

THE EFFECT OF HIGH PRESSURES ON THE RADIOLOGICAL IMAGE OF THE MAXILLARY SINUSES IN DIVERS

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ABSTRACT

The study was performed on 38 divers of the navy. The research consisted in an analysis of RTG images of paranasal sinuses performed during control examinations. The authors compared sinus aeration in particular tests and calculated planimetric indices. It was concluded that an exposure to pressure fluctuations caused changes in the image and aeration of maxillary sinuses, which however did not have an effect on the diving capabilities of the tested group. Moreover, it was revealed that in a certain group of the subjects an exposure to hyperbaric conditions did not manifest any detectable lesions in maxillary sinuses.

Key words: diving, mucous membrane barotrauma, sinus barotrauma.

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INTRODUCTION

The effect of atmospheric pressure variations on paranasal sinuses was examined primarily in the conditions of low pressures experienced in aviation. It was found that the said effect could be expressed as acute barotrauma of the mucous membranes of sinuses occurring at pressure differences inside and outside the sinus. The difference of pressures appears in the case of an occlusion of the paranasal exit. Working in low pressures can also be conducive to an occurrence of chronic inflammatory changes within paranasal sinuses [1, 2, 3, 8,9, 10].

The effect of high pressure on paranasal sinuses is mentioned only by some authors, for instance, Dolatowski, Stengel [4,6], however systematic observations of sinus conditions in divers are non-existent. This is what convinced us in 1960 to undertake an attempt aimed at determining the impact of diving on the radiological image of sinuses.

MATERIAL AND METHODOLOGY OF OWN STUDIES

Our material encompasses 38 healthy divers, seafarers of compulsory military service aged between 20 and 23 years. The average depth reached during the dives was 60 m, and the pressure in a hyperbaric chamber amounted to 7 atm. The subjects underwent general and laryngological examination before exercise

commencement and then systematically in the course of diving. The observation period of particular divers lasted on average 16 months (the shortest 10 and the longest 25 months).

During this period about 3 or 4 radiological examinations on paranasal sinuses were conducted (the first before diving commencement, next during the training and upon service completion). Radiological images were performed in occipito-dental projection [7] trying to maintain similar technical conditions.

Sinus observation was focused on the maxillary sinuses. The forehead and ethmoidal sinuses have narrow and complex connections with the nose and are more susceptible to acute trauma during pressure fluctuations [10] however the evaluation of changes occurring within their mucous membranes is difficult to normalise.

This process is easily performed on the maxillary sinus, whose limitation through the bone structure is easily traceable, and the changes in its aeration do not raise major doubts. In order to achieve numeric representation of the changes occurring in the maxillary sinuses in divers we have implemented a method using the so-called planimetric index of aeration of the maxillary sinuses.

The said index expresses the ratio between the aerial area of the maxillary sinus and the area enclosed within the bone structure. The difference between these two measured areas on a radiological image shows the thickness of the mucous membrane of the sinus (Fig. 1).

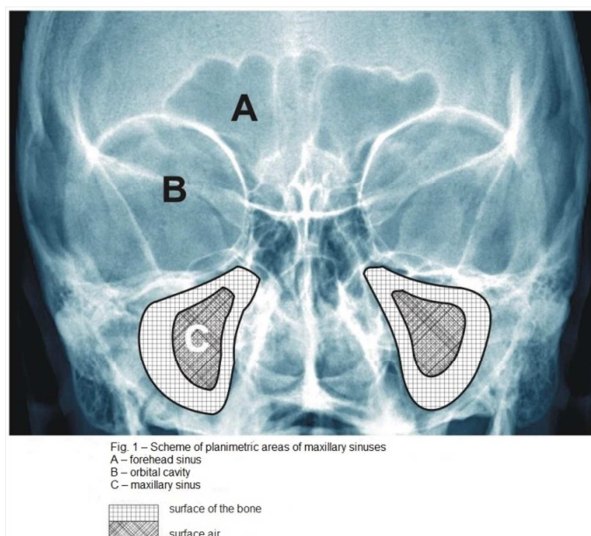


Fig. 1 – Scheme of planimetric areas of maxillary sinuses
 A – forehead sinus
 B – orbital cavity
 C – maxillary sinus

The indicators obtained during several consecutive tests on both maxillary sinuses allow observance of changes occurring in their aeration during dive performance. The measurement of sinus areas was carried out with the use of the Reiss planimeter. Contrary to the pneumatic indexes introduced by Pestieg [5] expressing the ratio of horizontal osseous diameter of the right maxillary sinus in comparison to that of the left, and nose diameter, the planimetric index takes into account changes in the configuration of the mucous membrane of a sinus.

Moreover, index calculations reduce errors that may occur in the performance of control images and facilitates comparison of various images. For the purpose of evaluation of the entire sinus it would be required to perform measurements also in the lateral projection. However, for our purposes it seems sufficient to consider solely the occipito-dental image. Below we present an example of a calculation of the planimetric aeration index for maxillary sinuses (Wpp.):

Tab.1

Sample Wpp calculation for maxillary sinuses.								
Maxillary sinus area in mm ²	Test 1		Test 2		Test 3			
	Sin. Wpp. R.	Sin. Wpp. L.	Sin. Wpp. R.	Sin. Wpp. L.	Sin. Wpp. R.	Sin. Wpp. L.	Sin. Wpp. R.	Sin. Wpp. L.
Aerial Osseous	360	380	310	300	290	240		
	0.9	0.9	0.76	0.72	0.72	0.57		
	400	420	405	415	400	420		
Average Wpp. for R. and L. sinus	0.9		0.74		0.64			

Planimetric aeration index of maxillary sinus

$$Wpp = \frac{\text{aerial area of maxillary sinus in mm}^2}{\text{maxillary sinus area enclosed with bone structure in mm}^2}$$

In order to facilitate material analysis we have additionally introduced an average index constituting the arithmetic Wpp mean for the right and left maxillary sinus:

$$Av.Wpp = \frac{Wpp \text{ for right maxillary sinus} + Wpp \text{ for left maxillary sinus}}{2}$$

Indexes close to 1 express ratios occurring in normal conditions in sinuses. Index reduction is an

expression of intensification of changes in the mucous membrane and a decrease in sinus aeration (see Tab. 1). An increase in the index is observed with an improvement in sinus aeration.

TEST RESULT

Our material, encompassing 38 divers, was divided on the basis of behaviour of planimetric indicators of the level of aeration of maxillary sinuses into 4 groups. The applied division and test results are presented on Tab.2.

Tab.2.

Average Wpp for both maxillary sinuses in 38 divers.						
o.	Group	Number of cases	Average Wpp value for both maxillary sinuses			
			Before diving	During diving	After diving completion	
1.	Worsening in maxillary sinus aeration	23	0.63	0.57	0.5	
2.	Unchanged sinus aeration	9	0.77	0.79	0.78	
3.	Improved sinus aeration	3	0.45	0.85	0.72	
4.	Periodic change in sinus aeration	3	0.75	0.61	0.77	

The most numerous group (23 cases) were divers with observable gradual characteristic ($d=4.3$) worsening in the aeration of the maxillary sinuses. The second group (9 cases) did not manifest any characteristic changes in sinuses ($d=1.2$) during the observation period. The third and fourth groups, the least numerous (3 cases each), and thus not allowing one to draw conclusions, consisted of divers manifesting a certain improvement in sinus aeration in the course of diving, or periodic worsening with return to the initial state.

Within forehead sinuses, by generally accepted evaluation criteria of radiological images, only in 2 cases was there transitional shading noted (which regressed without treatment), and in 1 case the absence of both forehead sinuses and in 1 case the absence of right forehead sinus. Changes in ethmoidal sinuses usually occurred parallel with changes in the maxillary sinuses.

In the observation period, the examined divers did not require specialised treatment. In 2 cases they reported transitional headaches during deep dives. In 7 cases the authors noted septum deviation without effect on its patency and not related to changes in the aeration of paranasal sinuses. Infectious foci related to

pathological changes in sinuses have not been confirmed. Mild rhinitis was rare among the observed divers, with equal distribution in all groups. This can be linked to uniform living conditions of the divers.

The analysis of our material allows the presumption that similarly to aviation [10] changes in the atmospheric pressure observed during diving can have an effect on the mucous membranes of the maxillary sinuses. Only some of the divers reacted positively to pressure variations.

The majority of subjects (23) revealed a gradual decrease in sinus aeration. Presumably, the reason can be sought in a "barotrauma" of the mucous membrane followed by vasomotor and secondary inflammatory changes causing a gradual reduction in the aeration of the maxillary sinuses. Nevertheless, the said changes did not affect the capabilities to perform dives and usually did not present subjective ailments.

A less numerous group (9 cases) consisted of divers with no observed changes in the aeration of the maxillary sinuses. They could be seen as resistant to pressure variations within these sinuses. Only in a limited number of subjects (groups with 3 cases each) was it possible to observe an improvement or only periodic



worsening in aeration. The limited material that is currently available does not yet enable the drawing of final conclusions.

It seems, however, that besides sensitive individuals there is a relatively numerous group of people resistant to pressure changes in the maxillary sinuses. In the examined divers the said ratios stand at 23:15 (group I to II+III+IV acc. to Tab.2). A question arises why the changes observed in our material were mainly related to the maxillary sinuses? According to the majority of authors observing the behaviour of paranasal sinuses in low pressures, it is the forehead sinuses that are mainly susceptible to barotrauma.

In divers subjected to observation over many months, the changes were probably mainly limited to the maxillary sinuses because of pressure variations with frequent and long-lasting microtraumatisation of the mucous membrane, or through repeated movement of pathological secretion from the nose into the sinuses, facilitated an occurrence of secondary inflammatory changes. This can be facilitated by broad and convenient connections between the maxillary sinus and the nose. Forehead sinuses, on the other hand, are more prone to

be affected by "acute barotrauma" with existing conditions of the nose and sinuses.

We have not noted significant differences in the aeration changes in the right and left maxillary sinus.

CONCLUSIONS

1. Changes in the atmospheric pressure that have an effect on humans during frequent dives can lead to an occurrence of changes in the mucous membrane of the maxillary sinuses.
2. In the assessment of changes occurring within the maxillary sinuses it seems favourable to use the planimetric sinus aeration index worked out by the authors.
3. Changes in the aeration of the maxillary sinuses in divers did not reduce their capabilities to work under water.
4. It appears that there are individuals who are resistant to pressure variations within the maxillary sinuses.

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