The Effect of Continuous Positive Airway Pressure on Middle Ear Pressure

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INTRODUCTION

- Obstructive sleep apnea (OSA) is a syndrome with recurrent respiratory tract obstructions causing decreased or cessation of breathing, i.e. hypopneas or apneas, often associated with oxygen desaturations.
- The cumulative effects of OSA have been associated with a wide range of deleterious health consequences including an increased risk of hypertension, diabetes, obesity, depression, heart attack, and stroke1-3.
- CPAP is a commonly used treatment modality for patients diagnosed with OSA where pressurized air is blown through a nasal or oronasal mask pneumatically stenting the airway open during sleep.
- Although CPAP has proven to be an effective treatment option for sleep-disordered breathing, the effects of treatment on other areas of the head and neck, such as the middle ear, are still under investigation.
- Does CPAP affect middle ear pressures? We hypothesize that middle ear pressures will have a directly proportional relationship to CPAP pressures through the Eustachian tube.

METHODS AND MATERIALS

Institutional Board Review granted permission for the study. To determine the range of normal middle ear pressures, we evaluated 3,066 tympanograms stored in a de-identified electronic database (Filemaker Pro 10.0v1, Santa Clara, CA, USA) maintained in our audiology clinic from April, 2010, until February, 2011. Tympanometry was obtained using standard ear canal probes from either a GSI Tympanometer (Grason-Stadler, Eden Prairie, MN, USA) or an Interacoustics AT235 audiometer (Interacoustics, Assens, Denmark). We filtered the database results to exclude anyone with missing audiometric data on their audiogram.

Ten healthy volunteers with no history of middle ear disease or Eustachian tube dysfunction were recruited. Each subject had a portable nasal mask CPAP (System One REMStar AutoCPAP, Philips Respironics, Murrysville, PA, USA) fit snugly and a tympanometer probe from a GSI Tympanometer (Grason-Stadler, Eden Prairie, MN, USA) placed in the left and right external auditory canal. CPAP pressure settings were placed at 0, 5, 10, and 15 cm of water and tympanometry was performed simultaneously at each pressure setting. Between each pressure adjustment, ME pressures were allowed to return to baseline as determined by pre-CPAP tympanometry and repeat measurements between each pressure adjustment. The tympanometer probe was then placed in the contralateral ear and tympanometry measurements were obtained at each of the three CPAP pressure settings. At each CPAP pressure setting, a pre-swallow and post-swallow middle ear pressure was also measured. Averages for the right and left ears were also averaged for each pressure setting.

RESULTS

Normal Range of Middle Ear Pressures
- 3,066 tympanograms met criteria for inclusion.
- The mean middle ear pressure was -11 daPa, with a median value of 15 daPa and a range of -395 to 195 daPa (Figure 1).
- 80 tympanograms (0.03%) had values at or above 40 daPa. 9 tympanograms (0.003%) had values at or above 100 daPa.

CPAP Pressure Settings

<table>
<thead>
<tr>
<th>CPAP Pressure Settings (cm of H2O)</th>
<th>Average Middle Ear Pressure (daPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>5</td>
<td>47</td>
</tr>
<tr>
<td>10</td>
<td>82</td>
</tr>
<tr>
<td>15</td>
<td>129</td>
</tr>
</tbody>
</table>

CONCLUSIONS

- While further investigation is necessary to determine clinical relevance, we have shown that middle ear air pressure is directly proportional to CPAP air pressure in subjects with normal Eustachian tube function.
- Normal ear pressures rarely exceed 40 daPa.
- Although the pre-swallow measurements were relatively unchanged, there was a statistically significant correlation of increased post-swallow middle ear pressures with increased CPAP pressure.
- Middle ear pressurization during CPAP likely occurs after opening of the Eustachian tube.
- Swallowing occurs naturally during sleep and often is associated with arousals.
- We recommend an open discussion of the potential risks, benefits, and alternatives of CPAP use in OSA patients undergoing otologic and neurotologic procedures.
- Clinicians should work closely with their sleep physicians to determine the optimal time to resume CPAP post-operatively as these findings may influence perioperative CPAP use.

REFERENCES