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ORIGINAL ARTICLE

Driving with cognitive deficits: neurorehabilitation and legal measures are needed for driving again after severe traumatic brain injury

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Abstract

Primary objective: This article presents a retrospective study on a group of survivors of severe traumatic brain injury with the purpose of discerning whether post-traumatic cognitive deficits prevent them from safely resuming driving and to see if holistic neurorehabilitation improves the rate of patients fit for returning to driving.

Methods and procedures: We studied 17 patients who had suffered severe traumatic brain injury (TBI) as measured by Glasgow Coma Scale scores. All subjects underwent a holistic, intensive and multidisciplinary neurorehabilitation program during a mean period of 10.53 months in the Centro de Rehabilitación de Daño Cerebral (CRECER®)—Center for Brain Injury Rehabilitation—in Seville, Spain. Patients were divided into two different groups: drivers (patients who drove despite strong and repeated recommendations from the Center to desist from doing so when they began the rehabilitation program) and non-drivers (patients not driving at the time they began the rehabilitation program although they had a pre-injury driver's license). The FIM+FAM-Revised Scale [1] was administered both before commencing treatment and upon termination.

Results and conclusion: (1) Patients showing physical functionality above 80% returned to driving, regardless of their cognitive and/or emotional deficits, and against doctor recommendations. (2) Severe TBI survivors that have not been certified as fit to drive are at increased risk for driving incidents other than collisions and traffic accidents. This is illustrated by significant incidents involving some of the subjects in our study that were due to disorientation, confusion and confrontations with people or situations. (3) We found that neurorehabilitation is worthwhile; after integral and multidisciplinary neuro-rehabilitation more than 70% of survivors of severe TBI can return to driving with regular safety. (4) We also suggest that laws be introduced to keep not-clinically-apt patients from driving.

Keywords: *Driving, acquired brain injury, neurorehabilitation, neuropsychology*

Introduction

Persons who have suffered a severe traumatic brain injury (TBI) present evident and visible physical and cognitive sequelae that, as long as they remain, impede them from driving safely. This is especially true for individuals with deficits in visual scanning, visual-spatial abilities, decision making, divided attention, reaction time, motor problems or cognitive and behavioral control [2–8], as well as, in our clinical experience, loss of motor automatisms. A driver must have or acquire higher order visuospatial abilities and basic visual recognition and response, anticipatory braking and defensive steering capabilities, and behavioral manifestations of complex attention [9]. However, the presence of problems which could significantly affect driving does not stop patients from driving after traumatic brain injury [10]. Clinical experience shows that many severe brain injury survivors who were licensed to drive before their injury insist on driving afterwards regardless of their cognitive, emotional or behavioral status. Being physically able to drive does not necessarily mean being apt to drive. Physicians, neuropsychologists, social workers, and especially families, are under extreme pressure from patients who insist on driving again regardless of their status. The problem is exacerbated in countries that have no specific laws to provide support in such cases. The question of whether a patient with brain injury can safely resume driving or not generally comes up during rehabilitation, and healthcare professionals need

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sound criteria upon which decisions regarding aptness for driving can be made [11, 12, 16, 17]. Fisk et al. [13] observed that most survivors of TBI (>60%) that returned to driving reported driving every day and more than 50 miles per week. Although they had frequently been advised against driving by family members, physicians or non-physician health care professionals, over half (63%) had not been professionally evaluated for driving aptness. Most of these patients were not cognizant to the fact that due to their physical and/or cognitive status it was unadvisable for them to drive motor vehicles or even bicycles. This lack of awareness of the impairments resulting from their cognitive deficits is the main reason why most physically independent patients have no qualms about driving again after discharge from the hospital. Perino and Rago [14] estimated that around 50% of survivors of severe TBI and 75% of survivors of moderate brain injury go back to driving cars or other motor vehicles, and rated as high the probability that patients driving against recommendations would be involved in accidents. Formisano et al. [15] found that 38% of their patients were involved in road accidents after resuming driving following discharge from the hospital. Their retrospective data showed that a person who had suffered severe brain injury (GCS > 8) with a coma lasting over 48 hours is at higher risk of being involved in a traffic accident (the Italian parliament recently passed a new law that requires a review of the driving license for patients who had been in coma over 48 hours).

The present article explores two hypotheses. First, although the literature indicates that cognitive impairment can negatively affect driving-related skills and should be a factor taken into consideration when determining driving ability, we hypothesize that cognitive deficits do not stop patients who have survived severe traumatic brain injury from resuming driving if they feel they are physically independent. Second, holistic neurorehabilitation of cognitive and physical deficits can increase the rate of patients apt to safely resume driving after severe traumatic brain injury.

Subjects and method

Subjects

We studied 17 patients who had suffered a severe traumatic brain injury with a mean Glasgow Coma Scale score of 6 (SD 2.54). The average age of the subjects was 22.94 (SD 6.93) years. The mean time period from trauma to commencement of neurorehabilitation was 10.94 (SD 15.65) months. All subjects underwent a holistic, intensive, and multidisciplinary neurorehabilitation program during an average period of 10.53 (SD 6.24) months [18, 19] in the Centro de Rehabilitación de Daño Cerebral (C.RE.CER.®) (Center for Brain Injury Rehabilitation, C.RE.CER.®) in Seville, Spain. Although all subjects had a valid driver's license pre-injury, they were each strongly advised against driving due to their physical and/or cognitive status at admission. For our retrospective study we found we could divide the patients into two different groups: drivers (patients who drove after returning home from their daily sessions despite repeated warnings and recommendations from the center) and non-drivers (patients who had not resumed driving at the time they began the rehabilitation program). All of the subjects in this study resided in Spain, which has no laws specifically restricting driving after traumatic brain injury.

Material and procedures

All patients had been administered the FIM+FAM-Revised Scale [1] before commencing treatment and upon termination. With this procedure three different scores were obtained for each of the sections in which the FIM+FAM is divided: the functionality percentage at admission (FPA), the functionality percentage at discharge (FPD), and the percentage of total functional gain (PFG). This allowed us to assess patient progress in the different areas being examined. The FIM+FAM was scored according to the results of the physical examination and a psychometric test battery administered to each of the patients (see Table I). Patients scoring less than or equal to 70% on global, physical or cognitive scales of the FIM+FAM were considered unfit to drive.

Data analysis

The FIM+FAM-R scores of the entire group of patients at the time of admission and again at discharge were compared using *t*-student analysis. Differences between drivers and non-drivers were determined using the same *t*-student. The statistical analysis was calculated with SPSS software for Windows (Version 6.1.2) with alpha set at 0.05 for all tests.

Results

FIM+FAM: general characteristics and comparison at admission and at discharge

Table II shows the general characteristics of both groups, based on the FIM+FAM scores obtained by the entire group of patients at the time of admission and again at discharge from the neurorehabilitation

Table I. Neuropsychological test battery related to the capacity to drive administered to the patients. Patients scoring under 2.0 *z* deviations were considered unfit to drive. Normative scores are in the manual of each of the tests.

Abilities for safe driving	Psychometric tests
Visual scanning	BNS tachistoscopic attention examination [32]
Visuo-spatial abilities	Hooper VOT [35]; Benton VRT [36]; Rey-Osterrieth complex figure [37]; Visual Form Discrimination Test [38]
Decision making	Tower of Hanoi-Sevilla [32]; Wisconsin Card Sorting Test [34]
Divided attention	Stroop test [32, 39]
Reaction time	BNS simple attention test [32]; BNS examination of vigilance [32]
Motor skills	Grooved Pegboard Test [40]; Tests for motor function of the Luria/ Christensen Test Battery [41]
Behavioural and emotional control	Nechapi [33]
Verbal and motor automatisms	C.RE.CER®. tasks

Table II. Group indices of functionality and percentage of gain in recovery at admission to the neurorehabilitation program.

	Functionality indices at admission		Functionality indices at discharge		% of gain		
Activity	Mean	SD	Mean	SD	Mean	SD	$p >$
Self-care	54.13	29.11	83.45	22.75	74.90	29.91	0.001
Sphincter control	22.55	20.45	78.55	29.65	80.50	24.53	0.006
Mobility	38.85	28.82	80.94	27.66	73.30	33.70	0.002
Locomotion	41.86	30.86	83.31	22.27	72.10	30.11	0.001
Communication	56.88	28.31	88.77	14.84	78.70	25.34	0.000
Psychosocial adjustment	48.43	25.22	88.01	21.78	83.50	28.33	0.000
Cognitive functions	53.73	27.36	91.75	16.71	87.40	23.93	0.000

program. At admission, data show that as a group the mean total index or percentage of functionality on the scale was 45.2%, with the most affected areas (those with the lowest functionality scores) being sphincter control (22.55%), mobility (38.85%) and locomotion (41.86%). Communication (56.88%), social adjustment (48.43%), cognitive functioning (53.73%) and self-care (54.13%), were low, nearly only half of what they should be. At discharge the mean total percentage of functionality for the group as a whole had risen to 80% with the best functionality scores being obtained in cognitive functioning (91.75%), social adjustment (88.01%), and communication (88.7%). The highest percentage of gain at discharge was also obtained in cognition (87.4%), social adjustment (83.5%), and in sphincter control (80.5%).

Drivers' and non-drivers' FIM+FAM comparison at admission and at discharge

Table III shows mean scores and standard deviation (SD) obtained on the Index of Functionality at Admission (IFA) and on the Index of Functionality at Discharge (IFD) by the two groups (drivers and non-drivers) before and after treatment. Scores show significant differences between the driver and non-driver groups in all of the functional areas explored by the FIM+FAM-Revised at the beginning of treatment. Scores also show that there were no differences in any of these areas between the driver and non-driver groups after completing treatment.

Driving status at admission and discharge

We finally observed that only 35.3% of the patients were driving at admission to the rehabilitation program (despite being warned against doing so at the time). Although they were driving, they were not considered apt owing to their physical and neuropsychological assessment scores at admission regarding cognitive and social functioning. Upon discharge from the program, 70.6% of the group was driving again (this amount includes the 35.3% who drove at admission despite warnings and were considered apt upon conclusion of the program based on cognitive and physical functioning scores).

Discussion

In general, data show that the survivors of severe TBI included in our study made up a very disabled group with regard to functionality in daily living activities, showing functionality at admission of 45.2%. All functional areas measured by the FIM+FAM Revised were severely affected, especially sphincter and locomotion. The subjects in both groups were

Table III. Index of functionality divided between drivers and non-drivers at admission and discharge; and significance level of comparison between groups and within groups.

Activities	Functionality	Drivers		Non-drivers		P> Inter-groups	P> Within groups
		Mean	SD	Mean	SD		
Self-care	Admission	88.22	9.46	34.64	12.26	0.00	0.001
	Discharge	99.47	1.05	74.30	24.36	0.07	0.001
Sphincter control	Admission	100.00	0.00	22.55	20.45	0.00	0.001
	Discharge	100.00	0.00	77.85	29.65	0.01	0.006
Mobility	Admission	78.55	10.11	27.51	20.37	0.01	0.002
	Discharge	100.00	0.00	75.50	29.40	0.29	0.002
Locomotion	Admission	79.53	19.83	25.80	17.15	0.02	0.001
	Discharge	96.00	5.54	77.53	24.57	0.23	0.001
Communication	Admission	87.70	16.45	48.54	25.95	0.04	0.000
	Discharge	98.07	3.35	85.98	15.92	0.23	0.000
Psychosocial adjustment	Admission	73.18	12.09	34.94	19.42	0.00	0.000
	Discharge	100.00	0.00	81.46	25.00	0.09	0.000
Cognitive functions	Admission	72.80	14.54	43.32	27.48	0.02	0.000
	Discharge	100.00	00.00	87.25	19.58	0.13	0.000
Mean Total scale	Admission	86.68	6.88	49.23	30.38	0.000	0.000
	Discharge	99.58	0.66	85.30	20.42	0.001	0.001
Gain at discharge		97.6%	4.35	78.3%	26.27	0.002	0.002

also very affected in their cognitive abilities, communication and social adjustment. Although the results of the neuropsychological and physical examinations at admission suggested that these patients were unfit to drive, our findings show that about one third (35.3%) of the patients continued to drive in spite of the need to undergo rehabilitation, and despite lacking the requisite cognitive abilities for safe driving. This percentage coincided with Formisano et al. [15], who found that 32% of survivors of severe TBI drove against doctor recommendations and despite not being fit to do so. Upon examining the physical characteristics of the group of patients driving at admission, we found that they displayed a functionality percentage of 75% before starting the rehabilitation program. This level of functionality allows for a quite acceptable degree of independence (functional normality starts at around 80%). This certain degree of independence is highlighted by the scores obtained by this group on the different FIM+FAM-Revised subscales analysed. The scores for self-care, communication and sphincter control were equal to or above 85%. The scores for transfers and locomotion were around 80%. Nevertheless, scores were below 75% in cognitive functions and in psychosocial adjustment. A high score (above 80%) on the more physical subscales seems to be the best predictor that a patient will insist on driving despite cognitive deficits that would belie safe driving. High scores on the physical subscales do not of themselves imply that survivors of severe TBI are not at higher risk for traffic accidents or driving incidents. A low functionality percentage on the subscales of cognitive functioning, psychosocial adjustment, and communication suggests that patients should not, as long as such scores are obtained, drive again (see next section). Consequently, patients with such scores should not be allowed to drive and a more detailed neuropsychological assessment should be carried out in order to plan rehabilitation and to precisely determine the threats to safe driving [20–24]. Hawley makes the same recommendation [25]: as the existence of problems which could significantly affect driving will not prevent patients returning to driving after traumatic brain injury, patients should be assessed for both mental and physical status before returning to driving after a head injury, and systems should be put in place to enable clear and consistent advice to be given to patients concerning driving.

As long as they display an acceptable level of ability to care for themselves and to move and transfer with a certain degree of ease, neither the patients nor their families contemplate the fact that cognitive problems or social misadjustment are obstacles to driving. In light of Hawley's recommendations, our data clearly indicate that if survivors of severe TBI with post-traumatic cognitive disorders display a functional percentage on physical subscales >80%, and had a pre-injury driver's license, they are going to continue to drive. They will not stop to consider that problems with memory, attention, temporal or spatial orientation, inappropriate emotional reactions, aggressiveness, epileptic focus, and so forth, are an obstacle to driving. Nor will they stop to consider the effects the psychotropic drugs that they may be taking could have on their driving abilities. Priddy et al. [26] also found that the recommendations of rehabilitation staff did not appear to have much influence on the final decision whether or not the survivor resumed driving activities. In the same way, Coleman et al. [27] observed that caregiver

perception of patients' fitness was the overwhelming determinant of whether and how much patients drive. The bases on which caregivers form their opinions affect the safety of patients and the public at large. The significant other's perceptions of the patient's fitness to drive were the strongest predictor of patients' driving status and driving frequency. However, they also found that years post-injury, disability at discharge, and current neuropsychological functioning best predicted post-injury driving safety as measured by actual incidents. The relation between perception of patients' fitness and actual driving incidents, however, was found to be modest.

Driving without cognitive resources

During their daily rehabilitation sessions we queried the patients who insisted on driving about their experiences and any incidents they had while driving the day before. Obtaining information was difficult given that the patients were obviously reluctant to report small incidents in order to avoid confrontation with the therapists. Nonetheless we found that three of the six patients (50%) had been involved in incidents too serious to hide. We cannot be certain that the other three had no mishaps while driving since it is possible that we were simply not informed of them. Following are the accounts of the three patients who were involved in serious driving incidents reported either by the patient or a family member.

The first is the case of a young man who had serious orientation problems while driving, to the point that he would get lost on his way home and end up in other parts of the city. The most serious of these events occurred one night when he became lost in the city and ended up in an area that was completely unfamiliar to him. As there was no way for him to phone home, he ended up spending the night in his car. When he woke up the next morning he found he was parked on a once familiar street not far from where he lived.

The second case is that of a young woman who, while backing up, mistook the accelerator for the brake and ended up crashing into the front window of a nearby shoe store.

The third case involved a young man with a serious frontal syndrome which included a pronounced lack of impulse control. Following an argument, he took the car keys and left his father and the car abandoned one night on a back road. Another day, enraged by an apparently trivial matter, he went outside, got into the car, started the engine, and began going back and forth on the driveway, angrily accelerating and braking until he had nearly burned out the tires.

These three cases demonstrate that driving with cognitive deficits not only could result in traffic accidents but could also lead to behavioral and/or social problems.

Driving again after neurorehabilitation

The other question we seek to explore is whether an intensive, integral and multidisciplinary rehabilitation program can help patients improve enough to be able to drive safely [1]. Our findings show that the survivors of severe TBI who were driving at the time of admission to the rehabilitation program, were, as a group, very different functionally from the group that did not drive at admission ($p < 0.05$). The non-driver group displayed much more severe functional damage than the driver group (see Table III), but after rehabilitation all patients showed significant recovery in all functional areas ($p < 0.05$). This was good news and indicated that the rehabilitation program (including the possible effects of spontaneous recovery [42]) can improve the rate of patients returning to driving. In our follow-up of patients after rehabilitation, and in addition to the initial group of driving patients that had achieved a satisfactory degree of cognitive functionality meriting safe-driving status, we found that 6 patients from the non-driving group had also achieved safe-driving status and had returned to driving as well.

Based on these results, it would seem that almost 75% of the patients who undergo a 6-month to one year long intensive, integral and multidisciplinary rehabilitation program will once again be able to safely drive a vehicle. The 29.4% of patients that could not drive following rehabilitation were in need of further treatment. Although these patients had improved, they still displayed persisting cognitive and motor deficits that were too important to authorize them to drive without risk. In a study by Schultheis et al. [28], survivors of TBI who successfully complete a driving evaluation program are able to reintegrate into the driving community with minimal difficulty. Comparison of self-reported and documented reports of aberrant driving behaviors did not reveal a significantly greater number of accidents or violations among TBI participants compared with normal control drivers.

To prevent traffic accidents in which innocent bystanders may suffer consequences, and to avoid unnecessary antagonism between patients and their families, we recommend that prior to returning to driving, patients be required to enroll in a holistic and multidisciplinary program for the rehabilitation of motor and cognitive deficits subsequent to traumatic brain injury [18, 29]. The Americans with Disabilities Act [30], in conjunction with the Rehabilitation Act (effective July 22, 1992) is another

good reason to include patients in a rehabilitation program. Compliance with these statutes requires that modifications be made—called reasonable accommodations—which permit individuals with disabilities to perform the 'essential functions' of the position they hold or seek. Neurorehabilitation would help people with brain injury to drive again when driving is an essential function of the position they hold or seek.

We also strongly suggest that legal precepts be established, as this would be an important aid to the health professional in dealing with patients who insist on driving despite being unfit to do so. Pidikiti and Novack [31] conducted a survey to determine if driving impairment secondary to a disabling injury is addressed in state licensing laws and training programs. Drivers can submit voluntarily to re-evaluation after disabling injuries in 35 states, but no provision is made for reporting such individuals. Only 15 states authorize physicians to report impaired drivers, and only seven require such reporting. Based on a survey of the 100 rehabilitation centers surveyed, only 36 provided on-site training for disabled drivers. Voluntary submission for re-evaluation after head injury does not often occur. None of the 35 patients with head injury, followed up to two years post-onset, sought re-evaluation despite being asked to do so, although 21 had resumed regular driving. Two of the 21 were involved in subsequent traffic accidents. We coincide with these authors in recommendations that common international legal guidelines be established to ensure re-evaluation of individuals with disabling conditions, delivery of accurate information concerning licensing, and availability of training programs.

Conclusions and suggestions

According to the data and discussion we can observe the following three main conclusions: First, patients showing a physical and motor functionality above 80% will return to driving, irrespective of their cognitive and/or emotional deficits, and despite doctor recommendations to the contrary. Second, collisions or traffic accidents are only part of the problem for survivors of severe TBI who drive without being fit to do so. Other significant incidents can occur that make driving a vehicle dangerous: disorientation, confusion and emotional confrontation with people or situations. Third, neurorehabilitation is worthwhile: after integral and multidisciplinary rehabilitation more than 70% of survivors of severe TBI can return to driving with regular safety.

We recommend that survivors of severe TBI with cognitive deficits undergo an integral and multidisciplinary neurorehabilitation program before resuming driving, and before being authorized to drive; over 70% of the patients in our study were apt for driving again after treatment. The FIM+FAM-Revised seems to be a good instrument to use as a functional measurement to envision the capacity of severe traumatic brain injury patients to safely return to driving. It is a quick, repeatable and easy to administer instrument that does not exclude the use of other neuropsychological tests and physical examination when patients have been identified as not-clinically-apt to drive. Our data also suggest a need to establish legal guidelines to prevent patients from driving during the intensive, holistic and multidisciplinary rehabilitation program. Legal precepts concerning return to driving would be very effective in preventing driving incidents and traffic accidents during and after the rehabilitation process, and would have the added advantage of sparing families and therapists unnecessary conflict with patients.

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