

# Diagnostic utility of Stenger test: reappraisal of its value

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## Abstract

**Objective:** Nonorganic hearing loss (NOHL) is a lack of consistency in audiological testing. Although NOHL is relatively rare, it is important to identify suspicious patients. This study was designed to evaluate the effectiveness of Stenger test and acoustic reflexes test (ART) in the evaluation of patients with suspicious of unilateral NOHL. Study Design: A prospective study **Methods:** In this study, 474 adult patients with suspicious unilateral profound or total hearing loss were included. Pure tone audiometry (PTA), speech audiometry, Stenger test, ART and click-evoked auditory brainstem response (ABR) measurements were performed. The sensitivity, specificity and predictive values of the Stenger test and ART for unilateral, profound to total NOHL were assessed by comparing these with the results of ABR. **Results:** The sensitivity and specificity of the Stenger test in verifying unilateral, profound hearing loss were 99% and 57%, respectively. The positive and negative predictive values of the test were 88% and 97%, respectively. The sensitivity and specificity of the ART in verifying unilateral, profound hearing loss were 96% and 60% at 1000 Hz and 98% and 60% at 2000 Hz, respectively. The positive and negative predictive values of the ART were 50% and 97% at 1000 Hz, and 75% and 97% at 2000 Hz, respectively. **Conclusion:** The Stenger test and ART are widely used for the evaluation of unilateral or asymmetrical NOHL. In our opinion, these tests are significantly powerful. More difficult cases require ABR to verify nonorganic hearing loss and to exclude specific diagnoses that may imitate NOHL.

**Keywords:** auditory, brain stem, evoked potentials, hearing loss, hearing tests, validity of tests.

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## INTRODUCTION

Nonorganic hearing loss (NOHL) is a condition in which there is an apparent hearing loss with no evidence of a known disorder or insufficient evidence to explain it. Different terminologies are used to define the same phenomenon in the literature, including pseudohypacusis, functional hearing loss, malingering and exaggerated hearing loss<sup>1</sup>. Less than 2% of the general population attempt to exaggerate a hearing loss, but the prevalence of NOHL can be much higher in subpopulations, when secondary gains are expected<sup>2</sup>. For example the prevalence of NOHL is estimated to be 10-50% in military personnel and 9-34% in medicolegal cases of industrial workers<sup>3</sup>.

Usually, NOHL grouped into three distinct categories: malingering, aggravation and psychogenic<sup>4</sup>. In the malingering category, a hearing loss is consciously feigned by a person with normal hearing. In the aggravation category, an organic hearing loss is present, but the patient consciously wants the examiner and other persons to believe that the hearing loss is greater than it is in reality. In psychogenic or functional hearing loss, the patient believes in having the hearing loss that she or he reports, though there is no organic hearing loss present. This last category of NOHL is mostly encountered in children<sup>4</sup>.

In most adult cases of NOHL, the subject usually aims at a financial reward or tries to evade taking up responsibility<sup>5,6</sup>. On the other hand, childhood NOHL may be presented as a conversion disorder from emotionally or physically traumatic events<sup>7,8</sup>.

Diagnosing NOHL and determining actual hearing thresholds are time- and energy-consuming procedures for audiology clinic staff. In addition, misdiagnosis of hearing levels may result in involvement in litigation proceedings<sup>9,10</sup>.

A variety of tests have been suggested for evaluating and diagnosing NOHL. These tests can be classified into two groups: special tests for NOHL and objective tests. Special tests for NOHL include Lombard test, Stengers test, delayed auditory feedback (Azzi's) test, the Doerfler-Stewart test and lengthened off-time Bekesy audiometry<sup>11</sup>. On the other hand objective tests, which include auditory brainstem response (ABR), electrocochleography (ECoG), tone decay, evoked otoacoustic emission (OAE), middle latency response, cortical electric response audiometry give more reliable results<sup>11-13</sup>. Acoustic reflex test (ART) is a non-invasive, objective diagnostic technique, which is used extensively to estimate NOHL<sup>14</sup>. Efficiency of the Stenger test and ART in detecting unilateral NOHL has not been reported previously to our best knowledge. The purpose of this study is to investigate the sensitivity, specificity and predictive values of Stenger test and ART in detecting unilateral NOHL.

## MATERIALS AND METHODS

The study was performed between October 2011 and February 2013. Ethics committee approval was received at 22.02.2013 with 8000-17-13 assignment number. 474 male candidates had already been evaluated and referred to our department with questionable profound or total hearing loss. Informed consent was received from all the subjects. All subjects have undergone further hearing evaluation including pure tone audiometry (PTA), Stenger test, tympanometry, ART and ABR.

Criteria for NOHL were a positive Stenger test and a positive acoustic reflexes at levels within 10 dB of the patient's alleged thresholds. The pure tone thresholds were compared with ABR thresholds in each individual.

PTA test was carried out for all subjects under a standard threshold search procedure using a clinical audiometer (Audiomed AC-40; Interacoustics, Assens, Denmark). Pure tone thresholds were typically obtained via headphones at a frequency range of 500 to 8000 Hz. The maximum intensity for stimulation was 120 dB HL, using 5 dB intensity steps. Pure tone threshold levels were determined using a 10 dB down and 5 dB up search technique in each stimulation frequency. All pure tone threshold tests were conducted in a sound-treated booth.

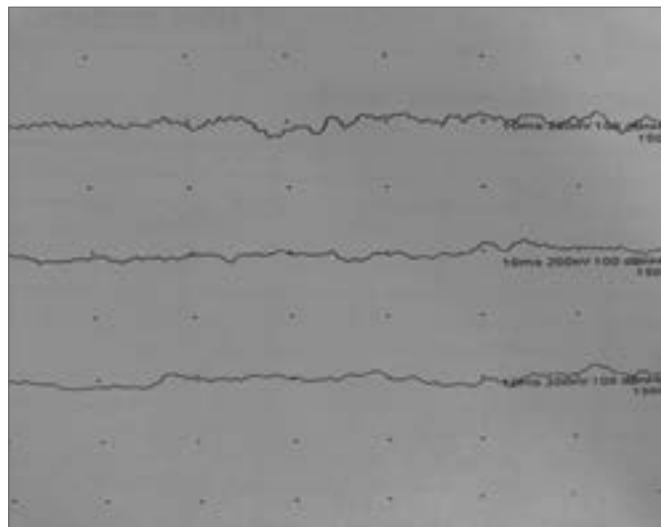
Stenger test was performed immediately after PTA. Stenger effect states that when a sound is presented to both ears, the listener is aware of its presence only in the ear where it has a higher sensation level. This effect used for clinically testing unilateral NOHL. Stenger test was initiated with presentation of a steady sound stimulus via headphones to the better hearing ear, at 1000 Hz and 5 dB higher than the patient hearing level. The patient was asked for to press the button when he heard the stimulus. Simultaneous stimuli at the same tone, beginning from 0 dB HL and increasing in 5 dB increments, were given to the worse hearing ear. Increment, by 5 dB-step was continued until the candidate ceased to respond or maximum intensity was achieved. The test was interpreted as negative when the patient continued to respond even when the stimulus to the poor ear was higher than the stimulus to the good ear. If the patient chose not to respond to the test when the stimulus to the poor ear was greater than the good hearing ear thresholds, then the test was interpreted as positive.

Immediately after the Stenger test, tympanometry and ART were performed using a clinical tympanometry (A766 Middle Ear Analyzer, Amplaid, Milan, Italy). Acoustic reflexes of the right and left ears at 1000 Hz and 2000 Hz were assessed in 390 of 475 patients. Reflex recordings (admittance *versus* time) were digitized, recorded, and stored on computer. The lowest level at which a measurable (0.1 mmho) change in admittance occurred was recorded as threshold.

Lastly, ABR testing was performed in a total relaxation (induced by intramuscular injection of midazolam (0.1 mg/kg)) and comfortable state. An auditory evoked potential system (Medelec Synergy, Viasys Health Care, Ireland) was used for recordings. Responses were measured to 100 ms rarefaction clicks presented monaurally at a repetition rate of 20 per second. ABR results were obtained initially at 40 dBnHL, and 1500 stimulus presentations were included in each average response, which was replicated at least once. A 10 dB increment or decrement was used to determine the threshold. The threshold was determined at the lowest level where wave V had been displayed. Candidates with no wave V at 100 dB nHL were diagnosed as having at least profound hearing loss (Figure 1). Detection of a wave V evoked by a stimulus intensity of less than 100 dB nHL in subjects whose PTA was suggestive of profound or total hearing loss were considered as NOHL (Figure 2).

Pure tone thresholds, Stenger test results and ART measures were confirmed with ABR thresholds.

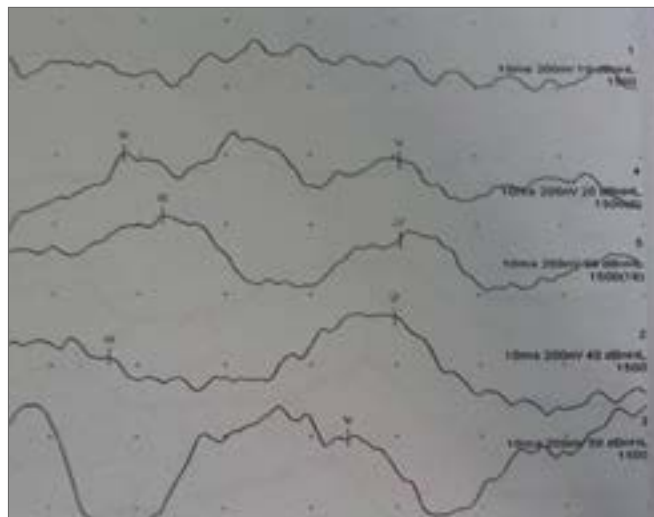
Statistical analysis of data was performed using SPSS software, version 15.0 (SPSS Inc. Chicago, IL. USA).



**Figure 1.** No V wave at 100 dB nHL.

## RESULTS

PTA, Stenger test and acoustic reflex test were performed to 474 male patients (mean age: 22 years; range 20 to 31) who had probable unilateral profound or total hearing loss. PTA and ABR results of the patients are shown in table 1. All patients were documented to have unilateral profound or total hearing loss with PTA. On ABR testing 446 (94.1%) of 474 patients either had wave V configuration which was identified only at



**Figure 2.** V wave evoked by a stimulus intensity of 20 dB nHL.

100 dB nHL (confirming profound hearing loss) or had no wave V at all (indicating total hearing loss). In the remaining 28 (5.9%) patients, wave V was identified by a stimulus intensity lower than 100 dB nHL, as opposed to audiometry findings and these 28 patients were diagnosed to have NOHL. The mean difference between pure-tone thresholds and ABR thresholds of all subjects was  $43.4 \pm 19.6$  dB.

Stenger test was positive in 18 patients whereas negative in 456 patients. Stenger test was found negative in 444 of 446 (99.5%) patients who were documented to have unilateral profound or total hearing loss with ABR. 16 of 28 (57%) patients who were diagnosed to have NOHL according to ABR had positive Stenger test (Table 2).

ART was performed in 390 and the results obtained at 1000 and 2000 Hz are given in Table 3. Among 370 patients documented to have unilateral profound or total hearing loss with ABR, 358 (96.7%) had no reflex at 1000 Hz, whereas 366 (98.9%) patients had no reflex at 2000 Hz. On the other hand, among 20 patients documented to have NOHL with ABR, 12 (60%) had identifiable acoustic reflexes at 1000 and 2000 Hz.

According to these results, the sensitivity and specificity of the Stenger test in verifying unilateral, profound hearing loss were 99% and 57%, respectively. The positive and negative predictive values of the test were 88% and 97%, respectively. The sensitivity and specificity of the ART in verifying unilateral, profound hearing loss were 96% and 60% at 1000 Hz and 98% and 60% at 2000 Hz, respectively. The positive and negative predictive values of the ART were 50% and 97% at 1000 Hz, and 75% and 97% at 2000 Hz, respectively.

**Table 1.** PTA and ABR results of the patients

	P&T	M&S	M&M	Total
PTA	474	-	-	474
ABR	446	21	7	474

PTA: Pure Tone Audiometry; ABR: Auditory Brainstem Response; P&T: Profound & total hearing loss (> 90 dBHL); M&S: Moderate & severe hearing loss (59-90 dBHL); M&M: Mild & moderate hearing loss (26-55 dBHL).

**Table 2.** Stenger test results.

		ABR		Total
		A	B	
Stenger Test	+	16	2	18
	-	12	444	456
Total		28	446	474

A: Normal hearing or hearing loss less than 90dB; B: Profound or total hearing loss; ABR: Auditory brainstem response.

**Table 3.** ART results.

		ABR results		Total
		A	B	
ART	1000 Hz +	12	12	24
	1000 Hz -	8	358	366
	2000 Hz +	12	4	16
	2000 Hz -	8	366	374
Total		20	370	390

A: Normal hearing or hearing loss less than 90 dB; B: Profound or total hearing loss; ART: Acoustic reflex testing; ABR: Auditory brainstem response.

## DISCUSSION

The term NOHL points to the fact that total hearing loss has both functional and organic components. In other words, functional loss is superimposed on an organic hearing loss<sup>10</sup>. The term 'exaggerated hearing loss' may seem more appropriate. These subjects are considered to feign hearing loss intentionally or to exaggerate the symptoms. Occasionally the subject may not be aware that he/she is exaggerating the symptoms as seen in hysteric cases. In our study, patients diagnosed to have unilateral NOHL (with ABR) were noted to have some degree of unilateral hearing loss (range of PTA: 30-70 dB). These patients were considered to exaggerate the hearing loss (range: 97 to 120 dB) (Table 1).

The prevalence of NOHL is variable and dependent on the demographic characteristics of the group examined, ranging from 2 to 90%<sup>9</sup>. Although the prevalence of NOHL is 2% in the general population<sup>2</sup>, it is much greater in industrial workers and military staff<sup>9</sup>. Secondary gain is the common denominator. Unilateral NOHL represents 28% of all NOHL cases<sup>15</sup>.

Most of the patients with NOHL may provide behavioral cues such as cupping hands over the ears, unexpected facial expressions, asking the examiner the repeat the question, speaking loudly and etc. Auditory-palpebral reflex may be elicited in NOHL cases by making a loud noise in the affected ear<sup>10</sup>. An experienced clinician or audiologist may quickly suspect NOHL before and during conventional testing and they may be alerted to the possibility of NOHL by a patient's incoherency in responding to PTA and speech audiometry testing, and by discrepancies between the patient's behaviour and the test results<sup>6</sup>. Several indicators may also be evident in standard audiometric testing including poor test-retest reliability, 'saucer-shaped audiogram' and the absence of a shadow curve in the case of a total unilateral loss<sup>16</sup>.

In the initial evaluation of a patient with suspected NOHL, potential sources of primary or secondary gain should be asked carefully. Otologic history taking including tinnitus, vertigo, aural fullness and neuro-otologic examination are of paramount importance<sup>10</sup>.

Stenger test is one the most commonly used tests designed to detect NOHL, but it can be used only for asymmetric hearing loss with an interaural difference of at least 30 to 40 dB. It is based on the principle that if two tones identical in frequency but different in amplitude are presented to both ears simultaneously, only the louder stimulus is recognized by the subject. A subject with NOHL hear the tone only in the so-called worse hearing ear and chooses not to respond which is considered diagnostic<sup>10</sup>.

Stenger testing was found to be diagnostically useful in determining unilateral NOHL in previous reports. Boyd et al. have reported an interesting study investigating the efficacy of the Stenger test. According to this study, although Stenger test can predict NOHL, the efficiency of the Stenger test is apparently affected by interaural sensitivity differences and by the size of the functional component in the better ear<sup>17</sup>. Durmaz et al. have noted that, the sensitivity and specificity of the Stenger test was 70% and 99.4%, respectively, in their study of 200 subjects. They concluded that Stenger test was effective in the diagnosis of pseudohypoacusis<sup>9</sup>.

Currently, on the other hand, objective tests of the auditory system play a prominent role in the diagnosis of NOHL. These objective tests must be used in patients with NOHL to objectively cross-test a subjectively obtained hearing threshold<sup>18</sup>. The objective tests used in this study were ART and ABR.

ART is a non-invasive objective diagnostic technique, which aids in the detection and assessment of NOHL. Advantages of ART, compared with auditory brain stem response (ABR), include shorter test time, greater availability, and lower cost. Acoustic reflex test is

commonly performed to screen for possible retrocochlear disease, particularly for individuals with asymmetric sensorineural hearing loss. ART can also be used in the diagnostic approach for auditory neuropathy<sup>19</sup>. Acoustic reflex is usually elicited at hearing thresholds ranging from 70 to 95 dB in subjects with normal hearing<sup>13</sup>. NOHL should be suspected if the reflex is present at levels within 10 dB of the patient's alleged thresholds<sup>10</sup>.

We routinely perform ABR testing to confirm hearing loss in patients with audiometric finding of profound to total unilateral hearing loss, or to confirm hearing loss in patients who are uncooperative in performing subjective tests or when a discrepancy exists between subjective tests. This test has been proven to be a reliable method for determining pure-tone thresholds<sup>3</sup>. Some investigators have reported that ABR thresholds are within 10 dB of real pure-tone thresholds<sup>3</sup>. ABR results are not affected from the patient's state of consciousness. On the other hand, it takes some time to perform the test and also is relatively expensive<sup>10,11</sup>. We typically use click-ABR testing, which affords a good estimate of the thresholds in the 2 to 4 kHz frequency region of the audiogram. Click-evoked ABR thresholds result in reasonable predictions of the average behavioral thresholds at 2 and 4 kHz, thus limiting their utility in patients with NOHL who have underlying high-frequency hearing loss<sup>9</sup>. However, previous studies have reported that ABR thresholds appear to be related most closely to the audiometric thresholds at 2 to 4 kHz, when the best hearing is in this region, and may underestimate the higher frequencies and partially the lower frequencies<sup>3</sup>.

In this study, the subjects were initially evaluated with PTA, Stenger test and ART. Thereafter, the accuracy of these tests were evaluated by comparing with ABR.  $43.4 \pm 19.6$  dB difference was detected between PTA and ABR thresholds, and no correlation was noted ( $r = 0.168$ ,  $p = 0.39$ ). However, this finding should be accepted as a sign of NOHL.

Our study revealed that, although the sensitivity and specificity of Stenger test and ART are similar, the positive predictive value of Stenger test is higher in the evaluation of unilateral NOHL.

We may speculate that Stenger test and ART are both sensitive techniques for detecting NOHL and provide a sensitive way for the evaluation of asymmetric hearing loss and alert the clinicians to the possible presence of any underlying psychological disturbance or malingering. We believe that it is worth performing Stenger test along with ART, because both tests are time-saving, economic and reliable. Using Stenger test and ART, along with the PTA, provides significant contribution to the diagnostic approach for NOHL.

Proper audiological investigation and management of subjects with this condition require adequate clinical experience, based on a thorough knowledge and understanding of NOHL.

As a result, NOHL may be intentionally malingering or psychogenic (conversion). Both may occur superimpose on an organic hearing loss. The initial evaluation of a patient with suspected NOHL requires the identification of the presence of secondary gains. The Stenger test is widely used for the evaluation of unilateral or asymmetrical NOHL, and it seems quite effective and reliable. ART is also an objective, noninvasive, reliable and cost-effective method in the diagnosis of unilateral or asymmetric NOHL.

#### Conflict of interest statement

No conflict of interest.

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