Determinants of recovery after traumatic brain injury

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Neuropsychological perspectives on cognitive complaints and cognitive impairments after mild traumatic brain injury

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Abstract

The prognosis following a mild traumatic brain injury (mTBI) is generally favourable. In the acute after trauma, patients may experience cognitive complaints (especially regarding attention and memory) and for the majority of patients, these cognitive complaints improve over time. However, for a subgroup of mTBI patients, persistent subjective cognitive complaints are reported that may interfere with the resumption of work and other (social) activities. Assessment with neuropsychological tests generally shows that about 6 months post-injury, patients on average do not show objective cognitive deficits; on a group level, there are no significant differences between mild TBI patients and healthy controls. In individual patients, neuropsychological assessment contributes to more clarity on the determinants of cognitive complaints. It is possible that the cognitive complaints still result from cognitive deficits that are a consequence of brain injury. It could also be possible that cognitive complaints are more likely explained by other determinants, for example, depression, pain or fatigue. This distinction is important to make for adequate follow-up care.

Introduction

Of all patients with traumatic brain injury (TBI), the majority sustain a mild TBI (80-85%). The prognosis for this group of patients with a mild TBI (mTBI) is generally favourable; most patients fully recover, yet, a subgroup of patients reports persistent complaints and for a small proportion of patients, these complaints can cause significant problems in daily life. In addition to complaints of for example headache, fatigue and dizziness, patients also often report cognitive complaints, especially regarding concentration and memory. In the context of follow-up care and therapeutic options, it is an important question whether these complaints can be interpreted as direct consequences of brain damage or can be traced back to other factors. To gain more insight into this, a neuropsychological examination can be performed.

Neuropsychological assessment

The neuropsychological assessment aims to identify impairments in cognition, emotion and behaviour, as a consequence of brain injury or brain diseases. Patients may report cognitive complaints, for which the main question for a neuropsychologist is, whether these complaints can be objectified with neuropsychological tests. In other words: is there an underlying neuropsychological impairment? However, the relationship between subjective, patient-reported cognitive complaints and objective, test-measured cognitive impairments is complex; many studies find low correlations between the two phenomena in both healthy and neurological populations.[1,2,3] It can be the case that patients experience cognitive complaints that are a direct result of acquired brain damage, in that case, the complaints and impairments are in line with each other. However, cognitive complaints can also be experienced without the presence of brain damage, and can then arise from other causes, for example, stress, pain or fatigue. Another possibility could be that patients do not report cognitive complaints, even though objective cognitive impairments are present, due to impaired self-awareness. For example, in the case of memory complaints, the memory paradox applies; to report memory complaints, patients need to remember what they have forgotten.

Standardized neuropsychological tests can be used to measure cognitive impairments and are therefore an important part of a neuropsychological assessment. These tests have good psychometric requirements such as validity and reliability and demand good standards. Based on these standards, certain test performances can be compared with a reference group, which is ideally comparable to the person tested in terms of age, gender and level of education. For this purpose, raw test scores are converted into standard scores; these can be, for example, normally distributed standard scores such as T or Z scores, but also percentile scores. There is no hard limit to determine whether test results are abnormal, but a common rule of thumb is two standard deviations below average (with the equivalents being a T-score of 30, a Z-score of -2 and a percentile score of 2). However, even when a test score is qualified as abnormal, it cannot be concluded that there is an impairment in the relevant brain function. The score should be interpreted in conjunction

with additional findings, so other possible explanations for low test performances are evaluated and excluded as far as possible. In particular, when inconsistencies between test scores are present, or when there are inconsistencies between test performance and the impression the patient gives, or when the test profile does not fit the specific brain injury, one should always be aware of interfering factors. For example, mood problems, anxiety, fatigue, pain, medication, lack of motivation but also a firm belief that a specific brain function (e.g. memory) is affected, can all result in subjective cognitive complaints in daily life and may also negatively affect the performance on neuropsychological tests. Therefore, a good (hetero) anamnesis, observations and questionnaires, capturing such interfering factors, are equally essential in performing a neuropsychological assessment. Symptom validity tests can determine whether a patient is able to perform to his or her best ability. The aforementioned interfering factors may cause patients to not be able to perform at his or her maximum level, and this may well occur without any conscious intentions. It also occurs, however, that patients consciously exaggerate a poor performance (to aggregate) or pretend to have an inability (simulating), usually for external reasons (e.g. financial reasons, avoiding punishment, obtaining medical attention, etc.). The symptom validity test does not allow for statements about the intention for underperformance, but information from (hetero)anamnesis, observations and questionnaires may contribute to possible explanations.

Cognitive deficits and recovery after mild traumatic brain injury

The severity of cognitive impairments after mTBI is often related to the duration of loss of consciousness, the duration of post-traumatic amnesia and/or abnormalities in neuroimaging. In the first month following injury (the acute phase), cognitive deficits within different cognitive domains are demonstrated in the existing literature. For example, a review by Prince and colleagues (2017)[4] describes that cognitive deficits after mTBI are most often found in attention, information processing speed, as well as in executive functioning (planning and organization of complex task behaviour) and memory. Regarding memory, specifically imprinting of new information is often affected, yet, the information is sufficiently remembered and recognized.[5] These cognitive deficits after mTBI are usually temporarily. Previous studies show that recovery processes mainly take place within the first three months (subacute phase) following injury for the majority of patients. As of six months after trauma (chronic phase), practically no permanent cognitive deficits have been demonstrated. This has also been shown in a systematic review of 11 meta-analyses by Karr and colleagues (2014)[6], in which they conclude that most patients with mTBI fully recover within 90 days following the injury. Carroll and colleagues (2014)[7] also found little evidence of objective cognitive impairments in the chronic phase following mTBI in their systematic review. However, occasionally some (subtle) cognitive deficits can still be objectively measured in the chronic phase after mTBI. For example, a study by Stapert and colleagues (2002)[8] showed subtle objective cognitive deficits in the chronic phase following mTBI for memory and information processing speed (for basic as well as complex attention) when compared to a group of healthy controls. Additionally, a longitudinal study by Heitger

and colleagues (2006)[9], with neuropsychological assessments at 1 week, 3 months, 6 months and 1 year following mTBI, showed that patients with mTBI, in comparison to a group of matched healthy controls, still showed mild cognitive deficits in verbal learning between 6 and 12 months after injury, and as of 1 year following mTBI, cognitive deficits could no longer be objectified.

Determinants of cognitive complaints after mTBI and the relationship with impairments measured with neuropsychological tests.

Several studies show that patients with mTBI may experience complaints that persist over time. In the *Upfront* study (van der Naalt and colleagues, 2017)[10] it was demonstrated that 84% of patients reported complaints at 2 weeks post-injury and still 72% of patients reported complaints after 6 months. Another study by van der Horn and colleagues (2013)[11] investigated complaints between groups of patients with a very minor mTBI (GCS=15) and mTBI patients (GCS 13-14) and found that even in the group of patients with the minor mTBI, more than half of patients still reported complaints six months after injury. Furthermore, the same group investigated whether complaints after mTBI were related to brain damage by examining micro lesions on MRI imaging.[12] No differences were found concerning the number, extent and anatomical location of the lesions between patients with and without complaints. Additionally, within the group of patients with complaints, the number of complaints was not significantly correlated with the number of lesions. The authors concluded that there is no relationship between complaints and demonstrable damage on an MRI scan in patients with mTBI. Furthermore, in the context of the *Upfront* study, Scheenen and colleagues (2017)[13] investigated which psychological factors may be related to persistent complaints. In addition to experiencing psychological distress, the use of a so-called passive coping style (a tendency to withdraw and worry) also proved to be a strong contributing factor. Van der Naalt and colleagues (2017)[10] showed that, in addition to having complaints, a depressed mood and a passive coping style are predictive factors for a poor outcome in the long term following mTBI.

To obtain more clarity on complaints after mTBI, de Koning and colleagues (2016)[14] investigated in the *Upfront* study the occurrence, profile and possible determinants of subjective complaints, as measured with a trauma complaints list (HISC: head injury symptom checklist), especially focusing on cognitive complaints. Comparisons were made between patients with mTBI and patients with non-neurological trauma. Two weeks after trauma, 40% of mTBI patients reported concentration problems and more than 35% of patients reported memory complaints, which was significantly more when compared to the trauma control group (10% and 2% respectively). In this study, factor analysis was performed, where it was a priori expected that the cognitive complaints would form a separate factor. However, this turned out not to be the case: the cognitive complaints were part of a factor that also included symptoms such as headache, dizziness, fatigue and anxiety, this factor was named " mental distress". This "mental distress" factor was also found to be significantly correlated with having a depressed mood. These findings provide strong

evidence that psychological distress should also be evaluated when considering persistent cognitive complaints following mTBI.

The fact that cognitive complaints do not have to be equivalent to cognitive impairments has also been shown by a study done by Jamora and colleagues (2012).[15] They compared cognitive complaints between a group of patients with mTBI and a group of patients with moderate-severe TBI and found that the mTBI group reported significantly more complaints in comparison to the patients with a more severe brain injury. Moreover, they investigated cognitive complaints in relation to neuropsychological test scores (in which they excluded patients who scored below the cut-off on a symptom validity test). In the mTBI group, memory complaints were not significantly correlated with performances on memory tests, however, some significant correlations existed between concentration complaints and performances on tests for attention and information processing speed. Additionally, questionnaires measuring anxiety, depression and post-traumatic stress (PTSS) were also included, and experiencing post-traumatic stress was related to more cognitive complaints. Another study by Donnelly and colleagues (2018)[1] investigated war veterans who sustained mTBI. They found that many mTBI patients reported cognitive complaints, which were not associated with lower scores on cognitive tests, yet, did show significant associations with psychological distress (anxiety, depression, posttraumatic stress). Similar findings were reported by Stulemeijer and colleagues (2007a)[16], as they found that nearly 40% of a group of mTBI patients reported cognitive complaints at six months after injury. These complaints were not related to scores on neuropsychological tests, nor patients' observations of their cognitive failures in daily life. The cognitive complaints did show associations with psychological distress, fatigue and a lower educational level. Stulemeijer and colleagues (2007b)[17] also investigated symptom validity testing during neuropsychological assessment in patients with mTBI. More than 25% of patients failed the effort test, and this subgroup also performed significantly worse on the neuropsychological tests. Underperformance was significantly related to having mental distress, a lower education level and higher levels of fatigue. Furthermore, Green and colleagues (2009)[18] found that underperforming is more common in patients with mTBI (30%) in comparison to patients with a severe TBI. They found that performances on neuropsychological tests by patients with mTBI who were underperforming were significantly lower in comparison to the performances of patients with a severe TBI.

Conclusion

The relationship between cognitive complaints and cognitive impairments after mTBI remains complex. Previous research has shown that cognitive complaints may persist for a long time and may strongly affect daily life for a subgroup of patients, even though neuropsychological tests on average do not show (substantial) cognitive impairments. From existent literature, we know that cognitive complaints may also be related to psychological distress and a passive coping style, which in some patients may result in underperformance on neuropsychological tests. With neuropsychological assessment, more clarity about the nature of possible persistent complaints can be obtained for individual patients, and

subsequently, an adequate referral can take place for appropriate ((neuro)psychological) treatment. Especially for patients who are at risk of an unfavourable long-term outcome (e.g. having many (cognitive) complaints, a depressive mood and a passive coping style[10]) timely referral for neuropsychological assessment is recommended.

The neuropsychological assessment may consist of a short test battery with neuropsychological tests most sensitive to the potential cognitive deficits following mTBI, specifically including tests for information processing speed, divided attention and memory (imprinting). Additionally, a symptom validity test should be included, as well as questionnaires for complaints, psychological distress, personality and coping style. With these instruments, statements can be made about whether or not neuropsychological impairments are present. In case patients pass the symptom validity test and show mild cognitive deficits reflecting a cognitive profile that fits mTBI, it can be concluded that patients have remaining cognitive deficits as a consequence of the brain injury. When this occurs (in the absence of psychological distress (e.g. depression, anxiety, PTSS)) and patients experience a persistent reduced cognitive capacity in daily life due to these cognitive deficits, these patients could be referred to neuropsychological rehabilitation. In case neuropsychological assessment shows cognitive impairments that are more severe than what would be expected following mTBI, additional diagnostics into other organic-cerebral explanations should be explored. In case neuropsychological assessment does not objectify cognitive impairments, yet, there are indications for the presence of psychological distress that resulted from the experienced traumatic brain injury, psycho-education focused on reassurance and emphasizing the favourable prognosis is a better option, potentially followed by psychotherapy aimed to improve mood and coping. Concerning patients whose symptom validity test was indicative of underperformance, it should be concluded that any abnormal test performance cannot be reliably interpreted as a cognitive impairment resulting from brain trauma. Information from (hetero) anamnesis and questionnaires may provide possible explanations, that could offer specific advice for follow-up care.

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