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ORIGINAL RESEARCH

Association Between High Jugular Bulb and Sudden Sensorineural Hearing Loss: A Computed Tomography Based Study

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Objective: To explore the correlation between high jugular bulb (HJB) and sudden sensorineural hearing loss (SSNHL) by collecting and analyzing data from patients diagnosed with sudden sensorineural hearing loss (SSNHL) accompanied by HJB.

Methods: A total of 62 patients with acute deafness admitted to the Otolaryngology ward of the First Affiliated Hospital of Anhui University of Chinese Medicine from October 2023 to June 2024 were included. Criteria were based on HJB reaching or exceeding the cochlear base. Patients were divided into two groups based on the presence of HJB. Both groups underwent thin-slice CT, pure tone threshold testing, and a tinnitus questionnaire. Age, sex, affected side, jugular bulb height, tinnitus handicap inventory (THI) score, and pure tone average (PTA) before and after treatment were recorded. The impact of these parameters on hearing loss and prognosis was analyzed, focusing on whether the elevation degree of the jugular bulb affected outcomes in sudden sensorineural hearing loss (SSNHL).

Results: Before treatment, no statistically significant difference in average hearing threshold was found between the two groups ($P>0.05$). After treatment, both groups showed decreased average hearing thresholds ($P<0.05$), but the non-HJB group had significantly better improvement ($P<0.01$). Pre-treatment THI scores in the HJB group were significantly higher than in the non-HJB group ($P<0.01$). Post-treatment THI scores improved in both groups ($P<0.05$), with the non-HJB group showing significantly better outcomes ($P<0.01$). The effective treatment rate for patients with mild HJB (64.7%) was higher than those with severe HJB (42.9%), though not statistically significant ($P>0.05$). In the HJB group, admission and discharge PTA and THI scores were positively correlated with HJB values ($P<0.05$).

Conclusion: Sudden sensorineural hearing loss (SSNHL) patients with high jugular bulb tend to have poorer hearing recovery and worse tinnitus outcomes compared to those without HJB.

Keywords: high jugular bulb, sudden hearing loss, correlation

Introduction

Sudden sensorineural hearing loss (SSNHL), commonly referred to as sudden sensorineural hearing loss (SSNHL), is a rapid-onset auditory condition characterized by an acute loss of hearing.[1,2] Defined as a hearing reduction of at least 30 dB in three consecutive frequencies within 72 hours, SSNHL is a frequent, yet challenging condition encountered in otolaryngology.[3] Epidemiological studies suggest a rising incidence of SSNHL with higher cases among young population is last few years.[4,5] Despite its clinical significance, the precise etiology remains elusive, and treatment strategies are largely empirical rather than targeted.[6,7]

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The pathogenesis of SSNHL is multifactorial, with proposed mechanisms including inner ear microcirculatory disturbances, viral infections, immune system dysregulation, and membrane labyrinth rupture.[8,9] Given the poor prognosis and the substantial impact on patients' quality of life, research efforts have intensified to elucidate potential anatomical and physiological factors contributing to this condition.[10] Among these, the anatomical variation of the jugular bulb has recently gained attention due to its potential association with auditory dysfunction.

The jugular bulb is a venous structure located at the skull base, playing a critical role in cerebral venous drainage.[11] A high jugular bulb (HJB), defined as an elevated position of the jugular bulb extending above the inferior margin of the internal auditory canal (IAC), has been implicated in various auditory pathologies.[12] Studies suggest that HJB may contribute to inner ear dysfunction by exerting mechanical pressure on adjacent cochlear structures, causing vascular compression, or inducing aberrant venous hemodynamics.[13] This venous anomaly has been reported in association with tinnitus, vertigo, and conductive hearing loss; however, its correlation with SSNHL remains insufficiently explored.[14,15]

Recent literature has indicated a possible link between SSNHL and HJB-related inner ear dysfunction.[4] The anatomical proximity of the jugular bulb to the cochlear aqueduct and vestibular structures suggests that venous congestion or aberrant pulsatile effects could disrupt cochlear function, leading to sudden auditory impairment.[12,16] Despite these findings, limited research has systematically examined the relationship between HJB and SSNHL severity, prognosis, and treatment outcomes.

To address this gap, the present study aims to analyze the correlation between high jugular bulb position and sudden sensorineural hearing loss (SSNHL) using internal auditory canal computed tomography (CT). By evaluating the clinical and radiological data of 62 SSNHL patients, this study seeks to determine whether HJB influences the degree of hearing loss and treatment outcomes. Understanding this correlation may provide valuable insights into the pathophysiology of SSNHL and inform more precise diagnostic and treatment approaches in clinical practice.

Data and Methods

General Information

Total of 62 patients with sudden sensorineural hearing loss (SSNHL) diagnosed in our hospital's ward from October 2023 to June 2024 were selected, including 31 patients in HJB group (group 1), 11 males and 20 females; The average age was (41.1 ± 14.96) years, with 31 cases in the non HJB group (Group 2), including 11 males and 20 females; The average age was 39.58 ± 13.82 years old. The general information of gender, age, and disease course of the two groups were balanced and comparable (P>0.05) (Table 1).

There was no statistically significant difference in the degree of hearing loss and hearing threshold curve classification between the two groups (P>0.05). (Table 2). When the hearing levels of two groups of patients are at the same baseline and the same treatment plan is adopted, the comparison of the therapeutic effects on hearing and tinnitus after treatment is more informative.

Table 1 Comparison of Clinical Data Between the Two Groups

Group	Number of Samples/Example	Gender/Example		Affected Side/Case		Age/Years	Course of Disease/Day
		Male	Female	Left	Right		
HJB Group	31	11	20	21	10	42.52±16.43	6 (2,10)
Non HJB Group	31	11	20	14	17	39.58±13.82	5 (2,10)
Statistic		χ^2=0.000		χ^2=3.215		*t*=0.761	*Z*=1.078
P		1.000		0.073		0.088	0.281
95% CI		0.353~2.831		0.907~7.165		−4.777~10.648	−1.00~3.00

Table 2 Comparison of Hearing Loss Characteristics Between the Two Groups

Factor	Characteristic	Number of Cases	HJB Group	Non HJB Group	χ^2	P
Degree of hearing loss						
	Mild	9	2 (22.2)	7 (77.7)	6.520	0.165
	Moderate	15	6 (40.0)	9 (60.0)		
	Moderate to severe	9	6 (66.6)	3 (33.3)		
	Severe	16	11 (68.7)	5 (31.2)		
	Extremely severe	13	6 (46.1)	7 (53.8)		
Hearing threshold curve classification						
	Low-frequency drop type	16	5 (31.2)	11 (68.7)	3.418	0.332
	High-frequency drop type	6	4 (66.6)	2 (33.3)		
	Flat descending type	22	12 (54.5)	10 (45.4)		
	Total deafness	16	9 (56.2)	7 (43.7)		

Note: Using corrected chi-square test, P>0.05 means the difference is not statistically significant.

Selection Criteria

Inclusion criteria: (1) Simultaneously meet the diagnostic criteria of both Western and Traditional Chinese Medicine for SSNHL;[17] (2) Age between 18 and 65 years old (including 18 and 65 years old); (3) Disease duration ≤ 14 days; (4) The patient signs an informed consent form. Exclusion criteria: (1) Pregnant and lactating women aged<18 or>65 years old; (2) The average hearing loss at each frequency of damage is less than 20dB; (3) Not meeting the diagnostic criteria of Western and Traditional Chinese Medicine for SHL; (4) Patients with a history of congenital inner ear diseases or other malignant conditions. Based on the above criteria, 62 patients were ultimately included.

Ethical Review

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. This experiment was approved by the Ethics Committee of the First Affiliated Hospital of Anhui University of Chinese Medicine (Approval Number: 2024AH-128) and informed consent was obtained from all participants.

Method

Hearing Examination

All patients underwent pure tone hearing threshold measurement before and after treatment, recording the degree of hearing loss, hearing threshold curve classification, and average hearing threshold. The classification criteria for hearing loss degree and hearing threshold curve were based on the grading standards of the ninth edition of "Otolaryngology". The degree of hearing loss was divided into five levels based on 250, 500, 1000, 2000, 4000, and 8000Hz (Table 3). According to the different hearing curves, it was clinically classified into low-frequency decline type, flat type, high-frequency decline type, and total hearing loss type (including extremely severe hearing loss).

Table 3 Degree of Hearing Loss

Hearing Grading	Mean Hearing Threshold
Normal	≤25dB
Mild	26–40dB
Moderate	41–55dB
Moderate-Severe	56–70dB
Severe	71–90dB
Extremely Severe (Total Deafness)	≥91dB

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Tinnitus Questionnaire Rating

Using the Tinnitus Disability Scale, a questionnaire was used to score two groups of patients with tinnitus before and after treatment, with a total score of 100 points. The higher the score, the more severe the tinnitus disability.

Internal Auditory Canal CT Examination

Scanning parameters: 130 kVp, 120 mAs, FOV 218 mm × 218 mm, window width 600/1500 HU, multi plane reconstruction with a layer thickness of 1 mm and an interval of 1 mm to obtain horizontal and coronal images (Figure 1A–D). There are different standards for determining the height of the jugular bulb.[12] In the past, the lower edge of the tympanic ring, circular window, and the bottom of the internal auditory canal were generally used as measurement markers.[7] In recent years, the base of the cochlea has been more commonly used as a marker.[18] When the height of the jugular bulb dome exceeds the marker, it is considered a high-level abnormality. This study used the commonly used cochlear base to the lower edge as a marker and measured the distance from the cochlear base to the jugular bulb dome in the coronal CT scan of the internal auditory canal. The results were independently measured blindly by two otolaryngologists, and different parts were determined through joint discussion after the third measurement. The values obtained were artificially classified as: mild: ≤ 1.5mm; Severe:>1.5mm.

Treatment Methods and Efficacy Evaluation

All patients adopted the same treatment scheme, including drug therapy to improve circulation, nutrient nerves and hormone shock (Ginkgo biloba extract injection 20mL with 0.9% sodium chloride 250mL intravenous drip qd, rat nerve growth factor 18ug with sterile water for injection 2mL intramuscular injection qd, dexamethasone sodium citrate injection 10mg with 5% glucose 100mL intravenous drip qd), and local dexamethasone sodium phosphate injection 5mg tympanic injection qd, in addition to traditional Chinese medicine treatment schemes such as acupuncture and moxibustion, auricular point pressing, ear scraping, etc., with a course of 7–10 days. After the treatment is completed,

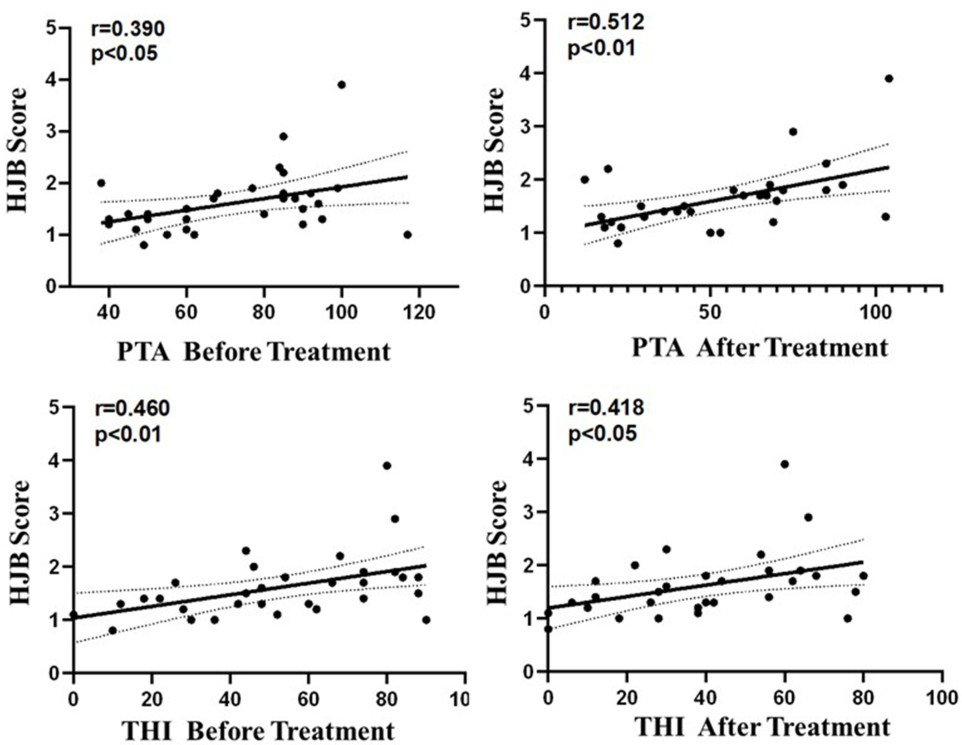

Figure 1 Computed tomography (CT) diagnostic value of the high jugular bulb (HJB) in internal auditory canal. (**A**) The normal jugular bulb (horizontal view); (**B**) normal jugular bulb (coronal view) arrow: the highest point of the jugular bulb does not reach the lower edge of the base of the cochlea (bilaterally); (**C**) high position of the right jugular bulb (horizontal position) arrow: The highest point of the jugular bulb exceeds the lower edge of the base of the cochlea (right side); (**D**) right position of high jugular bulb (coronal view) arrow: the highest point of the jugular bulb exceeds the lower edge of the base of the cochlea (right side).

pure tone audiometry will be rechecked, the average hearing threshold will be recorded, and THI scores will be recalculated for patients with tinnitus.

Hearing efficacy criteria: Referring to the evaluation criteria for sudden sensorineural hearing loss (SSNHL) proposed by the Otolaryngology Society of the Chinese Medical Association in 2015,[19] tinnitus efficacy criteria: Referring to the evaluation criteria for tinnitus efficacy proposed in the Diagnosis and Treatment Guidelines for Tinnitus in 2009:[20] (cured +significantly effective+effective)/total number of cases x 100%=total effective rate.

Observation Indicators

(1) Pure tone hearing threshold measurement: Conducted by professional outpatient doctors in soundproof rooms, observe and compare the hearing curves and average hearing thresholds of two groups of patients before and after treatment.
(2) Tinnitus Disability Scale: Record and compare the scale scores of two groups of patients before and after treatment.

Statistical Methods

Data was processed using SPSS 25.0 software. Metric data with normal distribution were represented and subjected to *t*-test. Metric data with skewed distribution were represented by quartile method, while count data were represented by n (%) and subjected to chi-square test or Fisher's exact test. Rank sum test was used for rank data, and Pearson correlation test was used for correlation analysis. P<0.05 indicates a statistically significant difference.

Results

Comparison of Hearing Efficacy Between Two Groups Before and After Treatment

There was no statistically significant difference in the average hearing threshold between the two groups of patients before treatment (P>0.05). After treatment, the average hearing threshold of both groups decreased compared to before treatment (P<0.05), and the non HJB group was better than the HJB group (P<0.01). See Table 4.

The total effective rate of the HJB group was 54.8% (17/31), while the total effective rate of the non HJB group was 87.1% (27/31). The overall efficacy difference between the two groups was statistically significant, and the non HJB group was superior to the HJB group (P<0.05). See Table 5. The height of the jugular bulb has a significant impact on the hearing efficacy of patients with sudden sensorineural hearing loss (SSNHL).

Table 4 Comparison of PTA Before and After Treatment Between the Two Groups

Group	Number of Examples	Before Treatment	After Treatment	t	P	95% CI
HJB Group	31	72.16±21.35	51.77±26.52	3.333	<0.01$^{\Delta}$	8.152~32.622
Non HJB Group	31	63.87±24.83	34.81±26.23	4.480	<0.01$^{\Delta}$	16.086~42.043
t		1.409	2.532			
P		0.164	0.014*			
95% CI		−3.477~20.057	3.564~30.317			

Note: Δ indicates the p-value from the Independent samples *t*-test, with P < 0.05 signifying statistical significance.

Table 5 Comparison of Clinical Efficacy Between the Two Groups

Group	Number of Samples	Recovered	Effective	Effective	Ineffective	Effective Rate (%)	Z	P
HJB Group	31	7	5	5	14	54.8	−2.614	<0.01*
Non HJB Group	31	15	4	8	4	87.1		

Note: *Using Mann–Whitney *U*-test, P<0.01 indicates a statistically significant difference.

Table 6 Comparison of Tinnitus Handicaps Inventory (THI) Scores Before and After Treatment Between the Two Groups

Group	Number of Examples/Examples	Before Treatment	After Treatment	t	P	95% CI
HJB Group	30	52.65±25.89	38.58±23.83	2.225	0.030*	1.422~26.707
Non HJB Group	31	36.26±20.60	23.39±17.17	2.673	0.010*	3.239~22.503
t		2.758	2.881			
P		0.008*	0.005*			
95% CI		4.500~28.274	4.643~25.744			

Note: *Using Independent samples *t*-test, P<0.05 means the difference is statistically significant.

Table 7 Comparison of Tinnitus Efficacy Between Two Groups

Group	Number of Examples	Recovered	Effective	Efficient	Non-Effective	Efficient %	Z	P
HJB Group	30	1	3	8	18	40.0*	−2.651	<0.01*
Non HJB Group	31	2	8	13	8	74.2		

Note: *Using Mann–Whitney *U*-test, P<0.01 means the difference is statistically significant.

Comparison of THI Scores Between Two Groups Before and After Treatment

Before treatment, the THI score in the HJB group was significantly higher than that in the non HJB group (P<0.01). After treatment, both groups showed improvement in THI scores compared to before (P<0.05), and the non HJB group was better than the HJB group (P<0.01). See Table 6.

The effective rate of tinnitus treatment in patients without high jugular bulb (74.2%) was significantly higher than that in patients with high jugular bulb (40.0%), and the difference was statistically significant (P<0.05), indicating that the prognosis of tinnitus in sudden sensorineural hearing loss (SSNHL) patients without high jugular bulb is better than that in sudden deafness patients with high jugular bulb as shown in Table 7.

Comparison of Efficacy in Patients with Different Degrees of HJB

The data presented in Table 8 showed the effective rate of treatment of patients with mild jugular hypertension (64.7%) was higher than that of patients with severe jugular hypertension (42.9%), but the difference was not statistically significant (P>0.05).

Correlation Analysis Between HJB Values and Patient Data, Hearing Threshold Levels, and Tinnitus Scales

Spearman correlation analysis was used for the classification of disease course and hearing threshold curve, while Pearson correlation analysis was used for age, admission PTA, discharge PTA, admission THI, and discharge THI as

Table 8 Comparison of Hearing Efficacy in Patients with Different Degrees of HJB

Group	Number of Examples	Efficient	Ineffective	Efficient %	χ^2	P
Mild	17	11	6	64.7	1.480	0.289
Severe	14	6	8	42.9		

Table 9 Correlation Between Patient Information, Hearing Threshold Level and Tinnitus Scale and HJB Values of the Group 1

	HJB Numerical value	
	R	***P***
Age	0.282	0.125
Course	−0.217	0.240
Hearing threshold curve typing	0.282	0.124
Hospitalization PTA	0.390*	<0.05
Discharge PTA	0.512*	<0.01
Hospitalization THI	0.460*	<0.01
Discharge THI	0.418*	<0.05

Note: *P<0.05 means the difference is statistically significant.

presented in Table 9, Figure 2A–D. The results showed that age, disease course, and hearing threshold curve classification were not significantly correlated with HJB values (P>0.05); The admission PTA, discharge PTA, admission THI, and discharge THI values of patients in HJB group (group 1) were positively correlated with HJB values (P<0.05).

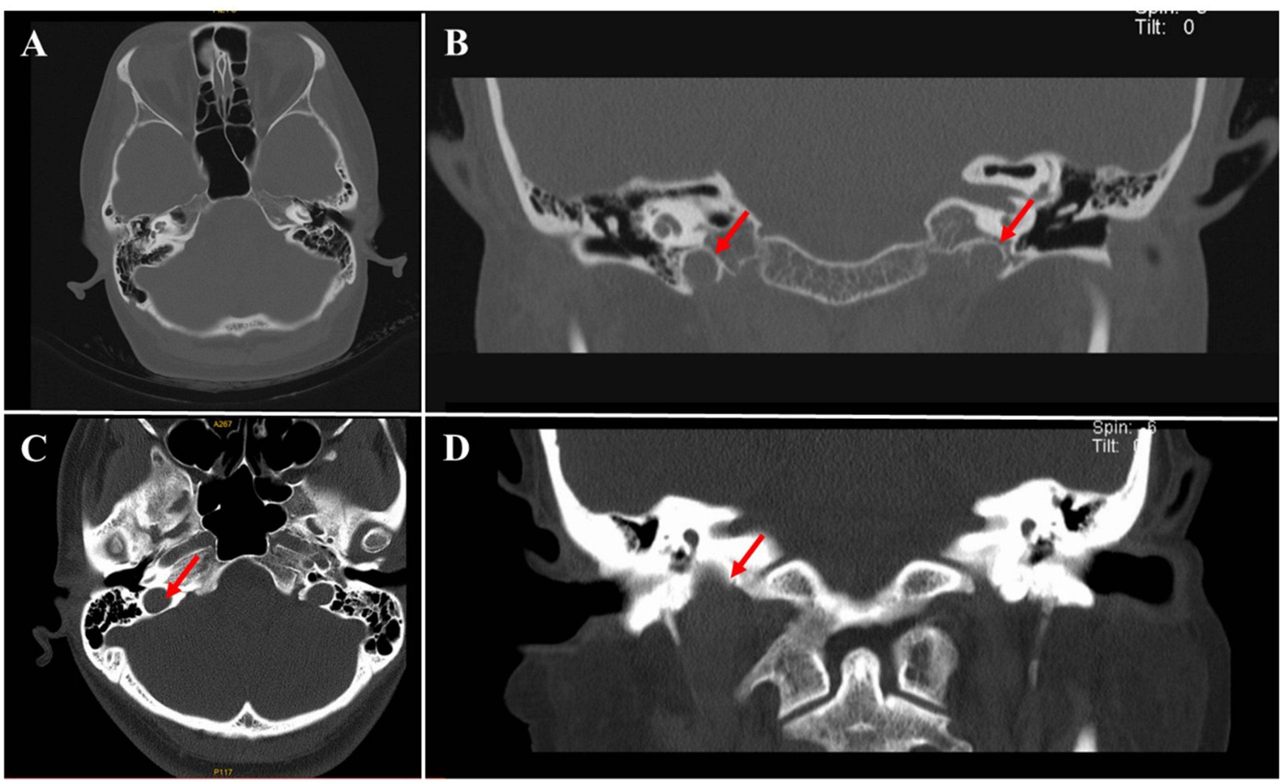

Figure 2 Correlation analysis between high jugular bulb (HJB) score, deafness classifications, admission pure tone average (PTA), discharge PTA, admission tinnitus handicaps inventory (THI) and discharge THIfigure.

Discussions

The etiology of sudden sensorineural hearing loss (SSNHL) is not yet clear, and microcirculatory disorders in the inner ear are currently recognized as one of the most common causes. Studies conducted by[21] and[22] have shown that when microcirculatory disorders in the inner ear cause tissue ischemia and hypoxia, it will lead to a decrease in the number of Corti's hair cells in the cochlear basement membrane, affecting the normal physiological function of auditory hair cells in the ear cochlea, and further leading to the occurrence of sudden sensorineural hearing loss (SSNHL). The jugular bulb is a venous connection between the horizontal area of the sigmoid sinus and the upper segment of the internal jugular vein. In normal anatomy, its upper edge is located below the lowest layer of the lower tympanic cavity, and a relatively thick bone layer separates the dome of the jugular bulb from the middle tympanic cavity. High position jugular bulb is one of the most common anatomical variations of the jugular bulb. Although the incidence and definition of high position jugular bulb vary in different investigation and research designs, its incidence is reported to be about 6–20%.[23,24] The high position of the jugular bulb shortens the distance between the jugular bulb and the cochlea. Therefore, from an anatomical perspective, it is inevitably one of the causes of microcirculation disorders in the ear. The high position of the jugular bulb not only compresses the round window or ossicular junction, causing conductive hearing loss,[25,26] but may also cause sensorineural hearing loss.[27] The reason may be that the excessively high jugular bulb directly or indirectly causes abnormal vibration of the lymphatic fluid, resulting in hair cell damage and abnormal release of neurotransmitters, causing hearing changes in the auditory center of the brain. It may also be related to the formation of blood eddies and pressure shock factors in the highly enlarged jugular bulb.[28]

The results of this study showed that patients with elevated jugular bulb had poorer prognosis and recovery of hearing and tinnitus after treatment compared to patients without elevated jugular bulb. It is possible that anatomical variations in the high position of the jugular bulb directly or indirectly affect the blood supply to the inner ear[29] leading to changes in the blood supply of spiral hair cells, causing swelling and even ischemia and hypoxia of cochlear hair cells, which is not conducive to the prognosis of patients. In this study, there was no statistically significant difference in hearing loss and hearing threshold curve classification between the two groups of patients, which contradicts previous research hypotheses. This may be because the patients in the high jugular bulb group included in this study had a milder degree, limited impact on the disease, and a smaller sample size, and therefore did not show significant differences.

The correlation analysis results showed that the HJB value of the high jugular bulb group was positively correlated with the average hearing threshold at admission and strongly positively correlated with the average hearing threshold at discharge, indicating that the more severe the high jugular bulb level, the more severe the hearing loss and poorer the prognosis of the patient at the time of onset. Chen Qi et al[19] found through their study on the hearing threshold levels of sudden sensorineural hearing loss (SSNHL) patients with different hearing curve subtypes that there were significant differences in the degree of deafness among patients with different subtypes. Another study showed that severe hearing loss and clinical classification as total deafness were independent risk factors affecting the prognosis of sudden sensorineural hearing loss (SSNHL) patients.[30] The HJB value of the high jugular bulb group is positively correlated with the admission THI score and discharge THI score, indicating that the more severe the high jugular bulb, the more severe the tinnitus at the time of onset, and the poorer the prognosis. Patients with sudden sensorineural hearing loss (SSNHL) often have accompanying symptoms such as tinnitus. The more severe the symptoms of tinnitus and other accompanying symptoms such as dizziness, nausea, vomiting, etc. are at the onset of the disease, the worse the prognosis is often compared to patients without or with mild accompanying symptoms.[31]

In summary, patients with sudden sensorineural hearing loss (SSNHL) accompanied by high jugular bulb have more severe hearing and tinnitus symptoms upon admission compared to those without high jugular bulb, and the overall therapeutic effect is poor. The discovery of high jugular bulb will help prevent and treat related tinnitus and hearing loss symptoms. However, the number of cases in this study is relatively small, and there is a lack of follow-up pure tone hearing threshold measurement results and tinnitus disability scale scores. In the future, large-scale clinical studies will be conducted to further verify and supplement these results. It will contribute to the exploration of the causes of sudden sensorineural hearing loss (SSNHL).

Data Sharing Statement

Data supporting reported results will be made available by the authors upon request.

Author Contributions

All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflicts of interest in this work.

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