

## SURVIVAL IN TRAUMATIC SPINAL CORD INJURY

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**Summary.** The present study was conducted on 1510 persons between 1 December 1973 and 31 December 1980. Of these, 1478 (97.9 per cent) were traced by questionnaire. Of those traced, 1252 were male and 226 were female. There were 194 deaths of whom 160 were male and 34 female. The main causes of death are cardiovascular, renal, respiratory, suicide and neoplastic. Compared with the 1973 study, there has been a marked decrease in deaths due to renal disease and a marked increase in deaths due to suicide and liver disease and the abuse of alcohol. A study of the new deaths allowed one to note a relative mortality rate to be 186 per cent for partial paraplegics, 209 per cent for partial tetraplegics; 318 per cent for complete paraplegics and 767 per cent for complete quadriplegics. The approximate application of these rates to current (1975-77) mortality tables permitted the calculation of theoretically derived life expectation at various ages. These indicated an improved life expectation for all categories.

**Key words:** Traumatic spinal cord injury; Complications; Survival.

THIS STUDY is an extension of three earlier studies previously reported (Breithaupt *et al.* 1961; Jousse *et al.*, 1968; Geisler *et al.*, 1977). All studied life expectancy mortality rate and the causes of death of the spinal cord injured patient. The first (Breithaupt *et al.*, 1961) reviewed 599 persons followed between 1 January 1945, and 31 December 1958, (published in 1961). It revealed genito-urinary sepsis as the chief cause of death and that the death rate of carefully treated spinal cord injured patients was three times that of the Ontario population mortality rate. In each of the four classes of spinal cord injury as defined by the level and completeness of the lesion, life expectancy was reduced when compared to the population mortality rate. It also revealed a dramatic reversal in the death rate over a period of more than a decade, compared to that reported prior to the Second World War. The second (Jousse *et al.*, 1968) reviewed 965 patients followed from 1 January 1945, to 31 December 1966 (published in 1968), the leading cause of death was kidney failure which accounted for 36 per cent of the deaths. Once again it revealed the mortality rate to vary with the extent of the disease and also revealed a modest improvement in life expectancy. The third (Geisler *et al.*, 1977) reviewed 1501 patients followed from 1 January 1945 to 30 November 1973 (published in 1977)—an interval of 29 years.

It included all of those studies on the two previous occasions. Of this number 428 (26 per cent) had died. Renal failure remained the leading cause of death as had been the case historically, however, its relative position

TABLE I  
Actual expected mortality comparison

	1958	1966	1973
Partial paraplegic	195 <sup>0</sup> / <sub>0</sub>	118 <sup>0</sup> / <sub>0</sub>	181 <sup>0</sup> / <sub>0</sub>
Partial tetraplegic	308 <sup>0</sup> / <sub>0</sub>	216 <sup>0</sup> / <sub>0</sub>	223 <sup>0</sup> / <sub>0</sub>
Complete paraplegic	665 <sup>0</sup> / <sub>0</sub>	400 <sup>0</sup> / <sub>0</sub>	464 <sup>0</sup> / <sub>0</sub>
Complete tetraplegic	1758 <sup>0</sup> / <sub>0</sub>	1200 <sup>0</sup> / <sub>0</sub>	1163 <sup>0</sup> / <sub>0</sub>

TABLE II  
Expectation of life (years)  
partial and complete  
tetraplegic

Age	1958	1966	1973
Partial tetraplegic			
20	38	41	41
30	30	32	32
40	22	24	24
50	14	16	16
Complete tetraplegic			
20	15	21	21
30	11	16	16
40	7	10	10
50	3	5	5

TABLE III  
Expectation of life (years)  
parital and complete  
paraplegic

Age	1958	1966	1973
Patial paraplegic			
20	42	45	42
30	34	36	34
40	25	28	25
50	18	22	18
Complete paraplegic			
20	27	34	32
30	20	27	25
40	14	19	19
50	8	12	12

had fallen from 50 per cent in the first study to 30·8 per cent. A comparison of the relative mortality rates of the four classes showed that there had been no improvement in mortality between the second study completed in 1966 and the third study completed in 1973 (Table I).<sup>1</sup>

There was, in fact, some evidence of regression in the partial paraplegic class, possibly the result of the selective referral of more difficult partial lesions of the paraplegic type for management. The third study also revealed a substantially increased mortality within the group for the common causes of death, excepting accidental death, when compared to the population at large. Finally, a comparison of the expectation of life for the partial and complete categories of paraplegics and tetraplegics derived from the relative mortality rates showed no significant improvement had been achieved in the previous decade (Tables II<sup>2</sup> and III<sup>3</sup>).

### Method

The current study was extended to review all patients suffering traumatic spinal cord injury who had been treated at Lyndhurst for rehabilitation and discharged between 1 January 1945, and 31 December 1980. It excluded all exposure and deaths up until 30 November 1973.\* These have been reported previously.<sup>1,2,3</sup> It was from this group that we decided

to look at the new deaths, so as to observe any variance from our observations of 1973. The whereabouts and status of the patients were determined by questionnaire.

A specific rate of mortality for male and female as the case might be depending upon his or her age at the time was added up for each year of exposure to give the expected deaths. The basis was the 1975-77 Province of Ontario Population Mortality rate tables. A table of expected duration of life was then calculated by the Actuarial Department of the Manufacturers Life Insurance Company, Toronto, from this same mortality table, using the relative mortality rates derived from the data.

### Results

One thousand nine hundred and thirty-eight patients had been followed from 1 January 1945, until 31 December 1980. All were traumatic spinal cord injured patients. Of this group 428 had died by the end of 30 November 1973. This left 1510 patients at the outset of the current study. Of this group 32 could not be traced (2.1 per cent); 1478 were located (97.9 per cent). Of those traced 1252 were male and 226 were female. There were 194 new deaths, 160 male and 34 female (Table IV).

TABLE IV  
1 December 1973—31 December 1980

	Male	Female	Total	Deaths	Female deaths	Not traced
Complete tetraplegic	205	26	231	33	2	3
Partial tetraplegic	336	60	396	48	8	13
Complete paraplegic	340	82	422	55	14	5
Partial paraplegic	371	58	429	58	10	11
Total	1252	226	1478	194	34	32

TABLE V  
December 1973—December 1980

	Lives	Life years	Actual	Expected	%	Extra deaths per 1000/years
Tetraplegic						
Complete	231	1174.5	33	4.3	767	24.4
Partial	396	2138	48	22.9	209	11.7
Paraplegic						
Complete	422	2420	55	17.3	318	15.5
Partial	429	2064.5	58	31.2	186	13.5
Total	1478	7797	194	75.7	256	15.2

\*All deaths within 12 months of trauma were excluded, as was all exposure during the year of trauma and half of the exposure during the second year of trauma. Likewise, in the year of death, only half a year's exposure was included.

On the exposure from December 1973 to December 1980, the 1478 lives accounted for 7797 life years of spinal cord injury and 194 deaths. During that time according to the 1975-77 Province of Ontario Population Mortality rate tables 75.7 deaths were expected. This results in a relative mortality rate of 2.56 (256 per cent) and can be expressed as 15.2 extra deaths per 1000 life years for the overall group (Table V). The female deaths, 34 in number, showed mortality similar to the total group.

Furthermore, the table categorizes the patients according to the level and completeness of the lesion. The following are noted:

1. Complete tetraplegics: There were 231 lives with 1174.5 life years of exposure. Thirty-three deaths were experienced when 4.3 were expected. This gave a relative mortality rate of 7.67 times normal (767 per cent) and can be expressed as 24.4 extra deaths per 1000 life years.
2. Complete paraplegics: There were 422 lives with 2420 life years of exposure. Fifty-five deaths were experienced when only 17.3 were expected. This gave a relative mortality rate of 3.18 times normal (318 per cent) and can be expressed as 15.5 extra deaths per 1000 life years.
3. Partial tetraplegics: There were 396 lives with 2138 life years of exposure. Forty-eight deaths were experienced when 22.9 were expected. This gave a relative mortality rate of 2.09 times normal (209 per cent) and can be expressed as 11.7 extra deaths per 1000 life years.
4. Partial paraplegics: There were 429 lives, giving 2064½ life years of exposure. Fifty-eight deaths were experienced when only 31.2 were expected. This gave a relative mortality of 1.86 times normal (186 per cent) and can be expressed as 13.5 extra deaths per 1000 life years.

The age of distribution at the time of the trauma is shown in Table VI. This reveals that over 75 per cent of the incidence occurs in the second to fourth decades of life. The peak incidence continues to be in the third decade, as previously noted.<sup>3</sup> An analysis of the age distribution based upon the percentage of life years of exposure shows the predominant exposure to have been in the 3-5th decades (Table VII).

TABLE VI  
Age at time of trauma

Age (years)	N	%
0-9	1	0.6
10-19	279	18.8
20-29	593	40.1
30-39	277	18.8
40-49	163	11.0
50-59	114	7.7
60+	51	3.5
	1478	99.96

## PARAPLEGIA

TABLE VII  
Exposure December 1973—December 1980, study (% of life years)

Age (years)	Complete tetraplegia	Complete paraplegia	Partial tetraplegia	Partial paraplegia
0—9	0	0	—	0·1
10—19	2·4	1	2·3	1·2
20—29	33·1	19	19·5	12·3
30—39	31·3	22·9	20·6	18·5
40—49	19·4	27·4	23·2	23·3
50—59	10·8	18·3	16·6	24·7
60—69	2·5	8·9	11·5	12·9
70—79	0·5	2·3	5·2	4·9
80—89	0	0·2	0·9	2·0
90+	0	0	0·2	0·1
	100 <sup>0</sup> <sub>0</sub>	100 <sup>0</sup> <sub>0</sub>	100 <sup>0</sup> <sub>0</sub>	100 <sup>0</sup> <sub>0</sub>

TABLE VIII  
Mortality years after trauma: complete tetraplegic

	Life years exposure	Deaths	Expected deaths	%	Extra D/M
2—5th years	284	10	0·73	1357	32·6
6—10th years	318·5	5	0·85	585	13·0
11—15th years	242	2	0·56	351	5·9
16+ years	330	16	1·98	805	42·4

TABLE IX  
Mortality years after trauma: partial tetraplegic

	Life years exposure	Deaths	Expected deaths	%	Extra D/M
2—5th years	400	5	2·6	186	5·7
6—10th years	455	6	2·9	205	6·7
11—15th years	450	10	4·5	219	12·1
16+ years	833	27	12·7	211	17·1

It is interesting to note that the younger years predominate in the more severe lesions and the older years in the less severe lesions.

Considering the number of years after the trauma, if one divides the mortality according to the years of duration of spinal injury then one has an opportunity to note where the extra mortality is.

1. Complete tetraplegics: (3 of 231 lives were not traced) (Table VIII).

TABLE X  
Mortality years after trauma: complete paraplegic

	Life years exposure	Deaths	Expected deaths	%	Extra D/M
2-5th years	332	4	0.9	418	9.1
6-10th years	506	12	2.2	528	19.2
11-15th years	408.5	8	2.3	335	13.7
16+ years	1173.5	31	11.6	265	16.4

TABLE XI  
Mortality years after trauma: partial tetraplegic

	Life years exposure	Deaths	Expected deaths	%	Extra D/M
2-5th years	325.5	3	1.1	258	5.6
6-10th years	459	8	3.0	263	10.8
11-15th years	384.5	7	4.4	156	6.4
16+ years	1269	40	22.2	179	13.9

TABLE XII  
Deaths

	1973	1980
Renal	30.8	15.3
Cardiovascular	20.4	19.6
Respiratory	12.2	13.9
Neoplastic	9.8	9.8
Cerebrovascular	6.8	4.6
Suicide	4.2	10.8
Liver/Alcohol	1.2	4.1
Other	15.6	26.9
Total	100.0%	100.0%
Total deaths	428	194

- The mortality is high in the 2-5th year and in the 16th and over years and it is lower in the 6-10th and 11-15th years after trauma.
2. Partial tetraplegics: (13 of 409 lives were not traced) (Table IX). The mortality is a little higher between the 11th and 15th and beyond the 16th years.
  3. Complete Paraplegics: (5 of 427 lives were not traced) (Table X). The mortality is a little higher from the 6-10th year. The mortality is relatively constant in all durations.
  4. Partial paraplegics: (11 of 440 lives were not traced) (Table XI). The mortality appears to be higher in the 6-10th year after injury and also beyond the 16th year.

5. These figures indicate that there is extra mortality in all duration. It is especially high in the complete tetraplegics from the 2–5th years—and in the complete paraplegics from the 6–10th years and again in both complete categories after the 16th year.

Table XII compares the incidence of the common causes of death in 1973 and present study.

Concerning the 1980 deaths, the category 'other' included deaths from the following causes—homicide; accidents; diabetes; incarcerated ventral hernia; perforated bowel; infections of bone and decubiti; septicaemia; G.I. hernia, bowel necrosis and gangrene of the gallbladder. The renal deaths were attributable to pyelonephritis, uremia, amyloidosis, and iliac conduit surgery, complicated by peritonitis. The cardiovascular deaths included myocardial infarction; heart failure, cardiac arrest; myocarditis; pulmonary embolism; mesenteric thrombosis; aortic stenosis and ruptured abdominal aneurysm. The respiratory deaths included pneumonia, pulmonary oedema; respiratory failure and death due to chronic obstructive lung disease.

It is known that the commonest causes of death in the normal population, excluding accidental causes, are heart disease; cancer; suicide and respiratory disease.

Table XIII reveals the actual incidence of these causes in the spinal injured and compares them to the expected incidence in the normal population. Renal diseases have been excluded.

What appears significant following an analysis of Tables XII and XIII is the marked decrease in deaths due to renal disease, and a marked increase in deaths due to suicide, liver disease, and an abuse of alcohol. A constant incidence of deaths due to cardiovascular, respiratory and neoplastic disease is noted. Regarding deaths due to neoplastic disease, the organ distribution is widespread: lung (five), G.I. (five), pancreas (two), and one instance each of metastatic, abdomen, breast, gallbladder, nasopharynx, vulva, lympho-sarcoma, and leukaemia. The data does not now suggest that the spinal

TABLE XIII  
Commonest causes of death (excluding renal)

	Complete tetraplegia 231		Complete paraplegia 422		Partial tetraplegia 396		Partial paraplegia 429	
Actual deaths	33		55		48		58	
Expected deaths	4.3		17.2		22.9		31.2	
	Actual	Expected	Actual	Expected	Actual	Expected	Actual	Expected
Respiratory disease	11	0.3	7	0.7	6	1.0	3	1.1
Heart disease	4	1.4	12	7.7	8	9.8	14	12.7
Suicide	4	1.0	4	2.4	5	2.1	8	2.4
Cancer	3	1.3	6	6.1	6	6.7	4	8.7

TABLE XIV  
Expectation of life (years) partial and complete tetraplegic

Age	1973	1980
Partial paraplegia		
20	41	44
30	32	36
40	24	27
50	16	18
Complete paraplegia		
20	21	30
30	16	23
40	10	15
50	5	9

TABLE XV  
Expectation of life (years) partial and complete paraplegic

Age	1973	1980
Partial paraplegia		
20	42	46
30	34	37
40	25	28
50	18	19
Complete paraplegia		
20	32	40
30	25	32
40	19	23
50	12	15

injured population are at a significantly increased risk to the development of cancer as had been earlier supposed.

Based upon the present relative mortality rates related to the level and completeness of the lesion, a table of theoretical or derived expectation of life was tabulated by the Actuarial Department of the Manufacturers Life Insurance Company at ages 20, 30, 40 and 50 years, using the 1975-77 Province of Ontario Population Mortality rate tables. These figures appear in Tables XIV and XV where they are compared with the earlier study. These tables indicate an improved life expectation for all categories regardless of the level of the lesion or the degree of completeness of the lesion.

### Discussion

Our patients were not treated with intermittent catheterisation except in a



few instances. This data reveals that spinal cord injured patients who have been discharged from a rehabilitation hospital continue to have a higher mortality rate than the population at large. It is highest for the complete lesions and lower for the partial lesions. In the complete category it is still very high for the tetraplegic (767 per cent). Nevertheless, comparing the relative mortalities now (1980) with those which were obtained in the study of 1973, mortality is down (excepting partial paraplegics, where it is relatively constant) and life expectancy has been prolonged. This is especially so in the complete lesions. That the incomplete categories do not appear to have been as greatly advantaged with time and treatment may point to their starting out better to begin with, or to the importance of even a small amount of continuity of spinal cord function in allowing the body a more normal homeostasis. This might offer a correspondingly more favourable protection against the risks leading to death. Accordingly their relative mortality rates are closer to those of the normal population. The continued high rates for the complete categories are not unexpected. However, it is gratifying to see a decline from earlier observations.

In looking for an explanation one is struck by the large decrease in deaths due to renal disease. Mindful that intermittent catheterisation was not practiced in the vast majority, we would speculate the following:

Perhaps improved knowledge in the fields of antibiotics, renal dialysis and in medical and surgical expertise, may be of significance. Furthermore, the educational impact of rehabilitation may be bearing fruit. Perhaps patients and their attendants and life associates are learning more about the prevention of complications and applying those lessons well.

It seems unlikely that the spinal population is at any greater risk of death due to heart disease or cancer than the population at large. However, deaths due to respiratory disease and suicide are alarmingly high when compared to the normal population and would appear to be significantly so. These require further attention, as do deaths from liver disease and the abuse of alcohol.

### **Conclusion**

Mortality has been decreased and life expectation prolonged in traumatic spinal injured patients.

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### **RÉSUMÉ**

L'étude actuelle a été effectuée sur 1510 personnes entre le 1er décembre 1973 et le 31 décembre 1980. D'entre celles-ci, 1478 (97,9 pour cent) ont été tracées par questionnaire. Des personnes qu'on a tracées, 1252 étaient mâles et 226 femelles. Il y a eu 194 morts dont 160 étaient mâles et 34 femelles. Les causes principales de mort sont d'origine

cardio-vasculaire, rénale, respiratoire et néoplastique ainsi que la suicide. En comparaison avec l'étude entreprise en 1973, il y a eu une diminution marquée des morts dues aux maladies rénales et une augmentation marquée des morts dues à la suicide, aux maladies du foie et à l'abus de l'alcool. Une étude des nouvelles morts a permis de noter que le taux de mortalité relatif est de 186 pour cent pour les paraplégiques partiels, de 209 pour cent pour les tétraplégiques partiels, de 318 pour cent pour les paraplégiques complets, et de 767 pour cent pour les quadriplégiques complets. L'application approximative de ces taux aux tableaux de mortalité actuels (1975-77) a permis la calculation de l'espérance de vie théoriquement dérivée à des âges divers. Ces chiffres indiquaient une espérance de vie améliorée pour toutes les catégories.

#### ZUSAMMENFASSUNG

Die jetzige Untersuchung betraf 1510 Personen, und wurde zwischen dem 1. Dezember 1973 und dem 31. Dezember 1980 durchgeführt. Aus diesen Personen sind 1478 (97.9 Prozent) durch Fragebogen nachgesucht worden. Aus den Nachgesuchten waren 1252 männlich und 226 weiblich. Es waren 194 Todesfälle wovon 160 Fälle männliche und 34 weibliche Personen betrafen. Die hauptsächlichen Todesursachen sind Kardiogefäss-, Nieren- und Atmungskrankheiten, Selbstmord und neoplastische Krankheit. Im Vergleich zu der in 1973 durchgeführten Untersuchung hat sich eine deutliche Verminderung der durch Nierenkrankheit verursachten Todesfälle gezeigt, aber auch eine deutliche Steigung der Todesfälle, die durch Selbstmord, Leberkrankheit und Alkoholmissbrauch verursacht worden sind. Eine Untersuchung der neuen Todesfälle hat es ermöglicht, zu beobachten, dass das relative Sterblichkeitsverhältnis 186 Prozent für die durch teilweise Paraplegie Getroffenen, 209 Prozent für die durch teilweise Tetraplegie Getroffenen, 318 Prozent für die durch völlige Paraplegie Getroffenen, und 767 Prozent für die durch völlige Quadriplegie Getroffenen beträgt. Die approximative Anwendung von diesen Verhältnissen auf die aktuellen (1975-77) Sterblichkeitstabellen hat die Berechnung der theoretisch hergeleiteten mutmasslichen Lebensdauer in verschiedenen Altern ermöglicht. Diese Ziffern zeigten eine verbesserte mutmassliche Lebensdauer für sämtliche Kategorien.

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