

Original Research Article

Tympanometry and computed tomography measurement of middle ear volumes in patients with unilateral chronic otitis media

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ABSTRACT

Background: Tympanometry and computed tomography (CT) measurement of middle ear volume in patients with unilateral chronic otitis media.

Methods: The prospective study was conducted on 50 patients of diagnosed unilateral chronic otitis media showing clinical symptoms which affect quality of life. Patients who were fulfilling inclusion criteria after screening were selected for study. We studied patients who had a unilateral tympanic membrane (TM) perforation and a normal TM in the contralateral ear which act as control group to estimate the ME volume in the lesioned ear. Further we have compared pre and postoperative middle ear volume (measured by CT and tympanometry) in control & diseased ear to correlate middle ear volume results obtained by CT and Tympanometry.

Results: The mean value of MEV measured by tympanometry and CT were (1.343 ± 0.580) and (1.106 ± 0.380) respectively (Figure 1). Volume measurement by tympanometry is higher as compared to volume measured by CT in lesioned ear, hence tympanometry measured volume in diseased ear were higher that measured by CT which is closer to normal values in both normal and Diseased ears. Also hearing shows improvement in diseased ear after surgery due to restoration of middle ear volume closer to normal.

Conclusions: It was concluded in our study that CT is more reliable investigation for middle ear volume measurement as compared to Tympanometry in diseased as well as normal ears.

Keywords: Tympanometry, Computed tomography, Middle ear volume, Chronic otitis media

INTRODUCTION

Perforation of tympanic membrane is common in otological practice and can result from various causes such as trauma and chronic otitis media.¹ It was notice that the degree of conductive hearing loss from a tympanic membrane perforation increases as the size of perforation increases and this loss varies inversely with the volume of middle ear and mastoid air space, that is hearing loss was greater in ears with small middle ear volume.¹⁻² Thus it has been suggested that in qualitative judgement about whether or not a given perforation can explain the

observed hearing loss based on perforation size and also some knowledge of middle ear volume.

Middle ear function is assessed by impedance audiometry which measures compliance and pressure of the system by tympanometry, which, in addition, also measures volume of the external auditory canal and the stapedial reflex tests.³ Tympanometry is essentially a measure of admittance (i.e. the reciprocal of impedance) of the middle ear system.⁴ The EAC volume can indirectly verify a tympanic membrane perforation or a patent grommet where the canal volume is higher than the average range of

the normal and the stapedial reflex tests provide information about the auditory nerve pathways.

The tympanic cavity is an irregular, air-filled space within the temporal bone between the tympanic membrane laterally and the osseous labyrinth medially. It contains the auditory ossicles and the tendons that attach them to the middle ear muscles. It is traditionally divided into three compartments: the epitympanum (upper), the mesotympanum (middle) and hypotympanum (lower). The epitympanum, or attic, lies above the level of the malleolar folds and is separated from the mesotympanum and hypotympanum by a series of mucosal membranes and folds. The hypotympanum lies below the level of the inferior part of the tympanic sulcus and is continuous with the mesotympanum above.

METHODS

All the cases registered during study period in ENT Department, GSVM Medical college, Kanpur were taken into consideration. This is Hospital based Prospective looking experimental comparative study on patients who were fulfilling inclusion criteria after screening were selected for study and the first 50 were chronologically taken with age group (15-45 years of age) and their middle ear volume is comparatively studied by tympanometry method as well as Computed tomography measurement. Tools of my study was Tympanometry and CT. The normal ear of study subject act as control group. We studied patients who had a unilateral tympanic membrane (TM) perforation and a normal TM in the contralateral ear to estimate the ME volume in the lesioned ear. We also measured the volumes of the external auditory canal (EAC) from 50 subjects who complained of tinnitus and they had a normal EAC to determine the normative EAC volumes. We performed a Prospective chart review of all the patients who had unilateral chronic otitis media (COM) together with a perforated TM at the time of surgery between January 2019 and October 2020. Only those patients who had undergone both CT scans and tympanometry before surgery were included. Fifty patients their age ranged from 15- 45 year were taken. All the patients showed a dry perforated TM in the lesioned ear and an intact TM in the contralateral ear. The other Ear Act as control group of 50 patients who showed a normal TM and A types on tympanometry were included for determining the normal EAC volumes.

Study period

About 22 months from January 2019 to October 2020, including development of study tools, collection of data, analysis and presentation.

Study design

This study was comparative, prospective, hospital based study

Inclusion criteria

Patient between 15-45 year of age, unilateral chronic otitis media and no associated morbidity were included.

Exclusion criteria

Patient <15, >45 year of age; bilateral chronic otitis media; chronic otitis media with complication; associated pathologies; poor general condition were excluded.

Tympanometric middle ear volume

An impedance audiometry machine with a probe tone frequency of 226 Hz was used. The tympanometry read-out for an ear with a TM perforation is an estimate of the combined volume within the EAC and ME, which includes the tympanic cavity and the mastoid air cell system. The term "Middle Ear volume" refers to the volume of the air contained within the tympanic cavity (including the epitympanum, hypotympanum and protympanum) and the mastoid collectively. Thus, the ME volume in the perforated ear can be calculated as the difference of volumes between the ear with a perforated TM and the contralateral ear with a normal TM. We used the EAC volume in the contralateral normal ear to provide an estimate of the EAC volume lateral to the TM in the ear with a perforation.

CT middle ear volume

All the CT examinations were done with a 16 slice multidetector Computed tomography. The patients were scanned in a supine position to obtain the image plane parallel to the orbitomeatal line. All the image data sets were transferred from the CT scanner to the PC workstation, and the data sets were analyzed using 3D medical imaging software. The area of the air-containing cavity was measured semi-automatically. A volume of interest (VOI) was applied manually to cover the unilateral temporal bone area on each slice. To define the air-containing cavity within the VOI. The threshold range was chosen to exclude the non-aerated portions such as bone and the soft tissue density. The volume of the air-containing cavity at each slice was computed by clicking on the air cavity within the VOI. No manual post-processing of the segmentation results was performed. The total volume of the air-containing cavity was calculated as the sum of the volumes of the air-containing cavities of each slice.

RESULTS

The mean value of tympanometry and Computed Tomography were (1.343 ± 0.580) and (1.106 ± 0.380) respectively. On applying t test the comparison between tympanometry and computed tomography comes statistically significant (p value=0.0259). Volume measure by tympanometry is higher in as compare to volume measured by Computed tomography in lesioned ear, hence

tympanometry measure higher volume in diseased ear. The mean value of tympanometry in leasioned ear and in control group (normal ear)is found to be (1.343±0.580) and (1.022±0.286) .on applying t test the comparision between these 2 group is found to be significant (p value=0.0014).

Volume measure by tympanometry is higher in as compare to volume measured by tympanometry in normal ear, hence tympanometry measure higher volume in diseased ear. The mean value of Computed tomography in leasioned ear and in control group (normal ear)is found to be (1.1068±0.38) and (0.8454±0.1634) on applying t test the comparision between these 2 group is found to be significant (p value=0.0001). Volume measure by computed tomography is close to normal middle ear volume measured by computed tomography. The mean value of Pure tone audiometry leasioned ear in preop and post op is found to be (37.84±4.569) and (31.454±3.688) on applying t test the comparision between these 2 group Is found to be statically significant (p value=0.0001), hearing is improved in diseased ear after operation due to restoration of middle ear volume.

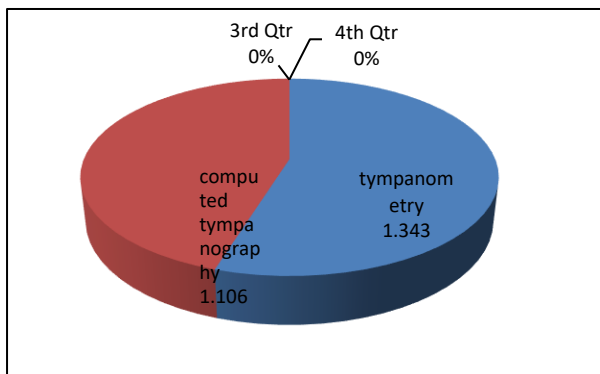


Figure 1: Tympanometry and CT measurement of (MEV) preoperative in study subjects.

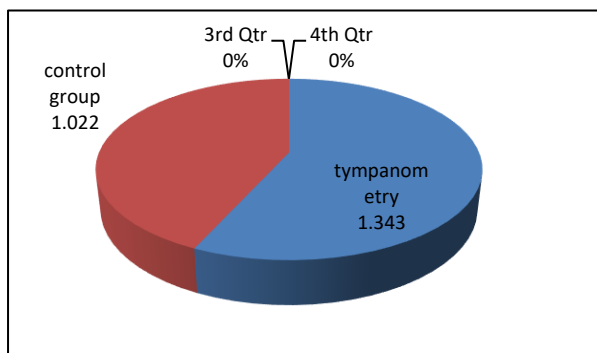


Figure 2: Tympanometry measurement of middle ear volume in study and control group.

DISCUSSION

The prospective study was conducted on 50 patients of diagnosed unilateral chronic otitis media showing clinical symptoms which affect quality of life. Study subject were

taken with prior consent is obtained before the start of study. patient after screening were selected according to inclusion and exclusion criteria (discussed in material and method).

We studied patients who had a unilateral TM perforation and a normal TM in the contralateral ear to estimate the ME volume in the lesioned ear. We also measured the volumes of the external auditory canal (EAC) from 50 subjects who complained of tinnitus and they had a normal EAC to determine the normative EAC volumes. We performed a Prospective chart review of all the patients who had unilateral chronic otitis media (COM) together with a perforated TM at the time of surgery between January 2019 and October 2020. Only those patients who had undergone both CT scans and tympanometry before surgery were included. Fifty patients from 15- 45 year were taken. All the patients showed a dry perforated TM in the lesioned ear and an intact TM in the contralateral ear. The other Ear Act as control group of 50 patients who showed a normal TM and A types on tympanometry were included for determining the normal EAC volumes.

The mean value of tympanometry and CT were (1.343±0.580) and (1.106±0.380) respectively. On applying t test the comparision between tympanometry and computed tomography comes statistically significant (0.0259). Volume measure by tympanometry is higher in as compare to volume measured by CT in lesioned ear, hence tympanometry measure higher volume in diseased ear.

Almost similar results were reported by Ahn et al. Forty-four patients who had unilateral chronic otitis media (COM) and contralateral normal tympanic membranes (TM) and 100 subjects with normal TMs were included in the study.⁵ The normal volumes of the external auditory canal (EAC) were measured in the normal group. The tympanometric ME volumes in the ears with a perforated TM were calculated as the difference of the tympanometric volumes measured from the both ears in patients with unilateral COM. The CT ME volumes were measured by a digital image processing program. The tympanometric volumes of the EACs in the ears with normal TMs were 1.4±0.3 m L. There were no significant differences according to gender, age and the side of the face the ear was on. The tympanometric volumes of the EAC in the normal-side ear of the patients with unilateral COM showed no significant differences when compared with those from the normal group. The ME volumes of the intact ears, as measured by CT, showed significantly higher values than those ME volumes of the lesioned ears. The ME volumes of the lesioned ears, as measured by tympanometry, showed a strong, significant linear correlation with those ME volumes calculated by CT; however, the ME volumes of the lesioned ears, as measured by tympanometry (1.5±1.4 mL), were significantly larger than those ME volumes measured by CT (1.1±0.8).

The mean value of tympanometry in leasioned ear and in control group (normal ear) is found to be (1.343 ± 0.580) and (1.022 ± 0.286) . On applying t test the comparison between these 2 group is found to be statistically significant (p value = 0.0014). Volume measure by tympanometry is higher in as compare to volume measured by tympanometry in normal ear, hence tympanometry measure higher volume in diseased ear.

Kim et al stated in their study, observed that 50 adult patients with COM and subsequent tympanic membrane perforation was performed.⁶ The volumes of the middle ear and mastoid were preoperatively calculated using tympanometry and three-dimensional computed tomography (CT) reconstruction of the temporal bone respectively. During surgery for COM, the patency of the middle ear and mastoid antrum was evaluated. The volumes of the middle ear and mastoid measured by tympanometry and CT were compared with the surgical findings. When the mastoid antrum was patent, the volumes of the middle ear and mastoid measured by tympanometry and CT were well correlated. Moreover, the difference in the volumes measured by tympanometry between the affected and unaffected ears was large. However, when the mastoid antrum was poorly aerated, the difference in the volumes measured by tympanometry between the affected and unaffected ears was small. Middle ear status can be evaluated according to the difference in tympanometric volume between the two ears. If the tympanometric volume suggests poor aeration of the middle ear and mastoid, clinicians should consider procedures for mastoid aeration.

The mean value of CT in leasioned ear and in control group (normal ear) is found to be (1.1068 ± 0.38) and (0.8454 ± 0.1634) on applying t test the comparison between these 2 group is found to be statistically significant (0.0001). volume measure by computed tomography is close to normal middle ear volume measured by computed tomography.

Ekinici et al The mastoid air cell system is an important contributor to the pathophysiology of middle-ear inflammatory disease.⁷ The mastoid cavity is not only an air reservoir, but also an active space for gas exchange. Various methods of temporal bone imaging have been designed to investigate mastoid pneumatization. In this study, we examined 100 normal temporal bones for the evaluation of mastoid pneumatization. Mastoid air cell systems were measured by reconstructed axial and coronal high resolution computed tomography (HRCT) images. The reconstructions were made by a three-dimensional multiplanar volume rendering (3D MPVR) technique. The mean volume of the mastoid air cell pneumatization was 7.9 cm³ (4.0-14.0 cm³), SD = 2.3 cm³. The ears were allocated to the groups with respect to measured mastoid air cell pneumatization. Twenty-eight per cent of the ears have small pneumatization with an air cell system not exceeding 6 cm. Fifty-two per cent had an air cell system between six and 10 cm, and 20 per cent had an air cell

system exceeding 10 cm. With its excellent imaging quality and the ability to eliminate bone and soft tissue, HRCT is the best method for evaluating the mastoid air cell system. The 3D MPVR technique must be used to measure the temporal bone/mastoid pneumatization for the best results.

The mean value of Pure tone audiometry leasioned ear in preop and post op is found to be (37.84 ± 4.569) and (31.454 ± 3.688) on applying t test the comparison between these 2 group is found to be statistically significant (p value = 0.0001), hearing is improved in diseased ear after operation due to restoration of middle ear volume.

Mehta et al displays the 62 perforations in terms of the middle-ear volume, perforation area, and perforation location. Of the 62 ears, 17 perforations were anterior, 19 were posterior, and 26 affected both halves of the TM.⁸ The area of the perforations ranged from 0.1 to almost 60 mm². There was no significant difference in the area or the middle-ear volume of the anterior versus the posterior perforation groups. In the whole population, there was a preponderance of volume estimates between 5 and 6.5 ml; over 40% of the perforations were associated with volumes in this small range. This clustering was attributable to a technical limitation in that the tympanometer used in the study was insensitive to combined ear canal and middle-ear volumes greater than 7 ml. Ears were divided into three subgroups on the basis of the area of the perforation: small perforations: 0 to 8 mm², $n = 30$ (20 ears in the large-volume group and 10 ears in the small volume group); medium-sized perforations, 9 to 30 mm², $n = 25$ (14 ears in the large volume group and 11 ears in the small-volume group); and large perforations, >30 mm², $n = 7$ (5 ears in the large volume group and 2 ears in the small volume group). The mean ABGs for each size category and audiometric frequency for the large-volume group. The differences in ABGs between small and large perforations were significant at all frequencies ($p < 0.05$, Student's t test). The differences between small and medium perforations and between medium and large perforations were significant ($p < 0.05$) at 1,000, 2,000, and 4,000 Hz. At each sound frequency, ABGs were larger with increasing perforation size. As noted previously, ABGs were largest at the lower frequencies. A similar pattern was seen in the small-volume group.

Neel 3rd et al stated that it is well known that myringotomy, aspiration of fluid from within the middle ear, and ventilation with any one of several types of tubes will restore hearing and mobility of the tympanic membrane in the vast majority of patients.⁹ The effects of these procedures on Eustachian tube function and on middle ear and mastoid volumes, particularly on a long-term basis, have not been clearly delineated. Thirty-six children (72 ears) with secretory otitis media were studied. During the course of the disease, fluid was aspirated from the middle ear and Silastic ventilation tubes were inserted. Hearing levels, tympanogram type, middle ear volume, and Eustachian tube function were determined before and after

operation. After myringotomy, aspiration of fluid, and ventilation, we found that: middle ear volume progressively increased during a period of three to eight months after operation; eustachian tube function remained abnormal while ventilation tubes were in place, and hearing was restored to normal levels.

Molvaer et al Ears with large and small perforations showed mean ABG values of 32.0 ± 15.7 dB and 16.0 ± 16.4 dB, respectively.¹⁰ A direct relationship was observed between MEV and CHL for ears with large perforations across all frequencies, whereas this relationship for small perforations was frequency-dependent.

Lindeman et al observed that it may be important to get a measure of the air volume in the middle ear mastoid air cell system.¹¹ Conventional mastoid X-ray investigations have so far been used for estimating this volume. As impedance audiometry has gained in popularity during recent years, it has been postulated that this tool may be useful for measuring the volume in the middle ear and the mastoid system. In this report we present data comparing the acoustically measured size to direct volumetric and planimetric size of the mastoid air cell system on the X-ray film. Temporal bone specimens with perforation of the tympanic membrane have been investigated. A good correlation between these methods is obtained, and we conclude that impedance audiometry enables a rapid and valuable estimation of the air reservoir in the middle ear.

Carpenter et al observed significant disagreement between MEV measurement techniques.¹² Differences between tympanometric (T) and 3DVR MEV values were significantly greater with increasing average. Studies that vary in MEV estimation techniques may be expected to demonstrate significantly different results. These preliminary results suggest that clinicians should endeavor to seek further confirmation when interpreting high tympanometric MEV values.

Limitations

Limitations The study is of short term and long term study is required for better assessment of result statistically.

CONCLUSION

It was concluded in our study that CT is more reliable investigation for middle ear volume measurement as compared to tympanometry in diseased as well as normal ears.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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