Fluid characteristics in pediatric otitis media with effusion

Kelley M. Dodson, MD1; Randall S. Cohen, MD2; Bruce K. Rubin, MD3
Virginia Commonwealth University Medical Center1 Department of Otolaryngology and Pediatrics3; Private Practice Arizona2

ABSTRACT
Objective: Persistent otitis media with effusion is caused by poor clearance of middle ear fluid usually following an episode of acute otitis media. This fluid is often viscous and poorly transportable by cilia. We hypothesized that the subset of children who require repeated myringotomy and tube procedures would have effusion fluid characteristics that were more viscous and less transportable than those having their first procedure.

Design: Prospective Clinical Study

Setting: Tertiary Care Center

Patients and Interventions: Middle ear secretions were collected at the time of myringotomy and tube insertion in 36 children accrued sequentially. Twenty-six of these children were having their first procedure and 10 had previously undergone myringotomy and tube placement.

Main Outcome Measures: In vitro mucociliary transportability and dynamic rheology in a magnetic microrheometer.

Results: Children with the need for repeated procedures had effusions with lower mucociliary transportability, and overall higher mean measures of surface mechanical impedance/frictional adhesion, but these did not reach statistical significance. Mucopurulent effusions had significantly greater transportability than both mucoid or serous effusions in both groups. Of those undergoing primary M&T insertion, 9 had concurrent adenoidectomy, while 6 underscored repeated tube insertion had either previous (N=2) or concurrent adenoidectomy (N=4). Population characteristics are detailed in Table 1.

Conclusions: Persistent or recurrent otitis media with effusion is associated with poorly transportable middle ear fluid which may have higher frictional adhesion.

INTRODUCTION

Otitis media with effusion (OME) is one of the most common disorders of childhood, with an economic burden of over 5 billion dollars annually. Sometimes, it causes hearing loss lasting which may have detrimental effects on speech and language development.

Effusions vary in their composition, but primarily consist of mucin, which plays an important role in mucociliary clearance through the Eustachian tube.3 MUC5B is the predominant mucin expressed under normal conditions; it is significantly upregulated in chronic and mucoid otitis media disease states, along with MUC4.3-5 EM analysis of middle ear fluid (MEF) in OME reveals thick chains of polymeric mucin thought to compromise the normal mucociliary transport down the Eustachian tube, with thicker mucoid effusions containing more glycoprotein.3,6-8 In addition to mucins, secretory IgA, interleukins, inflammatory cytokines, and lysozyme are present, and contribute to the viscosity.9-12

Mucociliary clearance may improve with ventilation tube insertion in children with chronic OME.13 A subset of these will not resolve after one set of tubes and will require additional M&T procedures.14 In addition to known risk factors for chronic OME, we hypothesized that children who require multiple procedures may also have MEF with higher viscosity and poorer clearability as defined by objective measurements.

MATERIALS AND METHODS

The study population consisted of 36 children (mean age 58.3 mo; 17F and 6M) who had primary bilateral ventilation tube insertion (N=26) or more than one (N=10) tube insertion. Of those with repeated tube insertion, 6 (17%) were receiving their second set of tubes and 4 (11%) were receiving a third set. All had failed previous medical management.

Of those undergoing primary M&T insertion, 9 had concurrent adenoidectomy, while 6 underscored repeated tube insertion had either previous (N=2) or concurrent adenoidectomy (N=4). Population characteristics are detailed in Table 1. Intraoperatively, a sample of middle ear fluid was obtained from both ears when possible, using an otologic suction and a microaspiration trap. Samples were stored at -80°C and viscoelasticity measurements were made within 24 hours.

The secretions were evaluated for mucociliary transportability (MCTR) on the mucus-depleted frog patate. Surface mechanical impedance (frictional adhesion or Gs*) and dynamic viscoelasticity was analyzed in a magnetic microrheometer. Statistical analyses were performed using StataView (SAS, Cary, NC). Data distribution was confirmed to be Gaussian by visual inspection of scatter plots. Summary statistics were calculated, and inferential tests, including contingency analyses with ANOVA Test and logistic regression, were performed.

RESULTS

There were no differences between the groups in terms of age, sex, or past medical history. Interaural correlation was statistically significant for all measures. There was no significant difference between the groups with respect to the type of effusion present, although there was a trend for more mucoid and mucopurulent confounders in the repeated tube insertion groups. However, MCTR was significantly better in the mucopurulent group than either the mucoid or serous groups (p=0.0004 and 0.0066; Figure 1).

Rheology is summarized below in Table 2. Mucociliary transportability (MCTR) was evaluated for each of the groups. There was a trend towards lower mucociliary transportability in children undergoing repeated tube insertion. When combining the mean MCTR data of the children with previous history of myringotomy tubes and comparing with a Mann Whitney test against children with no prior history of tubes, the trend almost reached statistical significance (p=0.057). MCTR was no different in the groups with or without adenoidectomy (p=0.06).

Surface mechanical impedance or frictional adhesion (Gs*) was also analyzed, and tended to be higher in children undergoing repeated M&T procedures, but these did not reach statistical significance (p=0.35). Elastic recoil (G’1) was also analyzed and was not different between the groups. Viscosity as a function of the loss modulus (G”1) was examined and did not reach statistical significance (p=0.40). Overall, viscosity was higher for mucoid and mucopurulent effusions than the serous effusions.

DISCUSSION

There was a trend towards lower mucociliary transportability and increased frictional adhesiveness of MEF in children requiring multiple sets of myringotomy tubes when compared with children having their first set of ear tubes. Although this did not reach statistical significance, there was a strong trend toward reduced transportability.

Previous studies in children have suggested that the rheological properties of MEF may be one of the causes of mucociliary dysfunction.5,7-8,15 Like our study, Majima et al were unable to find significant differences in G’ or viscosity between children undergoing their first M&T versus repeated sets, but did note that up to 26% of MEF specimens were not transported by cilia at all.15 A similar correlation was also shown between viscosity and transport rate, suggesting that alterations may underlie the poor mucociliary clearance in pediatric OME. In an animal model, a significant correlation has been established between the rheology of MEF and goblet cell hyperplasia.16 The thick mucoid effusion produced by goblet cells was much higher than the optimal viscoelasticity for effective ciliary transport.16 Interestingly, in our study MCTR was best for mucopurulent effusions, which may suggest that inflammatory mediators may play a role in improving clearability.

The strengths of our study lie in our prospective data collection, and use of the contralateral ear as an internal control. Our study was limited by sample size. It is likely that larger sample sizes would increase our power to detect a significant difference in mucociliary transport, as well as parse out likely differences in viscosity and elastic recoil in these subgroups of children.

CONCLUSIONS

Based upon our initial findings, the majority of children who require myringotomy and tube placement for OME have an unfavorable rheologic profile in terms of mucociliary transportability and surface mechanical impedance. Notably, mucopurulent effusions had better clearability than both mucoid and serous effusions. In the future, further refinement of rheologic data may lead to prognostic and ultimately therapeutic treatment options based upon a child’s MEF characteristics.

REFERENCES


Table 1. Study Population.

<table>
<thead>
<tr>
<th>N (%)</th>
<th>Duration of Effusion</th>
<th>Allergy History</th>
<th>Smoke exposure</th>
<th>Adenot-ectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Set of Tubes</td>
<td>26/36 (72%)</td>
<td>2.7 mo</td>
<td>2/26 (8%)</td>
<td>14/26 (54%)</td>
</tr>
<tr>
<td>Repeated Sets of Tubes</td>
<td>10/36 (28%)</td>
<td>3.4 mo</td>
<td>2/10 (20%)</td>
<td>5/10 (50%)</td>
</tr>
</tbody>
</table>

Table 2. Rheologic Characteristics of Effusions.

<table>
<thead>
<tr>
<th>Mucoid Effusion</th>
<th>Mean MCTR</th>
<th>Frictional adhesion (Gs*)</th>
<th>Elastic Recoil (G’1)</th>
<th>Viscosity or loss modulus (G”1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Set of Tubes</td>
<td>58%</td>
<td>0.51</td>
<td>160</td>
<td>208</td>
</tr>
<tr>
<td>Second Set of Tubes</td>
<td>83%</td>
<td>0.38</td>
<td>269</td>
<td>312</td>
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<tr>
<td>Third Set of Tubes</td>
<td>75%</td>
<td>0.21</td>
<td>285</td>
<td>143</td>
</tr>
<tr>
<td>P value</td>
<td>0.2148</td>
<td>0.076</td>
<td>0.057</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Figure 1: MCTR by type of effusion.

CONTACT
Kelley Dodson, MD
VCU Medical Center
Phone: 804/828-3966
www.vcu.edu/ent