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A clinical status: Serous otitis media infection with liquid characteristics prediction in middle ear of children

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Abstract

At the onset of infection in children with otitis media had fluid deposition starts in middle ear cavity, but it become thickened and more viscous as infection intensity shifting to a more chronic state and accumulated in the middle ear cavity. To access a clinical status of children with serous otitis media infection with liquid characteristics prediction in middle ear cavity.

Deposited fluids collected from middle ear cavity of 50 children at the time of surgery and tympanostomy tube insertion. These 34 children were undergoing for first the procedure and rest of 16 children undergone for a repeated set of surgery and tympanostomy tube placement.

These fluid dynamics properties can be analyzed through the magnetic rheometer device. In this study, children with a repeated set of tubes insertion had found lowest transferability rate but have higher lateral adhesion value. However, they had no statistically significant differences in between the same groups. Mucopyogenic fluids had significantly higher transportability rate compared to sticky/mucoid and watery or serous fluids with respect to other groups.

Keywords: Secretory otitis media, lateral adhesion, mucociliary cells, mucopyogenic fluids, transferability, tympanostomy tubes

Introduction

Secretory Otitis media is a defined as a kind of infection in a middle ear, causing fluid secretion or known as an effusion. Otitis media is a childhood disorder and its most prominent clinical sign is deafness if untreated, Otitis suffering children's may be a victim of chronic secretory otitis media adversely affecting children's speech and language development^[1]. The cost of treatment of otitis is exceeded to 5 billion dollars annually. Socio-economic status is an actual defining factor of sickness and death of children's suffering either from severe or acute otitis media. Otitis media infection is prevalent mostly in lower-classes compare to a higher class, because of differences in health treatment studied by Lynch and Kaplan^[2, 3]. Effusion is a secretion of mucilaginous fluids from the middle ear cavity and secreted fluids had differed composition, actually they are mucin belong to a glycosylated-proteins family. Mucins are important structural components of the mucociliary process system of the middle ear cavity, a path of the Eustachian tube into nasopharynx to eliminate the bacteria invasion. Normally, no mucin glycoprotein is present in the middle ear cavity^[4, 5]. Otitis media infection occurred in the middle ear cavity where persistent for a longer duration, it may result into mucin hyper production by excessive proliferation of mucous cells and other mucin-producing cells.

Recently, more than 20 human mucin genes were reported^[6] but some mucin genes were expressed only in inflammatory conditions such as MUC5AC, MUC5B, MUC4 and MUC1 in the middle ear, but the expression of these genes in chronic otitis media is still not clear, except in few cases of mucoid otitis media. The predominant species of mucin genes are MUC5B which is normally expressed in middle ear^[7], but overexpression of MUC5B gene is along with MUC4 gene is occurred when the otitis media infection reaches to a chronic state. Only reason of overexpression of mucin genes is due to extensive proliferation of inflammatory mucous cells^[8] imparting gel like properties in a nasal passage, ultimately blocked the nasal-airways. This impairment of the mucociliary transport system is cleared up by incorporating multiple tympanostomy tubes in children with secretory otitis media infection to expel out the viscous and non-transportable fluid from the middle ear cavity. The aim of the present study was designed to examine the fluid characteristics in infected Indian children with the secretory otitis media in middle ear cavity.

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Material and Methods

The number of children participated in this study were (N=50), in between the of age of 0-15 months, with 22 males and 28 females, out of these (N=34) undergo for first time bilateral tympanostomy tube insertion and remaining (N=16) had more than one tube insertion.

After 18 months (January-2024 to April-2024) of intensive study, results were obtained. All the participated children were subjected to the primary set of tympanic-tube insertion, as they all are suffered from otitis media infection. In addition, those Children suffered from any other diseases like immune-disorders or carry symptoms of acute otitis media at the time of surgery were not considered as study subjects. Another criterion of inclusion of subjects in this study, those children, who had taken antibiotics therapy, they all are treated as good candidates for surgery. Regular checkup was routinely offered to those children who had serious respiratory problems, when they all undergone for repeated sets of tubes insertion.

An accumulated fluid from both right and left ears was collected as sample *via* through a sterile otologic suction. Viscosity index measurement was made within 24hrs of collection of samples and then kept it at -80°C. In addition to this, middle ear fluids can be categorized further into watery, sticky or slimy and pyogenic fluids on the basis of visual appearance, that was investigated *via* through investigators. The fluid characterization, several factors are necessary to emphasis, fluids transferability by mucociliary cells, lateral adhesion of fluids, Elastance, adhesiveness and viscosity index.

Secreted fluids underwent for measurement of transferability from frog palate depleted of mucus content [9]. Frog palate was anatomized into two halves and stored it in a moisture chamber at standard condition of 25 °C with 90% humidity.

Under the standard conditions, a glycosylated protein product *i.e.* mucin production was stopped. During this event, 2ml of quantity was placed in a middle ear cavity along with iron particles serving as a marker, but carefully examined the ciliary cells in a motile mode. This motility behavior was detected with the help of a microscope and noted the time of motility of iron particles size of 5mm. However, thereby, the motility transport time was changed in reference to transfer velocity of sticky fluids, that was expressed in mm/sec unit. In addition, viscosity index and lateral adhesion are measured through the magnetic rheometer device, after placing the 4ml quantity of mucin within the mucocillary cells along with iron particles under the influence of magnetic field at same standardized condition [10].

The vibrating motion of the iron particles treats as a sphere, used to record its amplitude and phase lag of the iron spheres. All were used to calculate the mucin elastance and viscosity index values. The adhesiveness nature of secreted fluid was computed through the formula:

$$\text{Adhesiveness} = \sqrt{E + VI}$$

Whereas,

E=Elastance,

VI= Viscosity index

Statistical analysis

Data obtained from this study were statistically analyzed at Prism software version 11.0.

At $p < 0.05$ level was found statistically significant and observe at $p < 0.1$ level. Data distribution was visually confirmed to be

Gaussian by visual examination of scatter plots other than the including the statistical data: such as likelihood analysis. ANOVA Test and logistic regression methods were also included to analyze the stats data.

Results

Number of subjects

Children considered for the study were (N=50), all the children could not be pass out the preliminarily antibiotics test. Pie-chart presented the subject attributes of the study group of children. Out of these study group (N=50), the first 68% group children were subjected to primary tympanostomy tube insertion. Out of these, mostly 67.65% children were subjected to go for primarily inserted tympanostomy tube and remaining 32.35% children had tympanostomy tubes to investigate the recurrent respiratory problems. Around 44.11% children had viscous fluid secretion at the time of surgery. Other 11.77% had a mucopyogenic secretion while 8.83% children had watery secretion and rest of the 2.94% had a pyogenic (pus formation) secretion. The rest of the second sixteen grouped children (32%) subjected to further categorized into sub-groups which consists of second group (62.5%) and third group (37.5%) with tympanostomy tubes. However, second group children underwent to second set of tympanostomy tubes insertion, out of them, 7 children had a (70%) viscous fluid secretion while 3 had a (30%) mucopyogenic fluid secretion. A remaining third group of children underwent to third set of tympanostomy tubes insertion, out of them, 4 (66.67%) had a mucopyogenic secretion, 2(33.34%) pyogenic (pus formation) secretion as represented in Figure 1. Only two children have no sufficient quantity of fluids is found in their middle ear. No significant differences were observed between the studied groups with respect to fluid characteristics.

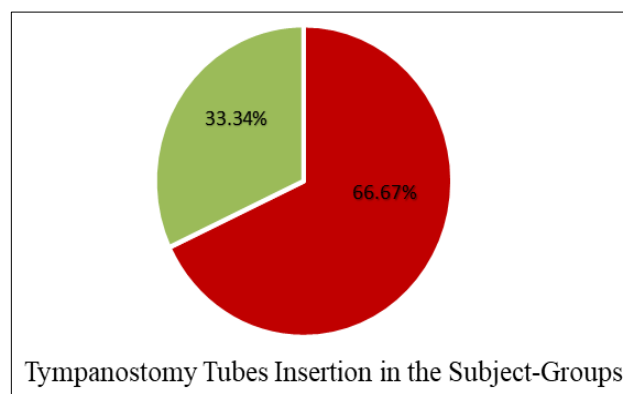


Fig 1: Pie-chart represents the multiple Tympanostomy tubes insertion in first group and second group

Table 1 discussed that the first/second group characteristics during the primary tubes and repeated set of tubes insertion occurred in a middle ear cavity. Fluid secretion occurred in a first group after the primary set of tympanostomy tubes insertion during the period of 0-12 months. The same results were obtained in a second group after 1-8 months (at $p=0.4$ level) of study duration. After the primary tubes' insertion in a first group, only 2 children (5.89%) found to had allergic signs and 15 (44.11%) were passive smokers while rest of the 32.35% suffered from respiratory problems.

Remaining second group had multiple set of tubes insertion, out of these, only 2 children (12.5%) had allergic signs and 4 (25%) passive smokers, while rest of the 7 (43.75%) children suffered from respiratory problems. Study results indicated

the younger aged children were more prone risk of OME infection because of lesser aged (1-11 years) as compared to older aged children. OME risk arises may be due to parental passive smoking which also initiates the respiratory problems in first group children as compared to second group children.

It means exposure of cigarette smoking is considered as risk factor for OME infection. No significant differences were found in between the other characteristics like age, gender or its past medical background.

Table 1: Subject group attributes

Tube insertion in Subject groups	Observed (N%) (N=50) subject group	Duration of fluid secretion	Allergic sign	Passive smoking	Respiratory illness
First group of tubes insertion	34/50 (68%)	0-12 months	5.89%	44.11%	32.35%
Second group of tubes insertion	16/50 (32%)	1-8 months	12.5%	25%	43.75%

Table 2: Fluid properties of subject groups

Tube insertion in Subject groups	Mean of MPS	Viscous Secreted Fluids	Lateral Adhesion	Elastance(E)	Viscosity Index (VI)
First group of tubes insertion	0.45	44.11%	146	187	53
Second group of tubes insertion	0.28	70%	229	291	107
Third group of tubes insertion	0.10	33.34%	257	67	42
At p-value	0.05	0.26	0.167	0.2322	0.162

Table 2 discussed the accumulated fluid properties like such as mucociliary process system (MPS), viscous secreted fluid, lateral adhesion, elastance (E) and viscosity index (VI) of each groups. Mucociliary process system (MPS) was calculated for each of the groups. As the fluid behavior was shifted towards the viscous state, the trend of transportability of fluids by mucociliary cells was lowered in a continuous fashion especially observed in second grouped Indian children. One of the reasons of lowered transport ability in children ear through the ciliary cells is just because of multiple set of tubes insertions. Children undergoing for primary tubes insertion at first attempt, had a mean MPS of 0.45, while those undergoing a second had a mean MPS of 0.28, and last third group had a mean MPS of 0.10 recorded at p value of 0.05. The mean value of MPS data of the children could be shared with the earlier reported studies of tympanostomy tubes. This comparison can be done with the help of Mann Whitney test against those children who do not have a past history of tubes insertion. Statistically, Mucocillary process system (MPS) significantly correlated the middle ear cavity of children of same group at p-value of < 0.0001.

MPS comparison depends on the fluid type secreting, mucopyogenic secretion at both secretory otitis and mucoid otitis infective conditions at p value of 0.0004 and 0.067, respectively. In addition, lateral adhesion property of fluids was also analyzed, and it was noted the trend of increment of lateral adhesion in those children who regularly undergone for multiple set of tubes insertion but it was not correlated significantly at p value of 0.167.

However, children with no tube's insertion had 146dyn/cm² of lateral adhesion value while those having one set of tubes insertion had a mean value of 229dyn/cm² and those with multiple set of tubes insertion had a higher mean value of 257dyn/cm² but it was noted statistically, the lateral adhesion value did not differed too much in between the middle ear cavity of the same groups. Another important property of fluids *i.e.* elastance was analyzed in these children. The first group children undergoing for tube insertion in ear had a mean value of 187dyn/cm², while the rest of the second and third groups had a mean value of 291dyn/cm² and the 67dyn/cm² least observed value. No significant differences were observed at p-value of 0.2322. Similarly, viscosity index (VI) values were also measured and it also follows the same trend of elastance. In first subjects group had a (VI) mean value of 53dyn/cm² with no tube's insertion while in case of second group had a higher (VI) mean value of 107dyn/cm²

with one set of tubes insertion and least value of 42dyn/cm² was observed in third group with two set of tubes insertion. No significant differences were observed at p-value of 0.162. otitis media with effusion (OME) is a chronic inflammatory condition. It typically observed in lesser aged children. It is characterized by the presence of an effusion, sticky glue-like fluid behind an intact tympanic membrane in the absence of signs and symptoms of acute inflammation; for this reason, the commonest reported symptom was hearing loss, which may lead to speech delay or educational problems. Histologically, it is a chronic inflammatory condition, characterized by inflammation in the middle ear mucosa, overproduction of mucin and production of altered, more viscous mucin responsible for the thick viscous properties of the glue with numerous other components including bacteria have been identified in the middle ear cavity.

Discussion

This study discusses about the setting up a multiple number of tympanostomy tubes in children ear with secretory otitis media infection. Because of placement of multiple set of tubes in infected children lowers the transferability efficiency of mucociliary cells, and increases the fluid stickiness compared to first groups with no tube's insertion. This study stated that there was no significant differences in data relevant to studied three subject groups, but it clearly demonstrates the trend of reduced transferability by mucocillary process system (MPS) especially observed in second group mucopyogenic cases. This study suggests the mucocillary process system (MPS) had significantly better compatibility in children with mucopyogenic secretion because of inflammatory mediators' participation *via* through the ciliary cells.

Studied data found similar to reported data by Krueger *et al.* [11] but not fully supported by other previous studies Lin *et al.* [4]; Juhn *et al.* [12], it may account for infiltration of so many inflammatory cells in the middle ear cavity even though the presence of bacterial culture. Liu *et al.* [3] and Monroy *et al.* [13], studied report support the mucocillary dysfunctioning events especially observed in children which ultimately resulted into an altered fluid characteristic. Notably, mucins are considered as critical molecules in terms of protecting epithelial cells of ear from bacterial components but their presence may also contribute into no effusion and non-clearance of existing and altered fluids by mucocillary cells and only reason of increased viscosity of existing fluids in children ear. Moreover, it has been postulated that these

mucin class molecules are MUC5B. Roy *et al.* [14] associated this event with neutrophil extracellular entrapment, that was commonly observed during the middle ear effusion [15], which stimulates the hyperactivity kind of reactions Evans *et al.* [16] in children ear. Presumably, these leukocytes molecules further contribute in marked increment in viscosity of the effusions [17] in those children middle ear cavity that are undergone for multiple set of tubes treatment as they observed through reduced transferability by mucociliary cells.

According to the recent report of Kutluhan *et al.* [18, 19] suggested that approximately 78% of middle ear fluids were efficiently transferable through the ciliary cells [18]. An estimated rate 21 dyn/cm² of transferability would be counted as positive correlation. It means there was a significant relationship in between the viscosity index and transferability, because of which, improper clearance of bacteria/viruses or any other foreign invaders can be restricted by mucociliary cells if there was an alteration in biomechanical characteristics of existing fluid as seen in case of children ear with otitis media infection. The result of this study was also supported by other earlier published studies on cat model where they showed the significant relationship in between the viscous nature of mucus and goblet cell hyperplasia as reported by Peng [5]; Preciado *et al.* [20]. The study results suggested that the viscous mucus produced by goblet cells in cat model had more viscosity index than the optimal viscoelasticity required for efficient passage of ciliary cells [21], thereby, more chances of OTE infections. Children with respiratory problems cannot be studied because of the limited size of the sample. Long term tympanostomy-tubes placement is usually observed in those children ear with recurrent secretory otitis media infection faces white patches appearances in tympanic membranes due to the deposition of calcium ions and very rarely causes hearing issues or retraction pockets appearances. These tympanic membrane changes can be resolved in children by surgical treatment. Therefore, long term usage of tympanostomy tubes insertion is avoided especially in case of recurrent secretory otitis media cases. Safety measures should be taken while setting up multiple tubes in ear cavity in order to avoid toxicity and bacterial infection which affects hearing losses or balance. Thus, the clinical toxicity testing is recommended before clinical application of surgical tubes. In this respect, some potential questions arise which would be helpful on future studies like how researchers can access the efficacy of tympanostomy tubes insertion in preventing children from otitis media infection or how to determine the role of long-term vs short term tubes in children with cleft-palate or down's syndrome. Researchers must focus on children with otitis media infection; child-health may be improved by inclusion of multiple set of tubes on short term basis at the starting phase of infection in children ear cavity.

Conclusions

The present study concluded that the children with otitis media infection require multiple set of tympanostomy tubes insertion, ultimately changed the fluids characteristics such as Viscosity index, fluid behavior and poor transferability of mucus from ear to nasopharyngeal cavity. Most notable points of study confirm that the mucopyogenic secretion had a better transferability rate than the secretory and slimy secretions. This study finding opened the pathway of future study which depends on the fluids characteristics or fluid dynamics and generates a new therapeutic treatment against secretory otitis media disease.

Conflict of interest

Authors declare that they have no conflicts of interest relevant to the content of this study.

Authors' Contributions:

All the authors contribute well in this study.

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