Annals of Case Reports
Wang Z, et al. Ann Case Rep: 8: 101550
www.doi.org/10.29011/2574-7754.101550
www.gavinpublishers.co7

Case Report

Chronic Traumatic Encephalopathy, Traumatic Encephalopathy Syndrome, Post-Concussion Syndrome, and the Therapeutic Potential of Hyperbaric Oxygen Therapy: A Comprehensive Case Study and Discussion

Zemer Wang[1*], Sherif Khairy[1], Umair Qureshi[1], Mouzayan Ginzarly[1], Raghda Zaitoun[1], Suzette Van Wyk[1], Shai Efrati[2,3]

[1]Aviv-Clinics by DP world, JLT, Dubai, United Arab Emirates.

[2]Sagol Center for Hyperbaric Medicine and Research, Shamir Medical Center, Israel

[3]Sackler School of Medicine and Sagol School of Neuroscience, Tel-Aviv University, Israel.

[*]**Corresponding author:** Zemer (Semer) Wang, Aviv-Clinics by DP world, JLT, Dubai, United Arab Emirates.

Citation: Wang Z, Khairy S, Qureshi U, Ginzarly M, Zaitoun R, et al. (2023) Chronic Traumatic Encephalopathy, Traumatic Encephalopathy Syndrome, Post-Concussion Syndrome, and the Therapeutic Potential of Hyperbaric Oxygen Therapy: A Comprehensive Case Study and Discussion. Ann Case Report 08: 1550. DOI: 10.29011/2574-7754.101550.

Received Date: 07 December 2023; **Accepted Date:** 12 December 2023; **Published Date:** 14 December 2023

Abstract

Chronic Traumatic Encephalopathy (CTE), Traumatic Encephalopathy Syndrome (TES), and Post-Concussion Syndrome (PCS) are increasingly recognized as significant consequences of repetitive head trauma, spanning both contact sports and non-sports-related injuries. This article presents a compelling case study of a patient afflicted by these conditions, elucidates the differential diagnosis, and explores the therapeutic promise of the new protocols of Hyperbaric Oxygen Therapy (HBOT).

Our case centers on 'FC,' a 36-year-old former captain of the English rugby national team, whose retirement was precipitated by progressive neuro-cognitive decline. Drawing upon an array of diagnostic modalities, including metabolic brain imaging (SPECT), perfusion MRI+DTI, computerized neurocognitive assessments, and physical evaluations, we arrived at the diagnosis of TES. FC underwent HBOT protocol, proved effective for PCS, leading to the resolution of his symptoms and marked improvements in neurocognitive functions that correlated with enhancements in his brain SPECT and MRI.

In addition to the clinical case, this article illuminates the critical distinctions between CTE, TES, and PCS, emphasizing the significance of early diagnosis and methods for confirmation. Furthermore, it delves into the emerging frontier of Hyperbaric Oxygen Therapy as a potential treatment avenue for individuals grappling with TES, and PCS. We scrutinize the underlying physiological mechanisms of HBOT and its neuroplasticity effects, underpinned by recent research findings and promising outcomes from clinical trials.

Citation: Wang Z, Khairy S, Qureshi U, Ginzarly M, Zaitoun R, et al. (2023) Chronic Traumatic Encephalopathy, Traumatic Encephalopathy Syndrome, Post-Concussion Syndrome, and the Therapeutic Potential of Hyperbaric Oxygen Therapy: A Comprehensive Case Study and Discussion. Ann Case Report 08: 1550. DOI: 10.29011/2574-7754.101550.

Keywords: Hyperbaric Oxygen Therapy; HBO; HBOT; Traumatic Brain Injury; CTE; TES; Post-Concussion Syndrome; Sports Injuries.

Introduction

Chronic Traumatic Encephalopathy (CTE) looms as a pressing concern for retired athletes from full-contact sports, such as rugby and American football [1]. While these sports are renowned for their intense physical demands and full-contact nature, in the context of rugby, the spotlight has primarily focused on the potential risks of recurrent Traumatic Brain Injuries (TBI) including its long-term consequence Post-Concussion Syndrome (PCS), with relatively less attention given to CTE. Both conditions share a critical commonality: the mechanism of action and the potential for long-term consequences. The primary distinction lies in CTE being a progressive neurodegenerative disease while PCS tends to be stable or to improve over time. A possible progression from PCS to CTE is being discussed [2].

A definitive diagnosis of CTE can only be obtained post-mortem through autopsy [3]. To address the challenges in diagnosing CTE during an individual's lifetime, the National Institute of Neurological Disorders and Stroke has developed clinical criteria for Traumatic Encephalopathy Syndrome (TES), a clinical disorder closely associated with CTE [4].

In this article, we present the case of a recently retired senior professional rugby player, formerly the captain of the UK national team, who exhibited symptoms suggesting CTE. This player underwent protocols of Hyperbaric Oxygen Therapy (HBOT), which have shown promise in treating PCS. Alongside the case presentation, we underscore the critical importance of raising awareness for the early diagnosis of TES and discuss the biological effects of the used HBOT protocol.

Case Presentation

A 36-year-old male, formerly the captain of the English rugby national team (with consent, hereafter referred to as 'FC'), retired from professional rugby two years prior due to concerns about his cognitive health. Despite his retirement, FC's cognitive challenges persisted to deteriorate and did not show any sign of improvement. Motivated by the potential benefits of Hyperbaric Oxygen Therapy (HBOT) for brain injuries, he sought medical evaluation at the AVIV hyperbaric clinic in Dubai.

Medical history: Over a twenty-year rugby career, FC sustained 20 documented concussions and numerous undocumented head injuries. Many of these went unreported due to their frequent occurrence. These repetitive traumas culminated in noticeable changes in FC's cognitive function: memory lapses, heightened sound sensitivity, difficulty maintaining grip, stuttering, dizziness during rapid head movements, and mood changes. Even though he retired from professional sports, these symptoms intensified over time, leading him to seek potential therapeutic intervention.

Initial Evaluation: A thorough pre-HBOT evaluation encompassed:

- A detailed physical assessment.
- A computerized neurocognitive test (NeuroTraxTM & CANTAB®) administered by a neuropsychologist.
- Advanced brain imaging, including MRI with perfusion and DTI, and a SPECT scan.

Physical examination revealed bilateral hematoma auris [5] and a mild horizontal nystagmus to the right. Brain MRI exhibited hyperintensities in both frontal and the right parietal regions, categorized as Fazekas grade 1 (Figure 1). The **SPECT scan showed** areas with reduced uptake, signifying decreased/altered brain metabolism in the frontal and parietal regions of the brain. Neurocognitive assessments identified significant impairments in focused and sustained attention, alongside reduced information processing speed.

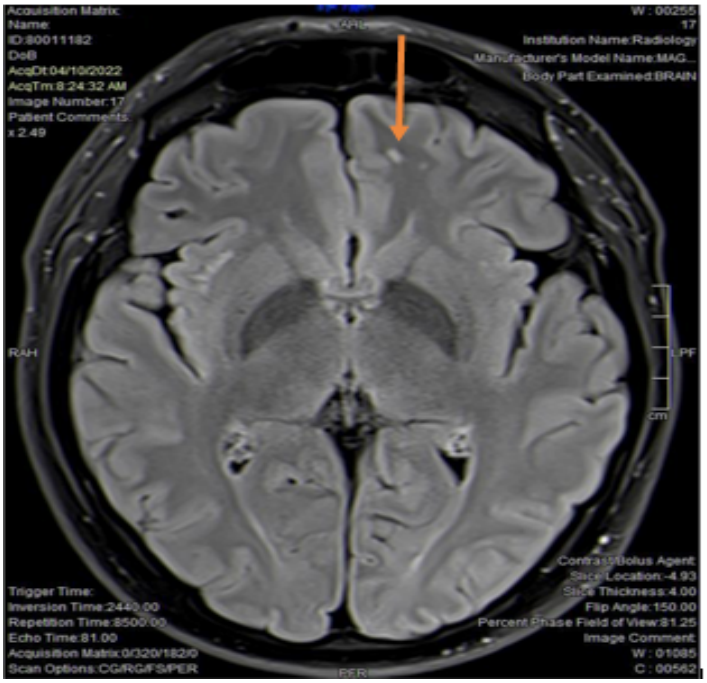


Figure 1: Brain MRI exhibited hyperintensities in both frontal and the right parietal regions.

Intervention: FC underwent 60 HBOT sessions, performed daily, 5 days per week. Each session, lasting 90 minutes, exposing him to 100% oxygen at two atmospheres (2ATA), interspersed with 5-minute air breaks every 20 minutes.

Post-HBOT Evaluation: Following the HBOT protocol, the initial assessments were repeated and compared to the baseline tests with the following findings:

- SPECT scan comparisons revealed evidence of enhanced uptake/activity in the previously affected brain regions and could determine improved uptake in areas related to facial recognition, written word meaning, attention, spatial memory, directionality, somatosensory integration, visuo-motor coordination, memory and control networks, language perception, processing and memory (Table 2).

Anatomical structure	Baseline	After intervention	Change in %	Functional domain
Entorhinal Cortex Right	41.74	59.91	43.5	Spatial memory, directionality
Superior temporal gyrus Right	46.43	65.39	40.8	Olfactory
Medial temporal lobe, parahippocampus Right	39.79	54.87	37.9	Memory encoding and retrieval
Superior parietal lobule Right	42.46	57.28	34.9	Visuo-motor coordination
Transverse temporal lobe Right	50.36	66.48	32	Auditory processing
Medial temporal gyrus Right	19.9	25.62	28.7	Memory
Superior temporal gyrus Right	44.54	56.96	27.9	Auditory processing and language
Transverse temporal lobe Right	42.94	54.68	27.3	Auditory processing

Table 1: Perfusion MRI

- MRI-perfusion scan showed marked improvements in the post-treatment MRI perfusion as compared to the baseline, in brain regions related to spatial memory, directionality, smell, memory encoding and retrieval, visuo-motor coordination, hearing and language processing (Figure 2, Table 1).

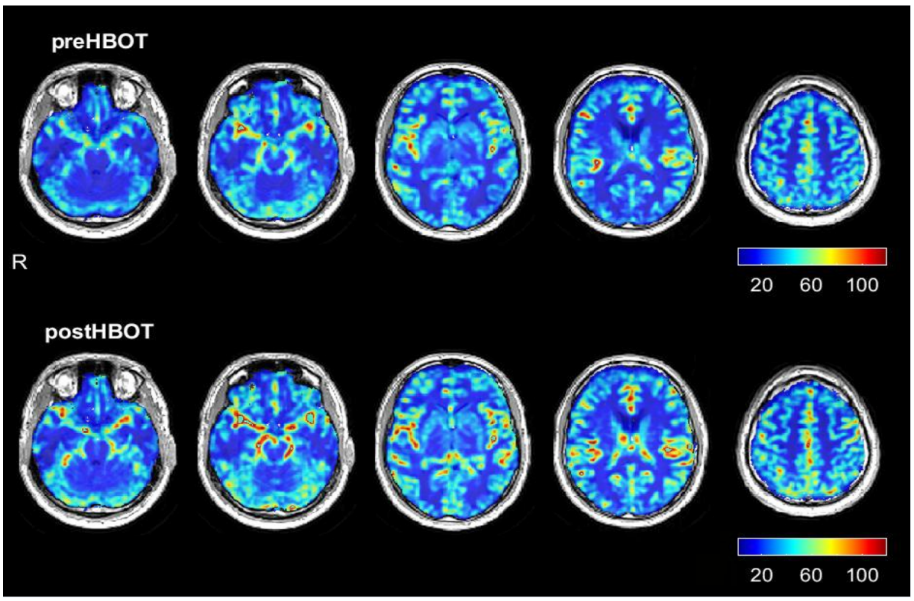
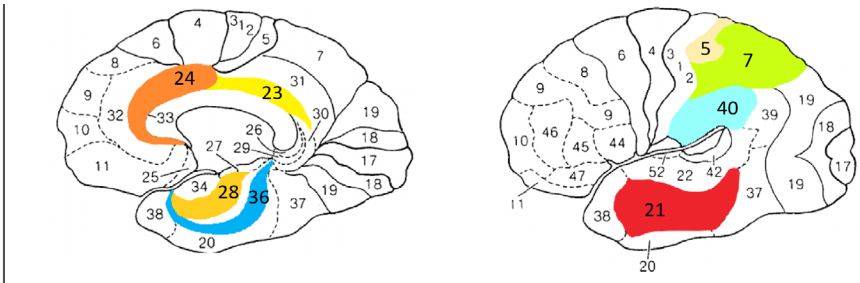


Figure 2: MRI-perfusion scan showed marked improvements in the post-treatment MRI perfusion as compared to the baseline.



Anatomical structure	Baseline	After intervention	Change in %	Functional domain
Broadman area 21 right	0.75	0.89	18.82	Face recognition, word meaning (reading)
Broadman area 24 right	0.69	0.81	16.73	Attention
Broadman area 28 left	0.72	0.83	16.35	Spatial memory, directionality
Broadman area 5 right	0.92	1.05	14.12	Somatosensory integration
Broadman area 7 right	0.93	1.03	10.98	Visuo-motor coordination
Broadman area 23 right	0.99	1.1	10.83	Memory and control networks
Broadman area 40 right	0.83	0.92	10.53	Language perception and processing
Broadman area 36 left	0.67	0.74	10.01	Memory

Table 2: (SPECT) The brain regions that had significant improvement post Hyperbaric Oxygen Therapy

- MRI-DTI revealed notable improvements in the post-treatment MRI-DTI compared to the baseline scan. The improvement in Fractional Anisotropy (FA), which assesses white matter integrity and directionality, in brain regions related to learning, memory, behavior, sensation, perception, visual processing, formation of new memories, decision making, cognitive processing of visual information, episodic memory, language and social emotional processing. The improvement in Mean Diffusivity (MD), which reflects white matter fiber density, in brain regions related to coordination of arms and legs, learning and formation of new memories, refinement of motor function, processing of visual information, episodic memory, language, social emotional processing, visual memory, face recognition, and sensory pathways.

Cognitive tests highlighted significant improvements, as compared to the baseline assessments, in the domains of verbal and nonverbal memory, executive function, cognitive flexibility, attention, information processing speed, and fine motor skills.

Clinical outcomes: Post-HBOT, the previous symptoms including sound sensitivity, stuttering, frequent dizziness, and involuntary release of objects were fully resolved. Notably, as reported by FC and those close to him, the mood disturbances had also ceased.

Discussion

Chronic Traumatic Encephalopathy (CTE) is a progressive neurodegenerative condition believed to be a consequence of repeated head trauma, encompassing both concussions and sub-concussive blows to the head [6]. Diagnosis of CTE, however, remains elusive during a person's lifetime, leading to the use of the term Traumatic Encephalopathy Syndrome (TES) in clinical practice. The diagnostic criteria for TES, as established by the National Institute of Neurological Disorders and Stroke, encompass four key components: substantial exposure to repetitive head impacts (RHIs), core clinical features of cognitive impairment or neurobehavioral dysregulation, a progressive course, and the exclusion of other neurologic, psychiatric, or medical conditions [4]. CTE shares a common etiological pathway with Post-Concussion Syndrome (PCS) or Chronic Traumatic Brain Injury (CTBI) [7]; however, there are significant differences in causation and presentation. While CTE is believed to result from recurrent head injuries at varying velocities, PCS may originate from a single head injury or multiple incidents. Although both conditions exhibit similar symptoms, CTE progresses chronically over time, whereas CTBI is diagnosed when there is a chronification of TBI symptoms, characterized by persistent but relatively stable symptoms.

In the case presented, FC experienced repeated brain injuries at different velocities, with at least 20 documented concussions and likely many more unreported incidents. His physical evaluation revealed the hallmark of repeated head trauma in contact sports: Cauliflower ears. This condition arises when the external portion of the ear sustains impact, forming a blood clot or fluid collection under the perichondrium. As a result, the cartilage becomes separated from its nutrient-supplying perichondrium, leading to the formation of fibrous tissue in the overlying skin. This results in a permanently swollen and deformed outer ear, resembling cauliflower, hence the name [5].

Despite retiring from rugby two years prior to seeking treatment, FC continued to deteriorate, experiencing cognitive decline, mood changes, heightened sound sensitivity, grip difficulties, stuttering and dizziness during rapid head movements. Computerized neurocognitive assessments identified significant impairments in focused and sustained attention, accompanied by reduced information processing speed. These cognitive dysfunctions correlated with metabolic abnormalities in FC's Brain SPECT, providing further evidence for the diagnosis of continuous brain injury.

Hyperbaric Oxygen Therapy (HBOT) involves inhaling 100% oxygen at pressures exceeding One Atmosphere Absolute (1 ATA) to increase the oxygen dissolved in the body's tissues. Historically, HBOT has been primarily employed for treating chronic non-healing wounds. However, recent research has unveiled its regenerative potential, referred to as the hyperoxic-hypoxic paradox [8, 9]. This paradox entails the intermittent increase of oxygen concentration, inducing cellular mechanisms similar to those triggered during hypoxia but without the hazardous effects of low oxygen levels. Among its many effects, intermittent hyperoxic exposure during HBOT can influence levels of HIF-1, Matrix Metalloproteinases (MMP) activity, VEGF, promote stem cell proliferation, enhance levels of Endothelial Progenitor Cells (EPCs), and facilitate angiogenesis and improved blood flow in ischemic areas. Additionally, HBOT can decrease the inflammatory response in endothelial cells mediated by TNF-alpha, promoting vascular recovery [8, 9]. Both animal and human studies have shown the potential benefits of HBOT for PCS [10-12].

Based on our knowledge, this is one of the first reported cases of the beneficial effects of HBOT on TES. As proved in PCS, FC's case illustrated the same expected beneficial effects in TES. HBOT has induced neuroplasticity by improving brain activity, increasing brain perfusion, and repairing the brain microstructure, as is evident by brain SPECT, perfusion MRI and DTI-MRI [9, 11, 12]. These improvements which were demonstrated by the brain imaging modalities correlated well with the significant neurocognitive improvements, and the alleviation of all TES-related symptoms.

Conclusion

In conclusion, early diagnosis of TES is imperative for athletes exposed to repeated concussions. Once diagnosed, athletes should avoid additional brain injuries and seek appropriate medical care. HBOT, previously shown to be effective in addressing PCS, holds promise as an intervention for patients suffering from TES. However, further clinical studies are needed to determine which patients can benefit most from HBOT and to establish the optimal HBOT treatment protocol for these individuals.

Conflict of interests

ZM, SK, UQ, MG, RZ and SV are employees of AVIV clinic in Dubai. SE chair the medical advisory board and shareholder of AVIV scientific.

References

1. McKee AC, Daneshvar DH, Alvarez VE, Stein TD (2014) The neuropathology of sport. Acta Neuropathol. 127: 29-51.
2. VanItallie TB (2019) Traumatic brain injury (TBI) in collision sports: Possible mechanisms of transformation into chronic traumatic encephalopathy (CTE). Metabolism. 100S: 153943.
3. McKee AC, Abdolmohammadi B, Stein TD (2018) The neuropathology of chronic traumatic encephalopathy. Handb Clin Neurol. 158: 297-307.
4. Katz DI, Bernick C, Dodick DW, Mez J, Mariani ML, et al. (2021) National Institute of Neurological Disorders and Stroke Consensus Diagnostic Criteria for Traumatic Encephalopathy Syndrome. Neurology. 96: 848-63.
5. Ingvaldsen CA, Tonseth KA (2017) Auricular haematoma. Tidsskr Nor Laegeforen. 137: 105-7.
6. Shively S, Scher AI, Perl DP, Diaz-Arrastia R (2012) Dementia resulting from traumatic brain injury: what is the pathology? Arch Neurol. 69:1245-51.
7. Mavroudis I, Kazis D, Chowdhury R, Petridis F, Costa V, et al. (2022) Post-Concussion Syndrome and Chronic Traumatic Encephalopathy: Narrative Review on the Neuropathology, Neuroimaging and Fluid Biomarkers. Diagnostics (Basel). 12: 740.
8. Hadanny A, Efrati S (2020) The Hyperoxic-Hypoxic Paradox. Biomolecules. 10: 958.
9. Hadanny A, Efrati S (2022) Editorial: Hyperbaric oxygen and the brain. Front Neurol. 13: 1078544.
10. Fischer I, Barak B (2020) Molecular and Therapeutic Aspects of Hyperbaric Oxygen Therapy in Neurological Conditions. Biomolecules. 10: 1247.
11. Amir Hadanny, Maroon J, Shai Efrati (2023) The Efficacy of Hyperbaric Oxygen Therapy in Traumatic Brain Injury Patients: Literature Review and Clinical Guidelines. Medical Research Archive. 11: 1-33.
12. Hadanny A, Efrati S (2016) Treatment of persistent post-concussion syndrome due to mild traumatic brain injury: current status and future directions. Expert Rev Neurother. 16: 875-87.