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Memory After Temporal Lobectomy

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Epilepsy is a common neurological disorder. Its mean prevalence is about 7 per 1000 people of the general population. Apart from drug therapy, recent advances in diagnostic technology and surgical techniques have led to increasing use of surgical treatment for certain specific epileptic syndromes that have responded poorly to drug therapy. Possible memory decline induced by epilepsy surgery becomes a major concern. This paper reviews the material-specific ipsilateral memory deficit and contralateral improvement after temporal lobectomy. According to the literature, the left and right mesial temporal systems process different types of material-specific information, mostly in accordance with the pattern of cerebral language dominance. In general, the temporal lobe of the dominant hemisphere is associated with verbal memory and that of the non-dominant hemisphere is associated with non-verbal memory. While surgical treatment may induce memory deficits related to the destruction of the ipsilateral mesial temporal system, improvement in memory functioning is observed in the contralateral hemisphere. The impact of factors, such as surgical procedure, focus of neuropsychological evaluation, timing of post operative measures of cognitive functions, and demographic variability of the surgical candidates, on the findings of the studies on memory after temporal lobectomy are reviewed.

Memoria Después de Lobectomía Temporal

La epilepsia es un desorden neurológico común cuya prevalencia media está cerca de 7 por 100 habitantes de la población general. Actualmente se están utilizando los tratamientos quirúrgicos para tratar síndromes epilépticos que no responden al tratamiento farmacológico. El principal problema en relación con las cirugías es la disminución de la memoria. En este trabajo se revisa el déficil ipsilateral de memoria para material específico y la mejoría contralateral posterior a la lobectomía temporal. En general, el lóbulo temporal del hemisferio dominante está asociado con la memoria verbal y el hemisferio no dominante con la memoria no verbal. De manera que mientras el tratamiento quirúrgico puede inducir déficits de memoria relacionados con la destrucción del sistema temporal mesial ipsilateral, se observan mejorías en el funcionamiento de la memoria en el hemisferio

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contralateral. Adicionalmente, se revisa el impacto de diversos factores sobre la memoria después de lobectomia temporal.

Epilepsy is a common neurological disorder characterized by recurrent seizures (Snyder & Nussbaum, 1998) presented as episodic hyperexcitability and hypersynchronous discharge of nerve cells in the brain (Lezak, 1995). Such abnormal neural activity may be the result of the easy discharge of some neurons due to alterations in membrane conductance or the failure of the inhibitory neurotransmission process (Dichter, 1997). The state in which the neuronal circuit becomes hyperexcitable, leading to spontaneous recurrent seizures is called epileptogenesis. The result of these seizure activities could be the loss of awareness or consciousness as well as the disturbance of movement, sensation, autonomic function, mood, and mental functions.

Epilepsy can be identified in any racial, age, gender, national, geographic, and social groups. It is estimated that 40 million people are suffering from epilepsy, based on the mean prevalence estimate of active epilepsy of 7 per 1000 people of the general population. This figure is pooled from many studies around the world. Epilepsy is up to twice as prevalent in the developing countries as in the developed countries (McQueen & Swartz, 1995). This difference may relate to the relatively higher risk of acute and chronic brain infections as well as some pre- and post-natal obstetric complications in these developing countries, which may predispose and/or precipitate the onset of epilepsy.

Of all the newly diagnosed cases of epilepsy, about 70% of which responded well to the anti-epileptic medications. Nevertheless, up to 30% of these cases showed a very poor response to drug therapy. To them surgical treatment becomes the only viable option for seizure control. Surgical treatment has been repeatedly demonstrated to generate treatment gains in terms of the reduction or elimination of seizure activity (Olivier, 1992). Moreover, when seizures do persist, they are usually more amenable to the control with drugs. However, as widely reported in the literature, impaired memory function is a well-known potential threat for those patients receiving temporal lobectomy (Jones-Gotman et al., 1997). With the rapid expansion of elective surgery as therapy for intractable epilepsy, it is important to examine any possible memory change as a result of such an operation.

Memory change associated with temporal lobectomy

Temporal lobe epilepsy is the most common among all types of seizure (Van Buren, Ajmone-Marsan, Mutsuga, & Sadowsky, 1975). Within the temporal lobe is a very significant gray body called hippocampus, which is known for its unique role for human learning and memory, particularly essential for the consolidation of novel information for its longer-term processing. Because of the specific role of the hippocampus, memory and learning disorders are very common among people whose epileptic foci are within the temporal lobe (Mirsky, Primac, Marson et al., 1960). Similarly, memory deficit induced by temporal lobectomy causing destruction to the hippocampal system has become one of the major concerns of those people receiving the operation.

Surgically induced memory decline is frequently reported in the literature (Trenerry, Westerveld, & Meador, 1995). The scope and severity of human amnesia can best be appreciated in Brenda Milner's pioneering studies of the noted patient H. M. (Scoville & Milner, 1957; Milner, 1958) who became amnesic in 1953 as the result of a bilateral surgical excision of the medial temporal region for control of his seizure. The anterograde amnesia that he suffered presented as a dramatically impaired capacity for learning new material, or for recollecting events that have recently happened. Since then much evidence has been accumulated showing that unilateral temporal lobectomy for seizure relief show ipsilateral material-specific memory deficits as well as possible contralateral improvement.

Approaches to memory change after temporal lobectomy

Implicit in the neuropsychological literature is different approaches to understand the nature of memory impairment after temporal lobe resection (Saykin, Robinson, Stafiniak, Kester, Gur, O’Connor, and Sperling,1992). The material-specific ipsilateral memory deficit suggests that the hemisphere on which the resection is performed influences the type of material affected by the surgery. Assuming a left cerebral dominance, left temporal lobectomy has been associated with a decline in verbal memory, and right temporal lobectomy has been associated with a decrease in nonverbal, particularly visual memory (Jones-Gotman, 1987). Extended from this approach is the proposition of contralateral improvement of memory functioning after the operation.

Material specific ipsilateral memory deficit

Material-specific ipsilateral deficit is frequently reported in the literature (Loring, Meador, Martin, & Lee 1988; Jones-Gotman, 1997). The left and the right temporal mesial systems are found to subserve differentiable types of material-specific information, mostly in accordance with the pattern of cerebral language dominance (Helmstaedter & Elger, 1996). Learning and retention of verbal materials is associated with the left temporal memory system and that of nonverbal materials is associated with the right temporal memory system, assuming a left cerebral language dominance. Following this theoretical approach, left temporal lobectomy may result in possible verbal memory deficits; whereas non-verbal learning deficit could be the result of right temporal lobe resection (Jones-Gotman et al., 1997). In other words, memory impairment associated with the temporal lobe dysfunction seems to be modality specific.

Jones-Gotman (1997) studied the learning of abstract words versus abstract designs in groups of patients with right or left temporal lobe resections. Learning, immediate and delayed recall for words was impaired in the group with left resection. Learning and immediate recall but not delayed recall for abstract designs was impaired in the group with right resection. Nevertheless, further comparison of the performance between those people with right and left resection indicated that the newly acquired words were subject to significant forgetting following left-sided excision. Design, though acquired slowly by patients with right-sided excision, was not subject to forgetting. To explain these observations, Jones-Gotman (1997) proposes that words are concepts that are well established in people's lexicons. The encoding process is relatively speedy. However, the opportunity for any interference to occur is high, hence, leading to more rapid forgetting. For the encoding of design, memory of representation is newly formed. The encoding process is relatively more time consuming. However, once learned, opportunity for any interference and forgetting is minimal. Therefore, any damage to the left temporal lobe results in both slower learning and more rapid forgetting of verbal information, and the damage to the right temporal lobe would impair the learning process of nonverbal material but would not affect retention.

Nunn, Polkey, and Morris (1998) advocate the association between deficits in performance of visuo-spatial tasks and right temporal damage. They studied 19 left and 19 right temporal lobectomy patients with that of 16 normal controls on the recall and recognition of the eight abstract designs presented in a spatial array. They observed a deficit in the right temporal lobectomy group on recall of the position of the designs. In one of their other study, they employed the temporal titration method to demonstrate the differential spatial memory impairment following right temporal lobectomy (Nunn, Graydon, Polkey, & Morris, 1999). This time they asked the 19 left and 19 right temporal lobectomy patients and the 16 normal controls to study an array of 16 toy objects, who were then subsequently tested for object recall, object recognition, and memory for the location of the objects. Again, they observed that when memory for the position of the objects was assessed at equivalent delays, the right temporal group revealed disrupted spatial memory, compared with the left temporal and the normal control groups. These clinical observations were further substantiated by the data of Magnetic Resonance Imaging, which showed that a disproportionately large involvement of the right hippocampus and adjacent regions in spatial memory (Nunn , Polkey & Morris, 1998; Nunn, et al., 1999).

The advancement of imaging technology allows an unparalleled opportunity to examine in vivo the relationship between the extent and laterality of hippocampal pathology and the associated memory impairments. In a MRI study by Baxendale et al. (1998), they observed that those patients with left hippocampal sclerosis performed more poorly than those with right hippocampal sclerosis on both immediate and delayed prose recall. The right hippocampal volume, on the other hand, was significantly correlated with the delayed recall of a complex figure. These data provide some confirmatory evidence for the laterlised model of material-specific memory deficits.

Data on Chinese are scarce. In a pilot study conducted by Ho (1998), the postopertive non-verbal memory functioning of patients treated by right temporal lobectomy was found to be relatively weak whereas their verbal memory functioning was relatively intact. This pattern is consistent with the notion of material-specific ipsilateral deficit after surgical treatment for epilepsy, which has been widely documented in the literature. For non-verbal memory functioning, the patients receiving right temporal lobectomy was weak in learning abstract designs whereas their short-term and long-term retention is relatively intact. These findings echoed the finding of Jones-Gotman (1997). For postoperative verbal memory functioning, the patients treated by right temporal lobectomy were comparable to the healthy sample in learning and long-term delayed recall of verbal information.

Further to all the reports above, there have been numerous other studies that supported the observations of ipsilateral memory deficit. Left temporal lobectomy is shown to be associated with the postoperative decline in learning or retention of various types of materials including digits (Corsi, 1972), words (Jones, 1974; Jones-Gotman & Milner, 1978) and prose (Frisk & Milner, 1990). Whereas right temporal lobectomy is consistently related to decline in the learning and retention of non-verbal materials, including abstract designs (Doyon & Milner, 1991; Jones-Gotman, 1986; Kimura, 1963; Pigott & Milner, 1993), spatial location (Smith & Milner, 1981; Smith & Milner, 1989), learning and recognition of faces (Milner, 1968).

Though there has been extensive evidence supporting the phenomenon of material specific change in accordance with the side of excision, the impact of left temporal lobe resection on verbal memory tends to be more consistently observed than that of right temporal lobe resection on non-verbal memory (Jones-Gotman et al., 1993). Ivnik , Sharbrough and Law (1987) assessed the cognitive functioning of 35 patients with right temporal resection and 28 patients with left temporal resection. Wechsler Memory Scale was used to assess the general memory functioning. Auditory Verbal Learning Test was used to assess the verbal memory processes including immediate memory span, learning, short-term retention, long-term retention, and recognition. For Wechsler Memory Scale, left temporal lobe resection was found to impair the immediate recall for verbal materials but enhanced the immediate recall for non-verbal materials. Right temporal lobe resection affected immediate recall for neither non-verbal nor verbal materials. For the Auditory Verbal Learning Test, the group with left temporal lobe resection performed significantly worse than the group with right temporal lobe resection on all measures. These findings supported the association between left temporal resection and the decline in verbal memory after surgical treatment. However, it failed to establish the association between right temporal resection and the postoperative decline in non-verbal memory ability. Hence, providing only partial evidence for the association between the side of excision and the proposed material-specific memory change.

Pigott and Milner (1993) studied the impact of anterior temporal-lobe resection on patient's non-verbal short-term memory. Thirty-three patients with a left-resection and 49 patients with a right resection were recruited. The patients were shown stimulus pattern for 2 seconds. They were then tested at a 2-sec and unfilled delay, a 10-sec unfilled delay, a 2-sec and a 10-sec delay with distraction. The group with right-resection did not show any impairment in all conditions. It seems that the patients with right temporal lobe resection tended to suffer relatively little or even no neuropsychological sequelae.

In a study conducted the Neurosurgical Unit at the Maudsley Hospital, 59 patients treated by temporal lobectomy since 1973 were recruited. Thirty cases with left resection and 29 cases with right resection were included (Powell, Polky, & McMillan, 1985). Logical memory was tested by asking these subjects to recall two prose passages. Rey-Osterrieth Figure Test was used as a measure of non-verbal memory. Post operatively the group with left resection had significantly lower score on the logical memory immediate recall as predicted by the notion of material specific ipsilateral deficit. For non-verbal memory and logical memory delayed recall, no significant association with a right hemispheric lesion was observed.

The above data demonstrated that a right temporal lobe resection may not affect the non-verbal memory. Nevertheless, there has been argument that the neutral impact of a right temporal lobectomy reflected difficulties to isolate verbal strategies in measuring non-verbal memory (Helmstaedter, Pohl, & Elger, 1995). In other words, the absence of adequate measures of nonverbal memory (Davies, Bell, Bush, & Wyler, 1998) may account for this phenomenon. Indeed, though Auditory Verbal Learning Test provides a comprehensive appreciation of the verbal memory processes, non-verbal memory processes are not as comprehensively assessed due to the lack of appropriate instruments. Until recently the Aggie Figure Learning Test (Jones-Gotman, 1997) was introduced as the nonverbal analogue to the Auditory Verbal Learning Test. However, it was argued that even when abstract materials were used, verbalization could not be completely eliminated. Nevertheless, although right-sided resections pose less consistent risk of memory impairment, the data so far did indicate some partial association between the side of excision and type of materials being affected in memory tasks.

Contralateral improvement of memory

Contralateral improvement referred to the improvement in memory functioning associated with the contralateral hemisphere as a result of some ipsilateral deficit. Evidence for this proposition is less rich as compared with the data showing ipsilateral deficits.

Saykin et al. (1992) assessed the verbal and non-verbal memory functioning of 64 patients with epilepsy. They were treated by anterior temporal lobectomy for partial seizures or secondarily generalized seizures. Thirty-two cases with left-resection, and 32 cases with right-resection. A normal control group was also included in this study. Post operatively, the group with right resection showed a decline in non-verbal memory but improvement in the verbal memory. The group with left-resection showed a decline in the verbal memory but improvement in the non-verbal memory. In Ivnik et al.'s (1987) study assessing the cognitive functioning of 35 patients with right temporal resection and 28 patients with left temporal resection, left temporal lobe resection was found to impair immediate recall for the verbal materials but enhanced immediate recall for the non-verbal materials. These findings were a typical demonstration of material-specific ipsilateral deficit and contralateral improvement.

Factors affecting memory post operation

There are several factors that would influence the data of the studies on memory after epilepsy surgery. The more pertinent ones are epilepsy surgical procedure, the focus of neuropsychological evaluation, timing of post operative measures of neuropsychological evaluation, and the demographic variability of the surgical candidates (Saykin et al., 1992).

Surgical procedure

Reports of different epilepsy surgery centers depended on various variables reflecting the center's surgical philosophy (Doyle & Spencer, 1997). Potential risk factors were weighted variously in their surgical decision. Furthermore, different centers used different methodologies in diagnosing seizure disorders and localizing a seizure focus. They also went through different pre operative evaluation procedures to arrive at a surgical decision (Lesser, Fisher, & Uematsu, 1992). Post operatively uniform criterion of success has not yet established.

Focus of neuropsychological evaluation

The selection of the neuropsychological measures varies widely between centers. Most centers assessed cognitive functioning and memory of patients by the Wechsler Adult Intelligence Scale-Revised and the Wechsler Memory Scale. However, apart from the consistent inclusion of Wechsler Memory Scale, there are great heterogeneity in the neuropsychological test batteries used (Saykin et al., 1992). To make the situation worse, attention to the intercorrelation and factor structure of these test batteries is far from adequate. Furthermore, there are very few attempts to validate the sensitivity and specificity of these tests in detecting baseline deficits and change after surgery in patients with epilepsy.

Timing of post operative timing of neuropsychological evaluation

Differences in timing of post operative measures of cognitive functions can account for the differences in findings on the post operative memory status. For example, anomia was found in some patients who had dominant anterior temporal lobectomy one month (Loring et al., 1988) but not 6 months after the surgery (Hermann & Wyler, 1988), suggesting that anomia might be present shortly after the surgery but it would diminish with time. While the course of any post operative recovery of neuropsychological functions is not yet clear, more effort is needed to establish the stabilization, progression and degradation of neuropsychological functioning after surgical treatment. The Consensus Conference on Surgery for Epilepsy (National Institutes of Health, 1990) recently recommended longitudinal assessment of neuropsychological and psychosocial outcome after surgery.

Demographic variability

Subject variables were mostly neglected in the early phase of development of the surgical treatment for epilepsy. Nevertheless, there are increasing attempts to identify predictor variables to post operative changes. For example, Helmstardter and Elger (1996) found out that high pre-surgical performance level, older age at time of surgery, longer duration of epilepsy, extensive enbloc resection, pre-existing deficits in visual/figural memory performance and pre operative secondarily generalized seizures were significant predictors of post operative deterioration in patients with a left resection. Powell, Polkey and Macmillan (1985) reported that the patients who showed no deterioration or most improvement post operatively tended to be younger, lower in pre operative intellectual ability and have onset of regular seizures at an earlier age. Davis et al. (1998) also observed that younger chronological age at the time of surgery carries a more favorable post operative outcome for the memory function. Hermann, Davies, Foley, & Bell (1999) also suggested that the age of onset of epilepsy is a powerful predictor of language outcome.

Gender is proposed to be a significant factor. Trenerry, Westerveld, and Meador (1995) found that pre operative performance on the logical memory percent retention score correlated significantly with both right and left hippocampal volume in women with left temporal lobe epilepsy. They suggested that verbal memory abilities may be less lateralised in women with left temporal lobe epilepsy stemmed from a mesial temporal sclerosis. Their results also suggested that women may have greater verbal memory. This position is supported by Baxendale et al.(1998) who pointed out the importance of gender in influencing the relationship between hippocampal volume, memory impairments, and the plasticity of functional return. Davis et al. (1998) also reported that a left resection and a male gender seemed to be factors predicting poorer post operative outcome relative to their counterparts.

Conclusion

Change in the memory status after temporal lobectomy has been widely reported in the literature. While material-specific ipsilateral memory deficit to left temporal resection has been quite well established, the association between the nonverbal memory impairment and a right temporal resection remains partial. Saykin et al.'s (1992) developmental hemispheric asymmetry approach may add insight into the understanding of this right-left discrepancy. The asymmetry component is based on the evidence that the left, compared to the right, medial temporal lobe is better able to simultaneously support both verbal and nonverbal memory after contralateral resection. Based on this approach, greater improvement, and greater change is expected after left resection and for verbal compared to visual material. This may explain why there are relatively less confirmatory data supporting the change in the nonverbal memory functioning associated with right temporal resection.

The observation of contralateral memory improvement after temporal lobectomy has yet only been loosely established. Apart from the fact that more time would be needed to accumulate substantial evidence, there are factors that need to be controlled in studies of memory change after temporal lobectomy so as to ensure the validity of the data. For example, it is important for employing a control condition in studies of memory change post operation so as to control for the impact of the practice effect. Furthermore, the control for the severity of seizure activities for right-left temporal lobectomy comparisons is of obvious important. The impact of demographic variability of the surgical candidates on memory change post operation has been discussed. The more significant factors appear to be the age at time of surgery and the gender of the surgical candidates, with younger age and being female being more advantageous. Taken all these into consideration, the employment of a standardized research protocols and instruments and the uniform control of variables including timing of measurement and demographic characteristics of the sample are of crucial importance for protecting the power of generalization of the findings across centers.

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