Prussak's Space: Anatomy Revisited

Alaa A. Abou-Bieh, MD[1], Thomas J Haberkamp, MD[2]
[1]Department of Otolaryngology, Faculty of Medicine, Mansoura University, Mansoura, Egypt
[2]Cleveland Clinic, Cleveland, OH, USA

Introduction

The anatomy of Prussak's space (Ps) was described in 1867 by Alexander Prussak when he published his studies on the anatomy of the human tympanic membrane.[1] As most of other middle ear (ME) spaces, studying and dealing with this space as a separate compartment based mainly on the concept of the studying of various mucosal folds (MFs) attached to the ossicular chain with its ligaments and the tendons of the tensor tympani (*) and stapedius muscle (**) along with the chorda tympani nerve (CTN).[2] This concept and studies were pioneered by Helmholtz, 1868; von Troeltsch, 1881; Hammar, 1902; Politzer, 1909; Balance and Green, 1919; Sobotta, 1920; Lowndes Yates, 1936; Maisonnet and Coudane, 1950.[2] Another concept closely related to the mucosal folds (MFs) and ME compartmental studying was introduced by Chatellier and Lemoine in 1946, which is the epitympanic diaphragm made up of various membranous ligaments and folds (MFs) which, together with the malleus(M) and the incus (I), formed the floor of the epitympanic compartment and the theory of routes and pathways of tympanic ventilation.[3] The problem with these mucosal folds, and therefore the concepts based on them, is that they are easily seen in the living and in fresh temporal bones (TBs) and they disappear or disintegrate rapidly if the TBs are permitted to dry, frozen or immersed in fixative solutions and disintegrate in disease processes involving ME or are often considered as residues of inflammation or as adhesions.[2] This problem together with the difficulty in documenting the ventilation pathways have led to the vague nature of this area and many conflicts about it the most prominent in them is the conflicting conclusions of the work of Proctor[2,4-6] and Palva[7-13]. The idea of utilizing different techniques in investigating ME compartmental anatomy and physiology has emerged.[14-17]
We aimed by our work to present the anatomical data obtained due to the incorporation of endoscopes as an untraditional method in its studying.

Methods and Materials

Anatomy and variations were studied in 55 Fresh frozen TBs. To the best of our knowledge, all TBs came from adult cadavers. There were 31 right TBs and 24 left. All TBs were dissected by the same approach and all were studied utilizing an operating microscope and otoendoscopes with 0º, 30º and 70º angles and 2.7 and 3 mm diameters. The photos were processed digitally by Photoswit® digital computer photo-system (Photoswit, USA).

Anatomy and Ventilation

Ps lies between the notch of Rivinus (NR), the anterior and posterior tympanic spines (A and PTyS) and the short process of the malleus (MSP).[4] The medial and inferior aspects of Ps are formed, respectively, by the neck (MN) and the short process of the malleus (MSP).[14] It is limited above by the lateral mallear fold (LMF) which arises from the junction of the malleus head (MHe) and neck (MN) and radiates out to insert on the entire bony rim of the notch of Rivinus (NR) and medial wall of the scutum (Sc), thus forming a firm roof for Ps and the floor of the lateral malleolar space (LMS).[2,7,14] The space is limited anteriorly, and to some degree inferiorly, by the terminal flaring out of the annulus fibrosus (AF) as it leaves the anterior tympanic spine (ATyS). As anteriorly when the annulus (AF) leaves the sulcus tympanicus (STy) it attach in part to the anterior tympanic spine (ATyS) then continues on as the stria membrana tympani anticus (SMTyA) to the short process (MSP), to radiate out to help form the floor of Ps, to interdigitate with fibres of the lateral malleolar fold (LMF), and to attach to the bony rim of the notch of Rivinus (NR).[2] Some authors[7-9,11,14] describe the anterior aspect of Ps being bounded by very thin membranous fold among the tympanic membrane (TM) and the anterior malleolar ligament fold (AMF) inserted laterally onto the tympanic membrane (TM) and medially onto the neck (MN) and long process (MLP) of the malleus. Posteriorly, on leaving the posterior tympanic spine (PTyS), fibers of the annulus (AF) end at the malleus neck (MN), forming Ps posterior floor.

Anatomy and Ventilation

As posteriorly when the annulus (AF) leaves the sulucs tympanicus (STy) its outer fibres insert on the posterior tympanic spine (PTyS) or extend in the stria membrana tympani posticus (SMTyP) to the short process of the malleus (MSP) while its inner fibres insert on the medially-placed pretympanic spine (PreTyS) or radiate out, forming the supporting structure for the posterior malleolar fold (PMF) and attaching on the postero-medial aspect of the upper third of the malleus handle (MH).[2,4] Between the posterior malleolar fold (PMF) and the tympanic membrane (TM) lies the posterior pouch of von Troeltsch (vTP) which represents Ps posterior wall.[2,14] The lateral aspect is represented by the pars flaccid (PF) of the tympanic membrane (TM).[7,14]
Beneath the attic floor (AT) and in the upper mesotympanum there are three compartments: the inferior incudal space (IIS) and the anterior (vTA) and posterior (vTP) pouches of von Troeltsch.[2] The inferior incudal space (IIS) extends from the inferior surface of the incus (I) laterally to the posterior malleolar fold (PMF) and is limited medially by the medial incudal fold (MIF) and anteriorly by the interossicular fold (IF) which lies between the long crus of the incus (ILP) and the upper two thirds of the malleus handle (MH). Between the posterior malleolar fold (PMF) and both the pars tensa (PT) and pars flaccid (PF) of the tympanic membrane (TM) lies the posterior pouch of von Troeltsch (vTP). The chorda tympani nerve (CTN) lies in the free margin of the posterior malleolar fold (PMF), although it may cross the posterior tympanum independent of this fold. The shallow anterior pouch of von Troeltsch (vTA) lies between that portion of the drumhead (TM) anterior to the malleus handle (MH) and the anterior malleolar fold (AMF) which draping the anterior malleolar ligament (AML).
The posterior pouch of von Troeltsch (vTP) is the main route of ventilation[2,14] and as this pouch opens at the most cranial portion of the mesotympanum, so in most subjects, ventilation of Ps occurs through the communication with the mesotympanum[2,12,14]. Laterally and posterior in the attic (AT) the floor of the superior incudal space (SIS) is formed by the lateral malleolar fold (LMF) and by the lateral incudal fold (LIF) which extends posteriorly to the posterior incudal ligament (PIL). The entrance into Ps is usually located between the lateral malleolar fold (LMF) and the lateral incudal fold (LIF).[2]
Embryologically, Ps develops from the medial saccule of the saccus medius which usually sends an offshoot forward between the lateral malleolar (LMF) and lateral incudal (LIF) folds to form Ps.[2]
(including anatomical abbreviations key to all figures)

Results

- ***Space boundaries*** were fixed in all specimens and were the same structures as was shown in the reviewed published literature:
-Medially: neck (MN) of the malleus.
-Inferiorly: short process of the malleus (MSP).
-Superiorly (roof): lateral malleolar fold (LMF) till notch of Rivinus (NR).
-Anteriorly: terminal flaring out of the annulus (AF) as it leaves the anterior tympanic spine (ATyS).
-Posteriorly: fibers of the annulus (AF) as it leave the posterior tympanic spine (PTyS) to end at the malleus neck with posterior pouch of von Troeltsch (vTP) lies between the posterior malleolar fold (PMF) and the tympanic membrane (TM).
-Laterally: Shrapnell's membrane (PF).
-Chorda tympani nerve (CTN) was laying s in the free margin of the posterior malleolar fold (PMF) in all of the study specimens.
- ***Space position and orientation in relation to surroundings:***
Ps had a fixed position in all our specimens and was usually a 3D sagittal space located laterally and superficially to the tympanum (in inferior position to the epitympanum and superior position to the mesotympanum).
- ***Ps Size*** depended mainly on the length of the neck of the malleus (MN). This was regardless the pneumatization of all the ME spaces and their type of development. The mean of the neck of the malleus (MN) length was 0.7 mm with difference +/- 0.4 mm.

Results

- ***Ps aeration routes and communication pathways with other spaces*** were the most remarkable variable has been noticed regarding the Ps anatomy. Therefore, they were used to classify the Ps in the study specimens and also due to their proclaimed role in the ME pathophysiology. ***Four types*** of Ps could be distinct:
-***1st:*** was the most common (39 TBs) (71%). The space aerated solely retrogradely via the posterior pouch of von Troeltsch (vTP).
-***2nd:*** (1 TB) (2%) aerated via the anterior pouch of von Troeltsch (vTA) only.
-***3rd:*** (1 TB) (2%) aerated only through a special superior mucosal pathway in the lateral malleolar fold (LMF), mainly posteriorly between it and the lateral incudal fold (LIF).
-***4th:*** (14 TB) (25%) aerated through combined or multiple (1 specimen) pathways of the above types.
- All types were ***lined by*** mucosa in all specimens.

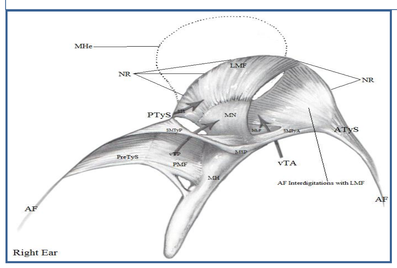

Figure 1. Ps: Outline & Types

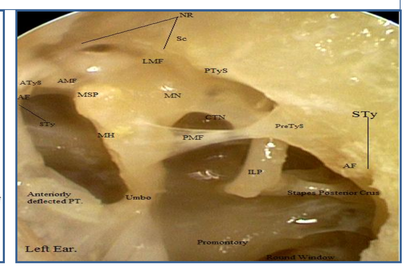

Figure 2. Ps: Outline

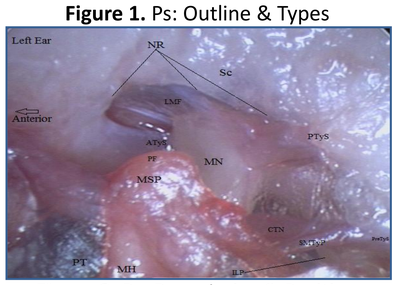

Figure 3. Ps: Boundaries & Position

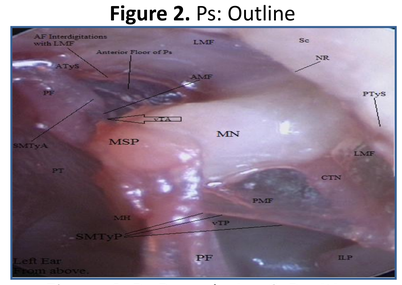

Figure 4. Ps Boundaries & Position

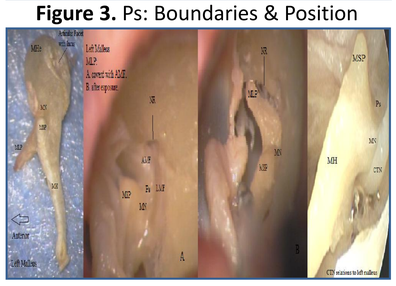

Figure 5. Ps: Malleus Relations

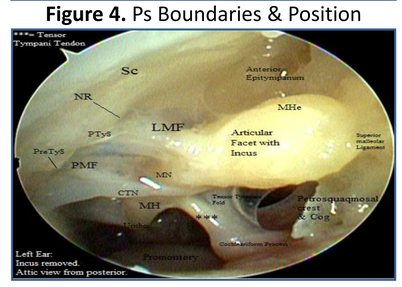

Figure 6. Ps: Attic View

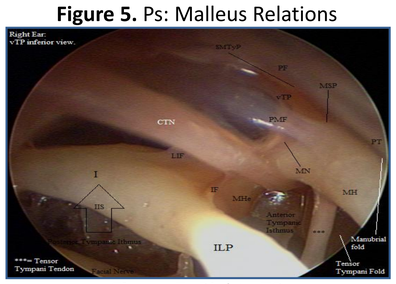

Figure 7. Right vTP

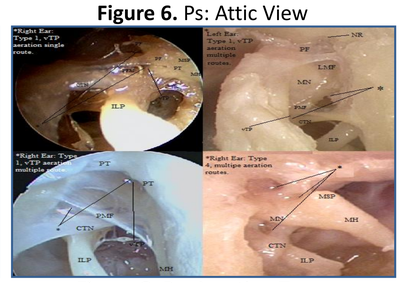

Figure 8. Ps: Aeration Types

Conclusions

Ps has different types depending on its ventilation and communication routes. A better understanding of the differences between these types might explain the development and progress of the space pathological conditions such as isolated infections and dysventilation, in addition to the related retraction pockets and cholesteatomas. Endoscopes could be a significant tool to provide further information about the ME folds and spaces anatomy and potential aeration mechanisms.

Contact

Alaa Ali Abou-Bieh
Mansoura Faculty of Medicine
Email: abenthn@.mans.edu.eg
Website: http://medfac.mans.edu.eg
Phone: +2001129828985

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