Neuropsychology: Behavioural Evaluation and Intracarotid Amobarbital Procedure (IAP)

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The impact of epilepsy on cognitive and emotion functioning has been widely documented\cite{12,13}. It is because of this very reason that clinical neuropsychologists, psychologists specialised in decoding the effect of changes in brain functioning on behaviours, are involved in the management of people with epilepsy.

Roles of Neuropsychologists

Neuropsychologists conduct comprehensive neuropsychological assessment for people with epilepsy for the understanding of their cognitive strengths and weaknesses and comparison of pre- and post-surgical cognitive functions. Neuropsychologists also assess the emotion status as adjustment difficulties are very common among people suffering from epilepsy that often exerts a negative effect on the academic, vocational and social lives of these people. With thorough understanding of the patients’ cognitive status, behavioural alterations, personality characteristics, and adjustment difficulties, neuropsychologists play an important role in planning cognitive rehabilitation and facilitating psychosocial adjustment of people with epilepsy.

In order to achieve the goal of assessing the cognitive and emotional status of people with epilepsy, a neuropsychological assessment is conducted.

Neuropsychological Assessment

A basic neuropsychological assessment evaluates different cognitive functions, such as intellectual functioning, attention, language, perception and nonverbal functions, memory, and executive functions, in order to test the status of different brain regions. Assessment of emotion functioning is also one of the goals, given the adjustment difficulties presented by people with epilepsy.

A thorough evaluation usually requires six to eight hours of direct contact between the examiner and the patient. By comparing an individual’s scores to norms of similar age and educational level, an objective conclusion of cognitive functioning can be drawn. A cognitive profile illustrating the strengths and weaknesses as well as highly specific aspects of brain functions provides an objective baseline to which later assessments can be compared when patients are re-evaluated.

General Intelligence

There is considerable evidence indicating that the IQ (intelligence quotient) scores of individuals with epilepsy tend to be skew toward lower values\cite{7}. As the verbal IQ is highly correlated with school performance, it allows us to use educational achievement to estimate pre-morbid IQ and to detect cognitive decline in patients. The IQ scores can also be used as comparison with performance on specialised tasks to detect specific deficits. The Wechsler Adult Intelligence Scale is commonly used in Hong Kong to assess general intelligence.

Attention

Attention is a complex cognitive construct that includes the ability to respond to basic sensory stimulation, selectively attend to relevant stimuli while suppressing responses to irrelevant stimuli, and maintain focus on the environment and respond according to the changing task/environmental demands. Attention problems have been reported in people with epilepsy, especially those who suffer from generalised type seizure\cite{26}. As problems with attention can interfere with performance in other cognitive domains, especially memory, the identification of attention problems could help us to better understand how results of other measures be accurately interpreted. Inattention, selective attention, sustained attention, vigilance, divided attention are the common types of attention measured.

Language

Language tasks measure the functioning of the dominant hemisphere and, when compared with performance on visual spatial tasks, can be used to detect lateralised dysfunction. A typical language assessment for epilepsy includes measures of naming, comprehension, generative fluency, single word reading, sentence repetition and reading\cite{9}.

Perception and Nonverbal Cognitive Functions

Nonverbal cognition is usually measured by tasks of visual perception and visual spatial ability. Visual perception can be measured by tasks of visual cancellation and visual scanning\cite{14}, as well as drawing of symmetric objects such as a clock face, a daisy or a Greek cross. More complex asymmetric drawing tasks such as the copy condition of the Rey-Osterrieth Complex Figure\cite{17,19} may also be helpful, if the deficit is subtle. The cognitive processing of spatial relationships can be evaluated by both measures that require only mental manipulation of stimuli, and procedures requiring the actual construction of drawings or objects. These measures of visual perceptual and spatial ability
are believed to assess the integrity of left or right parietal lobe or the non-dominant temporal lobe.

**Memory**
It has been widely recognised that medial temporal lobe structures play an important role in human memory. In particular, the hippocampus plays a unique role in human learning and memory, and is essential for the consolidation of novel information for its longer-term processing. Because of the specific role the hippocampus, memory and learning disorders are very common among people whose epileptic foci are within the temporal lobe.

A thorough memory assessment should address each hemisphere with tasks appropriate to is specialisation - verbal learning and memory tasks to evaluate the dominant temporal lobe, and visuo-spatial or visuo-perceptual learning and memory tasks to evaluate the non-dominant temporal lobe. Verbal tasks might use names, word lists, stories or number sequences as stimuli, while non-verbal tasks might use faces, places, music or abstract designs. It is important to select tasks that are as purely verbal, or purely non-verbal, as possible, in order to increase the probability that the tasks challenge primarily one temporal lobe. It is also highly recommended to use tasks that are as similar as possible in structure and procedure when assessing memory functions in the two hemispheres, to allow one to compare the efficacy of one temporal lobe to the other, even within individual patients. Instead of single-exposure tasks, task involving several learning trials is recommended, to rule out reasons other than true learning deficit for poor performance.

**Executive Functions**
The term "executive functions" has been used to describe a set of cognitive processes, namely initiation, planning, regulation of behaviour, overcoming of habitual responses, attention, working memory, mental flexibility, reasoning, which are necessary for the execution of goal-directed activity. Examination of executive functions in epilepsy is particularly useful for detecting focal deficits associated with frontal lobe epilepsy where attention deficits, impulsivity, motor coordination, and difficulty changing behavioural strategies are common.

Problems with inhibition which is associated with prefrontal cortex and the anterior cingulate cortex damage can be examined by using Stoop tests. The ability to switch attention which may be most sensitive to dorsolateral frontal damage can be measured by the Trail Making Test.

Verbal fluency can be measured by semantic tasks requiring patients to produce items by category such as animals or fruits. Non-verbal fluency can be tapped by the Design Fluency test, in which patients are asked to invent abstract designs. Comparing performance on verbal and non-verbal fluency helps detect lateralised frontal lobe dysfunction in patients with focal seizure disorders.

Frontal lobe damage may cause deficits in working memory, and as a result may present with learning or memory difficulties. Working memory deficits could be measured by Digit Span and Spatial Span subtests of the Wechsler Scales. Difficulty recollecting source of information is another problem which may occur and can be assessed by asking patients to differentiate two sets of stimuli in the recognition trial of memory test.

Planning is a complicated activity, comprising an ability to look ahead, conceive of alternatives, weigh choices, follow rules, inhibit impulses, and sustain attention. Planning can be tested with the various tower tasks (London, Hanoi, and Toronto). This ability has been shown to be related to prefrontal regions, possibly medial and dorsolateral.

The Wisconsin Card Sorting test, which requires the use of working memory, the ability to make inferences and deductions, to switch an ongoing action or adapt to circumstances, and the ability to benefit from feedback, has been widely used to assess concept formation. The Matrix Reasoning and Similarities subtests of Wechsler Adult Intelligence Scale - 3rd version can also assess conceptual reasoning.

Lesions of the orbital surface of the frontal lobes are capable of producing characteristic affective and personality changes, including poor social judgement, disinhibition or social inappropriateness, a tendency to place immediate gratification over long-term consequences of behaviour, or excessive behavioural rigidity.

**Emotion and Psychosocial Functioning**
It is not uncommon that epilepsy has psychological impact on people suffering from this disease. The unpredictable nature of some epilepsies is likely to produce anxiety in these patients. These patients are also more prone to depression than are those without epilepsy. Furthermore, the self-esteem of epilepsy patients is found to be significantly lower than that in those without the disease. In societies or culture where information and understanding of this disease is limited, people with epilepsy are at risk of experiencing social stigma, prejudice, or even hostility.

A local study found that self-perception and coping strategies are more powerful predictors of psychosocial adjustment in people with epilepsy than are the medical conditions of epilepsy. Seizure frequency was observed to be significantly correlated with self-perception of seizure, and self-perceived seriousness contributed positively to psychological maladjustment, implying that the more severe people with epilepsy think their condition is, the more disturbed they become. Furthermore, coping is another factor that predicts the well-being of people with epilepsy. Emotional- and avoidance-oriented coping strategies are more frequently used to cope with stress than task-oriented coping. While emotional coping positively relates to the severity of psychosocial difficulties, avoidance coping was inversely related to the severity of psychosocial disturbances. Such results could be interpreted to mean that emotional reactions, which may include self-preoccupation or fantasising, actually increase an individual's stress level. Even with avoidance coping, social support received by the epilepsy patients offers an opportunity to them for social diversion and escape, which may result in temporary relief from stress. The authors suggested that emerging importance of social factors as predictors of psychosocial adjustment in
epilepsy highlights the need for developing tailored counselling therapy and social support groups for people with epilepsy.

It is known that epilepsy not only increases the risk of disturbance among these affected individuals, but also has an adverse effect on the health of other family members. An unpublished local study exploring the factors associated with the quality of life and emotional states of the caregivers of people with epilepsy in Hong Kong found that twenty-two percent of respondents were considered to have severe levels of anxiety and 14% severe level of depression. Three-quarters of the caregivers interviewed had below average scores on the quality of life measure, indicating that the carers' psychosocial adjustment was impaired. Such findings suggest the importance of including systematic measures of social and psychological aspects of epilepsy.

**Intracarotid Amobarbital Procedure**

In order to determine the hemispheric language dominance and unilateral integrity of memory function, Juhn Wada introduced the intracarotid amobarbital procedure (IAP) in North America in the late 1950s. This procedure forms part of the neuropsychological evaluation performed on patients who will undergo surgical treatment for the uncontrolled epileptic seizures. Sodium Amytal injection was carried out following catheterisation of the internal carotid artery and angiography. Two successive injections were performed, one on each side, so as to achieve hemi-anæsthesia of the two cerebral hemispheres. The effect is short, and is usually dissipated after about 6 to 8 minutes, depending on the dosage and individual differences. Temporary anaesthetism of one hemisphere should allow one to apply simple tests to the awake hemisphere alone, and the results of such tests should allow one to predict language and memory functions post-surgery.

Since the IAP is an invasive procedure, it is recommended only for pre-surgical diagnostic evaluation of those surgical candidates who are left-handers, or have a family history of left-handedness, those who have suffered early trauma in or near speech areas of the left hemisphere, or those with anatomical and functional discordance. Those with significant deficits on verbal and nonverbal memory tests, documented in a noninvasive clinical memory evaluation carried out as part of a basic neuropsychological assessment, or on EEG or other radiological findings are also candidates for an IAP. Moreover, IAP should also be performed in cases where mismatch between EEG and MRI findings, such that an EEG focus is observed in one temporal lobe and significantly small hippocampus is found on the opposite side.

Non-invasive neuroimaging techniques such as PET, functional MRI, and Magnetic Source Imaging are rapidly gaining acceptance as methods of lateralising and localising language cortex. For instance, applications of fMRI in epilepsy has been used to determine hemispheric representation of language and memory functions, predict side of seizure focus and seizure outcome, study the nuances of functional reorganisation and, most recently, predict cognitive outcome after resection from the dominant temporal lobe. Thus far there has not been any clear evidence that resection of activated voxels obtained in a language protocol indeed correlates with language decline. Furthermore, while fMRI provides detailed information about functional localisation, it is unclear to what extent activated voxels represent networks critical for the performance of a cognitive activity or represent tertiary associated or non-task specific functions that could not be fully "subtracted" out. On the other hand, in cases where an IAP cannot be performed safely or IAP results are ambiguous, using the fMRI methodology for lateralisation of language and memory for surgical planning may be beneficial. With further research and empirical evidence on the applicability of fMRI for pre-surgical evaluation, and on the validity of carefully designed, well-controlled fMRI testing protocols, fMRI methodology could become a powerful method for functional localisation and for predicting language and memory outcome.

**References**