Suicide after traumatic brain injury: a population study

T W Teasdale, A W Engberg

Abstract

Objectives—To determine the rates of suicide among patients who have had a traumatic brain injury.

Methods—From a Danish population register of admissions to hospital covering the years 1979–93 patients were selected who had had either a concussion (n=126 114), a cranial fracture (n=7560), or a cerebral contusion or traumatic intracranial haemorrhage (n=11 766). All cases of deaths by the end of the study period were identified.

Results—In the three diagnostic groups there had been 750 (0.59%), 46 (0.61%), and 99 (0.84%) cases of suicide respectively. Standardised mortality ratios, stratified by sex and age, showed that the incidence of suicide among the three diagnostic groups was increased relative to the general population (3.0, 2.7, and 4.1 respectively). In all diagnosis groups the ratios were higher for females than for males, and lower for patients injured before the age of 21 or after the age of 60. The presence of a codiagnosis relating to substance misuse was associated with increased suicide rates in all diagnosis groups. There was a tendency, among patients with cerebral contusions or traumatic intracranial haemorrhages, for suicide risk to increase with duration of stay in hospital. Cox regression analyses for proportional hazards confirmed that there was a significantly greater risk of suicide among patients with cerebral contusions or traumatic intracranial haemorrhages than among patients with concussion or cranial fractures (hazard ratios=1.42 and 1.50 respectively). There was, however, no evidence of a specific risk period for suicide after injury.

Conclusion—The increased risk of suicide among patients who had a mild traumatic brain injury may result from concomitant risk factors such as psychiatric conditions and psychosocial disadvantage. The greater risk among the more serious cases implicates additionally the physical, psychological, and social consequences of the injuries as directly contributing to the suicides.

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A person with a traumatic brain injury can often experience devastating and enduring changes in all aspects of life, including employment, and family and social relationships. Profound emotional responses of anxiety and in particular major depression are not uncommon[1-3] and suicidal ideation and suicide attempts after traumatic brain injury have also been reported.[4-6]

Owing to its comparative rarity, however, there have been only few studies which have examined the occurrence of completed suicide after traumatic brain injury. In a recent review, Harris and Barraclough[7] listed six studies, all pre-1980, which together suggested increased rates of suicides among populations with brain injury. In by far the largest of these studies, Achté *et al*[8] found 85 suicide cases among 6498 war veterans with brain injury. In another early study, Roberts[9] found three cases of suicide in an up to 25 year follow up of 479 patients with traumatic brain injury. In more recent long term follow up studies, Wilson[10] reported three suicides among 55 patients with traumatic brain injury, Klonoff and Lage[11] found two suicides among a group of 111 patients from a rehabilitation programme and Tate *et al*[12] reported eight suicides from among 896 patients.

Excepting that of Achté *et al*, the above studies comprise only 24 cases of suicide after traumatic brain injury. These small numbers make it difficult to assess the extent to which the rate of suicide after traumatic brain injury may be increased above the rate of the general population. The situation is further complicated by the fact that some risk factors for suicide in the general population are also risk factors for traumatic brain injury—for example, young adults, males, involvement of substance misuse, especially alcohol,[13-15] and a range of other factors relating to psychosocial disadvantage. This means that any statistical association between traumatic brain injury and subsequent suicide could arise simply because of the association of both with such risk factors.

In the present study we have examined suicide rates among a large population derived sample of patients who had survived a traumatic cerebral lesion and who were followed up for a period of up to 15 years. To control for possible risk factors among these patients we have compared them with samples of patients, derived from the same population, who had either a concussion or a cranial fracture. These groups typically have fewer and much less severe sequella to their injuries but are generally similar in demographic and psychological characteristics.[16 17] Therefore, the extent to which suicide is found to be more

common among survivors of cerebral contusions or traumatic intracranial haemorrhage than among the groups who had either a concussion or a cranial fracture would be suggestive of a direct associative link between that injury and the subsequent suicide.

Methods

DATA SOURCES

Subjects in the present study were identified in a computerised National Bureau of Health register of hospitalisations which documents all admissions to hospital in Denmark since 1979, including admission and discharge dates and discharge diagnoses. As part of a larger study the register was searched for all cases with a discharge, between the years 1979 and 1993 inclusive, with a main or secondary diagnosis of traumatic brain injury. During this period the International Classification of Diseases (ICD) 8th edition codes were used in the register. On this basis we have therefore defined three groups.

(1) Concussion ICD 850
(2) Cranial fracture ICD 800, 801, 803
(3) Cerebral contusion/traumatic intracranial haemorrhage ICD 851–854

These groups are here termed "concussion", "fracture", and "lesion" respectively. Any patient who was discharged with more than one of the above diagnoses was classified in the highest category. Similarly, if a patient had more than one admission in the 15 year period, with differing diagnoses, then the admission with the most severe diagnosis was used. An exception to this was that admissions where the discharge diagnoses included epilepsy were discounted, as the admission might in such cases have been for observation after an epileptic convulsion, with the brain injury diagnosis recorded only as an earlier contributing cause of the epilepsy itself. Any additional non-traumatic brain injury diagnoses at discharge, in particular psychiatric diagnoses, were also registered.

Patients identified in the hospitalisation register were then screened in a national register of deaths, also for the period up to and including 1993. This register records date and cause of death. Cause of death is also categorised under a broad grouping as natural causes, accidents, suicide, or violence: in some few cases, this information is unspecified in the register.

PATIENTS

The initial search of the hospitalisations register identified 167 083 persons as having had some form of traumatic brain injury as defined above. Because suicide is very rare below the age of 15 we excluded from the present analyses the 17 394 cases who were born after 1978—that is, who were less than 15 years old at the end of the study period. Thereafter, we also excluded the 4249 patients who died in hospital or who did not survive at least 1 month after discharge. These criteria left 145 440 patients in the study, of whom 126 114 (87%) had had a concussion, 7560 (5%) had had a cranial fracture and the remaining 11 766 (8%) had had cerebral lesions.

At the end of the study period—31 December 1993—16 866 patients (11.6% of all who had survived until at least 1 month after hospital discharge) had died. Among these, deaths had been recorded as due to natural causes in 13 261 (9.1%) cases, accidents in 2003 (1.4%), suicides in 895 (0.62%), and violence in 68 (0.05%); the cause was unspecified in the remaining 639 (0.44%).

STATISTICAL ANALYSES

Standardised mortality ratios (SMRs)[18] were computed for all groups using annually published Danish tables for the period 1979 through 1993 for the total population numbers and for numbers of suicides, both of which are stratified by sex and by 5 or 10 year age bands. To examine the time interval between injury and suicide, we have employed a Cox regression analysis for proportional hazards.[19]

Results

Table 1 shows the age, sex, duration of stay in hospital, and mortality as a function of diagnostic group. The age at injury increased with the severity of the diagnosis, as did the proportion of males and, as would be expected, the duration of stay in hospital. Similarly, overall mortality was highest among the lesion group as was the percentage of suicide cases. It is noteworthy that, for each diagnosis, the proportion of males among the suicide cases was higher than among all cases. The median times from injury to suicide were about 3–3.5 years for all diagnostic groups and they did not differ significantly ($F(2,892)=0.67$, p>0.2).

The SMRs for suicide as a function of diagnosis and sex are shown in table 2. The ratios were increased above population rates for all three diagnoses, being roughly tripled for the concussion and fracture groups and quadrupled for the lesion group. The ratios for females were higher than for males in all three groups. All SMR values were highly significant and the 95% confidence intervals (95% CIs) fell below 2.0 only for a single subgroup—males with cranial fractures.

Table 3 shows the SMR values as a function of age at injury. It is noticeable that for all three groups, the ratios were lower for patients injured before the age of 21 or after the age of 60, than among patients injured at ages between 21 and 60. The ratios were highest among patients with lesions injured in that age range, being about five times the population rates. With a single exception SMRs in all groups and at all ages had 95% CIs above

Table 1 Age, sex, duration of stay in hospital, and mortality as a function of diagnostic group

	Concussion	Fracture	Lesion
No of patients	126114	7560	11766
Median age at injury (25%–75%)	25 (16–46)	32 (17–55)	38 (21–62)
Men (%)	60.2	64.6	68.2
Median days in hospital (25%–75%)	2 (1–4)	6 (3–12)	20 (9–48)
No dead before 1994 (% of total)	13358 (10.6)	1056 (14.0)	2452 (21.0)
No of suicides before 1994 (% of total)	750 (0.59)	46 (0.61)	99 (0.84)
Suicide (% men)	68.3	71.7	77.8
Median years from injury to suicide (25%–75%)	3.6 (1.4–6.7)	3.0 (0.9–8.0)	3.3 (1.1–6.3)

Table 2 Standardised mortality ratios for suicide as a function of diagnosis and sex

Sex	Number of cases	Observed No of years	Cumulative expected frequency	Observed frequency	Standardised mortality ratio	95% CI
Concussion	126114	1026546	247.92	750	3.02	2.82–3.25
Men	75972	627605	186.81	512	2.74	2.51–2.99
Women	50142	398940	61.11	238	3.89	3.43–4.42
Fracture	7560	62761	17.10	46	2.69	2.01–3.59
Men	4887	41005	13.53	33	2.44	1.73–3.43
Women	2673	21756	3.58	13	3.63	2.11–6.26
Lesion	11766	79104	24.44	99	4.05	3.33–4.93
Men	8030	54456	19.71	77	3.91	3.13–4.89
Women	3736	24648	4.73	22	4.65	3.06–7.06

Table 3 Standardised mortality ratios for suicide as a function of diagnosis and age at injury

Diagnosis age	No of cases	Observed No of years	Cumulative expected frequency	Observed frequency	Standardised mortality ratio	95% CI
Concussion:						
<21	49570	473235	47.53	102	2.17	1.77–2.61
21–40	38225	305224	90.44	359	3.97	3.58–4.40
41–60	19334	141070	62.00	201	3.24	2.82–3.72
>60	18985	107016	47.95	88	1.84	1.49–2.26
Fracture:						
<21	2535	25824	2.26	3	1.33	0.43–4.12
21–40	2036	16590	5.27	20	3.79	2.44–5.88
41–60	1503	11369	5.20	14	2.69	1.59–4.55
>60	1486	8978	4.38	9	2.06	1.07–3.95
Lesion:						
<21	2879	25816	3.17	11	3.47	1.92–6.27
21–40	3308	24244	7.50	35	4.67	3.35–6.50
41–60	2444	15130	6.96	36	5.17	3.73–7.17
>60	3135	13914	6.82	17	2.49	1.55–4.01

unity, the exception being patients with lesions injured before the age of 21, among whom there were only three suicide cases.

Among all 145 440 patients, 8684 (6%) also had a psychiatric diagnosis. In most patients (n=7421; 5%) this concerned substance misuse (ICD 291 alcoholic psychosis, ICD 303 alcoholism, or ICD 304 drug dependence), the most common single diagnosis being inebriation at the time of admission (ICD 303.90; n=5165; 3.6%). Substance misuse was more common among the lesion group (n=681; 5.8%) than among the fracture group (n=312; 4.1%) or the concussion group (n=6428; 5.1%) (χ^2(2)=26.3; p<0.001). However, table 4 shows that the presence of a codiagnosis of substance misuse markedly increased the

Table 4 Standardised mortality ratios for suicide as a function of diagnosis and substance misuse

Diagnosis of Substance misuse	Number of cases	Observed No of years	Cumulative expected frequency	Observed frequency	Standardised mortality ratio	95% CI
Concussion:						
No	119686	975890	228.90	654	2.86	2.67–3.09
Yes	6428	50656	19.03	96	5.05	4.13–6.16
Fracture:						
No	7248	60395	16.12	42	2.61	1.93–3.53
Yes	312	2366	0.99	4	4.05	1.52–10.80
Lesion:						
No	11085	74948	22.69	86	3.79	3.07–4.68
Yes	681	4156	1.75	13	7.44	4.32–12.82

Table 5 Standardised mortality ratios for suicide for lesion cases as a function of duration of stay in hospital

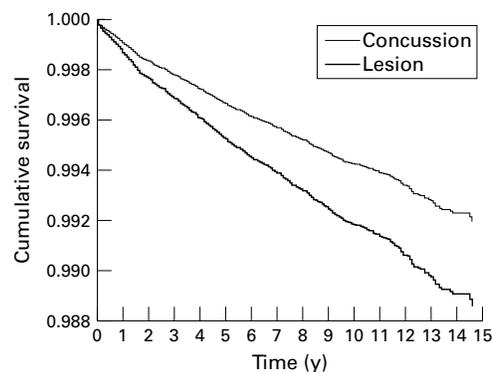| Stay in hospital	No of cases	Observed No of years	Cumulative expected frequency	Observed frequency	Standardised mortality ratio	95% CI
<1 week	2163	15342	3.99	14	3.51	2.08–5.92
1–4 weeks	4952	33411	10.41	38	3.65	2.66–5.02
1–3 months	3138	20145	6.74	31	4.60	3.23–6.54
>3 months	1513	10204	3.30	16	4.85	2.97–7.92

Figure 1 Cumulative proportional hazards for suicide in the concussion and lesion groups.

SMRs for suicide in all three groups. The highest SMR, greater than 7, was that for the lesion group, although the small numbers in the fracture and lesion groups were necessarily associated with large 95% CIs.

As shown in table 5 there seemed, among the lesion group, to be a monotonically increasing risk of suicide in proportion to duration of stay in hospital. However, the wide 95% CIs associated with the SMRs makes this interpretation tenuous.

To investigate the time course of suicide after injury we performed a Cox regression analysis in which sex, age at injury, and the presence of a substance misuse codiagnosis were entered in a first block before the inclusion of diagnostic group. In view of its apparently non-linear function, age at injury was entered as a category variable using the groupings shown in table 3. The analysis showed that diagnostic group made a significant improvement (p=0.004) to the overall model after the inclusion of sex, age at injury, and substance misuse. The lesion group had a significantly higher rate of suicides than both the concussion group (hazard ratio=1.42, 95% CI 1.15–1.75) and the fracture group (hazard ratio=1.50, 95%CI 1.06–2.13). The influence of sex, age at injury, and the presence of substance misuse on these ratios was not very substantial; before their inclusion in the analysis the hazard ratio for the lesion group relative to the concussion group was 1.67 (95%CI 1.36–2.06) and for the lesion group relative to the fracture group 1.66 (95%CI 1.17–2.35).

The survival functions (specific for suicide) for the concussion and fracture groups were found to be virtually identical. Figure 1 illustrates the contrasting functions for the concussion and lesion groups across the maximum of 15 years of follow up; both functions, although differing in slope, were essentially linear. Thus, there was no strong evidence for a specific risk period for suicide after injury in any of the groups.

The possibility exists, in cases of suicide after a traumatic brain injury, that the injury itself might have been the result of an unsuccessful suicide attempt. We have been able to examine this possibility, as the hospitalisation register has included, from 1987 onwards, a coding of whether the injury was self inflicted. Among all three diagnosis groups combined 48 298 cases

occurred in 1987 or later, and of these only 369 (0.8%) were recorded as having been self inflicted injuries. Seven of these 369 (1.9%) were subsequent suicides whereas there were 134 suicides among the remaining 47 929 non-self inflicted cases (0.3%). Although this association is highly significant (odds ratio=6.9, 95%CI 3.2–14.8) it is clear that for only a numerically negligible proportion of cases within our sample could the brain injury have been the result of a failed suicide attempt.

Discussion

The present study, although large scale and nationally representative, has some limitations. Firstly, the hospitalisation register is not completely accurate, particularly effecting the diagnosis grouping we have used here. Thus, from a subsample within the present study, involving review of the original hospital records, we have estimated that about 10% of coded diagnoses of intracranial lesions may be incorrect, especially involving overrecording of the ICD-8 854 diagnosis for "non-specific intra-cranial lesions" where a concussion diagnosis (ICD-8 850) would have been appropriate. Conversely, there may also be some underrecording of cerebral lesions. In a smaller earlier study[14] up to one third of patients who had a post-traumatic amnesia exceeding 1 week were found to be recorded with only concussion or cranial fracture diagnoses. The register itself contains no data concerning depth or duration of coma, nor duration of post-traumatic amnesia (we are currently conducting an intensive study of a representative sample of the patients with brain injury in which we are gathering such data directly from the hospital records). The lack of post-traumatic amnesia data is especially unfortunate considering the high predictive value of that measure for outcome after traumatic brain injury.[14]

Another issue which needs to be considered is the possible underreporting of suicides. Social and religious disapprobation of suicide is common in many cultures.[7 20] Although this is perhaps less true of Denmark than elsewhere, it remains the case that within our population some suicides—for example, from drug overdoses, drowning, and falls from high places—could have been erroneously recorded as accidental deaths. It should also be emphasised that it has not been possible for us within the present study to investigate other potentially related factors such as unemployment and marital status.

Within the constraints of these considerations, however, our results do seem to permit some clear conclusions about suicide after a traumatic brain injury, given survival through the acute phase.

Perhaps the most striking finding has been the increased rate of suicides among patients who have had no more than a concussion, leading typically to only a single day in hospital for observation, or a cranial fracture with no identified cerebral lesion. Our findings for the concussion and fracture groups have more similarities than differences and we consider them together, before discussing the findings for the lesion group.

The increased suicide rates for the concussions and fracture groups, by a factor of two or more relative to the general population, were found to a greater or lesser extent for both sexes and for all age groups. Particularly in the case of concussions there can hardly be any direct link between having sustained the injury and the subsequent suicide, and the association must have arisen from concomitant and perhaps premorbid characteristics.

Achté *et al*[8] noted that some characteristics, such as "broken homes" during childhood and alcohol misuse, occurred with greater frequency among their suicide patients with brain injury. They commented that "there is reason to suppose that a considerable proportion of those who later committed suicide had even prior to the injury manifested deviant psychic features". This is certainly supported by our finding of the substantial contribution towards suicide risk of a codiagnosis of substance misuse, in most cases no more than a registration that the patient was inebriated at admission. The associations of substance misuse with both traumatic brain injury and with suicide are well documented.[7 21]

Mortality rates were greater for females than for males, this despite the fact that there were relatively fewer suicides among females than among males in our population. Similarly Hartkopp *et al*[22] found increased mortality rates for females in a Danish cohort of patients with spinal injury. They speculated that this may be because "women build their self image much more on their physical attractiveness than men" and therefore find it more difficult to cope with the consequences of a spinal cord injury. This explanation will certainly, however, not account for the relatively greater mortality rate among females with a concussion. We suspect that concussion may be more strongly related to psychosocial disadvantage among women than among men, and thereby be more strongly predictive of suicide.

The effect of age may also be related to psychosocial disadvantage. Mortality rates for suicide are greater among patients who have traumatic brain injuries sustained at ages between 20 and 60 than those having such injuries at younger or older ages. We have elsewhere shown that concussions sustained in adolescents are less associated with premorbid cognitive deficit than concussions sustained by young adults,[23] a result which we interpreted to suggest that the injuries in the first group were more often associated with play and sports and less associated with alcohol, violence, and other psychosocial factors. The present results are consistent with this view. Similarly milder traumatic brain injuries among older people may also be relatively more often the result of physical frailties, accident proneness, and sheer ill luck—comparatively unrelated to psychosocial disadvantage.

For the lesion group, it is noticeable that mortality rates for suicide were consistently higher than for the concussion and fracture groups, for both sexes and at all ages. To the

extent that premorbid psychosocial factors are equated across the three groups, then the higher rate of suicide for the lesion group implicates the direct consequences of the injury itself on the suicide. This interpretation is supported by the clinical evidence stemming from smaller studies of similarly severe traumatic brain injuries.[11] [12]

That the suicide rates within the lesion group tended to increase with the severity of the injury, as gauged by the duration of stay in hospital, is also consistent with this interpretation. We have elsewhere reported duration of hospital stay after traumatic brain injury to correlate consistently with poorer long outcome in terms of education, employment, and disability.[24] [25] It might have been expected that suicide rate would decline at some level of severity where the person with brain injury would be lacking the cognitive and physical apparatus for the act. That we could not identify such a level within our data is probably due to the limitations of duration of stay in hospital as a measure of severity of injury relative to the generally much more sensitive post-traumatic amnesia.[14]

From their clinical evidence both Tate *et al*[12] and Klonoff and Lage[11] have suggested that, where relatively severe traumatic brain injury results in subsequent suicide, it is psychologically reactive to the identity crises and generalised social disruption experienced in such cases, rather than any more specific neuropsychological mechanism such as greater impulsivity consequent on frontal lobe injury. Similarly, in their larger study, Achté *et al*[8] found suicide to be related to the severity of the injury but not its localisation.

Although our evidence supports the view that suicide is indeed more common after a relatively severe traumatic brain injury we could find no evidence of a risk period. It is often suggested that the full impact of the consequences of such an injury is not felt immediately but only after some years of experiencing disappointments and fiascos, of ultimately confronting the fact that improvement, characteristic of early postinjury phases, will not continue to the point where full premorbid functioning returns. However, our present evidence suggests that the risk of suicide is a constant, continuing for at least the maximum of 15 years follow up we are reporting here. It is similarly noteworthy that Achté *et al*[8] found the suicide risk actually to increase to a maximum of 15 years after injury, an interval which, as Tate *et al*[12] note, was probably more related to the chronological age of his sample 15 years after injury (people then in their 40s and 50s) rather than the time interval itself.

In summary, we have found increased rates of suicide among patients with relatively severe traumatic brain injury. Present evidence suggests that no small degree of this increase may be due to premorbid psychosocial factors, as the increase is also present in patients with concussion and cranial fractures. The absolute magnitude of the rates is not of alarming proportions, being about 1% over a 15 year period. Nonetheless, as Tate *et al*[12] remark, "the small magnitude in no way corresponds to the seriousness of the problem" and awareness of a suicide risk should be present in the assessment of any traumatic brain injury.

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