Neuropsychological Rehabilitation After Traumatic Brain Injury

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Introduction

TBI is an important public health problem worldwide. Data from Brazil indicates that approximately 700,000 people suffer a traumatic brain injury (TBI) annually, of whom 20–30% have moderate or severe TBI. About 80% of those who suffer mild TBI are able to return to work, only 20% of moderate and 10% of severe TBI cases can return to their daily routine [1, 2]. TBI is a nondegenerative, noncongenital insult to the brain from an external mechanical force, potentially leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness [3].

Cognitive rehabilitation is a clinical area with interdisciplinary action focused on recovery as well as compensation of cognitive functions altered as a result of a head injury [4]. The aim of a cognitive rehabilitation program is to recover an individual's ability to process, interpret, and respond appropriately to environmental inputs and also to create strategies and procedures to compensate for lost functions that are necessary in familial, social, educational, and occupational relationships [5].

The programs of cognitive rehabilitation tend to focus on specific cognitive domains, such as attention, memory, language, and executive functions. By contrast, the focus of compensatory training procedures is generally on making environmental adaptations and changes to provide greater autonomy for patients. A successful cognitive rehabilitation program is the one whose aim is both recovery and compensation based on an integrated and interdisciplinary approach [6].

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Cognitive Impairments Following TBI

Depending on the severity and site of injury, the type and degree of cognitive impairment following TBI may vary widely. If a focal brain injury occurs, the consequence may be similar to the injury caused by a stroke, such as aphasia, apraxia, unilateral neglect, or visuospatial dysfunction. Nevertheless, these are not the typical findings following TBI. Due to the mechanisms of acceleration-deceleration that often damage the ventral and lateral regions of the frontal and temporal lobes, the most frequently found sequelae are attention and memory deficit, difficulty learning new information, resolving problems, planning, as well as problems associated with impulsivity and self-control. Some "subclinical" findings such as changes in naming, verbal fluency, and auditory discrimination are also reported. Initially, attention deficits are the most common and severe in the residual stage, usually involving difficulty maintaining divided attention. The long-term memory is generally restored, but some individuals continue having difficulties in learning new things and retaining new information. Working memory is frequently affected including the stages of encoding, storage, and retrieval of information. Such changes have a significant impact on social and vocational reintegration [7, 8].

Some individuals are left with amnesic syndrome, which is more common in those who have gone through periods of hypoxia and anoxia. Executive functions may be affected, being related to frontal lobe damage. When the frontal injury is severe, the patient may be inert or lack initiative (medial or lateral frontal injury) or display inappropriate and impulsive behavior. Many individuals with frontal lobe injury in post-TBI retain much of their skills but are unable to initiate, sequence, organize, or monitor their actions so as to meet the targets or goals set. The language disorders most commonly observed occur in the discursive (tendency to produce irrelevant information and omit important information), pragmatic (loss in production of inferences, difficulty in formulating arguments), and conversation levels (loss of initiative and maintenance of topics with inconsistent switching without signaling). These

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changes correlate with cognitive impairments in attention, memory, and slow mental processing [6].

Long-Term Neuropsychiatric Deficits

The most common syndromes post-TBI are behavioral disinhibition, depression, anxiety, psychosis, substance abuse, and attention/cognitive disorders. Post-traumatic stress disorder (PTSD) occurs in up to 27% of cases, including patients with no clear recall of the event. Depression has an incidence of 15–33% and prevalence of 18–42%. Mania occurs in <10% of patients with TBI [9]. Aggression occurs in variable frequencies (ranging from 20% to 49%), and psychosis occurs in <10% of the TBI population [10].

After the Hospital: Post-acute/Chronic Phase

The cognitive stimulation from the interdisciplinary team (several professionals attending the patient in a holistic manner to enhance operations) at this stage is fundamental because the patient is only able to embark on motor training if a minimum attentional state can be maintained which allows the patient to execute and repeat the tasks proposed [11].

At this stage, temporal-spatial orientation and attention call for redoubled efforts to maximize the communication with the patient so as to improve strategies that use motor and cognitive training. In terms of speech, intervention should promote the structuring of activity, with a highly predictable distraction-free environment and also activities that induce self-monitoring. The biggest hurdle at this stage stems from the fact that most patients have significant attentional deficit that limits the role of comprehensive rehabilitation [12].

After the most critical phase of hospital management, most patients return home. Although some patients manage to regain some degree of independence in their self-care, they are still incapable of applying critical thinking to decision-making processes, providing for the needs of their families, or continuing work, school, or social activities, which can cause difficulties in family relationships and result in a poor quality of life for patients and their relatives. Moreover, patients may manifest mood alteration and depression.

The rehabilitation of these patients after hospital discharge is aimed at a community integration program that provide continuity of patient care with vocational and professional training integrated into the rehabilitation process [12].

The Rancho Los Amigos Levels of Cognitive Functioning Scale is a widely used scale that systematically standardizes the functional level of post-TBI patients in order to establish the possibility of their rehabilitation management [13]. It is considered that a patient is able to enter a rehabilitation program when he is at least at level V, which means that he can pay attention for a few minutes – what is crucial for rehabilitation.

Rancho Los Amigos Scale (Los Amigos Research and Education Institute)

No Response

A person at this level will:

Not respond to sounds, sights, touch, or movement.

Generalized Response

A person at this level will:

Begin to respond to sounds, sights, touch, or movement.
Respond slowly, inconsistently, or after a delay.
Respond in the same way to what they hear, see, or feel. Responses may include chewing, sweating, breathing faster, moaning, moving, and/or increasing blood pressure.

Localized Response

A person at this level will:

Be awake on and off during the day.
Make more movements than before.
React more specifically to what they see, hear, or feel. For example, patient may turn toward a sound, withdraw from pain, and attempt to watch a person move around the room.
React slowly and inconsistently.
Begin to recognize family and friends.
Follow some simple directions such as "look at me" or "squeeze my hand."
Begin to respond inconsistently to simple questions with "yes" or "no" head nods.

Confused-Agitated

A person at this level will:

Be very confused and frightened.
Not understand what they feel or what is happening around them.
Overreact to what they see, hear, or feel by hitting, screaming, using abusive language, or thrashing about. This is because of the confusion.
Be restrained so they do not hurt themselves.

Be highly focused on their basic needs, i.e., eating, relieving pain, going back to bed, going to the bathroom, or going home.
May not understand that people are trying to help them.
Not pay attention or be able to concentrate for only a few seconds.
Have difficulty following directions.
Recognize family/friends some of the time.
With help, be able to do simple routine activities such as feeding themselves, dressing, or talking.

Confused-Inappropriate, Non-agitated

A person at this level will:

Be able to pay attention for only a few minutes.
Be confused and have difficulty making sense of things around them.
Not know the date, where they are, or why they are in hospital.
Not be able to start or complete everyday activities, such as brushing their teeth, even when physically able. They may need step-by-step instructions.
Become overloaded and restless when tired or when there are too many people around, have a very poor memory, and remembering past events from before the accident better than their daily routine or information they have been given since the injury.
Try to fill in gaps in memory by making things up (confabulation).
May get stuck on an idea or activity (perseveration) and need help switching to the next part of the activity.
Focus on basic needs such as eating, relieving pain, going back to bed, going to the bathroom, or going home.

Confused-Appropriate

A person at this level will:

Be somewhat confused because of memory and thinking problems, remembering the main points from a conversation but forgetting and being confused about the details. For example, they may remember having visitors in the morning but forget what they talked about.
Follow a schedule with some assistance but becomes confused by changes in the routine.
Know the month and year, except when they have a serious memory problem.
Pay attention for about 30 min but has trouble concentrating when it is noisy or when the activity involves many steps. For example, at an intersection, they may be unable to step off the curb, watch for cars, watch the traffic light, walk, and talk all at the same time and brush their teeth, get dressed, feed themselves, etc., with help.
Know when they need to use the bathroom.
Do or say things too fast, without thinking first.
Know that they are hospitalized because of an injury but will not understand all the problems they are having.
Be more aware of physical problems than thinking problems.
Associate their problems with being in the hospital and think they will be fine as soon as they go home.

Automatic-Appropriate

A person at this level will:

Follow a set schedule.
Be able to carry out routine self-care without help, if physically able. For example, they can dress or feed themselves independently, have problems in new situations, and may become frustrated or act without thinking first.
Have problems planning, starting, and following through with activities.
Have trouble paying attention in distracting or stressful situations. For example, family gatherings, work, school, church, or sports events.
Not realize how their thinking and memory problems may affect future plans and goals. Therefore, they may expect to return to their previous lifestyle or work.
Continue to need supervision because of decreased safety awareness and judgment. They still do not fully understand the impact of their physical or thinking problems.
Think slower in stressful situations.
Be inflexible or rigid and may be stubborn. However, their behaviors are related to their brain injury.
Be able to talk about doing something but will have problems actually doing it.

Purposeful-Appropriate

A person at this level will:

Realize that they have a problem with their thinking and memory.
Begin to compensate for their problems.

Be more flexible and less rigid in their thinking. For example, they may be able to come up with several solutions to a problem.
Be ready for driving or job training evaluation.
Be able to learn new things at a slower rate.
Still become overloaded with difficult, stressful, or emergency situations.
Show poor judgment in new situations and may require assistance.
Need some guidance making decisions.
Have thinking problems that may not be noticeable to people who did not know the person before the injury.

Strategies to Manage Post-TBI Patients

Cognitive Function Evaluation

First of all, patients will be subjected to a reading test, which consists of reading simple children's books to evaluate how long they focus on the book. According to the performance and education of each individual, slightly more complex texts will be presented.

After this first test, each patient will be classified according to the Rancho Los Amigos Scale, and only those who score greater than or equal to 5 (on the scale of 8) will be referred for cognitive rehabilitation. This is necessary because to be rehabilitated, the individual must maintain a minimum time set for the task of greater than 10 min [12].

The next intervention will be to conduct a neuropsychological evaluation, including the Mini-Mental State Examination [14, 15] and clock drawing. The neuropsychological assessment includes the evaluation of affective/emotional state, functional activity questionnaire, batteries of tests of executive functions (Wisconsin Card Sorting Test [16] and Stroop Interference Test [17]), as well as other tests including the Rey Auditory-Verbal Learning Test [18]; WAIS III attention, digit-symbol, and visuo-constructive tests [19]; Trail Making Test parts A and B [20]; verbal fluency tests [21]; and Rey-Osterrieth complex figure [22]. All tests have been previously validated in Brazil with scores for different levels of education. After the neuropsychological evaluation, individual rehabilitation strategies are developed in conjunction with the interdisciplinary team.

Tools Used in Cognitive Rehabilitation

Attention

The treatment is usually based on patient engagement in performing repetitive exercises including sustained, alternating, selective, and divided attention.

Sustained Attention Training

1. Listen to a word sequence and identify when you see a word stimulus, which was the one previously presented.
2. Understanding of spoken text of a paragraph (originally short and simple) that has progressively increasing difficulty throughout the course of training.
3. Sequencing of numbers in ascending order and/or decreasing verbally.
4. Math activities – mentally.

Alternating Attention Training

1. Exercise in which the patient must identify a previously defined word and word sequence, identifying when it appears in a text or string of words they will listen to, replacing the first word, when identified, with the previously given sequence
2. Tasks with pen and paper, where the patient has to write a number and a letter that complete a sequence written with gaps to be filled
3. Activities that start with a number, which must be sequentially added or subtracted by the other items that are being presented

Selective Attention Training

1. Any test which has been reported for sustained attention, with a distractor sound or motion associated
2. Tasks with visual distractors – such as tasks involving drawing with paper and pen (pencil) on a sheet full of tracings and background designs

Divided Attention Training

1. The patient reads a few paragraphs paying attention to their content while looking up the proposed word in advance.
2. The patient completes a test battery of sustained attention training, in which the patient has to respond to verbal or parallel visual stimuli (which can be accomplished by including computerized tests) [12].

Memory

In order to rehabilitate memory, the first aspect is to verify whether the patient maintains sufficient attention on the stimulus or task given (as seen in the previous topic). The second aspect is to assess whether the patient is able to "decipher" the stimulus given or if the patient knows the word or

object (verbal or visual stimulus) or can categorize them (words or objects) into any semantic grouping.

The exercise used for this type of injury consists of repetition of words. Concurrently, it involves categorization of words such as by asking if a cat is an animal seen at the zoo or by eliciting the rhyme of a given word.

Naturally, a team of speech therapists will evaluate losses involving comprehension and language.

Memory Storage This involves learning new tasks or old skills that were lost. When there are bilateral hippocampal lesions, the retention mechanism of long-term learning memory is lost. Processes of verbal repetition and writing are important for this training.

Evocation of Old Memories This entails training with pictures or words that are subsequently presented and evoked several times. Repetition, writing, drawing, and verbal processes are important in this training. Individuals sustaining frontal lobe injury can remember facts, but not associate them with a context or time of occurrence. Generally, they confabulate based on a preexisting fact. In order to rekindle the old memory, a strategy is to repeat the known facts which the patient is unable to remember, using pictures, or by repeating stories until they are remembered. This differs from the bi-hippocampal lesion, which preserves old memories (except the period of posttraumatic amnesia) but renders the individual incapable of retaining new learning [12].

Training Strategies Outside the Outpatient Unit

Initially, the patient undergoes neurological, neuropsychological, speech, and occupational therapy evaluation. Once the evaluation is finished, the interdisciplinary team defines the treatment strategy.

The sequence below lists possible training strategies to be developed concurrently with the behavioral training at home:

1. Remember events during the current day (at the end of the day) or for the previous day (in the morning).
2. After recalling the events, write them in a notebook whenever possible.
3. Receive new information – summaries of news about some event or family – and read a short informational text.
4. Plan the morning, day, or week's (whenever possible) activity.
5. Talk about past events that have been forgotten or are not well contextualized after the accident.
6. Follow the primer of daily activities with attention, executive functions, language, and memory activities as well as activities of daily living.
7. Medication approach when neurologist/psychiatrist thinks it is appropriate [12].

Conclusion

TBI is a major public health problem with neurobehavioral sequelae contributing to the long-term disability that is often associated with moderate to severe levels of injury. Rehabilitation of cognitive skills is fundamental to encouraging the full participation of the individual in home, vocational, and social roles. Cognitive rehabilitation begins with a neuropsychological evaluation to identify cognitive strengths and weaknesses and the degree of change in cognitive ability following a TBI. The conclusions of the assessment are used to formulate appropriate and individualized rehabilitation plans. Attention process training and tasks for attention deficits, compensatory strategies, learning training for memory deficits, social behavior guidance for cognitive-communication disorder, and problem-solving training for executive disorder are the focus of therapy.

Conflict of Interest There is no conflict of interest to declare.

References

1. Schewinsky SR. Reabilitação neuropsicológica da memória no TCE. 1st ed. São Paulo: Livraria Médica Paulista; 2008.
2. Harmon RL, Lawrence JH. Traumatic brain injury. In: Bryan J, Mark A, Steven A, editors. Physical medicine and rehabilitation secrets. 2nd ed. Philadelphia: Mosby; 2001. 2008: xvii.
3. Jang SH. Review of motor recovery in patients with traumatic brain injury. NeuroRehabilitation. 2009;24:349–53.
4. Cappa SF, Benke T, Clarke S, Rossi B, Stemmer B, van Heugten CM. Task force on cognitive rehabilitation: European Federation of Neurological Societies. EFNS guidelines on cognitive rehabilitation: report of an EFNS task force. Eur J Neurol. 2005;12:665–80.
5. Cattelani R, Zettin M, Zoccolotti P. Rehabilitation treatments for adults with behavioral and psychosocial disorders following acquired brain injury: a systematic review. Neuropsychol Rev. 2010;20:52–85.
6. Thornton KE, Carmody DP. Efficacy of traumatic brain injury rehabilitation: interventions of QEEG-guided biofeedback, computers, strategies, and medications. Appl Psychophysiol Biofeedback. 2008;33:101–24.
7. Mansur LL, Radanovic M. Neurolinguistica: princípios para a prática clínica. São Paulo: Edições Inteligentes; 2004.
8. Braakman R, Jennett WB, Minderhoud JM. Prognosis of the post-traumatic vegetative state. Acta Neurochir. 1988;95:49–52.

9. Tuel SM, Presty SK, Meythaler JM, Heinemann AW, Katz RT. Functional improvement in severe head injury after readmission for rehabilitation. Brain Inj. 1992;6:363–72.
10. Nicholl J, LaFrance WC Jr. Neuropsychiatric sequelae of traumatic brain injury. Semin Neurol. 2009;29:247–55.
11. Sohlberg MM, Mateer CA. Cognitive rehabilitation. London: The Guilford Press; 2001.
12. Freire FR, Coelho F, Lacerda JR, Silva MF, Gonçalves VT, Machado S, et al. Cognitive rehabilitation following traumatic brain injury. Dementia & Neuropsychologia. 2011;5(1):17–25.
13. Hagen C. The rancho levels of cognitive functioning, vol. 9. 3rd ed. Downey: Rancho Los Amigos Medical Center; 2008.
14. Folstein MH, Folstein SM, McHugh PR. "Mini-Mental State": a practical method for grading the cognitive state of patients for clinicians. J Psychiat Res. 1975;12:189–98.
15. Bertolucci PHF, Mathias SC, Brucki SMD, Carrilho PEM, Okamoto IH, Nitrini R. Proposta de padronização do Mini-Exame do Estado Mental (MEEM): estudo piloto cooperativo (FMUSP/EPM). Arq Neuropsiquiatr. 1994;52:225.
16. Wisconsin Card Sorting Test. Psychological Assessment Resources. Inc-Odessa; 1993.
17. Spreen O, Strauss E. Compendium of neuropsychological tests: administration, norms, and commentary. 2nd ed. New York: Oxford University Press; 1998a.
18. Rey A. L'examen psychologique dans les cas d'encephalopathie traumatique. Arch Psychol. 1941;28:286–340.
19. Wechsler D. Wechsler Adult Intelligence Scale, vol. 3. New York: Psychological Corporation; 1997.
20. Trail Making Test. In: Spreen O, Strauss E, editors. A compendium of neuropsychological tests: administration, norms, and commentary. 2nd ed. New York: Oxford University Press; 1998. p. 533–46.
21. Brucki SM, Rocha MS. Category fluency test: effects of age, gender and education on total scores, clustering and switching in Brazilian Portuguese-speaking subjects. Braz J Med Biol Res. 2004;37(12):1771–7.
22. Spreen O, Strauss E. A compendium of neuropsychological tests: administration, norms, and commentary. 2nd ed. New York: Oxford University Press; 1998b. Rey-Osterrieth complex figure test (SFT). p. 341–63.