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Hyperoxic Myopia: A Case Series of Four Divers

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Abstract

Introduction:

Hyperoxic myopia is a phenomenon reported in individuals who have prolonged exposure to an increased partial pressure of oxygen (PO₂) and subsequently have a myopic (nearsighted) change in their vision. To date, there are numerous accounts of hyperoxic myopia in dry hyperbaric oxygen treatment patients; however, there have only been three confirmed cases reported in wet divers. This case series adds four confirmed cases of hyperoxic myopia in wet divers using 1.35 ATM PO₂ at the Navy Experimental Diving Unit (NEDU).

Materials and Methods:

The four divers involved were the author’s patients at NEDU. Two divers’ conditions were confirmed via record review, whereas the other two stricken divers were diagnosed by the author. All subjects were interviewed to correlate subjective data with objective findings.

Results:

All subjects had six hours of exposure to a PO₂ of 1.35 ATM for five consecutive days. Each individual was within the U. S. Navy Dive Manual’s standards for general health. Prior to diving, visual acuity was measured. Within three to four days after diving, the individuals had complaints of blurry vision with a myopic refraction shift. Each diver had spontaneous resolution of his myopia over the next two to three weeks with no significant residual symptoms.

Conclusions:

The divers in this case series were exposed to an increased PO₂ (1.35ATM for 30 hours in 5 days) a lesser exposure than that in other reports of hyperoxic myopia in wet divers diagnosed with hyperoxic myopia (1.3-1.6 ATM for 45-85 hours in 12-18 days). Furthermore, this pulse of exposure is more concentrated than typically seen with traditional hyperbaric oxygen therapy. Hyperoxic myopia continues to be a risk for those conducting intensive diving with a PO₂ between 1.3-1.6 ATM. Additional investigation is warranted to better define risk factors and PO₂ limits regarding ocular oxygen toxicity.

Background

- Hyperoxic myopia is a phenomenon that has been observed in individuals who have prolonged exposure to an increased partial pressure of oxygen and subsequently have a myopic (nearsighted) change in their visual acuity.
- The first paper citing this incident in hyperbaric patients was Anderson et al (1978) who noticed there was a blurring of vision with exposure to increased PO₂ that spontaneously resolved after the exposure.¹
- Butler et al (1999) is the first known publication of hyperoxic myopia occurring in divers using closed circuit rebreathers.²
- Subsequent publications have cited incidents of myopic shifts in subjects’ vision during (or shortly after) exposure to hyperbaric oxygen.³⁻⁶ However, most reported incidents involved patients being given hyperbaric oxygen treatments for various medical conditions as opposed to operational divers.

OBJECTIVE:

To document four cases of hyperoxic myopia in divers who participated in research at the Navy Experimental Diving Unit (NEDU). By documenting the exposures and outcomes of four patients self-identified to the Investigators and NEDU, the database related to hyperoxic myopia and operational divers will be expanded. In the future, this database may improve the Navy’s ability to more clearly define exposure limits to mitigate the onset of hyperoxic myopia.

Methods

- Four subjects who previously participated in research protocols at NEDU have come forward with accounts suggestive of conditions consistent with hyperoxic myopia, possibly as a result of extended periods of increased partial pressure of oxygen.
- Validation of these accounts will involved retrieval of data from the respective studies to evaluate visual acuity before, during, and after the relevant exposures, as well as dates and length of exposures. Only those subjects who have self-identified to the Investigators and NEDU were included in this case series. No comparison was made to other subjects participating in the same protocols.
- Subjective accounts relating to the past participants’ experiences concerning hyperoxic myopia were recorded either through email or personal interview.
- Each diver was within the U.S. Navy Dive Manual’s standards for diving duty.
- Before and after each diving series, the participants had their visual acuity measured.

EXPOSURE:

- 1.35 ATM PO₂ via 100% oxygen on open circuit, MK 20 full face mask (FFM), at an approximate depth of 12-15 feet of water in the NEDU test pool.
- Five days of six hour dives with an 18 hour surface interval. The six hour dives were evenly divided into two three hour exposures separated by a 5-10 minute surface interval for hydration and food. (40.5 ATM-hrs)

Results

- Onset of blurred vision for the divers ranged from being on the last day of diving to four days after the last dive.
- The subjective complaints of blurry vision correlated with the objective findings of best corrected visual acuity being at least one line worse on the Snellen Eye Chart.
- Spontaneous recovery occurred between seven to thirty days after onset. All subjects felt that their vision went back to baseline.
- Subjects A and B had a ten year follow-up who reported no significant ocular history related to the hyperoxic myopia insult.

Diver	Age	Eye Color	Pre-Dive Visual Acuity	Onset of Symptoms	Post-Dive Visual Acuity (# Days After Diving)	Recovery
A	33	Blue	20/30 20/25	Dive day #5	Post +3 +4 +26 20/40 20/50 20/40 20/50 20/40 20/25 20/30 20/30	1 month
B	43	Blue	20/20 20/20	+4	N/A N/A +4 20/30 20/50	+10
C	41	Light Green	20/30 20/20	+3	Post +3 20/60 20/100 20/40 20/40	+10
D	44	Brown	20/16 20/16	Dive day #5	Post +3 20/16 20/30 20/16 20/16	+7

Discussion

These four divers meet the basic criteria for diagnosing hyperoxic myopia:

- The divers were exposed to an increased PO₂ for an extended period of time,
- The divers had a myopic shift in their best corrected visual acuity,
- The myopic shift spontaneously resolved over days to weeks.

This confirms a diagnosis of hyperoxic myopia in all four divers after 5 consecutive days of 6 hour dives at 1.35 ATM PO₂ (40.5 ATM-hrs).

Though the phenomenon of hyperoxic myopia has been reported in dry hyperbaric oxygen therapy patients, this case report **increases the number of wet divers** stricken with confirmed cases of hyperoxic myopia **from three cases to seven.**

- This may be from selection bias since few populations have repetitive dives at increased PO₂ outside of the medical setting. However, technical divers, research divers, commercial divers, and military divers are at higher risk due to their diving requirements
- There may be missed diagnoses or poorly reported since the condition typically occurs after an exposure to increased PO₂ and spontaneously resolves.
- Some divers will not report a change as a myopic shift will lead to more ease with reading is the diver has presbyopia.

The mechanism of hyperoxic myopic is still unknown. Many case reports and studies suggest that the myopia results from a change in the eye’s crystalline lens..

- Schaal et al. showed groups of bovine lenses exposed to increased PO₂ with **centripetally oriented lenticular changes.**
- Evanger et al. reported phakic and pseudophakic eyes in patients undergoing hyperbaric oxygen therapy whereby those individuals with phakic eyes experience hyperoxic myopia and pseudophakic patients did not. Furthermore, one patient was phakic and pseudophakic with a **myopic shift in ONLY the phakic eye.**

The divers in this case series had shorter exposure to hyperoxic conditions than in the other three reports. The NEDU divers were exposed to 40.5 ATM-hrs in five days compared to the 1.3-1.6 ATM for 45-48 hours in 12-18 days (58.5-76.8 ATM-hrs).^{2,6}

- Our divers were wearing MK20 FFM rigs which would be similar to a hybrid between a hood and oronasal mask.** This may be a reason for the accelerated hyperoxic myopia as discussed by Evanger, et al.³

CONCLUSIONS:

- A short pulse (when compared to other case reports) of 40.5 ATM-hrs via MK20 FFM rigs in wet divers can lead to hyperoxic myopia.**
- Additional investigation is warranted to better define risk factors and PO₂ limits regarding ocular oxygen toxicity resulting in hyperoxic myopia or other manifestations.**

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