

Transcranial laser emission diode (TLED) therapy for traumatic brain injury (TBI): what does the literature tell us?

Joao Gustavo Santos

Department of Neurosurgery, University of Sao Paulo School of Medicine, Sao Paulo, Brazil.

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Background

If you pay attention to the numbers, it is possible to estimate the impact of Traumatic Brain Injury (TBI) for public health policies. There are an estimated 235 000 hospitalizations per year for nonfatal TBI in the United States. About 1.1 million Americans are evaluated and released from an emergency department annually and approximately 50 000 die, most of them at the scene of the injury [1]. Current estimates indicate that 124 000 (43.1%) of persons discharged with TBI from acute hospitalizations develop TBI-related long-term disability [2].

Another problem that should be emphasized is that despite most of the victims of TBI recover satisfactorily, about 70% - 90% of them present psychological or neurological symptoms weeks or months after the original head trauma. [3] Persistent cognitive problems occur in 5-22% of cases. [4]

Neuropsychological disorders include obsessive-compulsive disorder (OCD), anxiety [5] irritability, apathy and depression [6,7]. Obviously these diseases can affect every aspect of an individual's life, such as education, potential employment opportunities and even social and family relationships [8].

Most brain lesion which leads to those symptoms [9] are not shown in structural Computed Tomography (CT) or Magnetic resonance image (MRI). These white matter injuries (diffuse axonal lesion) may be found in diffusion tensor imaging MRI scans [10]. Diffuse axonal lesion leading to brain interconnectivity loss is the responsible for the TBI cognitive, emotional, and behavioral problems [9].

Physiopathology

There are three main brain network highly specialized brain for cognition. In TBI, They often are dysregulated on fMRI scans. Default mode network (DMN) is the first and divides [4]:

1. Anterior areas: Medial frontal lobes (medial prefrontal cortex);
2. Posterior areas: Medial parietal lobes (precuneus and posterior cingulate) and and posterolateral areas in the lateral parietal lobes (angular gyri);
3. Deep areas: Medial temporal lobes/hippocampal areas.

The DMN, mainly the posterior area needs to *de-activate*, for normal cognitive function occurs. Thus a distinct network can *activate* (such as the central executive network) [11].

The second network that can be affected is the central executive network (CEN). It is anatomically the dorsolateral prefrontal cortex areas and the intraparietal sulcus areas [11].

The salience network (SN) is the third network affected in TBI. Anatomic and functionally it is the presupplementary motor

areas, the dorsal anterior cingulate cortex areas the anterior insulae. The SN is important for normal executive function and inhibition. The SN controls the DMN [12].

Once this circuit helps to do DMN inhibitory control (*de-activation process*) (mainly the posterior parts), the SN acts signaling the need to change behavior [13,14].

Transcranial, Red/Near-Infrared (Nir) Led Photobiomodulation For Tbi

More than 30 years ago it was observed in cadaver studies that NIR wavelengths (800-900nm) and RED (600 nm) are able to penetrate through skull (2-3%), [15,16] and to improve the subnormal cellular activity of compromised brain tissue by four actions:

- (1) Increasing adenosine triphosphate (ATP) production in the mitochondria [17,18].
- (2) Increasing regional cerebral blood flow [19,20].
- (3) An anti-inflammatory effect by inhibiting microglial activation, and also strong antioxidant effects (increase in mitochondrial superoxide dismutase) [21,22].
- (4) Increasing *neurogenesis* and *synaptogenesis* (described at first in small animal studies which was treated with NIR in the acute stage post-TBI) [23,24].

An eighteen patients' serie, treated with red/NIR tLED (26 J/cm² per LED cluster head placement red/NIR 500mW, 22.2 mW/cm², 22.48 cm² per treatment area) for chronic TBI (began red/NIR tLED at 10 months to 8 years post-TBI) presented improvements in cognition (mainly executive function and verbal memory) [25]. It was obtained before and after the treatments, fMRI scans resting-state in left-hemisphere from patients with chronic aphasia due to stroke and it was found significant increases in "naming ability", beyond significantly increased correlations between cortical nodes within each of three separate networks (DMN, CEN, SN).

Conclusion

The displayed data implies that transcranial LED therapy can be used as an effective therapeutic approach to increase brain function and are a promising treatment for traumatic brain injury patients.

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***Correspondence to:**

Joao Gustavo Santos
Department of Neurosurgery
University of Sao Paulo School of Medicine, Sao Paulo
Brazil
Email: joao_gustavo@icloud.com