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Intratympanic steroid injection for treating sudden sensorineural hearing loss in patients with hepatitis B virus infection

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ABSTRACT

Background: Sudden sensorineural hearing loss (SSNHL) is an acute auditory disorder commonly treated with steroids. However, the prognostic factors for patients with hepatitis B virus (HBV) undergoing intra-tympanic steroid injections (ITSIs) remain unclear. This research seeks to explore the prognostic factors affecting the outcome of ITSI treatment in HBV patients with unilateral SSNHL.

Methods: This retrospective study included 77 patients with HBV who presented with unilateral SSNHL from October 2018 to October 2024. All patients underwent ITSIs, and their clinical and audiological data were thoroughly analyzed.

Results: The mean age of the patients was 48.61 ± 15.98 years. Following ITSIs, the mean gain in hearing level was 15.51 ± 19.22 dB, the mean gain in speech reception threshold (SRT) was 16.23 ± 31.02 dB, and the mean gain in speech discrimination score (SDS) was 17.55 ± 30.69 %. According to Siegel's criteria, 6 patients (7.79 %) achieved complete recovery, 13 (16.88 %) experienced partial recovery, 33 (42.86 %) had slight recovery, and 25 (32.47 %) showed no improvement.

In univariate analyses, factors such as age ≥ 50 years (odds ratio [OR] = 0.3257, 95 % confidence interval [CI]: 0.1085–0.9781, $p = 0.0391$), the presence of vertigo (OR = 0.2656, 95 % CI: 0.0696–1.0137, $p = 0.0335$), and profound hearing loss as measured by pure-tone audiometry (PTA; OR = 0.0638, 95 % CI: 0.0080–0.5099, $p = 0.0003$) were identified as adverse prognostic factors. In the multivariate analysis, age ≥ 50 years (OR = 0.2799, 95 % CI: 0.0830–0.9437, $p = 0.0400$) and profound hearing loss (OR = 0.0609, 95 % CI: 0.0072–0.5133, $p = 0.0101$) emerged as independent negative prognostic factors.

Conclusions: ITSIs are effective in managing SSNHL in patients with HBV while minimizing the side effects associated with high-dose systemic steroids. Among the 77 HBV patients with SSNHL who received ITSI, age ≥ 50 years and profound hearing loss were identified as negative prognostic factors. For HBV patients with these risk factors, timely and proactive treatment is essential.

1. Introduction

Sudden sensorineural hearing loss (SSNHL) is an urgent auditory disorder that can lead to permanent hearing impairment [1]. SSNHL is often classified as idiopathic, as the underlying cause remains unidentified in most cases [2]. The standard treatment for SSNHL involves the use of steroids [3–5], which can be administered either orally or via intratympanic steroid injection (ITSI) [6]. In Taiwan, the annual

Abbreviations: HBV, hepatitis B virus; ITSI, intra-tympanic steroid injection; PTA, pure tone audiometry; SSNHL, sudden sensorineural hearing loss; SRT, speech reception threshold; SDS, speech discrimination score.

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incidence of SSNHL ranges between 6.49 and 10.21 cases per 100,000 individuals, with a higher incidence rate in men compared to women, and it is more prevalent in autumn [7,8]. Some patients may have contraindications to high-dose oral steroids, including poorly controlled diabetes mellitus (DM), chronic hepatitis, and a tendency for gastrointestinal bleeding [9,10]. Compared to systemic steroids, ITSI minimizes systemic steroid exposure and associated side effects [11]. By diffusing through the round window into the cochlea, ITSI achieves higher concentrations of steroids in the inner ear fluids [12]. Therefore, ITSI serves as a valuable alternative treatment for patients who are contraindicated for systemic steroid therapy.

Hepatitis B virus (HBV) is one of the most prevalent endemic infectious agents worldwide [13]. The acute complications of HBV can vary from fulminant hepatitis to severe conditions such as hepatic fibrosis, liver cirrhosis, and hepatocellular carcinoma, resulting in approximately 1 million deaths annually due to these complications [14]. In addition to hepatic issues, HBV is associated with extra-hepatic complications that can adversely affect hearing performance [15].

However, the risk factors and therapeutic outcomes of ITSI in HBV patients with SSNHL are not well elucidated, and there is a scarcity of studies exploring this topic. Consequently, we aimed to assess the prognostic factors in HBV patients with SSNHL who received ITSIs.

2. Materials and methods

Between October 2018 and October 2024, we conducted a retrospective review of the medical records of 77 patients with HBV diagnosed with SSNHL at Linkou Chang Gung Memorial Hospital, a teaching medical center in Taoyuan, Taiwan. We examined the clinical information, findings from physical and otoscopic examinations, and laboratory test results of the patients. In these 77 individuals, a positive HBsAg test indicates HBV infection, which may be either acute or chronic [15,16]. SSNHL is defined as a sudden loss of >30 dB of hearing acuity across three contiguous frequencies within a 72-h period [17,18]. The mean hearing level is calculated as the average hearing threshold at 500 Hz, 1 kHz, 2 kHz, and 4 kHz [19,20].

As presented in Table 1, we collected the clinical data of the patients, which included gender, affected side, age, presence of tinnitus, vertigo, aural fullness, duration of hearing loss, history of hypertension, and various laboratory parameters such as white blood cell (WBC) count, C-reactive protein (CRP) levels, hemoglobin (Hb) levels, platelet count, international normalized ratio (INR), activated partial thromboplastin time (aPTT), glycated hemoglobin (HbA1c) levels, sodium (Na) levels, potassium (K) levels, total cholesterol levels, and triglyceride levels.

Table 1
Clinical characteristics of the 77 HBV SSNHL patients.

Characteristics	*N* = 77 (%)
Gender	
Male	37 (48.05)
Female	40 (51.95)
Side	
Left	31 (40.25)
Right	46 (59.75)
Age, years ± SD	48.61 ± 15.98
Tinnitus	48 (62.33)
Vertigo	27 (35.06)
Aural fullness	17 (22.07)
Duration of hearing loss, day ± SD	2.11 ± 0.36
Hypertension	17 (22.07)
WBC, 1000/μL ± SD	10.18 ± 2.74
CRP, mg/L ± SD	1.76 ± 1.82
Hb, g/dL ± SD	13.94 ± 1.71
Platelet, 1000/μL ± SD	271.55 ± 69.79
INR ± SD	0.99 ± 0.06
aPTT, *sec* ± SD	27.83 ± 2.89
HbA1c, % ± SD	6.52 ± 0.52
Na, mEq/L ± SD	137.51 ± 15.83
K, mEq/L ± SD	4.13 ± 0.23
Total cholesterol, mg/dL ± SD	198.93 ± 46.95
Triglycerides, mg/dL ± SD	129.27 ± 27.54

SSNHL = sudden sensorineural hearing loss; N = numbers; Mean hearing level = average pure tone audiometry (PTA) at 500, 1 k, 2 k, 4 k Hz; SD = standard deviation; SRT = speech reception threshold; SDS = speech discrimination score; INR = international normalized ratio; aPTT = activated partial thromboplastin time; ITSI = intra-tympanic steroid injection.

Regarding audiological data, patients underwent pure tone audiometry (PTA), tympanometry, speech reception threshold (SRT), and speech discrimination score (SDS) assessments. Hearing thresholds were measured pre- and post- ITSI at frequencies of 500 Hz, 1 kHz, 2 kHz, and 4 kHz. The patterns observed in the PTA—ascending, descending, flat, and profound—as well as the pre- and post-ITSI variables for the affected ear, mean hearing level gain, SRT gain, and SDS gain are presented in Table 2.

We employed Siegel's criteria to categorize the recovery from SSNHL into four distinct levels:

(1) Complete recovery, defined as a final hearing level better than 25 dB;
(2) Partial recovery, characterized by a hearing gain of >15 dB with a final hearing level ranging from 25 to 45 dB;
(3) Slight recovery, indicated by a hearing gain of >15 dB but a final hearing level worse than 45 dB;
(4) No recovery, defined as a hearing gain of <15 dB accompanied by a final hearing level worse than 75 dB. [21].

The mean hearing level gain, SRT gain, and SDS gain were calculated by determining the differences between the pre- and post- ITSI results.

Table 2
Audiological data of the 77 HBV SSNHL patients.

Characteristics	N = 77 (%)
PTA pattern	
Ascending	10 (12.98)
Descending	16 (20.78)
Flat	23 (29.87)
Profound	28 (36.37)
Pre-ITSI of involved ears	
500 Hz, dB ± SD	72.85 ± 24.56
1 k Hz, dB ± SD	77.14 ± 23.73
2 k Hz, dB ± SD	76.49 ± 26.45
4 k Hz, dB ± SD	78.44 ± 26.84
Mean hearing level, dB ± SD	76.22 ± 22.81
SRT, dB ± SD	74.74 ± 23.81
SDS, % ± SD	42.64 ± 20.41
Post-ITSI PTA of involved ears	
500 Hz, dB ± SD	53.83 ± 29.35
1 k Hz, dB ± SD	59.48 ± 26.17
2 k Hz, dB ± SD	61.29 ± 25.42
4 k Hz, dB ± SD	68.24 ± 25.64
Mean hearing level, dB ± SD	60.71 ± 23.16
SRT, dB ± SD	58.51 ± 27.14
SDS, % ± SD	60.19 ± 28.95
Mean hearing level gain, dB ± SD	15.51 ± 19.22
SRT gain, dB ± SD	16.23 ± 31.02
SDS gain, % ± SD	17.55 ± 30.69
Hearing outcomes based on Siegel's criteria	
Complete recovery	6 (7.79)
Partial recovery	13 (16.88)
Slight recovery	33 (42.86)
No recovery	25 (32.47)

SSNHL = sudden sensorineural hearing loss; N = numbers; Mean hearing level = average pure tone audiometry (PTA) at 500, 1 k, 2 k, 4 k Hz; SD = standard deviation; SRT = speech reception threshold; SDS = speech discrimination score; ITSI = intra-tympanic steroid injection; Complete recovery = final hearing level better than 25 dB; Partial recovery = hearing gain >15 dB and final hearing level between 25 and 45 dB; Slight recovery = hearing gain >15 dB and final hearing level poorer than 45 dB; No recovery = hearing gain <15 dB and final hearing level poorer than 75 dB.

Audiological examinations were conducted prior to ITSI and approximately one month after the final ITSI treatment. For the procedure, a 20 % lidocaine spray was applied to the external auditory canal to provide local anesthesia. Once the local anesthetic had dried, 0.4–0.8 mL of dexamethasone (5 mg/1 mL/amp) was injected into the tympanic cavity under a microscope. In this study, all patients received ITSI once a week for a total of three treatments [6].

2.1. Exclusion criteria

Patients with drug-induced hearing loss, cochlear malformations [22], bacterial labyrinthitis, and syphilitic deafness were excluded from the study. Additional exclusion criteria included the presence of middle ear effusion, a non-type A result on tympanometry, tympanic membrane perforation, a history of head and neck malignancies, and abnormalities of the external auditory canal or middle ear [23–25]. Participants were also required to have no abnormalities in the ear canal as determined by otoscopic examination. After applying these exclusion criteria, 77 patients with HBV were enrolled in the study.

2.2. Statistical analysis

The data did not follow a normal distribution as indicated by the Kolmogorov–Smirnov test. Consequently, we utilized the chi-square test and Mann–Whitney *U* test to analyze categorical and continuous variables. Additionally, univariate and multivariate logistic regression analyses were conducted to evaluate the odds ratios (ORs) associated with various potential prognostic factors. Data from the univariate analyses were incorporated into the multivariate model using forward stepwise selection. A p-value of <0.05 was considered statistically significant for all hypothesis tests. Data analysis was performed using MedCalc software (version 18.6; MedCalc, Ostend, Belgium).

3. Results

Among the 77 patients with SSNHL, there were 37 males (48.05 %) and 40 females (51.95 %) (Table 1). The left ear was affected in 31 patients (40.25 %), while the right ear was affected in 46 patients (59.75 %). The mean age of the patients was 48.61 ± 15.98 years. In terms of symptoms, 48 patients (62.33 %) experienced tinnitus, 27 (35.06 %) had vertigo, and 17 (22.07 %) reported a feeling of aural fullness. The mean duration of hearing loss was 2.11 ± 0.36 days, and 17 patients (22.07 %) had a history of hypertension.

Table 1 also summarizes the laboratory data for the patients. The mean WBC count was 10.18 ± 2.74, 1000/μL, while the mean CRP level was 1.76 ± 1.82 mg/L. The mean Hb level was 13.94 ± 1.71 g/dL, and the mean platelet count was 271.55 ± 69.79, 1000/μL. The mean INR was 0.99 ± 0.06, and the mean aPTT was 27.83 ± 2.89 s. Additionally, the mean HbA1c level was 6.52 ± 0.52 %. The mean Na level was 137.51 ± 15.83 mEq/L, and the mean K level was 4.13 ± 0.23 mEq/L. Lastly, the mean total cholesterol level was 198.93 ± 46.95 mg/dL, and the mean triglyceride level was 129.27 ± 27.54 mg/dL.

Table 2 presents the audiological data for the 77 patients with SSNHL. Among these patients, 10 (12.98 %) exhibited an ascending pattern, 16 (20.78 %) had a descending pattern, 23 (29.87 %) demonstrated a flat pattern, and 28 (36.37 %) presented with a profound pattern on PTA. Before ITSI, the mean thresholds for the affected ears were 72.85 ± 24.56 dB at 500 Hz, 77.14 ± 23.73 dB at 1 kHz, 76.49 ± 26.45 dB at 2 kHz, and 78.44 ± 26.84 dB at 4 kHz. The overall mean hearing level was 76.22 ± 22.81 dB, with a SRT of 74.74 ± 23.81 dB and a SDS of 42.64 ± 20.41 %.

After ITSI, the mean thresholds for the affected ears improved to

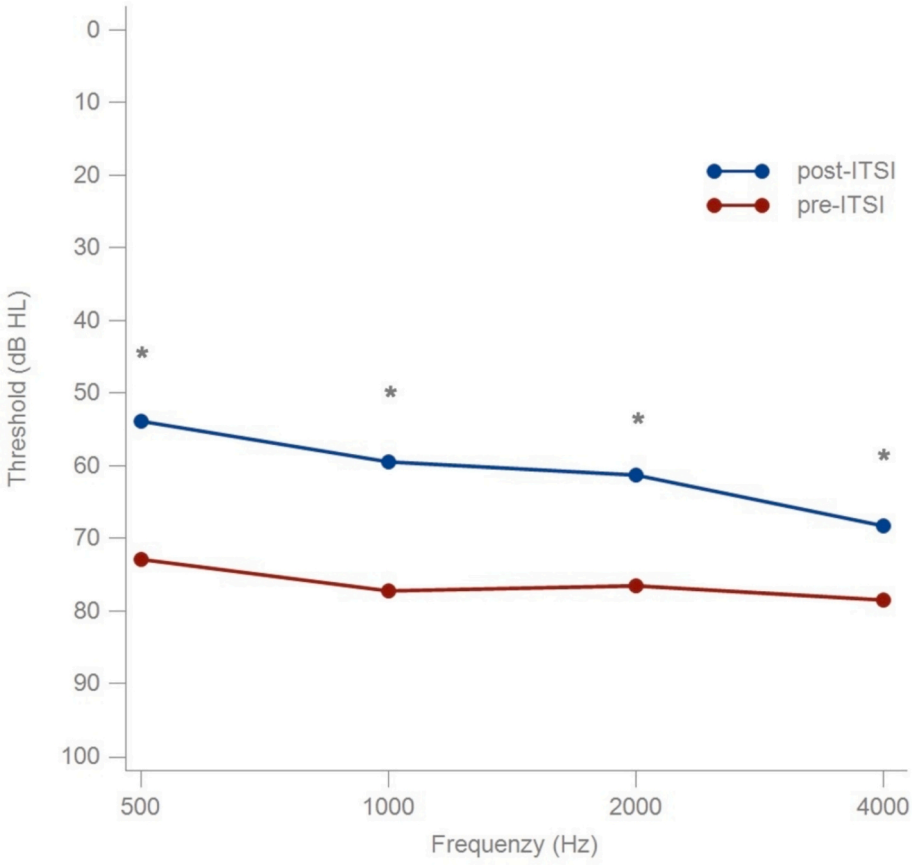

Fig. 1. illustrates the differences in hearing thresholds before and after ITSI at each frequency (500 Hz, 1 kHz, 2 kHz, and 4 kHz), with statistical significance indicated at all frequencies (asterisks represent $p < 0.05$).

53.83 ± 29.35 dB at 500 Hz, 59.48 ± 26.17 dB at 1 kHz, 61.29 ± 25.42 dB at 2 kHz, and 68.24 ± 25.64 dB at 4 kHz (Fig. 1). The mean hearing level was 60.71 ± 23.16 dB, with a SRT of 58.51 ± 27.14 dB and a SDS of 60.19 ± 28.95 %. This resulted in a mean hearing level gain of 15.51 ± 19.22 dB, a SRT gain of 16.23 ± 31.02 dB, and a SDS gain of 17.55 ± 30.69 %. According to Siegel's criteria, 6 patients (7.79 %) achieved complete recovery, 13 (16.88 %) experienced partial recovery, 33 (42.86 %) showed slight recovery, and 25 (32.47 %) had no recovery.

Table 3 presents a comparison between HBV patients with and without abnormal liver function following ITSI treatments. We used alanine aminotransferase (ALT) levels (normal ≤36 U/L) as an indicator of liver function status. The ALT levels for the abnormal liver function group and the normal liver function group were 56.34 ± 13.84 and 18.85 ± 8.21, respectively, with a significant difference ($p < 0.0001$). However, there were no statistically significant differences in mean hearing level gain, SRT gain, or SDS gain between the two groups (all $p > 0.05$). Additionally, when categorized according to Siegel's criteria, there was no statistical difference between the groups in terms of complete recovery, partial recovery, slight recovery, or no recovery (all $p > 0.05$).

Table 4 shows the results of univariate and multivariate analyses of prognostic factors in HBV patients with SSNHL. Recovery was defined as achieving either complete or partial recovery according to Siegel's criteria [26–28]. Univariate analyses revealed that age ≥ 50 years (odds ratio [OR] = 0.3257, 95 % confidence interval [CI]: 0.1085–0.9781, $p = 0.0391$), the presence of vertigo (OR = 0.2656, 95 % CI: 0.0696–1.0137, $p = 0.0335$), and profound-pattern pure tone audiometry (PTA) results (OR = 0.0638, 95 % CI: 0.0080–0.5099, $p = 0.0003$) were significant adverse factors affecting recovery in HBV patients with SSNHL. In the multivariate analysis, age ≥ 50 years (OR = 0.2799, 95 % CI: 0.0830–0.9437, $p = 0.0400$) and profound-pattern PTA (OR = 0.0609, 95 % CI: 0.0072–0.5133, $p = 0.0101$) emerged as significant independent risk factors for HBV SSNHL.

4. Discussion

The possible etiology of SSNHL includes cochlear ischemia, viral infections, vascular compromise, intra-cochlear membrane rupture, and immune disorders, making the optimal management strategy uncertain. [29–32]. Given that the cochlear vasculature is sensitive to hypoxia, damage to cochlear perfusion may serve as a risk factor for SSNHL [33,34]. According to the guidelines from the American Academy of Otolaryngology–Head and Neck Surgery [35], corticosteroids are the primary treatment for SSNHL. Research has shown that steroids can help protect hair cells from noise and other detrimental factors [36]. However, due to the potential side effects of systemic steroids—particularly in patients with DM, chronic kidney disease, glaucoma, and gastric ulcers—ITSIs are increasingly being utilized as an alternative therapy or as a salvage option following ineffective systemic steroid treatment [37].

Since the introduction of ITSIs in 1986, numerous clinicians and researchers have utilized this method to treat SSNHL [38]. ITSIs are considered an invasive procedure, and common complications associated with them include otalgia, vertigo, tongue numbness, and eardrum perforation [39].

Compared to systemic steroids, ITSIs can achieve higher drug concentrations in the inner ear, thereby minimizing most of the side effects associated with oral steroids [40]. ITSIs facilitate access to the inner ear through the round-window membrane, while systemic corticosteroids have a limited capacity to penetrate the inner ear due to the blood–labyrinth barrier [41]. The proposed mechanisms of action for steroids in the inner ear include downregulation of inflammation, enhancement of cochlear blood flow, improvement of stria vascularis function, and maintenance of ion homeostasis [42,43].

In our study, dexamethasone was used for ITSIs. A systematic review has indicated that both dexamethasone and methylprednisolone are commonly employed for this purpose and exhibit similar efficacies [44]. However, the literature presents inconsistent findings regarding the therapeutic effect of ITSIs, with various definitions of hearing recovery and a range of demographics examined [45]. Despite numerous studies demonstrating the efficacy of ITSIs in prospective, randomized, and placebo-controlled trials [46], the rate of complete hearing recovery for SSNHL remains disappointingly low [47]. Furthermore, some researchers have reported that for each day ITSIs are delayed after the onset of hearing loss, the likelihood of recovery diminishes by approximately 2 to 3 % [48,49]. This underscores the importance of prompt intervention in improving the chances of favorable outcomes.

Multiple factors contribute to sensorineural hearing loss, with viral infections being among the most prevalent causes [16]. Various viruses are known to cause acquired hearing loss, including measles, varicella zoster virus, mumps, and West Nile virus. Moreover, both congenital and acquired forms of hearing loss can result from infections by human immunodeficiency virus and herpes simplex virus types 1 and 2 [50,51]. Recognizing the role of these viral pathogens is crucial in understanding the broader context of hearing loss and developing effective strategies for prevention and management.

In this study, we assessed the outcomes of ITSI in a cohort of 77 patients with SSNHL who are also infected with HBV. The findings of various studies indicate that HBV can have a significant impact on both the quantitative and qualitative aspects of hearing performance. This is particularly concerning given the essential role that hearing plays in daily activities and overall quality of life. The high prevalence of HBV in the community, coupled with the virus's capacity to affect multiple body systems, further underscores the importance of this issue [15]. In regions with a high endemic rate, such as Taiwan, the prevalence of chronic HBV infection is estimated to be between 15 and 20 % [52,53]. As a critical global health issue, it is estimated that approximately 350 million individuals worldwide are infected with HBV [54]. The diagnosis of HBV infection typically occurs in individuals over the age of 40, with around 60 % of those diagnosed being male patients [55]. Research has shown that underlying HBV infection may play a significant role in the development of SSNHL [56–58]. For instance, Huang et al. discovered that unilateral hearing loss is often exacerbated by HBV infection, correlating with an increase in viral copies in the serum [59].

Chen et al. demonstrated that the incidence rate of SSNHL was 5.743 times higher in individuals co-infected with HBV/Hepatitis C virus (HCV) compared to the control group ($p < 0.001$). This indicates a significant correlation between the risk of developing SSNHL and the presence of HBV/HCV infections. Furthermore, an adjusted hazard ratio of 5.103 was established using Cox proportional hazards regression, reinforcing the association between these viral infections and SSNHL risk [56]. However, it is important to note that while population-based studies provide valuable epidemiological insights, they do not elucidate

Table 3
Comparison between HBV patients with and without abnormal liver function after ITSIs.

Characteristics	Abnormal, $N = 23$ (%)	Normal, $N = 54$ (%)	p value
ALT, U/L ± SD	56.34 ± 13.84	18.85 ± 8.21	**< 0.0001**
Mean hearing level gain, dB ± SD	13.85 ± 21.04	16.12 ± 18.66	0.7762
SRT gain, dB ± SD	16.08 ± 23.64	16.29 ± 33.88	0.9242
SDS gain, % ± SD	17.39 ± 27.43	17.62 ± 32.22	0.5305
Siegel's criteria			
Complete recovery	3 (13.04)	3 (5.55)	0.3557
Partial recovery	7 (30.44)	6 (11.11)	0.0505
Slight recovery	7 (30.44)	26 (48.15)	0.2094
No recovery	6 (26.08)	19 (35.19)	0.5960

N = number; HBV = Hepatitis B virus; ITSI = intratympanic steroid injection; abnormal liver function based on abnormal ALT (Alanine aminotransferase, normal range ≤ 36 U/L); $p < 0.05$, significant differences are shown in bold.

Table 4
Univariate and multivariate analyses of prognostic factors in HBV SSNHL patients.

Variable	Recovery		Univariate analysis			Multivariate analysis		
	Yes	No	OR	95 % CI	*p* value	OR	95 % CI	*p* value
Gender	19	58			0.9452			
Male	9	28	0.9643	0.3417–2.7212				
Female	10	30	1.0000					
Side					0.3691			
Left	6	25	0.6092	0.2032–1.8268				
Right	13	33	1.0000					
Age ≥ 50 years					**0.0391**	0.2799	0.0830–0.9437	**0.0400**
Yes	6	34	0.3257	0.1085–0.9781				
No	13	24	1.0000					
Tinnitus					0.9322			
Yes	12	36	1.0476	0.3584–3.0618				
No	7	22	1.0000					
Vertigo					**0.0335**	–	–	–
Yes	3	24	0.2656	0.0696–1.0137				
No	16	34	1.0000					
Aural fullness					0.9008			
Yes	4	13	0.9231	0.2608–3.2669				
No	15	45	1.0000					
Duration of hearing loss, day ± SD	2.11 ± 0.45	2.12 ± 0.32	0.8856	0.2042–3.8404	0.8703			
Hypertension					0.6128			
Yes	5	12	1.3690	0.4113–4.5575				
No	14	46	1.0000					
WBC, 1000/μL ± SD	11.04 ± 2.53	9.91 ± 2.77	1.1615	0.9603–1.4050	0.1195			
CRP, mg/L ± SD	1.82 ± 1.79	1.74 ± 1.84	1.0255	0.7741–1.3586	0.8612			
Hb, g/dL ± SD	14.43 ± 1.69	13.79 ± 1.69	1.2519	0.9169–1.7094	0.1525			
Platelet, 1000/μL ± SD	278.31 ± 74.71	269.34 ± 68.64	1.0019	0.9944–1.0094	0.6250			
INR ± SD	0.98 ± 0.05	1.01 ± 0.06	0.0355	0.0000–211.97	0.4465			
aPTT, sec ± SD	28.31 ± 2.95	27.68 ± 2.88	1.0765	0.9025–1.2842	0.4140			
HbA1c, % ± SD	6.54 ± 0.53	6.51 ± 0.53	1.1146	0.4185–2.9687	0.8286			
Na, mEq/L ± SD	140.47 ± 1.89	136.55 ± 18.14	1.1465	0.8769–1.4991	0.1388			
K, mEq/L ± SD	4.13 ± 0.06	4.14 ± 0.27	0.8670	0.0986–7.6256	0.8977			
Total cholesterol, mg/dL ± SD	192.89 ± 68.91	200.91 ± 37.47	0.9963	0.9850–1.0076	0.5134			
Triglycerides, mg/dL ± SD	136.11 ± 18.61	127.03 ± 29.68	1.0128	0.9924–1.0337	0.2041			
PTA								
Ascending	5	5	3.7857	0.9597–14.934	0.0614			
Descending	4	12	1.0222	0.2863–3.6504	0.9730			
Flat	9	14	2.8286	0.9578–8.3536	0.0611			
Profound	1	27	0.0638	0.0080–0.5099	**0.0003**	0.0609	0.0072–0.5133	**0.0101**

Recovery = sum of patients with complete recovery and partial recovery; PTA = pure tone audiometry; SD = standard deviation; OR = odds ratio; SRT, speech reception threshold; SDS, speech discrimination score; CI = confidence intervals; WBC = white blood cell (normal range: 3.5-11, 1000/μL); CRP = C-reactive protein (normal range < 5 mg/L); Hb = hemoglobin (normal range: 12-17.5 g/dL); Platelet (normal range: 150-400, 1000/μL); INR (normal range < 1.2); aPTT (normal range 23.9-35.5 s); HbA1c (normal <5.6 %); total cholesterol (normal range < 200 mg/dL); triglycerides (normal range < 150 mg/dL); $p < 0.05$, significant differences are shown in bold.

the precise mechanisms linking HBV/HCV infections to SSNHL. A significant challenge lies in the difficulty of extracting cochlear tissue pathogens or detecting cochlear injury through imaging techniques, which complicates our understanding of the pathophysiological processes involved [59,60]. This gap in knowledge highlights the need for further research to explore the mechanisms underlying the relationship between viral infections and auditory dysfunction.

Atrophic vestibular organs have been linked to SSNHL in various studies [61,62]. Our research identified age ≥ 50 years and profound hearing loss as significant adverse prognostic factors in patients with HBV-related SSNHL, as summarized in Table 4. Moreover, profound SSNHL is often associated with symptoms of vertigo, complicating the clinical picture for these patients [63]. Consequently, timely intervention is crucial, particularly for older patients with HBV who present with severe hearing loss. Early treatment may improve outcomes and potentially mitigate further auditory and vestibular complications, emphasizing the importance of prompt medical attention in this vulnerable population. Recognizing the interplay between age, hearing loss severity, and vestibular function can guide clinicians in formulating effective management strategies tailored to the needs of HBV-infected patients experiencing SSNHL.

4.1. Limitations of the article

This study is a retrospective observational analysis with a relatively small sample size. The patients with HBV included in this research exhibited varying degrees of HBV control, and the specific types and durations of HBV medications they received were challenging to document accurately. Furthermore, this study did not differentiate between acute and chronic states of HBV infection. It is important to note that we relied solely on the HBsAg test to identify HBV-positive infections, using the ALT index as a marker for abnormal liver function. Additionally, several potential confounding risk factors for SSNHL, such as alcohol consumption, smoking, ototoxic drug effects, and noise exposure, were not available in our dataset. This absence of information may have introduced bias into our findings [64]. Given the differing clinical characteristics and management among cases included in various studies, direct comparisons of results across studies may not be appropriate [8]. Future research involving a larger statistical population, along with comprehensive medical histories and family disease histories, may provide further insights into the role of HBV in hearing loss among infected individuals. Such studies could also benefit from investigating auditory brainstem responses, as well as considering liver enzyme factors and conducting other specific tests. Despite these limitations, we believe that this article contributes valuable insights to the

field of SSNHL, particularly given the scarcity of research in this area.

5. Conclusion

For patients diagnosed with SSNHL related to HBV infection, ITSIs have proven to be an effective treatment option. This approach allows for targeted delivery of steroids to the inner ear, minimizing the negative side effects often associated with high-dose systemic steroid therapy. Our findings identified age $\geq$ 50 years and profound-pattern PTA as significant risk factors in this patient population. Emphasizing the need for proactive care in older patients or those presenting with profound hearing loss underscores the importance of tailored treatment strategies in managing HBV-related SSNHL effectively.

CRediT authorship contribution statement

Shih-Lung Chen: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Chia-Ying Ho:** Conceptualization, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Shy-Chyi Chin:** Conceptualization, Project administration, Validation, Visualization, Writing – original draft. **Kai-Chieh Chan:** Funding acquisition, Investigation, Methodology, Writing – original draft. **Yu-Chien Wang:** Investigation, Resources, Writing – original draft.

Ethics statement

The requirement for informed consent was waived due to the anonymization of data prior to analysis and the retrospective nature of the study. This research was approved by the Institutional Review Board (IRB) of the Chang Gung Medical Foundation (IRB no. 202500237B0).

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Declaration of competing interest

All authors have read and agreed to the published version of the manuscript.

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