BCMJ, Vol. 48, No. 9, November 2006, page(s) 447-452˜Article

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Neuropsychological assessment in mild traumatic brain injury: A clinical overview

Neuropsychological testing can help with diagnosis, treatment, and rehabilitation planning.

ABSTRACT: Understanding the nature, the severity, and the modality of cognitive complaints is best served by a neuropsychological assessment. When cognitive complaints are reported or persist following mild traumatic brain injury in adults, neuropsychological testing can assist with diagnostic issues as well as with treatment and rehabilitation planning. The process typically begins with a clinical interview and then continues with tests that assess function in various cognitive and emotional domains. Because the difficulties caused by mild traumatic brain injury can have wide-ranging neurological, psychological, and psychosocial consequences, both patients and caregivers can benefit from an assessment that identifies and quantifies deficits.

- **Contents**

Three patients each present with cognitive complaints following a history of mild traumatic brain injury (mTBI). Patient 1 is a successful 45-year-old financial advisor with a large client base. He reports that 3 months following a rock climbing accident he canâ•˙t do his job anymore. He says, â•¿I canâ•˙t think straight.â•˘ Patient 2 is a 78-year-old independent-living woman who has had a few falls and may have bumped her head in the process. She says, â•¿I donâ•˙t seem able to remember where I put things anymore.â•˘ Patient 3 is a healthy 19-

year-old college football player with a history of repeated concussions. His mother reports that he is failing at school and is having difficulties remembering information and following lectures. Her son states that he is â•¿just fineâ•˘ and that his mother is being overprotective.

The value of neuropsychological assessment

Understanding the nature, the severity, and the modality of cognitive complaints is best served by a neuropsychological assessment performed by a qualified neuropsychologist. This would be a PhD psychologist from an accredited neuropsychology program with specialized training and experience in brain-behavior relationships, psychometrics, assessment, and neuroanatomy as well as psychopathology and abnormal psychology. Such an assessment provides useful information about the patientâ•˙s cognitive functioning, something that is not easy to obtain otherwise. At times, patients may have a hard time describing the difficulties they are having, or family members may report the problematic cognitive and emotional changes because the patient has little or no insight. The patient may be making errors at work but not understand why. As well as assisting with diagnostic issues, the results from a neuropsychological evaluation can be utilized for treatment and rehabilitation planning. While magnetic resonance imaging can reveal the structural appearance of the brain, it does not provide information regarding cognitive functioning. Functional MRI (fMRI) can illustrate how certain types of tasks activate the brain, but cannot yet tell us that an individual has a verbal memory problem involving retrieval but not encoding. Thus, fMRI findings cannot be used to prognosticate about an individualâ•˙s current work situation or to make recommendations about how a student needs to modify his educational pursuits.

Assessing mild traumatic brain injury is the second most frequent diagnostic activity in clinical neuropsychology.[1] The cognitive domains that are typically affected by a mild traumatic brain injury[2-7] include:

â•¢ *Attention:* There can be particular difficulties where attention must be shared between multiple stimuli or tasks. For example, the patient may burn food while cooking because she cannot divide her attention between boiling potatoes on the stove and preparing vegetables for a salad.

â•¢ *Memory:* There can be difficulties with recalling new information but also problems with working memory, which is an ability to temporarily hold information and manipulate the information to formulate an answer. The patient may be unable to do calculations in his head to figure out the tip for a restaurant bill.

â•¢ *Higher cognitive abilities (executive functioning):* There can be difficulties with setting priorities, planning, and sequencing. The patient may not be able to decide what are the three most important things that need to be done today and

what order they should be done in.

â•¢ *Information processing:* It can take longer to process information and to produce an answer. The patient may find the normal rate of speech too fast and may feel overwhelmed by conversations or being in time-pressured situations.

Tests such as the Mini-Mental State Exam (MMSE)[8] do not assess all of these domains well and can only provide a gross estimate of cognitive capacity. For example, the MMSE cannot assess mental flexibility, working memory, or aspects of memory functioning. More importantly, if the patient was premorbidly bright or well educated, the tasks involved in the MMSE are too easy. Also if the mild traumatic brain injury occurs in a patient with a psychiatric history, there may be practice effects present because the patient has repeatedly been given the MMSE over time.

Mild traumatic brain injury can often be complicated by behavioral and affective changes such as depression, anxiety, irritability, and compromised social functioning. Identifying risk factors (e.g., mTBI in the older patient, a significant depression score, or evidence of lesions on CT scans) for major depression in mTBI patients early on (at 1 week postinjury) may have important implications for outcome, but this intriguing work needs to be replicated.[9] Depression has been found as the most frequent psychiatric diagnosis at 1 year postinjury.[10]

Components of a neuropsychological assessment

A typical neuropsychological assessment will include a clinical interview with the patient to determine:

â•¢ Highest level of formal educational obtained.

â•¢ Presence of pre-existing learning difficulties.

â•¢ Medical and psychological history.

â•¢ Previous head injuries, including ones from childhood.

â•¢ A more detailed review of the patientâ•˙s cognitive complaints and emotional status.

Problems with attention can often masquerade as memory complaints. Potential issues that need to be factored into the assessment include the patientâ•˙s concerns about changes in his or her ability to make a living and role changes (e.g., a husband who believes that he must be the only breadwinner). Patients can also become hypervigilant and see any mistake as an indicator of â•¸brain damage,â•˘ or misinterpret information found on the Internet. Often patients will reveal information to the neuropsychologist that they have not shared with other

health care providers.

Based on the information gathered during the interview and from the documentation and referral questions, the neuropsychologist then decides what cognitive and emotional domains need to be assessed and will select the tests to be in the battery. A fixed battery of tests known as the Halstead-Reitan battery has been historically popular. However, most neuropsychologists now use a flexible battery approach, where the tests are chosen based on the information gathered, systematic hypotheses testing, and an understanding of the underlying medical condition that is purportedly responsible for the cognitive and emotional difficulties.[1]

Most mTBI assessments will be more comprehensive in nature than a screen. A screen can be appropriate if the patient is acutely ill or is behaviorally difficult to test. A comprehensive assessment (4 to 5 hours of testing) is more appropriate if there are multiple complaints across different cognitive domains or if the clinical presentation does not fit the nature of the injury.

While there may be concerns about the time needed for a more comprehensive battery, there may be no other options with a complex presentation. Most patients find the testing interesting and are cooperative when time has been spent before the start of testing to address their questions, identify the possible benefits from the assessment, and explain why the family physician or specialist wants the testing done. More importantly, for the patient who has limited insight, the assessment can make the deficits or problem areas more tangible. Learning that he has problems in the visual modality (with information he sees) as opposed to the auditory modality (information he hears) can be extremely important to the patient and to rehabilitation, vocational, and educational planning. There is no point in making lists for â•¸Dadâ•˘ when he has difficulty paying attention to information that he is looking at.

The cognitive and emotional domains that are typically assessed in a comprehensive neuropsychological assessment[11] are:

â•¢ *Intellect:* Establishing the level of intelligence is core to the assessment. The Weschler Adult Intelligence Scale (WAIS-III) is the most widely used, standardized IQ test. A Full Scale IQ, Verbal IQ, and Performance IQ are generated, with the latter being sensitive to aspects of visual-spatial functioning. The Verbal IQ and Performance IQ should not be interpreted as being measures of left and right hemisphere functioning. With the current version, special indices can be generated such as a Working Memory Index and a Processing Speed Index. The neuropsychologistâ•¨s report should indicate if a prorated technique or abbreviated battery was administered, as some caution must be used when interpreting these scores because they can either underestimate or overestimate functioning in some individuals. When the level of intellect has been established

in a standardized manner, then estimates of premorbid functioning can be used and opinion can be offered whether the patientâ•˙s current level of intellectual functioning appears to be a decline in functioning or not. There can be the appearance of a decline from the premorbid estimate but it does not mean that there has been an intellectual, brain-related drop in functioning. For example, depending on the task used, ESL issues can influence performance.

â•¢ *Higher cognitive abilities (executive functioning):* Tests assessing this cognitive domain are seen as being sensitive to the frontal lobes and frontal circuitry. They include measures assessing planning, abstraction, concept formation, organization, reasoning, inhibition, mental flexibility, initiation, and problem solving. The frontal lobes can also play a role in memory by utilizing strategies for the recall of the information. Many frontal lobe skills are often needed for competitive employability.

â•¢ *Attention:* A thorough assessment in this domain is crucial in an evaluation for mTBI. A significant attentional problem can affect any cognitive domain and can give the impression of more diffuse, impaired functioning. Determining if there are difficulties with focused, selective, alternating, divided, and sustained attention can help explain why a patient is unable to follow conversations or lectures in class, take telephone messages correctly, or function in noisy and distracting environments.

â•¢ *Memory:* Typically the evaluation will include ascertaining whether there are difficulties for certain types of information (e.g., verbal vs figural material). There are also different aspects of memory functioning that can be affected, such as the retrieval of information rather than encoding. Memory testing can help determine if the individual benefits from repetition and demonstrates a learning curve, whether cueing helps with the recall, or if there are more difficulties recalling information after a delay.

â•¢ *Visual-spatial abilities:* Although specific problems with visual, perceptual, or constructional abilities are not expected in mTBI, the time needed to complete many visual-spatial tasks can be an indicator of slow information processing. When â•¸testing the limitsâ•˘ is done, the task is administered in the standardized way. Additional time is then provided to see if the individual can complete the task correctly if given more time.

â•¢ *Motor and sensory abilities:* These abilities are assessed by tasks such as squeezing a dynamometer (grip strength), finger tapping (motor speed), or using a two-point athesiometer (tactile discrimination). Again, motor and sensory problems are not expected unless musculoskeletal or peripheral injuries were sustained. It may be appropriate to do some limited testing if vocational or educational concerns are expressed in the referral questions. For example, assessing fine motor dexterity may shed light on why the patient is now having

difficulties with typing, data entry, or handling small objects (e.g., a carpenter selecting nails).

â•¢ *Emotional status:* Self-report inventories assessing depression, anxiety, and other measures of psychological status are typically done to objectively assess and quantify the severity of any disturbance. However, if the referring physician finds the patient is severely depressed with neurovegetative signs, it is probably wise to treat the depression before referring the patient for neuropsychological assessment as depression can be a major confound to testing.

When the testing is completed, the neuropsychologist will then score the responses and compare the scores to relevant test norms, which takes into consideration variables such as the patientâ•˙s age, level of education, and gender. This is a very important part of the process. Although the patient may feel that she is doing poorly, she may not be according to the norms. However, the other clinical scenario can also occur. If a bright, well-educated professional is now functioning in the â•¸averageâ•˅ range on some tasks, this may in fact be an indicator of a drop in functioning. For example, it may not be acceptable for an air traffic controller to score at the low end of the â•¸averageâ•˅ range on tasks of attention and concentration, or to be accurate but at the cost of speed. The analysis of the data involves not only quantitative analyses (e.g., z scores, percentiles) but also qualitative analyses such as perseverative tendencies in drawings and responses.

The sanative, healing effects of being told that the neuropsychological profile has not indicated any significant cognitive deficits can also provide an opportunity to shift the focus of treatment (e.g., treating depression/anxiety) should the patient remain concerned about ongoing â•¸thinking difficulties.â•˅ Alternatively, patients and caregivers can benefit from explanation regarding compensatory strategies for dealing with identified cognitive deficits that affect functioning at work, school, and home (e.g., strategies that remind the patient to check if the stove has been turned off). Hearing from another professional that headaches or fatigue from a disrupted sleep cycle may in fact be contributing to the cognitive difficulties can also be beneficial.

During a neuropsychological feedback session, explanations and a framework can be provided to the patient and recommendations can be made. For example, Patient 1, the financial advisor, may need to be educated about doing his work differently during the 3 to 12 months postinjury when multitasking should be avoided. He may also need some treatment of his anxiety.

Patient 2, the elderly woman referred with a possible mild traumatic brain injury, may have more severe compromised functioning because of dementia already in progress. In this case, the neuropsychologist may need to consider differential diagnoses such as MCI (mild cognitive impairment)[12,13] or CINDS (cognitively

impaired but not demented).[14] The effects of mild traumatic brain injury in patients over the age of 50 have been reported to be cognitively comparable to noninjured controls within the first 3 months.[15]

For Patient 3, the young football player, the index injury was in fact his sixth concussion. The neuropsychologist learned during the interview that other injuries were sustained during games of hockey, skateboarding, and a diving accident. The patient was advised that not only did he need to stop playing sports because of the cumulative effects of mild traumatic brain injury, but that he would now need to contact student services. He would need a longer time to write exams and a quiet room without distraction for writing the exam. Because of his slower information processing, he would also need a â•¸study buddyâ•¯ to share notes from class.

Assessment controversies

One of the growth industries in neuropsychology has been the development of methodologies and tests to assess effort. There are no pure tests for â•¸malingeringâ•¯ and no test has a 100% â•¸hitâ•¯ rate for detecting it. There is variability between effort tests for sensitivity and specificity as well.[16] More importantly, the base rate for actual malingering varies and is dependent on the diagnosis being considered, the severity of the condition, and the methodology and context used to estimate the base rate.[17] Anyone with hands-on experience in the field knows that variability in test results and effort can happen for a variety of reasons, including unconscious ones, and that you must use the â•¸Mâ•¯ word with caution, and if so, you must have other substantive data and collateral information to support this opinion and not just one score from an effort test. The clinical neuropsychologistâ•¯s role in head injury should not be seen as being a malingerer detector.

In the past few years computerized test batteries and online assessments have become more common.[18] In the United States pressures from HMOs have resulted in the demand to use the cheapest assessment available. But there are two important questions to ask when a computerized battery has generated data: What database of norms underlies the software? Is the sample size adequate for each age cell? All too often, the attractions of easy use (all you need to do is sit the patient in front of a computer terminal for 20 minutes; the program scores the information and prints a report) are greater than the quality of data. I have seen this with psycho-vocational assessments as well as in other situations.

When to refer

Deciding when to refer for a neuropsychological assessment needs to be done on a case-by-case basis. Although many symptoms should dissipate by 3 months,[2,5,6,19] the speed and rate of recovery can be variable. Histories that

include pre-existing psychiatric problems, learning disabilities, or substance abuse can be influential. Anxiety in the bright individual who is in a high-performance job may indicate a need for early assessment (prior to the 3-month postinjury anniversary date) to determine if attentional problems do exist. At times it may be important to obtain baseline data and then do repeat testing at a later date to determine the extent of recovery. In general, referring for assessment sooner rather than later is the best approach, as this allows patients to receive feedback and guidance. It is also important to write good referral questions so that you and your patient get the information you need (see the Table).

Although the focus of this article has been on adults, many of the issues also apply to pediatric cases of mild traumatic brain injury, where assessment and early intervention can have significant impact on academic pursuits.[20] Milder forms of brain injury prior to the age of 12 do not appear to result in persistent cognitive dysfunction in adulthood.[21] However, outcome can be different if the injury is more severe or if there is a history of repeated concussions, particularly within a short time frame. Neuropsychologists with pediatric specialization should assess these children.

Obtaining a neuropsychological assessment in BC

Finding out where to obtain a neuropsychological assessment can be one of the biggest hurdles, particularly in smaller towns or more remote areas of the province. First, there are many hospitals with psychology departments or acquired brain injury programs that will take referrals or can direct you to resources in the community. Unfortunately, there are wait lists for most clinical programs and it is possible that patients involved in litigation will be rejected. Often personal injury lawyers and the coordinators in the rehabilitation department of ICBC or WorkSafeBC will pay for neuropsychological assessments. There are some training clinics at the University of Victoria (which has a sliding fee scale) and at Simon Fraser University, but acceptance is dependent on student availability and training needs. Finally, some patients may be eligible for â•¸psychology servicesâ•˘ through their EAP (employee assistance program) at work or through their extended health benefits plan, particularly when there are vocational issues. The total fee for the assessment may not be covered but some funding may be available.

If the assessment is done by someone in private practice, the cost can easily exceed $1500. The cost depends on the time needed for testing, the referral questions to be answered, the amount of collateral information to be reviewed, and the time needed to score the tests, write a report, and provide feedback. The patient should ask about the estimated cost ahead of time. If your patient is already on disability assistance because of pre-existing conditions, you can write on the attending physician form that you recommend a neuropsychological

assessment be done. The BC Psychologists Association has a referral registry organized by geographical location and subspecialty. As always, recommendations from colleagues regarding good neuropsychologists in your area may be the best way to find the right clinician for your patient.

Summary

Like many medical conditions, mild traumatic brain injury is often a multifactorial condition that includes neurological, psychological, and psychosocial factors. A neuropsychological assessment can be extremely helpful in identifying and quantifying the deficits that may be present as well as identifying and defining the many other factors contributing to the clinical presentation of mild traumatic brain injury.

Competing interestsNone declared.

Table. Referring patients for neuropsychological assessment.

Reason for referral	Examples of referral questions
For diagnostic clarification	â•¢ Is this an attentional problem or a r retrieval deficit? â•¢ Are there other factors present (e.g that could be contributing to the cogniti presentation? â•¢ Are the patientâ•˙s complaints incc the nature of the injury (i.e., the compla exceed what is expected either in inter number)?
To establish a baseline, which can be used later to confirm improvement/change and provide an evaluation of the efficacy of a particular rehabilitation plan	â•¢ Does the patient have deficits? â•¢ How severe are the deficits?
To retest the patient to objectively compare current status to earlier assessment	â•¢ Have the patientâ•˙s deficits chang severity?
To determine cognitive strengths and weaknesses to implement appropriate rehabilitation and cognitive interventions	â•¢ Does the patient require any rehab â•¢ How can the rehabilitation best be whom? â•¢ Is information needed to educate th professionals involved and family mem there is consistent understanding of th presentation?
To establish a cognitive profile for prognostic recommendations regarding return to work, return to school, or the ability to handle functioning at home	â•¢ Will subtle cognitive deficits have a the patientâ•˙s ability to work? â•¢ Should the patient return to full-tim time work?

	â•¢ Can the patient (a student) handle and course load being considered? â•¢ Does the patient (an elderly perso occupational therapy consultation rega manage activities of daily livin

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