Oxygen-Enriched Air: Is it bad for the diver?

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Background

While SCUBA diving, the increasing ambient pressure increases pO_2 in parallel with increasing depth. Usage of oxygen enriched air (=Nitrox) as breathing gas, additionally increases pO_2 and thus, oxidative stress. On the other hand, pN_2 is decreased with Nitrox, thereby decreasing potential narcotic N_2 effects.

Aim of study

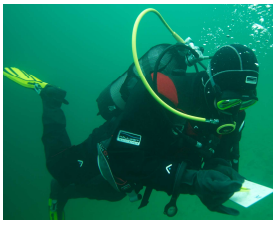
Investigate whether increasing O_2 and reducing N_2 exerts effects on
(1) pulmonary function,
(2) elastic properties of blood vessels,
(3) cognitive competence, and
(4) bubble formation.

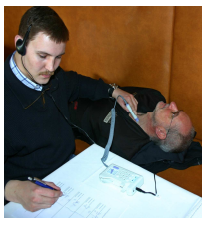
Volunteers & Methods

25 divers (~40 ys) performed one dive with air and another with Nitrox40 (i.e. ~60 % N_2 and 40 % O_2). Maximum depth was 25 m, and dive time was 40 min.

Before and after the dive, pulmonary function (MasterScreen-IOS, CareFusion; top, left) and reactive hyperemia (RH) measured with Laser-Doppler (Periflux5000, Perimed; top, right) were assessed.

Cognitive competence (memory; after Helmstaedter C, VLMT-A 2001 & alertness; Oswald WD, Roth E; ZVT-A; 1970; bottom, left) was assessed during the dive, and bubbles in the internal jugular vein (Doppler; bottom, right) were counted 30, 60, and 90 min after the end of the dive.





Results

1. Pulmonary function

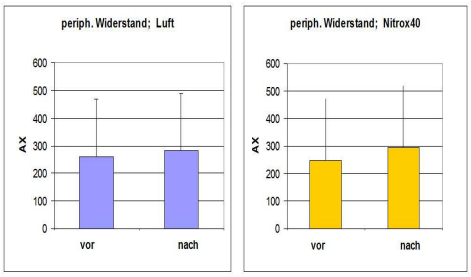


Fig. 1: Diving with either breathing gas left total pulmonary resistance unchanged but lead to an increase of the peripheral pulmonary resistance (AX): air: +9 %, Nx40: 19 %.

2. Reactive hyperemia (RH)

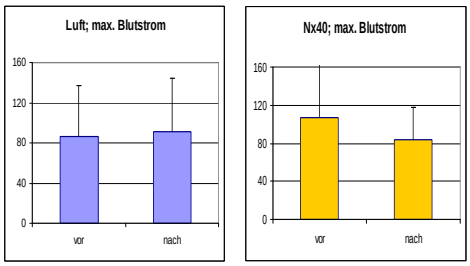


Fig. 2: RH after air remained unchanged but was reduced by 29.5% after Nx40

3. Cognitive competence

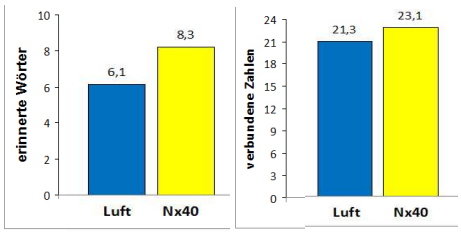


Fig. 3: Nx40 improved memory and alertness.

3. Bubble trouble

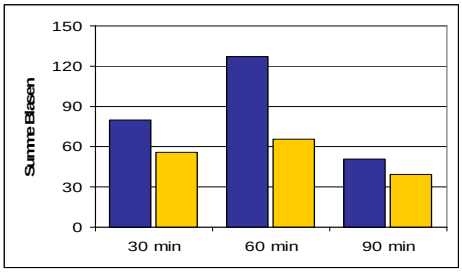


Fig. 4: Nx40 reduced bubble formation by 15 % (30 min) and 50 % (60 min). Bubble amount peaked at 60 min relatively late after end of dive

Discussion

Already in 1878, Paul Bert investigated Nitrox and described its potential toxicity (O-radicals; oxidative stress).

Nitrox is increasingly used by recreational divers, in particular by dive guides. Thus, possible harmful effects could become more relevant.

Until now, predominantly O_2 effects on CNS and lungs were investigated. We suggest to also address other organs like skeletal and cardiac muscle, blood and the eyes, as oxidative stress likely induces injury in all cell types.

With the advent of newer measuring devices, more subtle aspects (peripheral pulmonary resistance) and/or other aspects (RH) were investigated in this study.

Our results suggest that the increased oxidative stress impairs small pulmonary airways as well as the vascular compliance. On the other hand, cognitive competence is better preserved with less narcotic N_2-effects and less N_2-bubbles are formed (see table).

	Nitrox40	
Lungs	peripheral resistance↗	☹
Blood vessels	dilatative capacity↘	☹
Cognition	memory / alertness ↗	☺
N_2-bubbles	bubble trouble ↘	☺

Conclusion

Under the conditions of this study, Nitrox40 exerts both advantages and disadvantages. As disadvantages might accumulate over time, dive pauses should be allowed for injured organic tissue to recover.

Acknowledgements

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