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Review Article

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Attic retraction pocket: a review

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ABSTRACT

Attic retraction pocket (ARP) is one of the important sequelae of eustachian tube dysfunction or otitis media with effusion. It is associated with the loss of original histological and anatomical structure at the attic region. Clinical observation usually shows that negative nasopharyngeal pressure is associated with the development of ARP. However, LaPlace's law states that the pressure within a sphere varies with the inverse of the radius, which gives a dynamic explanation for why the pars flaccida retract more frequently than the pars tensa leading to the development of ARP. It may develop ossicular chain erosion, cholesteatoma formation, and potentially life-threatening complications due to cholesteatoma. It is thought that blockade of the tympanic isthmus results in isolation of the attic and adjacent middle ear spaces and that subsequent makes negative pressure in these spaces leading to pars flaccida retraction. The severity of ARP with cholesteatoma varies from well-localized pathology to advanced involvement with complications. The choice of treatment is surgery that depends on the initial pathology, which is also associated with hearing outcomes and the rate of recurrence. This review article discusses on epidemiology, etiopathology, classification, clinical manifestations, diagnosis, treatment, and prognosis of ARP.

Keywords: ARP, Cholesteatoma, Ossicular erosion, Hearing loss

INTRODUCTION

A localized retraction of the tympanic membrane is known as a retraction pocket.[1] This condition involves the inward displacement of the tympanic membrane from its normal position, typically affecting a fragile part of the pars tensa or pars flaccida.[1] Acquired cholesteatoma originating from a retraction pocket can be classified into two groups based on the location of the retraction pocket: pars flaccida (attic cholesteatoma) and pars tensa retraction pocket.[1] The extent of the retraction and ossicular or scutum erosion, the contents of the retraction pocket determine the grade of ARP.[2] The different locations for retraction cholesteatoma have different etiologies, pathogenesis, extensions, and clinical manifestations.[2] The middle ear pressure changes following negative nasopharyngeal pressure can result in ARP formation.[2] ARP is associated with greater collapse of middle ear volume when negative pressure is developed at the nasopharynx.[3] In ARP, cholesteatoma may develop in the attic area. This type of cholesteatoma is often associated with a non-pneumatized mastoid caused by negative pressure.[4] ARP with its grade, condition of the tympanic membrane, status of the middle ear, and air-bone gap with pure tone average are considered before treating this condition. The therapeutic approach for ARP is somewhat controversial. In fact, surgery is usually planned when signs of clinical progression such as pocket rupture or skin ingrowth become evident. Treatment of ARP and cholesteatoma depends on their nature, evolvement, and pneumatization of the mastoid. Patient of ARP need reconstruction of ossicular and scutum which provide long-term stability of the tympanic membrane, middle ear and hearing of the patient. The objective of this review article is to history, discusses on epidemiology, etiopathology, grading, clinical manifestations, diagnosis, and current treatment of ARP.

LITERATURE SEARCH

Research articles exploring the ARP were identified using several approaches. Initially, a thorough online search was performed across databases such as Scopus, PubMed, Medline, and Google Scholar. The search method was structured following PRISMA (Preferred reporting items for systematic reviews and meta-analysis) guidelines to ensure a systematic and comprehensive review of relevant literature. Apart from manually retrieving research publications from references, our search methodology included screening the abstracts of published studies. Eligibility criteria encompassed randomized controlled trials, observational studies, comparative studies, case series, and case reports that presented information on the ARP. Total 41 papers were included such as 14 case reports, 12 case series, and 15 research articles (Figure 1). This article comprehensively discusses the history, epidemiology, etiopathology, clinical presentations, complications, investigations, and current treatments of ARP. Serving as a foundational resource, this review paper aims to spur the development of future prospective trials and encourage further investigation into this pathology. Currently, there is limited research available on ARPs, making this review a crucial starting point for future studies.

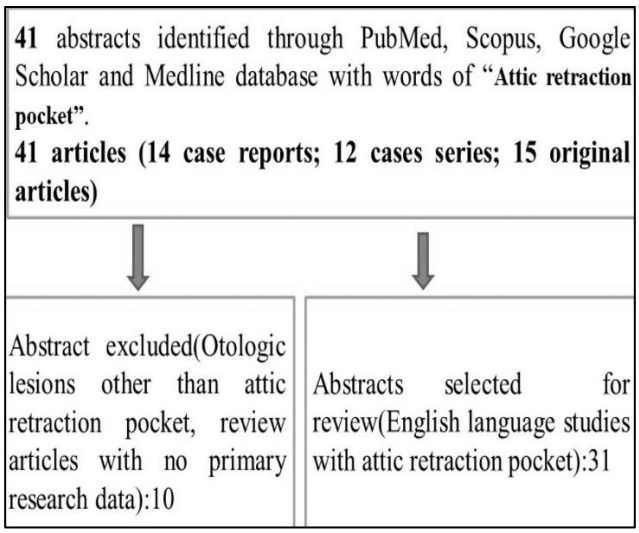

Figure 1: Methods of literature search.

HISTORY

Sade documented the stages of retraction of the pars flaccida and tensa with adhesive otitis media and ossicular erosion in 1970.[5] The first staging system for ARP was proposed by Sade and Berco in 1976.[6] There were several classifications were approved in the past for grading the ARP.[7] In 1980, Paparella and colleagues described the management of ARP and other retractions coupled with adhesive otitis media.[8] Different authors described various repairs of the ARP with the help of the fascia, dura, bone paste, and cartilage.[9] There are various surgical techniques described later.[10]

EPIDEMIOLOGY

During decades of treatment for patients with retraction of the tympanic membrane, there may be due to negative pressure in the middle ear that contributes to the ARP. The incidence of ARP formation in the otitis media with effusion have been documented as statistically higher than in those of the control group.[11] Attic cholesteatoma is developed from ARP among more than 1000 cases of otitis media with effusion or serous otitis media with a relatively long latency period.

ETIOPATHOLOGY

The primary cause of ARP appears to be dysventilation syndrome, characterized by the intact lateral incudo-malleolar fold and tensor folds, but with a blocked isthmus between the long process and manubrium.[12] The eustachian tube dysfunction may be the important cause for development of ARP.[1] The dysfunction of the eustachian tube causes negative pressure in the middle ear.[13] Longstanding eustachian tube dysfunction and absence of a pneumatized mastoid are causes of negative pressure of the middle ear and ARP formation.[13] The aeration of the epitympanum relies on the condition of the tympanic isthmus, which is the narrow passage between the atticomastoid air space and the tubotympanic cavity. When this area is blocked, gas exchange occurs primarily within the mastoid cells.[14] ARP is one of the important sequelae of otitis media with effusion. It is also very unclear when and how ARP turns into cholesteatoma. Middle ear cholesteatoma is a serious condition that can develop from ARP. According to Tos's definition, a pre-cholesteatoma is a deep-seated ARP where the bottom is visible under an otomicroscope, and there is periodic accumulation of debris that can be cleared using suction. Middle ear cholesteatoma with canal wall-up mastoidectomy can lead to recurrent attic retraction and cholesteatoma formation in the attic region. In one study on rats, the pars flaccida position reflects middle ear pressure. [15] This study revealed that positive middle ear pressure causes the pars flaccida to bulge whereas negative middle ear pressure causes retraction. From this study, the position of the pars flaccida or Shrapnell's membrane can act as a pressure indicator for middle ear pressure. Sniffing induces negative middle ear pressure which is common among children with otitis media with effusion, and these patients often have difficulty with pressure equalization.[16] It is well recognized that pars flaccida is the weakest part of the tympanic membrane.[17] ARP is linked to increased collapse of middle ear volume when negative pressure occurs in the nasopharynx. This phenomenon is further explained by LaPlace's law, which describes how differential retraction leads to the development of ARP.[18] According to LaPlace's law, the pressure within a sphere varies inversely with its radius.[19] Therefore, air within the smaller epitympanic area should evacuate more easily compared to air in the larger middle ear space.[20,21] This law, combined with the structure of the pars flaccida,

helps explain why the attic area retracts more significantly than the pars tensa of the tympanic membrane.

CLASSIFICATION

The classification of the ARP is done on the basis of depth and erosion of the retraction pocket by otoscopic, microscopic, or endoscopic examination.[22] The extent of the retraction pocket and erosion of the ossicles and scutum, and contents of the ARP decide the grading of the ARP.[22] Tos and Poulsen classified the ARP into grade 0 to grade IV in 1980.[23] This classification for ARP remains the standard globally. Tos grade 0: Shrapnell's membrane is normal without any retraction, and there is air between the neck of the malleus and the membrane. Tos grade I: There is retraction of Shrapnell's membrane towards the neck of the malleus, but air space in the attic is still visible. Tos grade II: Shrapnell's membrane is retracted onto the neck of the malleus, and air space in the attic area is visible. Tos grade III: The retraction extends medially to the osseous annulus, but the bottom of the retraction can still be seen when the head is tilted. Tos grade IV: There is bony resorption of the osseous annulus, and the retraction extends towards the head of the malleus. Due to the bone resorption, the bottom of the retraction may be visible. The extensive destruction by ARP like ossicular chain destruction or scutum erosion does not come into their classification. Tegmen erosion or fistula of the lateral canal is also not included in the classification. The qualitative criteria for a retraction pocket describe its behavior, particularly whether it is self-cleaning or not. The loss of self-cleaning ability is considered a precursor to or indicative of cholesteatoma formation. Another qualitative criterion is the presence of bone erosion, which can manifest as thinning or erosion of the process of the incus, stapes supra-structure, and/or erosion and recession of the scutum. Although ARP have been classified into grade 0 to IV, it is not always possible to assign ARP into a single specific category. The new classification system is mainly based on otoscopic and endoscopic visualization of the fundus of the retraction pocket, ossicular status in the attic area, and degree of the scutal erosion. In contrast to Tos classification, this newer classification also includes the presence or absence of cholesteatoma within the retraction pocket.[24] In new classification (Table 1), grade I, the pars flaccida is dimpled-retracted towards the neck of the malleus but not adherent to it. In grade IIa, the pars flaccida is adherent to the neck of the malleus whereas in grade IIb, the pars flaccida is adherent to the head of the malleus causing the neck to be completely visible, the head of the malleus to be partially visible, with mild erosion of the scutum. In grade II, the fundus of the ARP is completely visible on the otoscopic examination without the requirement of an endoscope. In grade IIIa, IIIb, and IIIc classifications of ARP, IIIa: The fundus of the ARP is not visible on routine otoscopic examination but can be fully visualized using endoscopy. There is moderate scutal erosion, but no ossicular erosion. The pars flaccida drapes over the neck and head of the malleus and onto the incus. IIIb: Similar to IIIa, the fundus of the ARP is not visible with routine otoscopy but is fully visible with endoscopy. In addition to moderate scutal erosion, there is erosion of the ossicles. IIIc: The fundus of the ARP is not visible on routine otoscopy but is fully visible with endoscopy. This grade indicates the presence of cholesteatoma within the ARP. These classifications describe the extent of visibility of the retraction pocket and associated pathological changes observed during examination. In grade IVa, IVb, IVc, and V classifications of ARP, IVa: The ARP in the attic area is completely or partially visible on endoscopic examination alone. There is severe scutal erosion. The pars flaccida drapes over the neck and head of the malleus and entire incus without erosion. IVb: Similar to IVa, the ARP is visible on endoscopic examination with severe scutal erosion. There is attic pars flaccida retraction with erosion of the ossicles. Cholesteatoma may also be present. IVc: The ARP in the attic area is visible on endoscopic examination with severe scutal erosion. This grade indicates the presence of cholesteatoma within the ARP V: There is extensive retraction with complete outer attic (scutum) erosion. There is also ossicular erosion, and erosion of the lateral semicircular canal may be present. Erosion of the tegmen plate may or may not be observed. These classifications describe the visibility of the retraction pocket and the severity of associated pathological changes, including erosion of surrounding structures, observed during endoscopic examination.[24]

Table 1: Grading ARP.

Grading	Features of ARP
I	Pars flaccida is dimpled and retracted towards neck of malleus but not adherent to it.
IIa	Pars flaccida is adherent with mild erosion of scutum to neck of malleus.
IIb	Pars flaccida is adherent with mild erosion of scutum to head of malleus.
IIIa	Fundus of ARP is completely visible only by endoscope with moderate scutum erosion without any ossicular erosion.
IIIb	Fundus of ARP is completely visible only by endoscope with moderate erosion of scutum and ossicles.
IIIc	Fundus of ARP is completely visible only by endoscope with moderate erosion of scutum and with cholesteatoma.
IVa	Fundus of ARP is completely or partly visible on endoscopy with severe scutum erosion and without ossicular erosion.
IVb	Fundus of ARP is completely or partly visible on endoscopy with severe scutum erosion and with ossicular

Continued.

Grading	Features of ARP
	erosion.
IVc	Fundus of ARP is completely or partly visible on endoscopy with severe scutum erosion and with cholesteatoma
V	Extensive ARP with complete outer attic erosion with ossicular necrosis and with erosion of the lateral semicircular canal and/or tegmen plate. No cholesteatoma is present.

COMPLICATIONS OF ARP

The ARP leads to loss of original histological and anatomical structure. A pre-cholesteatoma is a deep ARP, the bottom of which is seen by otoendoscope or otomicroscope with periodic accumulation of debris that can be cleaned by suction.[25] Acquired cholesteatoma arising from ARP causes invasion into adjacent areas with subsequent clinical manifestations. The sequelae are associated with ossicular chain erosion, cholesteatoma formation, and potentially life-threatening complications due to cholesteatoma. When ARP is associated with inflammation, it causes otorrhea, granulation, and accumulation of debris. Once the ARP loses the capacity for self-cleaning, it may be then difficult to clear the debris accumulation under an otomicroscope. In most cases, cholesteatoma develops in ARP. Negative pressure in the middle ear cleft is a nidus for the formation of the ARP and subsequent cholesteatoma development.

CLINICAL MANIFESTATIONS

ARP with cholesteatoma is a progressive disease.[26] The clinical presentations of ARP with cholesteatoma range from localized pathology with normal hearing to advanced cases with serious extracranial and intracranial complications. Symptoms vary widely; some patients are asymptomatic, while others develop infections that rapidly cause bony destruction. Many patients with ARP present with otorrhea, progressive hearing loss, vertigo, and facial nerve paralysis. An endoscopic examination typically reveals ARP (Figure 2), seen as defect adjacent to posterior-superior portion or pars flaccida of tympanic membrane, with keratin debris at center of defect.

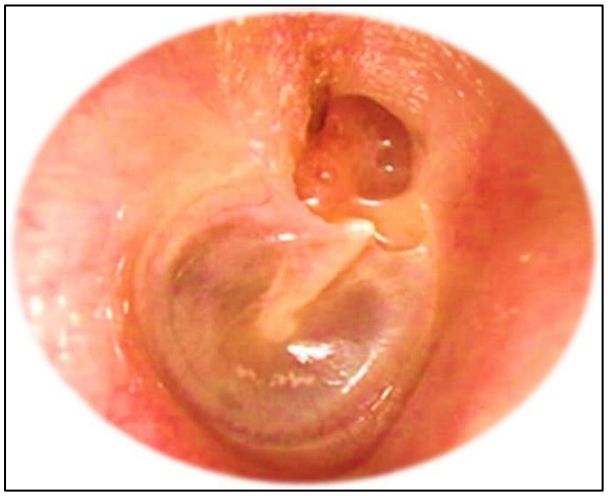

Figure 2: An endoscopic picture of ARP.

INVESTIGATION

Clinical examinations, otoendoscopic examination, audiological evaluation and imaging are important components for assessment or grading of ARP. All patients of ARP are evaluated or classified using the ARP classification system, from grades I to V. CT scan is an excellent technique for showing even small abnormalities of the thin and complex bony structure of the temporal bone.[11] The high resolution of the CT scan is helpful in determining the precise extent of bony erosion in the attic and adjacent region. The assessment of depth of ARP can be done by a water-enhanced CT scan. It is helpful for careful follow-up for deep ARP of a potential risk of development into cholesteatoma. MRI is helpful to assess the ARP to the dura and surrounding soft tissues, especially if intracranial extension is suspected.[27] It is also indicated if the lesion extends into the adjacent vascular structures such as the sigmoid sinus and jugular vein. Endoscopic evaluation is helpful to assess the depths and extension of the ARP. The preoperative endoscopic evaluation is useful to preserve the middle ear and epitympanic airflow passages.[28] The use of an endoscope is also helpful to determine which reparative operation is performed. The depth and anatomy of the ARP are determined by the microscopic and endoscopic examination. A high-resolution, fine, rigid micro-endoscope with an outer diameter of 1.0 mm can be used to see the extent of retraction of ARP.[9] In addition to this, a CT scan using water as the contrast media can be utilized to know the extent of the ARP.

MANAGEMENT OF ARP

The therapeutic approach for ARP is somewhat controversial. There are many treatment options for ARP and the therapeutic challenge for evaluation of the correct timing for surgical treatment, which often depends on the progression of the pathology, and consequent worsening symptoms.[29] The treatment of ARP depends on its grading and ranges from conservative to surgical intervention (Table 2). However, surgery is usually planned in case of definite ARP.[30] The surgical management of ARP includes atticotomy, and canal wall up and canal wall down tympanomastoidectomy surgical procedures. The reconstruction of the scutum and attic lateral wall is done by dissection of the tympanic membrane with intact pars flaccida and opening of the lateral wall of the attic. The bony barrier is usually reconstructed by the patient's conchal cartilage and crushed perichondrium.[11] The intact tympanic membrane is then returned to its original position. To reduce or obliterate the mastoid cavity following a canal wall down

mastoidectomy, the mastoid cortex is lowered to the level of the sigmoid sinus. The peri-cranial graft can be placed into the additus and antrum/tegmen mastoideum area. A posteriorly based pericranium flap can be draped into the reduced antrum. Finally, the meatoplasty skin is sectioned horizontally from lateral to medial and reattached for a reduced or obliterated mastoid cavity. Additionally, acetic acid is administered for 15 days to prevent granuloma formation. Bone pate scutum plasty can be performed to reconstruct eroded attic bony wall.[31] Bone plate scutum plasty is beneficial for preventing postoperative retraction pockets by creating a smoothly shaped attic wall. The wide view provided by the endoscope allows for minimally invasive trans-canal access to the attic region, enabling complete disease removal without the need for a postauricular approach or incision. The endoscopic technique is particularly useful for the trans-canal, minimally invasive eradication of limited cholesteatoma caused by ARP. Continuous postoperative endoscopic surveillance in the office is essential for a successful outcome with this approach.[32] Surgery for ARP involves atticotomy, as well as canal wall up and canal wall down tympanomastoidectomy procedures.[30] The scutum and lateral attic wall are reconstructed by dissecting the intact tympanic membrane along with the pars flaccida, reflecting it forward to facilitate scutal removal and access to the attic region. The bony barriers of the lateral attic area are rebuilt using the patient's conchal cartilage and crushed perichondrium. The intact tympanic membrane is then placed back in its original position, ensuring that no tympanic membrane graft is needed and the mastoid cavity and epitympanum are not left exposed. In a canal wall down mastoidectomy, the mastoid bowl is reduced or obliterated by lowering the mastoid cortex to the level of the sigmoid sinus.[33] Peri-cranial free grafts can be inserted into the additus and antrum to decrease the size of the antrum. The meatoplasty skin is then cut horizontally from the lateral to medial side and attached to the peri-cranial tissue used for obliteration. Post-operative care for a reduced or obliterated mastoid cavity involves administering acetic acid for a minimum of two weeks to prevent the formation of granulation tissue.[34] The outcomes of the surgical treatment of the ARP are different according to the grading of the lesion.

Table 2: Treatment options for different grading of ARP.

Grading of ARP	Treatment
I	Avoiding sniffing behavior only
IIa	Transcanal atticotomy with attic reconstruction
IIb	Transcanal atticotomy with attic reconstruction
IIIa	Transcanal atticotomy with attic reconstruction. Trans-mastoid epitympanic attic reconstruction.
IIIb	Transcanal atticotomy with attic reconstruction. Trans-mastoid epitympanic attic reconstruction.
IIIc	Canal wall down mastoidectomy
IVa	Trans-mastoid epitympanic attic reconstruction. Canal wall down mastoidectomy.
IVb	Canal wall down mastoidectomy.
IVc	Canal wall down mastoidectomy.
V	Canal wall down mastoidectomy.

CONCLUSION

ARP is one of the important sequelae of otitis media with effusion and usually classified on the basis of otoscopic findings or otomicroscopy/ otoendoscopy. ARPs are often implicated in the pathophysiology of cholesteatoma formation, so correct diagnosis is the important for prevention of this pathology. The ontological endoscope allows a more precise assessment of the extent of ARP than previously commonly used operating microscope. It is usually unclear when and how ARP turns into cholesteatoma. Precise observation of the ARP by micro-endoscope reveals the extent of retraction. ARP is classified by degree of invasion and erosion. The reconstructions of the ossicles and eroded scutum according to grading of the ARP show long-term stability of the tympanic membrane, middle ear, and hearing status.

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