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Retraction pockets of the tympanic membrane – introduction to the development of cholesteatoma

Kieszonki retrakcyjne błony bębenkowej – wstęp do rozwoju perlaka

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Summary

The tympanic membrane retraction pocket is a phenomenon that is described as a deformation of the tympanic membrane (most often hollow) caused by long persistent negative pressure inside the tympanic cavity.

There are many theories about the pathomechanism of the formation of retraction pockets, but the most probable seems to be the one that talks about pockets as a natural attempt by the body to heal inflammation in the tympanic cavity. Most untreated retraction pockets can lead to the development of cholesteatoma, which is so important knowing the classification of pockets. Due to it, it is possible to properly assess pathology and apply an appropriate treatment.

There is no standardized scheme to the treatment of retraction pockets. Everything depends on the severity of the disease as well as on the co-occurrence of the upper respiratory tract infections or ear effusion.

Streszczenie

Kieszonka retrakcyjna błony bębenkowej to zjawisko, które jest opisywane jako deformacja błony bębenkowej (najczęściej wpuklenie) spowodowana długotrwałym utrzymującym się nadmiernie ujemnym ciśnieniem wewnątrz jamy bębenkowej. Istnieje wiele teorii patomechanizmu powstawania kieszonek retrakcyjnych, jednak najbardziej prawdopodobną wydaje się ta, która mówi o kieszonkach jako o naturalnej próbie samowyleczenia przez organizm stanu zapalnego w jamie bębenkowej. Większość nieleczonych kieszonek retrakcyjnych może doprowadzić do rozwoju perlaka, dlatego tak istotna jest znajomość klasyfikacji kieszonek. Dzięki niej istnieje możliwość właściwej oceny patologii oraz zastosowania odpowiedniego leczenia.

Nie ma ujednoczonego schematu postępowania w leczeniu kieszonek retrakcyjnych. Wszystko jest uzależnione od stopnia zaawansowania schorzenia i od współwystępowania infekcji górnych dróg oddechowych czy wysięku z ucha.

ETIOLOGY AND PATHOMECHANISM OF THE FORMATION OF RETRACTION POCKETS

The retraction pocket is a partial or complete deformation of the tympanic membrane, most often in the form of an indentation in the middle of the tympanic cavity. Originally, the formation of retraction pockets was associated only with the consequences of closed tympanoplastics, which led to recurrence of cholesteatoma. Later, on the basis of research and observations, the formation of these characteristic pits was confirmed, also when no operations were performed on the tympanic

membrane (1). Currently, retraction pockets are mainly referred to as secondary membrane changes that arise as a consequence of excessively long negative pressure inside the tympanic cavity which is maintained for too long. This phenomenon is related to the dysfunction of the Eustachian tube. In a properly functioning ear – air is present in the tympanic cavity. Under physiological conditions, this air is absorbed by the middle ear lining, which determines the formation of negative pressure (normally, in healthy people, a slightly negative pressure is maintained in the middle ear).

In the middle ear, the Eustachian tube is responsible for gas replenishment, which opens during swallowing or yawning, which allows the pressure in the tympanic cavity to equilibrate during this time. Thus, if a patient has impaired functioning of the Eustachian tube, he experiences significant pressure drops in the middle ear. The three-layer structure of the tympanic membrane (skin, elastic layer, mucosa) maintains its strength. However, in a situation of maintaining a strong negative pressure, the elastic layer may be significantly weakened (of a diffuse or limited nature), while the entire tympanic membrane is inclined towards the medial wall of the tympanic cavity. This indentation may be uneven and affect different parts of the tympanic membrane, but the most common location of the retraction pockets is the epitympanal (due to the lack of elastic fibers) and the postero-superior quadrant of the taut eardrum. The location of the indentations in this quadrant and in the flaccid part of the tympanic membrane is probably caused by frequent inflammations of the middle ear, which lead to a particularly intense inflammatory reaction of these parts of the membrane (1, 2).

It is recognized that the indirect causes of the development of retraction pockets may be frequent middle ear infections or recurrent catarrh of the Eustachian tubes. However, the presence of pockets is also strictly associated with the presence of exudative fluid in the tympanic cavity (exudative otitis media) containing numerous enzymes (2).

The formation of retraction pockets includes: loss of collagen fibers of the tympanic membrane, formation of a hernia sac and symptoms of bone or malleolus destruction. The degree and extent of all these processes change as the pocket evolves. The mechanisms causing the formation and evolution of retraction pockets can be divided into: intra-drum and extra-drum. The first are collagenases and other proteolytic enzymes. At the beginning, the structure of collagen fibers in the lamina propria of the tympanic membrane is broken down into parts, which are then digested by proteolytic enzymes. These compounds are present in both the inflammatory exudate and the swollen lining of the middle ear. Destructive processes that affect both the lamina propria and the epidermis, first lead to the suction of the tympanic membrane – the formation of a retraction pocket, and ultimately most often lead to perforation of the membrane. On the other hand, the determinant of the extra-tympanic mechanism is the proteolytic activity of the inflammatory epidermis. The epidermal hydrolases and lysozymes are capable of destroying not only the collagen fibers of the eardrum, but also the adjacent bones and ossicles. This process is very intense in deep pockets with accumulated epidermis inside (possible infection) (2).

It is worth knowing that some pockets may regress spontaneously, some will remain unchanged, some will enlarge, causing the destruction of the ossicles and hearing loss, and some will deepen, leading to the development of cholesteatoma. The new hypotheses

interpret the origin of the retraction pocket as a natural attempt by the body to heal the inflammation in the tympanic cavity, just like analogous phenomena in the body, such as the migration of the greater net towards local inflammation in the abdominal cavity (1-6).

TREATMENT OF RETRACTION POCKETS

The therapeutic management of retraction pockets remains an open topic. At present, there is no unified scheme of action, as well as no single generally accepted classification for the clinical advancement of pockets. Treatment of patients depends mainly on the degree of lesions development, the coexistence of diseases of the upper respiratory tract or the coexistence of exudative inflammation of the middle ear (3). The therapeutic management should take into account in particular:

- regular, thorough examination of changes using an operating microscope and an endoscope,
- elimination of epidermal deposits mainly from the epitympanal part of the pockets,
- efficient and adequate treatment of infections as well as exudative and acute otitis media,
- treatment related to nasal obstruction, inflammation of the nose, sinuses and throat.

If we exclude the presence of fluid in the middle ear, conservative treatment is recommended in various forms: from observation, administering anti-inflammatory and mucolytic drugs, to blowing the Eustachian tube or using KINETUBE or AMSA aerosol therapy (4). Such actions result from clinical observations, and these indicate regression of invaginations with age (such delicate changes most often concern children) (5).

As for the coexistence of the retraction pocket with the exudate, it is usually associated with a worse course and a lower tendency to regress. The rule in this situation is to drain the tympanic cavity or cut out a pocket that will allow the opening of the middle ear space. The healing process, on the other hand, should contribute to the spontaneous closure of the perforation. However, if the eardrum does not rebuild, after some time (when there are frequent infections of the main respiratory tract), myringoplasty can be performed (4).

The third stage of the retraction pocket (according to Charachon's classification) severity indicates early, preventive tympanoplasty, strengthening of the tympanic membrane with cartilage and drainage. Surgical treatment can effectively protect the patient against the development of cholesteatoma, and also gives a better chance of recovery (4).

Pockets, which are also classified for tympanoplasty surgery, are indentations of the tympanic membrane without the possibility of controlling it under a microscope (usually these are preperlastic states). The only alternative to determine or rule out the development of cholesteatoma is to view them with a 30° endoscope. This type of pockets is often characterized by conduction hearing loss (above 30 dB) caused by the destruc-

tion of the ossicular chain or infection of the pocket, which is manifested by: epidermal accumulation, leakage, and even the development of a polyp (4, 7).

As in the case of precocular conditions, actions undertaken in situations of generalized retraction of the tympanic membrane. This is justified because clinical practice shows that conservative treatment gives no results and drainage is usually impossible. Tympanoplasty in these cases consists in increasing the strengthening of the tympanic membrane and ossiculoplasty (if the ossicles have been damaged) (4, 5, 7).

Based on the above assumptions, it is possible to present a universal algorithm for the treatment of patients with retraction pockets of the tympanic membrane, which is presented in the table 1 (4).

Tab. 1. The scheme of therapeutic management in patients with retraction pockets

Type of retraction pocket/localization	Stage in modified Charachon scale
Epitympanal	I – observation (if exudation over 3 months – drainage); II – drainage (when auditory ossicles chain is damaged – preventive tympanoplasty is recommended); III – preventive tympanoplasty
Upper-posterior	I – observation or drainage; II – drainage or resection; III – preventive tympanoplasty
Mixed	I – observation or drainage; II – drainage or resection; III – preventive tympanoplasty
Total	I – observation or drainage, resection II and III – observation or preventive tympanoplasty
Precocular condition	Tympanoplasty

ETIOLOGY AND ORIGIN OF CHOLESTEATOMA

A cholesteatoma is a structured cystic body from multilayered keratinizing squamous epithelium, filled with keratin deposits and surrounded by inflamed connective tissue. During development, cholesteatoma grows within the middle ear and destroys nearby bone structures (8).

There are many theories about the origin of the squamous multilayer epithelium present in the tympanic cavity. According to the theory of migration, this epithelium grows from the external auditory canal or the eardrum due to earlier perforation. The theory of metaplasia assumes that the epithelium covering the ear mucosa under the influence of inflammatory factors transforms into multilayered keratinizing epithelium. Another hypothesis, which is related to the retraction pockets, is that the cells of the basal layer grow as a result of microdamages caused by inflammation (6).

Each of the theories mentioned is supported by arguments, which makes them credible, but none is clearly proven. It is believed that the most likely pathway for cholesteatoma is development from retraction pockets, or the intussusception theory. It says that the evolution of the retraction pocket is due to the growth of the multilayered squamous epithelium and the loss of self-cleaning ability. As a consequence, masses of keratin accumulate in the resulting cavity, causing in-

flammation similar to the reaction to a foreign body. It is obvious that the direct factors for the development of these invaginations are negative pressure in the tympanic cavity and inflammation. However, it is still unclear what circumstances favor the reconstruction of the stable flat epithelium of the retraction pockets into an actively multiplying epithelium with disturbed migration process (6, 8, 9).

According to Jackler et al., the reason for the further intrusion of the retraction pocket into the tympanic cavity is its contact with the mucosa of the middle ear and its subsequent pulling due to the moving mucus layer on the mucosa or directly by the movement of the cilia of the mucosa. Also, the gradual sticking of the two surfaces and the disappearance of the mucosa can determine the inward pull of the pockets. This mechanism would explain the development of cholesteatoma in patients in whom tympanic disturbances were not observed. However, this still does not prove why, in many cases of fixed retraction pockets, they were never modified into cholesteatoma (10).

It is said that inflammation of the middle ear is inherent in the development of the retraction pocket and cholesteatoma, and if they persist for a long time, they destroy the fibrous layer of the strained tympanic membrane. As a result, this layer becomes flaccid and is easily pulled into the tympanic cavity, where there is negative pressure due to the dysfunction of the Eustachian tube and inflammation. Hüttenbrink (6) believes that both retraction pockets and cholesteatoma develop as a result of the natural self-healing mechanism of inflammation within the body cavities. It works by covering inflammation with immunologically active tissue in order to contain and close it. Considering that in the vicinity of the tympanic cavity only the tympanic membrane is a movable element, it serves as the tissue to close the inflammation. Thus, the eardrum is sucked to close the inflamed space (6, 8).

The epithelium of cholesteatoma resembles in many ways the changes that can be seen during the healing of skin wounds. The difference is that this process stops at the inflammatory stage when it proliferates (multiplies), and scarring never occurs. We can see a special similarity when compared to the healing process of the perforation of the tympanic membrane – at the beginning, the perforation heals by the growth and migration of the multilayered squamous epithelium. The wound healing mechanism would probably be stimulated as a result of microcracks in the basal membrane of the retraction pocket. This process triggers a number of inflammatory response mechanisms that activate hyperproliferation of epithelial granulation tissue as well as neovascularization (the formation of new blood vessels in tissues where they usually do not exist). By analogy with the development of cholesteatoma, epithelial cells and stroma interact – these structures mutually determine their growth with the help of growth factors, mediators of inflammation (8).

Apart from the aforementioned causes of cholesteatoma, leading directly to the development of retraction pockets, it has also been proven that cholesteatoma is much more common in patients with congenital craniofacial defects (e.g. cleft palate). Injuries to the ear – especially the eardrum, may also be responsible for the development of cholesteatoma.

DIAGNOSIS OF CHOLESTEATOMA

In clinical practice, there are two types of cholesteatoma:

- congenital cholesteatoma – diagnosed in young children (up to 4-5 years), visible in otoscopy as a pearly color and structure, located behind the preserved tympanic membrane; such cholesteatoma develops from persistent embryonic tissue in the rocky part of the temporal bone; the most common location is the antero-superior quadrant of the tympanic membrane, but as cholesteatoma grows, it occupies the posterior part of the tympanic cavity, the parapet and mastoid cells; in the non-advanced stage, this cholesteatoma may be similar to purulent otitis in otoscopy (11),
- acquired cholesteatoma:
 - primary – occurs if it is a consequence of the development of the retraction pocket and its ingrowth into the middle ear,
 - secondary – occurs when it has developed from a multilayered squamous epithelium that has grown into the tympanic cavity due to a pre-existing perforation (11).

Primary acquired cholesteatoma constitute the majority of recognized cholesteatoma. Therefore, many classifications for this type of disease have been created.

In Tos' classification, which was made based on the speculum image, acquired cholesteatoma was divided according to their location:

- attic cholesteatoma (in the epitympanal/flaccid eardrum),
- cholesteatoma of the posterior upper part of the strained eardrum (tensa cholesteatoma I),
- cholesteatoma of the central part of the strained eardrum (tensa cholesteatoma II) (12).

The extent of cholesteatoma and the condition of the ossicular chain may also be determined according to the Saleh and Mills classification (intraoperatively). The extent of cholesteatoma (S) is determined by the number of anatomical structures of the middle ear that are within its range. These structures include the attic, tympanic cavity, antrum, mastoid, Eustachian tube, labyrinth, and middle fossa.

The diagnosis of cholesteatoma by a specialist is based on a detailed case history and additionally recommended diagnostic tests. When making a diagnosis, it is important to ask about earaches, the frequency and type of discharge from the ear, infections and inflammation of the ear, hearing problems, and medical conditions. Then the examination includes palpation of the ear and its surroundings. Subsequently, an otos-

copy (otoscope, microscope, videotoscope) is performed, which allows you to assess the condition of the eardrum and diagnosing the presence of cholesteatoma. During otoscopy, we take into account the following factors:

- the presence of exudate,
- the presence of tympanosclerotic changes,
- presence of retraction pockets,
- the presence of perforation of the tympanic membrane,
- presence of cholesteatoma.

Imaging examination of the ear may be additionally recommended, i.e. computed tomography of the temporal bones. Due to the fact that developing cholesteatoma causes hearing loss, audiological tests (mainly tonal audiometry and tympanometry) are also important tests.

Symptoms that patients with diagnosed cholesteatoma report to an otolaryngologist most often include foul mucopurulent exudates from the ear and hearing loss (in tonal audiometry tests, conductive hearing loss) and a feeling of ear congestion. However, some patients also complain of tinnitus, ringing or earache. Much less often, dizziness, paralysis of the facial nerve or meningitis occur. Many sources also report that symptoms can sometimes manifest in the contralateral (healthy ear) ear – these are usually exudates. The occurrence of various symptoms depends on the location and severity of cholesteatoma. However, it should be remembered that cholesteatoma may be asymptomatic for a long time, and the results of tympanometry and audiometry may be normal in the initial stage of the disease (11, 12, 14).

TREATMENT OF CHOLESTEATOMA

Treatment of cholesteatoma is primarily based on surgical procedures (13). Pharmacological treatment (mainly steroids and antibiotics) is started in the case of acute ear inflammation and purulent discharge and is a preparation for the necessary surgery. As for the surgical procedure itself, it is aimed at elimination of the lesions and then reconstructing the ossicular chain. The measure of the success of treatment is the closure of the cochlear reserve, but it is worth remembering that the improvement may not occur immediately after the surgery, even at the beginning the hearing may deteriorate. It is related to the conduction of sounds in the period – before surgical treatment, by the mass of cholesteatoma, which remained in close connection with the damaged conducting system (bone chain). The technique of the procedure depends on the extent and location of cholesteatoma (radical surgery, osteoplastic surgery or tympanoplasty) (13, 14).

After the removal of the cholesteatoma, persistent ear effusions or recurrent inflammation are poor prognostic factors, which is why observation of the changes and regular checkups with a specialist doctor are so important (13, 15).

CONCLUSIONS

The formation of retraction pockets is a result of a chronic disturbance of ventilation in the middle ear, which translates as the body's natural attempt to heal the inflammation in the tympanic cavity.

Accurate assessment of retraction pockets and their classification allows for appropriate treatment. There is no one-size-fits-all treatment for retraction pockets. Retraction pockets are the most common cause of cholesteatoma.

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