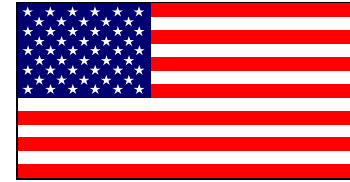




Pulmonary Oxygen Toxicity: PO₂, not F_IO₂



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Background

- The presence of inert gas in a breathing mixture should help to prevent alveolar collapse.
- As little as 20% N₂ has been found to be protective in anesthetized patients.¹
- Significant atelectasis has been measured during head-out water immersion with 100% oxygen.²

Hypothesis

- We postulated that dives at the same oxygen partial pressure (PO₂) would produce fewer toxic effects with lower inspired oxygen fraction (F_IO₂) than with 100% oxygen if absorption atelectasis contributes to the generation of pulmonary oxygen toxicity.

Table 1.
Pulmonary Oxygen Toxicity Definition

Pulmonary function decreased from baseline by³

Forced vital capacity (FVC)	7.7%
Forced expired volume in 1 s (FEV ₁)	8.4%
Mid forced expired flow (FEF ₂₅₋₇₅)	16.8%
Maximum forced expired flow (FEF _{max})	17%
Diffusing capacity of the lung for carbon monoxide (D _L CO)	14.2%

Symptoms reported

Cough	Chest tightness
Inspiratory burning	Shortness of breath

Methods

- Baseline: Pulmonary function tests (PFTs) within the week before diving, flow-volume loops again prior to diving
- Postdive: PFTs within 2 hours of surfacing, then daily for 3 days
Collins CPL, Ferraris Respiratory

Eight-hour resting dives, PO₂ = 1.3 atm, 50%, 84%, and 100% oxygen

50% oxygen (Deep Dives)

- Navy Diving and Salvage Training Center (NDSTC) buoyant ascent tower – 50 feet deep
 - 17 divers on the bottom
 - MK 16 Mod 1 rebreather underwater breathing apparatus (UBA), 50% N₂, 50% O₂

84% oxygen (Intermediate depth)

- Navy Experimental Diving Unit (NEDU) Ocean Simulation Facility wet pot
 - 31 divers on a platform under four feet of water with chamber pressure equivalent to 16 feet of water for regulator depth of 20 feet.
 - Open circuit 16% N₂, 84% O₂, humidified, to demand regulators and full face masks [MK20, Aga mask]

100% oxygen (Shallow dives)

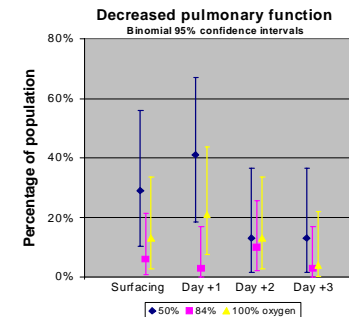
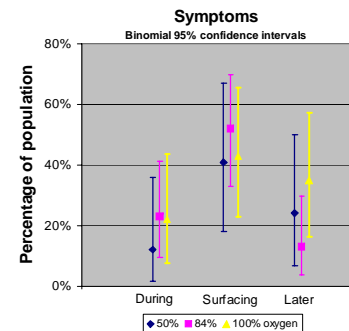
- NEDU 15-foot deep test pool
 - 23 divers on lawn chairs for regulator depth of 12 feet
 - Open circuit 100% humidified oxygen to demand regulators and full face masks [MK20, Aga mask]
- Air breaks
 - Total air break time matched across studies
 - **50% oxygen dives:** Surface air breaks irregularly for gear change-outs, food, and drink
 - **84% oxygen dives:** Air at 16 feet, 5 minutes per hour for food and drink
 - **100% oxygen dives:** Surface air breaks, 5 minutes per hour for food and drink

Results

- Neither severity nor frequency of pulmonary oxygen toxicity was altered by the presence of nitrogen in the breathing gas.
- Average decrements: Not significant
- Worst decrements:

	50%	84%	100% oxygen
FVC	?11%	?10%	?18%
FEV ₁	?20%	?13%	?21%
D _L CO	?22%	?23%	?23%

- Frequency of incidence of pulmonary oxygen toxicity as defined in Table 1: see graphs



Discussion

- Eight hours with PO₂ = 1.3 atm cannot be recommended, even for resting divers.
- Pulmonary oxygen toxicity appears to be a function of PO₂— that is, of chemical activity of oxygen, not F_IO₂.
- Atelectasis is well-known with oxygen immersion. Why might our results differ from others?
 - Use of the MK 16 UBA may have obscured some protective effects of nitrogen.
 - Alveoli that close on the bottom because of oxygen absorption may be reopened by gas expansion on ascent.

Conclusions

- Pulmonary oxygen toxicity results obtained with 100% oxygen are applicable to diving situations with the same PO₂, regardless of the gas fraction.
 - Switching from 100% O₂ to Nitrox breathing while going deeper is not similar to taking a surface interval.
- Absorption atelectasis is at most a minor source of pulmonary oxygen toxicity in divers.

References

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