Test–Retest Reliability of High-Frequency Thresholds at Bedside with Sensorineural Hearing-Impaired Listeners

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Abstract

Previous investigations have established the reliability of high-frequency thresholds performed in a sound suite using headphones. In addition, test–retest reliability of high-frequency thresholds in adults with normal hearing in a hospital room versus a sound-treated booth has also been established. The current study evaluated the test–retest reliability of thresholds in the 8000- to 18000-Hz range in 15 hearing-impaired adults (26 ears) with varying degrees of sensorineural hearing loss. A high-frequency audiometer and supra-aural earphones were used to measure thresholds in a typical hospital room. Results revealed no significant difference between repeated threshold measures. This study represents the third phase of an ongoing project to develop reliable bedside monitoring of patients undergoing ototoxic medical treatment.

Key Words: High-frequency audiometry, ototoxicity

It has been documented, as early as 1969, that monitoring high frequencies has the potential to detect ototoxicity as early as 2 months before conventional audiometric frequencies (Jacobson et al, 1969). Dreschler et al (1985) observed a decrease in hearing sensitivity between the frequencies of 10 and 20 kHz in 68 percent of his patients undergoing ototoxic medical treatment. In a subsequent work, he reported that threshold shifts were 10 to 15 dB greater in the 10- to 20-kHz frequency range and were detected before decreases were observed between the frequencies of 1 and 8 kHz (Dreschler et al, 1989). Tange et al (1985) reported a decrease in high-frequency thresholds in 35 percent of subjects receiving cisplatin therapy. Furthermore, it has been demonstrated that intrasubject reliability of high-frequency thresholds falls within a clinically acceptable range for a high-frequency audiometer (Fausti et al, 1990).

One deterrent to ototoxic monitoring is that many patients are too ill to travel to a sound-treated booth. A previous study observed no significant differences between thresholds measured in a sound suite and those measured in a typical hospital room (Valente et al, 1992). In this report, the test–retest reliability of high-frequency thresholds in adults with normal hearing in a hospital room was also established. Many critically ill patients exhibit pre-existing sensorineural hearing loss due to presbyacusis or noise exposure. Therefore, the goal of this study was to evaluate the test–retest reliability of high-frequency thresholds in a typical hospital room when the subjects already have a sensorineural hearing loss.

SUBJECTS

Twenty-six ears from 15 adults (ages 22 to 79, mean age 55.3 years) were recruited from the outpatient population of the Department of Otolaryngology, Washington University School of Medicine. Subjects exhibited a sensorineural hearing loss up to 60 dB HL at 8000 Hz. Configurations varied and there was measurable hearing up to and including 14 kHz. All were free of middle ear pathology as determined by a normal otoscopic inspection and the absence of an air-bone gap at the frequencies tested. Good general health was reported by all subjects.

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EQUIPMENT

The Maico MA 40 portable audiometer with TDH-39P headphones was used to assess thresholds at the conventional test frequencies. The Interacoustics AS10HF high-frequency audiometer (calibrated to dB SPL) and Koss HV-1A supra-aural earphones were used to assess high-frequency thresholds.

PROCEDURES

Testing was performed in a semi-private hospital room with the patient sitting upright on the edge of the bed. Ambient noise measurements were made with the GR 1565-D sound level meter and ranged from 36 dBA to 47.5 dBA with a mean of 43.3 dBA. No attempt was made to artificially restrict environmental conditions within the room. An otoscopic examination was performed on each subject by an otolaryngologist prior to testing. For each threshold procedure, the diaphragm of the headphone was placed directly over the opening to the external auditory canal. The headphones were positioned by the same examiner for each test and for every subject. Air-conduction thresholds were measured from 250 Hz through 8000 Hz in octaves including the interoctaves of 3 and 6 kHz using the Maico MA 40 portable audiometer and TDH 39P headphones. Bone-conduction thresholds were measured from 250 Hz through 4 kHz using the same audiometer. High-frequency thresholds were measured immediately following the conventional audiologic test as they would be in the case of a patient undergoing ototoxic monitoring. The Interacoustics AS10HF high-frequency audiometer with HV-1A supra-aural earphones was used to test the frequencies of 8 through 18 kHz in 2-kHz steps. All thresholds were determined by the modified Hughson-Westlake procedure (Carhart and Jerger, 1959). In order to determine test–retest reliability, two additional high-frequency threshold assessments were measured upon the subjects' return. In addition, the intervals between test sessions varied from 2 hours to 2 weeks, depending upon subject availability. Hospital rooms were randomly assigned based upon availability, which is how inpatients are customarily assigned.

RESULTS

The present study evaluated (1) the intersubject variability and (2) the test–retest reliability of high-frequency (8 to 18 kHz) thresholds in patients with sensorineural hearing loss. Mean thresholds and ranges for 250 through 8000 Hz are given in Figure 1. Results indicate a wide range of sensorineural hearing impairment of varying configuration across subjects. The mean thresholds and ranges for 8 through 18 kHz are given in Figure 2. Thresholds were obtained up to 14 kHz for all subjects; 16- and 18-kHz thresholds were highly dependent on the degree of sensorineural hearing loss. Therefore, data could not be obtained for all subjects above 14 kHz.

Table 1 shows the percentage of sessions having test–retest differences within 0, 5, 10, and 15 dB for each frequency. A repeated measures ANOVA was performed to determine if there was a statistically significant difference for repeated thresholds. This analysis was performed using the repeated statement in PROC GLM in SAS, and it allows the examination of variance between trials within a given ear. No statistically significant differences were found ($p > .05$), indicating strong test–retest stability. Ninety-nine percent of the trials had test minus retest thresholds within 10 dB at 8 kHz, 99 percent at 10 kHz, 99 percent at 12 kHz, and 100 percent at 14, 16, and 18 kHz. Data for 16 and 18 kHz, however, were limited due to the significant degree of hearing loss exhibited in the subjects (up to 60 dB at 8000 Hz).

DISCUSSION

The current study provides evidence that serial monitoring of high-frequency hearing measured at bedside with critically ill pa-
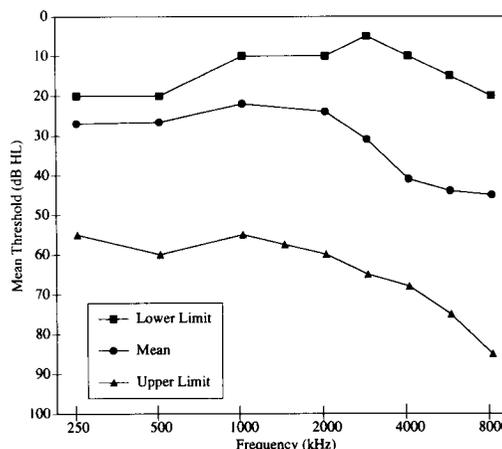
Figure 1 Mean thresholds in dB HL and ranges for ears (n = 26) over the frequency range from 250 through 8000 Hz.

Table 1   Distribution (%) of Test–Retest Threshold Differences

	Frequency (kHz)					
	8 (n = 78)	10 (n = 78)	12 (n = 76)	14 (n = 74)	16 (n = 37)	18 (n = 17)
0 dB	39	46	42	51	57	65
± 5 dB	55	50	49	45	35	35
± 10 dB	5	3	8	4	8	0
± 15 dB	1	1	1	0	0	0

n = number of measures.

tients is feasible, even in those patients who exhibit a pre-existing sensorineural hearing loss. Because of a diversity in ages and hearing sensitivity in patients undergoing ototoxic medical treatment, it is critical that a baseline evaluation be performed within 72 hours of the initial administration of the ototoxic agent. This is necessary so that any significant changes in threshold can be interpreted accurately and without question. A significant shift is defined as a threshold shift greater than 10 dB at two or more frequencies in the same ear (Lerner et al, 1986; van der Hulst et al, 1988). Ototoxicity causes subjective and objective changes in hearing and balance. Subjective symptoms (i.e., tinnitus, aural fullness, and vertigo) may precede objective clinical signs, especially on conventional audiometry. Therefore, obtaining a current subjective assessment of symptoms such as vertigo, tinnitus, and aural fullness would also be of benefit. We would hope that through appropriate serial monitoring procedures, the shift in high-frequency sensitivity would be-

come apparent before the patient becomes symptomatic.

The potential benefits of bedside monitoring are numerous. Critically ill patients can receive optimal care without having to leave the hospital room. Furthermore, the test is easy to administer, results are reliable, and the testing procedure is well tolerated by most patients. Limitations include patient noncompliance, severe high-frequency hearing loss, and conductive hearing loss.

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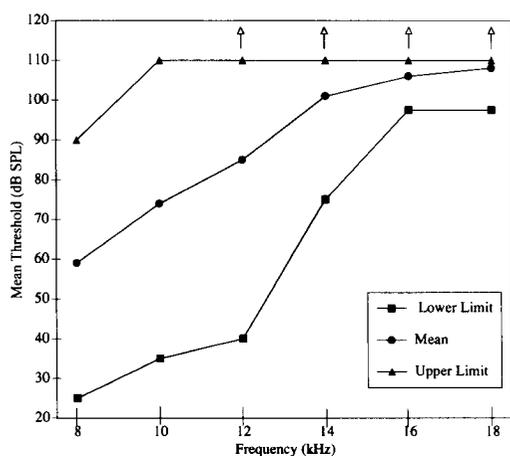

Figure 2   Mean thresholds in dB SPL and ranges for the frequency range from 8 through 18 kHz. Thresholds were obtained up to 14 kHz for all subjects. Thresholds at 16 and 18 kHz were dependent on the degree of sensorineural hearing loss; therefore, data could not be obtained for all subjects.