into five age groups (injury cohort). Figure 1 presents survival rates at each age for SCI by injury cohort. When benchmark age for comparison was set at 70 yr of age, the survival rate for the injury cohort of twenties showed 30%. Meanwhile survival rate for the general population was 75%, then calculated difference was 45%. The difference indicates the excess death due to SCI. Figure 2 showed survival rates at years after injury by injury cohort. Survival rates for injury cohorts of forties and fifties were lower than the younger injury cohorts at same age by log rank test ($p<0.05$). Regarding the site of injury, rates for each of the 5 groups of SCI persons presented similar values resulting in no appreciable differences between the groups.

Mortality and Cause Specific Standardized Mortality Ratio (SMR)

To compare with the mortality of general population, a SMR (general population=100) was calculated (Table 2).

Fig. 1. Survival rates at each age for SCI males by injury cohort.

Fig. 2. Survival rates for SCI males by years after injury by injury cohort.

The SMR of total mortality showed 280, which means the total mortality is 2.8 times higher than the general population. The leading cause of death according to major classification of the ICD10 was neoplasms in 28 persons (SMR=184), followed by circulatory system disease (258), external cause (291), disease of genitourinary system (3,920), certain infectious and parasitic disease (1,288). The SMRs according to detailed classification were 249 at heart diseases and 513 at suicide. In complications of SCI, SMR showed extremely high figures, such as 6,827 for septicemia that was mainly a result of decubitus, because the value of general population was small. Also the SMR of renal failure showed 3,739. All of the above SMRs were significant at the 1% level.

In the subgroups of malignant neoplasms, the SMR was 6,619 for cutaneous carcinomas and 1,482 for bladder carcinomas, which were recognized as significant at the 1%

level by a probability test based on Poisson distribution (Table 3). All 3 cases of cutaneous carcinoma were described as generating from decubitus. Liver carcinoma was the prominent cause of neoplasm mortality and the SMR presented 251 ($p<0.05$).

Discussion

We have considered that long-term SCI accelerates the aging process, especially the prognosis of vascular disease resulting from arteriosclerosis, and some kind of malignant neoplasms. As Menter¹⁸⁾ described that SCI is one form of instant aging: persons with SCI might become vulnerable to further injury in multi-systems. In our study, the SMR of total death in long-term SCI was 2.8 times higher than general population ($p<0.01$). Regarding the survival rate by age at

Table 2. Standardized Mortality Ratio (SMR) by causes of death in patients with spinal cord injury for a long time

ICD code	causes of death based on international classification of diseases (10th revision)	number of death	SMR
02000	neoplasms	28	184 **
02100	malignant neoplasms	26	175 **
09000	diseases of the circulatory system	24	258 **
09200	heart diseases	12	249 **
09300	cerebrovascular diseases	12	301 **
20000	death by external causes	18	291 **
20101	traffic accident	4	126
20200	suicide	14	513 **
14000	diseases of the genitourinary system	15	3920 **
14200	renal failure	13	3739 **
01000	infectious or parasitic diseases	12	1288 **
01300	septicemia	10	6827 **
10000	diseases of the respiratory system	6	269 *
10200	pneumonia	2	176
11000	diseases of the digestive system	5	189
11200	hernia	3	3326 **
06000	diseases of the nervous system	1	239
	total death	109	280 **

**: $p < 0.01$, *: $p < 0.5$.

Table 3. Details in SMR of malignant neoplasms in patients with spinal cord injury for a long time

ICD code	primary site of malignant neoplasms based on ICD10	number of death	SMR
02103	stomach	2	68
02105	colon	3	176
02106	liver	7	251 *
02108	pancreas	3	340
02110	trachea, bronchus and lung	3	121
02111	skin	3	6619 **
02116	bladder	2	1482 **
02120	lymph and hematopoietic tissue	3	359

**: $p < 0.01$, *: $p < 0.5$.

injury, it indicated especially lower in injury age groups over 40-yr-old than the younger injury age groups. The result is consistent with the interpretations by Whiteneck¹¹⁾. The difference might be caused by the aging process that occurred before injury which reduced the resilience of the individual to adapt to the changes brought by SCI^{19, 20)}. Regarding level of spinal cord injury, any difference was not detected. The reason is considered that almost all of SCI above T5 were incomplete paralysis, contrary SCI lower than T6 were mostly complete paralysis.

The mortality rate of persons with longstanding SCI seems

to stem from secondary complications of SCI. The SMRs of septicemia resulting from decubitus complications and that of renal failure were extremely high, 6,827 and 3,739 respectively. Decubitus and renal failure have been decreasing, but they are still the most primary complications. Soden²¹⁾ described high incidence of death caused by septicaemia, pneumonia, diseases of urinary system and suicide in long-term SCI. Furthermore decubitus and urinary tract complications might promote the carcinogenesis in each lesion. The SMR of cutaneous carcinoma developed from decubitus lesion was extremely high as 6,619 ($p < 0.01$), also

bladder carcinoma showed a high SMR at 1,482 ($p < 0.01$). Thus cutaneous carcinoma and bladder carcinoma are considered to be complications of SCI. West²²⁾ suggested the association between bladder malignancy and indwelling catheterization. Zeling²³⁾ described the causes of deaths among SCI after 50 yr follow-up, the top was cardiovascular, and the second was neoplastic diseases.

The second cause of death based on our research was circulatory diseases. The SMR of heart disease was 249 ($p < 0.01$), and that of cerebrovascular disease was 301 ($p < 0.01$). Especially an increase of ischemic heart disease is anticipated in the future, because the frequency of hypertension and diabetes mellitus in SCI persons were higher than those of general population (2.5 times and 3 times higher, respectively) in our previous study²⁴⁾. In the background, the prognosis of arteriosclerosis is influenced by the glucose intolerance. Glucose intolerance may be due in part to the atrophy in large mass of muscle and decrease of physical activity, both of which may promote insulin resistance and cause carbohydrate metabolism abnormality^{25–30)}. With careful management of caloric intake and a physical fitness, an improvement in these complications is expected. However, there are no proper guidelines for nutritional assessment and physical fitness standards for paraplegics and tetraplegics, further studies should be devoted to these areas.

The third cause of death was external cause, suicide and accident. In accidental deaths, suspected cases for suicides were included. In this backgrounds, the metabolic changes of the central nervous system shown as a decrease of urinary tryptamine^{31, 32)} in SCI are suspected. One reason explaining depression on SCI is serious psychosocial difficulties inherent in a long-term SCI. Another reason is endocrinological and neurogenic change due to paralysis.

The problem of this survey is the use of the death statistics in 1995 alone as the standard population for the calculation of SMRs, while observed data were from 1965 to 1995. The reason of this procedure is the adoption of ICD10 in this study. Precisely the calculation of SMRs by summation of deaths from 1965 to 1995 for standard population by using ICD9 should be done. This paper has a limited interpretation of the situation of death analysis. However, the trend of deaths in SCI persons is conspicuous and this result is to provide valuable information for the health control in SCI persons.

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