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ORIGINAL ARTICLE

Incidence of Seizures After Traumatic Brain Injury—A 50-Year Population Survey

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Morbidity Abstract 217-M5

Background.—Records of the Rochester Epidemiological Project were used to determine the incidence of secondary seizures after traumatic brain injury (TBI) in all cases treated for this condition in the population of Olmsted County, Minn, from 1935 to 1984. Medical records of the Mayo Clinic and all other medical facilities in Olmsted County, Minn, are in the database of this Project. Incidence rates after TBI were compared with incidence rates of idiopathic epilepsy previously determined for Olmsted County.

Results.—TBI cases were divided into 3 defined severity categories: mild, moderate, and severe. Out of 4541 cases of TBI accumulated in 50 years only 97 cases developed 1 or more seizures (46 cases of seizure secondary to other definite causes were excluded). Incidence rates were highest in the first year after the head injury. The overall excess incidence rate was very low in mild TBI, only 0.3 per 1000 per year, but was higher in severe TBI, with an excess rate of 10 per 1000 per year. Only 7.2% of the TBI cases were classified as severe (loss of consciousness or amnesia for more than 24 hours, subdural hematoma, or brain contusion).

Conclusion.—The long-term incidence of seizures beyond the incidence rate of idiopathic epilepsy is low after mild or moderate TBI, but is at the rate of 10 excess cases per 1000 per year in the minority of cases with severe TBI.

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Reference

1. Annegers JF, Hauser WA, Coan SP, et al. A population-based study of seizures after traumatic brain injuries. *N Engl J Med.* 1998;338:20–24.

OBJECTIVE OF THIS ABSTRACT

The objective of this abstract is to present the comparative incidence rates of seizures after traumatic brain injury (TBI) in all cases recorded in Olmsted County, Minn, during the period 1935–84, as reported in the source article.

SUBJECTS STUDIED

The Rochester Epidemiological Project, operated by the Mayo Clinic, provides a database of all patients treated in Olmsted County since 1935 through linkage of records systems of other medical facilities with those of

Table 1. Epidemiological Data: Seizures Following Traumatic Brain Injury in Olmsted County, Minn, 1935–1984

Age Distribution and Severity			Seizure Characteristics	
Factor	Number	Percent	Characteristic	Number
Age group			Unprovoked seizures	
0–4 years	542	11.9	Single	22
5–14	1184	26.1	Multiple	75
15–64	2546	56.1	Total subjects	97
65 and up	269	5.9		
All ages	4541*	100.0*		
Severity group			Due to other causes	
Mild	2758	60.7	Alcohol withdrawal	20
Moderate	1455	32.1	Cerebrovascular	7
Severe	328*	7.2*	Toxic factor	8
Total cases	4541*	100.0*	Brain trauma	4
			Fever and other	7
			Total subjects	46

* Survivors at 1 month only (626 early deaths excluded). See text for definition of severity.

the Mayo Clinic. Many mortality and morbidity follow-up studies have been carried out through this database, including a mortality and incidence study for epilepsy, reported as Abstracts 213M1–213M3 in this journal in 1992. The present study includes 4541 patients with TBI diagnosed in Olmsted County in the 50-year period 1935–84. Multiple diagnoses were searched for, including concussion and fractured skull, but records were retrieved for additional details. Mild TBI was defined as loss of consciousness or amnesia for less than 30 minutes; moderate TBI was defined as loss of consciousness or amnesia for 30 minutes to 24 hours or skull fracture without the complications of severe TBI; severe TBI was defined as loss of consciousness or amnesia for more than 24 hours, or subdural hematoma, or brain contusion. Patients were excluded if they had known epilepsy, if they died within 1 month of the injury, if they were subject to a later TBI, or if the original TBI was not documented. When these exclusions were made on the 5984 patients originally found in the database the number for follow-up was reduced to 4541. Age distribution and other characteristics of the TBI cohort are given in Table 1. The data include other causes of seizures in 46 cases terminated for follow-up because of an intercurrent condition producing secondary seizures.

FOLLOW-UP

Follow-up to 1995 was accomplished through the medical records in the Project database. Of the 4541 entrants 2588 were known to have been alive in 1995. Others terminated during follow-up included 334 because of a subsequent TBI, 10 because of intracranial surgery, 373 because of death, and 1159 because of migration out of southeastern Minnesota. There were 97 persons who had seizures not attributable to any new cause observed during 53,222 person-years of follow-up. An additional 46 persons had seizures caused by other conditions, as listed in Table 1. The average duration of follow-up was 11.7 years.

RESULTS

Acute mortality within 1 month of injury, q_a, can be estimated from the 626 such deaths reported: $q_a = 626/(44541+626) = 626/5167 = 0.121$. If the acute deaths were, ipso facto, classified as severe cases, the acute mortality would be much higher: $q_a = 626/(328+626)$

Table 2. Comparative Incidence of Seizure Following Head Injury–Olmsted County, Minn, 1935–1984

Follow-up Duration t to t ± Δt	No. Alive at Start ℓ	Exposure* Person-Years E	Number of Seizures		Morbidity Ratio 100n/n′	Mean Annual Seizure Rate per 1000		
			Observed n	Expected† n′		Observed r	Expected r′	Excess (r − r′)
Mild head injury								
0–1 year	2758	2620	5	1.6	310%	1.9	0.6	1.6
1–5 years	2483	8281	11	5.2	210	1.3	0.6	0.7
5–10	1751	7219	4	4.3	93	0.6	0.6	0.0
0–10	2758	18,120	20	11.1	180	1.2	0.6	0.6
10 up	1191	(14,338)	8	7.4	108	0.6	0.5	0.1
All	2758	(32,478)	28	18.5	152	0.9	0.6	0.3
Moderate head injury								
0–1 year	1435	1381	6	0.9	665%	4.3	0.6	3.7
1–5 years	1307	4442	9	2.9	310	2.0	0.6	1.4
5–10	634	3945	7	2.3	305	1.8	0.6	1.2
0–10	1435	9768	22	6.1	360	2.3	0.6	1.7
10 up	660	(7897)	8	4.4	182	1.0	0.5	0.5
All	1435	(17,663)	30	10.5	285	1.7	0.6	1.1
Severe head injury								
0–1 year	328	301.5	19	0.2	9500%	63	0.6	62
1–5 years	275	900.0	10	0.6	1670	11.1	0.6	10.5
5–10	181	982.5	6	0.5	1200	7.7	0.6	7.1
0–10	328	1984.0	35	1.3	2700	17.7	0.6	17.1
10 up	136	(1675)	4	1.0	400	2.4	0.6	1.8
All	328	(3659)	39	2.3	1700	10.6	0.6	10.0
All head injury cases								
0–1 year	4541	4302	30	2.7	1110%	7.0	0.6	6.4
1–5 years	4065	13,623	30	8.7	345	2.2	0.6	1.6
5–10	2867	11,946	13	7.1	183	1.1	0.6	0.5
0–10	4541	29,272	73	18.5	395	2.5	0.6	1.9
10 up	1987	23,930	24	12.8	188	1.0	0.5	0.5
All	4541	53,222	97	31.3	310	1.8	0.6	1.2

* Exposures estimated by accurate approximation method 0–10 years, and fair approximation 10 years and up, but total E of 53,222 is given in the article.

† Basis of expected seizure rates (in idiopathic epilepsy): prior data from Rochester Epidemiological Project (see text).

= 0.656. Even if some of the deaths occurred in injuries initially classified as less than severe, it is clear that major head injuries involve a very high acute mortality risk. On this basis the prevalence of severe TBI would have been (328+626)/5167, or 22.3%, instead of the 7.2% in Table 1, when early deaths are omitted.

Comparative morbidity or incidence of seizure events after TBI is given by severity group and duration after in the injury in Table 2. As indicated in the footnote, exposures have been estimated from survivors at 5 and 10 years as given beneath Figure 1 in the source article, an approximation regarded as accurate for the E data in Table 2. Total exposures for all durations have been estimated as the proportion of the total E of 53,222 person-years weighted according to the initial number of entrants. The exposure for 0–10 years duration was then subtracted from the approximate total to give an approximate E value for durations of 10 years and up. Exposures for durations of 10 years up and for

the total have thus been enclosed in parentheses, whereas the better approximations at earlier durations have not been. The numbers of seizure events in each duration period are so small that the incidence or event rates are little affected by the uncertainty in the exposure values.

Morbidity or incidence ratios and excess event rates (EER) were highest in the first year after injury. The ratio ranged from 310% in the mild cases to 9500% in the severe cases, all significant at the 95% confidence level, although barely so for mild TBI. EER values ranged from 1.3 to 62 extra seizures per 1000 per year. Excess risk of seizures was no longer significant after 5 years in mild cases, and after 10 years in moderate cases, but was slightly significant even after 10 years in severe cases (only 4 observed and 1.0 expected events).

The authors also analyzed various features of the TBI for excess risk of late seizure on both a univariate and a multivariate basis. When the cases of brain contusion, subdural hematoma, and both of these were combined the total of 232 patients was found to have 36 observed and 2.97 expected seizures, giving a combined incidence ratio of 12.1, higher than that for any of the other factors analyzed. If we assume the average duration is also 11.72 years for this sample of the total TBI cohort, the exposure would be 2719 person-years and the EER would be 12.1 per 1000 per year. These are univariate data. Multivariate incidence ratios were uniformly somewhat lower than the univariate ratios. The combination of brain contusion with subdural hematoma had the highest univariate incidence ratio of 30.3, but this was based on only 13 late seizures in 37 cases.

The reader is referred to the source article for more detailed results, including a 30-year graph of the cumulative probability of having a late seizure, in the 3 severity groups and the total cohort of TBI patients.

COMMENT

The authors provide no mortality data except for the 626 deaths within 1 month, and the 373 late deaths after 1 month. With an exposure of 53,222 person-years the mean annual mortality rate over this very long duration study was 373/53,222 or 7.0 per 1000. Unfortunately the age distribution is not detailed enough to permit any reliable estimate of expected mortality or comparative mortality. The current study has provided for the excellent results of this Morbidity Abstract on the incidence of seizures after a population-based analysis of TBI, but other studies must be relied upon for comparative late mortality following head injury.