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Experimental Hematotympanum – Aspects to the Tympanosclerosis Development

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A B S T R A C T

The etiology of tympanosclerosis is very complex and has not been entirely clarified. In order to find out if blood could be a provoking factor and cause tympanosclerosis, the authors injected the blood into the ears of 32 guinea pigs. The animals were sacrificed at weekly intervals up to one month and the histological analysis of the temporal bones was performed. Their experiment has shown that mucosal changes, similar to those seen in the early stage of tympanosclerosis, can appear in a certain number of cases. As a result, they recommend the aspiration of blood from the middle ear cavity in the cases of middle ear trauma with hematotympanum. They recommend the same procedure for operations of the middle ear, which should be performed with adequate hemostasis to prevent possible tympanosclerosis development.

Introduction

Tympanosclerosis is a disease in which acellular hyaline and calcified deposits accumulate within the tympanic membrane and the submucosa of the middle ear. The characteristics of tympanosclerosis were first mentioned and described by von Tröltsch in 1869[1]. Aboulker offered a good definition of this pathological process: tympanosclerosis is the fibrohyalin degeneration in the submucosa of the middle ear, but with the preservation of the middle ear cavities[2]. Tympanosclerosis appears in two different forms. The diffuse form is very rare and converts the mucosa of the middle ear to the thick, hard, white mass which makes the middle ear look like the inside of the sea shell. In the localized form of the tympanosclerosis, hyalinization and calcification with osteoneogensis within the lesions occur in various parts of the ear – from tympanic membrane (plaques) to the hearing ossicles (ossicular fixation is most frequent in the attic). Although tympanosclerotic plaques on the eardrum are clinically insignificant and cause lit-

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tle or no hearing impairment in most cases, the ossicular fixation in the middle ear in advanced stages of the illness (or in the case where tympanosclerosis occur around the stapes plate) often leads to major conducting hearing loss.

The final answer to the question of the etiology of tympanosclerosis has not yet been found[3]. Acute and chronic inflammation of the middle ear are the most frequent causes, but trauma, iatrogenic damage to the middle ear, rheumatic diseases, collagenosis and allergy have also been cited as potential causes[4–7]. Development of tympanosclerosis is a slow process; according to Gunersen, it takes at least 10 years for mature forms of tympanosclerosis to appear[8]. Histological analysis in the early stages of tympanosclerosis shows severe inflammatory infiltration and the presence of collagenic tissue. Mature stages of tympanosclerosis are characterized by presence of cartilage or bone.

In management of the disease, a tympanoplasty and ossicular reconstruction as well as a stapedectomy can be performed. In spite of the fact that hearing loss in tympanosclerosis can be successfully surgically treated[9,10], some long -term follow-up studies reported a large number of recidives[11], questioning the advisability of stapedectomy in the ears with tympanosclerosis.

The focus of our interest was the appearance of tympanosclerosis in certain number of cases induced by trauma. We wanted to know whether blood as a provoking factor could cause the tympanosclerosis.

Material and Methods

Thirty-two healthy guinea pigs, approximately one year old and weighing 300 to 450 grams were used in the experiment. Otoscopy was performed initially to establish that both ears of each guinea pig were healthy prior to the beginning of the experiment.

The chest of each guinea pig was shaved so that it was completely hairless. The animals were anaesthetized by ether, shaved area of the chest was cleaned, and about 1 cc of blood was aspirated from the heart with a gouge needle. The ear and external meatus were cleaned with Desdermann solution, and blood was then injected through the tympanic membrane to the bulla tympanica. This procedure was performed on one ear of each animal, while the other ear was used as a control. No surgery or any other procedure was performed on the control ear. The guinea pigs were postoperatively treated with antibiotics for a week, in order to prevent possible infections. The animals were sacrificed at regular post-operative intervals of one, two, three, and four weeks. Both temporal bones of each animal were removed and fixated in Heidenhaim Susa solution for three days. Following the procedure, the bones were rinsed in water for 24 hours. After that, they were dehydrated and set in celoidin, where they were kept for two months before being placed in 70 % alcohol until cutting. Each bone was cut serially, the thickness of the cut ranging from 12 to 16 microns. Staining was carried out using the hematoxin-eosin, Mallory and Azan techniques.

Results

Histological analysis of the temporal bones of the first eight animals, sacrificed seven days after the instillation of blood, gave us the following results. No changes were found in three animals, the mucous membrane was completely unaffected, and there was no trace of blood (Figure 1). Remains of the hemolyzed blood and inflammatory infiltration in the lamina propria were found in the remaining five animals.

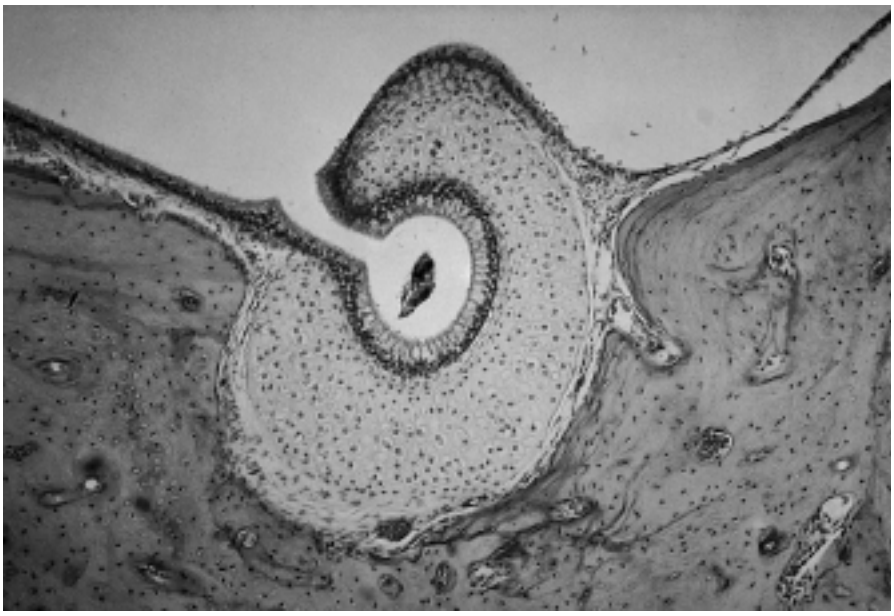

Fig. 1. Normal epithelium of the middle ear of a guinea pig. Magnified 90×.

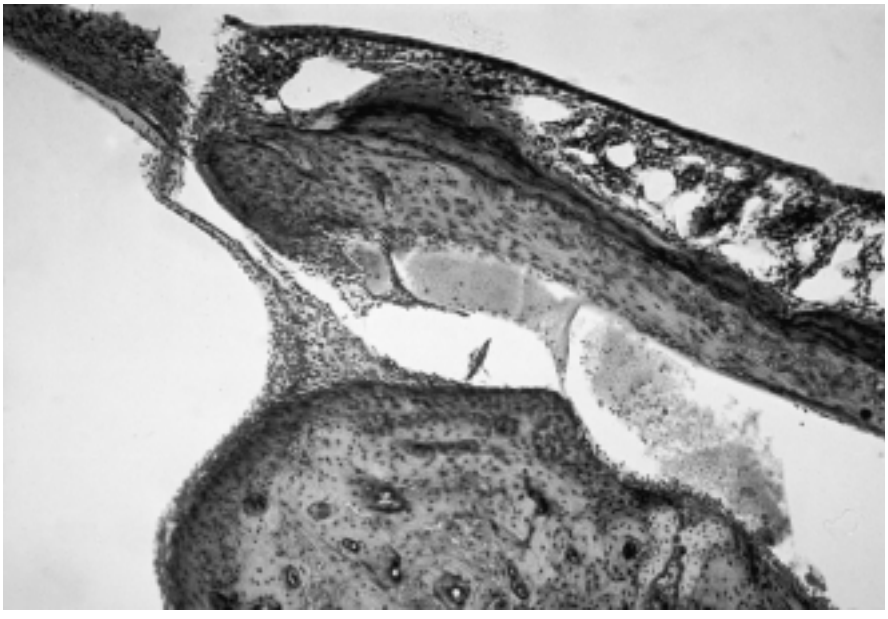

Fig. 2. Severe edema in the lamina propria of the middle ear mucous membrane of a guinea pig, 14 days after the instillation of blood. The surface layer of the epithelium is completely normal (arrow). Swollen capillaries full of erythrocytes can be seen. Magnified 175×.

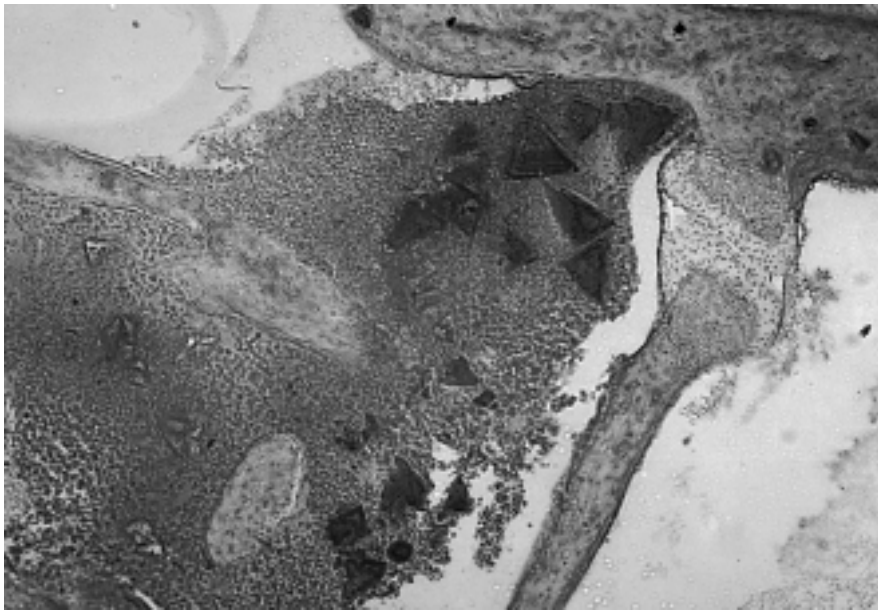

Fig. 3. The beginnings of the appearance of loose connective tissue in the lamina propria can be seen, as well as a few hemosiderin crystals next to the surface layer. Histological picture of the mucous membrane of guinea pig four weeks after the instillation of blood. Magnified 175×.

No change was found in two animals from the group sacrificed fourteen days after the instillation of blood, while inflammatory infiltration in the lamina propria, accompanied by severe edema of the mucous membrane, was found in the remaining six animals (Figure 2). The epithelial layer of the mucous membrane was completely unaffected. Siderophages were identified in the remains of the blood. It should be noted that certain bundles of collagenic tissue were detected in the edematous layer with the Mallory and Azan techniques.

Except in five animals, which showed no histological changes in the middle ear mucosa, inflammatory infiltration accompanied by severe edema of the mucous membrane and hemosiderin crystals was found in all other animals in the third and fourth group. The continued presence of the edema in the subepithelial layer of the lamina propria, together with the appearance of the inflammatory cells and collagenic tissue, was found in only four animals after the histological analysis of the temporal bone taken from the animals sacrificed three or four weeks after the instillation of blood in the middle ear (Figure 3). The epithelial layer of the middle ear mucosa was intact in all 16 animals.

Discussion

Trauma is undoubtedly one of the factors in the etiology of tympanosclerosis. Since we were interested whether bleeding could be one of the triggers in the process of tympanosclerosis development, we have performed a study in which we tried to imitate this process in experimental conditions.

The experiment has shown that the instillation of blood in the middle ear under sterile conditions can produce changes in the lamina propria of the mucous membrane, similar to those found in the early stages of human tympanosclerosis. Disorders in blood elimination from the middle ear lead to hemolyzation and the formation of hemosiderin, which is fagocitozed by macrophages in the lamina propria of the middle ear mucosa. This leads to the inflammatory process and development of edema in this area, with formation of the connective tissue later on. Since development of tympanosclerosis is an extremely long process (about 10 years), it is obvious that we have found no specific changes typical for this disease (cartilage and bone tissue) during the histological analysis of our samples. In addition, no changes in the middle ear mucosa were found in 10 animals: we believe the blood was eliminated through the Eustachian tube, and therefore the inflammation process did not occur. We believe that for the characteristics of advanced tympanosclerosis to appear, the experiment needs to be carried out over a period much longer than four weeks. Nevertheless, the changes found in the first month after the beginning of the experiment resemble those in the early stage of tympanosclerosis to such a degree that we accept as true that bleeding in the middle ear may cause tympanosclerosis.

Conclusion

Tympanosclerosis is a pathological state of the middle ear, which can be caused by various etiological factors. One of these factors could be bleeding, which in some cases may lead to the tympanosclerosis development after a certain number of years. If further, long term investigation, confirm our study, we think it would be wise to eliminate the blood found in the middle ear after the trauma, in order to avoid the possible appearance of tympanosclerosis later on. In addition, operations of the middle ear should be performed on a maximally dry ear, so that the blood left in the middle ear could not influence to the possible postoperative development of tympanosclerosis and subsequent hearing loss.

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EKSPERIMENTALNI HEMATOTIMPANON – UTJECAJ NA RAZVOJ TIMPANOSKLEROZE

S A Ž E T A K

Timpanoskleroza je bolest srednjeg uha čija etiologija još uvijek nije dovoljno razjašnjena. Kako bi potvrdili hipotezu da je prisustvo krvi u kavumu timpani mogući uzročni faktor te bolesti, autori su načinili pokus u kojem su u srednje uho 32 zdrava zamorčića ubrizgali krv. Životinje su žrtvovane 7, 14, 21 te 28 dana nakon ubrizgavanja krvi, nakon čega je provedena histološka analiza njihovih temporalnih kostiju. U određenom broju preparata nađene su promjene u sluznici srednjeg uha koje su bile identične onima koje se pojavljuju u ranim stadijima timpanoskleroze. Obzirom na prikazane rezultate, a s ciljem sprečavanja mogućeg razvoja timpanoskleroze, autori preporučuju odstranjivanje krvi iz srednjeg uha u slučaju pojave hematotimpanona nakon traume ili tijekom operacije na srednjem uhu.