

Factors associated with hearing recovery in acute low-frequency sensorineural hearing loss: a retrospective cohort study

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Short Report

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Abstract

Objectives Acute low-frequency sensorineural hearing loss (ALFHL) has traditionally been classified as a subtype of idiopathic sudden sensorineural hearing loss (ISSHL). However, emerging evidence suggests that ALFHL represents a distinct clinical entity characterized by favorable short-term recovery and a relatively high recurrence rate. Identification of factors associated with hearing recovery may facilitate prognostic stratification and clinical management.

Data description We retrospectively reviewed 62 patients diagnosed with ALFHL at a tertiary medical center between July 2015 and June 2020. Patients had unilateral acute sensorineural hearing loss of ≥ 30 dB at two consecutive low frequencies (250 and 500 Hz) within 3 days, with preserved thresholds (≤ 25 dB) at 1000, 2000, and 4000 Hz in the affected ear. Patients were categorized into recovery (complete or partial recovery) and no-recovery groups. Clinical variables were analyzed using chi-square tests. Treatment initiation within 7 days of symptom onset was significantly associated with hearing recovery ($P = 0.003$), as was age ≤ 40 years ($P = 0.006$). Sex, affected ear, presenting symptoms, comorbidities, season of onset, interaural 1000 Hz threshold difference ≥ 10 dB, and treatment modality were not significantly associated with recovery. One week after treatment, 77.4% of patients achieved complete or partial recovery.

Introduction

Idiopathic sudden sensorineural hearing loss (ISSHL) is a common otologic emergency, with an annual incidence of approximately 5–20 cases per 100,000 individuals in Western populations [1]. Its etiology remains incompletely understood and has been attributed to viral infection, labyrinthine dysfunction, or autoimmune mechanisms [2]. In comparison, the reported annual incidence of acute low-frequency sensorineural hearing loss (ALFHL) in Asian populations ranges from 20 to 60 per 100,000 individuals [3, 4].

Although historically classified as a subtype of ISSHL, ALFHL is increasingly regarded as a distinct clinical entity. It predominantly affects younger women [5] and is characterized by acute low-frequency hearing loss with relative preservation of middle- and high-frequency thresholds. Despite generally favorable short-term recovery, ALFHL has been associated with a relatively high recurrence rate. Long-term follow-up studies have reported recurrence rates ranging from approximately 15% to over 40% [4, 6–8].

The underlying pathophysiology of ALFHL remains unclear. Its preferential involvement of low frequencies has led to hypotheses involving localized cochlear dysfunction, reversible endolymphatic hydrops, or pressure dysregulation within the scala media. The fluctuating clinical course and recurrence tendency have also raised the possibility of an association with hydropic inner-ear disorders. A subset of patients with recurrent ALFHL may subsequently develop features consistent with Ménière's disease [8, 9].

Diagnostic criteria for ALFHL were first described in 1981 and have subsequently been modified [8, 9]. Current clinical criteria commonly include acute onset of ≥ 30 dB hearing loss at two consecutive low frequencies (250 and 500 Hz), preserved middle- and high-frequency thresholds, and the absence of an alternative cause [6]. These criteria distinguish ALFHL from other patterns of sudden sensorineural hearing loss. The reported recurrence rate of ISSHL ranges from 1.4% to 17% [4], whereas ALFHL demonstrates a higher recurrence tendency [8, 9].

Given its favorable short-term prognosis and potential for recurrence, identification of factors associated with hearing recovery is clinically important. This retrospective cohort study aimed to evaluate demographic and clinical variables associated with auditory recovery in patients with ALFHL and to compare outcomes among different treatment strategies.

Materials and methods

Study design, participants, and ethical approval

This retrospective cohort study was conducted at a tertiary medical center in northern Taiwan. Medical records from July 1, 2015 to June 30, 2020 were reviewed. The study protocol was approved by the Institutional Review Board of Cathay General Hospital (CGH-P1100289). All procedures conformed to institutional ethical standards.

Patients presenting to the otolaryngology outpatient clinic with tinnitus, aural fullness, or unilateral sudden sensorineural hearing loss were screened for eligibility. Middle-ear pathology was excluded using tympanometry (TympStar; Grason-Stadler, Eden Prairie, MN, USA). Pure-tone audiometry was performed using a GSI 61 audiometer (Grason-Stadler, Eden Prairie, MN, USA), and audiometric results were reviewed by certified audiologists.

Cases were identified using diagnostic codes for sudden hearing loss (ICD-9 3882), sudden idiopathic hearing loss of the right ear (ICD-10 H9121), or left ear (ICD-10 H9122). Patients were included if they were aged 20 years or older and met the audiometric criteria for ALFHL. Specifically, inclusion required unilateral acute sensorineural hearing loss with a threshold shift of ≥ 30 dB at two consecutive low frequencies (250 and 500 Hz) within three days in the affected ear, preserved hearing thresholds (≤ 25 dB) at 1000, 2000, and 4000 Hz in the affected ear, normal thresholds (≤ 25 dB) at 250, 500, 1000, 2000, and 4000 Hz in the contralateral ear, and absence of vertigo or spontaneous nystagmus.

Patients were excluded if they were younger than 20 years, presented more than four weeks after symptom onset, had recurrent ALFHL, conductive or mixed hearing loss, bilateral hearing loss, fluctuating hearing loss, recurrent vertigo, central nervous system disorders, or retrocochlear pathology such as vestibular schwannoma.

Clinical variables

Demographic and clinical data were extracted from medical records, including sex, age, affected ear, presenting symptoms (tinnitus, aural fullness, and upper respiratory tract infection), medical comorbidities (hypertension and/or diabetes mellitus), season of onset, treatment timing, hearing thresholds at 250 and 500 Hz at initial presentation, hearing thresholds at one week and one month after treatment, interaural threshold differences at 1000 Hz ≥ 10 dB, and treatment modality. Treatment modalities included oral corticosteroids, diuretics, or combination therapy with corticosteroids and diuretics.

Outcome assessment

Outcome assessment

Hearing recovery was evaluated in accordance with the Clinical Practice Guideline: Sudden Hearing Loss established by the American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS) [3, 10]. Complete recovery was defined as restoration of hearing to within 10 dB of the contralateral ear. Partial recovery was defined as an improvement greater than 10 dB that did not meet the criteria for complete recovery. No recovery was defined as hearing improvement of less than 10 dB. For prognostic analysis, patients were categorized into recovery (complete and partial recovery combined) and no-recovery groups.

Statistical analysis

Statistical analyses were performed using SPSS version 23 (IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for demographic and clinical variables. Associations between categorical variables and hearing recovery were analyzed using chi-square tests. A two-tailed P-value < 0.05 was considered statistically significant.

Results

Baseline demographic and clinical characteristics

A total of 62 patients were included in this study, comprising 45 females and 17 males. The age ranged from 21 to 69 years, with a mean age of 40.9 ± 12.5 years. Patients aged 20–40 years constituted the largest proportion of the cohort ($n = 33$), followed by those aged 41–60 years ($n = 24$), while 5 patients were older than 60 years.

With respect to laterality, 33 patients (53.2%) had right-ear involvement and 29 (46.8%) had left-ear involvement. The most common presenting symptoms were tinnitus ($n = 33$) and aural fullness ($n = 37$), while one patient reported concurrent upper respiratory tract infection. Only a small proportion of patients had hypertension ($n = 3$) or diabetes mellitus ($n = 1$). Seasonal distribution of disease onset was evenly divided between spring–summer ($n = 31$) and autumn–winter ($n = 31$). Thirty-two patients sought medical attention within 7 days, including day 7, of symptom onset. An interaural threshold difference $\geq$

10 dB at 1000 Hz was observed in 37 patients (59.7%). Oral corticosteroids were the primary treatment modality, administered to 44 patients (70.9%) (Table 1).

Table 1

Baseline characteristics of patients with acute low-frequency sensorineural hearing loss (N = 62)

Variable	Category	N	Percentage (%)*
Age (years)	21–30	16	25.8
	31–40	17	27.4
	41–50	15	24.2
	51–60	9	14.5
	≥ 61	5	8.1
Sex	Male	17	27.4
	Female	45	72.6
Affected ear	Right	33	53.2
	Left	29	46.8
Presenting symptoms	Tinnitus	29	46.8
	Aural fullness	25	40.3
	Upper respiratory infection	1	1.6
Comorbidities	Hypertension	3	4.8
	Diabetes mellitus	1	1.6
Season of onset	Spring–Summer	31	50.0
	Autumn–Winter	31	50.0
Delay to treatment (n = 57)	≤ 7 days	25	40.3
Interaural 1000 Hz difference ≥ 10 dB	Yes	37	59.7
Treatment modality	Oral corticosteroids	44	70.9
*Percentages are calculated based on N = 62 unless otherwise specified.			

Changes in hearing thresholds after treatment

Audiometric evaluation demonstrated elevated low-frequency hearing thresholds at initial presentation, which improved significantly one week after treatment. Mean hearing thresholds improved across frequencies, from 44.8 ± 8.1 to 23.8 ± 15.2 dB HL at 250 Hz, from 36.9 ± 7.6 to 20.3 ± 13.4 dB HL at 500 Hz, and from 19.5 ± 5.1 to 13.1 ± 8.4 dB HL at 1000 Hz; the average threshold across 250 and 500 Hz

also decreased from 40.5 ± 2.0 to 22.3 ± 14.0 dB HL. Improvements at all evaluated frequencies were statistically significant ($P < 0.001$ for all comparisons) (Table 2).

Table 2
Comparison of hearing thresholds before and one week after treatment

Frequency (Hz)	Baseline (dB HL), mean $\pm$ SD	One week after treatment (dB HL), mean $\pm$ SD	P value
250	44.8 ± 8.1	23.8 ± 15.2	$< 0.001^*$
500	36.9 ± 7.6	20.2 ± 13.4	$< 0.001^*$
1000	19.5 ± 5.1	13.1 ± 8.4	$< 0.001^*$
250 & 500 (mean)	40.5 ± 8.2	22.3 ± 14.0	$< 0.001^*$
*Data were analyzed using paired t-tests. $P < 0.05$ was considered statistically significant.			

Factors associated with hearing recovery

Factors associated with hearing recovery were evaluated in patients with ALFHL (Table 3). Sex, affected ear, presenting symptoms, medical comorbidities (hypertension and diabetes mellitus), season of onset, treatment modality, and interaural threshold difference ≥ 10 dB at 1000 Hz were not significantly associated with recovery (all $P > 0.05$).

Table 3
Prognostic factors associated with hearing recovery in patients with ALFHL

Variable	Category	Recovery (n)	No recovery (N)	P value
Sex	Male	13	4	0.913*
	Female	31	14	
Age	≤ 40 years	23	10	0.006*
	≥ 41 years	16	13	
Affected ear	Right	26	7	0.739*
	Left	18	11	
Presenting symptoms	Yes	22	10	0.290*
	No	20	5	
Hypertension	Yes	0	3	0.155*
	No	43	16	
Diabetes mellitus	Yes	0	1	0.225*
	No	45	16	
Season of onset	Spring–Summer	22	9	0.155*
	Autumn–Winter	22	9	
Delay to treatment	≤ 7 days	20	5	0.003*
	> 7 days	22	10	
Treatment modality	Corticosteroids	32	12	0.212*
	Other	12	6	
Interaural 1000 Hz difference ≥ 10 dB	Yes	30	7	0.132*
	No	16	9	
*Associations were evaluated using chi-square tests.				

In contrast, age and timing of treatment initiation were significantly associated with recovery. Patients aged ≤ 40 years had a higher recovery rate than those aged > 40 years ($P = 0.006$). Patients who initiated treatment within 7 days of symptom onset also had a higher recovery rate than those who began treatment after 7 days ($P = 0.003$).

Discussion

In this retrospective cohort, younger age and earlier treatment initiation were significantly associated with hearing recovery in patients with ALFHL. Patients aged ≤ 40 years had better outcomes than older patients, while treatment initiated within 7 days of symptom onset was associated with a higher recovery rate. These findings highlight the potential importance of patient age and treatment timing in the short-term recovery of ALFHL.

The association between younger age and better recovery may reflect greater cochlear resilience or differences in vascular or cellular function with aging; however, the underlying mechanism remains uncertain [8, 11]. Because this study was retrospective and did not assess these mechanisms directly, this interpretation should be considered hypothesis-generating.

The association between earlier treatment and better recovery is consistent with previous reports emphasizing the potential importance of early intervention in ALFHL [8, 9]. Delayed treatment has been associated with increased rates of incomplete recovery [9]. However, because treatment timing was not randomly assigned in this retrospective cohort, the observed association should not be interpreted as proof of a causal treatment effect.

Consistent with previous studies, our cohort showed a female predominance [6, 9] and a mean age in the fourth decade of life [3, 8]. These demographic features have been described as differing from typical ISSHL and have contributed to the view that ALFHL may represent a distinct clinical entity [8, 12].

Tinnitus and aural fullness were common presenting symptoms [6, 8]. Aural fullness has also been reported more frequently in low-frequency hearing loss than in high-frequency sudden hearing loss [13, 14]. In our cohort, however, presenting symptoms were not significantly associated with recovery. Tinnitus alone has likewise been reported to be insufficient for predicting recurrence risk [15]. Because these symptoms may overlap with Ménière's disease and Eustachian tube dysfunction, careful audiometric and tympanometric evaluation remains important for accurate diagnosis.

Systemic vascular comorbidities were uncommon in this cohort. Although the small number of affected patients limits interpretation, this finding is consistent with previous observations in ALFHL [16].

The overall complete and partial recovery rate at one week was 77.4%, consistent with the generally favorable short-term outcomes reported in previous studies [8, 9]. Nevertheless, a subset of patients did not recover, indicating clinical heterogeneity. The absence of vertigo does not necessarily exclude cochlear hydrops, and hydropic inner-ear mechanisms have been proposed as one possible explanation for the characteristic low-frequency pattern. Magnetic resonance imaging studies have described expansion of cochlear or vestibular endolymphatic spaces in related hydropic conditions [16]. Whether ALFHL and Ménière's disease share a common pathophysiological mechanism remains unresolved.

ALFHL has been reported to show a higher relapse tendency than ISSHL [8, 9], whereas reported recurrence rates of ISSHL range from 1.4% to 17% over several years of follow-up [4, 7]. Given this

recurrence tendency, follow-up remains clinically relevant even after favorable short-term recovery. Longer-term prospective studies are needed to determine whether the factors associated with short-term recovery in this cohort also predict recurrence or long-term hearing outcomes.

Treatment modality was not significantly associated with hearing recovery in our cohort. Because treatment allocation was not randomized and may have been influenced by clinical characteristics, treatment selection bias cannot be excluded. Therefore, the present findings should not be interpreted as evidence that different treatment strategies are equivalent. Systemic corticosteroids are widely used in sudden sensorineural hearing loss, but potential adverse effects have been described in the literature [17–21]. Alternative strategies, including intratympanic corticosteroid administration and combination therapy, have also been proposed for selected patients [22]. Prospective comparative studies are needed to clarify the relative effectiveness and safety of these approaches in ALFHL.

Implications of findings

These findings suggest that prompt recognition and early treatment may be important for achieving favorable hearing recovery in patients with ALFHL, particularly among younger patients. The results may also assist clinicians in counseling patients regarding short-term prognosis. Larger prospective studies are required to validate these associations and to clarify optimal treatment strategies and long-term outcomes.

Strengths and limitations

This study provides real-world clinical data on factors associated with hearing recovery in patients with ALFHL using standardized audiometric diagnostic criteria and outcome assessment. However, several limitations should be considered. First, this was a retrospective, single-center study with a relatively small sample size, which may limit the generalizability of the findings. Second, treatment allocation was not randomized and may have been influenced by clinical characteristics, introducing potential treatment selection bias. Third, the analysis was based on chi-square tests of categorical variables and did not include multivariable adjustment; therefore, residual confounding cannot be excluded. Finally, vestibular functional testing and advanced imaging were not routinely performed, precluding comprehensive evaluation of inner-ear pathology. Future prospective multicenter studies with larger cohorts, longer follow-up, vestibular assessments, and magnetic resonance imaging are warranted to validate these findings and improve prediction of long-term outcomes and recurrence.

Conclusion

In this retrospective cohort of patients with ALFHL, younger age and earlier treatment initiation were significantly associated with better hearing recovery. Treatment modality was not significantly associated with recovery in this cohort. These findings support prompt recognition and early clinical management of ALFHL, while the limitations of the retrospective design and small sample size should

be considered. Prospective multicenter studies are warranted to validate these associations and determine their relevance to long-term hearing outcomes.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of Cathay General Hospital (approval no. CGH-P1100289). The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. All patient data were anonymized, and no personally identifiable information was collected or recorded. The requirement for informed consent was waived by the Institutional Review Board because of the retrospective nature of the study.

Consent for publication

Not applicable.

Declaration of competing interests

The authors declare no competing interests.

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Author Contribution

YCL: Study design, methodology, investigation, data curation, and drafting; CJH: Study design, methodology, data analysis, investigation, and review; HCL: Investigation, data curation, and review; CYH: Investigation, data curation, and review; TYF: Methodology, investigation, data curation, and drafting; JPW: Methodology, investigation, data curation, and drafting. All authors read and approved the final manuscript and agreed to be accountable for all aspects of the work.

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Data availability

The data generated and/or analyzed during the current study are not publicly available but may be obtained from the corresponding author upon reasonable request.

Availability of data and materials

The authors confirm that the data supporting the findings of this study are available within the article.

References

1. LeGros TL, Murphy-Lavoie H, REPRINTED FROM. THE 2023 HYPERBARIC INDICATIONS MANUAL 15(th) Edition: Sudden Sensorineural Hearing Loss. Undersea Hyperb Med. 2024;51(4):425–48.
2. Tsuzuki N, Wasano K. Idiopathic sudden sensorineural hearing loss: A review focused on the contribution of vascular pathologies. *Auris Nasus Larynx*. 2024;51(4):747–54. <http://doi.org/10.1016/j.anl.2024.05.009>.
3. Kitoh R, Nishio SY, Sato H, Ikezono T, Morita S, Wada T, et al. Clinical practice guidelines for the diagnosis and management of acute sensorineural hearing loss. *Auris Nasus Larynx*. 2024;51(4):811–21. <http://doi.org/10.1016/j.anl.2024.06.004>.
4. Zhang BY, Wang YC, Chan KC. Recurrent sudden sensorineural hearing loss-A literature review. *Laryngoscope Investig Otolaryngol*. 2022;7(3):854–62. <http://doi.org/10.1002/lio2.828>.
5. He X, Huang C, Jiang F, Lan H, Huang Y, Liu M, et al. The role of stimuli of life events and sleep quality in the incidence of acute low-tone sensorineural hearing loss. *Front Neurol*. 2024;15:1480216. <http://doi.org/10.3389/fneur.2024.1480216>.
6. Jung AR, Kim MG, Kim SS, Kim SH, Yeo SG. Clinical characteristics and prognosis of low frequency sensorineural hearing loss without vertigo. *Acta Otolaryngol*. 2016;136(2):159–63. <http://doi.org/10.3109/00016489.2015.1094824>.
7. Psillas G, Rizou A, Rachovitsas D, Tsiropoulos G, Constantinidis J. Hearing Outcome of Low-tone Compared to High-tone Sudden Sensorineural Hearing Loss. *Int Arch Otorhinolaryngol*. 2019;23(1):65–9. <http://doi.org/10.1055/s-0038-1657789>.
8. Diao T, Chen Y, Jing Y, Ma X. Clinical characteristics and prognosis of acute low-frequency hearing loss and ascending sensorineural sudden sensorineural hearing loss. *Front Neurosci* 2022, 16:1076109 <http://doi.org/10.3389/fnins.2022.1076109>
9. Jiang L, Wang Q, Chen L. Impact of Endolymphatic Hydrops and Semicircular Canal Dysfunction on the Incomplete Recovery of Acute Low-Frequency Sensorineural Hearing Loss. *Ear Nose Throat J* 2023;1455613231196094 <http://doi.org/10.1177/01455613231196094>
10. Prince ADP, Stucken EZ. Sudden Sensorineural Hearing Loss: A Diagnostic and Therapeutic Emergency. *J Am Board Fam Med*. 2021;34(1):216–23. <http://doi.org/10.3122/jabfm.2021.01.200199>.

11. Del Vecchio V, Tricarico L, Pisani A, Serra N, D'Errico D, De Corso E, et al. Vascular Factors in Patients with Midlife Sensorineural Hearing Loss and the Progression to Mild Cognitive Impairment. *Med (Kaunas)*. 2023;59(3). <http://doi.org/10.3390/medicina59030481>.
12. Morita S, Suzuki M, Iizuka K. A comparison of the short-term outcome in patients with acute low-tone sensorineural hearing loss. *ORL J Otorhinolaryngol Relat Spec* 2010, 72(6):295–9 <http://doi.org/10.1159/000314695>
13. Bogacz A, Sinkiewicz A, Burduk P, Kozakiewicz-Rutkowska A, Kubala-Owiesny. A High-frequency audiometry in the diagnosis of tinnitus. *Ir J Med Sci*. 2024;193(1):383–8. <http://doi.org/10.1007/s11845-023-03462-y>.
14. Choo OS, Yang SM, Park HY, Lee JB, Jang JH, Choi SJ et al. Differences in clinical characteristics and prognosis of sudden low- and high-frequency hearing loss. *Laryngoscope* 2017, 127(8):1878–84 <http://doi.org/10.1002/lary.26382>
15. Pecorari G, Riva G, Bruno G, Naqee N, Nardo M, Albera A, et al. Recurrences in Sudden Sensorineural Hearing Loss: A Long-Term Observational Study. *Am J Audiol*. 2020;29(1):18–22. http://doi.org/10.1044/2019_AJA-19-00061.
16. Shin SH, Byun SW, Park S, Kim EH, Kim MW, Lee HY. Optimal First-Line Therapy for Acute Low-Tone Sensorineural Hearing Loss. *J Audiol Otol*. 2021;25(4):209–16. <http://doi.org/10.7874/jao.2021.00269>.
17. Zhang J, Cao J, Liu Y, Zhao H. Advances in the Pathogenesis of Steroid-Associated Osteonecrosis of the Femoral Head. *Biomolecules* 2024, 14(6) <http://doi.org/10.3390/biom14060667>
18. Rahman A, Haider MF A comprehensive review on glucocorticoids induced osteoporosis: A medication caused disease. *Steroids*. 2024;207:109440. <http://doi.org/10.1016/j.steroids.2024.109440>.
19. Tavares LCP, Caetano LVN, Iannuzzi M. Side effects of chronic systemic glucocorticoid therapy: what dermatologists should know. *Bras Dermatol*. 2024;99(2):259–68. <http://doi.org/10.1016/j.abd.2023.05.005>.
20. Motta F, Timilsina S, Gershwin ME, Selmi C. Steroid-induced osteonecrosis. *J Transl Autoimmun*. 2022;5:100168. <http://doi.org/10.1016/j.jtauto.2022.100168>.
21. Halevy N, Elias B, Shilo S, Muhanna N, Handzel O, Oron Y et al. Real life safety of systemic steroids for sudden sensorineural hearing loss: a chart review. *Eur Arch Otorhinolaryngol* 2022, 279(10):4787–92 <http://doi.org/10.1007/s00405-022-07264-3>
22. Lee CK, Lee JB, Park KH, Lee HY, Choi MJ, Ban W, et al. Significance of 1 kHz Pure-tone Threshold in Acute Low-frequency Sensorineural Hearing Loss. *Otol Neurotol*. 2018;39(10):e950–5. <http://doi.org/10.1097/MAO.0000000000002023>.