

Oxygen and Pressure Epigenetics: Understanding Hyperbaric Oxygen Therapy After 355 Years as the Oldest Gene Therapy Known to Man

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References

1. Proclamation 6158-Decade of the Brain, 1990-1999, July 17, 1990. <http://www.presidency.ucsb.edu/ws/index.php?pid=1869>
2. Dementia and Alzheimer's Disease statistics. <https://www.cdc.gov/chronicdisease/resources/publications/aag/pdf/2016/alzheimers-agg.pdf>.
3. Satz P. Brain Reserve Capacity on Symptom Onset After Brain Injury: A Formulation and Review of Evidence for Threshold Theory. *Neuropsychology*. 1993;7(3):273-295.
4. Harch PG. Testimony: "The Impact of Hyperbaric Medicine on Government Health Care, Disability and Education Expenditures." Hearings, before the Labor, Health and Human Services and Education Subcommittee of the Committee on Appropriations, United States House of Representatives, One Hundred Seventh Congress, Second Session, Ralph Regula, Ohio, Chairman. Part 7A, Testimony of Members of Congress and Other Interested Individuals and Organizations. US Government Printing Office, Washington, May 2, 2002. Pps. 589-619.
5. Harch PG, McCullough VM. *The Oxygen Revolution*: Third Edition. Hatherleigh Press, New York, NY, 2016. Pps. 216-218, xxii, and 18-26.
6. Trimble VH. *The Uncertain Miracle, Hyperbaric Oxygenation*. Doubleday and Company, Inc., Garden City, NY, 1974.
7. Jain KK. History of Hyperbaric Medicine, Chapter 1. In: *Textbook of Hyperbaric Medicine*, ed. K.K. Jain. Hogrefe and Huber Publishers, Toronto, Canada, 1996. Pps. 2-9.
8. https://www.accessdata.fda.gov/cdrh_docs/pdf5/k052713.pdf.
9. Hampson NB, chairman and editor. Hyperbaric oxygen therapy: 1999 committee report. Kensington, MD: Undersea and Hyperbaric Medical Society, 1999.
10. Jain KK. Worldwide Overview of Hyperbaric Medicine, Chapter 49. In: *Textbook of Hyperbaric Medicine*, 6th Edition, ed. Kewel K. Jain. Springer, Cham, Switzerland, 2017. Pps. 609-614.
11. Harch PG, Neubauer RA. Hyperbaric Oxygen Therapy in Global Cerebral Ischemia/Anoxia and Coma, Chapter 18. In: *Textbook of Hyperbaric Medicine*, 3rd Revised Edition, ed. K.K. Jain. Hogrefe and Huber Publishers, Gottingen, Germany, 1999. Pps. 319-349.
12. Kazantseva NV. Mechanisms of Curative Effect of Minimized Hyperbaric Treatment in Cerebral Ischemia, in: The Proceedings of the 2nd International Symposium on Hyperbaric Oxygenation for Cerebral Palsy and the Brain-Injured Child. JT Joiner (ed). Best Publishing Co: Flagstaff, 2002. Pps. 199-212.
13. Collet JP, et al, HBO-CP Research Group. Hyperbaric oxygen for children with cerebral palsy: a randomized multicentre trial. *Lancet*. 2001;357, 582-86.
14. Macdonald AG, Fraser PJ. The transduction of very small hydrostatic pressures. *Comp Biochem Physiol A Mol Integr Physiol*. 1999;122 (1), 13-36.
15. Harch PG. Hyperbaric Oxygen Therapy for Post-Concussion Syndrome: Contradictory Conclusions from a Study Mischaracterized as Sham-Controlled. *J Neurotrauma*. 2018;30:1995-1999.
16. Rossignol DA, et al. Hyperbaric treatment for children with autism: a multicenter, randomized, double-blind, controlled trial. *BMC Pediatr*. 2009;9:21.
17. Wolf G, et al. The effect of hyperbaric oxygen on symptoms following mild traumatic brain injury. *J Neurotrauma*. 2012;29(17), 2606-12.
18. Harch PG, et al. A phase I study of low-pressure hyperbaric oxygen therapy for blast-induced post-concussion syndrome and post-traumatic stress disorder. *J Neurotrauma*. 2012;29, 168-185.
19. Harch PG. Hyperbaric oxygen in chronic traumatic brain injury: oxygen, pressure, and gene therapy. *Med Gas Res*. 2015;5:9. doi: 10.1186/s13618-015-0030-6.
20. Harch PG, Fogarty EF. Subacute normobaric oxygen and hyperbaric oxygen therapy in drowning, reversal of brain volume loss: a case report. *Med Gas Res*. 2017;7(2):144-149.
21. Siddiqui A, Davidson JD, Mustoe TA. Ischemic tissue oxygen capacitance after hyperbaric oxygen therapy: a new physiologic concept. *Plast. Reconstr. Surg*. 1997;99:148-155.
22. Gutsaeva DR, et al. Oxygen-induced mitochondrial biogenesis in the rat hippocampus. *Neuroscience*. 2006;137(2):493-504.
23. Ishii Y, et al. Effects of hyperbaric oxygen on procollagen messenger RNA levels and collagen synthesis in the healing of rat tendon laceration. *Tissue Eng*. 1999;5(3):279-86.
24. Freiberger J, et al. Superoxide dismutase responds to hyperoxia in rat hippocampus. *Undersea Hyperb Med*. 2004;31(2):227-32.
25. Kim CH, et al. Hyperbaric oxygenation pretreatment induces catalase and reduces infarct size in ischemic rat myocardium. *Pflugers Arch*. 2001;442(4):519-25.
26. Yin W, et al. Down regulation of COX-2 is involved in hyperbaric oxygen treatment in a rat transient focal cerebral ischemia model. *Brain Res*. 2002;926(1-2):165-71.
27. Lin S, et al. Hyperbaric oxygen selectively induces angiotensin-2 in human umbilical vein endothelial cells. *Biochem Biophys Res Commun*. 2002;296(3):710-5.
28. Shyu WC, et al. Hyperbaric oxygen enhances the expression of prion protein and heat shock protein 70 in a mouse neuroblastoma cell line.

- Cell Mol Neurobiol.* 2004;24(2):257-68.
29. Li Y, et al. Multiple effects of hyperbaric oxygen on the expression of HIF-1 alpha and apoptotic genes in a global ischemia-hypotension rat model. *Exp Neurol.* 2005;191(1):198-210.
 30. Hirata T, et al. The temporal profile of genomic responses and protein synthesis in ischemic tolerance of the rat brain induced by repeated hyperbaric oxygen. *Brain Res.* 2007;1130(1):214-22.
 31. Godman CA, et al. Hyperbaric oxygen induces a cytoprotective and angiogenic response in human microvascular endothelial cells. *Cell Stress and Chaperones.* December 2009.
 32. Ezkurdia L, et al. Multiple evidence strands suggest that there may be as few as 19,000 human protein-coding genes. *Human Molecular Genetics.* 2014;23(22):5866-5878.
 33. Oh S, et al. Comparison of the effects of 40% oxygen and two atmospheric absolute air pressure conditions on stress-induced premature senescence of normal human diploid fibroblasts. *Cell Stress and Chaperones.* 2008;13(4):447-458.
 34. Chen Y, et al. Microarray Analysis of Gene Expression in Rat Cortical Neurons Exposed to Hyperbaric Air and Oxygen. *Neurochem Res.* 2009;34:1047-56.
 35. Dupont C, Amant DR, Brenner CA. Epigenetics: Definition, Mechanisms, and Clinical Perspective. *Semin Reprod Med.* 2009;27(5):351-357.
 36. Rossignol DA. Hyperbaric oxygen therapy might improve certain pathophysiological findings in autism. *Med Hypotheses.* 2007;68:1208-27.
 37. Harch PG. HBO therapy in global cerebral ischemia/anoxia and coma, Chapter 20. In *Textbook of Hyperbaric Medicine* 6th ed., K.K. Jain, ed. Springer, Cham, Switzerland. 2017, pp. 269-319.
 38. Niu CC, et al. Hyperbaric oxygen treatment suppresses MAPK signaling and mitochondrial apoptotic pathway in degenerated human intervertebral disc cells. *J Orthop Res.* 2013;31(2):204-209.
 39. Suematsu M, Suganuma K, Kashiwagi S. Mechanistic probing of gaseous signal transduction in microcirculation. *Antioxid Redox Signal.* 2003;5(4):485-92.
 40. Apodaca G. Modulation of membrane traffic by mechanical stimuli. *Am J Physiol Renal Physiol.* 2002;282:F179-190.
 41. Murphy-Lavoie H, et al. Hyperbaric oxygen therapy for idiopathic sudden sensorineural hearing loss. *Undersea Hyperb Med.* 2012;39(3):777-92.
 42. Rockswold SB, et al. A prospective, randomized Phase II clinical trial to evaluate the effect of combined hyperbaric and normobaric hyperoxia on cerebral metabolism, intracranial pressure, oxygen toxicity, and clinical outcome in severe traumatic brain injury. *J Neurosurg.* 2013;118(6):1317-28.
 43. Shandling AH, et al. Hyperbaric oxygen and thrombolysis in myocardial infarction: the "hot MI" pilot study. *Am Heart J.* 1997;134:544-50.
 44. Alex J, et al. Pretreatment with hyperbaric oxygen and its effect on neuropsychometric dysfunction and systemic inflammatory response after cardiopulmonary bypass: a prospective randomized doubleblind trial. *J Thor and Cardiovasc Surg.* 2005;130(6):1623-30.
 45. Fischer BH, Marks M, Reich T. Hyperbaric oxygen treatment of multiple sclerosis. A randomized placebo-controlled double-blind study. *N Engl J Med.* 1983;308:181-6.
 46. Camporesi EM, et al. Hyperbaric oxygen therapy in femoral head necrosis. *J Arthroplasty.* 2010;25(6 Suppl):118-23.
 47. Yildiz S, et al. A new treatment modality for fibromyalgia syndrome: hyperbaric oxygen therapy. *J Int Med Res.* 2004;32(3):263-7.
 48. Kiralp MZ, et al. Effectiveness of hyperbaric oxygen therapy in the treatment of complex regional pain syndrome. *J Int Med Res.* 2004;32(3):258-62.
 49. Wang SP, et al. Hyperbaric oxygen combined with donepezil in the treatment of vascular dementia. *Chinese Journal of Physical Med & Rehab.* 2009;31(7):478-80.
 50. Gabb G, Robin ED. Hyperbaric oxygen, a therapy in search of diseases. *Chest.* 1987; 92(6):1074-82.