Dialogues in Clinical Neuroscience & Mental Health

DOI 10.26386/obrela.v1i2.50 ISSN 2585-2795

General article

Neurosurgical Neuropsychology: an emerging sub-specialty

George Stranjalis & Evangelia Liouta

Department of Neurosurgery, National and Kapodestrian University of Athens, Evangelismos Hospital & Hellenic Center of Neurosurgical Research "Prof. Petros Kokkalis", Athens, Greece

ABSTRACT

In this review the role of neuropsychology in the management of neurosurgical pathologies is highlighted. The main neurosurgical disorders that a neuropsychologist can work with are head injuries, brain tumors, epilepsy, movement disorders, hemorrhagic strokes, and idiopathic normal pressure hydrocephalus (iNPH). Neuropsychology plays a significant role during the two main phases of the neurosurgical management: (a) the pre-operative assessment, i.e. the diagnosis of the impact of a lesion on cognitive functions and (b) the post-operative or post-traumatic one, which will evaluate the cognitive result of the injury or of the surgical treatment. In the challenging field of neuro-oncological surgery, a third phase is added, namely the intraoperative one, where the neuropsychologist monitors patient's brain function during electrostimulation in order to avoid damage to the eloquent areas. All the above stress the role of neuropsychology in neurosurgery and designate the need for neuropsychologists to be incorporated in the neurosurgical teams.

Corresponding Author:
George Stranjalis, Department of Neurosurgery, National and Kapodestrian University of Athens, Evangelismos Hospital, e-mail: stranjal@otenet.gr

Received: March 21, 2018, Accepted: April 5, 2018

DOI 10.26386/obrela.v1i2.50 ISSN 2585-2795

INTRODUCTION

Although the role of neuropsychology is well established in the diagnosis of neurological diseases, the contribution of neuropsychologists in the management of the neurosurgical diseases has been only recently recognised. In this review we focus on the main neurosurgical disorders that a neuropsychologist can face in a daily clinical basis and its role in their management. Traumatic Brain Injury (TBI) is not included in our review, since the role of neuropsychology in its diagnosis and cognitive rehabilitation is well established.

NEUROPSYCHOLOGY AND EPILEPSY

In patients with epilepsy, neuropsychological assessments are most frequently used to aid diagnosis, evaluate the cognitive side effects of antiepileptic medications and monitor the cognitive decline associated with some epileptic disorders.

In conjunction with Magnetic Resonance Imaging (MRI) and other presurgical investigations, neuropsychological scores are also used to assess the suitability of patients for epilepsy surgery and can be used to predict post-operative outcome, both in terms of cognitive change and seizure control.

In 2015, the International League Against Epilepsy (ILAE) Diagnostic Commission Neuropsychology Task Force published guidelines concerning the minimum standards in the neuropsychological assessment of patients with epilepsy.

Pre- and post-operative neuropsychological evaluation in epilepsy

Neuropsychological assessment plays an important role in the evaluation of the candidates for temporal lobe surgery. Bilateral hippocampal excision is associated with profound anterograde amnesia. Unilateral resections are traditionally associated with material-specific memory dysfunction.

Post-operative deficits are dependent upon both the functional adequacy of the tissue removed and the functional reserve of the remaining structures. Some plasticity and the development of compensatory strategies post-operatively may also influence the nature and extent of post-operative neuropsychological deficits. Pre-operative neuropsychological scores, in conjunction with MRI and other clinical data, can be utilized to predict post- operative neuropsychological change.

The Intracarotid Amobarbital Procedure (Wada Test)

Traditionally the Intracarotid Amobarbital Procedure (IAP) or Wada test has been used to ensure that the memory capacity of the contralateral temporal lobe is adequate to maintain useful memory functions unilaterally prior to surgery and it is an effective test for language lateralization.

The role of neuropsychologist during this procedure is (a) the choice and the administration of behavioral stimuli whilst the cerebral hemisphere is anesthetized, as well as (b) the interpretation of patient's performance.

Functional Magnetic Resonance Imaging (fMRI)

A number of fMRI paradigms have been developed to localize language function in adults and children. fMRI paradigms have been also recently used in order to examine memory function in prospective temporal lobectomy patients. These techniques have superseded the complex and invasive IAP procedure in language lateralization. They are also combined with the traditional memory tests in order to provide lateralizing and prognostic information for medial temporal epilepsy patients.

NEUROPSYCHOLOGY AND MOVEMENT DISORDERS

The most common movement disorders treated by Neurosurgery are Parkinson's disease (PD) and dystonia. The current neurosurgical treatment of PD and dystonia is based on the results of studies indicating that the reduction of excessive neuronal activity in the internal segment of globus pallidus (GPi) and subthalamic nucleus (STN) can result in a dramatic

DOI 10.26386/obrela.v1i2.50 ISSN 2585-2795

improvement in motor control.

The neuropsychologist plays an important role in the two phases of the neurosurgical management: (a) the preoperative screening and (b) the outcome evaluation. During the screening, the differential diagnosis of dementia, the impact of depression or other psychiatric conditions, and the influence of disease and medication-induced symptoms on cognitive performance must be evaluated. It is thought that this impact is proportional to the risk of postoperative cognitive compromise.

Postoperatively, systematic evaluations elucidate the cognitive costs or benefits of the neurosurgical procedure. The neuropsychologist is then able to provide feedback and counselling to the professional staff, the patient and the family. Neuropsychologists also study alteration of cognitive processing due to lesions or stimulation, which, in tandem with functional imaging, shed light on plasticity in cortical and subcortical processing.

NEUROPSYCHOLOGY AND HEMORRHAGIC STROKE

Subarachnoid hemorrhage (SAH) involves bleeding into the space between the pia and the arachnoid matter. Ninety-percent of the cases with spontaneous SAH are due to ruptured brain aneurysms. Other causes of SAH include arteriovenous malformation (AVM), vascular inflammation and carotid artery dissection. Ruptures aneurysms are treated with either surgical clipping or endovascular coiling, though the latter is the preferred treatment due to its more favorable functional outcomes.

The neuropsychologist can be valuable in regard to the effectiveness of the two main types of treatments mentioned above. In a recent meta-analysis, neuropsychological functioning in patients after coiling and clipping of the cerebral aneurysms were compared. The coil-treated patients outperformed the clip-treated patients on executive function. In addition, all patients showed impairments when compared with healthy controls. Conclusively, coiling of ruptured aneurysms may promote superior neuropsychological functioning under certain circumstances. However, future studies needed to explore thoroughly the effect of different types of SAH interventional treatment on neurocognition.

NEUROPSYCHOLOGY AND INPH

Idiopathic Normal Pressure Hydrocephalus (INPH) is a progressive neurologic disorder which typically presents after the sixth decade of life. It is clinically characterized by disturbances in gait and balance, cognition and control of urination. The main radiological feature is ventriculomegaly in the absence of extensive atrophy.

The predominant therapy for INPH is currently the surgical placement of a cerebrospinal fluid (CSF) shunt device. While the benefits of this interventional treatment have been shown to outweigh its risks, complications can arise.

Keeping with this, diagnosis of INPH should be as accurate as possible. However, INPH diagnosis can be challenging. Alzheimer's dementia is not an uncommon comorbidity in INPH patients; in parallel, a wide range of additional neurological conditions (e.g. Binswanger disease, frontotemporal dementia, Lewy body dementia, PD and corticobasal syndrome) can resemble INPH symptomatology thus making its diagnosis challenging. In this context neuropsychological evaluation can significantly contribute to differential diagnosis and should be conducted on all patients referred with suspected INPH.

The second phase where a neuropsychologist can play a crucial role is the post-supplemental testing. At present several supplemental interventional tests are used for the diagnostic workup of INPH patients and the prediction of a favourable outcome following shunt placement. Thus, clinical improvement, mainly in gait, following lumbar puncture (LP) tap test, Lumbar Infusion Test (LIT) or External Lumbar Drainage test (ELD) is associated with an increased likelihood of improvement after shunt placement.

DOI 10.26386/obrela.v1i2.50 ISSN 2585-2795

An increasing number of studies indicate that neuropsychological investigations can provide valuable information on specific cognitive functions and their deficits in relation to INPH during the diagnostic workup and/or following supplemental tests. The cognitive impairment of INPH is typically characterized by frontal lobe dysfunctions such as psychomotor slowing (increased response latency), deficits in attention and short-term memory and decreased fine motor speed and accuracy. Improvement in frontal executive functions following the LP test is indicated by some studies and this can support patients' candidacy for shunt placement, when gait assessment is difficult to be conducted.

The third phase where neuropsychological assessment is considered important is the post-shunt period. As mentioned above, cognition is one of the three core elements affected in INPH; thus, changes in cognitive status should be reported in order to investigate treatment's efficacy. Lastly, INPH patients should followed-up in order to assess proper long-term shunt function.

NEUROPSYCHOLOGY AND BRAIN TUMORS

Brain tumor is one of the most challenging disorders for the neurosurgeons as well as for the neuropsychologists. The role of a neuropsychologist is mainly related to the effect that a tumor and/or its treatment may have on neurocognition.

Although brain tumor localization and classification is primarily performed by neuroimaging and biopsy of brain tissue, these techniques do not provide information regarding the functional impact of the tumor on cognition and behavior.

Both primary (benign or malignant) and metastatic brain tumors can produce a range of global and/or domain specific impairments in cognitive functions, with reports varying from 15 % to 90%, depending on the characteristics of the tumors studied, the patient demographics, and the treatments received.

The neuropsychological assessment should be part of the standard assessment and management of individuals with brain tumors in the following three stages:

Evaluation prior to surgery

Assessment prior to surgical resection provides insight into the functional impact of tumors and establishes a baseline against which later functioning can be compared. Neuropsychological testing can also identify functional disability that is not diagnosed by imaging and/or neurologic exams, and could not be predicted by tumor type or volume.

While rapidly progressing tumors may cause significant physical and cognitive impairment due to increased intracranial pressure and lesion momentum that outpaces brain plasticity, slowly growing tumors may allow the brain to adapt to the physical presence of the tumor, although may affect the cognitive functions.

Evaluation during surgery - Awake craniotomy

Another role of neuropsychology in the assessment and management of brain tumors, mainly gliomas, is the evaluation of cognitive and sensorimotor functions during awake craniotomy. There is a growing body of evidence that suggests better outcomes, including longer progression-free survival and superior seizure control, with greater extent of resection (EOR) and decreased contrast-enhancing residual tumor volume. However, in patients with tumors infiltrating regions of 'functional' brain, the extent of resection may be limited by the desire to preserve cognitive and motor functions, and in the absence of clear parameters regarding the location of these eloquent regions, the surgeon may be less prone to perform an extensive resection.

Functional imaging techniques can identify the areas that participate in language, motor, and sensory functions, whereas electrocortical stimulation mapping of the neurocognitive functions during awake craniotomy allows the specification of sites that are essential for the preservation of these functions.

During the awake craniotomy, the neuropsychologist administers language and cognitive tasks, monitors for involuntary movements or motor arrest in the mouth, face, and hands, and directs the patient to notice any sensory symptoms as the sur-

DOI 10.26386/obrela.v1i2.50 ISSN 2585-2795

geon stimulates selected sites. Patient's responses are reported back to surgeon in 'real time', and this allows the demarcation of brain areas with an essential role in language, motor, and/or sensory functions that should be preserved, from areas that can be safely resected during tumor removal.

Assessment during and after adjuvant therapies

The treatments used to combat brains tumor can cause damage to the healthy tissue. Screening of neurocognitive functions with neuropsychological measures during and after treatment with chemotherapy and radiation can provide information that may be missed with a brief mental status exam.

Finally, serial neuropsychological testing can also reveal regrowth of tumor weeks to months before there is radiographic evidence of tumor progression.

NEUROPSYCHOLOGY IN THE DEPARTMENT OF NEUROSURGERY AT EVANGELISMOS HOSPITAL

The University Department of Neurosurgery at Evangelismos Hospital in Athens is the first and the only one that provides advanced neuropsychological service.

The Neuropsychology Service was established in 2007 and since then it has been providing clinical and research work mainly in the fields of brain tumors, INPH, TBI, movement disorders and epilepsy.

CONCLUSION

In this review we examine the role of neuropsychology in neurosurgery. According to the literature, neuropsychologists can significantly contribute to the management of neurosurgical disorders. By combining the advanced knowledge of brain anatomy and functions, provided by neurosurgeons and neuropsychologists respectively, we can have a better understanding of the human brain and aim in a more effective treatment of patients suffering from neurosurgical disease.

References

1. Wilson S, Baxendale S, Barr W.Indications and expectations for neuropsychological assessment in routine epilepsy care: Report of the ILAE Neuropsychology Task Force. *Epilepsia* 56: 674-81, 2015, PMID: 25779625 , DOI: 10.1111/epi.12962

2. Jean A. Saint-Cyr. Neuropsychology for Movement Disorders Neurosurgery. *Can J Neurol Sci* 30: 1 – 93, 2003, PMID: 12691481

3. Egeto P, Loch Macdonald R, Ornstein TJ, Schweizer TA. Neuropsychological function after endovascular and neurosurgical treatment of subarachnoid hemorrhage: a systematic review and meta-analysis. *J Neurosurg* 14: 1-9, 2017, PMID: 28409729 , DOI: 10.3171/2016.11.JNS162055

4. Peterson KA, Savulich G, Jackson D, Killikelly C, Pickard JD, Sahakian BJ. The effect of shunt surgery on neuropsychological performance in normal pressure hydrocephalus: a systematic review and metaanalysis. *J Neurol* 263: 1669–77, 2016, PMID: 27017344 , PMCID: PMC4971036 , DOI: 10.1007/s00415-016-8097-0

5. Liouta E, Koutsarnakis C, Stranjalis G. Finger tapping and verbal fluency post-tap test improvement in INPH: its value in differential diagnosis and shunt-treatment outcomes prognosis. *Acta Neurochirurgica*, 2017 , PMID: 28828534, DOI: 10.1007/s00701-017-3301-2

6. Liouta E, Koutsarnakis C,Liakos F, Stranjalis G. Effects of intracranial meningioma location, size, and surgery on neurocognitive functions: a 3-year prospective study. *Journal of Neurosurgery*; 124: 1578-84, 2016 , PMID: 26636380 , DOI: 10.3171/2015.6.JNS1549

7. Hoffnung DS. The Role of Neuropsychology in the Assessment and Management of CNS Tumors. *Clin Oncol* 1: 1065, 2016