

Oxygen Toxicity Seizure During Hyperbaric Oxygen Therapy: A Case Report

Ibrahim Sarbay, Halil Dogan*, Bugra Ilhan

Department of Emergency Medicine, Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey

Received: August 14, 2018; Accepted: October 08, 2018; Published: October 09, 2018

*Corresponding author: Halil Dogan, Department of Emergency Medicine, Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Istanbul, Turkey, Email: drhalildogan@gmail.com

Abstract

Introduction: Several neurological and other side effects and complications from hyperbaric oxygen (HBO) therapy have been described in the literature. Possible complications during HBO therapy include barotraumatic lesions, oxygen toxicity, claustrophobia, and ocular effects.

Case Report: We presented a 29-year-old woman without any known history of neurological illness who had seizure during HBO therapy for Idiopathic Sudden Sensorineural Hearing Loss (ISSNHL).

Conclusion: There are several options for ISSNHL treatment which have been studied in the past with conflicting results. HBO is one of the treatment options. We presented a case with possible neurotoxic effects of HBO therapy. Clinicians should be aware of the complications of this procedure.

Keywords: Hyperbaric Oxigenation; Toxicity; Seizure;

Introduction

Idiopathic sudden sensorineural hearing loss (ISSNHL) is the clinical manifestation of diverse pathological processes. Because of the complex nature of the disease, many different options have been tried as therapy, including hyperbaric oxygen (HBO) [1]. While corticosteroids and HBO are supported by the clinical practice guidelines, other treatment options are not usually recommended.

HBO therapy is essentially breathing 100% oxygen at a pressure level higher than 1 atmosphere absolute in a special chamber. HBO therapy is thought to have complex effects on immunity, oxygen transport, and hemodynamics, reducing hypoxia and edema and potentiating normal host responses to infection and ischemia. It is used to treat several medical conditions in the past. Decompression sickness, arterial gas embolism, carbon monoxide poisoning, nonhealing wounds, hearing loss are among these conditions [2].

Vascular compromise and associated cochlear ischemia can contribute to SSNHL. HBO therapy allows for delivery of increased oxygen levels to cochlea, therefore it is believed to be an effective intervention for ISSNHL [2]. There is a time frame for

HBO therapy in ISSNHL: It's believed to be useful within 3 months of diagnosis [3].

HBO is a relatively safe treatment, but does carry some risks, due to the increased pressure and hyperoxia. HBO seems to have some neurological risks due to oxygen neurotoxicity such as seizures. The exact incidence of oxygen toxicity seizures varies in the literature. While a study reported the rate as low as 0.002% [4], a 1990 study reported a surprising rate of 4.7% [5]. A recent study published in 2014 showed that incidence of seizure is one in 2,121 treatments (0.05%) [6]. In a 2016 study, retrospective analysis of 62,614 HBO treatment sessions showed an overall seizure incidence of 0.011% [7]. Differences of patient selection, indications and protocols make it difficult to compare the studies. For example; most of the studies in the literature included patients with carbon monoxide poisoning, which is itself a cause of seizures [8]. To the best of our knowledge, there are no reports of seizures during HBO therapy for ISSNHL in the literature.

We have emphasized with our case that seizure is a rare complication of HBO therapy, and have benign outcome.

Case Report

A 29-year-old woman presented to the Emergency Department (ED) after losing consciousness, and having a series of tonic spasms for approximately 3 minutes during the second hour of HBO therapy (at 2.5 atmospheres absolute for 120 minutes). When paramedics arrived on the scene, the patient was conscious with a Glasgow Coma Score of 14 with confusion. Vital parameters were normal with a blood pressure of 125/73 mmHg, a heart rate of 69 beat/min., sPO₂ of 99%, and a blood glucose level of 133 mg/dl.

Vital parameters at the time of admission to the ED were similar, and interpreted as normal. Full neurological examination showed no pathological findings other than the confusion.

The patient's medical history and records indicated that she had sudden severe hearing loss three weeks ago with left ear affected, and diagnosed with ISSNHL. She had no known risk factors or family history for neurological disorders. She was currently using betahistine 24 mg twice a day (Vasoserc BID; Abdi İbrahim, Istanbul, Turkey), vitamin B12, 1 mg once a day (Benexol B12; Bayer Türk, İstanbul, Turkey), and proton-pump inhibitor 40 mg once a day (Lansor; Sanovel, İstanbul, Turkey)

drugs at the time as prescribed by her physician for the treatment of ISSNHL. It is learned that the treatment started two weeks ago and the patient had no side effects. She also used corticosteroid therapy (Prednol; Mustafa Nevzat, Istanbul, Turkey) for a week but the treatment ended one week before her presentation to the ED. HBO therapy was added to the medical therapy from the beginning. The therapy was planned as a series of 20 sessions over three weeks, and the patient was having the 13th session during the incident. Previously she reported no side effects of HBO therapy.

Post-admission laboratory analysis and blood works showed elevated blood lactate level (4.8 mmol/L). All other conducted blood parameters were normal. Electrocardiography, cranial computerized tomography (CT), and diffusion-weighted magnetic resonance imaging (DW-MRI) were also normal. In-hospital consultation with Neurology confirmed the incident as a seizure, and an EEG test was planned.

The patient regained full consciousness after 30 minutes. She was monitored for another 6 hours in the ED, and had no seizures or new pathological findings throughout the observation period. A control arterial blood gas analysis showed that the lactate level returned to normal (1.6 mmol/L).

As an interesting detail, patient described that she felt she gained full recovery of hearing after the seizure.

The patient was discharged after the observation period in ED, and decided to discontinue the HBO therapy. EEG test results of the patient was normal. Follow-up for 1-month showed that the patient had no seizures or other neurological symptoms during this period.

Discussion

Sudden hearing loss is defined as a rapid onset of a subjective sensation of hearing impairment in one or both ears. ISSNHL is defined as sudden sensorineural hearing loss with no identifiable cause despite adequate investigation. It is common and often results in permanent hearing loss. HBO therapy is one of the various treatment options.

There are a number of studies in the literature supporting HBO therapy for ISSNHL, especially within 2 weeks to 3 months of diagnosis. Young age, starting the therapy early, and severity of the hearing loss seems to be the related factors for the efficacy of HBO therapy [3]. A 2012 Cochrane Review on this topic reported that there is no evidence of any functionally important improvement,

and the routine use of HBO therapy in ISSNHL patients cannot be justified. The review doesn't give any information regarding the safety [3,9].

HBO is a relatively safe treatment, but carries some risks. Possible complications can be divided into four categories: 1) Barotraumatic lesions, 2) Oxygen toxicity, 3) Confinement anxiety and 4) Ocular effects. Oxygen toxicity can have effects on Central Nervous System (Paul Bert effect), and lungs (Lorraine Smith Effect). Central Nervous System oxygen toxicity presents itself with seizures. Seizure incidence seems to be correlated by treatment pressure, as there is significant increased risk of seizure with increasing treatment pressure [6]. Yildiz et al. presented a case of a 22-year-old man who developed tonic-clonic convulsions in the last HBO session, and eventually died in status epilepticus after four days. A case report published in 2017 presented a patient who had hyperbaric oxygen-associated seizure leading to stroke. But underlying cause of the seizures in these two patients could not be definitively diagnosed [4,10]. There has been no other report on sequelae in patients with seizures due to oxygen toxicity presented in the literature. Sanders et al.'s literature review of oxygen toxicity seizures showed 112 cases presented in the literature until 2012, and most of the time seizures were self-limited, without any adverse effects [11]. A review of the literature regarding HBO therapy related seizures was performed (Table 1) [12-21]. The literature review showed that there are only 18 articles published relative to the issue. Nine of them included the HBO treatments for all indications, while 5 of them included only CO toxicity cases, and 4 of them included non-emergent cases (excluding CO, arterial gas embolism, decompression sickness). There were 1,973,333 HBO treatments, and 419 seizures (0.021%) in total. Number of total treatments, and number of seizures were also calculated for each indication group. Seizure rates were 0.027% for "All" indications, 0.018% for "Non-emergent" indications, and 2.246% for "CO toxicity". These rates may indicate that patients with CO toxicity are more prone to seizures.

While most of the seizing patients received no treatments for seizures, some of them received anti-convulsants [4,22]. Suspected risk factors for oxygen toxicity include family history [23], conditions reducing the seizure threshold (like epilepsy, hypoglycemia, hyperthyroidism), and specific risk factors like hypercarbia, acetazolamide or disulfiram medication [24,25]. Our case had none of these risk factors and did not need any additional treatment. (Table 1)

Table 1: Literature review of seizure incidence during hyperbaric oxygen therapy

Source	Number of Total Treatments	Number of (Seizures %)	Indications
Hart, 1987(16)	Unknown	44 (0.008)	All
Davis, 1989(17)	52,758	5 (0.009)	All
Sloan et al., 1990	297	14 (4.714)	CO
Welslau, 1996(18)	107,264	16 (0.015)	All
Hampson et al., 1996	900	16 (1.777)	CO
Plafki, 2000	11,376	4 (0.035)	Non
Weaver, 2002(19)	152	0 (0)	CO
Hampson and Atik, 2003(20)	20,328	6 (0.030)	Non
Yildiz et al., 2004	80,679	2 (0.002)	All
Yildiz et al., 2004(21)	36,500	3 (0.008)	All
Hampson et al., 2006(22)	30	0 (0)	CO
Sanders et al., 2008	5,972	2 (0.033)	All
Banham, 2011(23)	41,273	25 (0.061)	All
Heyboer et al., 2014	23,328	11 (0.047)	All
Hadanny et al., 2016	62,614	1 (0.002)	All
Marziali et al., 2016(24)	1	1 (100)	CO
Warchol et al., 2017	1	1 (100)	Non
Jokinen-Gordon et al., 2017(25)	1,529,859	267 (0.017)	Non
<i>Present Case</i>	<i>1</i>	<i>1 (100)</i>	<i>Non</i>
TOTAL of All Indications	410,388**	109 (0.027)	
TOTAL of Non Indications	1,561,565	279 (0.018)	
TOTAL of CO Indication	1,380	31 (2.246)	
TOTAL	1,973,333**	419 (0.021)	

* *Indications included in study: All: all indications; CO: CO toxicity only; Non: non-emergent cases, excludes CO, arterial gas embolism, decompression sickness. OT: Oxygen toxicity; CO: carbon monoxide.*

** *Incomplete due to Hart, 1987's unknown total treatments number.*

Conclusion

HBO therapy is a treatment option for ISSNHL, which can be used in some cases especially in the early period. We presented a case with oxygen neurotoxicity that occurred during the HBO therapy. Although these seizures are self limited, clinicians should be aware of this risk, and further studies are necessary to understand the nature of oxygen toxicity.

References

- Fujimura T, Suzuki H, Shiomori T, Udaka T, Mori T. Hyperbaric oxygen and steroid therapy for idiopathic sudden sensorineural hearing loss. *Eur Arch Otorhinolaryngol.* 2007;264(8):861-866.
- Gill AL, Bell CN. Hyperbaric oxygen: Its uses, mechanisms of action and outcomes. *QJM.* 2004;97(7):385-395.
- Stachler RJ, Chandrasekhar SS, Archer SM, Rosenfeld RM, Schwartz SR, Barrs DM, et al. Clinical practice guideline: Sudden hearing loss. *Otolaryngol Head Neck Surg.* 2012;146(3 Suppl):S1-35. doi: 10.1177/0194599812436449
- Yildiz S, Aktas S, Cimsit M, Ay H, Toğrol E. Seizure incidence in 80,000 patient treatments with hyperbaric oxygen. *Aviat Space Environ Med.* 2004;75(11):992-994.
- Sloan EP, Murphy DG, Hart R, Cooper MA, Turnbull T, Barreca RS, et al. Complications and protocol considerations in carbon monoxide-poisoned patients who require hyperbaric oxygen therapy: Report from a ten-year experience. *Ann Emerg Med.* 1989;18(6):629-634.
- Heyboer M, Sharma D, Santiago W, McCulloch N. Hyperbaric Oxygen Therapy: Side Effects Defined and Quantified. *Adv Wound Care (New Rochelle).* 2017;6(6):210-224. doi: 10.1089/wound.2016.0718
- Hadanny A, Meir O, Bechor Y, Fishlev G, Bergan J, Efrati S. Seizures during hyperbaric oxygen therapy: retrospective analysis of 62,614 treatment sessions. *Undersea Hyperb Med.* 2016;43(1):21-28.
- Seidel R, Carroll C, Thompson D, Diem RG, Yeboah K, Hayes AJ, et al. Risk factors for oxygen toxicity seizures in hyperbaric oxygen therapy: case reports from multiple institutions. *Undersea Hyperb Med.* 2013;40(6):515-519.
- Bennett MH, Kertesz T, Perleth M, Yeung P, Lehm JP. Hyperbaric oxygen for idiopathic sudden sensorineural hearing loss and tinnitus (Review). *Cochrane Database Syst Rev.* 2012;10:CD004739. doi: 10.1002/14651858.CD004739.pub4
- Warchol JM, Cooper JS, Dising TS. Hyperbaric oxygen-associated seizure leading to stroke. *Diving Hyperb Med.* 2017;47(4):260-262. doi: 10.28920/dhm47.4.260-262

11. Sanders RW, Katz KD, Suyama J, Akhtar J, O'Toole KS, Corll D, et al. Seizure during hyperbaric oxygen therapy for carbon monoxide toxicity: A case series and five-year experience. *J Emerg Med.* 2012;42(4):e69-72. doi: 10.1016/j.jemermed.2008.12.017
12. Jokinen-Gordon H, Barry RC, Watson B, Covington DS. A Retrospective Analysis of Adverse Events in Hyperbaric Oxygen Therapy (2012-2015). *Adv Skin Wound Care.* 2017;30(3):125-129. doi: 10.1097/01.ASW.0000508712.86959.c9
13. Alfred A Bove, Arthur J Bachrach, Leon Jack Greenbaum. Undersea and hyperbaric physiology IX Proceedings of the Ninth International Symposium on Undersea and Hyperbaric Physiology. Undersea and Hyperbaric Medical Society. 1987;695-699.
14. Davis JC. Hyperbaric Oxygen Therapy. *J Intensive Care Med.* 1989;4(2):55-57.
15. Welslau W, Almeling M. Incidence of oxygen intoxication to the central nervous system in hyperbaric oxygen therapy. In: Marroni A, Oriani G, Wattel F, editors. *Proceedings of the International Joint Meeting on Hyperbaric and Underwater Medicine.* Milan: EUBS; 1996. p. 211- 6.
16. Weaver LK, Hopkins RO, Chan KJ, Churchill S, Elliott CG, Clemmer TP, et al. Hyperbaric Oxygen for Acute Carbon Monoxide Poisoning. *N Engl J Med.* 2002;347(14):1057-1067.
17. Hampson N, Atik D. Central nervous system oxygen toxicity during routine hyperbaric oxygen therapy. *Undersea Hyperb Med.* 2003;30(2):147-153.
18. Yildiz S, Ay H, Qyrdedi T. Central nervous system oxygen toxicity during routine hyperbaric oxygen therapy. *Undersea Hyperb Med.* 2004;31(2):189-190.
19. Hampson NB, Dunford RG, Ross DE, Wreford-Brown CE. A prospective, randomized clinical trial comparing two hyperbaric treatment protocols for carbon monoxide poisoning. *Undersea Hyperb Med.* 33(1):27-32.
20. Banham ND. Oxygen toxicity seizures: 20 years' experience from a single hyperbaric unit. *Diving Hyperb Med.* 2011;41(4):202-210.
21. Marziali S, Di Giuliano F, Picchi E, Natoli S, Leonardi C, Leonardi F, et al. Non-convulsive status epilepticus in a patient with carbon-monoxide poisoning treated with hyperbaric oxygen therapy. *Neuroradiol J.* 2016;29(6):431-435.
22. Hampson NB, Simonson SG, Kramer CC, Piantadosi CA. Central nervous system oxygen toxicity during hyperbaric treatment of patients with carbon monoxide poisoning. *Undersea Hyperb Med.* 1996;23(4):215-219.
23. Binnetoğlu A, Yumuşakhuylu AC, Demir B, Bağlam T, Derinsu U, Sarı M. Association between Family History and Idiopathic Sudden Sensorineural Hearing Loss. *J Int Adv Otol.* 2015;11(1):30-32. doi: 10.5152/iao.2015.607
24. Plafki C, Peters P, Almeling M, Welslau W, Busch R. Complications and side effects of hyperbaric oxygen therapy. *Aviat Space Environ Med.* 2000;71(2):119-124.
25. Manning EP. Central Nervous System Oxygen Toxicity and Hyperbaric Oxygen Seizures. *Aerosp Med Hum Perform.* 2016;87(5):477-486. doi: 10.3357/AMHP.4463.2016