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Bezpieczeństwo helioksowych nurkowań saturowanych

Nurkowania saturowane są to wielodniowe pobyty nurków w warunkach hiperbarii kończące się jednorazową długą dekompresją. Ważnym kryterium oceny zagrożeń chorobą dekompresyjną powinna być ocena aktywacji hemostazy i fibrynolizy, która może nie tylko towarzyszyć objawom choroby dekompresyjnej, ale nawet ją wyprzedzać.

Słowa kluczowe: *nurkowania helioksowe, saturacja, tabele dekompresyjne, bezpieczeństwo*

Safety in heliox saturation diving

Diving saturation are a divers in the multi-day stays hyperbaric conditions leading to a single long decompression. An important criterion for assessing the decompression sickness risk assessment should be evaluations of active hemostasis and fibrinolysis, which may not only be accompanied by symptoms of decompression sickness, but even to overtake it.

Key words: *heliox diving, saturation, decompression tables, safety*

CEL BADAŃ

Ocena bezpieczeństwa tabel saturowanych helioksowych do 100 m i dokonanie korekt czasu dekompresji za pomocą oceny zmian w hemostazie i fibrynolizie.

MATERIAŁ I METODY

Dane uzyskano podczas symulowanych nurkowań saturowanych, przy użyciu helioksu. Przeprowadzono trzynaście symulowanych helioksowych nurkowań saturowanych w których uczestniczyło 39 nurków.

WYNIKI I DYSKUSJA

Helioks daje możliwość zmniejszenia gęstości czynnika oddechowego, co w znaczny sposób zmniejsza opory oddechowe i eliminuje także ekstazę głębin.

W helioksowych symulowanych nurkowaniach saturowanych do głębokości 100 m przeprowadzano korekty czasu dekompresji. W niektórych nurkowaniach na podstawie hemostazy zmniejszono czas dekompresji o 10 godzin. Nurkowania odbywały się bezwypadkowo i nie stwierdzono istotnych zmian wskazujących na aktywację czynników krzepnięcia. Korekty czasu nie wpłynęły na zmiany parametrów hemostazy i fibrynolizy.

WNIOSEK

Po nurkowaniach saturowanych helioksowych po których nie wystąpiły zmiany w układzie hemostazy, przeprowadzano korekty czasu dekompresji.

INTRODUCTION

Saturation dives are stays of several days in hyperbaric conditions finished in one long decompression. After 48 hours stay in the plateau diver's body reaches a state of gas balance, in which all the body tissues are saturated with the gases contained in the artificial gas breathing mixtures. Having achieved a full gas saturation of his body, the diver is able to stay in the plateau for many number of days, and the decompression period remains the same, irrespectively the time spent under pressure, be it a day, a week or a month.

Canadian helium tables for short time diving (3), recommend as long as 8-hour decompression after a 30-minute stay at 100 m. Saturated dives allow to develop a more favourable proportion between the period of stay in hyperbaric conditions and decompression time.

AIM OF STUDY:

1. Safety assessment of tables for saturated heliox divings to 100 m and introducing corrections made on the basis of changes in hemostasis and fibrinolysis.
2. Search for the parameters revealing development of gas bubbles in the diver's body during decompression, with a particular attention to parameters of fibrinolysis and the blood coagulation system.

MATERIAL AND METHODS:

The data were obtained during simulated heliox saturation dives.

There were performed 12 simulated heliox saturation dives with participation of 39 divers.

The dives performed differed in the plateau duration. Diver's body reaches state of gas balance after 48 hours under hyperbaric environment, regardless of the length of plateau. For that reason, despite different individual plateau duration, the decompression time was calculated as though the divers remained at plateau for only two days. And so, the shortest decompression was 44 hours, and the longest 104 hours and 16 minutes.

Tab. 1.

Simulated heliox saturation exposures (4)

Exposures	Plateau Pressure	Breathing medium	Plateau Duration of stay		Continuous Decompression	
			hour	min	hour	min
1.	0,4 [30]	Heliox	49	00`	44 00`	
2.	0,4 [30]	Heliox	54	00`	40	00`
3.	0,4 [30]	Heliox	53	00`	40	00`
4.	0,4 [30]	Heliox	55	30`	38	00`
5.	0,4 [30]	Heliox	56	17`	35	48`
6.	0,5 [40]	Heliox	80	00`	60	34`
7.	0,5 [40]	Heliox	50	00`	45	53`
8.	0,6 [50]	Heliox	55	30`	61	19`
9.	0,6 [50]	Helioks	57	30`	56	58`
10.	0,9 [80]	Heliox	51	30`	86	27`
11.	0,9 [80]	Heliox	51	30`	86	27`
12.	1,1 [100]	Heliox	58	34`	104	16`

All the divers were informed about the purpose of the study and gave their written consent to participate.

RESULTS

In simulated heliox saturation dives to depths of 30, 40 and 50 m corrections of decompression duration were made. The dives went on without accidents and no particular changes indicating to haemostasis activation were revealed. The dives to depth of 30 m were performed in the exposures No1, 2, 3, 4 and 5 (Tab.1). In each exposure a correction was made – the duration of decompression was shortened on the warrant of evaluation of haemostasis. In the heliox exposure No1 the length of decompression was 44 hours, in the exposure No2 and 3 – 40 hours, exposure No 4 - 38 hours, whereas in the final exposure No 5 it was only 35 hours and 48 minutes, so it was almost by 10 hours shorter than the in the first exposure. The correction of time did not affect the changes in the haemostatic parameters.

Analogically, the corrections of decompression time were made in the series of simulated heliox saturated dives to the depth of 40 m. In the exposure No 6 the decompression time was 60 hours and 34 minutes, after the correction in the subsequent dive – No 7 it was reduced by almost 15 hours and lasted only 45 hours and 53 minutes.

In simulated heliox saturated dives to the depth of 50 m following corrections were made: in the exposure No 8 the decompression time was 61 hours and 19 minutes, after the correction in the subsequent exposure No 9 the decompression time was reduced by 4 hours 21 minutes. So it was as short as 56 hours and 58 minutes.

DISCUSSION

Heliox is a medium that allows to reduce density of breathing medium, what considerably reduces breathing resistance and eliminates the phenomenon of ecstasy of depths. Helium is a 6 times better thermal conductor than nitrogen. For that reason it is necessary to warm heliox mixtures up and to use heated diving suits. In decompression chambers with the use of heliox the zone of warmth comfort gets narrowed. During heliox dives the warmth comfort remains within narrow range of temperatures: from 28 to 32C.

During compression partial pressure of the mixture gases grows proportionally to the rise of the ambient pressure. Proportionally to the pressure the gases diffuse through the alveoli walls into the blood and then to all the body tissues. The process is called saturation of tissues. In the course of decompression all these phenomena develop in the reverse sequence and if they proceed slowly they do not pose any particular risk to the body. Decompression, which should allow for a physiological elimination of the excessive dissolved gas from the organism and ensure a safe return to surface constitutes one of the most difficult medical problems of life and health safety of divers. A particularly high number of cases of decompression sickness - about 30% after saturated dives testifies to difficulty level. Decompression performed in the way preventing from complete elimination of the gases releasing from the tissues in time generates a serious risk of a decompression disease.

During decompression as well as after its completion in the diver's blood a certain amount of non-symptomatic, tolerated bubbles, which are also referred to as silent bubbles, may appear (2, 5, 6).

The criterion of the divers safety evaluation which is most popular and with the longest history of application is the absence of „bends".

Another criterion is Doppler examination for detecting microbubbles in divers. It is regarded that microbubbles may appear after almost every exposure, even when the tables are obeyed. A valid criterion at assessment of decompression sickness risk should be activation of fibrinolysis and haemostasis, which not only may accompany the symptoms of, but even may precede decompression sickness. This is of great importance for solid evaluation of diving safety (1, 2, 7, 8, 9).

So it seems appropriate to monitor for the changes which are a further consequence of gas bubbles in the blood. The intravenous bubbles cause changes in haemostasis, and the grade of activation of platelet and plasmatic haemostasis in divers after decompression may be useful in assessment of decompression sickness risk. Any changes observed in the parameters of haemostasis and fibrinolysis may point to incorrectness in the decompression tables, and revealing them may serve as a valuable instrument of decompression safety evaluation (1, 7, 8, 9).

CONCLUSION

After heliox saturation dives, without haemostatic changes observed, decompression time was corrected. In some dives the correction allowed to shorten the time of decompression even by 10 hours.

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