



The Israeli Society for Hyperbaric Medicine & Diving (ISHMD)

Application of hyperbaric oxygen therapy in Post-Traumatic Stress Disorder

Summary of Available Data and clinical Recommendations

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Background

Post-traumatic stress disorder (PTSD) affects up to 30% of veterans returning from combat zones. Unfortunately, a significant proportion of these individuals do not respond to guideline-based treatments, leaving them with long-term social, behavioural, and occupational dysfunction. Accumulating evidence suggests that persistent symptoms of PTSD are associated with alterations in brain activity and structure, particularly disruptions in the fronto-limbic circuitry. This highlights the importance of biologically-based treatments aimed at repairing brain structures and restoring their functional integrity.

Dedicated protocols of Hyperbaric Oxygen Therapy (HBOT) have been shown to induce neuroplasticity and significantly improve clinical outcomes in conditions such as post-stroke, post-concussion syndrome, central sensitization disorders (e.g., fibromyalgia), and most recently, PTSD. The therapeutic benefits of HBOT are observed even years after the initial insult. To induce neuroplasticity, HBOT protocols utilize repeated fluctuations in both pressure and oxygen levels. These fluctuations trigger a cascade of biological responses typically associated with hypoxia- without its related hazard- by leveraging a hyperoxygenated environment in a phenomenon called Hyperoxic-Hypoxic Paradox (HHP) the process stimulates key mechanisms including HIF-induced gene expression, mitochondrial biogenesis and migration, stem cell proliferation (including neuronal stem cells), angiogenesis, and modulation of the inflammatory response. The recent research findings highlighting the positive impact of HBOT on veterans with treatment-resistant PTSD, demonstrate improvements in intrusive symptoms, avoidance behaviours, mood, cognitive function, and hyperarousal. These improvements correlate with enhanced brain function and improved structure.

However, it is important to recognize that the HBOT treatment course may sometimes lead to temporary symptom exacerbation, which may result in treatment discontinuation if not adequately addressed. A particularly notable phenomenon observed in some patients during HBOT is the surfacing of previously inaccessible memories. While this process provides an opportunity for memory integration and the resolution of intrusive symptoms, it can also provoke significant distress if not managed appropriately. Proper support and guidance during treatment are essential to ensure safe and effective treatment course.

Improper management of these challenges may have contributed to the suboptimal outcomes observed in previous clinical trials. In these studies, worsening of symptoms led to premature discontinuation of treatment. Effectively addressing the dynamic fluctuations in symptoms during the HBOT course is critical for optimizing the therapeutic benefits for PTSD patients. A



structured approach that anticipates and manages these fluctuations can enhance patient adherence and significantly improve outcomes.

The following guidelines outline essential strategies for preparation, management, and follow-up practices thus ensuring a safe and effective HBOT treatment course. This perspective is based on data assembled from clinical-research studies (1-4) as well as on eight years of practice with hundreds of veterans treated at Sagol Center for Hyperbaric Medicine and Research.

General principles

- Patient selection and thorough preparation are crucial to ensure safety and efficacy.
- The treatment course is daily, extended and often subjectively demanding.
- Temporary worsening of symptoms is common.

The HBOT protocol is demanding, as it is based on daily sessions and can be associated with temporary symptom exacerbation. To ensure a safe and effective treatment experience, patient selection and thorough preparation are crucial. Patients should be well-informed about the expected effects of the treatment, including both the anticipated benefits and potential challenges that they may face along the way, such as alterations in sleep patterns, anxiety, changes in mood and energy levels, and the surfacing of previously inaccessible memories. Comprehensive patient education plays a key role in promoting adherence and compliance with the treatment regimen. Additionally, incorporating self-regulation techniques—practiced both before and during the course—can help patients manage symptom worsening and maintain emotional balance throughout the treatment process.

Treatment protocol, facility and staff

- The protocol consists of sixty daily sessions, 5 days per week, with the pressure of 2ATA, 100% O₂ for 90 minutes with 5 minutes air brakes every 20 minutes.
- Multiplace, rather than monoplace chambers are suited for the treatment of patients with PTSD.
- Daily interactions with trauma informed staff, within the chamber or outside it, as well as with other patients are essential factors in the treatment protocol.



The protocol used for the treatment of PTSD consists of 60 consecutive daily sessions, 5 days per week, with the pressure of 2ATA, 100% O₂ for 90 minutes with 5 minutes air brakes every 20 minutes. The protocol length and pressure provided were shown to have direct effect on its results (5).

Generally, HBOT can be administered in either multiplace or monoplace chambers. Multiplace chambers are designed to accommodate multiple patients simultaneously, breathing oxygen through oxygen masks and allow medical staff to be present in chamber with the patients during treatment. Monoplace chambers are compact, single-patient units typically pressurized with pure oxygen. The unique needs of post-traumatic patients who are prone for potential negative emotional experiences that may lead to treatment discontinuation - it is recommended that therapy be conducted in a multiplace facility. Having medical staff with expertise in PTSD present in the chamber during the entire session, ensures that panic attacks and other acute distress responses or physical discomforts, are effectively managed, promoting adherence to the treatment course.

The HBOT protocol obligates interactions with secretaries, nurses, and other patients, on top of the formal interactions with the treating staff. These networks of multiple interactions promote detection and alleviation of difficulties, such as avoidance behaviours. It is therefore recommended to place trauma-informed staff that interact positively with this post-traumatic population, facilitating a safe and supportive environment.

Patients' selection

- HBOT should not be provided as first line treatment for PTSD.
- HBOT should be provided alongside with ongoing, psychotherapy.
- To ensure a continuum of care, the patient's therapist and the therapist at the HBOT center should collaborate.

HBOT should be considered for post-traumatic patients who have undergone trauma-focused psychotherapy with or without pharmacotherapy but continue to experience a significant symptom burden, regardless of the time that had elapsed since the traumatogenic event.

HBOT may be provided earlier in the treatment course for patients who exhibit severe symptoms and do not respond to, or cannot tolerate, psychotherapy or pharmacotherapy



HBOT is not recommended as a first-line therapy or for patients with minimal symptoms due to the lengthy nature of the treatment and its associated costs. Therefore, the patient's case manager (typically the treating psychiatrist for Israeli veterans) should assess the patient's condition and the available PTSD treatment options before referring the patient for an HBOT treatment course.

HBOT should not be initiated while exposure to traumatic events is still ongoing. Persistent exposure to trauma during the HBOT treatment course may undermine the therapy's potential effectiveness and compromise outcome.

Continuation of psychotherapy during and after HBOT is required for the integration of therapeutic changes. That may include newly surfaced memories that may alter the patient's narrative, and new personal social and occupational insights that need to be sorted out and incorporated. Furthermore, stable psychotherapy will ensure ongoing support after the HBOT course is over, and extended therapeutic encounters are suggested when indicated.

The therapist should be informed that exposure therapy is not recommended during the HBOT treatment course. Psychotherapy should be responsive and supportive, led by the thoughts and emotions that surface during treatment, presumably by the biological effect of treatment.

Suicidal ideation is common among post-traumatic patients. Patients should be aware of the fact that symptom worsening may be accompanied by the emergence or intensification of suicidal thoughts, but these are likely to diminish as treatment progresses. If such thoughts arise at any time, day or night, patients should be encouraged to contact their therapist, or any member of the center-staff who work as a team to address these challenges together.

The issue of compensation, such as disability benefits or other support provided by governmental authorities for PTSD, significantly affects the course of symptoms and motivation for recovery. Therefore, the intensive and demanding course of HBOT should not be offered when the compensation claim is still unresolved.

Pre-Treatment Evaluation and Preparation

- Medication regimen should be adjusted to stabilize
- Benzodiazepines should be withheld, if possible.
- Smoking should be ceased before beginning HBOT.
- Self-regulation techniques should be taught.

Adjustment of medication regimen



Concerns have been raised regarding the effect of HBOT on pulmonary function, as some studies suggest potential toxicity, such as reduced forced vital capacity and impaired diffusion(6). To minimize this risk, smokers were excluded from both clinical studies and routine practice, and baseline pulmonary function tests were conducted to rule out uncontrolled obstructive lung disease.

Indeed, a study evaluating the effect of HBOT on pulmonary function revealed that the treatment can be considered safe(7). To ensure safety, patients should be instructed to quit smoking before starting HBOT.

Smoking is highly prevalent in the post-traumatic population. Visiting the treatment center, learning about the potential effects of HBOT on post-traumatic symptoms, and engaging with the treating staff may enhance motivation for smoking cessation. Therefore, smokers should be encouraged to attend an initial meeting at the center. For many patients, quitting smoking has been a first step in their healing journey. Framing this success as a meaningful achievement can serve as a marker of the patient's strengths.

Benzodiazepines depress multiple gene expression in the brain (8, 9), including the neuroplasticity-related genes and should thus be withheld if possible before starting HBOT. In some cases, severe insomnia and or distress may accompany benzodiazepines cessation and thus recommendations should be based on heavy consideration of this cost.

Adjusting and stabilizing the dose of other psychiatric medications should be recommended before HBOT, as HBOT-related symptom fluctuations may complicate the assessment of medication effects and make it difficult to evaluate the impact of HBOT-both its desired effects and potential adverse reactions.

Cannabis use is very common among post-traumatic veterans, offering significant acute symptom relief. However, its long-term effects may include reduced motivation, memory impairment, and other cognitive challenges. The self-titrating nature of cannabis dosing makes it well-suited to the fluctuating symptom load during HBOT. It allows patients to manage symptom exacerbations by increasing the dose when needed, while also enabling them to reduce or withhold cannabis use when symptoms subside. Cannabis should not be consumed by smoking but rather through vaporization or as a tincture.

Acquisition of self-regulation techniques

Prior to the initiation of HBOT, training in self-regulation techniques is recommended. These may include trauma-focused yoga, physical activity, and grounding techniques, tailored to each



patient's needs. Acquiring these skills before treatment can help ensure optimal management of symptom exacerbation, should it occur during the treatment course.

Pre-Treatment Analyses

- Functional and structural brain imaging
- Evaluation of symptoms
- Pre-treatment meeting for the integration of clinical and imaging-based finding

- Brain MRI

Brain MRI should be performed at baseline to rule out alternative diagnoses.

- Functional brain imaging (SPECT or fMRI)

Functional brain imaging allows most patients to visualize, often for the first time, abnormalities in the function of their temporal and frontal lobes. Encountering an objective measure that highlights dysfunction in specific brain regions can be crucial for self-validation, reducing feelings of shame, and challenging the stigma associated with their condition. Additionally, it supports patient dedication by fostering understanding of their condition and enhances cooperation with the protocol of a treatment aims to target these changes. Functional brain imaging can also serve as a baseline for comparison with imaging conducted at the end of treatment to assess the effects of the intervention.

- CAPS-V inventory

An interview by a therapist with expertise in trauma for the evaluation of symptom load is done as part of the pretreatment evaluation. The inventory will contribute to patient's and staff understanding of PTSD severity. Another essential role of this inventory is educating patients about the symptoms that are part of post-traumatic stress. As part of the pretreatment evaluation, a therapist with expertise in trauma conducts an interview to assess the symptom load. This evaluation contributes to both the patient's and the staff's understanding of PTSD severity. Another key role of this assessment is to educate patients about the symptoms associated with post-traumatic stress. This awareness can help patients recognize changes in their symptoms over time, enhancing their engagement in the treatment process.



A pre-treatment meeting for integration

Following the completion of the pre-treatment evaluation and before the beginning of HBOT, an integration meeting with a lead therapist is conducted. The purpose of the meeting is to review the patient's symptoms and brain imaging and integrate this information for a better understanding of the patient's baseline condition.

The therapist will re-inform the patient about potential adverse effects that may arise during treatment, including the potential surfacing of inaccessible memories and temporary worsening of symptoms. They will also outline the resources available within and outside the center to support the patient if needed.

The comprehensive treatment program is reviewed, emphasizing the role of each supportive therapy provided as part of the overall care plan.

Treatment Course

- HBOT sessions should be scheduled at the same time of the day to promote routine.
- Psychotherapy should be provided by a therapist familiar with the effects of HBOT and how to manage them
- Physical activity, nutritional consultation, and yoga practice will support the HBOT course.

HBOT

The HBOT protocol consists of 60 daily sessions, with the pressure of 2ATA and 90min 100% O₂ with 5 minutes air brakes every 20 minutes.

The treatment should be provided at the same time each day to enable the patient to create routine, and preferably with the same fallow patients within the multiplace chamber. The treatment should be provided in a multiplace facility, with a trained nurse present in the chamber and available if any assistance is needed.

Psychotherapy

Weekly meetings with the center's therapist should be scheduled to monitor symptoms, strengthen self-regulation techniques, and assess any worsening symptoms or surfacing memories. Psychoeducation is an essential treatment tool, providing a biological rationale for the symptoms that arise.



In the case of surfacing memories, patients will be encouraged to describe the event and answer questions about the place, time, and sequence of events to support verbal representation of the new memory. Daily meetings may be necessary if the memory evolves gradually. Self-regulation techniques and psychoeducation are essential elements during these events.

In some cases, an unfamiliar memory of childhood or sexual abuse may surface, necessitating consultation with an expert in these fields.

Occupational and social rehabilitation should be considered toward the end of the treatment course.

Additional support

Techniques that contribute to better self regulation should be encouraged. Trauma-sensitive yoga focuses on regulating and balancing the autonomic nervous system through the tools of yoga: movement, breathing, concentration, and relaxation. The guiding principles of this approach include restoring and establishing a sense of safety, fostering personal efficacy and agency, and enhancing vagal activity (10, 11).

Physical activity should be promoted both for its role in self-regulation and its positive effect on neurogenesis. Nutritional consultation is essential to ensure adequate levels of elements such as B12 and iron, as well as sufficient protein intake to support recovery. At the same time, a low-carbohydrate diet should be recommended to avoid fluctuations in glucose levels, which can negatively affect mood and stress.

Psychiatric consultation

Changes in psychiatric regimens are not recommended during the treatment course, as they may complicate the identification of HBOT's effects on mood and stress. In cases of worsening distress, short-term or 'as-needed' treatments, such as quetiapine or olanzapine, may be provided. Benzodiazepines should be avoided.

Post-Treatment Evaluation and Treatment Summary

- Patient narrative
- Symptoms load
- Changes in brain activity and structure
- Integration
- The full treatment effect may evolve in a course of few months

Post-Treatment Analysis



- Functional brain imaging (fMRI and/or SPECT)

End of treatment analysis will enable comparison to the pre-treatment functional imaging. Areas with significant change between the the pre and post treatment analyses will be marked.

- CAPS-V inventory

An interview by a therapist with expertise in trauma for the evaluation of symptom load after treatment will provide data about the symptom's status and evaluation of changes in symptoms severity following treatment.

End of treatment meeting

The meeting typically takes place 4 to 6 weeks after the completion of the HBOT course, following the administration and analysis of end-of-study tests. It begins with the patient's subjective assessment of the treatment effect, focusing on the anticipated versus actual outcomes. Special attention should be given to the potential surfacing of unfamiliar memories. The therapist must ensure that any such memories received adequate attention and processing. The meeting then proceeds to evaluate changes in symptom load as reported in questionnaires, alongside changes in brain perfusion and structure. Emphasis should be placed on integrating the observed changes in symptoms with alterations in brain activity.

Patients should be informed that the full beneficial effect of the treatment may take several months to manifest fully. Therefore, a re-evaluation three months after treatment completion is advisable.

Indications for repeated treatment course

Repeated treatment should not be initiated immediately after completing the initial HBOT course as further improvement often occurs within the first three months following the initial course. The additional improvement likely reflecting the continued neuroplastic changes initiated during treatment. Allowing this natural progression is essential to maximize the therapeutic impact before considering additional sessions.

A repeated course of 40 to 60 HBOT sessions may be considered in cases where symptom improvement was initially achieved but later diminished, or when significant progress was made during the first course, yet additional improvement is still needed. The decision to pursue a second course should be made collaboratively, involving the patient's therapist and a hyperbaric physician with expertise in treating PTSD.



Following the treatment course, as core symptoms improve, it is important to address longstanding avoidance behaviors. These habits should be gradually challenged, supported by structured plans for occupational and social rehabilitation. Notably, even patients who were unsuccessful in achieving rehabilitation before undergoing HBOT may find new opportunities for integration and recovery as their symptoms improve.



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