

## **„CARDIOVASCULAR TOP THREE” - CAN PATIENTS WITH THE MOST COMMON CARDIOVASCULAR CONDITIONS BECOME CANDIDATES FOR RECREATIONAL SCUBA DIVING?**

Ewa Mańka, Bartosz Skuratowicz, Sebastian Kwiatek, Maciej Krupowies, Karolina Sieroń

Sergeant Grzegorz Załoga Hospital of the Ministry of the Interior and Administration in Katowice, Poland

### **ABSTRACT**

Cardiovascular diseases such as coronary artery disease, hypertension, and diabetes are some of the most common conditions among the population. An ever-increasing number of recreational divers forces us to consider the impact on unprepared diving patients with cardiovascular diseases, in whom profound changes occur during the dive. People in at-risk groups should have a medical check-up before diving to minimise the risk of possible complications.

**Keywords:** SCUBA diving, cardiovascular diseases.

---

### ARTICLE INFO

---

PolHypRes 2020 Vol. 73 Issue 4 pp. 47 – 52

**ISSN:** 1734-7009 **eISSN:** 2084-0535

**DOI:** 10.2478/phr-2020-0022

Pages: 6, figures: 0, tables: 0

**page www of the periodical:** [www.phr.net.pl](http://www.phr.net.pl)

**Publisher**

Polish Hyperbaric Medicine and Technology Society

**Original article**

**Submission date:** 25.07.2020 r.

**Acceptance for print:** 27.09.2020 r.



## INTRODUCTION

The growing interest in recreational diving with self-contained underwater breathing apparatus (SCUBA) raises the need to monitor the effects of full-body immersion on cardiovascular changes. The high prevalence of cardiovascular disease among the population increases the risk of a person interested in recreational diving being also at cardiovascular risk [1–3]. The centralisation of circulation that results from immersion is caused by an increase in hydrostatic pressure, which leads to an increased venous return of blood to the heart, thus increasing preload. The high partial pressure of oxygen in the SCUBA gas mixture activates the parasympathetic nervous system by increasing the phrenic nerve tone and decreasing the sympathetic component. These changes lead to bradycardia and increased cardiac output [4,5].

Unprepared amateur divers are particularly at risk from exposure to these changes, which may result in the occurrence of decompression sickness, which can manifest as symptoms ranging from a minor rash to death [6,7]. Many factors influence the severity of cardiovascular complications that may occur during diving, such as age, body mass index, level of fitness preparation, and comorbidities [8,9]. Cardiovascular diseases are one of the most common conditions, which with the ever-increasing number of recreational divers, forces us to consider the impact of unprepared diving patients with cardiovascular diseases, in which serious changes occur during the dive [4,9]. This review summarises the knowledge on the correlation between diving and its effect on patients suffering from coronary artery disease, hypertension, and diabetes.

## CORONARY ARTERY DISEASE

SCUBA diving increases oxygen demand by the heart muscle and thus may increase ischemia in patients with heart disease. Even dives generally considered safe that do not involve great depths can be associated with significant cardiovascular changes [19]. With 80–90% of diving deaths occurring in patients over the age of 50, the Divers Alert Network (DAN) recommends assessing coronary artery disease (CAD) in patients already over the age of 40. Such recommendations emphasise how high the risk of diving with undetected CAD can be. This assessment should be made by evaluating risk factors and electrocardiographic examination [25].

Among the risk factors that are significant in assessing the occurrence of complications in a diving patient are family history, smoking, high blood pressure, high cholesterol, obesity, diabetes mellitus, and sedentary lifestyle, as well as other classical risk factors such as age, male gender, cocaine and amphetamine use, obstructive sleep apnoea, and parameters such as low potassium and magnesium levels. Further management depends on the changes - often, an exercise electrocardiogram is recommended, during which a person wishing to dive should tolerate an effort of 13 METs. In patients after myocardial infarction or surgical treatment of coronary artery disease, it is recommended to abstain from diving for at least 6 to 12 months with subsequent assessment of the patient's condition by a specialist [25,26]. CAD is not an absolute contraindication to recreational diving. However, people who undertake recreational diving with

CAD should be aware of the risks and should be screened periodically.

## HYPERTENSION

Hypertension is one of the most common diseases in the general population. As many cohort studies also show a large number of divers suffer from this condition, and as a result, they take anti-hypertensive medications. The 2018 Divers Alert Network (DAN) survey reports that among US divers surveyed, as many as 24.6% have hypertension, and the European Society of Cardiology's 2018 Cardiovascular Risk Factors report showed an even higher percentage of hypertension among divers, at 32.7% [18,19]. Pharmacotherapy of hypertension in the diver needs to take into consideration the physiological aspects resulting from the sport. Among the most important of these are centralisation of circulation, vasoconstriction of peripheral vessels reflex bradycardia. As a consequence, arterial pressure increases [4,5,9].

- **Angiotensin-converting enzyme inhibitors (ACEIs)** are a safe group of antihypertensive drugs to use, but particular attention should be paid to whether the diver does not develop the most commonly described adverse effect - dry cough. SCUBA divers breathing a dry gas mixture may be particularly susceptible to its occurrence. In this case, a change from ACEi to an angiotensin II receptor blocker is recommended. However, ACEIs still remain the first choice of treatment for hypertension among divers when no other therapy is indicated.
- **Calcium antagonists** are vasodilators whose common adverse effect is orthostatic hypotension. During a dive, a sudden drop in blood pressure may occur during ascent when the centralising effect of the circulation is reversed. Therefore, divers taking calcium antagonists should be cautioned to leave the water carefully so that the circulatory system can adapt to returning to functioning conditions after ascent.
- **Thiazide diuretics** are a relatively safe group of antihypertensive drugs to use. However, the effect of dehydration should be taken into account, and care should be taken to ensure adequate hydration before and after diving.
- **Beta-Blockers** may affect safety during diving through several mechanisms. Their effects on bronchial receptors may cause a decrease in forced expiratory volume in 1 second (FEV1), and their Chronotropic negative effects on the myocardium may potentiate reflex bradycardia after a dive. Once these adverse effects have been ruled out in the patient, they may be used in divers [20–23].

It has been reported that divers with hypertension are at particular risk of developing immersion pulmonary oedema, during which there is a relatively sudden accumulation of fluid in the lungs as a result of circulatory changes occurring after immersion. This can cause significant shortness of breath, chest pain, and coughing. This is not a common occurrence but is difficult to predict and can be fatal, and hypertension has

been described as a significant risk factor [1,24].

Well treated hypertension is not a contraindication to diving. Its prevalence among the population indicates how important it is that a person wishing to begin recreational diving be under control, taking into account the adverse effects of individual drugs, which may have a specific course due to changes occurring in the cardiovascular system during diving.

## DIABETES

Diabetes mellitus (DM) was previously considered a contraindication to recreational SCUBA diving, primarily because of the risk of underwater hypoglycemia, which carries with it impaired consciousness. There were no specific guidelines for the eligibility of patients with DM for amateur diving, and regulations regarding this issue varied widely from country to country [10–12]. In the United Kingdom, diving was restricted in 1992 to people with diabetes mellitus who require drug therapy. Recommendations from the Australian Society in 1994 described diving by people treated with insulin as strongly discouraged. However, increasing scientific evidence, including epidemiological studies and controlled case studies, indicates that some patients with DM can safely dive under appropriate conditions. Especially in type II DM where hypoglycemia occurs much less frequently due to residual pancreatic cell function [9,12,13].

In 1997, a study of patients with DM type 1 was performed in a hyperbaric chamber. Its results showed no difference in blood glucose levels measured at sea level and in the chamber under conditions mimicking a dive to a depth of 27 meters [13]. Based on the current state of knowledge, it is possible to qualify a diabetic patient for admission to diving. However, it is worth emphasising that such a patient must report for such qualification, and unfortunately, in many centres where amateur diving is practiced, it is not required. There are still differences in guidelines and recommendations depending on the scientific society [11]. Despite their differences, however, they all emphasise the four most important pillars that must be met for a patient with DM to be safely allowed to dive:

- A patient with well-adjusted DM without the occurrence of episodes of severe hypoglycemia and without serious complications.
- It is suggested that the maximum number of immersions per day should not exceed two and the interval between them should be longer than 60 minutes, and the depth of immersion should be a maximum of 30m.
- Glycemic measurements should take place 60 minutes, 30 minutes, and immediately before immersion and after immersion.
- Educate the dive partner on the symptoms of hypoglycemia and hyperglycemia, have oral, readily available glucose on the surface and during the dive, and have glucagon for parenteral administration on the surface-the dive partner must also be trained in its application. When training a partner, it is worth paying attention to the signalling of hypoglycemia - a diver with DM sensing a drop in blood glucose during the dive shows his

- partner a sign in the form of the letter L formed by the thumb and forefinger. This is the "low" sign and thus signals a low blood glucose level [14–17].
- An important recommendation is to give up sulphonylurea derivatives on the day of diving, which is prone to hypoglycemia [13]. A diver with DM may also, after appropriate training, take glucose paste while still underwater; however, the priority is always to ascend as quickly as possible and take oral glucose on the surface [11,13,14].

This structured approach allows the patient with DM to safely qualify for amateur diving, including those treated with insulin.

## SUMMARY

The popularity of recreational SCUBA diving is growing, and so is the need to make people aware that cardiovascular disease is the leading cause of diving accidents. People in at-risk groups should have a medical check-up before diving to minimise the risk of possible complications. DAN emphasises the importance of training and educating people with CAD, hypertension, and diabetes. This systematic approach allows for the safe qualification for amateur diving of people burdened with one of the diseases from the cardiovascular top three.

## REFERENCES

1. K. Åsmul, A. Irgens, M. Grønning, A. Møllerlækken, Diving and long-term cardiovascular health, *Occup. Med. (Chic. Ill.)*. (2017) 371–376. doi:10.1093/occmed/kqx049;
2. C. Marabotti, A. Scalzini, D. Cialoni, M. Passera, A. Ripoli, A. L'Abbate, R. Bedini, Effects of depth and chest volume on cardiac function during breath-hold diving, *Eur. J. Appl. Physiol.* 106 (2009) 683–689. doi:10.1007/s00421-009-1068-8;
3. C. Marabotti, A. Scalzini, D. Menicucci, M. Passera, R. Bedini, A. L'Abbate, Cardiovascular changes during SCUBA diving: An underwater Doppler echocardiographic study, *Acta Physiol.* 209 (2013) 62–68. doi:10.1111/apha.12112;
4. R. Vann, M. Lang, *Recreational diving fatalities*, 2011;
5. J.F. Cheng, M. Diamond, SCUBA diving for individuals with disabilities, *Am. J. Phys. Med. Rehabil.* 84 (2005) 369–375. doi:10.1097/01.PHM.0000159974.01251.E2;
6. K.D. Torp, H.M. Murphy-Lavoie, *Diving, Return To Diving*, StatPearls Publishing, 2018. <http://www.ncbi.nlm.nih.gov/pubmed/29763198> (accessed May 18, 2018);
7. V. Papadopoulou, P. Germonpré, D. Cosgrove, R.J. Eckersley, P.A. Dayton, G. Obeid, A. Boutros, M.X. Tang, S. Theunissen, C. Balestra, Variability in circulating gas emboli after a same scuba diving exposure, *Eur. J. Appl. Physiol.* 0 (2018) 1–10. doi:10.1007/s00421-018-3854-7;
8. R. Pougnet, L. Di Costanzo, B. Lodde, A. Henckes, L. Dherbecourt, D. Lucas, D. Jegaden, J.-D. Dewitte, Cardiovascular risk factors and cardiovascular risk assessment in professional divers., *Int. Marit. Health.* 63 (2012) 164–169. <http://ovidsp.ovid.com/ovidweb.cgi?T=JS&PAGE=reference&D=medl&NEWS=N&AN=23129099>;
9. R. Pougnet, M. Uguen, G. Verdier, L. Pougnet, D. Lucas, B. Lodde, J.-D. Dewitte, Predicted nine-year risk of diabetes among professional divers: a prospective study., *Int. Marit. Health.* 66 (2015) 87–92. doi:10.5603/IMH.2015.0021;
10. L. Eichhorn, D. Leyk, *Tauchmedizinische Sprechstunde*, *Dtsch. Arztebl. Int.* 112 (2015) 147–158. doi:10.3238/arztebl.2015.0147;
11. T. Koufakis, S.N. Karras, O.G. Mustafa, D. Karangelis, P. Zebekakis, K. Kotsa, Into the deep blue sea: A review of the safety of recreational diving in people with diabetes mellitus, *Eur. J. Sport Sci.* 20 (2020) 1–16. doi:10.1080/17461391.2019.1606286;
12. C.J. Edge, M. St Leger Dowse, P. Bryson, Scuba diving with diabetes mellitus--the UK experience 1991-2001., *Undersea Hyperb. Med.* 32 (2005) 27–37;
13. D. Ługowska, T. Ługowski, O. Krzywińska, M. Kozakiewicz, P. Grzelakowski, Diabetic Patients Who are Amateur Divers, *Polish Hyperb. Res.* 64 (2018) 39–44. doi:10.2478/phr-2018-0017;
14. R. Johnson, A day in the life of a diabetic diver: the Undersea and Hyperbaric Medical Society/Divers Alert Network protocol for diving with diabetes in action., *Diving Hyperb. Med.* 46 (2016) 181–185;
15. R. Johnson, Insulin-dependent diabetes mellitus and recreational scuba diving in Australia., *Diving Hyperb. Med.* 46 (2016) 181–185;
16. J. Jendle, P. Adolffson, H. Ornhaugen, Swedish recommendations on recreational diving and diabetes mellitus., *Diving Hyperb. Med.* 42 (2012) 231–233;
17. N. Jepson, R. Rienks, D. Smart, M.H. Bennett, S.J. Mitchell, M. Turner, South Pacific Underwater Medicine Society guidelines for cardiovascular risk assessment of divers., *Diving Hyperb. Med.* 50 (2020) 273–277. doi:10.28920/dhm50.3.273-277;
18. P. Buzzacott, C. Edelson, C.M. Bennett, P.J. Denoble, Risk factors for cardiovascular disease among active adult US scuba divers, *Eur. J. Prev. Cardiol.* 25 (2018) 1406–1408. doi:10.1177/2047487318790290;
19. S.I. Ranapurwala, K.L. Kucera, P.J. Denoble, The healthy diver: A cross-sectional survey to evaluate the health status of recreational scuba diver members of Divers Alert Network (DAN), *PLoS One.* 13 (2018) 1–12. doi:10.1371/journal.pone.0194380;
20. L. Vanhees, J.G. Defoor, D. Schepers, P. Lijnen, B.Y. Peeters, P.H. Lacante, R.H. Fagard, Effect of bisoprolol and atenolol on endurance exercise capacity in healthy men., *J. Hypertens.* 18 (2000) 35–43. doi:10.1097/00004872-200018010-00006;
21. D.R. Morales, C. Jackson, B.J. Lipworth, P.T. Donnan, B. Guthrie, Adverse respiratory effect of acute  $\beta$ -blocker exposure in asthma: a systematic review and meta-analysis of randomized controlled trials., *Chest.* 145 (2014) 779–786. doi:10.1378/chest.13-1235;
22. Niklas, A. Flotyńska, A. Puch-Walczak, M. Polakowska, R. Topór-Mądry, M. Polak, W. Piotrowski, M. Kwaśniewska, P. Nadrowski, A. Pająk, W. Bielecki, K. Kozakiewicz, W. Drygas, T. Zdrojewski, A. Tykarski, Prevalence, awareness, treatment and control of hypertension in the adult Polish population – Multi-center National Population Health Examination Surveys – WOBASZ studies, *Arch. Med. Sci.* 14 (2018) 951–961. doi:10.5114/aoms.2017.72423;
23. G. Mancia, G. De Backer, A. Dominiczak, R. Cifkova, R. Fagard, G. Germano, G. Grassi, A.M. Heagerty, S.E. Kjeldsen, S. Laurent, K. Narkiewicz, L. Ruilope, A. Rynkiewicz, R.E. Schmieder, H.A.J.S. Boudier, A. Zanchetti, 2007 Guidelines for the Management of Arterial Hypertension: The Task Force for the Management of Arterial Hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC), 2007. doi:10.1097/HJH.0b013e3281fc975a;
24. M. Coulangue, P. Rossi, O. Gargne, Y. Gole, J. Bessereau, J. Regnard, Y. Jammes, A. Barthélémy, J.P. Auffray, A. Boussuges, Pulmonary oedema in healthy SCUBA divers: new physiopathological pathways., *Clin. Physiol. Funct. Imaging.* 30 (2010) 181–186. doi:10.1111/j.1475-097X.2010.00922.x;
25. P.J. Denoble, DAN annual diving report 2019 edition, 2019;
26. J.H. Lynch, A.A. Bove, Diving medicine: A review of current evidence, *J. Am. Board Fam. Med.* 22 (2009) 399–407. doi:10.3122/jabfm.2009.04.080099.

**Ewa Mańka**

SP ZOZ MSWiA w Katowicach im. Sierżanta Grzegorza Załogi  
 ul. Głowackiego 10  
 40-052 Katowice  
 e-mail: ewa.irena.manka@gmail.com  
 tel.: +48 783 790 909