

Severe craneoencephalic trauma and brain plasticity in children

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Abstract

Craneoencephalic trauma is one of the principal etiologies of brain damage in young people around the world, its consequences depends on severity, injury's place, intellectual level, and principally age, given that if younger, the patient's brain is more liking for reorganization and adaptability because of the plasticity's procedures.

A 12years case is presented, who suffered Sever Craneoencephalic Trauma in a car accident, with a loss of most physical and cognitive functions; six months later and due to his brain plasticity, the patient recovers high percentage of

his cognitive and self-sufficiency skills, with Trauma's sequences regarding to anterograde memory, lengthy reaction times, executive functioning and low frustration tolerance. The case is handled under empirical analytical paradigm, with a quantitative approach and non-experimental design. Results on neuropsychological assessment show a cognitive profile with deficiencies especially on academics, learning and peers' relationship. His prognostic is favorable due to his age and personal and familiar commitment with each one of the therapists involved.

Keywords: cerebral damage, craneoencephalic trauma, cognitive profile, neuropsychology, cerebral plasticity

Introduction

In Colombia, since the 90's, it has been registered that Craneoencephalic Traumas (CET) have been part of the main death or disability's causes on 40 or lower aged, being children, adolescents and young adults the most exposed to this kind of traumas; the CET are principally car accidents, domestic violence and others.¹⁻³ Prevalence is between 150 and 350 cases per 100.000 habitants in developed countries.^{4,5} In a Clinica Universidad De la Sabana's report, it's estimated that, on average, there are 200 cases of CTE per 100.000 habitants in Colombia, where 70% achieves satisfactory recovery.⁶

Aftermaths of this traumas depends on medical attention given to the patient, specific zone where the injury is locked, age and premorbid educative level, more than severity level, though this last one is used as prognostic method for the patient, it's been found in several studies that there's no differences on long term in patient's symptomatology according to severity level, but according to affected zone,^{7,8} being altered principally attention, memory, language, executive functions, social skills and processing speed.^{9,10}

There's another variable that influxes on the sequels of these patients, the type of CET that has been presented, which can be opened, where it's manifested focalized and specified symptoms of the injury's area, normally there's no conscience's lost and has a better prognostic. On the other hand, the closed type presents more complications and a less favorable prognostic given that mechanical forces' lessons can damage not only the direct hit zone, but the contralateral zone, just

like damage on the parenchyma and axonal connections because of the twist, compression and elongation of the encephalitic mass, causing breaking of fibers and contusion on an extended form generating conscience's lost.¹¹

Moreover, hematomas, edemas or bleedings can be generated on a secondary way, which increases intracranial pressure, causing generalized damage on the specific zone where increased pressure begins.¹²

The CET most affected brain zones are predominant frontal lobe, and parietal lobe, which generate generalized symptomatology with damage on spatial-global perception, motor sequencing,⁸ monitoring ability, selective and alternant attention, long and short term memory, negative emotional states,¹³ behavior's planning and organization.¹⁴ Several of these disturbances appear on failures on the information integration and the higher hierarchy's functional systems, which difficult on a complex way the adaptation of the patient and let him on a functional deficit.¹⁵

CET's caused injuries are source of inabilities and adaption issues on its patients, however, most of these alterations (especially on cognitive process) begins their recovering approximately six months after the lesson (sometimes even less time), during this time the brain decongests and controls damage suffered through spontaneous process of recovery.¹⁶ It can also been given a recovery on cognitive functions on a greater measure through brain plasticity, understood as the ability of reorganize and generate new neuronal connections,

in order to establish new functional systems on non-affected areas or compensating affected areas functioning.¹⁷

Plasticity gives brain the ability of readapting its neuronal and synaptic organization, in order to recover cognitive functions which were diminished because of the damage, but many of these functions can't be recovered on a premorbid stage. This is evidenced with the Kennard principle, which establish that the lower the age, the best is the recovery and adaptability's capacity prognostic, given that functions aren't that specialized and allow brain to generate an important process of reorganization.¹⁸ This process can be upgraded if there's a neuropsychological rehab on an early stage, which handles the same principals as brain neuroplasticity and is performed with bases on the patient's specific needs, propending for its autonomy.¹⁹

Method

It was started on the empirical-analytical paradigm in order to corroborate hypothesis, describe phenomenon and relate variables, with a quantitative approach, and a case study's type, since it was looked for to describe and analyze a case study's characteristics and non-experimental design.²⁰

Ethical principles

It was taken in account the Law 1090 from 2006 and the resolution 008430 from 1993, which regulate the professional exercise of the psychologist in Colombia and are based on the universal principle of respect to the integrity, wellness and personal interests' protection, nondiscrimination, not perform interventions with minors without the assent of attendant; and not accept any condition or pressure which limits researcher's objectivity.

Clinical case description

Is about a 12year old female patient, with 7years of schooling, coming from a nuclear family, with a low socioeconomic stratum and basic schooled parents. The minor had a severe CET of a closed type at her 9years, car accident by run over, presented left frontal subdural hematoma and left intraventricular edema, whereby she was surgically intervened though a subdrotomy for a reduction of the intracranial pressure. The patient had lost of conscience during the accident. She was interned on intensive care for 28 days. During this time she presented a generalized regress on the development, showing mutism, amnesic syndrome, walking difficulties, behavioral changes, especially aggressiveness and basic daily activities, also she lost sphincter control; six months after the injury she had a spontaneous recovery which gave her back great part of her functionality.

Premorbid Stage

It's reported that the patient didn't present cognitive functioning deficits, she had an average academic performance and didn't presented emotional or behavioral problems (introvert behavior, as own from idiosyncrasy). Relationship with her mother was close and respectful, but regarding to the father, relationship was distant; with her brother, it was a normal relationship. She had a few relations with pairs and her only close friend died at the same accident. Her daily activities were focused on house and schoolwork, having low interactions with pairs due to living on a rural zone.

Test results

Neuropsychological assessment is performed three years after lesson, being the reason for consultation some difficulties on memory and mood changes.

In order to make an assessment, there were applied the Kaufman & Kaufman's brief intelligence test (K-BIT) and the Neuropsychological Assessment for Children battery ENI, the results of these tests are presented on Table 1 for K-BIT and 2-4 for the ENI.

Instruments

Kaufman's brief intelligence test K-BIT

The K-BIT is a psychological test which gives an approximation of the intellectual capacity. It's designed for application on people from 6 to 90years and assess two areas: Vocabulary and matrices. The vocabulary's subtest assess the verbal abilities related to scholar education such as language, verbal concepts' comprehension and word knowledge; this subtest has two sections, first one is regarding to expressive vocabulary and second one is regarding to definitions. Matrices' subtest evaluates non-verbal abilities such as problems solving, figures relation's comprehension and analogies' ratiocination.²¹

Neuropsychological assessment for Children (ENI)

The ENI looks for evaluate cognitive activity on children and adolescents from 5 to 16years, analyzing fundamental symptoms of the neuropsychological processes. Components evaluated with ENI are family background, patient's dynamics at home, soft neuropsychological signs, constructional abilities, long and short term memory, perceptual abilities, language, metalinguistic abilities, reading, writing, arithmetic, special abilities, conceptual abilities and executive functions (Table 1).²²

There are no significant differences between subtests' punctuations on Vocabulary and Matrices, showing a good performance on expressive vocabulary's subscale which indicates an adequate ability for words' correct using and cultural knowledge. With regard to Matrices' subtest, which implies non-verbal reasoning and flexibility on application of problem solving strategies, the patient got a low performance according to her age, showing some difficulties on verbal analogies solving at abstract stimulus, just like verbal reasoning, adaptability and flexibility on unforeseen situations.

These results points to a composed IQ, which offers an estimated coefficient of intellectual aptitude on problem solving ability, adaptability on unforeseen situations, and verbal aptitude, which was normal and expected for patient's age (Table 2).

Results obtained on cognitive process were normal on graphical abilities, tactile perception and visual perception; lower scores on auditory perception, repetition, language expression, visual attention and conceptual skills; very low scores on long and short term memory, visual and verbal information, metalinguistic abilities, special abilities and visual attention (Table 3).

Regarding to abilities related with academic performance, the consultant presents a normal-high performance on writing accurateness, normal performance on reading comprehension, while, in accurateness, reading speed and writing speed she presented low performance. Moreover, consultant presented a very low performance on narrative coherence of writing and in arithmetical abilities in general (Table 4).

As seen above, the patient presented very low results regarding to fluency, verbal and graphical, and a very low percent of answering. Regarding to cognitive flexibility, she had a high number of perseverations and achieves just one out of three possible categories.

According to planning and organizing, patient had a low performance in amount of correct designs and number of moves done, and a very low performance on designs made with the minimum moves.

According to the assessment of soft neurological signs, patient show some difficulties in right-left differentiation, as well as opposed moves.

Table 1 Results obtained in the Kaufman's Brief Intelligence Test K-BIT

Subscale	Obtained punctuation	Typical punctuation	Centile	Descriptive category
Vocabulary	Expressive Vocabulary	39		
	Definitions	12		
	Total	53	98±9	45 (36-54) Mid
Matrices	27	89±8	23 (15-31)	Mid low
Compost IQ K-BIT	187	90±7	25 (18-32)	Mid

Note: Table of own creation. In the centile, there can also be observed the confidence interval in parenthesis, with a significance of 0.05.

Table 2 Results of Neuropsychological Assessment for Children (ENI). Cognitive Skills

Domain	Direct punctuation	Standard punctuation	Centile	Category descriptive	
Graphical Skills	23/47	90	26	Normal	
Short term memory	Verbal Codification	17/63	65	1	Very Low
	Visual Codification	6/48	60	0,4	Very Low
Long term memory	Verbal Evocation	17/63	55	0,1	Very Low
	Visual Evocation	7/63	≤55	≤0,1	Very Low
Perceptual Skills	Tactile Perception	16/16	105	63	Normal
	Hearing Perception	24/36	75	5	Low
	Visual Perception	41/50	110	75	Normal
Language	Repetition	26/32	85	16	Low
	Expression	100/329	85	16	Low
	Compression	18/23	90	26	Normal
Metalinguistic Skills	8/32	≤55	≤0,1	Very Low	
Spatial Skills	21/40	55	0,1	Very Low	
Attention	Visual	51/106	75	5	Low
	Hearing	6/16	70	2	Very Low
Conceptual skills	17/32	85	16	Low	

Note: Table of own creation. Results shown on direct punctuation column are equal to patient's obtained punctuation over expected punctuation. Descriptive categories are: High normal, mid normal, normal, low and very low. This is applied over the next two tables as well.

Table 3 Results of Neuropsychological Assessment for Children (ENI). Academic performance related skills

Domain	Direct punctuation	Standard punctuation	Centile	Category descriptive	
Reading	Precision	36/39	85	16	Low
	Compression	18/26	105	63	Normal
	Speed	176/380	85	16	Low
Writing	Precision	42/54	135	99	High normal
	Narrative Coherencies	60/130	70	2	Very Low
	Speed	29/60	80	9	Low
Arithmetic	Counting	3/8	55	0,1	Very Low
	Numerical Manage	10/32	≤55	≤0,1	Very Low
	Calculating	3/52	≤55	≤0,1	Very Low
	Mathematic Logic Reasoning	3/8	60	0,4	Very Low

Note: Table of own creation.

Table 4 Results of Neuropsychological Assessment for Children (ENI). Executive Functions

Domain		Direct punctuation	Standard punctuation	Centile	Category descriptive
Fluency	Verbal	18/84	≤55	≤0,1	Very Low
	Graphical	12/70	70	2	Very Low
Cognitive Flexibility	Correct answers percentage	19,4%	≤55	≤0,1	Very Low
	Perseverative answers percentage	72,2%	≤55	≤0,1	Very Low
	Number of categories	1/3	80	9	Low
Planning and organization	Inability to maintain organization	0/0	105	63	Normal*
	Correct designs	9/11	80	9	Low
	Moves done	69/54	85	16	Low **
	Correct designs on the minimum of moves	4/11	70	2	Very Low

Note: Table of own creation. *Inability to maintain organization was not presented due to patient perseverated too much, bringing a positive influence in this result, but during the process there were identified difficulties on the patient according to maintain organization. **The less moves patient makes, the better punctuation is.

Discussion

CET is one of the cerebral damage etiologies than generates more inability on child population,²³ its main causes are car accidents, falls, violent events, working accidents and sports.²⁴ More prevalent causes concerning to CET revolves around three areas: physical problems, cognitive disturbances and emotional and behavioral issues.

In the first area it can be found paralysis, headaches, seizures and fatigues, as common. In the second area there are issues referred to information processing speed, attentional deficit, anterograde spatial memory, learning, language and communication alterations, as well as executive functions deficit. In the third area it may be depression, anxiety, aggressiveness, personality changes and substance abuse.^{2,24}

Exposed CET shows a patient with typical profile disturbances in this kind of cerebral damage etiology, with difficulties on focalized, sustained and divided attention, long reaction times, changes of moods related to low tolerance to frustration, anterograde memory difficulties, which hinders storing and evoking of information, this is directly reflected onto her learning levels and her academic performance which is low on a broader level, in addition she presented low results on executive functions, especially on verbal and non-verbal fluency, cognitive flexibility, planning, organization and inhibition.

This is related to studies made by González, Giraldo, Ramírez & Quijano,²⁵ about consequences of CET, who mentioned that on mid and long term there are affections on physical, cognitive (might be disabling for the person), behavioral and social levels, within the common ones there is the alertness and processing speed decrease, attentional, memory and learning deficits, language alterations (especially regarding to communication), and executive function deficits.

In addition, authors such as Levine, Mangels y Perbal,²⁶ refers that CET lead to frequent neuropsychological deficits that have to do with attention, processing speed, memory and executive functions; likewise, a CET may lead to consciousness altered, followed by a state of confusion and memory lost (posttraumatic amnesia or amnesic loop hole).

On the other hand, in IQ assessment, it's noted that obtained results in the executive scale are lower than verbal scale, due to the last one permeate the learning that the minor integrated before the accident (crystalized intelligence because it doesn't change), while the executive scale shows current intelligence (non-verbal) and ability of problem solving (fluent because it's active), according to the obtained results (low and very low) it can be identified problems to further learnings as well as behavior organization and spatial hand-eye coordination.²⁷

Severe CTE generates grave intellectual consequences on children, most achieves a good recovery approximately oneyear after the injury (Rodríguez et al., 2014). In addition, multiple studies found that there's a significant relation between posttraumatic amnesia and factors such as IQ six months after injury, which affects principally cognitive functioning, memory, social development, and subsequent labor situation, among others. Cause, injury type, fracture or another injury's existence related predict the complications that the patient can experience.^{4,28}

Faced to these adversities, there's the cerebral plasticity, being the ability that the nervous system has for adapting, reorganizing and changing into some limits, especially on neurodevelopment phases, on learning, by experience and as in this case by brain damage, all this in view of minimize effects of structural or physiological alterations caused by endogenous and exogenous influences at any point of live, modifying its proper structural and functional organization.

This brain's ability of adapting and overcome injury's effects is partially bigger in earlyyears of live,^{14,29} which explains good recovery presented on the patient, especially on the first six months after occurrence, where she regains on a high percentage her independency level on behaviors such as walking, grasp, feeding, sphincter control and personal care. Spontaneous recovery continued, but on a slower rhythm, and with the assistance of different professionals such as occupational therapists, language physicals, psychologists and neuropsychologists among others, which contributed through different intervention and rehabilitation techniques for the minor's rehabilitation.

As mentioned by Aguilar,³⁰ every cerebral functions can be re-established, on a high percentage across cerebral plasticity, sometimes on a spontaneous way but most times therapeutically, pharmacologically, through neurobehavioral adaptations and sensitive stimulation with physical and psychological rehabilitation.

Finally, in the case is emphasized mood changes reported by closer relatives, regarding to her before the injury, since currently is described as an irritable person, impatient, sulky; this phenomenon matches with findings on a research in Cali (Colombia), where 75% of patients' relatives (being 134 patients with several CET) report changes of personality and irritability; similarly 65% report changes of mood,¹⁴ which can be worked from areas like clinical psychology or child psychiatry.^{31,32}

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Conflict of interest

The author declares no conflict of interest.

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