Sudden Sensorineural Hearing Loss in Children: Clinical Characteristics, Etiology, Treatment Outcomes, and Prognostic Factors

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Objective: To investigate the clinical characteristics, etiology, treatment outcomes, and prognostic factors of sudden sensorineural hearing loss (SSNHL) in children to guide the clinical diagnosis and treatment of SSNHL in the pediatric population.

Study Design: Retrospective case review.

Setting: Tertiary referral center.

Patients: Patients diagnosed with SSNHL from November 2011 to December 2017 with relatively complete clinical data.

Intervention: Diagnosis and systemic treatment of SSNHL.

Main Outcome Measures: Patients' clinical characteristics, etiology, laboratory tests, imaging, pure-tone audiometry at admission, and discharge were analyzed.

Results: A total of 25 children and 149 adults with SSNHL were included. Recent or previous viral infection rates (81.8%) and fasting blood glucose level ($5.23 + 1.47$ mmol/L) in children with SSNHL were lower than those in adult SSNHL patients ($p = 0.033$, $p = 0.033$). Autoimmune abnormalities (90.0%) and plasma fibrinogen abnormalities (27.3%) were higher in children with SSNHL than those in adult SSNHL patients (40.0%, 8.8%, respectively, $p < 0.05$). The recovery rate in children (38.4%) with SSNHL is comparable to that in adults (22.6%), but children have a higher complete rate compared to adults (26.9%, 11.3%, respectively, $p < 0.05$). Children with a profound audiometric curve had a worse prognosis in comparison to other types of audiometric curves ($p = 0.041$).

Conclusions: Children with SSNHL have a lower rate of viral infection in comparison to adults with SSNHL. Fasting blood glucose levels, complement C3, C4, and fibrinogen may be closely related to childhood SSNHL. The recovery rate in children with SSNHL is comparable to that in adults, but children have a higher complete rate compared to adults. A profound hearing curve is an unfavorable prognostic factor in both children and adults with SSNHL.

Key Words: Children—Sudden sensorineural hearing loss.

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Sudden sensorineural hearing loss (SSNHL) is a unilateral or bilateral sensorineural hearing loss with at least 30 dB decrease in threshold in three contiguous test frequencies occurring over 72 hours or less (1). In the United States, the incidence of SSNHL has been reported to be 27 per 100,000 per year (2). The age of SSNHL mainly occurred in 25–60-year-old patients, of whom 46–49 years old was the most common (3–5). Studies of SSNHL in children are rare in the literature. There were 6.6% of patients with SSNHL under 18 years of age (4,11). Due to the low incidence of SSNHL in children, its clinical characteristics, etiology, treatment outcomes, and prognosis have been most likely deemed to be less relevant. At present, the etiology of childhood SSNHL still remains unclear. It has been reported in the literature that childhood SSNHL is mostly idiopathic and may be related to viral infections (cytomegalovirus, herpes simplex virus type 1 and type 2, rubella virus, etc.), congenital causes (large vestibular aqueduct syndrome, Mondini deformity), trauma, tumors (acoustic neuroma, multiple myeloma, etc.), autoimmune diseases, systemic immune diseases (SLE, Cogan's syndrome, Wegener's granulomatosis, etc.), ototoxic drugs, vascular diseases, metabolic disease, Meniere's disease, central deafness, etc. (1). Currently, there are no specific tests or diagnostic

criteria for children with SSNHL caused by viral infections, autoimmune diseases, systemic diseases, vascular diseases and metabolic diseases. In the present study, a series of laboratory tests were performed on pediatric patients with SSNHL in an attempt to find out the possible causes of hearing loss.

The clinical features, therapeutic effects, and prognostic factors of pediatric SSNHL are still unclear. The main reason is that the incidence of SSNHL in children is low and the research is relatively few. Xie et al. (6) reported that the hearing loss in children with SSNHL was severe and often accompanied with tinnitus and vertigo, and a profound hearing curve. These authors also described the therapeutic effect as equivalent to that of adults. Na et al. (7) pointed out that the level of hearing loss, gender, side and recovery rates in children and adults with sudden deafness were similar but the proportion of children with complete recovery was higher. Younger age, steeply sloping hearing curve, late initial diagnosis, higher initial hearing thresholds, and the absence of tinnitus and vertigo were poor prognostic factors for recovery (1,8,9). This study retrospectively analyzed the clinical data of 174 patients diagnosed with SSNHL upon admission to the Department of Otolaryngology—Head and Neck Surgery, Tongji Hospital, in affiliation with the Huazhong University of Science and Technology, from November 2011 to December 2017. Patients included children (<18 years old) and adults ($\geq$ 18 years old). The clinical data of children and adults with SSNHL were compared to explore the clinical features, etiology, efficacy of treatment, and prognosis so as to guide the clinical diagnosis and treatment for the pediatric population.

MATERIALS AND METHODS

Study Design and Patients

In this retrospective study, 25 children (26 ears) with SSNHL treated and hospitalized from November 2011 to December 2017 were selected as study subjects. All subjects met the following inclusion criteria: unilateral or bilateral sensorineural hearing loss with a threshold decrease of at least 30 dB at three consecutive test frequencies in 72 hours or less; age<18 years; specialist otolaryngology examination, laboratory tests, and imaging studies to exclude acute or chronic otitis media; no previous history of surgery for otitis media; no diabetes or hypertension. At the same time, 149 cases (159 ears) of adult SSNHL (age $\geq$ 18 years) diagnosed and hospitalized in the same period were used for comparative analysis. Clinical data collected included age, gender, side (unilateral/bilateral, left/right ear), timing of treatment initiation, pure tone audiometry (PTA) at admission and discharge, tinnitus, vertigo, ear fullness, laboratory tests for viral infection (CMV, RV, HSV-1, and HSV-2, etc.), autoimmune (C3, C4) and antinuclear antibodies (ANA), erythrocyte sedimentation rate (ESR), coagulation profile (FIB, APTT), blood viscosity, fasting glucose, absolute neutrophil and lymphocyte ratio (NLR), and imaging studies including middle ear CT and/or internal auditory canal MRI. This study was approved by the institutional review board of the hospital ethic committee.

Audiometric Assessment

Pure tone audiometric air conduction thresholds were recorded at 0.25, 0.5, 1, 2, 4, and 8 kHz on admission. According to standards established by the WHO (1997), hearing loss is classified on the basis of pure tone averages for air conduction at 0.5, 1, 2, 4 kHz, and is as follows: Level 0 (normal): $\leq$ 25 dBHL; Level 1 (mild hearing loss): 26–40 dBHL; Level 2 (moderate hearing loss): 41–60 dBHL; Level 3 (severe hearing loss): 61–80 dBHL; Level 4 (profound hearing loss): > 80 dBHL. Four types of audiograms were defined based on the pattern of hearing loss in the initial PTA: ascending (the average threshold at 0.25–0.5 kHz was 20 dB higher than the average threshold at 4–8 kHz), descending (the average threshold at 4–8 kHz was 20 dB higher than the average threshold at 0.25–0.5 kHz), flat (similar threshold observed across the entire frequency range and hearing threshold not exceeding 90 dB HL), 4. profound (the average thresholds at 0.5, 1, 2, and 4 kHz over 90 dB HL) (8). After treatment, the patients were again examined for pure tone air conduction thresholds at 0.25, 0.5, 1, 2, 4, and 8 kHz. The hearing gain was calculated as the difference in hearing level (PTA) between admission and discharge. Siegel's criteria (21) were employed to assess the treatment results. Accordingly, hearing recovery was defined as complete recovery (CR, final hearing level <25 dB); partial recovery (PR, final hearing between 25 and 45 dB with hearing gain of $\geq$15 dB); slight recovery (SR, final hearing poorer than 45 dB with hearing gain of $\geq$15 dB); no improvement (NI, patients who showed <15 dB of gain). The hearing recovery rate is the sum of complete recovery (CR) and partial recovery (PR), and the complete recovery rate is the ratio of CR.

Treatment Protocols

All patients received a 14 day course of the following conservative treatment: corticosteroids (methylprednisolone 1 mg/kg/d, gradually tapered every 4 days), vasoactive drugs (ginkgo biloba extract, alprostadil) and anticoagulant thrombolytic drugs (fibrinolytic enzyme) were given by intravenous drop infusion. In addition, all patients also received intramuscularly neurotrophic drugs (methyl cobalt ammonium, mouse nerve growth factor) and hyperbaric oxygen therapy.

Statistical Analysis

All statistical analysis was carried out with SPSS version 21.0 for windows. For continuous variables, nonparametric Mann–Whitney U test or Student's t test were used. Chi-square test or Fisher's exact test were used for categorical data. Nonparametric Mann–Whitney U tests were applied to investigate continuous variable prognostic factors. p values <0.05 were considered statistically significant.

RESULTS

Clinical Characteristics of Children with SSNHL

We diagnosed 174 cases of SSNHL between 2011 and 2017. Patients were divided into two groups by age: children (< 18 years) and adults ($\geq$ 18 years). Table 1 is a summary of the clinical characteristics of both groups. The age of pediatric patients ranged from 5 to 17 years (mean, 12.44 $\pm$ 3.17 years). Patients in the adult group were 18 to 67 years old (mean, 38.22 $\pm$ 11.63 years). In patients with unilateral SSNHL, there was a statistically significant difference in the left/right ratio ($p = 0.047$). The prevalence of tinnitus, vertigo, and

TABLE 1. *Clinical haracteristics of the SSNHL patients*

	Children (< 18 y) N = 25	Adult (≥ 18 y) N = 149	p Value
Age, years, mean ± SD	12.44 ± 3.17	38.22 ± 11.63	<0.001[c]
Sex (male/female)	16/9	76/73	0.228[a]
Side (unilateral/bilateral)	24/1	139/10	0.943[a]
Unilateral sudden deafness (left/right)	6/18	65/74	0.047[a]
Initial treatment time, days),mean ± SD	9.20 ± 7.77	11.62 ± 14.40	0.409[d]
Accompanying symptoms			
Tinnitus	20 (76.9%)	129 (81.1%)	0.615[a]
Vertigo	13 (50.0%)	63 (39.6%)	0.319[a]
Ear fullness	6 (23.1%)	31 (19.5%)	0.672[a]
Initial hearing level, dB, mean ± SD	72.64 ± 33.46	78.67 ± 26.11	0.294[c]
Degree of deafness			
Mild	4 (15.4%)	20 (12.6%)	0.939[a]
Moderate	6 (23.1%)	21 (13.2%)	0.186[a]
Severe	4 (15.4%)	41 (25.8%)	0.368[a]
Profound	12 (46.2%)	77 (48.4%)	0.830[a]
Type of audiogram			
Ascending	2 (7.7%)	10 (6.3%)	1.000[a]
Descending	8 (30.8%)	38 (23.9%)	0.452[a]
Flat	8 (30.8%)	55 (34.6%)	0.703[a]
Profound	8 (30.8%)	56 (35.2%)	0.658[a]

[a]Pearson chi-squared test.
[b]Fisher's exact test.
[c]Student's t test.
[d]Mann–Whitney U test.
* Indicates statistical significance ($p < 0.05$).

aural fullness were 76.9%, 50.0% and 23.1%, respectively, in children while in adult patients these were 81.1%, 81.1% and 39.6%, respectively; no statistically significant difference ($p > 0.05$) was found with respect to the three symptoms. The initial hearing level of children/adults was mild (15.4%/12.6%), moderate (23.1%/13.2%), severe (15.4%/25.8%), and profound (46.2%/48.8%). The pattern of the audiograms of children/adults was ascending (7.7%/6.3%), descending (30.8%/23.9%), flat (30.8%/34.6%), and profound (30.8%/35.2%). There were no significant differences in the grades of the initial hearing level and in the type of the initial hearing threshold curve between children and adults with SSNHL ($p > 0.05$).

Etiology

A thorough history was collected for all patients. One of the 25 children had a history of upper respiratory tract infection before the onset of hearing loss and 24 had no remarkable causes of SSNHL; of the 149 adults with SSNHL, two patients had a history of upper respiratory tract infection, one patient had an autoimmune disease (rheumatoid factor +), one patient had been subjected to noise trauma, two patients had Meniere's disease and two patients had a history of mumps. (Table 2)

Laboratory Tests and Imaging

Some patients underwent laboratory testing; the test results are depicted in Table 3. Among the 25 cases of

children with SSNHL, 11 cases received viral serology examination. Among them, nine cases had a previous viral infection, including seven cases with CMV-IgG (+), seven cases with RV-IgG (+), seven cases with HSV I-IgG (+), and four cases with HSV II-IgM (+). Of 149 cases of adult patients with SSNHL, 50 underwent viral serology examination, all of whom had recent and / or previous viral infection. Viral serology results showed CMV-IgG (+) in 49 cases, RV-IgM (+) in 1 case, RV-IgG (+) in 43 cases, HSV I-IgG (+) in 42 cases, HSV II-IgM (+) in 3 cases and both HSV I-IgG (+) and HSVII-IgG (+) in 4 cases. It is a very interesting finding that children had a lower incidence of recent and/or previous viral infections than adults with SSNHL ($p = 0.033$). Among the 25 children, 10 patients underwent immunological examination, and 9 turned out with abnormal results. Around 55 of 149 adults patients underwent immunological examination, of which 22 were abnormal. Immunological examination abnormalities were mainly manifested in the reduction of complement C3 and/or C4. The incidence of immunological abnormality was higher in children than in adult patients ($p = 0.01$). There was no significant difference in coagulation function abnormality between children and adults ($p > 0.05$), but there was a significant difference in fibrinogen abnormalities ($p = 0.011$), manifested as a decrease in fibrinogen levels. Fasting blood glucose was lower in children (5.23 ± 1.47 mmol /L) with SSNHL than in adults (5.79 ± 1.02 mmol/L) with SSNHL ($p = 0.033$). There

TABLE 2. *Past medical history of children and adults with SSNHL*

Etiology	Children (N = 25)	Etiology	Adult (N = 149)
Idiopathic	24	Idiopathic	139
Anatomic deformity	0	Circulatory disorders	0
Ototoxicity	0	Cochlear membrane disruption	0
Trauma	0	Immunologic diseases	1
Noise induced	0	Noise induced	1
Meningitis	0	Parotitis	2
Parotitis	0	Meniere's disease	2
Meniere's disease	0	Anatomic deformity	1
Autoimmune	0	Coustic neuroma	1
Upper respiratory tract infection	1	Upper respiratory tract infection	2
Perilymphatic fistula	0		
Suppurative labyrinthitis	0		
Cerebral white matter signal abnormalities	0		

was no significant difference in blood viscosity, ANA, ESR, and NLR between children and adults ($p > 0.05$) (Table 3). Twenty-one of 25 children and 110 of 149 adults underwent CT or MRI examination of the middle ear. Eight children had otomastoiditis or sinusitis, and in adults 33 cases of otomastoiditis or sinusitis, one case of acoustic neuroma and one case of large vestibular aqueduct syndrome were found.

Treatment Outcomes

All patients received systemic treatment after admission. Of the 25 children (26 ears), seven ears (26.9%) recovered completely, three ears (11.5%) recovered partially, seven ears (26.9%) recovered slightly, and nine ears (34.6%) had no improvement; the recovery rate was 38.4% and the complete recovery rate was 26.9%. There was no significant difference in the recovery rate (38.4% vs 22.6%) between the children with SSNHL and the adult patients ($p > 0.05$) (Fig. 1). However, the complete recovery rate was significantly higher in pediatric SSNHL patients than in adults ($p = 0.031$).

Prognostic Factors

Mann–Whitney U test was used to investigate the effect of gender, unilateral or bilateral involvement, visit time, tinnitus, vertigo, ear fullness, the initial degree of hearing loss, and the type of audiogram on the prognosis of children with SSNHL (Table 4). A profound audiometric curve was found to adversely affect the prognosis of SSNHL in children ($p < 0.05$). Gender, side, treatment time, tinnitus, vertigo, stuffy ears, and the initial degree of hearing loss each had no effect on the prognosis SSNHL ($p > 0.05$). As shown in Table 5, the prognostic factors affecting adults with SSNHL were profound hearing loss and a profound type of audiometric curve ($p < 0.05$).

DISCUSSION

Reports on SSNHL in the pediatric population are scarce in the literature. This may not only be related to the low incidence of sudden deafness in this population group but also to poor language expression in children

TABLE 3. *Laboratory tests*

	Children (< 18 y) N = 25	Adult (≥ 18 y) N = 149	p Value
Viral infection	9/11 (81.8%)	50/50 (100.0%)	0.033[b],*
Autoimmunity	9/10 (90.0%)	22/55 (40.0%)	0.010[a],*
Anti-nuclear antibody (ANA)	1/8 (12.5%)	4/51 (7.8%)	1.000[a]
ESR	0/14 (0.0%)	4/77 (5.2%)	1.000[b]
Coagulation function	10/22 (45.5%)	35/137 (25.5%)	0.054[a]
Fibrinogen (FIB)	6/22 (27.3%)	12/137 (8.8%)	0.011[a],*
APTT	4/22 (18.2%)	50/137 (36.5%)	0.150[a]
Blood viscosity	10/13 (76.9%)	57/79 (72.2%)	0.982[a]
Fasting blood glucose (mmol/L), mean ± SD	5.23 ± 1.47	5.79 ± 1.02	0.033[c],*
NLR, mean ± SD	5.08 ± 4.74	5.07 ± 3.58	0.411[d]

[a]Pearson chi-squared test.
[b]Fisher's exact test.
[c]Student's t test.
[d]Mann–Whitney U test.
*Indicates statistical significance ($p < 0.05$).
APTT indicates activated partial thromboplastin time; ESR, erythrocyte sedimentation rate; NLR, neutrophil-to-lymphocyte ratio.
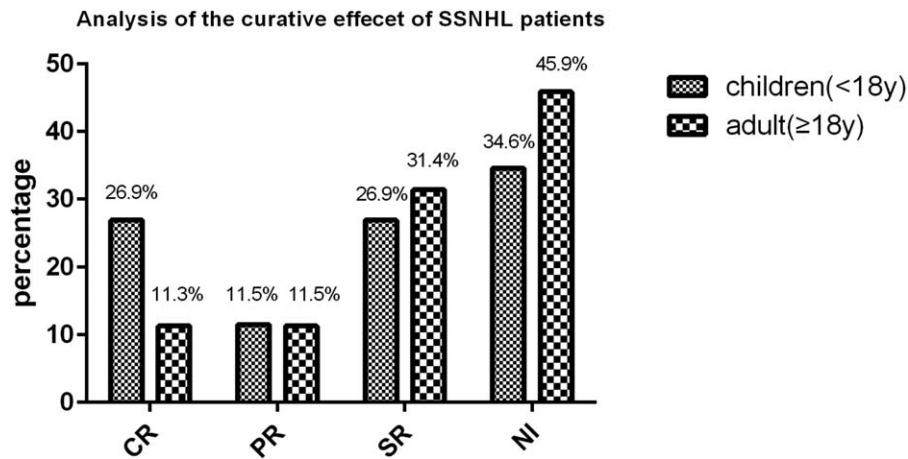
FIG. 1. According to Siegel's criteria, hearing recovery was defined as complete recovery (CR), partial recovery (PR), slight recovery (SR), and no improvement (NI). The recovery rate = CR + PR, the complete recovery rate = CR, according to Siegel's criteria. The recovery rate was 38.4% in pediatric group and 22.6% in adult group, with no significant difference between the two groups ($p = 0.084^a$). The complete recovery rate was 26.9% in pediatric group and 11.3% in adult group, with a statistically significant difference between the two groups ($p = 0.031^{a*}$).

(10). Currently, no guidelines for the diagnosis and treatment of children with SSNHL exist, and so far diagnosis and treatment protocols of childhood SSNHL have been extrapolated from guidelines for the management of sudden hearing loss in adults.

As reported in the literature, unilateral SSNHL was common while bilateral occurrence was rare (4,7,12,13,22). In this study, unilateral prevalence rates of sudden deafness in children and adults were 96.0% and 93.3%, respectively. Our finding in the pediatric age

TABLE 4. *Relationship between prognostic factors and curative effect in children with SSNHL*

	CR	PR	SR	NI	Ear number n = 26	Total effective rate (%)	p Value
Sex							
Male	5	3	5	4	17	8/17 (47.0%)	0.168[a]
Female	2	0	2	5	9	2/9 (22.2%)	
Side							
Unilateral	5	3	7	9	24	8/24 (33.3%)	0.057[a]
Bilateral	2	0	0	0	2	2/2 (100.0%)	
Initial treatment time, days							
≤14	7	3	5	6	21	10/21 (47.6%)	0.072[a]
>14	0	0	2	3	5	0/5 (0.0%)	
Accompanied by tinnitus							
Yes	4	2	7	7	20	6/20 (30.0%)	0.310[a]
No	3	1	0	2	6	4/6 (66.7%)	
Accompanied by vertigo							
Yes	4	3	2	4	13	7/13 (53.9%)	0.378[a]
No	3	0	5	5	13	3/13 (23.1%)	
Accompanied by ear fullness							
Yes	3	0	2	1	6	3/6 (50.0%)	0.228[a]
No	4	3	5	8	20	7/20 (35.0%)	
Degree of deafness							
Mild	3	0	0	1	4	3/4 (75.0%)	0.260[a]
Moderate	2	0	3	1	6	2/6 (33.3%)	
Severe	1	1	1	1	4	2/4 (50.0%)	
Profound	1	2	3	6	12	3/12 (25.0%)	
Type of audiogram							
Ascending	2	0	0	0	2	2/2 (100.0%)	.041[a,*]
Descending	3	0	4	1	8	3/8 (37.5%)	
Flat	1	3	2	2	8	4/8 (50.0%)	
Profound	1	0	1	6	8	1/8 (12.5%)	

[a]Mann−Whitney *U* test.
*Indicates statistical significance ($p < 0.05$).

TABLE 5. *Relationship between prognostic factors and curative effect in adult with SSNHL*

	CR	PR	SR	NI	Ear Number n = 159	Total Effective Rate (%)	p Value
Sex							
Male	10	8	29	36	83	18/83 (21.7%)	0.675[a]
Female	8	10	21	37	76	18/76 (23.7%)	
Side							
Unilateral	16	16	41	66	139	32/139 (23.0%)	0.534[a]
Bilateral	2	2	9	7	20	4/20 (20.0%)	
Initial treatment time, days							
≤14	16	15	33	52	116	31/116 (26.7%)	0.228[a]
>14	2	3	17	21	43	5/43 (11.6%)	
Accompanied by tinnitus							
Yes	15	11	41	62	129	26/129 (20.2%)	0.198[a]
No	3	7	9	11	30	10/30 (33.3%)	
Accompanied by vertigo							
Yes	5	5	23	30	63	10/63 (15.9%)	0.346[a]
No	13	13	27	43	96	26/96 (27.1%)	
Accompanied by ear fullness							
Yes	5	1	14	11	31	6/31 (19.4%)	0.373[a]
No	13	17	36	62	128	30/128 (23.4%)	
Degree of deafness							
Mild	6	0	6	8	20	6/20 (30.0%)	<0.001[a,*]
Moderate	5	3	7	8	21	8/21 (38.1%)	
Severe	4	9	19	9	41	13/41 (31.7%)	
Profound	3	6	18	50	77	9/77 (11.7%)	
Type of audiogram							
Ascending	4	0	1	5	10	4/10 (40.0%)	<0.001[a,*]
Descending	2	5	19	12	38	7/38 (18.4%)	
Flat	12	8	19	16	55	20/55 (36.4%)	
Profound	0	5	11	40	56	5/56 (8.9%)	

[a]Mann–Whitney U test.
*Indicates statistical significance ($p < 0.05$).

group is consistent with that reported by Li et al. (4), who found a unilateral SSNHL prevalence of 80.1% in children. Similarly, Qian et al. (22) reported a unilateral incidence of 96% in children with SSNHL. There is no relevant report on the difference in the onset of sudden unilateral deafness between children and adults. However, in our study, the incidence of pediatric unilateral SSNHL was higher on the right side, and no difference was noted between the right and left side for adult SSNHL patients. This finding is likely due to the relatively small sample size of pediatric patients compared to adult patients.

The etiology and mechanism of sudden deafness are not completely clear yet. Ječmenica and Bajec-Opančina (1) reported that in children SSNHL is mostly idiopathic and may also be related to viral infections, anatomical malformations, tumors, autoimmune diseases, and systemic diseases. In our study, out of 25 cases of children with SSNHL, only one had the history of upper respiratory tract infection before the onset of deafness while in the remaining 24 cases no known cause could be identified from their past medical history. Eleven children underwent viral serology examination and nine were found to be positive for CMV, RV, and HSV-1 and HSV-2 infection; the infection rate was 81.8%. In the

149 adult patients, two cases had a prior upper respiratory tract infection and two cases suffered from parotitis. Fifty adults received viral serology examination, all of whom showed previous or new viral infection. The infection rate was higher in adults than in the children group. These findings suggest that the disease in both children and adults may be associated with viral infection. This is inconsistent with the high rate of viral infection in children with sudden deafness reported by Hou and Wang (14). The possible causes for this outcome are: fewer cases of pediatric patients; the viral infection rates calculated in this study were obtained by viral serology rather than by past medical history.

Patients with SLE and juvenile rheumatoid arthritis (JRA) can develop symptoms of sensorineural hearing loss (15). Therefore, some studies have pointed out a possible relationship between SSNHL and autoimmune diseases. In clinical practice, immunological tests are often conducted on patients to rule out SSNHL caused by autoimmune diseases. Mafong et al. (15) collected laboratory profiles of 114 pediatric patients and carried out an analysis of ANA, ESR, and rheumatoid factor. Their report concluded that ESR had little diagnostic value in rheumatoid arthritis and that ANA was highly indicative of lupus, but in a retrospective series the

positive predictive value was only 11.0%. Our study found that there was no significant difference between children and adult SSNHL patients in regard to positive ANA and elevated ESR. Antinuclear antibodies were present in 12.5% of children with SSNHL, similar to the 11.0% reported by Mafong et al. However, to our surprise, autoimmune abnormalities in children (90.0%) were significantly higher than the 40.0% seen in adult patients. Complement C3 and C4 were mainly found to be decreased in patients with autoimmune disorders. Decreased complement levels of C3 and C4 are associated with worsening of SLE. Since SLE is regarded as a possible cause of childhood SSNHL, we hypothesized that complement C3 and C4 may be involved in the pathogenesis of childhood SSNHL. No relevant research has been carried out in this domain, and the specific pathogenesis involved is doubtful.

In their clinical guideline published in 2012, Stachler et al. (16) pointed out that in about 90.0% adult patients with SSNHL the cause is unknown while also emphasizing on vascular, viral, or multiple etiologies as possible risk factors. These authors strongly suggested ruling out acoustic neuroma, stroke, and cancer in the management of SSNHL in adults. Vascular causes are therefore one of the important speculative etiologies of SSNHL in adults. Similarly, Ječmenica and Bajec-Opančina (1) considered vascular disease as one of the possible causes of SSNHL in children while stressing on its rarity. In this study, we also examined the coagulation function and blood viscosity of patients. Following preliminary analysis, we found no statistically significant differences in abnormal coagulation function and abnormal blood viscosity between children and adults. However, we found differences in fibrinogen abnormalities between the two groups. A total of 27.3% (6/22) children showed elevated or decreased fibrinogen, of which 83.3% (5/6) patients showed decreased fibrinogen. It is a known fact that an increase in fibrinogen is closely related to atherosclerosis, cardiovascular, and cerebrovascular diseases. Kanzaki et al. (17) reported that high fibrin level was an adverse prognostic factor of SSNHL. Our findings showed that a small percentage of children with sensorineural hearing loss had reduced fibrinogen levels and as a result suggested that children were less likely to have SSNHL caused by a vascular process.

It has been reported that diabetes is a risk factor for SSNHL (18). In this study, we excluded patients with diabetes, but we nevertheless assessed fasting glucose in all patients enrolled. Analysis showed that adults had significantly higher fasting blood glucose levels than children. This may be due to the higher incidence of type 2 diabetes in adults than the incidence of type 1 diabetes in children. It may also be one of the reasons why adults have a higher incidence of SSNHL than children.

Mafong et al. (15) noted that imaging studies such as high-resolution CT and MRI could determine the specific cause of hearing impairment when assessing children with unexplained SSNHL. Temporal bone CT may help in finding a large vestibular aqueduct, Mondini malformation and other diseases while MRI can be used to localize lesions in the labyrinth, internal auditory canal, cerebellopontine angle, brainstem, and cerebral cortex. In our study, 21 children underwent imaging studies and all had normal temporal bone CTs or MRIs. Temporal bone CT or MRI imaging in adults revealed only 1 case (0.9%) of acoustic neuroma and 1 case (0.9%) of a large vestibular aqueduct. However, because large vestibular aqueduct is the most common imaging abnormality in children with SNHL and since patients with large vestibular aqueduct are at a higher risk of progressive hearing loss after minor head injury, children should be evaluated promptly for SSNHL.

Currently, the efficacy of different treatment regimens in children with SSNHL vary and many scholars believe that SSNHL in children has a worse prognosis than in adults (7). Chung et al. (11) showed that the total effective treatment rate in children with SSNHL was higher than that in adult patients, especially the complete recovery rate (46.0% and 30.8% in children and adults respectively). While Na et al. (7) compared treatment efficacy in both children and adults, they found no significant difference in the total effective rate (72.7% and 70.6%, respectively). The recovery rate of all 25 children with SSNHL in this study was 38.4% (10/26) compared with 22.6% (36/159) in adults, but no statistical difference was found ($p > 0.05$). Moreover, the complete recovery rate was 26.9% (7/26) in children compared to 11.3% (18/159) in the adult group; this difference being statistically significant ($p < 0.05$). The recovery rates of children and adults were similar, but the complete recovery rate of the former was higher, which was similar to that reported by Chung et al. (11).

There are conflicting reports of factors associated with childhood SSNHL outcomes. Many believe that severe initial hearing loss and vertigo were poor prognostic factors for SSNHL in children (1,5,11,19). Some authors believe that the absence of tinnitus, decreased hearing curve, steep hearing curve were poor prognosis indicators in children with SSNHL (1,5,8) while others believe that tinnitus did not influence prognosis (1). This study suggests that profound hearing loss is a poor prognostic factor in children with SSNHL. Gender, side involved, visit time, tinnitus, vertigo, ear stuffiness, and grade of initial hearing loss are not related to prognosis of SSNHL. As reported by Hikita-Watanabe et al. (20), tinnitus by itself may not be a sign of poor hearing prognosis but instead, might be an essential auditory stimulus for the initiation of repair of a damaged auditory system.

In summary, SSNHL had a unilateral presentation in the majority of patients. In our cohort of children, unilateral SSNHL was more common in the right ear. Children had a lower incidence of recent and/or previous viral infections than adults with SSNHL. Fasting plasma glucose level, complement C3 and C4, and fibrinogen may be closely associated with childhood SSNHL. The recovery rate in children with SSNHL is comparable to that of adults with SSNHL, but the complete recovery rate in children is higher than in adults. A profound audiometric curve is a

common adverse prognostic factor in children and adults with SSNHL. There are some deficiencies in this study: this study being retrospective in nature; the small number of patients in the children group due to the low incidence of childhood SSNHL. Therefore, larger sample data is needed to further explore the clinical features, etiology, treatment, and prognosis of SSNHL in children in order to better guide clinical practice.

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