HAEMATOLOGICAL CHANGES AMONG DIVERS

Adil G Fadhil, Jasim N Al-Asadi, Narjis A. H. Ajeel

ABSTRACT

Diving as a job, exposes individuals to a variety of environmental stresses not often encountered in other types of activities. These stresses lead to changes in many organ systems in the body of divers including haemopoietic system. No previous study was carried out in Iraq to examine the changes in haematological parameters among divers and the association between the diving environmental factors and these changes.

This is a cross-sectional comparative study with a practical component. Eighty divers and 160 non-divers from the Iraqi Navy Force were included. Twenty-five divers were exposed to 2.5 ATA (Absolute Atmosphere) pressure for 15 minutes in a hyperbaric chamber.

All the studied haematological parameters, which were evaluated, including WBC count, RBC count, Hb concentration, PCV, MCV, MCH, MCHC, platelet count, MPV, and ESR were found to be different in divers as compared to non-divers. The MCV, PCV, MCH, platelet count, were significantly lower in divers. While Hb, and MCHC values were lower in divers but without a statistical significant difference. In addition, the mean RBC count, MPV, and ESR were significantly higher in divers. While WBC count was not significantly higher in divers.

The study confirmed the previous findings of other studies, which indicate that diving has an effect on the haemopoietic system. The need to introduce haematological investigations as part of the pre-employment check-up of divers, as well as periodic investigations of divers are recommended.

INTRODUCTION

Diving, just like other occupations, has its specific and related health problems; one of them is haemopoietic system changes. These changes result from underwater environmental stress mainly increased ambient (hydrostatic) pressure and increased partial pressure of oxygen or hypoxia, and cold stress[1-3]. Application of hydrostatic pressure of several atmospheres such as that applied in diving or hyperbaric chamber has been shown to induce the release of red blood cells (RBCs) membrane component which might apply changes in RBCs shape and volume[4], increase in RBCs aggregability[5]. Small but definite decrease was found in levels of red cells, white cells, haematocrit and platelets when normal persons were subjected to pressure of 100 Feet Seawater (FSW) for 60 minutes[6]. High partial pressure of oxygen depresses the erythropoiesis. This effect is a reverse of the changes experienced in acclimatization to high altitude[7]. Oxygen at high pressure has been shown to have deleterious effects on red blood cell morphology and/ or decreases in red cells mass. Also, some reports revealed haemolytic episodes following hyperbaric oxygen exposure, but these seem to be related to individuals and idiosyncrasies differences such as specific enzyme defects[7]. Under conditions of hyperoxia, physically dissolved oxygen has been shown to damage RBCs by direct inhibition of glycolytic enzyme containing SH group[7], and the formation of lipid peroxides from lipid moieties of RBC membrane lipoprotein. Also under hyperoxic conditions the products of catecholamine oxidation were found to have deleterious effect on RBCs in vitro[8]. It has been reported that peripheral blood leukocytes are influenced by various kinds of diving activities, not only in morphological features but also in functional capacities[9]. It was noticed that the number of peripheral blood leukocytes significantly decreases after diving[10]. Platelets count and haematocrit were measured in 10 divers during the course of 4 experimental deep diving (450-600 meters). In this study, the mean platelets count decreased, while the haemartocrit percentage increased [11]. An increase in the erythrocyte sedimentation rate (ESR) was noted in the later stage of decompression, it was not directly related to depth or oxygen partial pressure[7]. Haematological changes related to various kinds of diving activities as well as hyperbaric oxygen therapy have been reported by many investigators abroad[12]. No study had been carried out before to find out the changes in haematological parameters among Iraqi

Adil G Fadhil, MBChB, MSc, Al-Shafaa General hospital, Basrah.
*Jasim N Al-Asadi, MBChB, PhD, *Narjis A.H. Ajeel, MBChB, PhD.
* Department of Community Medicine, College of Medicine, University of Basrah, Iraq.

divers. Therefore, it seems that this study is the first attempt to determine the changes in selected haematological parameters which might occur in divers as a result of diving activities, and to study the immediate *(acute)* changes in the same selected haematological parameters after exposure to simulated diving in a hyperbaric chamber. Also, to identify possible risk factors which may be associated with these changes.

SUBJECTS AND METHODS

It is a cross-sectional comparative study with a practical component.

Subjects: The study population included 80 professional divers from the Iraqi Navy as a study group, and 160 military non-diver personnel also from the Iraqi Navy as a comparative group. Both groups were matched for age, years of service, and residence.

Methods: Data were collected by interviewing according to special questionnaire form that covered the following aspects: personal characteristics, medical history, family history of hereditary anaemia and bleeding disorders, drugs intake or blood transfusion history, history of smoking and alcohol intake, and professional history of diving. Physical examination was performed including general appearance (pallor or jaundice) looking for signs of blood diseases, heart examination, abdominal examination for liver and spleen enlargement. Temperature was measured to postpone persons with fever. Haematological measurements were done in Al-Basrah general hospital using computerized electronic machine (MS9). The Westergren method was used for measuring the ESR.

For the practical part of the study, a sub-sample of 25 divers were selected randomly and were exposed to hyperbaric pressure equal to 2.5 ATA (15 meters depth) in a hyperbaric chamber for 15 minutes.

RESULTS

Table-1 shows the general characteristics of the study population. All the subjects were young adults, but the majority was 30-41 years of age. Most of them have ≥ 10 years of service, and mostly were with <12 years of education. Most of them were non-smokers and non-alcoholics. The differences between the two groups regarding the above characteristics were not significant.

Table1. ***General characteristics of the study population***

Character	Divers		Non-divers		P-value
	No.	*%*	*No.*	*%*	
Age group (years)					
18 – 29	30	37.5	66	41.3	NS
30 – 41	50	62.5	94	58.7	
Years of service					
< 10	30	37.5	59	36.8	NS
≥ 10	50	62.5	101	63.2	
Education (years)					
< 12	67	83.7	134	83.7	NS
≥ 12	13	16.3	26	16.3	
Smoking					
Smokers	30	37.5	61	38.1	NS
Non-smokers	50	62.5	99	61.9	
Alcohol consumption					
Yes	6	7.5	6	3.8	NS
No	74	92.5	154	96.2	
Residence					
Urban	50	62.5	88	55.0	NS
Rural	30	37.5	72	45.0	

Table-2 shows the haematological findings of the divers and comparison groups. As shown in this table, the mean white blood cells count (WBC) of divers was slightly and not significantly higher than that of non-divers, while the mean RBCs count was significantly higher for divers as compared to the comparison group. The mean haemoglobin (Hb) level of divers was slightly and not significantly lower than that of the non-divers group. On the other hand, the mean values of the mean cell volume (MCV), the packed cell volume (PCV), and the mean cell haemoglobin (MCH) were significantly lower in divers as compared to the non-divers. The mean cell haemoglobin concentration (MCHC) was not significantly lower in divers than in non-divers. The mean platelets count was significantly lower in divers as compared to the non-divers, while the mean value of the mean platelet volume (MPV) was significantly higher in divers. The mean value of the erythrocyte sedimentation rate (ESR) was significantly higher in divers in comparison with non-divers.

Table 2. ***Mean values of selected hematological parameters in divers in comparison with non-divers.***

Haematological parameter	**Divers Mean ±SD**	**Non-divers Mean ±SD**	**P-value**
WBC count (10^9/l)	6.94 ±1.69	6.62 ±1.43	*NS*
RBC count (10^{12}/l)	5.31 ±0.57	5.04 ±0.71	< 0.01
MCV (fl)	76.9 ±13.8	84.22 ±6.43	< 0.01
MCH (pg)	26.1 ±3.59	27.03 ±2.6	< 0.05
MCHC (g/dl)	31.77 ±3.4	31.79 ±2.25	*NS*
PCV (%)	41.8 ±3.42	42.11 ±3.23	< 0.01
Hb concent. (g/dl)	13.3 ±9.97	13.5 ±0.88	*NS*
Platelets (10^9/l)	180.5 ±23.18	203.2 ±42.8	< 0.01
MPV	7.71 ±1.02	6.95 ±0.67	< 0.05
ESR (mm/hr)	14.7 ±5.64	13.1 ±4.76	< 0.05

L= liter, fl= femoliter, pg= picogram, mm/hr= millimeter/hour

Table-3 displays the percentage of divers with low levels of the studied haematological parameters in relation to selected diving risk factors. It is clear that divers with duration of service of 10 years or more showed higher prevalence of low levels of haemoglobin, RBC count, PCV, and MCHC in comparison with divers with shorter duration of service. While the reverse was true regarding MCV, MCH, MPV, and WBC count. However, none of the differences were found to be statistically significant. The percentage of divers with low level of Hb, PCV, and MCHC was higher among divers with maximum depth reached of 10 meters or more than among those with depth < 10 meters. The reverse was true for RBC count, MCV, MCH, MPV, and WBC count, with no significant differences for all parameters. Higher percentage of divers with 1000 hours of diving or more showed low level of Hb, PCV, MCH and MCHC than those with <1000 hours. On the other hand, the reverse was observed regarding RBC count, MCV, MPV, and WBC count; the differences were not statistically significant. Seawater divers showed higher prevalence of low levels of Hb, RBC count, PCV, and WBC count than among fresh water divers. The reverse was true for MCV, MCH, MCHC, and MPV levels, with no significant differences for all parameters except for MCH low level which was significantly prevalent in freshwater divers. Divers using mainly pure oxygen during diving had a higher prevalence of low levels of Hb, RBC count, MCV, PCV, and MCHC, while they had a lower prevalence of low levels of MCH, MPV, and WBC count than divers using air, with a significant difference for Hb only.

Table 3. ***The prevalence of low levels of haematological parameters in relation to selected risk factors***

Risk factor	No. divers	Hb level < 13.5g/dl		RBC count < 4.5million		MCV level < 80 fl		PCV level < 40%		MCH level < 27 pg		MCHC < 30g/dl		MPV level ≤ 6		WBC ≤ 10000	
		No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Dur. Service																	
< 10 years	30	14	46.7	1	3.3	14	64.7	8	20.7	20	66.7	5	16.7	29	96.7	1	3.3
≥ 10 years	50	32	64.0	4	8.0	22	44.0	20	40.0	25	50.0	11	22.0	46	92.0	1	2.0
P-value			NS		NS		NS		NS		NS		NS		NS		NS
Max. depth																	
< 10 meters	38	20	52.6	3	7.9	19	50.0	11	28.9	22	57.9	6	15.8	37	97.4	1	2.6
≥ 10 meters	42	26	61.9	2	4.8	17	40.5	17	40.5	23	54.8	10	23.8	38	90.5	1	2.4
P-value			NS		NS		NS		NS		NS		NS		NS		NS
Hrs of diving																	
< 1000 hr	59	32	54.2	4	6.8	27	45.7	19	32.2	33	55.9	11	18.6	56	94.9	2	3.4
≥ 1000 hr	21	14	66.7	1	4.7	9	42.8	9	42.8	12	57.1	4	19.1	19	90.5	0	0
P-value			NS		NS		NS		NS		NS		NS		NS		NS
Type of water																	
Fresh water	55	26	47.3	2	3.6	25	45.5	15	27.3	33	60.0	11	20.0	52	94.5	1	1.8
Sea water	10	6	60.0	2	20	4	40.0	3	30.0	3	30.0	1	10.0	8	80.0	1	10.0
Mixed	15	14	93.3	1	6.6	7	46.7	10	66.7	9	60.0	4	26.7	15	100.0	0	0.0
*P-value**			NS		NS		NS		NS		<0.05		NS		NS		NS
Type of gas																	
Air	60	20	33.3	3	5.0	26	43.3	18	30	35	58.3	13	21.7	56	93.3	2	3.3
Oxygen	9	8	88.9	1	11.1	4	44.4	5	55.6	5	55.6	3	33.3	8	88.9	0	0.0
Mixed	11	9	81.8	1	9.1	6	54.4	5	45.5	5	45.5	0	0	11	100	0	0.0
*P-value**			<0.01		NS		NS		NS		NS		NS		NS		NS

X^2 or Fisher Exact tests, where applicable, were used
* Exclusion of mixed in calculation of p-value

Table-4 shows the haematological changes after exposure to hyperbaric state in a hyperbaric chamber. The table shows that the WBC count, MPV, and ESR values were significantly increased after exposure to hyperbaric state, while the RBC count, Hb, MCV, MCH, MCHC, PCV, and platelet count were significantly decreased.

Table 4. ***The hematological changes after exposure to a hyperbaric state in a hyperbaric chamber***

Haematological parameter	Mean of the differences*	P-value
WBC count	- 0.95	< 0.01
RBC count	0.46	< 0.01
PCV	1.69	< 0.01
MCV	1.88	< 0.01
MCH	0.94	< 0.01
MCHC	0.51	< 0.05
Hb	0.44	< 0.01
Platelet count	27.48	< 0.01
MPV	- 0.95	< 0.01
ESR	- 4.44	< 0.01

*Mean difference = the level before exposure -the level after exposure

DISCUSSION

Both divers and non-divers groups were young adults. It seems that the matching process had achieved comparability of divers and non-divers regarding age, place of residence, smoking, alcohol intake, and years of service which may control the effect of these factors on the studied haematological factors. The mean value of RBC count was found to be significantly higher in divers as compared to non-divers. This could be attributed to acclimatization to hypoxia[13], to which divers were frequently exposed or it may be due to hypothermia since cold exposure is associated with an increase in erythrocytes [14] . However, the exposure of the divers to 2.5 ATA for 15 minutes in the practical part of the study, led to a significant reduction in RBC count. The latter finding agrees with the results reported by Edmond et al[7]. This reduction of RBC count after hyperbaric exposure can be explained by the fact that hyperbaric environment causes an aggregation of RBC[5]. The mean WBC count of divers was found to be higher than that of non-divers, also hyperbaric exposure in the chamber was associated with increase in WBC count which could be a generalized stress response to physical environment and psychological factors or it may be due to exercise which may induce an increase in lymphocytes count[15]. These results agree with that of other studies[7,16]. On the other hand, it is in contrast with the findings of Shinomyia et al[10], who demonstrated a significant decrease in the WBC count after diving. The mean haemoglobin concentration was found to be insignificantly lower in divers in comparison with non-divers. Similarly the hyperbaric exposure in the chamber showed a highly significant reduction in the haemoglobin level. This result is in agreement with that of Bergo et al[17], and Thorsen et al[18]. This reduction in haemoglobin could be explained by the haemolytic episode which might occur during the hyperbaric exposure[19]. The MCV, PCV, MCH, MCHC, and platelet count were found to be lower in divers as compared with non-divers. The same results were obtained in the practical part of the study where the values of these parameters were reduced in divers after exposure to the hyperbaric state. These results are consistent with that of other studies[6,11,16,20]. The reduction in MCH and MCHC may be attributed to the reduction in Hb level. While the reduction in platelet count could be due to platelets aggregation at high pressure[21]. The increase in ESR which was found in divers is in agreement with the results reported by Edmond et al[7]. This could be partly due to increased clumping of RBC and roulex formation[22].

In conclusion, divers were found to have changes in some haematological parameters in comparison with non-divers. These results were confirmed by exposure of those divers to hyperbaric state (2.5 ATA) for 15 minutes in a hyperbaric chamber. The need to introduce haematological investigations as a part of pre-employment check up of divers, and the periodic haematological investigations especially for those who have symptoms related to haemopoietic system, are recommended.

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