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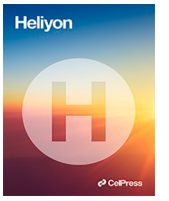

Research article

Correlation of Apo B/A1 ratio with hemodynamics and hearing impairment degree in elderly patients with sudden sensorineural hearing loss

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ABSTRACT

Objective: To investigate the correlation of apolipoprotein B/A1 (Apo B/A1) ratio with hemodynamics and degree of hearing impairment in elderly patients with sudden sensorineural hearing loss (SSNHL).

Methods: A total of 82 elderly patients with SSNHL diagnosed and treated in our hospital from July 2019 to September 2022 were retrospectively selected as the research group. The patients were divided into the mild group (22 cases), the moderate group (45 cases), and the severe group (15 cases) according to the degree of hearing impairment. 82 elderly people who underwent physical examination in our hospital during the same period were selected as the control group. The ApoB/A1 ratio and hemodynamic [whole blood low-shear viscosity (LSV), whole blood high-shear viscosity (HSV) and plasma viscosity (PV)] were measured in the two groups. The correlation of ApoB/A1 ratio with hemodynamics and degree of hearing impairment was analyzed. The predictive value of ApoB/A1 ratio and hemodynamics for the severity of SSNHL in elderly patients was analyzed.

Results: Compared with the control group, the ApoB/A1 ratio, and the levels of LSV, HSV and PV were higher in the research group ($P < 0.001$). The ApoB/A1 ratio and content of LSV, HSV and PV in the moderate group were significantly increased compared with these in the mild group ($P < 0.05$). Compared with the moderate group, the ApoB/A1 ratio and the levels of LSV, HSV and PV in the severe group were significantly increased ($P < 0.05$). Pearson correlation analysis showed that ApoB/A1 was positively correlated with LSV, HSV and PV ($r = 0.303, 0.312, 0.228$, $P < 0.01$). Logistic regression analysis showed that the ApoB/A1 ratio, LSV, HSV and PV levels were independent risk factors for the degree of hearing impairment in elderly patients with SSNHL ($P < 0.05$). The area under the curve (AUC) of ApoB/A1, LSV, HSV and PV for predicting the severity of SSNHL in elderly patients was 0.701, 0.817, 0.838, and 0.765, respectively. The AUC of combined prediction was 0.926, the sensitivity was 86.67 %, and the specificity was 90.06 %. The sensitivity and specificity of combined detection were higher than those of single detection.

Conclusion: The contents of ApoB/A1, HSV, LSV and PV were significantly increased in elderly patients with SSNHL, and their levels are significantly related to the degree of hearing impairment. The combined detection has high value in evaluating the severity of the disease.

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1. Introduction

Sudden sensorineural hearing loss (SSNHL) is most commonly defined as sensorineural hearing loss of 30 dB or greater at least three consecutive hearing frequencies over a period of 72 h [1]. According to relevant statistics, the annual incidence of SSNHL is about 10/100,000 people, and most of them are male people around 50 years old [2]. The pathogenesis of SSNHL is complicated. Research showed that, blood circulation disorders, autonomic nervous disorders and metabolic abnormalities may be closely related to the occurrence and development of the disease [3,4]. With the increase of age, the underlying diseases increase, the blood viscosity of the elderly population is significantly higher than that of the young population, and the elasticity of blood vessels is significantly lower, so the prognosis is poor [5]. Therefore, exploring the pathogenesis of SSNHL, early diagnosis and timely treatment play an important role in improving the prognosis of patients. The previous studies in patients with hearing loss or in rats with single-sided deafness have found that abnormal lipid metabolism is the main factor leading to inner ear microcirculation disorder, which is closely related to the occurrence of SSNHL [6,7].

Apolipoprotein (Apo) is the main structural protein of lipoprotein particles, which plays a central role in cholesterol metabolism by guiding lipid transport and promoting lipid uptake and deposition into tissues [8]. Research shows that, apolipoprotein B/A1 (ApoB/A1) can partly reflect the balance between atherosclerosis and atherogenic cholesterol transport, and has an important relationship with lipid metabolism and utilization [9]. At present, the hypotheses of the pathogenesis of SSNHL include virus infection theory, microcirculation disorder theory, autoimmunity theory and membrane labyrinth rupture theory. Among them, SSNHL may be most closely related to microcirculation disorder of the inner ear [10]. Plasma viscosity is the index of blood viscosity, which is the inverse of flow rate. The higher the viscosity is, the slower the velocity through capillaries is, and the more prone to micro-thrombosis. The indexes affecting plasma viscosity mainly include the concentrations of fibrinogen, lipoprotein, and globulin [11]. Previous reports have pointed out that hemodynamic changes may have an important relationship with the prognosis of patients [12]. Seo et al. found that the concentration of platelets and neutrophils in the blood of SSNHL patients was significantly higher than that of the control group, suggesting that the concentration of neutrophils can be used as a new potential indicator to predict the rehabilitation prognosis of patients [13]. However, there is no relevant reports on the relationship between ApoB/A1 ratio and hemodynamics or the degree of hearing impairment.

In this study, the correlation of Apo B/A1 ratio with hemodynamics and degree of hearing impairment in elderly patients with SSNHL was analyzed, aiming to provide some reference for early clinical treatment of diseases and improvement of prognosis of patients.

2. Materials and methods

2.1. General materials

A total of 82 elderly patients with SSNHL aged 60–80 years who were diagnosed and treated in our hospital from July 2019 to September 2022 were retrospectively selected as the research group. The patients were divided into mild group (26～55 dB, 22 cases), moderate group (55～89 dB, 45 cases) and severe group (≥90 dB, 15 cases) according to the degree of hearing impairment [14]. According to the strict 1:1 matching principle (age, gender, etc.), 82 elderly people aged 60–80 years who underwent physical examination in our hospital during the same period were selected as the control group. Inclusion criteria: (1) Patients aged between 60 and 80 years old; (2) Patients who met the diagnostic guidelines for SSNHL [15]; (3) Patients with sudden onset of hearing loss of no clear cause within 72 h and hearing loss of more than 20 dB at least two adjacent frequencies; (4) Patients were accompanied by symptoms such as dizziness and nausea. Exclusion criteria: (1) Patients with organic lesions in the middle ear; (2) Patients with hearing loss due to neurological disorders, vestibular schwannomas, or the use of medications with ototoxic side effects. This study was approved by the hospital Ethics Committee and conformed to medical ethics.

2.2. Sample collection

All study subjects were forbidden to drink water for 4 h and fasted for 8 h, and 4 mL of fasting elbow vein blood was collecting in the morning the next day. Venous blood was centrifuged at room temperature using a low-temperature high-speed centrifuge at a speed of 4500 r/min to separate the upper supernatant. The upper supernatant was stored at −80 °C for subsequent detections of various indicators such as apolipoprotein and hemodynamics.

2.3. Outcome measures

Degree of hearing impairment: The hearing threshold level of the patients was detected by a diagnostic audiometer AD226 (Denmark International Hearing Equipment Company, Registration No. 20142075840). All patients were tested in a standard soundproof room. The air- and bone-conduction pure tone audiometry was measured by the ascending and descending method. According to the order of the healthy ear followed by the affected ear, and then conducting air conduction followed by bone conduction, the detection was conducted at 1, 2, 4, and 8 kHz. The recheck frequency was 1 kHz, followed by a sequence of 0.5 and 0.25 kHz. Bone conduction only performed 0.25–4 kHz frequency doubling detection. Audiogram was drawn, and the point of tinnitus was determined by matching pitch and loudness. Notably, cross-hearing can be produced when the difference between the air conduction threshold of

the test ear and the bone conduction threshold of the non-test ear is more than 40 dB (interaural attenuation). At this time, the non-test ear should be masked to reduce the sensitivity of the cochlea and not respond to the acoustic signal, so as to obtain the correct hearing threshold of the test ear. According to the degree of hearing impairment, patients were divided into mild (26–55 dB) group, moderate (56–89 dB) group, and severe (≥90 dB) group.

The ApoB/A1 detection: The automatic biochemical analyzer (Shanghai Aiyitong Network Technology Co., Ltd., model: BK-1200) was used to detect the levels of serum ApoB and ApoA1 in patients, and the ApoB/A1 ratio was calculated.

The hemodynamic detection: Automatic hematology analyzer (XDS RapidLiqui, model: Wandong China Co., Ltd., Switzerland) was used to measure the levels of hemodynamic parameters in the control group and the study group, and in patients with different degrees of hearing impairment, including low shear viscosity (LSV), high shear viscosity (HSV), and plasma viscosity (PV).

2.4. Statistical analysis

Enumeration data such as gender in this study were expressed as [cases (%)], and compared using χ^2 test. The ApoB/A1 ratio, hemodynamic parameters and other measurement data were tested by normal distribution test, and all conform to the normal distribution, using the form of ($\bar{x} \pm s$). The independent sample *t*-test was used for the measurement data between the two groups, and the one-way ANOVA was used for the variance homogeneity of the multiple mean comparisons. The LSD-t-test was used for the pairwise comparison between two groups. Pearson correlation test was used for correlation analysis. Multivariate logistic regression was used to analyze the influencing factors of the severity of SSNHL in elderly patients. The receiver operating characteristic (ROC) curve was used to analyze the predictive value of ApoB/A1 ratio and hemodynamics for the severity of SSNHL. SPSS23.0 software was used for statistical data analysis, and the $P < 0.05$ was considered as statistically significant.

3. Results

3.1. Comparison of general information

The enrollment process for 82 patients with SSNHL was shown in Fig. 1. There was no significant difference in age and gender between two groups ($P > 0.05$, Table 1).

3.2. Analysis of ApoB/A1 ratio and hemodynamic levels in elderly patients with SSNHL

Compared with the control group, the ApoB/A1 ratio, the levels of LSV, HSV and PV were significantly increased in the research group ($P < 0.001$, Table 2 and Fig. 2A–D).

3.3. Analysis of ApoB/A1 ratio and hemodynamic levels in elderly patients with SSNHL of different conditions

The ApoB/A1 ratio and content of LSV, HSV and PV in the moderate group were significantly increased compared with these in the mild group ($P < 0.05$). Compared with the moderate group, the ApoB/A1 ratio and the levels of LSV, HSV and PV in the severe group were significantly increased ($P < 0.05$, Table 3 and Fig. 3A–D).

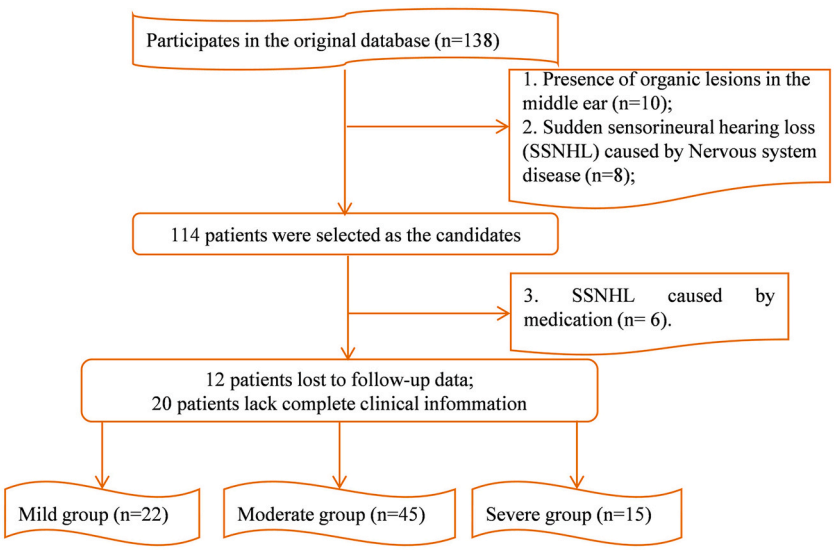

Fig. 1. Flow chart for inclusion of 82 patients with SSNHL

Table 1
Comparison of general information ($\bar{x} \pm s$, %).

Groups	Cases	Gender (Male/Female)	Age (years)	The degree of hearing impairment		
				Mild group	Moderate group	Severe group
The research group	82	50/32	70.50 ± 5.21	22 (26.83)	45 (54.88)	15 (18.29)
The control group	82	45/37	71.22 ± 5.36	/	/	/
t/χ^2		0.626	0.872			
P		0.429	0.384			

Table 2
Analysis of ApoB/A1 ratio and hemodynamic levels in elderly patients with SSNHL ($\bar{x} \pm s$).

Groups	Cases	ApoB/A1	LSV (mPa/s)	HSV (mPa/s)	PV (mPa/s)
The research group	82	0.78 ± 0.18	28.24 ± 5.59	5.17 ± 1.18	1.84 ± 0.43
The study group	82	0.63 ± 0.15	19.53 ± 3.80	4.00 ± 0.59	1.32 ± 0.27
t		5.797	11.669	8.031	9.274
P		<0.001	<0.001	<0.001	<0.001

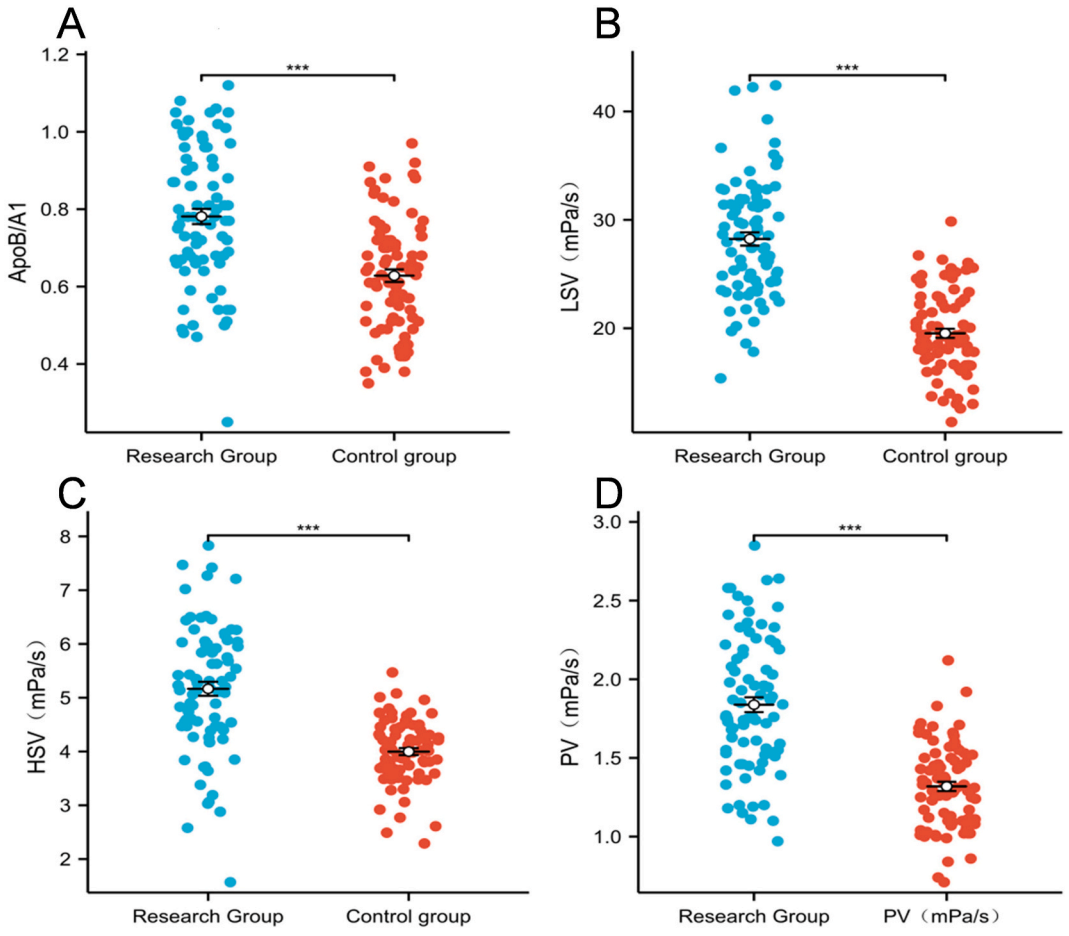

Fig. 2. Analysis of ApoB/A1 ratio and hemodynamic levels in elderly patients with SSNHL. A: Comparison of ApoB/A1; B: Comparison of LSV; C: Comparison of HSV; D: Comparison of PV. Note: ***$P < 0.001$ compared between groups.

3.4. The correlation between ApoB/A1 ratio and hemodynamics

Pearson correlation analysis showed that ApoB/A1 was positively correlated with LSV, HSV and PV (r = 0.303, 0.312, 0.228, $P < 0.01$, Table 4 and Fig. 4A–C).

Table 3
Analysis of ApoB/A1 ratio and hemodynamic levels in elderly patients with SSNHL of different conditions ($\bar{x} \pm s$).

Groups	Cases	ApoB/A1	LSV (mPa/s)	HSV (mPa/s)	PV (mPa/s)
The mild group	22	0.69 ± 0.15	22.36 ± 3.63	4.32 ± 0.63	1.50 ± 0.33
The moderate group	45	0.80 ± 0.17*	25.94 ± 3.39***	4.65 ± 0.56***	1.82 ± 0.54***
The severe group	15	0.91 ± 0.20***##	31.36 ± 2.57***###	5.49 ± 0.77***###	2.13 ± 0.42***#
F		7.550	32.620	16.400	8.14
P		0.001	<0.001	<0.001	0.001

Note: ***$P < 0.001$ compared with the mild group;#$P < 0.05$, ##$P < 0.01$, ###$P < 0.001$ compared with the moderate group.

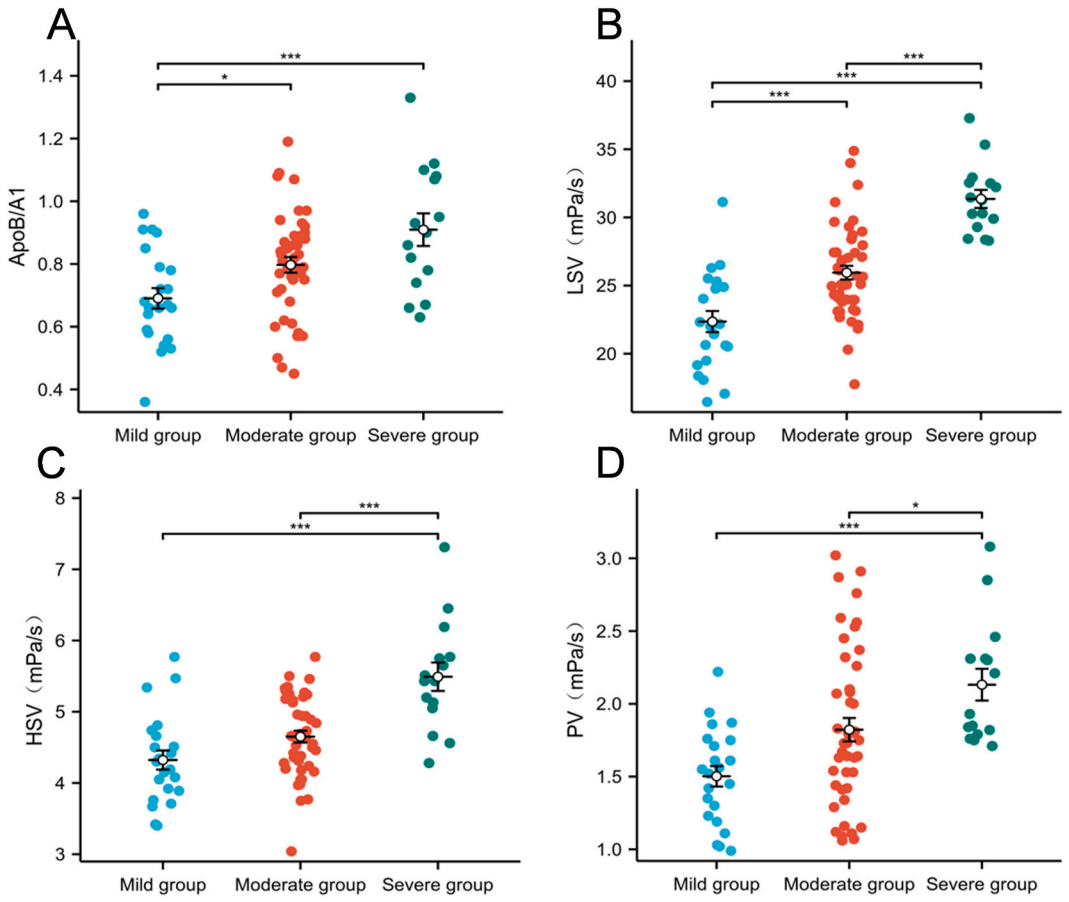

Fig. 3. Analysis of ApoB/A1 ratio and hemodynamic levels in elderly patients with SSNHL of different conditions. A: Comparison of ApoB/A1; B: Comparison of LSV; C: Comparison of HSV; D: Comparison of PV. Note: *$P < 0.05$, ***$P < 0.001$ compared between groups.

3.5. Analysis of influencing factors on the degree of hearing impairment in elderly patients with SSNHL

The ApoB/A1 ratio, LSV, HSV, and PV were included in the multivariate logistic regression analysis that affected the degree of hearing impairment in elderly SSNHL patients. Each indicator was assigned based on the median, and the assignment method was shown in Table 5. Logistic regression analysis showed that the ApoB/A1 ratio, LSV, HSV and PV levels were independent risk factors for

Table 4
The correlation between ApoB/A1 ratio and hemodynamics.

Indicators	ApoB/A1	
	r	*P*
LSV (mPa/s)	0.302	<0.001
HSV (mPa/s)	0.312	<0.001
PV (mPa/s)	0.228	0.003

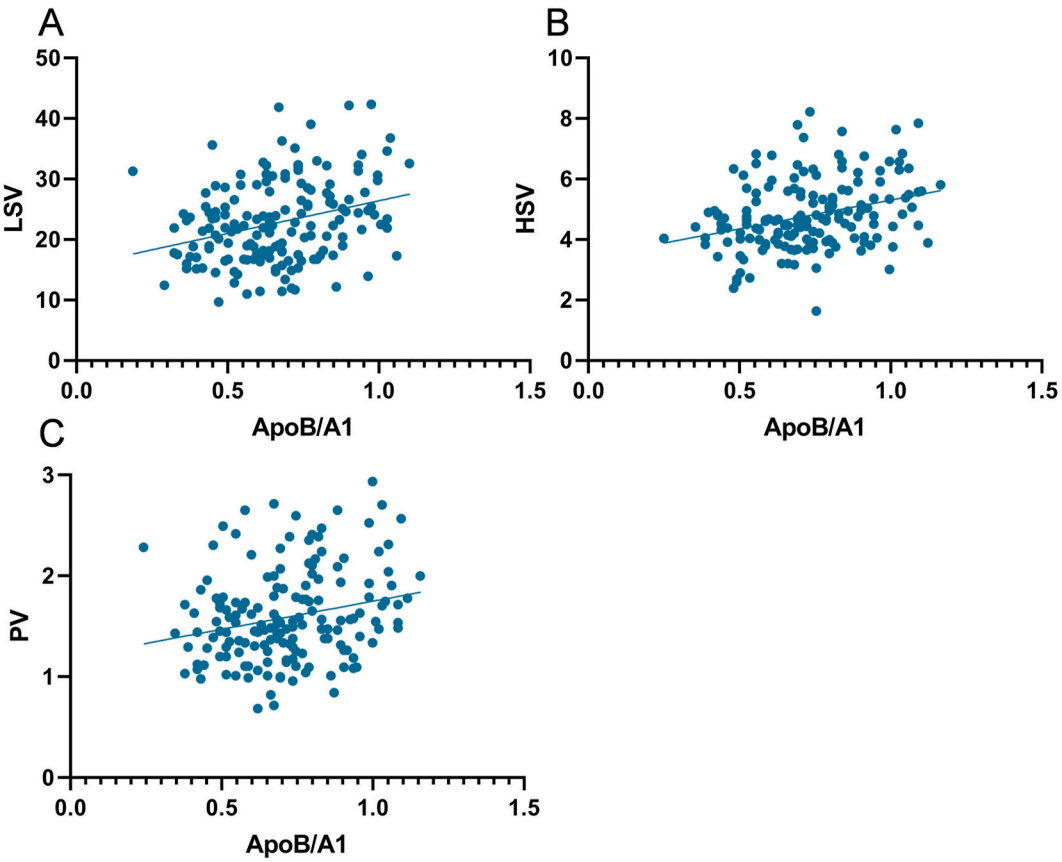

Fig. 4. Correlation analysis between ApoB/A1 ratio and hemodynamics. A: Correlation between ApoB/A1 and LSV; B: Correlation between ApoB/A1 and HSV; C: Correlation between ApoB/A1 and PV.

the degree of hearing impairment in elderly patients with SSNHL ($P < 0.05$, Table 6).

3.6. The predictive value of ApoB/A1 ratio and hemodynamics for the severity of SSNHL in elderly patients

ROC curve showed that the AUC of ApoB/A1, LSV, HSV and PV for predicting the severity of SSNHL in elderly patients was 0.701, 0.817, 0.838, and 0.765, respectively. The AUC of the combined prediction was 0.926, with a sensitivity of 86.67 % and a specificity of 90.06 %, which was higher than that of the single detection (Table 7 and Fig. 5).

4. Discussion

SSNHL is a common emergency in the department of otolaryngology, and it is more common to have unilateral onset. There are many factors that affect the incidence and prognosis of SSNHL. However, in order to find better treatment measures, it is necessary to further study the pathogenesis of SSNHL. This study investigated the changes of serum ApoB/A1 ratio and hemodynamic parameters in patients with SSNHL and healthy people, and the differences of serum ApoB/A1 ratio and hemodynamic parameters between patients with different degrees of SSNHL. The results provided important clues for further exploring the pathogenesis of SSNHL in the elderly.

It is reported that hyperlipidemia is one of the important factors affecting cardiovascular disease, which can increase the blood viscosity and change the vasomotor properties of blood vessels, and is closely related to the severity of the disease [16]. Patients with

Table 5
Assignment of each variable.

Variable		Assignment
X1	ApoB/A1	0 = ≤0.79 , 1=>0.79
X2	LSV	0 = ≤26.31 mPa/s , 1=>26.31 mPa/s
X3	HSV	0 = ≤4.63 mPa/s , 1=>4.63 mPa/s
X4	PV	0 = ≤1.70 mPa/s , 1=>1.70 mPa/s
Y	The degree of hearing impairment	0 = mild , 1 = moderate , 2 = severe

Table 6
Analysis of influencing factors on the degree of hearing impairment in elderly patients with SSNHL.

Indicators	*β*	*SE*	*Wald* χ^2 value	*P* value	*OR* value	*95%*CI
ApoB/A1	2.015	0.361	8.469	<0.001	6.485	1.748–25.130
LSV	1.268	0.270	5.982	0.005	3.667	1.451–9.701
HSV	3.894	0.471	5.997	0.003	4.723	1.954–8.150
PV	2.483	0.389	9.154	<0.001	8.117	2.160–18.564
ApoB/A1	1.978	0.215	6.673	<0.001	5.124	1.037–8.457

Table 7
The predictive value of ApoB/A1 ratio and hemodynamics for the severity of SSNHL in elderly patients.

Indicators	AUC	Sensitivity (%)	Specificity (%)	cut-off value	Youden index	*P* value	95%CI	
							Lower limit	Upper limit
ApoB/A1	0.701	46.67	86.57	0.79	0.332	0.001	0.547	0.855
LSV (mPa/s)	0.817	80.00	83.58	27.98	0.636	0.001	0.698	0.937
HSV (mPa/s)	0.838	81.25	76.83	5.01	0.581	0.001	0.727	0.950
PV (mPa/s)	0.765	70.25	80.85	1.69	0.511	0.001	0.661	0.869
Combined prediction	0.926	86.67	90.06	/	0.767	0.001	0.846	0.978

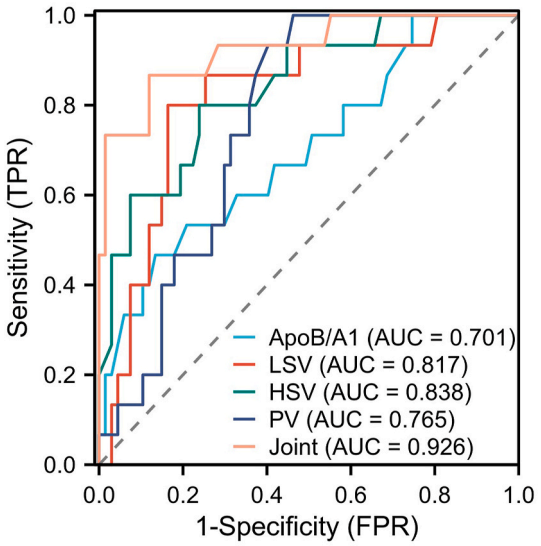

Fig. 5. The predictive value of ApoB/A1 ratio and hemodynamics for the severity of SSNHL in elderly patients.

hyperlipidemia have increased blood viscosity, which increases platelet aggregation and predisposes them to atherosclerosis. The arteries of the inner ear are very small, and there is no collateral circulation, which makes the blood flow of the inner ear slower, resulting in insufficient blood supply to the inner ear, causing microcirculation perfusion disorder, and then affecting the hearing of the inner ear. Apo, the major structural protein of lipoprotein particles, plays a central role in lipid metabolism by promoting lipid uptake and deposition into tissues. The ApoB/A1 ratio reflects the cholesterol balance between potentially atherogenics and anti-atherogenics lipoprotein particles [17]. Research shows that, the ApoB/A1 ratio may be a better marker of cardiovascular disease risk than high density lipoprotein (HDL), low density lipoprotein (LDL) and other indicators, and it is a useful predictor of cardiovascular events [18]. Scholars such as Li et al. have found that HDL, LDL, APOA1, and APOB are related to the onset and prognosis of SSNHL [19]. This study found that compared to healthy subjects, the levels of ApoB/A1 in patients with SSNHL were significantly increased. Besides, the level of ApoB/A1 also gradually increased with the degree of hearing damage, and there was a significant correlation between ApoB/A1 and the degree of hearing damage in patients. Kaneva et al. conducted a detailed analysis of blood lipid metabolism in patients with SSNHL, and found that hearing dysfunction was related to the non-thermogenic increase in blood lipid profile, but there was no significant difference in routine parameters of blood lipid metabolism (TC, TG and HDL-C) between patients with sudden sensorineural hearing loss and the control group. However, the ApoB/A1 ratio was significantly increased, and binary Logistic regression analysis showed that the ApoB/A1 ratio was significantly associated with an increased risk of SSNHL [20]. It can be seen that the observation of ApoB/A1 levels plays an important role in judging the patient's condition, so as to give timely intervention to patients, regulate the body's blood lipid balance, and prevent or avoid the occurrence or progression of the disease.

The blood of the inner ear comes mainly from the labyrinthine artery in the human body. Because this artery has no collateral circulation, once thrombosis or vasospasm occurs, it will lead to ear ischemia, hypoxia, microcirculation disturbance, further damage to the inner ear, and even irreversible deafness [21]. Clinical research showed that, vascular disease plays a very important role in SSNHL, and cochlear microcirculation disorder caused by vascular diseases is a common cause of SSNHL [22,23]. The results of this study showed that the levels of hemodynamic indexes in patients with SSNHL was significantly higher than that of healthy subjects, and the levels of hemodynamic indicators were gradually increased with the increased degree of hearing loss, which were significantly correlated with the degree of hearing loss in patients. Analyzing the related reasons, HSV and LSV are comprehensive manifestations of serum viscosity, hemorheological properties and so on, whose changes in levels are closely related to the diagnosis and treatment of thrombotic diseases. PV level is an important basis for the change of whole blood viscosity. With the increase of HSV, LSV, PV and other hemorheology indicators, the blood viscosity of patients increases significantly, which affects the hearing level of patients and aggravates the development of the disease. Fibrinogen can affect the hemorheology of the inner ear. The increase of plasma fibrinogen in patients with SSNHL can increase the blood viscosity. Red blood cell aggregation is increased, and platelet aggregation is increased, thus putting the blood in a hypercoagulable state [24]. Previous studies have already confirmed that high fibrinogen level is closely related to the occurrence of SSNHL [25]. It is not only a risk marker for SSNHL, but also a possible factor for the occurrence of SSNHL. In addition, the results of this study indicated that observing ApoB/A1 and blood flow indicators played an important role in determining the severity of a patient's condition, which further confirmed the importance of detecting ApoB/A1 and blood flow indicators in evaluating the progression of SSNHL in elderly patients.

5. Limitations

However, this study also had some limitations. Firstly, it is necessary to increase the sample size of patients with SSNHL to verify the above conclusion. Secondly, the patients in this study were all from the one hospital, which might result in certain regional biases. Thirdly, this study only addressed the correlation between ApoB/A1 ratio and hemodynamics and the degree of hearing impairment in elderly SSNHL patients, but did not involve the treatment effect. In the future, it is still necessary to explore the changes of ApoB/A1 ratio and hemodynamics before and after treatment in SSNHL patients. In addition, because this study included only elderly patients, the underlying diseases such as diabetes did not be considered, which might affect the incidence and severity of hearing loss in elderly patients. Therefore, more clinical data are needed to increase the accuracy of the study.

6. Conclusion

In general, the contents of ApoB/A1, HSV, LSV and PV were significantly increased in elderly patients with SSNHL, and their levels are significantly related to the degree of hearing impairment. The combined detection has high value in evaluating the severity of the disease.

Ethics approval and consent to participate

This study was approved by The Ethics Committee of The First Affiliated Hospital of Zhengzhou University (2019-KY-0341-003). Informed consent was obtained from participants for the participation in the study and all methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Informed consent was obtained from all individual participants included in the study. The patients participating in the study all agreed to publish the research results.

Funding

Not applicable.

Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

CRediT authorship contribution statement

Xingcheng Li: Writing – original draft, Resources, Methodology, Investigation, Formal analysis, Data curation. **Jing Xu:** Writing – review & editing, Validation, Software, Methodology, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

influence the work reported in this paper.

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