

Spontaneous recovery of cognitive functions after severe brain injury: When are neurocognitive sequelae established?

José León-Carrión¹, Fernando Machuca-Murga²

¹ *Laboratorio de Neuropsicología Humana. Universidad de Sevilla*

² *Centro de Rehabilitación de Daño Cerebral (C.RE.CER.), Sevilla*

Abstract: *Introduction:* This study analyzes the evolution of neurocognitive deficits observed in a group of patients with severe traumatic brain injury (TBI), that were not treated with any type of neuropsychological rehabilitation. We endeavor to establish the moment in which deficits cease to show spontaneous recovery and can be categorized as sequelae. *Subjects, Material and Method:* This study was carried out with 28 patients that had suffered a severe TBI. Subjects had been neuropsychologically assessed on an average of 8 months after the trauma, and revised around 11 months later. The following tests were administered for the neuropsychological assessment: Simple Attention Test, Conditioned Attention Test and Tower of Hanoi/Seville, from the Seville Neuropsychological Test Battery (BNS), the Trail Making Test and Benton's Visual Retention Test. *Results and Conclusions:* The results obtained in the statistical analysis do not show statistically significant differences between the initial neuropsychological study and the 11-month revision. Data suggest that neurocognitive sequelae in severe TBI patients are established approximately 8 months post-trauma, and do not show significant improvement after this period in patients who do not receive neuropsychological treatment. **Key words:** neurorehabilitation, cognitive rehabilitation, brain injury, TBI.

Recuperación espontánea de las funciones cognitivas después de daño cerebral severo: ¿Cuándo están establecidas las secuelas neurocognitivas?

Resumen: *Introducción:* El presente trabajo pretende analizar la evolución que presentan los déficits neurocognitivos observados en un grupo de pacientes con traumatismo craneoencefálico (TCE) grave, a los que por diversos motivos no se les aplicó ningún tipo de tratamiento de rehabilitación neuropsicológica. Se pretende establecer el momento a partir del cual los déficits no van a mostrar una evolución espontánea y

Corresponding author: Prof. José León-Carrión, Ph.D.

Laboratorio de Neuropsicología Humana, Universidad de Sevilla

Sevilla, España. E-mail: JLEON@CICA.ES Tlf: 954 557 688

se establecen como secuelas. *Sujetos, Material y Método:* Se realizó un estudio con 28 pacientes que habían sufrido un traumatismo craneoencefálico grave y que fueron evaluados neuropsicológicamente por término medio a los 8 meses del TCE y revisados aproximadamente unos 11 meses después. Para la evaluación neuropsicológica se administraron las siguientes pruebas: Trail Making Test, Test de Retención Visual de Benton, Test de Atención Simple, Test de Atención Condicionada y Torre de Hanoi/Sevilla, de la Bateria Neuropsicológica Sevilla (BNS). *Resultados y Conclusiones:* Los resultados obtenidos no muestran diferencias estadísticamente significativas entre la ejecución en dichas pruebas en el primer estudio y en la revisión posterior. Estos datos sugieren que las secuelas neurocognitivas en los pacientes con TCE grave van a quedar establecidas aproximadamente a los ocho meses del traumatismo, no observándose una mejoría significativa transcurrido este tiempo en los pacientes no tratados neuropsicológicamente. **Palabras clave:** neurorehabilitación, rehabilitación cognitiva, daño cerebral, TCE.

One of the questions that the families, therapists and insurance companies of people with neurocognitive disorders consequential to a traumatic brain injury (TBI) most frequently ask is whether there is any possibility of spontaneous recovery from these disorders. The answer to this is especially important as it enables us to correctly plan a therapeutically- and cost- effective treatment program for a patient. We cannot overlook the more than \$37 billion per year that physical, cognitive, behavioral, and social impairments after TBI cost in the United States alone (Max, Mackenzie, and Rice, 1991; Chesnut, Carney, Maynard, et al., 1999); nor that many ask whether rehabilitation as currently practiced is an effective and cost-efficient method of returning TBI patients to their maximum potential (Salazar, Warden, Schwab, et al., 2000).

In a legal process, neuropsychologists must to be able to determine at what point the disorders that a patient suffers as a consequence of TBI will be definitive and irreversible and therefore classified as sequelae. In 1938, Conkey (1938), in the first study carried out concerning this matter, determined that the spontaneous stage of recovery of cognitive functions occurs within the first six months post-TBI. Bond (1986), however, argues that it is not until between 18 and 24 months post-trauma that sequelae are established. The controversy regarding spontaneous recovery of patients with neurocognitive disorders is patent and studies offering data towards obtaining answers are necessary. The aim of this study is to analyze the cognitive course of a group of patients that did not receive any kind of rehabilitation for cognitive functions affected by TBI.

Method

Participants

The sample was made up of 28 patients who survived, after critical care treatment, to a severe traumatic brain injury.

Inclusion criteria when selecting subjects for the study follow:

1. Subject suffered a severe traumatic brain injury.
2. Subject had no history of alcohol or drug abuse.
3. Subject had no medical or psychological history pertinent to his/her condition prior to the TBI.
4. Subject had at least 2 records of neuropsychological assessment.
5. Subject did not receive any kind of neurocognitive rehabilitation prior to undergoing the two neuropsychological evaluations.

The question as to why these patients had not received treatment for their TBI-related cognitive problems is answered by the fact that the health systems to which they belonged simply did not cover this type of rehabilitation at the time they suffered their injuries. The 85.7% of the subjects were male, 14.3% female. The average age was 25.32 years, and the groups' mean score on the Glasgow Coma scale was 6.88. On the average, the subjects were evaluated at 8.5 months post-event and underwent a neuropsychological revision 11 months after the first study. (See Table 1).

VARIABLE	N	\bar{X}	SD
AGE	28	25.32	11.15
GCS	17	6.88	1.45
1 ST EVALUATION	28	8.42	7.15
2 ND EVALUATION	28	11.10	6.70

Table 1. *Data regarding age, GCS, and date, in months, of first and second evaluation.*

Most of the patients studied (60.7%) had an educational level of less than 8 years and had been employed at jobs that did not require any academic qualification. (See Table 2)

VARIABLE	N	%	VARIABLE
EDUCATION	28	100	PROFESSION
0-7 years	8	28.6	Unqualified
8 years	9	32.1	Mid-level
9-11 years	7	25.0	Student/Unemployed
12 years	1	3.6	Administrative position
13-15 years	3	10.7	Upper level
16 + years	0	0	

Table 2. *Subjects' educational levels and professions*

As for clinical variables, more than 80% presented abnormal Intracranial Pressure (ICP) during the acute stage and close to 60% presented Endocranial Hypertension (ECH). Only one of the patients in the study displayed normal images (not indicative of lesions) on Computerized Axial Tomography (CAT), the rest of the patients presented alterations mainly due to contusions (37%) and subdural hematomas (25.9%). As to the locus of lesions, 42.3% were located in the right hemisphere, 30.7% in the left hemisphere and the remaining 23% of lesions were diffuse. The other 3.8% corresponds to a patient in whose CAT no lesions were visible. (See Table 3.)

VARIABLE	N	%
Glasgow Coma Scale	17	100
Severe	17	100
Moderate	0	0
Slight	0	0
Psychopathological History	28	100
Yes	0	0
No	28	100
ICP (intracranial pressure)	16	100
Abnormal	14	87.5
Normal	2	13.5
CT (computerized tomography)	27	100
No alteration	1	3.8
Epidural Hematoma	1	3.8

SPONTANEOUS RECOVERY AFTER TBI

Subdural Hematoma	7	25.9
Intraparenchymatous Hematoma	5	18.5
Subarachnoidal haemorrhage (SAH)	3	11.1
Contusion	10	37
Localization	26	100
Right Hemisphere	11	42.3
Left Hemisphere	8	30.7
Diffuse	6	23
Not visible	1	3.8

Table 3. *Subjects' relevant clinical variables*

Material

All subjects underwent neuropsychological assessment including:

1. Evaluation of attention (Tonic Alert)
2. Evaluation of vigilance (Phasic Alert)
3. Tower of Hanoi/Seville (executive function, reasoning)
4. Trail Making Test
5. Benton's Visual Retention Test

Because only these tests were coincidental in all subjects' first evaluation and subsequent revision, they are the only ones we included in our study.

Simple attention (Tonic Alert), was assessed in all subjects using the computerized version of the Seville Neuropsychological Assessment Battery (BNS), a classic simple letter cancellation test that takes about 5 minutes.

Assessment of vigilance (Phasic Alert), was done with an adaptation of the above-mentioned test to evaluate conditioned attention. The basis of the test is the same as above, but the task is modified to include a stimuli which informs the subject that s/he must be prepared to emit an immediate response. For a more detailed description of both tests see León-Carrión, (1997).

The third test included is the Trail Making Test (TMT), [(Armitage, 1946, from the Halstead- Reitan Neuropsychological Test Battery (Halstead, 1947; Reitan, 1955)]. In this test the subject is given a pencil and eraser and asked to join, as quickly as possible and in ascending order, the numbers 1 to 25 which are distributed over a page in the form

of a large A, as well as the numbers 1 to 13 and the letters A to L which are printed in the form of a large B (see León-Carrión, 1984; 1986).

The fourth test included is the Tower of Hanoi (TH) (Horman, 1965; Egan, 1973; León-Carrión et al., 1991). As Anzai y Simon (1979), Karat, (1982) and Simon (1975) note, this test requires a task demanding complex reasoning in problem solving and learning procedures. The task to be performed on this test is of the problem transformation type and requires that the subject achieve a goal through a series of movements (Karat, 1982). To achieve this, an active search through possible solutions is necessary which takes up a significant amount of spatial working memory. In this process, the solution to the problem must be maintained in short-term memory and transported through the appropriate sequence of movements before the goal can be reached. (Owen et al., 1990). The “Sevilla” version of the Tower of Hanoi (TH/S) (León-Carrión, 1991,1998) restricts part of the information needed to solve the task and the subject must discover on his/her own the criteria that needs to be followed in order to solve it.

The fifth and last test included was mode A administration, form C of the Benton Visual Retention Test (BVRT) (Benton, 1963). This test is a clinical research instrument, designed to assess visual perception, visual memory and visuoconstructive skills.

All subjects were administered the computerized tests on an IBM-compatible PC, with a conventional keyboard and color screen. The scores on the T.M.T and the T.R.V.B. were obtained manually.

Procedures

All subjects were selected from a general population of traumatic brain injury survivors following the criteria described in the *Subjects* section.

A detailed revision of the patients’ clinical histories showed an interesting sample of subjects with severe TBI on whom data had been compiled regarding neurocognitive functioning through the different stages of each subject’s evolution. Data included the corresponding biographical and medical histories.

In view of the initial formulation of this study, from the available subjects we selected only those who conformed to the prerequisite criteria described in the *Subjects* section.

In the statistical analysis of the data obtained through the aforementioned neuropsychological testing, a mean comparison t-test was used for related samples, with a confidence interval of 95%. This was done for each of the variables studied with the aim of finding any

significant differences between performance a few months post-trauma and performance approximately 1 year (11.10 months) post-trauma.

The SPSS version 6.0.1. for Windows statistical package was used for analysis.

Results

Table 4 shows the results obtained after statistical analysis of the results of the patients' neurocognitive tests. Displayed in column 1 are the variables analyzed in each test; columns 2 and 3 show the mean and standard deviation of the group of patients in the first study and then in the second evaluation; the last column shows the statistical significance of the analyzes.

VARIABLE	1 st STUDY		2 nd STUDY		SIGNIF. P > .05
	X	SD	X	SD	
Total correct letters on Tonic Alert Test	96.24	6.06	98.28	4.49	No
Total correct letters on Phasic Alert Test	45.57	3.81	47.23	3.56	No
Total time on Part A of TMT	93.45 sec.	38.8	79.63 sec.	36.89	No
Total time on Part B of TMT	235.63 sec.	106.26	191.78 sec.	113.41	No
Total errors on TH/S	14.4	18.08	7.45	9	No
Total movements on TH/S	50.2	73.82	23.55	21.83	No
Total time on TH/S	351.2	197.3	277.4	346.4	No
Total correct designs on BVRT	5.57	2.06	5.76	2.04	No
Total errors on BVRT	7.34	4.17	6.57	3.98	No

Table 4. Mean, standard deviation and significance of analyzed variables.

Discussion and conclusions

The most salient result of the data obtained is clear evidence that from a psychometric focus there was no spontaneous recovery in our patients studied beyond the 8th month post-TBI.

Results show that as time goes by there are no significant reductions in subjects' omissions, nor significantly more correct answers in either tonic or phasic alert attention tasks. Neither is there a significant reduction in the performance time of the tests.

Also, the problem solving abilities and executive functioning of patients with severe TBI do not show significant improvement either in efficiency or speed.

Participants' performance on the visual memory, and visospatial and visoconstructive skills tasks, where deficits consequential to TBI are frequently observed, indicate no spontaneous recovery in the observed deficits. Again, in the second evaluation, we found neither a significant decrease in the number of errors nor a significant increase in the number of correct answers.

The results of our study show that the neurocognitive deficits observed in patients with severe traumatic brain injury who do not undergo neuropsychological rehabilitation do not tend to significantly improve as time goes by.

Based on the results of the statistical analysis of the performance of the subjects in our study on the different neuropsychological tests, we conclude that:

1. As group, patients with severe TBI will display neurocognitive deficits in attention, memory, visospatial and visoconstructive skills, executive functioning and problem solving, among others.
1. Patients continue to exhibit the same type of deficits at approximately 1.5 years post-trauma that they did 8 months after the accident.
3. Cognitive disorders seem to be established within the first eighth months following TBI.
4. No spontaneous recovery is seen after the eighth month post-TBI.
5. There is a need for more studies with a psychometric and clinical focus to analyze the spontaneous evolution of deficits in patients with severe traumatic brain injury.

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Received October 10, 2000

Accepted January 18, 2001