



Société Belge de Médecine Hyperbare et Subaquatique asbl
Belgische Vereniging voor Overdruk- en OnderwaterGeneeskunde vzw

Position of the Belgian Society for Diving and Hyperbaric Medicine on Oxygen First Aid for Diving Accidents

November 15, 2020

a) Introduction

In October 2019 the Belgian Society for Diving and Hyperbaric Medicine (SBMHS-BVOOG) has organized a Workshop on the matter of Oxygen Administration as First Aid in case of diving accidents, by persons who 'do not belong to one of the categories legally authorized to administer oxygen without direct order and supervision of a medical doctor'. During this Workshop, after having exposed the legal and non-legal aspects of the matter, an open discussion was held with active participation of members of the SBMHS-BVOOG and the other participants (many of whom representing the different Belgian diver federations).

The act 'administration of oxygen' is described in the 'Official list of technical nursing acts allowed for registered nurses' (Annex I to the Royal Decree of 18 June 1990: Royal Decree determining the list of technical nursing acts) as a 'B1' act (B1: 'acts for which no medical prescription is required'). Furthermore, a position statement issued in 2018 by the Technical Commission for Nursing (TCAI-TCV) reads "unlicensed persons who perform this technical act, are punishable by law (Law on the exercise of health-related professions of 10 May 2015, Art.23.1)". This article does not discriminate, regarding the necessity to administer oxygen, between medical or traumatic situations causing a decrease of the oxygen saturation in the blood, and specific diving injuries. This article does not discriminate either between the administration of oxygen in a 'repeated' or 'chronic' way and the administration 'in cases of emergency'. Whereas the administration of oxygen to divers suffering from well-defined diving-related pathologies is described by national and international diving medicine associations as a 'specific case' of emergency first aid, this point of view is not shared by the TCAI-TCV.

The Board of the SBMHS-BVOOG finds it necessary to make a Position Statement in this matter, as a basis to

- a) ensure, as much as possible, that adequate first aid is delivered in case of diving accidents, not only in Belgium but also abroad
- b) engage a discussion with the Lawmaker, in order to create more legal clarity in this specific issue.

b) Workshop presentations

The workshop was organized in the Auditorium of the Military Hospital in Neder-over-Heembeek, Brussels, as a regular scientific meeting of the SBMHS-BVOOG, on October 12th, 2019. All presentations are freely downloadable in PDF format from the SBMHS-BVOOG website (www.sbmhs-bvoog.be).

c) Considerations

‘Oxygen administration as first aid for diving accidents’ is a very specific form of medical first aid, which is not comparable to oxygen administration for other diseases and accidents. When considering this unique situation for diving pathologies, the following factors must be taken into account:

1. Divers, who participate in underwater activities in Belgium or in the context of one of the Belgian diver federations, or those who hold an internationally recognized diving certification (CMAS, PADI, SSI, IANTD, or other), have in the vast majority knowledge of the basic physical condition and medical fit-to-dive criteria to safely undertake this activity. They have subjected to a yearly basic medical fitness examination, and/or are informed by international organizations such as the Divers Alert Network (DAN Europe) as to the importance of a good physical and mental health and to the possible medical risks incurred while diving.
2. Many divers have received additional training in first aid for diving accidents, including the skills to administer oxygen in a safe way, either by following a (compulsory) training module while pursuing higher certification, or by taking part in optional courses ‘diver-first-aid’ or ‘DAN Europe Oxygen Provider’ or ‘DAN Europe First Aid Provider’ courses.
3. Diving physiology is complex, and concerns factors such as
 - a. Immersion
 - b. Respiratory changes
 - c. Exercise physiology
 - d. Saturation and desaturation of ‘inert’ (non-metabolic) gases

These factors are responsible for the fact that despite an optimal medical and physical condition and preparation, and the scrupulous following of accepted procedures regarding decompression from depth, a certain risk remains for the sudden occurrence of diving-related pathology, requiring urgent medical first aid. These pathologies are thus happening to people that – in the vast majority of cases – do not have primary cardiac or cerebral disease. The basis for emergency first aid for all of these diving related conditions is immediate administration of 100% oxygen (see below).

4. The procedures that have been adopted in Belgium for Emergency Medical Services consist of a chain of 'actors', regulated by '112 Central Dispatch' operators:
 - a. Immediate first aid provided by '112 Ambulances' which are manned by certified ambulance personnel; these have at their disposal a "book of protocols' indicating specific paramedical actions to be taken in case of certain pathologies or symptoms ('Procedures and Standing Orders').
 - b. The optional availability of a 'Rapid Medical Interventions' vehicle (MUG – Medische Urgentie Groep; SMUR – Service Mobile d'Urgence Medicale) with a medical doctor and registered nurse that are specialized in emergency medicine. These have complete autonomy for therapeutic decisions.
 - c. Possible deployment of a 'Prehospital Intervention Team' (PIT) with a certified paramedic and nurse (holding a Specific Certification for Emergency Nurse), in those areas of the country where it is difficult to provide a MUG/SMUR team with sufficiently short delays.

In most cases, for a diving-related accident, the Book of Protocols of the 112 Regulation would mandate the immediate dispatch of a 112 Ambulance and also a MUG/SMUR or PIT Team. The mean maximum travel time of such an ambulance in Belgium is fixed at 15 minutes for 95% of calls. Many places where Belgian divers are practicing their sport however are in 'blind spots' where these 'maximum travel times' are impossible to attain: Namur/Philippeville, Tournai, Jodoigne, Aywalle; or also, the North Sea or the Eastern Scheldt areas.

5. Without any exception, international recommendations for first aid in case of diving-related accidents mention the importance of immediate administration of 100% oxygen. The rationale for this recommendation is based on animal experimentation and years of experience in military and professional diving. The importance of a maximal FiO₂ (as close as possible to 100% of oxygen) bears a direct relation with the specific pathophysiology of diving accidents:

- a. *Decompression sickness*: during ascent from a dive, nitrogen (inert gas) bubbles may form in the bodily tissues and blood, which act as gas emboli to obstruct small (capillary, venous or arterial) blood vessels. This causes local ischemia which may rapidly become irreversible. The only way to rapidly dissolve these gas-emboli is to reduce the nitrogen pressure in the inhaled air and alveoli to zero, and replace it with oxygen. That way,
 - i. the cells in the affected tissue will, despite the inevitable presence of oedema and extravasation of fluids, be provided with as much oxygen as possible (anti-ischemic effect)
 - ii. the inert gas pressure in the tissues will be reduced rapidly to minimal levels, allowing the inert gas from within the bubbles to re-diffuse into the tissues, decreasing the volume of the bubble and making it, eventually, disappear.

The longer this ischemia is allowed to persist, the more important inflammatory reactions and cell necrosis will become, reducing the therapeutic effect of a subsequent treatment with hyperbaric oxygen (in a pressure chamber). Optimal first aid with oxygen and rehydration thus play an important role in the chances of a good result from the definite

treatment. The persistence of neurological, vestibular or orthopedic sequelae of diving accidents may cause lifelong disability and have a profound effect on the quality of the remaining life in these often young persons.

- b. *Cerebral air embolism* caused by pulmonary overpressure: here, actual air emboli are swept into the pulmonary veins and thus in the arterial circulation, to end up (predominantly) in the cerebral blood vessels. Here again, just like Basic Life Support, 100% oxygen is crucial as emergency first aid, and for the same reasons as above. It is most effective when administered within minutes (see also the recent Guidelines by the UK Intensive Care Society, Reference 3).
 - c. *Immersion Pulmonary Edema*: this particular affliction is characterized by pulmonary edema, occurring while the diver is at depth and provoking the need for emergency ascent. However, the dyspnea and shortness of breath which started at depth (caused by arterial hypoxemia) actually increases during ascent because the partial pressure of oxygen in the alveoli decreases with decreasing environmental pressure. Due to this hypoxia, divers may lose consciousness before reaching the water surface (and most likely drown) or, they may develop cardiac ischemia at or near the surface. While waiting for positive pressure ventilation (CPAP), cardiac monitoring and possibly administration of diuretics, administration of as high as possible a concentration of oxygen will save lives. Vastly underreported, the exact cause of this pathology is multifactorial and in many cases difficult to ascertain.
6. The diagnosis of all these conditions is almost exclusively made on clinical grounds, based in the nature and time of occurrence of the symptoms, but also taking into account the preceding dive (depth, dive time, breathing gas, incidents during the dive) as well as clinical features and medical history of the diver. While diving in Belgium, all divers have the benefit of almost immediate (within minutes) consultation with an experienced diving medicine (specialist) physician, through the toll-free telephone number 0800-12382, who can pinpoint with near-certainty a diagnosis based on these data. This physician can also recommend logical and optimal first aid measures while awaiting Emergency Medical Services to arrive. Once the patient is taken care of by EMS, this physician is available for telephone consulting and recommendations regarding the best medical care and the most appropriate evacuation strategy (e.g. emergency medical transport towards the closest hyperbaric facility). If, in concertation with the MUG/SMUR physician, it is concluded that it does NOT concern one of these specific diving pathologies, the medical care can be continued following the general recommendations (among others, restriction of the concentration of oxygen to be given).
7. Not administering oxygen upon (suspicion of) these clinical syndromes, as recommended by international expert panels in diving medicine, can be considered a medical fault and/or 'non assistance of a person in vital danger', thus subjecting one to possible criminal charges. Administering oxygen in a competent manner ('lege artis') by a diver first aid-provider, on the instructions of an experienced, certified

diving medicine specialist (be it over the phone) would never lead to criminal charges being laid unless done so by the victim; even then, the 'culprit' would be covered by his/her diving insurance for the possible financial consequences of an (unlikely) conviction.

d) Recommendations:

1. For diving accidents, administration of 100% oxygen by qualified and certified divers is essential to maximize the chances of complete cure with no or only minimal sequelae, even so if a hyperbaric oxygen treatment can be started within a short delay.
2. The possible negative effects of 100% oxygen, as indicated in the general recommendations for emergency first aid, do not weigh against the certain advantages in the case of diving pathology. Moreover, after arrival of the Emergency Medical Services, it can be decided in concertation with the diving medicine physician on the phone, to discontinue the administration of 100% oxygen. In case of non-necessity, the maximum duration of this 'too high dose' of oxygen would be at most one hour.
3. Divers should continue to receive a thorough education in recognizing emergency situations that need oxygen first aid, as well as in the correct and safe administration of 100% oxygen with the specific available first aid materials (type of mask, flow rate,...). It is recommended that diving medicine specialists or –organizations, because of the very specific nature of diving-related pathology, give these courses. This education should also encompass the supplementary measures and precautions in relation to the propagation of the SARS-CoV2 virus, in order to make certain that it does not impede the rapid administration of oxygen.
4. Divers must be encouraged to seek immediate telephone consultation with a diving medicine physician in all cases of diving-related pathology to receive precise instructions and formal (oral) authorization to administer oxygen (and other first aid measures). Information on how to reach this telephone 'hotline' is already communicated to all Belgian divers through the diving federations and DAN Europe.
5. The legal dispositions and texts dealing with oxygen administration as a first aid measure need to be adapted as soon as possible, to allow oxygen administration by trained divers to injured divers, according to the above-described modalities.

e) References:

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