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THE INVESTIGATIONS ON THE IMPACT OF THE OXYGEN HYPERBARY ON THE IMMUNOLOGIC RESPONSE OF THE ORGANISM

Kazimierz Ulewicz

Department of Maritime Medicine of the Military Medical Academy

ABSTRACT

Knowledge of the impact of hyperbaric conditions, especially hyperbaric oxygen, on human and animal organisms, is of great theoretical and practical importance, particularly in reference to the increased application of hyperbaric oxygen for therapeutic purposes.
It must be said that unfortunately our knowledge on the impact of hyperbaria, including oxygen hyperbaria, on the immunological response of the animal and human organisms is still not sufficient and is incomplete. The Institute of the Naval Medicine of the Naval Academy in Gdynia has been carrying out tests in this field for some years now. The tests have been carried out on animals (rabbits, guinea pigs) as well as on humans (commercial divers, scuba divers, and candidates to these activities) within immunology investigations. The impact of hyperbaric oxygen at pressures ranging between 2.8 and 3.1 ata, in single or multiple expositions, have been tested as well as the relations between hyperbaria in air and the different conditions of the exposure.The study revealed important shifts in the immunological response of both the animals and humans.
Keywords: hyperoxia, immunity, hyperbaric, complement, opsonic index.

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INTRODUCTION

Knowledge of the influence of oxygen hyperbaria on the human and animal system is of great theoretical and practical importance. This is due to the fact that hyperbaric oxygenation is finding an increasingly broader application in the treatment of various diseases. In addition, it is possible to use hyperbaric oxygenation for complement production, a product which is widely used in complement fixation tests in bacteriological, immunological or virological laboratories [5,6].

Properly documented observations and experimental studies indicate that hyperbaric oxygenation, depending on the overpressure value and exposure time, as well as the mode of application, affects the nervous system, cardiovascular system, haematopoietic respiratory system, the organs of the visual system, cellular metabolism and, moreover, the immunological system and immunity. It should be added that data on the influence of hyperbaria, including hyperbaric oxygenation, on the immunological system and immunity are still scarce, and that furthermore, the information obtained by us regarding this subject matter is insufficient and in many cases contradictory [3,4,7,8].

The Institute of Maritime Medicine has been conducting research on the influence of hyperbaria, including oxygen hyperbaria, on the immunological reactions of humans and animals for several years. When discussing this research in confrontation with the limited data which is available from literature, it is noted that upon comparison and interpretation of the research results from this field, in many cases one encounters difficulties due to the often inadequately described experimental conditions, methodology, and also because of the difficulty in organising these studies, the imposed restrictions on the use of experiments, and the like.

Additional difficulties result from the fact that when investigating the influence of hyperbaria on the diver's body, while under water or in a pressure chamber, it is necessary to consider an entire combination of factors (hydrostatic pressure, partial pressure of particular gaseous components, time, cooling, effort made while under water or in a hyperbaric chamber, the nature of the exposure, etc.), as well as keep in mind that their impact may vary in each individual case. When considering the influence of hyperbaroxia on the immunological reactions of a human, or any other warm-blooded animal, one should take into consideration particular elements of an early and late response of the immunological system, i.e. humoral and cellular response.

Whereas when it comes to the impact of this factor on immunity it is necessary to analyse its effect on various types of microorganisms during both in vitro and in vivo experiments with regard to their metabolism, resistance to environmental influences, the phase of production of antigens, and factors acting in the human or animal body, and finally on the conditions for the development of microorganisms in the tissues and cells of the body. Hence, this influence needs to be examined very carefully and broadly, and the conclusions must be drawn cautiously.

The aim of the study was to determine the effect of oxygen hyperbaria on the immunological response. The research was carried out both on animals and humans.

MATERIAL AND METHODS

The effect of oxygen hyperbaria on the immunological reactions of the human organism was determined on the basis of the average complement level in the blood serum using the 50% haemolysis method.

The study was attended by 133 men aged 18 – 25 years, soldiers and sailors. They were divided into the following groups:

I – candidates for military divers – 51 persons subjected to a 60-minute hyperbaric air exposure to the overpressure of 2.8 ata;

II – candidates for military divers – 15 persons subjected to a 60-minute normobaric oxygen exposure;

III – candidates for military divers – 32 persons subjected to a 60-minute hyperbaric air exposure to the overpressure of 2.8 ata;

IV – control group – 35 persons; seafarers and diver candidates who were not subject to any procedures.

Blood was collected from the ulnar vein immediately before the exposure; "measurement 0", 72 hours after the exposure "measurement 1", 5 days after the exposure "measurement 2" and 10 days after the exposure "measurement 3".

The part of the experiment conducted on animals was performed on rabbits previously immunised with microorganisms S.typhi F7. The value of the opsonic index was determined in the animals' blood.

The animals were divided into 3 groups of 5 animals, in total 15 rabbits, and subjected to a one-time 60-minute hyperbaric exposure with 100% oxygen used as the breathing mix.

The exposures were conducted in a specially constructed hyperbaric chamber for small animals. The chamber was designed as a hermetically closed pressure tank with a capacity of 30 liters. The chamber facilitates the selection of controlled pressures of up to 10 atm, and therefore the compression of the experimental animals, maintaining them in hyperbaric conditions for various time spans, as well as a slow or fast decompression.

Group A animals were pressurised to 1.8 atm, group B animals to 2.4 atm and group C animals to 3.1 atm. The blood for the study was collected from the auricular marginal vein immediately before the exposure, 60 minutes after exposure, 24 hours after the exposure, 48 hours after the exposure and 10 days after the exposure.

RESULTS

The obtained values of the opsonic index in the divers' blood are presented in Table 1.

Tab. 1

Mean complement activity.

	Group size.	Measurement 0	Measurement 1	Measurement 2	Measurement 3
Group I –	51	21.5 u.	27.75 u.	24.55 u.	22 u.
Grupa II –	15	25.9 u.	25.4 u.	25.9 u.	25.2 u.
Group III –	32	24.4 u.	23.85 u.	24.2 u.	24 u.
Group IV CONTROL	35	_	24.3 u.	23.6 u.	24 u.

The studies on humans showed an increase in complement activity in the blood serum immediately after and 3-5 days from the exposure to oxygen hyperbaria. There is also a visible difference in the reaction of the organism between groups of experienced divers and diver candidates. In the group of experienced divers complement activity is maintained at a constant level, similarly to the control group.

The obtained values of the opsonic index in rabbits are shown in table 2.

Tab. 2

Opsonic index values in rabbits.

	Animals from group A					Animals from group B					Animals from group C					Statistical analysis		
	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	/ẍ/	/ẍ/	P=99.9 t groups
before	0.6	0.4	0.7	0.8	1.4	0.3	0.3	0.5	0.5	0.7	0.7	0.4	0.6	0.6	0.5	0.6	0.26	
60`	4.8	2.3	2.3	2.8	2.3	0.5	2.8	3.8	2.1	4.5	1.6	3.0	2.0	2.8	2.3	2.66	1.08	7.1 t
24 h	1.5	2.0	3.8	2.3	2.3	1.1	3.0	3.1	2.5	4.6	1.8	4.1	3.0	4.3	3.8	2.89	0.99	8.5t
48 h	1.8	3.0	4.6	2.3	2.1	1.8	3.3	3.1	1.8	X[1]	2.3	3.1	3.0	4.1	3.1	2.81	0.82	9.3 t
10 days	1.1	1.0	0.8	1.5	2.0	2.3	0.8	1.1	1.0	1.1	1.3	0.8	1.3	2.3	1.3	1.31	0.50	5.0 t

[1] not tested

The studies on rabbits showed an increase in the opsonic index in the period of 3-5 days following the exposure, particularly in specimens that had not been previously exposed to the immunising agent.

DISCUSSION

Other studies demonstrated that with lower overpressure values there is a decrease or a downward trend in specific antistreptolysins O, particularly for flagellar antigens S. typhi, S. typhi murium (less for somatic antigens), also there is a noted haemagglutinin drop and partial decrease of IgG, less IgA, IgM in the normalisation in the period of 10 to 15 days [3,6,11].

In a number of cases, especially with regard to agglutinins, haemagglutinins and immunoglobulins, deviations were observed, which we believe should be accounted for as natural variances between individuals. In these conditions, for example, guinea pigs showed a significant increase in complement activity within 3-5 days from the exposure.

Such shifts in the scope of the above-mentioned immunological indicators were observed already after a single 60-minute exposure to oxygen hyperbaria in the overpressure range between 0.588 ata and 2.8 ata. These displacements, in the field of the aforementioned immunological factors, could be explained by the fact that the studied immunological factors react differently to irritation of the vegetative nervous system under the influence of stimulus in the form of oxygen hyperbaria in the first period of a stress alarm reaction.

During a hyperbaric exposure with the use of oxygen as a breathing mix, the sympathetic vegetative system is irritated which leads to an increase in complement activity in the blood serum and the opsonic index, thus suppressing the reaction of the cholinergic vegetative system, which results in a decrease or sometimes a downward trend in the content of agglutinins, antystreptolysins O, IgG immunoglobulins, and to a lesser extent of IgA and IgM. The above shifts are not normally observed following multiple exposures to oxygen hyperbaria, as the organism is known to adapt to this new environment [3,5,10].

The above observations are partially confirmed in the observation of agglutination changes in the studies carried out by other authors [1], and are linked to the observed generally higher incidence of various infections in divers [2,4,9].

The described observations in the area of human and animal immunological responses under the influence of hyperbaria, including hyperbaric oxygenation, are important for the study on the possibility of treating infections with oxygen hyperbaria as well as, presumably, immunological disorders. Nonetheless, they require further detailed research in this respect on a sufficiently broad and diverse material using modern research methodology.

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Kazimierz Ulewicz
Department of Maritime Medicine of the Military Medical Academy