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Original Article

The Value of Plasma Atherogenic Index in Prognosis of Sudden Hearing Loss

Zehra Betül Paksoy, Fatma Cemre Sazak Kundi

Department of Otorhinolaryngology, Ankara City Hospital, Ankara, Turkey

ORCID iDs of the authors: Z.B.P. 0000-0001-9818-8010, F.C.S.K. 0000-0002-5148-9593.

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BACKGROUND: The impact of lipid parameters on hearing loss has been extensively studied in the literature. However, there is currently no study investigating the prognostic factor of plasma atherogenic index in patients with sudden hearing loss. This study aimed to evaluate the relationship of plasma atherogenic index in patients with sudden hearing loss.

METHODS: Plasma atherogenic index is calculated using the logarithmic ratio of triglycerides [mg/dL] to high-density lipoprotein cholesterol ([mg/dL]) based on lipid parameters. The patients were divided into tertiles according to their plasma atherogenic index values and the role of plasma atherogenic index on prognosis was investigated among the tertiles. The difference between baseline and control audiometer values for each patient was calculated, and a linear regression analysis was used to determine its statistical significance.

RESULTS: A total of 84 sudden hearing loss patients (57 male: 68%; 27 female: 32%) were included in the study. The mean age of the study participants was 45.3 ± 14.0. There was an inverse relationship between plasma atherogenic index and difference of audiometer values. Linear regression analyses revealed odds ratio and 95% confidence intervals of 0.405 (0.123-1.331) with $P = .135$ for 500 Hz, 0.371 (0.071-0.990) with $P = .048$ for 1000 Hz, 0.319 (0.119-0.851) with $P = .024$ for 2000 Hz and 0.406 (0.161-0.992) with $P = .049$ for 4000 Hz.

CONCLUSION: To the best of our knowledge, this is the first study to demonstrate that plasma atherogenic index can serve as an indicator of a poor prognosis in the treatment of sudden hearing loss.

Keywords: Atherosclerosis, sudden hearing loss, LDL cholesterol, cardiovascular disease, lipid metabolism

INTRODUCTION

Sudden hearing loss (SHL) is a sudden-onset subjective hearing loss in 1 or both ears.[1] While the majority of cases are idiopathic, with less than 30% of patients presenting with a specific identifiable cause for SHL, vascular pathologies, viral infections, and autoimmune disorders have been identified as the most commonly known causes.[2,3] Studies demonstrating an increase in the incidence of SHL with age support the presence of different etiological factors.[4] Among vascular etiologies, acute vascular hemorrhage, pulmonary embolism, arterial or venous vascular pathologies including spasms, and alterations in blood viscosity are included.[5]

Ischemic disorders resulting from atherosclerosis affect the ear and auditory pathways, much like they do various organs in the body.[6] Prior studies investigated whether the presence of risk factors for cardiovascular thromboembolic disease increases the risk of SHL. Vascular damage can lead to cochlear ischemia and hypoxia.[7]

Numerous studies have supported the significant role of lipid metabolism disorders in the underlying mechanism of atherosclerosis. Additionally, age, infections, inflammation, and genetic factors play important roles in atherosclerosis. Many studies have demonstrated a correlation between hyperlipidemia and hearing loss.[8-10] Hyperlipidemia can reduce blood flow to the inner ear due to increased blood viscosity, leading to inner ear damage.[8] Furthermore, lipid disorders can result in lipid accumulation in cochlear hair cells, leading to cochlear cell damage and a decrease in neural transmission.[11]

Corresponding author: Zehra Betül Paksoy, e-mail: zehrabetulpaksoy@gmail.com
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Plasma atherogenic index (PAI) is associated with atherosclerosis.[12] Recent studies have shown that PAI is more discriminatory in predicting atherosclerotic events than the standard lipid panel.[13]

Since it is well-known that vascular pathologies are involved in the etiology of SHL, in current study, it was aimed to investigate the relationship between lipid profile, PAI, and their impact on prognosis in patients with SHL.

MATERIAL AND METHODS

This study is a retrospective and cross-sectional study conducted at the Department of Otolaryngology at Ankara City Hospital. The study protocol was approved by the Institutional Ethics Committee of Ankara City Hospital HOspital (Approval No: E2-23-3259, Date: January 18, 2023), and it adhered to the principles of the Helsinki Declaration. All patients agreed and provided informed consent.

Patients diagnosed with SHL between 2019 and 2023 were included in the study. Those patients without control audiometers were excluded. Additionally, patients with acute systemic infections, autoimmune or inflammatory disorders, prior or current cancer, failure of kidney or liver, alcohol dependence, the use of medical treatments that could affect blood parameters (e.g., antihyperlipidemic drugs), otitis media, barotrauma, or recent head and neck trauma were excluded from the study. Our routine treatment protocol involves initiating intravenous or oral prednisolone at a dose of 1 mg/kg/day and gradually tapering the dose by 10 mg every 3 days until completion of the treatment.

First, control audiometry of the patients was performed. Then, the differences between the first audiometer and the fifth day audiometer (control) for each Hz were calculated. Pure-tone audiometry was standardized using an AC40 clinical audiometer (Interacoustics, Assens, Denmark) in a soundproof room to determine the hearing thresholds at 500, 1000, 2000, and 4000 Hz. Air conduction thresholds between 500 and 4000 Hz were measured using TDH-39 earphones and an MX41/AR coupler. Bone conduction thresholds between 500 and 4000 Hz were measured using an Oticon 60273 vibrator.

All hematological examinations were performed using the same device after the at least 12 hours of fasting. Levels of triglycerides (TG [mg/dL]), high-density lipoprotein cholesterol (HDL-C [mg/dL]), low-density lipoprotein cholesterol (LDL-C [mg/dL]), total cholesterol (TC [mg/dL]), lipoprotein ratios, and PAI (log (triglycerides [mg/dL]/high-density lipoprotein cholesterol [mg/dL])) were calculated. The patients were divided into tertiles according to PAI values.

MAIN POINTS

- The prognosis of sudden hearing loss was worse in the high plasma atherogenic index (PAI) group.
- There is an inverse relationship between hearing loss prognosis and PAI in the presence of high-frequency hearing loss.
- Moderate and high PAI values were associated with high frequencies hearing loss at 500-1000-2000-4000 Hz in control audiometric data.

Stata 17.0 (STATA Corporation, College Station, Texas, US) (MP) software was used to analyze the data. Data were expressed as the means ± SD for quantitative variables and as percentages for categorical variables. Differences between the tertiles were assessed using either the Student's t test or Mann–Whitney *U*-test for continuous variables and the categorical data were analyzed using the chi-square test or Fisher's exact test where appropriate. The difference between baseline and control audiometer values for each patient were plotted in a scatter plot and an age-adjusted linear regression analysis was used to show whether it is statistically significant or not. In addition, box plots were presented as the same method.

RESULTS

In total, 84 SHL patients (male: n = 57, 68%; female: n = 27, 32%) were included in the final analyses. The mean age of the study was 45.3 ± 14.0. After calculation of PAI, study population divided to tertiles and each tertile was included 28 patients. As shown in Table 1, there was no statistically significant differences among tertiles for age, gender, total cholesterol, low-density lipoprotein, and pure tone audiometer values (500-4000 Hz).

As shown in Figure 1, there was an inverse relationship between PAI and difference of audiometer values. As presented in Table 2, age-adjusted linear regression analyses revealed that the odds ratio and 95% CIs were 0.405 (0.123-1.331); $P = .135$ for 500 Hz, 0.371 (0.071-0.990); $P = .048$ for 1000 Hz, 0.319 (0.119-0.851); $P = .024$ for 2000 Hz and 0.406 (0.161-0.992); $P = .049$ for 4000 Hz. Our findings were also supported for each ear. As shown in Figure 2, the difference between baseline and control audiometer values were higher in tertile 1 compared to tertile 2 and tertile 3 for each ear.

DISCUSSION

Sudden hearing loss is observed at a rate of 5-27 per 100 000 individuals per year, and approximately 66 000 new cases are reported annually.[14] Vascular pathologies are among the nonidiopathic causes of SHL. Factors such as the patient's age, degree of hearing loss, audiometric configuration, presence of vertigo and the time between the onset of symptoms, hearing loss, and treatment initiation have an impact on the prognosis.

In general, an increase in lipid profile and atherogenicity has been found to be associated with auditory dysfunction in the literature.[8,15] There is currently no existing study in the literature investigating the role of PAI on SHL prognosis. In our study, a reverse relationship between PAI and SHL prognosis was found. It was observed that in the group with moderate and severe PAI, there was less improvement in hearing loss, and this difference was statistically significant. In high-frequency hearing losses, it was observed that the return of hearing loss was less in the group with high PAI.

The vascular diseases and sensorineural hearing disorders are closely related due to the fact that the blood supply to the inner ear is provided by end arteries without collateral circulation.[16] Diseases such as diabetes mellitus and dyslipidemia can affect the inner ear and therefore hearing due to their microvascular effects. Some studies have shown that SHL is more commonly observed in individuals with diabetes compared to nondiabetic control groups.[17] In current study, it was found that high-frequency hearing loss was more pronounced in the group with high PAI.

Table 1. Baseline Characteristics of the Study Population

	Total n = 84	Low PAI (Tertile 1) n = 28	Intermediate PAI (Tertile 2) n=28	High PAI (Tertile 3) n = 28	*P*
Age	45.3 (14.0)	44.1 (14.7)	47.2 (15.1)	44.6 (12.4)	.68
Gender					
Male	57 (68%)	17 (61%)	19 (68%)	21 (75%)	.52
Female	27 (32%)	11 (39%)	9 (32%)	7 (25%)	
Total cholesterol	192.6 (43.0)	192.3 (36.6)	189.7 (53.5)	195.9 (38.3)	.87
LDL-C	112.8 (35.6)	115.2 (29.0)	118.4 (44.0)	104.7 (31.8)	.33
Triglycerides	186.7 (153.1)	92.2 (26.8)	149.5 (42.1)	318.3 (202.3)	<.001
HDL-C	45.8 (14.4)	58.6 (15.8)	41.5 (8.3)	37.3 (7.3)	<.001
PAI	4.7 (4.3)	1.7 (0.5)	3.6 (0.6)	8.7 (5.5)	<.001
Audiometer values (Hz)					
500/1	57.2 (33.3)	59.8 (34.5)	57.7 (31.6)	53.8 (34.7)	.81
1000/1	56.8 (36.2)	58.3 (39.3)	60.0 (32.1)	52.1 (37.5)	.71
2000/1	55.2 (34.4)	58.7 (37.9)	57.5 (32.8)	49.2 (32.7)	.56
4000/1	59.8 (34.0)	63.3 (35.4)	63.5 (36.4)	52.5 (29.7)	.41
500/2	37.7 (31.2)	40.0 (32.3)	33.1 (26.0)	39.8 (35.0)	.66
1000/2	38.7 (34.5)	39.6 (37.4)	36.0 (28.5)	40.4 (37.7)	.89
2000/2	40.5 (33.4)	43.9 (37.9)	36.9 (26.6)	40.6 (35.2)	.75
4000/2	47.8 (33.9)	50.4 (36.2)	49.6 (32.6)	43.5 (33.8)	.72

HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; PAI, plasma atherogenic index.

Risk factors for coronary artery disease, such as hypercholesterolemia and low HDL-C levels, have also been investigated for their association with SHL. A study conducted on 142 patients demonstrated that smoking and high fibrinogen levels were increased risk factors for SHL.[18]

Dyslipidemia reduces antioxidant defense and leads to endothelial dysfunction. Ischemic diseases affect various tissues in the body due to atherosclerosis. A study conducted on 65 patients diagnosed with ischemic neuropathy found a significant difference in PAI compared to a healthy control group.[19]

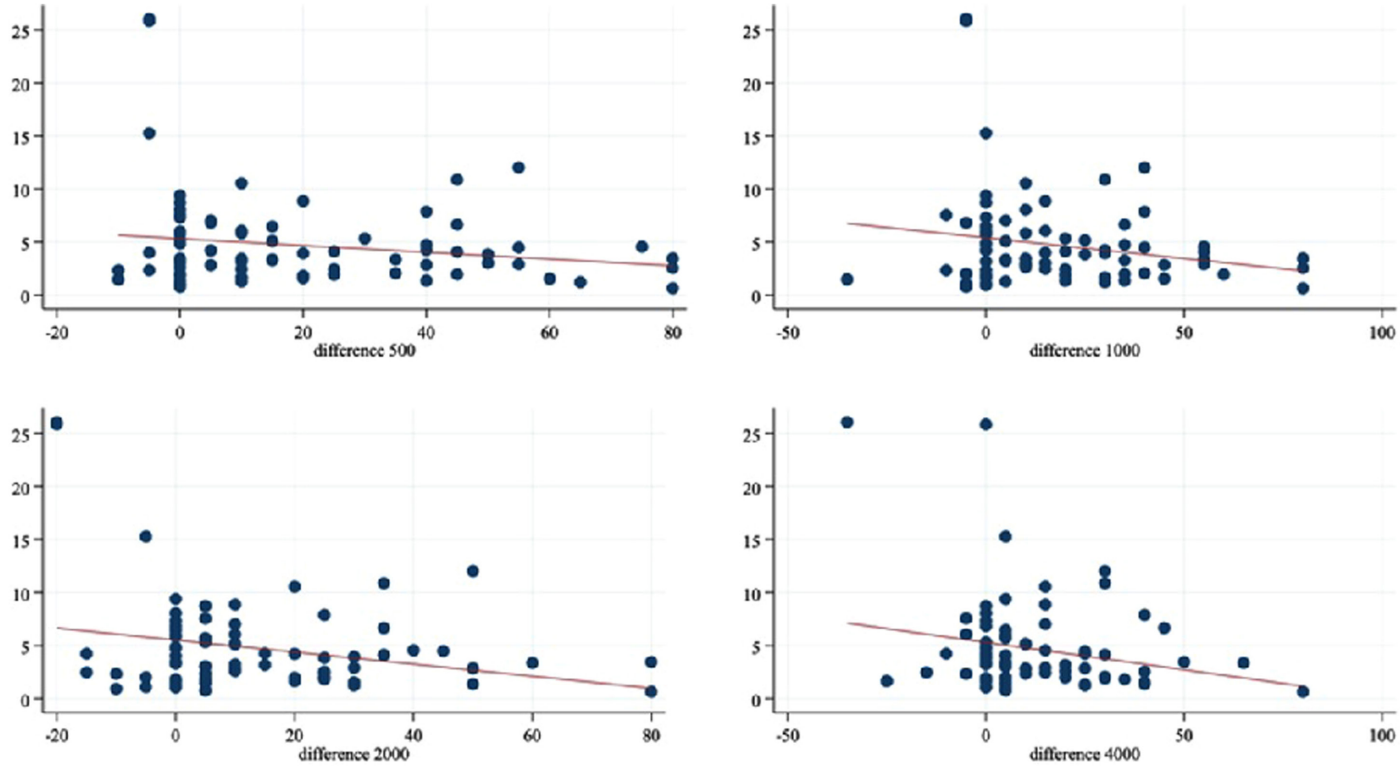

Figure 1. Scatter plots to show the relationship between PAI and difference of audiometer values. PAI, plasma atherogenic index.

Table 2. Age-Adjusted Linear Regression Analyses Showing the Difference of Baseline and Control Audiometer Values and Plasma Atherogenic Index

	Odds Ratio (95% CIs)	Coefficient	*P*
Difference 500 Hz	0.405 (0.123-1.331)	−0.903	.135
Difference 1000 Hz	0.371 (0.071-0.990)	−0.989	.048
Difference 2000 Hz	0.319 (0.119-0.851)	−0.901	.024
Difference 4000 Hz	0.406 (0.161-0.992)	−1.140	.049

Cochlear ischemia is considered one of the major causes of idiopathic SHL.[20] Hyperlipidemia and increased blood viscosity can lead to inner ear damage and subsequently affect hearing.[8] Additionally, lipid metabolic disorders can result in lipid accumulation in cochlear hair cells and damage to cochlear neural cells, thereby impairing neural transduction.[11] The finding in our study, where there was less improvement in hearing loss in the group with high PAI, supports the existing literature in this regard.

According to the World Health Organization, the best method of protection against cardiovascular diseases is disease prevention.[21] In this regard, molecular biomarkers such as adipocyte-fatty acid binding protein (FABP4), asymmetric dimethylarginine (ADMA), adiponectin, chemerin, C-reactive protein and troponin have been used to identify high-risk patients.[22-24] Individual lipid risk factors (total cholesterol, triglycerides, LDL-C, HDL-C, and non-HDL-C) have also been recommended as valuable tools for predicting cardiovascular risk. Recently, there has been a consensus that nontraditional serum lipid ratios are superior to traditional lipid parameters in distinguishing atherogenic events. Low-density lipoprotein cholesterol/high-density lipoprotein cholesterol and TC/HDL-C ratios have been reported as cost-effective and robust indicators of the presence of atherosclerosis and cardiovascular diseases.[25] In clinical practice, the non-HDL-C/HDL-C ratio has been shown to be a more useful, better, and economical marker for predicting coronary artery disease risk compared to HDL-C, non-HDL-C, and LDL-C alone.[26] Additionally, the TG/HDL-C ratio is a more effective marker than individual lipid parameters in predicting cardiovascular diseases and insulin resistance.[27,28]

In a study investigating the PAI in the population with hearing loss, positive correlations between lipoprotein parameters and pure-tone averages were observed, in addition to age and gender.[29] Considering that hyperlipidemia is a treatable condition, appropriate treatment for high atherogenic index (PAI) in patients with SHL may lead to positive outcomes. Early diagnosis and treatment are important prognostic markers in SHL prognosis. In the treatment of SHL, corticosteroids, vasodilators, antivirals, drugs that promote hemodilution, hyperbaric oxygen, intratympanic treatments, or combinations of these therapies are used.[30] The treatment aims to improve cochlear microcirculation, suppress inflammation and autoimmune damage, and reduce edema. After the first month, the probability of recovery from SHL is considered low. However, 1 study showed that positive results can be obtained even 1 month after diagnosis when antihyperlipidemic treatment is applied for SHL associated with hyperlipidemia.[31]

The identification of prognostic markers of the disease can also influence the selection of the appropriate treatment in terms of cost-effectiveness. This can aid in making the right treatment decisions after diagnosis.

There is currently no study in the literature that explores the relationship between PAI and the prognosis of SHL. Considering that hyperlipidemia is a treatable disease, appropriate treatment for high PAI in patients with SHL can yield positive results.

Our results showing higher PAI values in SHL patients with poor prognosis demonstrate the potential impact of lipid profile atherogenicity on SHL risk.

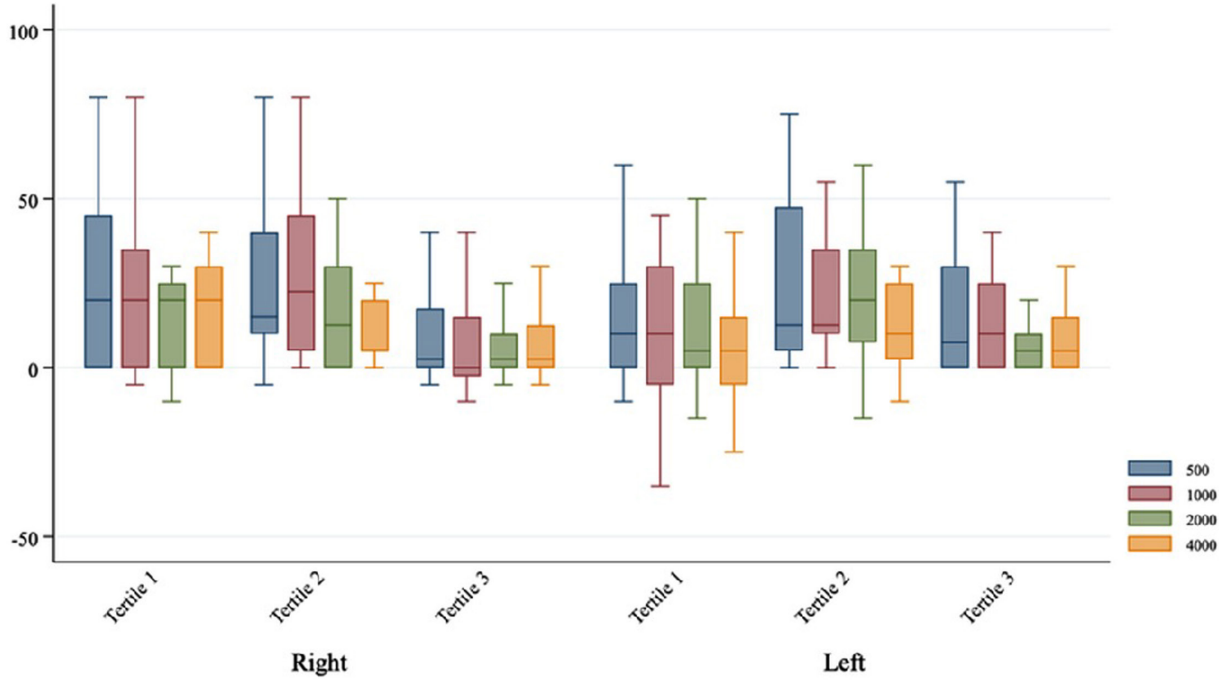

Figure 2. Box plots for the difference of baseline and control audiometer values and PAI according to each tertile. PAI, plasma atherogenic index.

The PAI is an important indicator that allows us to detect abnormalities in lipid metabolism in the early stages when traditional lipid indexes are still normal. Examining the PAI in patients diagnosed with SHL is important from both a cost-effectiveness perspective and for the prevention of SHL, which is a possible consequence of a treatable and controllable disease. Further studies with a larger sample size are needed to determine the importance of the atherogenic index in the prognosis of SHL.

Ethics Committee Approval: This study was approved by Ethics Committee of Ankara Bilkent City Hospital, (Approval No: E2-23-3259) Date: January 18, 2023).

Informed Consent: Informed consent was obtained from the patients who agreed to take part in the study.

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Declaration of Interests: The authors have no conflict of interest to declare.

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