ON THE TOXICITY OF OXYGEN FOR PIG ASCARIDS

N. P. Kravets

From the Stanislav Regional Antimalaria Station (Head - T. I. Yunosheva)

(Received November 1, 1955. Submitted by Academician E. N. Pavlovsky)

As many observations have shown, the majority of preparations which have been used recently to eliminate ascarids from the intestines have not fulfilled the hopes placed in them; some were eliminated on account of low effectiveness, others on account of their toxicity for man. Santonin and wormseed proved to be best. Recently Sankafen (to a lesser degree oil of chenopodium and hexylresorcinol) are becoming widely used in everyday practice.

The mechanism by which these preparations act on the ascarid and human system has not yet been fully studied. The inadequacy of our knowledge concerning some of the physiological peculiarities of ascarids, without which it is sometimes impossible to affect their life and to work out an effective therapy, plays a substantial role in this problem. With respect to type of metabolism, helminths must be placed in this or that group not according to the usual morphological signs, but according to their existence under these or those conditions which have a special effect on the biochemical processes which are carried out in the organism of the parasite.

Data of an analysis of the intestinal gases (Brand and Veze, 1932, cited from I. I. Ivanov) show that in the large and small intestines of animals and man, oxygen can exist as traces only, at most (from 0 to 0.358% by volume with respect to the other intestinal gases).

The fact that the microflora in the intestines is represented by typically anaerobic microorganisms also indicates the presence of anaerobic or almost anaerobic conditions in the digestive tract of mammals. Consequently, ascarids live in an environment practically devoid of oxygen.

Much polysaccharide is required in order to obtain energy under anaerobic conditions and ascarids actually as the investigations of I. I. Ivanov [2] showed, contain from 4.2 to 7.1% glycogen, from 20-34% in the desiccate. It is the result of this large accumulation of glycogen that the existence of helminths in the intestines of the animal hosts is possible.

The splitting of polysaccharides in ascarids can proceed by virtue of the enzymes of the host, as well as of the parasite itself (amylase has been found in the intestines of ascarids). The metabolic end products of ascarids have been found to be CO_2 and volatile fatty acids (chiefly valeric), as well as a small amount of lactic acid.

Consequently, ascarids live in an anaerobic atmosphere; their metabolism is based on the anaerobic type (I. I. Ivanov).

On the basis of the above it seemed interesting, from our point of view, to change the atmosphere surrounding the ascarids by introducing oxygen into the intestines, which, as is known, is well tolerated by the human organism.

However, before introducing oxygen into the human intestine, we considered it necessary to carry out experimental investigation of pig ascarids because, on the one hand, it is very difficult, if not impossible, to obtain a live human ascarid, and on the other hand, pig ascarids differ little from human ascarids in their biological and morphological properties.

We succeeded in obtaining live parasites in sufficient quantity at the Stanislov Meat Combine, where we carried out observations directly at the slaughterhouse. Usually 15-20 minutes after the pig was killed, it was skinned and the carcass was hung on hooks. Immediately, at a slight distance, the abdomen was opened and (without removing the internal organs) the small intestine was examined (the intestine was palpated throughout its length with both hands at once). We compared our data on finding ascarids with the data of the controllers of the intestine shop. Having examined 450 pigs, we found ascarids in all but two cases. We found ascarids in the small intestine primarily by palpation. We assigned especial significance to the spastic state of the small intestines, since we usually found ascarids at the places where there was spasm.

The following observation is very significant: an "ascarid" was found by us through palpation in one animal, but there was no spasm in this section of the intestine.

After the intestine was opened, instead of an ascarid, a piece of rope about 30 cm long was found in its contents. It must be assumed that intestinal spasm develops as a result of the fact that the ascarids, either by their active movements or by excreting some toxic substance, irritate the intestinal walls.

Ascarids, which are usually found in the intestines in an extended position, can move slowly (up to 1 cm in 30 minutes) back and forth along the intestine.

Having found ascarids (in the first series of experiments), we removed them from the intestines and placed one of them (or two, depending on the number of parasites) in a glass cylinder which was hermetically sealed and filled with oxygen, and another in the same kind of cylinder filled with atmospheric air. The temperature of the air in the cylinder was 22-24°.

The ascarids which were placed in the cylinder with oxygen, after making a few motions, seemed to become quiescent. From the 20th minute, no independent motions of any kind could be observed among them and only after the position of the cylinder was changed did they make a few pendulum-like movements within a range of 2-3 mm) with their anterior and posterior ends. From the 30th and 40th minute it was impossible to evoke the indicated movements of the parasites, even when the position of the cylinder was changed, and only heating the metal base of the cylinder on an alcohol lamp caused a hardly noticeable movement of the ascarid.

Of 14 parasites which were in an atmosphere of oxygen, 4 died in 50 minutes, 3 in 60 minutes, 4 in 70 minutes and 3 in 80 minutes. Thus, the death of the parasites occurred in 50 to 80 minutes according to our observations.

The life span of the ascarids which were placed in a cylinder filled with atmospheric air was different. We observed more active movements here at first, which later became weaker and weaker. Beginning with the fourth hour of their existence in the cylinder, it was only possible to bring the parasites out of their torpor by heating. In 4 hours, 2 of the 14 experimental ascarids died; in 4 hours 30 minutes, one; in 6 hours, one; in 8 hours, 4; in 10 hours, 4; in 11 hours, one; and in 12 hours another one. The average life span of the ascarids in atmospheric air, according to our data, varied between 6 and 7 hours and exceeded even 10 hours for a small number of worms.

In the second series of experiments we tried to observe the ascarids under the physiological conditions most natural for them.

Having found ascarids in the small intestine after the slaughter of a pig, we tied off this area of the intestine (about 30 cm in length) on both sides, placed it in a vessel filled with warm physiological solution, and filled the intestine with oxygen. The temperature of the physiological solution was maintained all the time at 40-42° (the temperature of the animal's abdominal cavity). The average life span of the ascarids in the intestine filled with oxygen and in the cylinder with oxygen equalled approximately one hour.

In 10 cases, the ascarids were left in an intestine which was filled with atmospheric air and immersed in warm physiological solution. The results obtained differed little from the data which were obtained by us when the ascarids were placed in a cylinder with atmospheric air; the average life span of the ascarids in atmospheric air was 10 hours according to our observations.

In our observations we did not observe any significant difference between the behavior of the males and females, but we got the impression that the males are less hardy than the females.

Thus, experimental data prove with sufficient force that oxygen has a fairly rapid, toxic, paralyzing effect on ascarids, shortens their life span by many times, and, which is especially important, the parasites which are killed, die on the spot, without crawling along the intestine.

These observations served as the basis of the highly effective therapy of ascariasis in man which has been worked out by us.

The direct reason for the death of the ascarids, it can be assumed, is the accumulation of hydrogen peroxide. The content of catalase (the enzyme which decomposes H_2O_2) was indeed found to be low in the body of the ascarid.

According to Moulder [8], the possible mechanism of the toxic effect of oxygen on ascarids can occur in three ways:

1) oxygen can oxidize some essentially important enzymes, growth substances or substrates which are active only in their reduced form;

2) oxygen can form free, inactive complexes with some essentially important enzymes, growth substances and substrates;

3) oxygen can take part in a reaction in which toxic substances are formed.

Oxygen is very reactive and can combine for a variable period of time with substances essential for the normal functioning of the ascarid organism.

SUMMARY

A toxicity of oxygen for pig ascarids has been determined; in air they live from 2 to 12 hours, in pure oxygen they die on an average within 1 hour.

LITERATURE CITED

[1] Kh. I. Vainshtein, Oxygen Insufficiency and Oxygen Therapy,* 1948.

[2] I. I. Ivanov, in the book: Work of the Helminthological Laboratory, Moscow-Leningrad, 1950, vol. 4, pp. 139-166.

[3] N. P. Kravets, Meditsinskaya Parazitologiya, 1951, vol. 20, issue 2, pp. 122-124.

[4] N. P. Kravets, Vrachebnoe Delo, 1954, No. 3, pp. 219-222.

[5] V. P. Podyapolskaya and V. F. Kapustin, The Helminthic Diseases of Man,* Moscow, 1950.

[6] N. N. Savitsky, Oxygen Therapy,* Leningrad, 1940.

[7] T. Brand, J. Parasitol, 1950, vol. 36, No. 3, pp. 178-192.

[8] J. W. Moulder, J. Parasitol., 1950, vol. 36, No. 3, pp. 193-200.

* In Russian.