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ORIGINAL ARTICLE

A preliminary investigation of road traffic accident rate after severe brain injury

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Abstract

Primary objective: to investigate the road traffic accident rate in patients who have resumed driving after severe brain injury.
Research design: a retrospective study conducted by means of telephone interviews.
Methods and procedures: The caregivers of 90 patients suffering from severe brain injury were included. All of the patients had sustained severe brain injury and prolonged coma, i.e. lasting for at least 48 hours. The caregivers were interviewed by means of a Questionnaire that investigated several aspects of driving competence after coma and the incidence of road traffic accidents.
Main outcomes and results: All patient outcomes were evaluated by means of the Glasgow Outcome Scale (GOS). The 90 caregivers reported that 29 patients (32%) had resumed driving and that 11 of the 29 (38%) were subsequently involved in road traffic accidents. During the total duration of our patient population risk exposure, we found 11 cases in our study group, against the 4.7 expected cases calculated in the normal population. The relative risk of road traffic accidents in severe brain injury patients versus uninjured individuals was 2.3.
Conclusions: Our preliminary data show that a subject who has suffered from severe brain injury and coma lasting for at least 48 hours has a statistically significant higher risk of being involved in a road traffic accident.

Keywords: *Severe brain injury, coma, traffic accidents, car driving*

Introduction

Driving involves a complex interaction of cognitive and perceptual abilities (especially related to visual input), motor skills, and environmental factors [1, 2].

A brain-damaged patient may have difficulty discriminating among many simultaneous inputs, a critical factor in complex traffic situations. In particular, the patient's ability to anticipate dangerous situations, an important component of safe driving, may be impaired [3].

Evaluation by a driving specialist includes visual testing, reaction time estimation, evaluation in the driver simulator and actual behind-the-wheel assessment [4]. In one study, subjective evaluation by the driver educator was also a good predictor of driving performance [5]. A follow-up study showed that patients with cognitive deficits could be trained to improve their driving performance. Simple pen-and-pencil activities designed to improve deficient perceptual skills were associated with improved driving skills [6].

However, some authors have reported a lack of criteria for assessing whether patients are sufficiently recovered from their injuries to drive in traffic [7]. On laboratory tasks, the same authors found that brain-injury patients had significantly longer reaction times than control participants [7].

On the other hand, it is understandable that many individuals with brain injury want to drive if possible. This permits them to be independent, have access to employment and social activities and keep their self-esteem, which is also related to mobility in the community [8].

As Van Zomeren et al. [3] pointed out, clinicians must often decide whether their patients can drive; however, they cannot be requested to guarantee that their patients will always be safe or will always use their abilities optimally.

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Some authors have reported that insight and self-criticism may be more important for a patient's fitness to drive than the degree of cognitive deficit [9].

We selected certain variables for analysis based on the international literature on features, such as age [10–12] and coma duration [13–15], which predict the final outcome of persons with severe brain injury. Concerning the time post-injury, it is well known that in persons with moderate to severe traumatic brain injury neuropsychological recovery may continue for several years after injury with substantial recovery [16].

The main aim of this study was to determine the percentage of road traffic accidents in a population of patients with severe brain injury who resumed driving compared to normal subjects.

A secondary aim was to compare the Glasgow Outcome Scale (GOS) [17] scores of the two groups of patients (involved or not in road traffic accidents) after they resumed driving in order to investigate whether any outcome scale could predict the risk of road traffic accidents.

Methods

Subjects

In an epidemiological study of the social reintegration of patients who had suffered severe brain injury and coma and were consecutively admitted to Santa Lucia Rehabilitation Hospital from 1993 to 1995, we studied 90 patients (66 males and 24 females) diagnosed as suffering severe brain injury (Glasgow Coma Scale [18], $GCS < 8$ and coma lasting for at least 48 hours [19]) of different genesis: traumatic brain injury (80%), ischemic or hemorrhagic stroke (7%), subarachnoid hemorrhage (6%) and other causes (5%). The patients' mean age was 32.29 years ($\pm$12.45), and the mean time post-injury was 4.67 years ($\pm$2.35).

The common clinical characteristics of the patients included in the study were severity and duration of coma. In fact, it is well known that severe acquired cerebral lesions may share the coma condition in the acute phase as well as the cognitive and behavioural sequelae in the chronic phase. Extensive ischemic or hemorrhagic stroke may cause coma, especially when the brainstem is involved, as well as subarachnoid hemorrhage (SAH), which may be considered the second cause of coma after traumatic brain injury (TBI). SAH is usually considered separately because of its high incidence and the frequent necessity for neurosurgical intervention (aneurysm clipping, embolization or ablation of arterio-venous malformations, etc.).

We excluded patients who had not suffered severe brain injury or who had suffered severe brain injury without coma or with coma duration of less than 48 hours.

Measures

A telephone interview was used to ask caregivers whether patients had resumed driving and, if so, whether they had subsequently been involved in a traffic accident. We decided to interview the caregivers, to rule out any false information due to poor patient awareness of their cognitive and/or behavioural disorders. Moreover, by using this method, very minor accidents may have been excluded, because some patients may not have told family members about them, but only about accidents without vehicle or physical sequelae.

We divided the patients into two groups (the first involved in accidents and the second not involved), and analysed the differences between them.

We then calculated the frequency of road traffic accidents requiring secondary emergency room treatment in one year in the general Italian population; this was age and sex matched to the patient group, using the national evaluation of the Istituto Superiore di Sanità (National Institute of Health) [20]. We also calculated the volume of exposure to road traffic accidents (years of driving) of our patients with severe brain injury who resumed driving compared to the normal population during the exposure time. Then, we compared the frequency of road traffic accidents in the patients and in the normal population.

All patients were evaluated by means of GOS [17], where GOS 1 indicates death and 5 good recovery, at least 1 year after brain injury.

Statistical Methods

The Poisson distribution [21], the Fisher exact probability test for proportions [22] and standard concepts of epidemiology were used for the statistical analysis.

Results

From the 90 interviews with the caregivers, we found that 29 patients (32%) had resumed driving and 11 of the 29 (38%) had subsequently been involved in road traffic accidents. In particular, 5 out of 11 patients (45%) who had had road traffic accidents had actually been involved in more than one accident.

Concerning the general characteristics of the group involved in road traffic accidents compared to

Table I. Demographic and clinical data for the two groups of patients.

	Accident group ($n = 11$)	Non-accident group ($n = 18$)	Stat. Sign.
Age	28.0	28.8	$p =$ n. s.
Mean and SD (years)	9.55	9.68	
Sex (% male)	81.8	83.8	$p =$ n. s.
Time post-injury	5.27	3.58	$p < 0.05$
Mean and SD (years)	1.42	1.31	
Coma duration	24.4	26.3	$p =$ n. s.
Mean and SD (days)	19.4	23.1	

Table II. Total volume of exposure for the two groups of patients.

	N	Time post-injury (years)	Risk exposure
Subjects *involved* in a traffic accident	11	5.3	$11 \times 5.3 = 58.3$
Subjects *not involved*	18	3.6	$18 \times 3.6 = 64.8$
		Total volume of exposure	123.1 years

the group not involved, there were no statistically significant differences in the demographic and clinical data except for time post-injury (see Table I).

In Italy, an estimated 800 000 drivers are involved in road traffic accidents every year and require emergency room treatment (i.e. accidents sufficient to require medical or paramedical involvement) [20]. Therefore, in one year the probability of a patient having a road traffic accident and requiring emergency room treatment, is 0.014 286 (800 000/56 000 000 of the Italian population). The exact figure of this probability is 0.013 941 0, based on the fact that 65% of the injured persons are drivers and the drivers' population is about 37 300 000. In the following calculation, for simplification we will consider all the 800 000 arrivals as if they were drivers (like our 29 subjects). An evaluation of the number of expected cases will, therefore, be overestimated because only some of them were really drivers.

We know that for a young male (more than 80% of our patient group) the relative risk of being involved in a car accident is 2.7 times greater than in the general population (Italian Central Institute of Statistics (ISTAT) [23] and National Institute of Health [20]). Therefore, the young male per year probability of being involved in a traffic accident and needing emergency room treatment is 0.038 58 ($0.014\,286 \times 2.7$).

Estimates of years of exposure to road traffic accidents were calculated for the two groups of subjects, i.e. those involved in road traffic accidents and those not involved (see Table II).

As shown in Table II, the total volume of exposure to risk of road traffic accidents in our patients with severe brain injury was 123 years.

Calculating the probability of a normal young male being involved in a road traffic accident every year during the total duration of the exposure to risk of our patient group, we found 11 cases in our study group against the 4.7 expected cases ($0.038\,58 \times 123$).

The difference between the number of expected cases and the observed cases was statistically significant (in Poisson's distribution with a mean of 4.7, the probability of 11 or more cases is $p = 0.009\,022$), with a relative risk of road traffic accidents in severe brain injury patients vs uninjured people equal to 2.3, which is the result of the 11 observed cases divided by the 4.7 expected cases.

Although there were non-specific items on our questionnaire about the number of accidents the patients were involved in, the patients' relatives reported more than one accident in five cases (45%). One patient, in particular, was involved in nine road traffic accidents as a driver. In this latter case, the neuropsychological evaluation demonstrated the prevalence of behavioural disorders rather than cognitive deficits.

A comparison of GOS scores in the group of patients involved in road traffic accidents and in the group not involved showed a distribution difference that approached statistical significance (Fisher Exact p: one-tailed $p < 0.0530$; two-tailed $p < 0.0641$). In the GOS 5 (good recovery) group, there was no difference in the distribution of involvement in road traffic accidents; conversely, in the GOS 4 (moderate disability) group there was, paradoxically, a lower risk of road traffic accidents, likely due to this group's greater caution when driving because of possible motor difficulties (see Table III).

Table III. Comparison of GOS scores in the two groups of patients.

	Traffic accidents	
	Yes	No
GOS 4	2	10
GOS 5	9	8

GOS 4 = Moderate disability. GOS 5 = Good recovery.

Discussion

The main result of our study is that many patients with severe brain injury have road traffic accidents after they resume driving.

Our preliminary data show that a subject who has suffered severe brain injury (GCS < 8) and coma lasting for at least 48 hours has a statistically significant higher risk of being involved in a road traffic accident.

Eleven out of 29 patients who resumed driving (38%) and were involved in road traffic accidents is a worrisome percentage. In fact, based on our pessimistic approximations the relative risk of road traffic accidents in coma survivors is 2.3 times higher than in uninjured individuals.

In light of what is reported in the literature about the poor statistical power resulting from use of the accident rate (relatively rare) as a measurement criterion [20], our data seem even more significant, due to the statistically significant higher accident rate in our study group compared to normal controls.

Other criticisms of existing studies regard the heterogeneity of samples with respect to the severity of brain damage, the error in controlling for various demographic variables, and the appropriateness of using accident rate as the primary measure of safety, since problematic drivers may make errors that cause others to experience near or actual accidents without getting into accidents themselves [24, 25].

In light of our preliminary results, the relatively high rate of road traffic accidents may be secondary to our longer time post-injury (3–5 years) compared to that of previous studies. In fact, the higher accident rate in subjects with longer time post-injury suggests that longer exposure to risk increases the probability of road traffic accidents. This increased risk may be due to the progressive growth in confidence with driving and consequent less caution. In this regard, another consideration is that even longer periods of road experience after resuming driving seem to be insufficient 'on the road' training to protect subjects with severe brain injury from the risk of accidents. Instead of discouraging retraining programs, this interpretation seems to underline the possible learning disorders of our patients and the need for specific rather than general retraining programs. In fact, the driving evaluation protocol should be followed up by retraining programs conducted by driver educators. Indeed, it has already been reported that generic retraining programs are an inefficient and more costly use of clinical and road time than deficit-specific retraining programs [26].

However, a follow-up study of the road traffic accident rate would not provide information about false negative errors, such as drivers judged to be incompetent who were prevented from driving and may actually have been safe drivers [24].

Our data must be considered preliminary, because further information is needed on the characteristics, dynamics and severity of road traffic accidents, and on the volume of exposure to risk of subjects involved and not involved in accidents in terms of driving habits and especially overall driving time (yearly). Further limitations of our study may be the lack of information provided on the interval between head injury and restarting driving, and the kind of driving typically undertaken by the patients (e.g. short distance, local journeys, long distance, etc.).

In conclusion, the preliminary results of our study need further confirmation on a larger number of patients with severe brain injury and sufficient long-term follow-up evaluation (2–5 years after resuming driving).

In fact, the higher accident rate found in the population studied compared to normal subjects requires checking the pre-coma accident rate in these patients in order to exclude a pre-morbid personality resulting in higher proneness to the risk of accidents.

Additional studies are needed to confirm our results because of the limitations of our findings with regard to sample representativeness, size and measurement.

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