Clinics in Surgery

Review Article
Published: 01 Nov, 2018

The Cognitive Reserve Model and Its Relation to Preoperative Neuropsychological Rehabilitation in Patients with Refractory Medial Temporal Lobe Epilepsy: A Perspective Review

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Abstract

Introduction: Literature findings on cognitive rehabilitation procedures pre- and particularly post-operatively are very scarce in epilepsy patients. Specifically, in the domain of Medial Temporal Lobe Epilepsy (MTLE) representing the most frequent type of localization-related epilepsy most of these studies have focused on postoperative cognitive interventions to aid patients overcoming neuropsychological deficits after Temporal Lobectomy (TL). Little attention has been given to preoperative neurorehabilitation aiming to promote patients cognitive outcome. The aim of this review is mainly to highlight theory approaches enabling neuropsychologists to plan theory-guided effective cognitive rehabilitation interventions in MTLE patients before TL to the dominant temporal lobe.

Methods: Only peer reviewed articles published in English have been searched in PubMed and Psycholit from the 1940 to 2017.

Results: We propose the functional resource model and notions coming from functional hemispheric asymmetry as a potential theory tools to guide such preoperative neurorehabilitation efforts.

Conclusion: By orienting preoperative cognitive rehabilitation towards enrichment of cognitive resources of the whole brain in general and the non-surgical hemisphere in particular, we expect a positive cognitive and memory post-operative outcome in MTLE patients undergoing dominant hemisphere temporal lobectomy.

Keywords: Neurorehabilitation; Memory; Cognition; Medial Temporal Lobe Epilepsy; Temporal Lobectomy; Epilepsy Surgery

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Received Date: *24 Sep 2018*
Accepted Date: *30 Oct 2018*
Published Date: *01 Nov 2018*

Citation:
Patrikelis P, Lucci G, Alexoudi A, Verentzioti A, Sakas D, Gatzonis S. The Cognitive Reserve Model and Its Relation to Preoperative Neuropsychological Rehabilitation in Patients with Refractory Medial Temporal Lobe Epilepsy: A Perspective Review. Clin Surg. 2018; 3: 2192.

Introduction

Since memory deficits represent the most frequent subjective complaint in epileptic patients [1], compensation models and their therapeutic applications have been considered for treatment [2]. People with Medial Temporal Lobe Epilepsy (MTLE) show deficits in word-finding, naming, attention, visuospatial abilities, executive functions, and intelligence, in addition to impaired long-term storage and recall of novel mnemonic material, and learning difficulties [3,4]. Patients suffering from MTLE show several cognitive deficits. The more prominent are deficits in declarative memory and, more specifically, in episodic memory [5].

In the context of neurorehabilitation the concept of cognitive reserve, i.e., the inherent potential of the brain in order to cope with damage, represents a key concept. In the domain of MTLE surgery, the concept of cognitive reserve has been applied in two different models of hippocampal functioning, i.e. *hippocampal adequacy vs. functional reserve,* in relation to the risk for memory decrements following Temporal Lobectomy (TL).

The functional adequacy model regards postsurgical memory deficits as dependent on the functional integrity of the tissue to be resected. There is rising evidence that the functional adequacy of the tissue to be resected determines the nature and extent of postoperative memory

loss. It has been repeatedly observed that patients, whose mnemonic abilities were sufficiently intact before surgery, are adversely affected following TL [6-9]. In line with these findings, studies on memory functioning derived from IAT injections contralateral to the seizure focus indicated that patients with good memory before surgery were at much greater risk for memory loss than those who performed poor at baseline [10,11]. A weak point of the functional adequacy model, however, is that it does not predict mild material-specific memory deficits following TL.

Although the contralateral temporal lobe alone does not determine the probability of memory loss following TL, this is not to say that its functional capacity should be ignored, especially if we consider ample clinical evidence documenting the devastating consequences for memory following bilateral hippocampal damage [12].

According to *functional reserve* theory, the severity of memory deficits after surgery could depend on the capacity of the healthy temporal lobe to cope the loss of the affected-contralateral temporal lobe [13].

The prediction of postoperative memory outcomes in patients affected by epilepsy has recently received considerable attention in neuropsychological research. Data from studies on brain function (i.e., baseline cognitive performance and Wada test) and morphology (i.e., histological cell densities and MRI volumetric) provide strong convergent support to the idea that the risk for memory impairment after MTLE surgery is inversely related to the functional adequacy of the tissue to be resected [14]. Although the bulk of empirical evidence favours the adequacy model in predicting cognitive outcomes following surgery, it appears not helpful when attempting to plan preoperative neurorehabilitation interventions targeting cognition and memory, in particular. Recently, stemming from notions of cognitive reserve and functional hemispheric asymmetry we provided preliminary evidence of the possible beneficial effects of preoperative cognitive interventions to determine positive post surgery memory outcomes in MTLE patients, by enriching cognitive resources in general and promoting memory potential of the healthy contralateral areas in particular [15].

Interesting insights to future preoperative rehabilitation programs formulations of left MTLE patients may come from classical theoretical models. For instance, Levy's key distinction between the concept of dominance and capacity [16] suggesting that dominance is the tendency for one hemisphere to process certain kinds of information and to use this processing outcome to control behaviour, whereas capacity refers to the potential of a hemisphere to assume processing responsibilities when the dominant hemisphere for that kind of information is otherwise engaged. Further, the proved ability of the right hemisphere to process lexical-semantic information and mediate verbal memory through its ability to process highly imageable words is of importance in left-MTLE post surgery memory outcome. This later notion is known as *imagery mediated verbal recall* and may constitute the basic rehabilitation procedure to train the right-hemisphere to support verbal memory after surgery.

Jones, Confirming Patten reported that both healthy individuals and left TLE patients improve their performance in a verbal paired-associate task by using the strategy of imagery mediated verbal recall, while right TLE patients do not. Accordingly, further evidence suggested the critical role of the right temporal lobe in processing verbal material with high imageability, such as recalling concrete words [17,18]. This is further corroborated by evidence that right TLE patients may face verbal memory difficulties when the material presents a strong imagery component [19].

The different degree of functional engagement of the cerebral hemispheres to verbal recall becomes more evident in the presence of pictorial stimuli. Jaccarino et al. [20,21] suggests that damage to either the right or left temporal lobe led to compromised recall of line drawings' names presented a day earlier. Similarly, Moscovitch et al. [22] showed that right temporal damage can influence even immediate verbal recall, suggesting that beyond the early stage of processing each hemisphere encodes the identical information in a way corresponding to its processing abilities [23]. As to the cognitive interference produced by seizures, findings steaming from classic studies imply that a seizure focus in one temporal lobe can interfere with complementary cognitive functions presumably mediated by related areas of the opposite hemisphere. It is therefore suggested that postoperative memory improvement in patients undergoing Anterior Temporal Lobectomy (ATL) seems to be related to the degree of seizures reduction and the amount of remaining epileptic activity interfering with the healthy hemisphere. Moreover, the type of improvement (*verbal* or *visuospatial memory*) is related to the side of surgery. Age at operation may also constitute a potential contributing factor [24,25].

In line with her antecedents has claimed that cognitive improvement following TL reflects nonspecific enhancement of brain function linking to seizure frequency [26-28]. This is explained by the fact that both the anterior commissure and the middle third of the corpus callosum contain fibers connecting homotopic areas of each temporal lobe [29]. As a result the spread of a discharging lesion in one temporal lobe to the contralateral temporal lobe may disrupt in a rather selective fashion the specific memory functions preferentially mediated by that structure.

The relatively limited literature in the domain of cognitive rehabilitation for epilepsy surgical patients has mainly focused on postoperative memory training [30-32], while there is only one study dealing with preoperative memory rehabilitation, which failed to find better memory outcomes as compared to postoperative interventions [33], as well as a single case-study design of preoperative neurorehabilitation [15].

Having reviewed the scarce though relevant literature and analyzed its results, we herewith propose functional reserve model as a potential theoretical tool to guide preoperative neurorehabilitation options aiming at increase postoperative cognitive, memory in particular, outcomes in patients suffering intractable left-MTLE.

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