Factors contributing to the increased threat to life following spinal cord injury

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An analysis of the mortality rate of 3486 spinal injured patients treated in the early posttraumatic period in the years 1965–1989 in Konstancin, Poland is presented. The data show that the life of the spinal cord injured is threatened by several factors, the most important of which appear to be: the level and degree of the spinal cord lesion; certain causes of injury predisposing to severe nervous system injury; advanced age; and to some extent, concomitant injuries and methods of treatment. The significance of age is demonstrated by a nearly tenfold increase in mortality in the oldest age group of patients with complete spinal cord lesions as compared to the youngest age group of up to 20 years with the same degree of spinal cord damage.

Keywords: traumatic spinal cord injury; mortality.

Introduction

The problem of mortality following spinal cord injury is rarely tackled in medical literature.^{1,2,3} Still less frequently discussed are the causes of death and the factors contributing to this from such causes.^{4,5,6} The usually reported data concern the total mortality rate in the spinal cord injured, regardless of the degree and the level of the spinal cord injury and of the age of the patient. Therefore the mortality rates reported by some authors sometimes show surprising disparities, but do not reflect the value of the actual method of treatment that was provided. The mortality rate may be as low as a few percent in patients with partial injuries involving the lower segments of the spinal cord; and may be 10 times higher in patients with high location complete spinal cord lesion, especially in older patients.^{7,8} Therefore the only comparable groups must consist of patients with similar degrees of spinal cord lesion, and at the same level. Based on a large number of treated patients the author attempts to evaluate the various factors that appear to increase the possibility of death in patients with a spinal cord injury.

Material and methods

To illustrate this problem better an analysis of the mortality of 3486 patients with a spinal injury admitted in the early posttraumatic period (from a few hours to 2 weeks following injury) in the years 1965–1989, is provided. Table I details the clinical material, including the level and degree of the spinal injury, and the number of deaths in the particular groups. It confirms two earlier observations. (1) The mortality is to a large extent dependent upon the level of the spinal cord lesion: in those with cervical spinal lesions it exceeded 15%, in thoracic lesions it was 7.5% and in those with lumbar lesions 2.4%. (2) The mortality rate is largely dependent on the degree of spinal cord injury and amounted to nearly 18% in those with complete injuries, was much lower in those with massive injuries and definitely lowest in those with injuries with the least degree of neurological involvement (0.7%).

The mortality rate was highest in patients admitted with evidence of a complete spinal cord injury, being 29.7%, 9.3% and 4.7% in the cervical, thoracic and lumbar regions, respectively. The remaining tables include

Table I Mortality and the level of the spinal injury

Nervous system injury	Level of spinal injury						Total	Mortality %
	Cervical		Thoracic		Lumbar			
	Alive	Dead	Alive	Dead	Alive	Dead		
Complete								
Frankel grade A	487	206	391	40	326	16	1466	17.9%
Incomplete								
Frankel grade B	195	12	28	1	62	1	299	4.7%
Frankel grade C	312	22	45	3	134	6	522	5.9%
Frankel grade D	368	3	23	1	130	—	535	0.7%
Without neurological involvement								
Frankel grade E	243	—	100	—	321	—	664	0
Total	1605	243	597	45	973	23	3468	8.9%
		(15.1%)		(7.5%)		(2.4%)		

smaller numbers of patients because only those with symptoms of spinal cord injury on admission were included. Table II shows the number of patients who were treated because of injury to particular segments of the spine, and the number of deaths in those with complete and those with partial spinal cord lesions. The number of patients tends to increase in the subsequent periods. The mortality rate in the analysed group of patients was 11%, with a tendency to diminish in the subsequent periods, from 12.6% to 8.8% in the last period.

The most frequent causes of the spinal injuries (Table III) were: falls from a horse-cart (17% of all cases), diving (12%),

automobile accidents (12%), motorcycle accidents (8%), and falls from a ladder or stairs (7%). The mortality rate was highest in: falls from scaffolding (21%), from a horse-cart (20%), from a roof (19%), injuries sustained by pedestrians struck by motor vehicles (16%), and falls from a great height (10%).

The mortality in subsequent age groups in relation to the level and to the degree of spinal cord injury is set out in Table IV. In the first two age groups the mortality is relatively low. The mortality rate increases markedly in those over the age of 40 years, and is nearly tenfold higher in individuals over 60 years of age than in the youngest

Table II Mortality 1965–1989

Injury location	Deaths			
	1965–1973	1974–1981	1982–1989	Total
Cervical	396	445	521	1362
Complete	73	79	54	206
Incomplete	10	16	11	37
Thoracic	114	179	209	497
Complete	13	10	17	40
Incomplete	1	3	1	5
Lumbar	217	238	197	652
Complete	7	5	4	16
Incomplete	1	3	3	7
Total	832	973	1017	2822
Mortality (%)	12.6	11.9	8.8	11

Table III Mortality and the level of the spinal injury

Cause of injury	Injured spinal cord segment						Total	Deaths %
	Cervical		Thoracic		Lumbar			
	Alive	Dead	Alive	Dead	Alive	Dead		
Falls								
Horse-cart	317	82	40	11	28	3	481	20
Diving	298	31	1	—	—	—	330	9
Roof	36	20	46	8	43	2	155	19
Scaffolding	23	13	22	5	36	3	102	21
Ladder, stairs	114	12	24	3	50	3	206	9
Tree	48	7	32	5	70	—	162	7
Suicidal jumps	8	2	23	1	59	1	94	4
From small height	92	5	18	—	34	1	150	4
From great height	32	8	28	2	46	2	118	10
Road accidents								
Automobile	162	26	73	1	66	—	328	8
Motorcycle	51	9	98	5	41	1	205	7
Bicycle	29	2	6	—	4	—	41	5
Pedestrians	39	14	24	1	39	5	122	16
Other	25	2	7	—	20	1	55	6
Compression by a heavy object	41	5	27	—	85	1	159	4
Wounds	2	—	15	1	4	—	22	5
Other causes	45	5	13	2	27	—	92	8
Total	1362	243	497	45	652	23	2822	11

Table IV Age and mortality

Segment	Degree of injury	Age				Total
		0-20	21-40	41-60	Over 60	
Cervical	Complete	103	222	117	45	487
	Deaths	11	44	73	78	206
	Incomplete	106	269	294	209	875
	Deaths	2	2	12	21	37
Thoracic	Complete	68	180	108	35	395
	Deaths	—	8	12	20	40
	Incomplete	22	46	25	13	106
	Deaths	—	2	2	1	5
Lumbar	Complete	46	175	82	23	326
	Deaths	1	4	2	9	16
	Incomplete	46	163	94	23	326
	Deaths	1	—	4	2	7
Total	Complete	229	633	394	210	1466
	Deaths (%)	5	9	22	60	
	Incomplete	177	482	428	269	1356
	Deaths (%)	2	1	4	9	

group. Cervical spinal cord injuries are most frequent and have a higher mortality rate, in particular if the lesion is complete. Even in the youngest group the mortality amounts to nearly 10% and gradually increases with age to over 60% in those aged over 60 years who had been admitted with clinical evidence of a complete cervical lesion.

The leading causes of death, diagnosed partly on the basis of the anatomopathological findings and partly on the clinical data are shown in Table V, together with the level and degree of nervous system injury. The leading cause of death was pneumonia (52%). Pulmonary complications accounted for 74% of total deaths. These complications were understandably most frequent in patients with complete injuries to the cervical spinal cord. In that group alone there were some 13% of deaths caused by primary respiratory insufficiency, usually due to the high location of the complete spinal cord injury with associated diaphragm paralysis and sometimes also with brainstem disturbances and dysfunction of vital centers.⁹ Many patients in this group were brought to hospital with respiratory insufficiency, whilst others developed this within a few hours of the injury.

Next in relevance, although definitely less frequent (8%), was death from abdominal complications (bleeding from the alimentary canal, rupture of gastric ulcers, etc). A slightly less frequent cause of death was severe, irreversible brain injury (6%), usually accompanied by injury to the cervical spinal cord. Pneumonia was also the most commonly observed complication in those with complete thoracic and lumbar lesions (35–31%).

The final table (VI) shows the survival time with regard to the most frequent causes of injury. The average survival time in the analysed group was 26.3 days, but varied greatly. In the first week after injury the mortality rate amounted to 74% in patients with primary respiratory insufficiency, and was also quite high in patients with rapidly developing bilateral pneumonia (27%). In the second and third week after injury death was usually due to pneumonia (over 60% of deaths). Pulmonary embolism and abdominal complications were also likely to result

in a fatal outcome in that period of time. In the late posttraumatic period mortality was low and was due mainly to late urinary complications, decubiti and subsequent septic conditions.

Discussion

Analysis of the clinical material shows that the life of the spinal cord injured individuals is threatened to various degrees by a number of factors of which the most relevant appear to be: the level and degree of the spinal cord injury; certain causes of the injury with the sequela of serious neurological involvement; older age of the patients and consequent cardiorespiratory problems; and the method of treatment, taking into account advanced medical techniques and the effectiveness of intensive care.¹⁰ The data in Tables I and II show irrefutably that the threat to life is greatest in patients with evidence of a complete cervical spinal cord injury. This refers not only to the relatively small number of patients who had been successfully transported to hospital despite the complete high location of the spinal cord lesion with diaphragm paralysis, but also to patients with complete spinal cord lesions from involvement of the lower cervical and sometimes of the higher thoracic spinal cord segments. Disturbed balance of the autonomic nervous system with preponderance of the parasympathetic system^{11–13} contributes to the increased retention of secretions in the respiratory tract. Simultaneous bronchospasm and inability to cough effectively, and to expectorate, caused by the paralysis of the chest muscles and often also by diaphragmatic paresis, render the removal of excessive secretions from the respiratory tract difficult. This leads to the rapid development of atelectasis, to reduction of the active respiratory space within the lungs, respiratory insufficiency and increasing anoxia. The retained secretions favour the development of bronchitis and bronchopneumonia. Understandably this is a great threat to life, in particular for patients advanced in years with a previously somewhat poor cardiorespiratory system. The cause of the injury also influences

Table V Cause of death

Cause of death	Level and degree of spinal cord lesion							
	Cervical		Thoracic		Lumbar		Total	
	Complete	Incomplete	Complete	Incomplete	Complete	Incomplete	Complete	Incomplete
Primary respiratory insufficiency	26	1	—	—	—	—	26	1
Pneumonia	122	17	14	1	5	2	141	20
Pulmonary embolism	9	5	4	1	3	2	16	8
Other pulmonary	9	3	2	—	2	—	13	3
Myocardial infarction	1	—	2	—	—	—	3	—
Brain injury	13	2	4	1	1	—	18	3
Abdominal complications	17	3	2	1	1	1	20	5
Renal insufficiency	7	4	8	—	3	1	18	5
Decubiti sepsis	—	—	1	—	1	1	2	1
Neoplasm	1	1	2	1	—	—	3	2
Other causes	1	1	1	—	—	—	2	1
Total	206	37	40	5	16	7	262	49

Table VI Time from injury to death

Cause of death	Survival time						Total
	1 week	2-3 weeks	4-6 weeks	7-12 weeks	4-6 months	Over 6 months	
Primary respiratory insufficiency	20	7	—	—	—	—	27
Pneumonia	44	97	14	7	1	—	161
Pulmonary embolism	—	9	12	3	—	—	24
Other pulmonary	3	5	7	1	—	—	16
Myocardial infarction	—	1	2	—	—	—	3
Brain injury	9	7	4	1	—	—	21
Abdominal complications	5	15	4	—	1	—	25
Renal insufficiency	—	3	8	3	4	5	23
Decubiti sepsis	—	—	—	—	2	1	3
Neoplasm	—	1	3	1	—	—	5
Other causes	1	2	—	—	—	—	3
Total	82	147	54	14	8	6	311

prognosis. A fall from a height may result in relatively slight damage to vital organs and tissues, including the spinal cord, but such an occurrence is rather exceptional. Falls from great heights (scaffolding, roofs etc) usually cause a very high mortality rate. In motor vehicle accidents the most serious sequelae are incurred by pedestrians struck by motor vehicles. Falls from horse-carts also often result in a very high mortality, largely age related, with patients in their sixth or seventh decade.

The fact that the mortality rate is highest in patients with cervical lesions points to the important role of pulmonary complications as a cause of death.^{14–16} Such complications are less frequent but can also be life

threatening in those with lower spinal cord lesions. Other factors which contribute to the increased life threatening effect in the early posttraumatic period and should be mentioned here are concomitant severe brain injury^{17–19} and abdominal complications,^{20,21} in particular bleeding from the alimentary tract.²² In the later posttraumatic period the greatest risk to life results from urinary complications leading to urosepsis, uraemia and renal insufficiency. Knowledge of the actual threats to life in SCI patients makes it possible to incorporate adequate preventative measures into the treatment process with the hope of further improvements from the results of treatment and a reduction in mortality.

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