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Multimodal Therapeutic Approach for Post-Concussive Symptoms and Cognitive Recovery: A Case Report

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Abstract

A 60-year-old female with post-concussion syndrome (PCS) presented with persistent cognitive deficits and functional limitations following a slip and fall. She underwent a multimodal therapeutic protocol including hyperbaric therapy (HBT), photobiomodulation (PBM), and molecular hydrogen (MH) therapy over 10 sessions. Pre- and post-treatment assessments demonstrated significant improvements in cognitive function and neurophysiological markers, as evidenced by WAVi EEG and Trail Making Test (TMT) results. This case highlights the potential of a non-invasive, multimodal therapeutic approach to address persistent post-concussion symptoms, an area with limited effective interventions. Findings suggest that integrating these therapies into standard rehabilitation protocols may enhance recovery trajectories, particularly for patients with persistent cognitive symptoms. This case report explores the clinical course, treatment efficacy, and the potential for combining these therapies in addressing complex neurological recovery.

Keywords

Post-Concussion Syndrome, Cognitive Recovery, Traumatic Brain Injury, Hyperbaric Therapy, Photobiomodulation

1. Introduction

Post-concussion syndrome (PCS) is a condition characterized by prolonged cognitive and functional impairments following a traumatic brain injury (TBI) [1]. Symptoms such as memory deficits, impaired attention, and slowed cognitive processing often persist beyond the acute phase, significantly impacting quality of life.

Current treatments for PCS typically focus on symptomatic relief but do not address the underlying neurophysiological dysfunctions, such as reduced neuroplasticity, mitochondrial dysfunction, and neuroinflammation [2].

Recent advancements in therapeutic modalities have provided promising interventions for PCS. Hyperbaric therapy (HBT) is proposed to enhance neuroplasticity through changes in pressure dynamics rather than oxygenation [3]. HBT has historically been used to treat decompression sickness, carbon monoxide poisoning, and wound healing due to its capacity to improve tissue oxygenation and promote cellular repair. In neurological conditions, HBT has shown promise in improving neuroplasticity, reducing neuroinflammation, and enhancing cerebral blood flow, contributing to cognitive recovery.

Photobiomodulation (PBM) supports mitochondrial function and cellular resilience by enhancing adenosine triphosphate (ATP) production and reducing oxidative stress [4] [5]. Molecular hydrogen (MH) therapy, an emerging approach, reduces oxidative stress and inflammation, potentially augmenting recovery [6] [7].

Emerging therapies like neurofeedback, transcranial magnetic stimulation (TMS), and vagus nerve stimulation (VNS) are also being explored for their potential in neurorehabilitation, offering additional avenues for addressing PCS. Neurofeedback, for instance, aims to train brain function by providing real-time feedback on neural activity, while TMS and VNS modulate neural circuits to promote recovery. Analogous cases in neurorehabilitation, where multimodal approaches have shown synergistic benefits, further substantiate the potential efficacy of combining these therapies.

This case report describes the application of HBT, PBM, and MH therapy in a patient with persistent PCS symptoms, demonstrating significant cognitive and neurophysiological improvements.

2. Case Presentation

2.1. Patient Description

A 60-year-old right-handed female sustained a concussion following a slip-and-fall incident in June 2023. Her presenting symptoms included frequent headaches, impaired word recall, slowed cognitive processing, and episodic "zoning out," especially during fatigue. Sleep disturbances, characterized by non-restorative sleep, further exacerbated her cognitive symptoms. The patient was diagnosed with post-concussion syndrome (PCS) and adjustment disorder due to the impact of her injury on daily life and productivity. The adjustment disorder diagnosis was made in addition to PCS, reflecting the emotional and psychological response to her persistent symptoms and functional limitations.

2.2. Medical History and Prior Treatments

The patient had no prior history of neurological disorders or cognitive impairments. Before the incident, she was in good health, with no significant comorbidities.

Initial treatments included over-the-counter analgesics for headaches, cognitive rest, and physical therapy aimed at balance and coordination. Despite these interventions, her cognitive symptoms persisted, leading to the exploration of alternative therapies.

2.3. Diagnostic Criteria

The diagnosis of PCS was made based on the International Classification of Diseases (ICD-10) criteria, which include persistent symptoms such as headaches, dizziness, fatigue, irritability, insomnia, concentration difficulties, and memory impairment following a concussion. The patient's symptoms met these criteria, with cognitive deficits persisting beyond three months post-injury.

2.4. Case History

At presentation, the patient reported a few headaches per week, with a severity of 5/10, triggered by extended screen time or prolonged driving. Cognitive symptoms improved by approximately 80% compared to immediate post-injury, as assessed by self-reported symptom tracking and performance on neuropsychological assessments such as the Trail Making Test (TMT) and Montreal Cognitive Assessment (MoCA). However, she continued to experience deficits later in the day, characterized by increased word-finding difficulties, mental fatigue, and reduced concentration, particularly in the evening or after mentally demanding tasks.

Sleep remained disrupted, with the patient reporting 6 - 8 hours of non-restorative sleep nightly.

2.5. Treatment Plan

The patient underwent 10 sessions of multimodal therapy over a five-week period, with two sessions per week. HBT was delivered at a pressure of 1.5 ATA for 40 minutes per session to stimulate neuroplasticity through pressure-induced mechanisms [8]. PBM was administered using near-infrared light at wavelengths ranging from 530 - 940 nm for 20 minutes per session to support mitochondrial function [9]. MH therapy was provided at a flow rate of 2100 cc/min for 20 minutes per session to reduce oxidative stress and inflammation [10]. Each modality was administered consecutively within a single session.

2.6. EEG Data Acquisition and Analysis

Cognitive function was assessed using WAVi EEG to measure P300 latency and voltage. EEG recordings were conducted with electrodes placed according to the 10-20 international system, focusing on frontal (F3, F4) and parietal (Pz) sites. Data preprocessing included artifact rejection, band-pass filtering (0.1 - 30 Hz), and baseline correction. Normative values for P300 latency (250 - 350 ms) and amplitude (>10 μV) were used for comparison.

Trail Making Test (TMT) A and B, were administered to provide a comprehensive evaluation of cognitive function.

3. Results

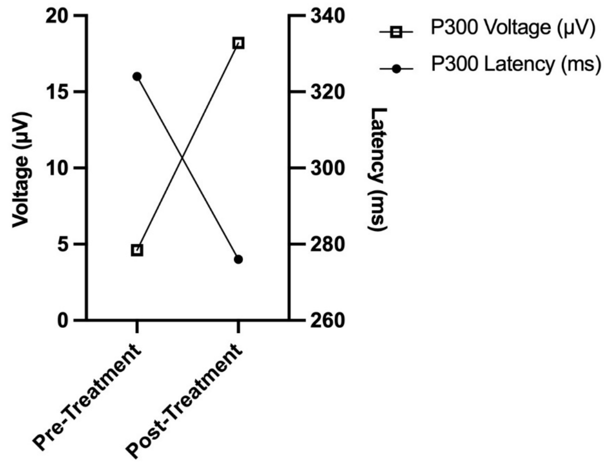

Figure 1. P300 latency and voltage changes pre- and post-treatment.

Following treatment, a notable reduction in P300 latency from 324 ms to 276 ms was observed, indicating improved cognitive processing speed [11]. Additionally, P300 voltage increased from 4.6 μV to 18.2 μV, suggesting enhanced attentional engagement and neurophysiological responsiveness [11]. These improvements reflect underlying enhancements in synaptic efficiency and neuroplasticity, which are critical for cognitive recovery in PCS patients. A dual-axis graph illustrates these changes, emphasizing the relationship between faster information processing and increased cortical activation.

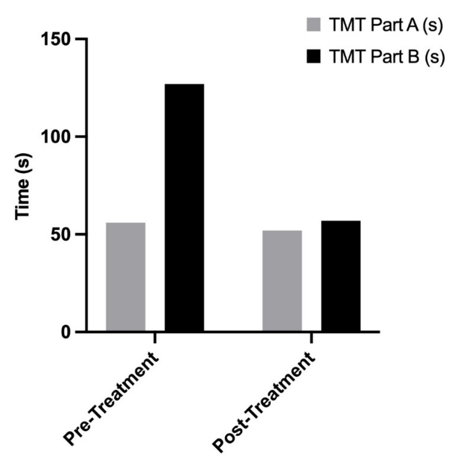

Figure 2. Trail Making Test (TMT) performance pre- and post-treatment.

Post-treatment results demonstrated a reduction in TMT Part A completion time from 56 seconds to 52 seconds, suggesting improved visual scanning and motor speed [12]. TMT Part B, which evaluates cognitive flexibility and executive function, showed a substantial improvement, with completion time decreasing from 127 seconds to 57 seconds [12]. A bar graph visualizes these reductions, reinforcing the observed cognitive benefits. All post-treatment assessments were conducted within one week of completing the 10-session protocol.

4. Discussion

The observed improvements in cognitive function, illustrated in **Figure 1** and **Figure 2**, provide objective evidence that HBT, PBM, and MH therapy may enhance neurophysiological recovery in PCS patients. The reduction in P300 latency from 324 ms to 276 ms (**Figure 1**) correlates with faster cognitive processing, reinforcing the potential neuroplastic benefits of this intervention [11]. Similarly, the increase in P300 voltage from 4.6 μV to 18.2 μV suggests greater cognitive engagement [11]. The enhanced performance in TMT Part A and Part B (**Figure 2**) highlights comprehensive cognitive recovery across multiple domains [12].

While the improvements observed are promising, it is important to consider other factors that may have contributed to these outcomes. The natural recovery trajectory post-concussion, the passage of time since injury, and potential placebo effects may have influenced the results. However, the magnitude of improvement across multiple objective measures suggests that the multimodal intervention played a significant role.

Future research should focus on validating these findings in larger, controlled studies to establish standardized protocols and investigate the long-term efficacy of these interventions. Extending the follow-up period to 3- and 6-month post-treatment would provide insights into the sustainability of cognitive improvements. Additionally, exploring biomarkers, such as inflammatory cytokines and mitochondrial activity, may further elucidate the mechanisms underlying recovery.

Given the potential costs associated with multimodal therapy, future studies should also aim to identify which individual treatments or combinations yield the most significant benefits. Understanding the relative contributions of HBT, PBM, and MH therapy will help optimize treatment protocols, making them more accessible and cost-effective for broader clinical applications.

5. Conclusion

This case demonstrates the efficacy of combining HBT, PBM, and MH therapy for post-concussion syndrome. Significant improvements in cognitive function and neurophysiological markers were observed, highlighting the potential for these therapies to address key aspects of PCS recovery. While sleep disturbances showed minimal improvement, the findings suggest that a multimodal approach may offer comprehensive benefits in managing PCS. Further research is warranted to optimize treatment protocols, determine the most effective components, and broaden clinical applications.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Leddy, J.J., Haider, M.N., Noble, J.M., Rieger, B., Flanagan, S., McPherson, J.I., *et al.* (2021) Management of Concussion and Persistent Post-Concussive Symptoms for Neurologists. *Current Neurology and Neuroscience Reports*, **21**, Article No. 72. https://doi.org/10.1007/s11910-021-01160-9

[2] Zetterberg, H. and Blennow, K. (2016) Fluid Biomarkers for Mild Traumatic Brain Injury and Related Conditions. *Nature Reviews Neurology*, **12**, 563-574. https://doi.org/10.1038/nrneurol.2016.127

[3] Harch, P.G. (2022) Systematic Review and Dosage Analysis: Hyperbaric Oxygen Therapy Efficacy in Mild Traumatic Brain Injury Persistent Postconcussion Syndrome. *Frontiers in Neurology*, **13**, Article 815056. https://doi.org/10.3389/fneur.2022.815056

[4] Hamblin, M.R. (2017) Photobiomodulation for Traumatic Brain Injury and Stroke. *Journal of Neuroscience Research*, **96**, 731-743. https://doi.org/10.1002/jnr.24190

[5] Dompe, C., Moncrieff, L., Matys, J., Grzech-Leśniak, K., Kocherova, I., Bryja, A., *et al.* (2020) Photobiomodulation—Underlying Mechanism and Clinical Applications. *Journal of Clinical Medicine*, **9**, Article 1724. https://doi.org/10.3390/jcm9061724

[6] Hirano, S., Ichikawa, Y., Sato, B., Yamamoto, H., Takefuji, Y. and Satoh, F. (2021) Potential Therapeutic Applications of Hydrogen in Chronic Inflammatory Diseases: Possible Inhibiting Role on Mitochondrial Stress. *International Journal of Molecular Sciences*, **22**, Article 2549. https://doi.org/10.3390/ijms22052549

[7] Ohta, S. (2015) Molecular Hydrogen as a Novel Antioxidant: Overview of the Advantages of Hydrogen for Medical Applications. *Methods in Enzymology*, **555**, 289-317. https://doi.org/10.1016/bs.mie.2014.11.038

[8] Hadanny, A., Golan, H., Fishlev, G., Bechor, Y., Volkov, O., Suzin, G., *et al.* (2015) Hyperbaric Oxygen Can Induce Neuroplasticity and Improve Cognitive Functions of Patients Suffering from Anoxic Brain Damage. *Restorative Neurology and Neuroscience*, **33**, 471-486. https://doi.org/10.3233/rnn-150517

[9] Cardoso, F.d.S., Gonzalez-Lima, F. and Coimbra, N.C. (2022) Mitochondrial Photobiomodulation as a Neurotherapeutic Strategy for Epilepsy. *Frontiers in Neurology*, **13**, Article 873496. https://doi.org/10.3389/fneur.2022.873496

[10] Slezak, J., Kura, B., LeBaron, T.W., Singal, P.K., Buday, J. and Barancik, M. (2021) Oxidative Stress and Pathways of Molecular Hydrogen Effects in Medicine. *Current Pharmaceutical Design*, **27**, 610-625. https://doi.org/10.2174/1381612826666200821114016

[11] Pavarini, S.C.I., Brigola, A.G., Luchesi, B.M., Souza, É.N., Rossetti, E.S., Fraga, F.J., *et al.* (2018) On the Use of the P300 as a Tool for Cognitive Processing Assessment in Healthy Aging: A Review. *Dementia & Neuropsychologia*, **12**, 1-11. https://doi.org/10.1590/1980-57642018dn12-010001

[12] Ashendorf, L., Jefferson, A., Oconnor, M., Chaisson, C., Green, R. and Stern, R. (2008) Trail Making Test Errors in Normal Aging, Mild Cognitive Impairment, and Dementia. *Archives of Clinical Neuropsychology*, **23**, 129-137. https://doi.org/10.1016/j.acn.2007.11.005