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Prospective comparison of handheld pneumatic otoscopy, binocular microscopy, and tympanometry in identifying middle ear effusions in children

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ABSTRACT

Objectives: To compare pneumatic otoscopy, binocular microscopy, and tympanometry in identifying middle ear effusions in children and to determine if a significant difference exists in sensitivity and specificity based on patient age and/or experience of the examiner.

Methods: A prospective study of 102 patients, or 201 ears, enrolled over a 1-year period in a tertiary medical center. Sensitivity, specificity, positive predictive value, and negative predictive value were determined for staff and resident-performed pneumatic otoscopy, staff and resident-performed binocular microscopy, and tympanometry. Tympanometry data were stratified for age. A kappa correlation was used to compare each tool to myringotomy result (gold standard) and to compare staff versus resident.

Results: Binocular microscopy by staff pediatric otolaryngologist was the most sensitive, 88.0% (95% CI 81.4–94.7), and specific, 89% (95% CI 83.1–94.9). Resident binocular microscopy revealed a sensitivity of 81.5% (95% CI 73.6–89.5) and specificity 78.9% (95% CI 71.2–86.6). Staff was more sensitive and specific than resident at pneumatic otoscopy, sensitivity 67.9% (95% CI 57.6–78.3) and specificity 81.4% (95% CI 73.8–88.9) versus 57.7% (95% CI 46.7–68.7) and 78.4% (95% CI 70.4–86.4). Tympanometry had a much lower specificity for ages 5–12 months than for older children.

Conclusions: Binocular microscopy by staff pediatric otolaryngologist revealed the best sensitivity and specificity. Pneumatic otoscopy even performed by an inexperienced examiner is more sensitive and specific than tympanometry. The tympanometer is less specific in children under 1 year of age.

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1. Introduction

Acute otitis media and otitis media with effusion remain two of the most common ailments in children. Despite accounting for an estimated 20 million office visits per year in the US, they are extremely difficult conditions to diagnose with our current technology. Several studies have been published addressing the sensitivity and specificity of pneumatic otoscopy and tympanometry in detecting middle ear effusions. Primary care physicians are taught that pneumatic otoscopy represents the gold standard. However, to our knowledge, there have been no published studies examining the cumulative effects of patient age and clinician experience on the accuracy of pneumatic otoscopy, binocular microscopy, and tympanometry.

Patient cooperation during pneumatic otoscopy is extremely important to make an accurate diagnosis, and this is often dependent on the patient's age. A thorough examination and adequate seal may not be possible in some age groups. In addition, the anatomy of an infant's ear canal differs from that of an older child or adult. Younger patients have smaller ear canals and less support, leading to collapse of the cartilaginous ear canal with minor pressure changes. Paradise et al. found that infants less than 7 months of age with middle ear effusions tended to have normal tympanograms, presumably due to this phenomenon [1].

Furthermore, identifying middle ear effusions using pneumatic otoscopy improves with clinical experience. Pneumatic otoscopy is a subjective assessment which relies on the skill of the operator [2]. This fact was demonstrated by an intensive 4 month training program using pneumatic otoscopy in one otolaryngology residency. They found that this training improved the accuracy of junior residents in detecting middle ear effusions with pneumatic otoscopy [3].

Most tympanometers in primary care clinics today use low-frequency probe tones (220–226 Hz) to classify tympanograms as Jerger A, B, or C [4]. A represents normal compliance of the tympanic membrane, B decreased compliance, and C negative pressure in the middle ear. However, low-frequency probe tones have been shown to be less accurate in younger patients. One study

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has recommended using high-frequency probe tones (>660 Hz) for patients under 4 months of age [5]. Audiologists often utilize multi-frequency tympanometers.

Binocular microscopy is commonly performed in the otolaryngology clinic. Most children tolerate this exam well. A recent study found binocular microscopy to be quite accurate in identifying middle ear effusions, but it did not assess the experience of the examiner [6].

The purpose of this study is to better delineate the sensitivity and specificity of handheld pneumatic otoscopy, binocular microscopy, and tympanometry in identifying middle ear effusions in children. A secondary aim is to determine if the sensitivity and specificity change when patient age and examiner experience are considered.

2. Methods

The Madigan Army Medical Center Institutional Review Board approved this study. Informed consent was obtained from the parents of the study participants. Patients between the ages of 5 months and 5 years who met indications for myringotomy and tympanostomy tube placement were enrolled over a 1-year period. Inclusion criteria included children with a history of recurrent otitis media or chronic otitis media with effusion. Specifically, the children had at least 3 episodes of otitis media in 6 months, 4 episodes of otitis media in 1 year, or otitis media with effusion for at least 3 months. Patients with craniofacial syndromes or those who already had ear tubes were excluded.

The patients were identified in the preoperative holding area on the day of surgery. An otolaryngology junior resident, either PGY2 or PGY3, performed handheld pneumatic otoscopy followed by a staff pediatric otolaryngologist prior to surgery. The pneumatic otoscope (WelchAllyn™, Skaneateles Falls, NY) was the same model and configuration used by the primary care providers at our hospital. Each examiner recorded whether or not a middle ear effusion existed, and each was blinded to the other's results. Occasionally, cerumen obstructed the view of the tympanic membrane, and no result could be obtained.

The patient then was anesthetized utilizing an inhalational agent. Binocular microscopy was performed by the resident and staff, and the results were individually recorded. If cerumen was occluding the ear canal, this was removed during binocular microscopy to allow adequate visualization (a technique that would also be performed on children in the otolaryngology clinic). The staff otolaryngologist then performed tympanometry. The tympanometer (WelchAllyn™ MicroTymp®2, Skaneateles Falls, NY) was recently calibrated, and was the same tympanometer used by our primary care providers. Its probe tone frequency was 226 Hz. Only a Jerger type B (flat) tympanogram was considered indicative of middle ear effusion. Lastly, a myringotomy was performed to determine whether an effusion actually existed.

The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for staff pneumatic otoscopy, resident pneumatic otoscopy, staff binocular microscopy, resident binocular microscopy, and tympanometry. The finding at myringotomy was considered the gold standard. A kappa correlation was used to compare each tool to the finding at myringotomy and to compare staff versus resident in pneumatic otoscopy and binocular microscopy. A kappa value from .20 to .40 was considered fair agreement, .41 to .60 moderate agreement, and .61 to .80 good agreement.

3. Results

A total of 102 patients, or 201 ears, were enrolled and completed the study (Table 1). Three patients had a myringotomy on only one ear. During pneumatic otoscopy, 21 ears (10.4%) had enough cerumen present to preclude examination of the tympanic membrane. Myringotomy revealed a middle ear effusion in 92 ears (45.8%).

Table 1
Patient demographics.

Characteristic	Children (n = 102, or 201 ears)
Age (months)	
5–18	33 (32.4%)
19–30	34 (33.3%)
31–69	35 (34.3%)
Sex	
Male	60 (58.8%)
Female	42 (41.2%)
Cerumen precluding pneumatic otoscopy	21 ears (10.4%)
Middle ear effusion at myringotomy	92 ears (45.8%)

Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were determined for each tool and examiner (Table 2). Binocular microscopy performed by staff revealed the best results, with a sensitivity of 88.0% (95% CI 81.4–94.7), specificity of 89.0% (95% CI 83.1–94.9), PPV 87.1%, and NPV 84.7% (kappa = .77, 95% CI .68–.86). Resident binocular microscopy showed a sensitivity of 81.5% (95% CI 73.6–89.5), specificity of 78.9% (95% CI 71.2–86.6), PPV 76.5%, and NPV 70.7% (kappa = .60, 95% CI .49–.71). Staff pneumatic otoscopy revealed a sensitivity of 67.9% (95% CI 57.6–78.3), specificity of 81.4% (95% CI 73.8–88.9), PPV 73.6%, and NPV 80.1% (kappa = .50, 95% CI .37–.63). Resident pneumatic otoscopy resulted in a sensitivity of 57.7% (95% CI 46.7–68.7), specificity of 78.4% (95% CI 70.4–86.4), PPV 67.2%, and NPV 79.8% (kappa = .37, 95% CI .23–.51). The kappa correlation between staff and resident binocular microscopy was .61 (95% CI .50–.72), representing good agreement. The kappa correlation between staff and resident pneumatic otoscopy was .40, representing only moderate agreement. This suggested that staff was indeed more accurate than resident at both binocular microscopy and pneumatic otoscopy, but more so for pneumatic otoscopy. Tympanometry for all ages combined showed the third best sensitivity, 83.7% (95% CI 76.1–91.2), but the worst specificity, PPV, and NPV, 47.7% (95% CI 38.3–57.1), 57.5%, and 30.2%, respectfully (kappa = .30, 95% CI .17–.43).

The tympanometry results were then stratified for age (Table 3). Tympanometry in patients aged 5–12 months showed a sensitivity of 90.9% (95% CI 73.9–100), specificity of 28.6% (95% CI 0–62), PPV 66.7%, and NPV 13.7% (kappa = .22, 95% CI 0–.73). For patients aged 13–24 months, the tympanometer revealed a sensitivity of 92.1% (95% CI 83.5–100), specificity of 38.3% (95% CI 24.4–52.2), PPV 54.7%, and NPV 18.2% (kappa = .29, 95% CI .09–.48). In patients aged 25–69 months, the tympanometer demonstrated a sensitivity of 74.4% (95% CI 61.4–87.5), specificity of 58.2% (95% CI 45.1–71.2), PPV 58.2%, and NPV 45.1% (kappa = .32, 95% CI .13–.50). Although the tympanometer was sensitive in all age groups, the specificity

Table 2
Comparison of diagnostic tools.

Tool	Sensitivity ([a])	Specificity ([a])	PPV	NPV	Kappa
Staff Mic	88.0% (81.4–94.7)	89.0% (83.1–94.9)	87.1%	84.7%	.77
Res Mic	81.5% (73.6–89.5)	78.9% (71.2–86.6)	76.5%	70.7%	.60
Staff PO	67.9% (57.6–78.3)	81.4% (73.8–88.9)	73.6%	80.1%	.50
Res PO	57.7% (46.7–68.7)	78.4% (70.4–86.4)	67.2%	79.8%	.37
Tymp	83.7% (76.1–91.2)	47.7% (38.3–57.1)	57.5%	30.2%	.30

Abbreviations: Staff Mic: staff binocular microscopy; Res Mic: resident binocular microscopy; Staff PO: staff pneumatic otoscopy; Res PO: resident pneumatic otoscopy; Tymp: tympanometry for all ages; PPV: positive predictive value; and NPV: negative predictive value.

[a] 95% confidence interval.