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A case of COVID-encephalopathy imaged with fMRI and treated with near infrared light

1. Introduction

Neurocognitive disturbances resultant from COVID-19 infection, whether severe or asymptomatic, are not yet fully understood [1]. Of those reported, the most frequent appear to be disorders of executive function. In an observational study of 45 patients hospitalized with COVID-19 and later discharged, 15 were found to have a syndrome involving inattention, disorientation, and memory impairment [2]. Eleven of these patients obtained MRIs in an attempt to detect encephalopathic features; each of these imaging studies showed bilateral frontotemporal hypoperfusion. Another recent study intended to examine cognitive function among patients with asymptomatic COVID-19; patients with asymptomatic COVD-19 yielded, on average, lower neuropsychological testing scores than controls [3]. Further research is needed to better understand COVID-19-related cognitive sequelae as well as possible treatments.

Recently, numerous studies have emerged with a focus on NIR light therapy in humans and its effects on emotional and cognitive functioning. NIR light therapy involves the use of a device containing light-emitting diodes (LEDs) at a wavelength which is able to penetrate the skull for the purpose of stimulating and healing underlying tissue. Transcranial brain stimulation using low-level light/laser therapy (LLLT) utilizes directional low-power and monochromatic light from lasers in the near-infrared wavelengths to encourage neurotherapeutic effects in a nondestructive manner [4,5]. When applied to the frontal lobes, it appears to improve frontal cortex oxygen consumption and metabolic capacity, increasing frontal cortex-based memory function [6,7].

This paper details a case in which neuroimaging and cognitive testing were used to evaluate a patient with post-COVID-19 cognitive changes before and after NIR therapy.

2. Materials and methods

2.1. Case description

A 35 year-old male professional Poker player had undergone a mild bout of COVID-19 without respiratory failure or hospitalization. The patient had a previous history of occasional panic attacks, but reported always having an ‘excellent memory.’ Post-recovery, he experienced ongoing shortness of breath and mental fogginess, as well as increased agitation, anhedonia, difficulty with spatial concepts such as puzzles, and significant memory impairment. This contributed to a decline in his ability to function in his profession.

The patient was diagnosed with COVID-19 encephalopathy accompanied by dysautonomia. Based on the reported success of NIR in treating other forms of encephalopathy, the patient was prescribed 8 weekly, 40-min sessions of NIR light therapy.

A multimodal MRI including T1 and T2-weighted sequences and arterial spin labeling (ASL) was performed prior to receiving NIR therapy. The anatomical images demonstrated normal volume and configuration of the structure of the brain, and no significant abnormalities were noted. This indicated that the patient's cognitive dysfunction was not a result of atrophy. However, ASL demonstrated a markedly decreased signal in the right prefrontal region, particularly in the orbitofrontal region compared to the left side (Fig. 1).

After completing the NIR protocol, the patient obtained a follow-up MRI scan including identical sequences to baseline scans. Compared to pre-NIR scans, the follow-up ASL demonstrated a markedly improved signal in the right prefrontal region and a complete resolution of the former dropout of signal (Fig. 1).

Post-intervention testing showed improvements in memory recall, executive function, planning, and attention compared to baseline testing. Patient also reported a Global Rating of Change (GRC) of +3, reflecting a noticeably positive perception of his improvement. Since completing the NIR protocol, he has also been able to return to competing in professional Poker.

3. Data acquisition

All structural and functional data was acquired on a 1.5 T Siemens Espree scanner with a 16-channel head coil. Structural data was magnetization-prepared, rapid-acquisition gradient-echo (MPRAGE) T1-weighted sequence (TR = 1810 ms; TE = 3.50 ms; FoV = 180 × 240mm; resolution 1mm isotropic). ASL was obtained from the base of the skull to the top of the calvarium in resting state with correction for arterial signal and quantification of obtained signal.

4. Near infrared light therapy

The device used for these NIR light therapy sessions was the Cytonsys CytonPro 5000 apparatus. CytonPro 5000 has pilot laser control, with a focused wavelength of 1064 nm, and a maximum output power of 10W. The maximum optical power density of CytonPro 5000 is 500 mW/cm^2 with an effective area of 4.5 cm^2 in diameter. For each of the 8 sessions, treatment was administered at 250 mW/cm^2 for 10 minutes at the bilateral orbitofrontal cortices and bilateral dorsolateral prefrontal cortices.

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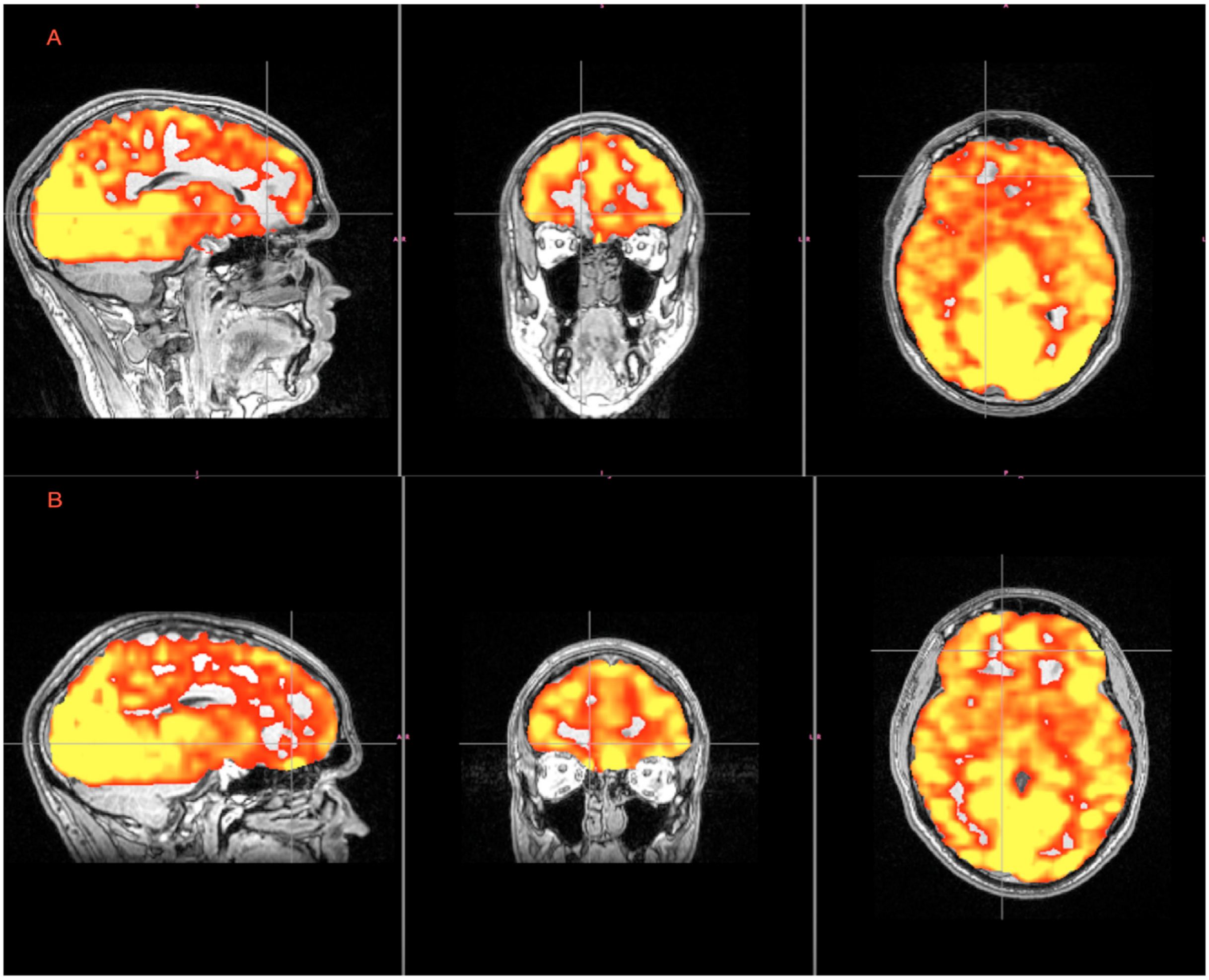

Fig. 1. a) Pre-treatment ASL with dropout of signal in the right orbitofrontal region; **b)** Post-treatment ASL showing a normal signal throughout the brain, and a return of signal in the right prefrontal area.

5. Discussion

The present case study demonstrates 1) a neurocognitive executive dysfunction brought on by a non-severe case of COVID-19, and 2) a return to normal cognitive functioning, following NIR light treatment directed at the frontal lobes. It is hypothesized that this patient had an exposure to SARS-CoV-2, entering the nervous system through the cribriform plate, thereby causing decreased functioning of the nearby hippocampus (memory), olfactory/sensory nerves, and frontal lobes (attention and executive function). This mechanism of action is extant in the literature, though it has primarily been documented in cases of severe, respiratory, hospital-necessitating cases of COVID-19 [8]. In a retrospective study of patients with neurological complications following a COVID-19 infection, cognitive disturbances were seen in 14.8% of severe cases, while seen in only 2.4% of non-severe cases [9]. This case suggests that there may be others around the world who are suffering from long-term cognitive deficits as a result of the virus, even if they were unaware of contracting it in the first place. Furthermore, NIR light therapy may be a promising technique for the treatment of cortical hypoperfusion brought on by COVID-19 infection.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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