

The Effects of Positive Airway Pressure on the Middle Ear: Systematic Review and Meta-Analysis

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Abstract

Background: Positive airway pressure (PAP) is thought to increase middle ear pressure (MEP) which is of interest to otolaryngologists.

Objective: To systematically review the literature for articles evaluating the effects of PAP on the middle ear and to perform a meta-analysis on the data.

Data Sources: MEDLINE, OVID, Scopus, Web of Science and the Cochrane Library.

Review Methods: A search was performed from inception through March 28, 2017. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was followed.

Results: Seven studies reported various effects on the middle ear due to PAP. Patients who used PAP had higher MEP compared to controls. Higher PAP settings are associated with higher MEP ($R^2 = 0.9516$, $p < 0.0001$). Swallowing markedly increases the MEP when using PAP. Two studies assessed PAP in patients with Eustachian tube dysfunction (ETD) and retracted tympanic membranes. Both reported improvement in pure tone average (PTA) with an overall improvement of 7.3 dB HL (95% CI 3.45, 11.17, $p = 0.0002$). One study reported visual improvements/resolution in attic retraction pockets secondary to PAP.

Conclusion: PAP seems to increase middle ear pressure which may be of concern to an otologic surgeon. PAP treatments may also help mitigate the effects of ETD in some patients. Better data is needed to more definitively assist surgeons reach management conclusions when caring for otologic patients that use PAP.

Introduction

Obstructive sleep apnea (OSA) is a common disorder frequently treated by Positive Airway Pressure (PAP) devices.¹ PAP is thought to increase middle ear pressure (MEP) which is of interest to otolaryngologists. Several studies have assessed various effect of PAP on the middle ear. The aim of this study was to systematically review the evidence regarding the effects of PAP on the middle ear.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was used as guidance when developing this project. MEDLINE, OVID, Scopus, Web of Science and the Cochrane Library were searched from inception through March 28, 2017.

Keywords and phrases searched included “positive airway pressure”, “PAP”, “middle ear”, “middle ear pressure”, “tympanogram”, “retraction pocket”, “atelectasis”, “Eustachian tube”, “hearing”, and “audiometry”. This study was exempt from formal review by the University of Virginia Institutional Review Board.

Study (year)	Study Design	Subjects	Follow-up	Middle Ear Pressure	Hearing Outcome	Retraction Pockets
Yung (1999)	PCS	30	Immediate	Increased	Improved PTA	Improved
Lin (2012)	PCS	10	Immediate	Increased	-	-
Sivri (2013)	PCC	156	6-months	Increased	-	-
Akbulut (2015)	RCT	35	5-weeks, 3-months, 6-months	Increased	Improved PTA	Improved
Askoy (2015)	CSS	51	-	Mixed	-	-
Thom (2015)	PCS	7	Immediate	Increased	-	-
Li (2016)	PCS	50	Immediate	Increased	-	-

Table 1. Studies that assessed the effects of positive airway pressure on the middle ear. -, not reported, PCS, prospective cohort, PCC, prospective case control, RCT, randomized controlled trial, CSS, cross-sectional study.

Results

Seven studies had enough useful data to assess the effects on the middle ear due to PAP (Table 1).²⁻⁸ In all six of the prospective studies, use of PAP increased MEP. Four studies reported sufficient data to pool the immediate effects on MEP with a PAP pressure of 10cm of water. The mean pressure increase was 82.23daPa (95% CI 56.51, 109.95, $p < 0.0001$, Figure 1). Two studies showed a long-term increase on MEP after 6-months of PAP use (Figure 2). Higher PAP settings are associated with higher MEP ($R^2 = 0.9516$, $p < 0.0001$, Figure 3). Swallowing markedly increases the MEP when using PAP. Two studies assessed PAP in patients with Eustachian tube dysfunction (ETD) and retracted tympanic membranes. Both reported improvement in pure tone average (PTA) with an overall improvement of 7.3 dB HL (95% CI 3.45, 11.17, $p = 0.0002$, Figure 4). One study reported visual improvements/resolution in attic retraction pockets secondary to PAP.²

Figures

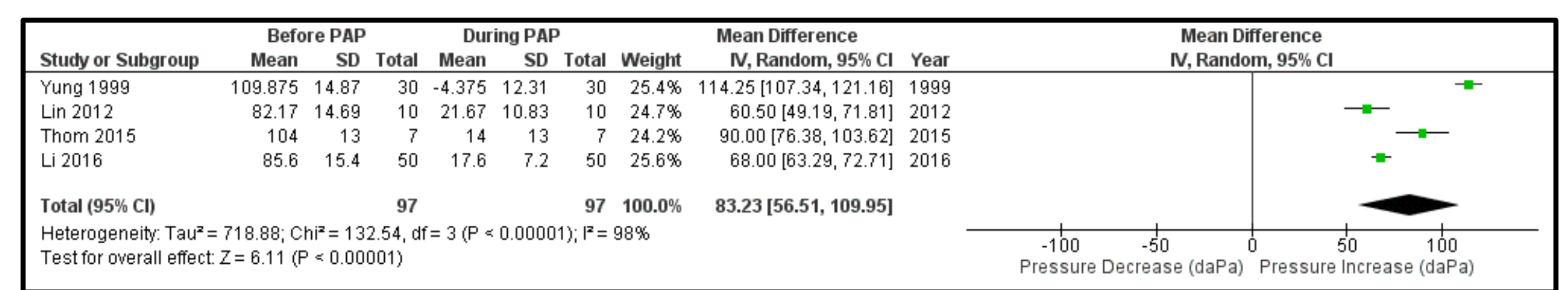


Figure 1. Forrest plot of four studies that assessed the immediate effect on MEP with a PAP setting of 10cm water.

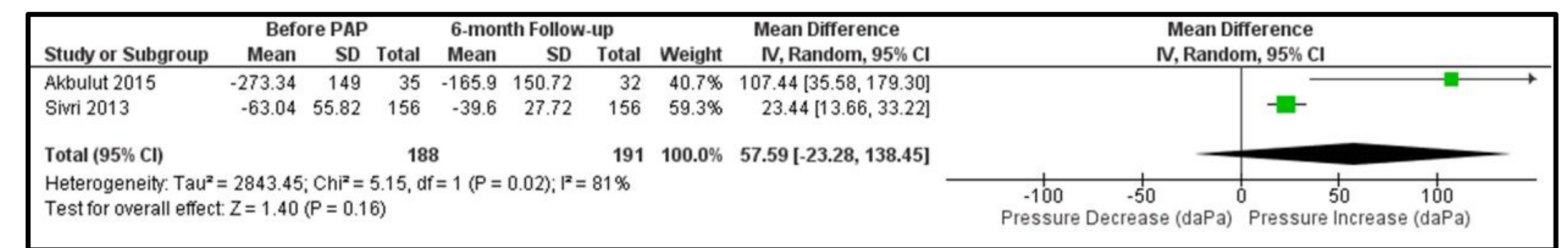


Figure 2. Forrest plot of two studies that assessed the effect on MEP after 6-months of PAP use.

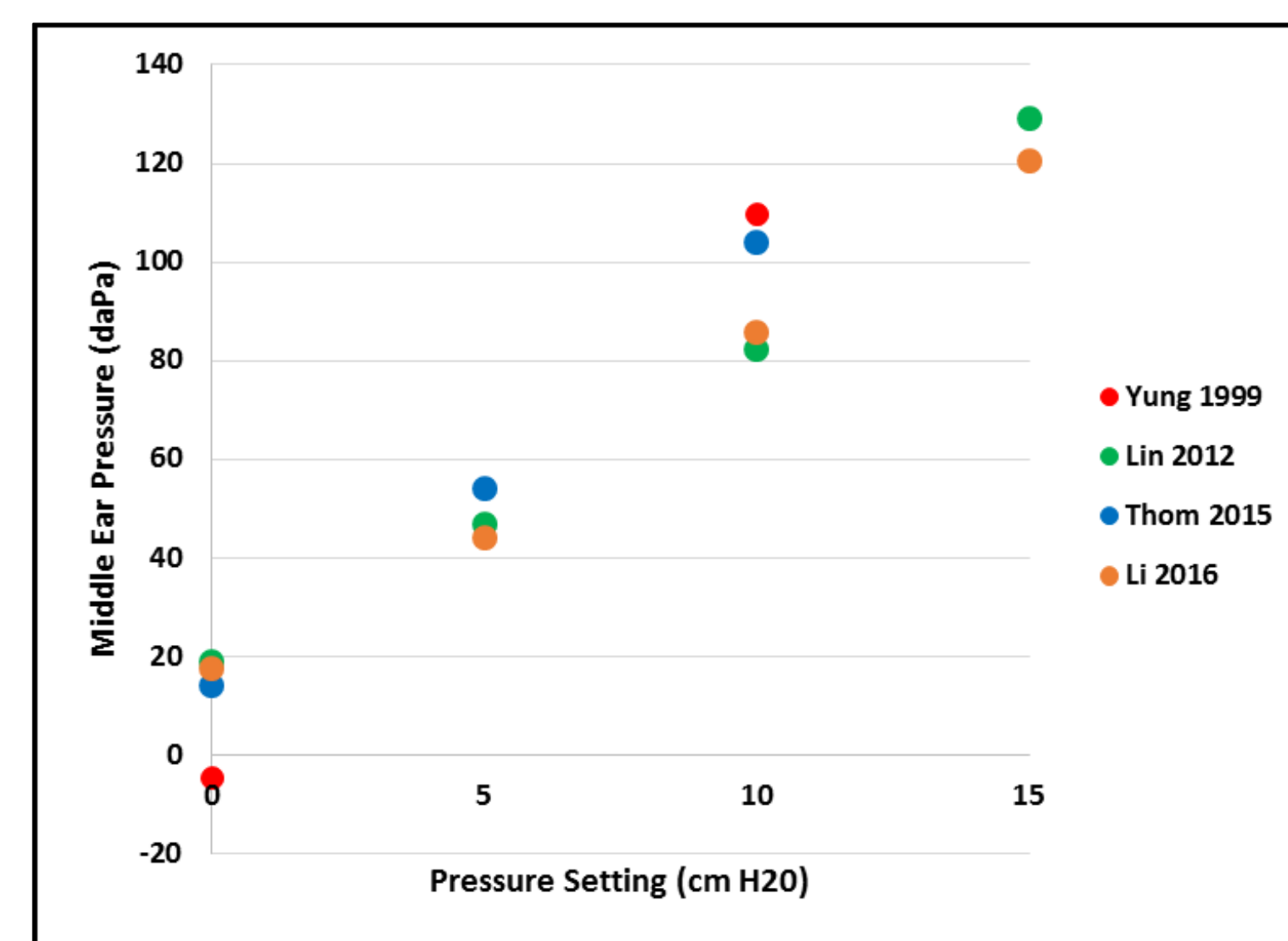


Figure 3. Linear regression of four studies that assessed the immediate effect on MEP with serial PAP settings. ($R^2 = 0.9516$, $p < 0.0001$).

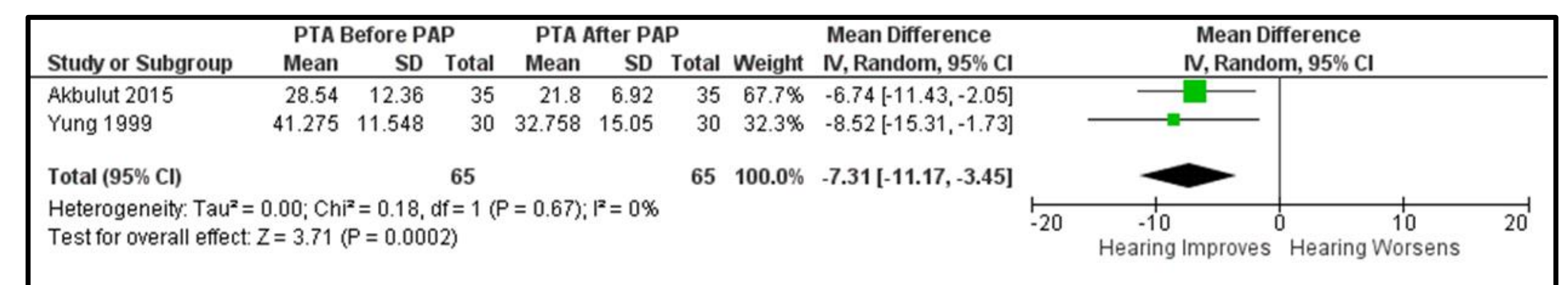


Figure 4. Forrest plot of two studies that assessed the effect on hearing via pure tone average (PTA) after PAP use.

Discussion

The prevalence of OSA continues to rise and an increasing number of patients utilize PAP therapy.¹ As otolaryngologists, it is important that we understand the potential effects that PAP may have on the middle ear.

Our data of seven studies²⁻⁸ demonstrates that MEP increases during PAP use. This increase remained after 6-months in two studies that assessed long-term follow-up.^{2,5} Additionally, a linear relationship exists between pressure setting and MEP – higher PAP settings are associated with higher MEP.^{3,4,5,7} Understanding this effect may be important when assessing or counseling patients because those who use PAP devices may have symptoms such as aural fullness. It is unclear if postoperative management should be different when patients that use PAP have middle ear surgery. A recent survey of otologists showed a wide spectrum of postoperative PAP advice after middle ear surgery.⁹

PAP treatments may inadvertently mitigate the effects of ETD in some patients. Atelectatic retraction pockets were resolved in two studies and the degree of conductive hearing loss improved in those studies.^{2,7} This may suggest that PAP could offer therapeutic benefit in patients with ETD.

This study had several limitations that are inherent to this type of research. First, a limited number of studies allowed data to be pooled for analysis. The data on MEP had high heterogeneity which may draw suspect to pooled results. However, a random effects model was utilized for those data since that is a more conservative means to aggregate studies. Also, several studies used different PAP treatments. The most similar data was used for calculating pooled means. However, the direction of effect for each outcome was similar in all of the prospective studies.

Conclusions

PAP therapy can increase middle ear pressure which may be of concern to an otologic surgeon. PAP treatments may also help mitigate the effects of ETD in some patients. Better data is needed to more definitively assist surgeons reach management conclusions when caring for otologic patients that use PAP.

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