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REVIEW

Cognitive impairment after liver transplantation: residual hepatic encephalopathy or posttransplant encephalopathy?

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Abstract: Liver transplantation (LT) represents the definitive treatment for end-stage liver disease. Cognitive impairment following LT is frequent, referred to as postliver transplant encephalopathy (PLTE). LT removes the underlying chronic liver disease, and until recently hepatic encephalopathy (HE) was assumed to be fully reversible after LT. However, increasing evidence indicates that some degree of cognitive impairment may be present after LT. To which extent PLTE reflects cognitive impairment caused by residual HE (RHE) or the combined effect of other factors affecting brain function before, during, and after LT is not clarified. None of the available psychometric and neurophysiological tests used for detecting HE is shown to be able to distinguish between etiologies. The available, mostly retrospective, clinical studies indicate a high prevalence of abnormal psychometric tests after LT, and not all seem to recover completely. The patients with earlier HE show the most marked improvements, suggesting that the clinical picture of the early PLTE, in fact, represents RHE. Other early post-LT etiologies for PLTE comprise cerebral ischemia, critical illness encephalopathy, and immunosuppressive therapy. Late-onset etiologies comprise diabetes and hypertension, among others. PLTE regardless of etiology is a worrying issue and needs more attention in the form of mechanistic research, development of diagnostic/discriminative tools, and standardized prospective clinical studies.

Keywords: liver transplantation, hepatic encephalopathy, cirrhosis, cognitive impairment

Introduction

Liver transplantation (LT) represents the definitive treatment for end-stage liver disease irrespective of etiology.[1–3] Many patients experience hepatic encephalopathy (HE) while waiting for LT or at the time of LT.[4–7] Likewise, the HE burden is a decisive factor when patients are considered as candidates for the LT waiting list, although HE is not part of the Model for End-Stage Liver Disease (MELD) score often used for prioritization of liver grafts.[8]

After LT, cognitive impairment is frequently reported with encephalopathy as the predominant presentation.[9–12] LT removes the underlying chronic liver disease that by definition causes HE and thereby effectively removes the suspected main pathogenic factor of HE, the hyperammonemia. The understanding of the nature of the cognitive impairment present after LT is insufficient, and no clear consensus of the nomenclature exists. In this article, the cognitive impairment after LT is referred to as postliver transplant encephalopathy (PLTE).

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Whether PLTE reflects residual cognitive impairment caused by and remaining after HE or the combined effect of other factors affecting the brain function before, during, and after LT is largely unknown.

Until recently, HE was widely assumed to be fully reversible. However, increasing evidence indicates that some degree of cognitive impairment may persist in patients after LT, but also in un-transplanted patients after HE resolution.[13–16] Such cognitive impairment following LT attributable to earlier HE will in this article be referred to as residual HE (RHE). RHE may, in fact, reflect lasting cognitive impairments, but clarification is difficult due to the lack of validated testing methods, and because the pathophysiology of HE is complex and not completely understood. Several studies investigated the reversibility of HE after LT. A recent study by Campagna et al supports the hypothesis that some cognitive remnants of HE, ie, RHE, may persist after LT. They prospectively studied 65 patients before and 9–12 months after LT.[17] Before LT, global cognitive function was worse for patients with previous HE than for patients without previous HE. Both patients with and without previous HE showed a clear improvement of global cognitive function after LT. Notably, although the degree of improvement was higher for patients with previous HE, their cognitive function did not completely recover to the level of patients without previous HE.

HE is aggravated in the presence of systemic and cerebral inflammation and by eg, diabetes, drugs, and alcohol.[18–22] It has been proposed that hyperammonemia increases the brain's susceptibility to aggravating factors.[23] Furthermore, aggravating factors may cause cognitive impairment independent of that caused by hyperammonemia and thus may persist in spite of normalized ammonia levels after LT. Furthermore, the immunosuppressive therapy after transplantation has an undeniable negative impact upon brain function, particularly related to the use of calcineurin inhibitors.[24,25]

Lewis et al showed that in long-term survivors of LT cognitive impairment was frequent and that health-related quality of life was significantly worse than in the healthy control group.[26] Pflugrad et al could detail this finding.[27] They studied the effect of pre-LT HE and neurological complications post-LT on employment status and health-related quality of life. Independent predictors of post-LT employment status were pre-LT employment status and post-LT health-related quality of life, while pre-LT HE and post-LT neurological complications surprisingly were not. However, patients not employed pre-LT had a higher frequency of pre-LT HE, and patients not employed post-LT performed worse in the psychometric tests than patients employed post-LT.

In conclusion, it is not at present possible clearly to distinguish the impact of pretransplant HE on post-transplant cognitive impairment from that of other possible contributing factors. Importantly, cognitive impairment following LT has a heavy socioeconomic impact on the patients' health-related quality of life and working ability.

Hepatic encephalopathy (HE)

Around 50% of patients with cirrhosis will experience at least one episode of overt hepatic encephalopathy (OHE), and the 1-year mortality after the first bout is reported as high as about 50%.[28–30] Even more will experience minimal HE (MHE), that is HE without clinical signs, but with measurable cognitive impairment. Furthermore, MHE carries a high risk for progression into OHE, recurrent or even persistent HE.[31] HE is one important factor with major impact on the health-related quality of life (of patients and caregivers), cognitive function, as well as working ability.

The clinical presentation of HE is graded by the West Haven classification ranging from unimpaired (grade 0) to frank coma (grade IV).[31] However, a large fraction of the clinically unimpaired patients (grade 0) shows cognitive deficits in neuropsychological and/or neurophysiological tests, which define MHE.[32,33] A large array of tests are proposed and in use and to some extent validated to detect MHE with the basic limitation that no gold standard for the condition exists.[31] These tests include psychometric tests and neurophysiological tests. Of the psychometric tests, the PSE (portosystemic encephalopathy) syndrome test – also known as the PHES (psychometric hepatic encephalopathy score) – is widely used. It comprises five paper-and-pencil tests and evaluates cognitive function regarding domains of attention, executive functions, psychomotor processing speed, and visuomotor coordination.[34] Computerized psychometric tests include the continuous reaction time test,[35] the inhibitory control test,[36] the Stroop test,[37] and the SCAN test.[38] The neurophysiological tests include the critical flicker frequency (CFF) test[39,40] and the electroencephalogram (EEG). The EEG is independent of cognitive stimulation and patient cooperation and demonstrates a characteristic, but not specific, shift in electric activity in patients with HE.[41,42] In clinical routine, liver centers can use the tests they are

familiar with, given that normative reference data are available. However, none of the tests is specific for HE, and the correlation between them is poor, likely due to the multidimensional dysfunctionality in HE.[31] Thus, already the diagnosis of MHE presents unsolved difficulties, and when it comes to the diagnosis of RHE it must be kept in mind that the features of RHE are not well characterized. It can be expected, however, that RHE covers all or parts of the cognitive domains affected by MHE or OHE.

The available studies on cognitive function after LT are based on several of the tests used for diagnosing and monitoring MHE, sometimes combined with brain scans, mostly MRI. Some patients with cirrhosis perform worse than healthy controls in psychometric and neurophysiological tests, and whether these patients experience full cognitive recovery following successful LT is debated. The study by Campagna et al reported worse global cognitive function before LT for patients with previous HE compared with patients without previous HE.[17] Both patients with and without previous HE showed a clear improvement of global cognitive function after LT. But their attention and executive function showed no improvement. Of interest, the EEG normalized in 98% of patients, underscoring the different capacities of psychometric and neurophysiological tests. Tryc et al studied changes in cognitive function before and 6 and 12 months after LT in 50 patients with cirrhosis.[43] What they took to be RHE was almost resolved within 6 months after LT. Again, the patients with previous HE showed the greatest improvement in psychometric tests and tests of global cognitive function. As an important observation, the patients with no previous HE showed a decline in cognitive function 12 months or later after LT, especially in visuospatial and visuoconstructive function. This seems to demonstrate that PLTE may occur independently of RHE and likely represents a distinct pathological cognitive entity. Mechtcheriakov et al prospectively followed 14 patients with cirrhosis before and 11–33 months after LT.[44] They similarly reported that about half of their patients improved their visuomotor and visuoconstructive functions, while the other half showed no improvement or even worsening in neuropsychiatric tests after LT. Mattarozzi et al studied the effect of LT on MHE 6–18 months after LT[45] and again at 7–10 years later.[46] They concluded that cognitive function improved in patients with previous MHE and that these improvements remained stable at the long-term follow-up. RHE seems to improve gradually 1–2 years following LT.[17,43–46]

Neuroimaging with MRI in patients with HE depicts characteristic abnormalities with high signal intensity in the basal ganglia in T_1-weighted images[47] and along the corticospinal tract on T_2-weighted images.[48] The latter is considered to represent mild astrocytic swelling and low-grade cerebral edema and correlates with functional abnormalities of the corticospinal tract, while the hyperintensity in the basal ganglia has been shown to be due to a manganese deposition in the brain with preference in the basal ganglia that represents liver cirrhosis but has no correlation to HE.[48–50] Such MRI alterations are reversible within 6–12 months after LT. Garcia-Martinez et al[51]. studied whole brain volume by MRI 6–12 months after (but not before) LT and found that lower post-transplant whole brain volumes were associated with increasing age, previous HE, time since first episode of HE, and alcohol etiology. The importance is uncertain, but lower whole brain volume was associated with poorer function on motor tests, although the post-transplant cognitive function on average was in the normal range.

Taken together, such studies convincingly indicate that some cognitive components of HE can persist after LT – in lack of better terminology coined RHE. The studies also suggest that RHE is most evident in the early phase after LT and in some cases may disappear in the long run, but the mechanistic background is not yet clarified. Thus, as for PLTE (cf. below), it seems to be meaningful to distinguish between early RHE within the first 12 months after LT and late or persistent RHE more than 12 months after LT.

Non-RHE PLTE

Numerous factors must be taken into account when evaluating post-LT cognitive function, and a number of these are better characterized and described than RHE (Figure 1). Thus, non-RHE PLTE is a less controversial issue than is RHE. Pre-LT factors include comorbidities (to the liver disease) and individual cognitive reserves represented by education or crystalline intelligence. Peri-LT factors include repeated and prolonged surgery, electrolyte dysbalance, or ischemia, while post-LT factors include immunosuppression, infections/sepsis, stroke, increasing age, cardiovascular risk factors/-disease, critical illness encephalopathy, etc.[52] The recovery from cognitive impairment is a slow process and so it is important to differentiate between early and late PLTE which may even be a late-onset event years after LT. Neurotoxicity and PLTE are known side effects to immunosuppression with calcineurin inhibitors experienced by 30%

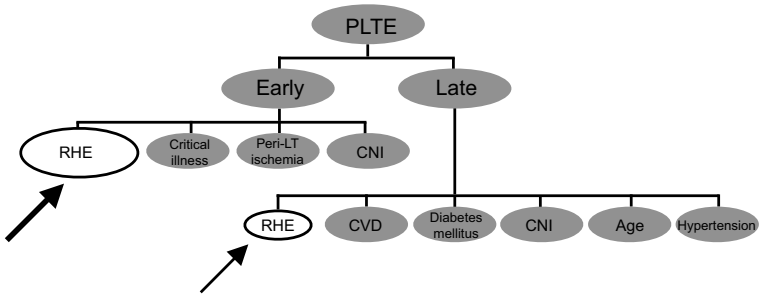

Figure 1 Risk factors for PLTE. Early PLTE: <12 months after LT. Late PLTE: >12 months after LT.
Abbreviations: PLTE, postliver transplantation encephalopathy; RHE, residual hepatic encephalopathy; LT, liver transplantation; CNI, calcineurin inhibitor; CVD, cardiovascular disease.

of patients within the first weeks after transplantation.[24,25] Long-term side effects of calcineurin inhibitors have also been suspected with premature atherosclerosis and microangiopathy as proposed mechanisms.[53] Pflugrad et al[54] studied the long-term effect of calcineurin inhibitors on cognitive function for 10 years following LT. Calcineurin inhibitor use was a clear negative prognostic factor for post-transplant cognitive function. The treatment was also associated with increased white matter hyperintensity on MRI especially in the parietal and temporal regions. There was no association between MRI pathology and previous HE. Nonetheless, calcineurin inhibitor treatment was associated with impaired cognitive function in the cognitive domains of visuospatial/visuoconstructional ability, which is often impaired in HE as well.

Another important contributing factor to PLTE is the development of cerebrovascular disease.

Increasing age of the recipients and high incidence of cardiovascular risk factors, but also calcineurin inhibitor treatment, are positive predictors. Schoening et al showed that the risk of cerebrovascular events was around 3.5 times higher in the first decade after LT and 2 times higher in the second decade after LT compared with the standard population.[55]

Several factors cause similar cognitive impairment, which further highlights the difficulty in isolating the contributing factors in PLTE.

Conclusion

Cognitive impairment, PLTE, is a frequent complication following LT. It is associated with the severity of underlying liver disease particularly as manifested by a history of MHE or OHE, pretransplant extrahepatic comorbidities, peritransplant factors such as prolonged and repeated surgery or ischemia, and post-transplant immunosuppressive therapy and its complications. The majority of the patients have experienced HE, and the available knowledge indicates that some RHE may persist after LT. The impairment seems to improve with time, but it remains unsolved whether it is completely reversible. The existence of RHE may challenge the general understanding of the clinical course of HE. Currently, distinguishing between RHE and PLTE as the reason for cognitive impairment after LT is complicated as the pathophysiologies of both entities are not fully understood, and many factors contribute to the cognitive impairment after LT. PLTE, regardless of etiology, is a cause of worry and needs more attention in the form of mechanistic research, standardized prospective clinical studies, and development of diagnostic/discriminative tools. Such tests are not available, but ideally, they should offer the possibility for organizing tailored treatments for each afflicted post-transplant person's problems.

Abbreviation list

LT, Liver transplantation; HE, hepatic encephalopathy; PLTE, postliver transplant encephalopathy; RHE, residual HE; OHE, overt HE; MHE, minimal HE; PSE, portosystemic encephalopathy; PHES, psychometric hepatic encephalopathy score; CRT, continuous reaction time; ICT, inhibitory control test; CFF, critical flicker frequency; EEG, electroencephalogram; MRI, magnetic resonance imaging; MR, magnetic resonance.

Disclosure

The authors declare no conflicts of interest in this work.

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