Int. Adv. Otol. 2011; 7:(1) 4-8

ORIGINAL ARTICLE

The Value of Multifrequency Tympanometry in the Management of Otitis Media with Effusion

Kerem Ozturk, Sercan Gode, Fatih Ogut, Cem Bilgen, Tayfun Kirazli

Ege University Medical School, Department of Otolaryngology, Izmir, Turkey, (KO, SG, FO, CB, TK)

Background: There is little evidence about the value of multifrequency tympanometry (MFT) in children with otitis media with effusion (OME).

Purpose: To evaluate the diagnostic value of the ear resonance frequency (RF) and 226 Hz traditional tympanometry (TT) among children with OME.

Research design: Cross-sectional controlled study.

Study sample: 52 ears of 35 patients with OME and 50 ears of 25 normal controls.

Intervention: Sweep frequency MFT and TT were performed for patient and control groups.

Data collection and analysis: Transtympanic aspiration was performed in diseased group. Characteristic of effusion was noted as serous or mucoid. Analyzed by t-test and ROC curve.

Results: Mean peak static acoustic admittance (Y_{tm}) value of patient and control groups were 0.25 ml and 0.52 ml ($p<0.01$); and mean RF value were 570 Hz and 1043 Hz respectively ($p<0.01$). Mean peak Y_{tm} value of mucoid and serous groups were 0.14 ml and 0.34 ml ($p<0.01$); and mean RF value were 478 Hz and 643 Hz respectively ($p<0.05$).

Conclusions: MFT was effective in differentiating normal ears from ears with OME. RF values below 650 Hz were highly specific in the diagnosis of OME. 226 Hz peak Y_{tm} was better than MFT for differentiating mucoid OME from serous OME.

Submitted : 23 July 2010 *Revised: 22 December 2010* *Accepted : 05 January 2011*

Introduction

Tympanometry, which is a non-invasive, quick, and inexpensive method, has been widely used for examining the middle-ear function. Tympanometry performed using conventional 226 Hz probe tone frequency has proven valid in identifying a variety of middle ear disorders [1]. However, conventional 226-Hz tympanometry often fails to distinguish normal middle ears from ears with pathologies that affect the ossicular chain [1-5]. Multifrequency tympanometry (MFT) is an advanced, recently clinically established, sweep-frequency or sweep-pressure method of acoustic immittance measurement. MFT provides values for the resonance frequency (RF) of the middle ear; this is the frequency in which the total susceptance is zero [4,6,7].

Otitis media with effusion (OME) is one of the most common ear diseases of childhood world [8-10]. Diagnosis of OME with TT remains a challenging situation especially in neonates and toddlers [11]. TT has some shortcomings and may yield misdiagnosis of patients. The positive predictive value of an abnormal (flat, type B) tympanogram has been shown to be between between 49 and 99 percent [12]. A type C (negative pressure) curve itself, is an imprecise estimate of middle ear pressure and does not have high sensitivity or specificity for middle ear disorders [12]. There is growing evidence for MFT to be superior than TT in the diagnosis and follow-up of patients with otitis media [13-15]. The middle ear RF has been demonstrated to be declined in patients with OME [16].

There is little information about follow-up or treatment differences regarding consistency of the effusion in OME. It is advocated in an experimental study that, mucoid effusion can undergo a process of organization and may end up with granulation tissue and cholesterol granuloma [17]. Diagnostic value of TT and MFT in differentiating mucoid OME from serous OME is not well studied.

Corresponding address:
Sercan Gode MD
Ege Universitesi Hastanesi Kulak Burun Bogaz Bolumu, 35100, Bornova, Izmir, Turkey.
Phone: +902323902600 • Fax: +902323902670
E-mail: sercangode@yahoo.com

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The aim of the study was to evaluate the diagnostic utility of the resonant frequency and peak compensated static admittance at traditional 226 Hz probe tone frequency in distinguishing children with OME from normal hearing children. It was also within the scope of this study to investigate whether the above parameters are able to distinguish between mucoid OME and serous OME.

Materials and Methods

Subject selection

This study was conducted at Ege University Medical School with 52 ears of 35 patients (15 male, 20 female) who diagnosed as OME and underwent trans-tympanic aspiration and ventilation tube application. A control group of 50 ears of 25 individuals (12 male, 13 female) with normal middle ear function were recruited.

The inclusion criteria of diseased group are as follows:

1. Age between 0-10 years (mean 5.0 years).
2. No signs or symptoms of acute otitis media such as pain in the ear.
3. Effusion in the middle ear in otoscopy confirmed with pneumotic otoscopy.
4. Middle ear effusion succesively confirmed in surgery with trans-tympanic aspiration.

The inclusion criteria of control group are as follows:

1. Age between 0-10 years (mean 5.8 years).
2. Normal physical and otolaryngological examinations.
3. Tympanometric pressures within ±50 daPa, and normal acoustic reflexes at frequencies between 0.5 and 4 kHz.

Instrumentation

Complete physical and otolaryngologic examinations were conducted for the diseased and the control groups. All individuals underwent pure-tone audiometry (if applicable) or behavioral tests, acoustic reflex analysis, TT, and MFT. TT and MFT were performed with GSI Tympstar v2 instrument (Grason-Stadler USA).

Finally, 35 patients underwent surgery with diagnosis of OME. All audiological tests of diseased group were performed on the same day with the operation.

Procedure

TT was performed at 226 Hz. Peak tympanometric pressure and peak static acoustic admittance (Y_{tm}) values were calculated by GSI software and noted.

RF was taken as the quick estimate of sweep frequency analysis between 0.25 and 2 kHz given by GSI Tympstar v2. In this algorithm, susceptance was measured in a frequency sweep at one extreme pressure and at tympanometric peak pressure, and the frequency at which total susceptance was equal to zero was taken as RF, The system used negative tail. The operator did not confirm sweep frequency estimation manually with sweep pressure analysis.

All operations were under general anesthesia. Middle ear effusion pattern was determined as serous or mucoid. Serous ears were determined with easily aspirated serous effusions, whereas mucoid ears with thick mucoid effusions that can't be aspirated easily and inverting when not aspirated. Ventilation tube was applied with adenoidectomy for all patients.

Statistical analysis

Results are expressed as means ± standard deviation (SD). Analysis of data was performed using software SPSS v17.0. Levene's t-test and analysis of variance (ANOVA) was used to compare means and receiver operating characteristic (ROC) curve analysis was performed whether middle ear RF is superior to peak Y_{tm} or not, in differentiating normal ears from OME.

Results

The diseased and the control groups comprised of 52 ears of 35 patients (15 male and 20 female) and 50 ears of 25 individuals (12 male and 13 female), mean age was 5.0 years (2-10 years) and 5.8 years (2-10 years) respectively (Table 1).

Table 1. Distribution of the diseased and the control groups, indicating mean RF and Peak Ytm values.

Group	N	Mean age (yr)	Mean Peak Ytm (ml)	Mean RF (Hz)
Diseased group	35	5.0	0.25	570
Control group	25	5.8	0.52	1043

Mean Peak Y_{tm} value of the diseased and the control ears were 0.25 ml (0.1-0.8 ml; SD: 0.15 ml) and 0.52 ml (0.2-1.4 ml; SD: 0.21 ml) respectively ($p<0.01$). Mean RF value of the diseased and control ears were

570 Hz (250-1450 Hz; SD: 174.0 Hz) and 1043 Hz (600-1450 Hz; SD:236.6 Hz) respectively ($p<0.01$). The RF values for the diseased and the control groups were given in Figure 1.

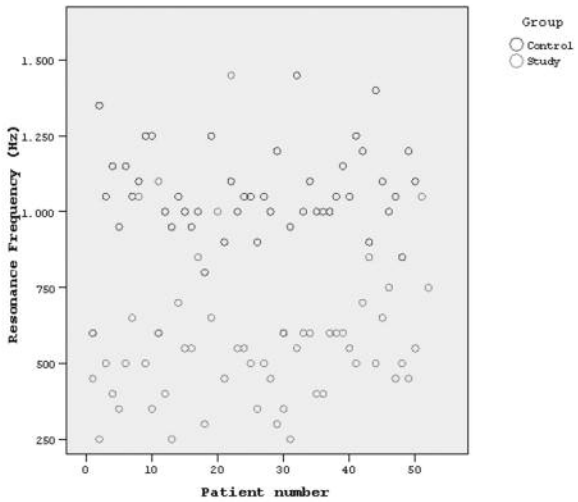

Figure 1. Distribution of both patient and control groups according to RF values.

Within the diseased group 29 (55.8%) patients had serous and 23 (44.2%) had mucoid type effusion in the middle ears. Mean peak Y_{tm} value of the mucoid and the serous groups were 0.14 ml (0.1-0.2 ml; SD: 0.05 ml) and 0.34 ml (0.1-0.8 ml; SD: 0.15 ml) respectively ($p<0.01$). Mean RF value of the mucoid and the serous groups were 478 Hz (250-650 Hz; SD: 111.6 Hz) and 643 Hz (250-1450 Hz; SD: 282.4 Hz) respectively ($p<0.05$).

ROC analysis was used to objectively compare the performance of Y_{tm} at 226 Hz versus RF estimate and to determine the optimal decision criterion or cut off value by means of OME diagnosis and effusion type prediction. Regarding OME diagnosis, area under curve (AUC) for RF and 226 Hz Peak Y_{tm} were 0.93 and 0.88 respectively ($p<0.01$) (Figure 2). MFT evaluation yielded 100% specificity and 63.5% sensitivity in OME diagnosis for results lower than 575 Hz. Regarding the differentiation of the effusion type, AUC for RF and 226 Hz Peak Y_{tm} were 0.67 and 0.89 respectively ($p<0.01$) (Figure 3). 226 Hz Peak Y_{tm} evaluation had 100% sensitivity and 65.5% specificity in mucoid OME diagnosis for results lower than 0.25 ml.

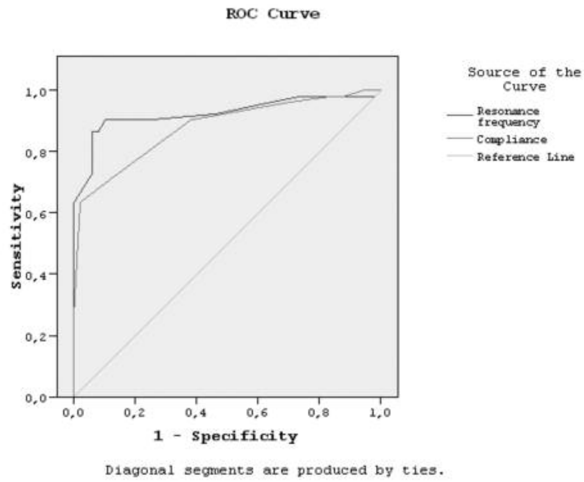

Figure 2. ROC analysis for OME diagnosis. Area under curve (AUC) for RF and Peak Ytm are 0.93 and 0.88 respectively ($p<0.01$, $p<0.01$ respectively).

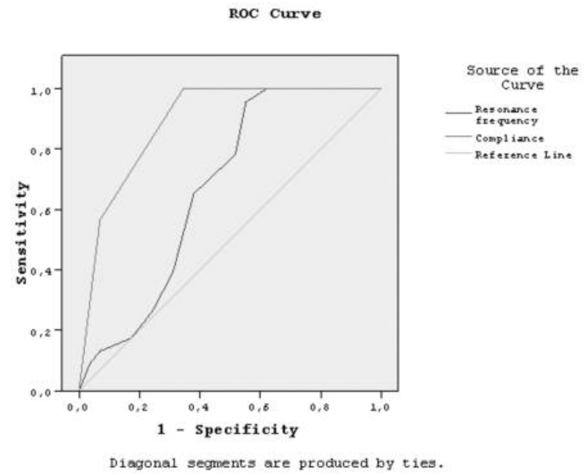

Figure 3. ROC analysis for mucoid OME diagnosis. Area under curve (AUC) for RF and Peak Ytm are 0.67 and 0.89 respectively ($p<0.05$, $p<0.01$ respectively).

Discussion

One of the most commonly encountered ear diseases in children is OME. Highly variable nature of OME may cause a diagnostic and therapeutic dilemma in clinical practice. Audiometry, TT and pneumatic otoscopy are most widely used diagnostic tools in patients with OME. There is growing evidence for MFT as a diagnostic tool for detection of OME.

The normal range of RF value for normal-hearing ears varies in different reports. Most studies suggested an RF range for middle ear from 800 to 1,200 Hz [6,13,18]. Results of this study was not apart from others with mean RF value of 1043 Hz (SD:174.0 Hz) among normal ears. The normal 90% range for middle ear RF was 650 Hz – 1350 Hz in this study. This difference between studies may be attributed to the methods that middle ear RF values were gathered, such as sweep frequency or sweep pressure as well as the experience of the performer.

Stiffness and mass components of the middle ear system are frequency dependent. The RF of the middle ear system may be shifted higher or lower compared to normal ears by various pathologies. RF is directly proportional to the square root of stiffness and indirectly proportional to the square root of mass. These low mean RF values from the ears with OME indicates a mass loading of the middle ear [13,14,19]. In agreement with those of current literature, in this study, mean RF value was significantly lower among OME patients than normal controls, 570 Hz and 1048 Hz respectively (Figure 1). Mean RF range among OME patients reported in previous studies is between 380 Hz - 428 Hz [12,13,16]. The different results of current literature about RF values of OME patients might be due to the highly variable mass loading of middle ears with different consistency of fluid. Those variations of RF values reported in different studies, may limit the use of MFT in the routine diagnostic work-up of OME.

The most widely accepted clinical interpretation method of 226 Hz TT is to classify the tympanogram into three types of A, B, C, As and Ad mainly according to the middle ear pressure and static admittance differences according to Jerger classification. As far as we know from our own clinical practice and previous reports, type B tympanograms generally reflect a pathology, whereas highly variable nature of type A and C tympanograms may yield misinterpretation of the test and eventually a misdiagnosis [12,20]. This misdiagnosis is more prominent among infants due to the ear canal anatomy in whom OME is most frequent. The false positive rate of type B tympanograms reported by a previous study is 17%, and higher for type C and A tympanograms [20]. By accepting the type A tympanogram for inclusion criteria of normal controls in this study, evaluation of TT just as Jerger types might end-up with misinterpretation of the data.

The major objective of this study is to evaluate the diagnostic value of MFT in the diagnosis of OME.

The secondary aim was to evaluate whether it is superior to 226 Hz static admittance measurement or not. In order to investigate this, ROC analysis was performed for both middle ear RF and 226 Hz Peak Y_{tm}. MFT was superior to TT in the diagnosis of OME (Figure 2). The specificity was 95% and 100% for RF values below 625 Hz and 575 Hz respectively. There is not any other report to compare 226 Hz static admittance values with middle ear RF in OME. It has been reported in a previous study that, regarding the components of TT, neither static acoustic admittance nor tympanometric width have enough specificity in the diagnosis of OME [21]. Diagnostic value of MFT over TT in detecting middle ear pathologies was also reported in some previous studies [22,23]. It was reported in a previous study that, the percentage of positive tympanocentesis was zero when the RF was in normal range [20]. Result of this study is quite apart from that report. Fourteen out of 52 (26%) ears in the OME group were in normal accepted range of 650 Hz - 1300 Hz, in this study. All 14 ears in normal RF range, were proved to have serous effusions.

The type of effusion was reported to be important in the management of OME [17,24]. Mucoid OME has reported to have urgent and long-lasting pathologic process compared to serous OME. The diagnostic value of MFT was also investigated in this study by means of differentiating mucoid OME from serous OME. In ROC curve analysis, 226 Hz static admittance did a better job than RF in the detection of mucoid OME (Figure 3). TT was highly sensitive with 100% sensitivity for static admittance values below 0.25 ml. Although RF was lower in mucoid OME, neither sensitivity nor specificity was better than TT. This finding resembles the information reported by previous studies which advocated MFT to be better in mild pathologies that could not be detected by TT [12,25]. Static admittance measurement as well as MFT has shortcomings in the detection of type of effusion in OME when used as single diagnostic tools.

This study has some limitations regarding highly variable nature of OME and the study design. The first one is the mass of middle ear effusion, which is highly variable and generally cannot be easily classified as mucoid or serous. Another limitation is the lack of comparison with other tympanometric findings such as tympanometric width. However, the aim of this study was to evaluate the diagnostic value of the ear RF in the diagnosis of OME and compare it with static admittance measurement as a differentiating tool of mucoid and serous ears, not to evaluate MFT thoroughly in OME.

In conclusion; middle ear resonance frequency analysis proved to be effective, and at least as good as 226 Hz static admittance measurement, in differentiating normal ears from ears with OME. RF values below 650 Hz were highly specific in the diagnosis of OME. 226 Hz static admittance measurement was better than MFT in differentiating mucoid from serous OME. We advocate using the 226 Hz TT with the multifrequency tympanometry in the management of patients with OME. OME patients with below 650 Hz middle ear RF and below 0.25 ml 226 Hz peak Y_{tm} has most probably mucoid OME and may deserve closer follow-up or eary intervention. Additional studies are needed to clarify the role of MFT among OME patients.

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