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Original Research Article

MANAGEMENT STRATEGIES FOR SUDDEN SENSORINEURAL HEARING LOSS: AN EVIDENCE-BASED REVIEW

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ABSTRACT

Background: Sudden sensorineural hearing loss (SSNHL) is a rapid-onset otologic emergency characterized by an unexplained hearing loss of ≥30 dB over three contiguous frequencies within 72 hours. Despite multiple treatment modalities available, an optimal therapeutic approach remains uncertain. The objective is to evaluate and compare the effectiveness of systemic corticosteroids, intratympanic steroid injections, and adjunctive hyperbaric oxygen therapy (HBOT) in improving hearing outcomes in patients with idiopathic SSNHL.

Materials and Methods: A prospective, randomized clinical study was conducted at a tertiary care center from March 2024 to February 2025. A total of 132 patients with idiopathic SSNHL were enrolled and divided into three treatment groups: Group A (n=44): Systemic corticosteroids (oral prednisone 1 mg/kg/day for 10 days with taper), Group B (n=45): Intratympanic dexamethasone (4 mg/mL, administered 3×/week for 2 weeks), Group C (n=43): Combined systemic corticosteroids and HBOT (daily 100% oxygen at 2.4 ATA for 60 minutes over 15 sessions). Pure-tone audiometry (PTA) was performed at baseline, 2 weeks, and 1 month. Hearing recovery was assessed using Siegel's criteria.

Results: The results demonstrated a significant improvement in hearing across all three study groups. Group C exhibited the highest proportion of complete or partial hearing recovery at 72%, in comparison to 61% in Group A and 58% in Group B, with this difference being statistically significant ($p < 0.05$). Furthermore, early initiation of therapy specifically within seven days of symptom onset was strongly associated with better hearing outcomes ($p < 0.01$). Importantly, no serious adverse effects were noted in any group; however, a small proportion (8%) of patients undergoing intratympanic therapy experienced mild, transient vertigo.

Conclusion: While all treatment modalities demonstrated efficacy in managing SSNHL, combination therapy with systemic steroids and HBOT was superior in terms of hearing recovery. Early diagnosis and prompt initiation of treatment remain critical. Further multicentric studies with larger cohorts are needed to validate these findings and support the integration of HBOT into standard treatment protocol.

Keywords: Sudden sensorineural hearing loss; SSNHL; corticosteroids; intratympanic steroid; hyperbaric oxygen therapy; hearing recovery; clinical study; otology; randomized controlled trial.

INTRODUCTION

Sudden sensorineural hearing loss (SSNHL) is a medical and otologic emergency characterized by the abrupt onset of hearing loss, typically unilateral, developing over a period of fewer than 72 hours. The condition is clinically defined by a decrease of at least 30 decibels across three contiguous

frequencies as measured by pure-tone audiometry.[1] Although SSNHL is relatively uncommon, affecting an estimated 5 to 20 per 100,000 individuals annually, the impact on quality of life can be profound. Patients often present with not only hearing loss but also accompanying symptoms such as tinnitus, ear fullness, and, in approximately 30–40% of cases, vertigo. These manifestations can lead to anxiety, communication difficulties, social withdrawal, and in some cases, permanent auditory disability.[2] The unpredictable nature of both its onset and recovery further complicates patient management and therapeutic decision-making.

Despite extensive clinical observation, the precise pathophysiological mechanisms underlying SSNHL remain elusive. In the majority of cases nearly 90% the cause is classified as idiopathic, though several etiological theories have been proposed. Viral insults, particularly from herpes simplex or other neurotropic viruses, have been hypothesized as a common trigger due to the sudden and acute presentation of symptoms.[3] Vascular compromise, such as micro thrombi or ischemic infarction of the cochlear artery, is another suspected mechanism, as the cochlea has a terminal blood supply that renders it particularly vulnerable to hypoxia. Autoimmune inner ear disorders, traumatic cochlear injury, perilymphatic fistula, and even neoplastic processes such as vestibular schwannoma must also be considered in the differential diagnosis.[4] However, the idiopathic nature of most cases has led to a standardized empirical approach to treatment, primarily focused on anti-inflammatory, immunosuppressive, and oxygen-enhancing strategies.

Corticosteroids remain the cornerstone of SSNHL treatment due to their anti-inflammatory and immunomodulatory effects. Systemic administration, often in the form of oral prednisone, has long been considered the first-line therapy, with several studies demonstrating improved rates of hearing recovery when initiated promptly.[5] However, systemic steroids carry a risk of adverse effects, particularly in patients with comorbid conditions such as diabetes, hypertension, or peptic ulcer disease. This concern has led to the increasing use of intratympanic steroid injections, which allow for targeted drug delivery to the cochlea with reduced systemic exposure.[6] Intratympanic dexamethasone or methylprednisolone injections have been used either as primary therapy or as salvage treatment for patients who do not respond to systemic therapy.

In recent years, adjunctive therapies such as hyperbaric oxygen therapy (HBOT) have gained attention for their potential to improve cochlear oxygenation and promote hair cell recovery. HBOT involves the inhalation of 100% oxygen at elevated atmospheric pressures, enhancing oxygen diffusion to the inner ear and mitigating ischemic or hypoxic damage.[7] While some studies and meta-analyses have suggested that HBOT may offer additive benefits when combined with corticosteroid therapy, especially in cases of severe or profound hearing loss, its limited availability, cost, and logistical demands have prevented it from being widely adopted in standard protocols.[8]

The wide array of therapeutic options, combined with varying degrees of efficacy reported in the literature, underscores the need for more robust, comparative, and prospective clinical data. Many existing studies are retrospective, heterogeneous in design, and limited by small sample sizes or lack of control groups.[9,10] Consequently, there is still no universally accepted treatment algorithm for idiopathic SSNHL, and clinical practice varies significantly based on physician preference, institutional resources, and patient characteristics.[11]

This original study was therefore designed to prospectively compare the efficacy of three commonly used management strategies in a well-defined cohort of patients with idiopathic SSNHL: systemic corticosteroid monotherapy, intratympanic steroid injection, and combination therapy involving systemic corticosteroids with HBOT. By evaluating hearing recovery through standardized audiometric criteria and accounting for treatment timing, patient comorbidities, and side effect profiles, this study aims to contribute meaningful clinical evidence toward the development of an optimized, evidence-based treatment paradigm for SSNHL. Furthermore, this study reinforces the importance of early diagnosis and intervention, with the goal of maximizing auditory recovery and minimizing long-term morbidity in affected patients.

MATERIALS AND METHODS

This prospective, randomized clinical study was conducted at Government Medical College, Jagityal, Telangana, between March 2024 and February 2025 after taking permission from the Institutional Ethics Committee. The study included patients aged 18 to 65 years who presented with a clinical diagnosis of idiopathic sudden sensorineural hearing loss (SSNHL), defined as a hearing loss of at least 30 decibels (dB) across three contiguous frequencies within 72 hours of symptom onset. All participants underwent a thorough otological examination, including pure-tone audiometry (PTA), tympanometry, and speech discrimination scores at baseline. Magnetic resonance imaging (MRI) of the internal auditory canal with gadolinium contrast was performed to exclude retrocochlear pathology such as vestibular schwannoma. Laboratory workups were conducted to rule out identifiable causes such as autoimmune disease, syphilis, or viral infections. Patients with conductive or mixed hearing loss, previous ear surgery, active middle ear infection, chronic otitis media, Meniere's disease, or acoustic trauma were excluded from the study, as were pregnant women and patients with contraindications to steroids or hyperbaric oxygen therapy.

A total of 132 eligible patients were randomly allocated into three treatment groups using a computer-generated randomization table. Group A (n=44) received systemic corticosteroid therapy, consisting of oral prednisone at a dose of 1 mg/kg/day (maximum 60 mg/day) for 10 days, followed by a tapering schedule over the next 4 days. Group B (n=45) was treated with intratympanic steroid injections of dexamethasone (4 mg/mL), administered three times per week for a total of six sessions over two weeks. Group C (n=43) received a combination of systemic corticosteroids (same regimen as Group A) along with hyperbaric oxygen therapy (HBOT), which was administered as daily sessions of 100% oxygen at 2.4 atmospheres absolute (ATA) for 60 minutes per session, over a course of 15 consecutive treatments. All procedures were performed by experienced otologists, and intratympanic injections were administered via tympanic membrane puncture under local anesthesia.

Audiological evaluations using PTA were conducted at baseline, two weeks, and one month post-treatment. Hearing outcomes were assessed according to Siegel's criteria, which classify recovery into complete, partial, slight, or no improvement based on hearing thresholds. Data were analyzed using SPSS version 26.0. Descriptive statistics were used to summarize demographic and clinical variables. Chi-square tests and ANOVA were applied to compare recovery rates and hearing improvements across groups, with a p-value < 0.05 considered statistically significant. Additionally, subgroup analysis was conducted based on duration of symptoms before treatment initiation, presence of vertigo, and severity of initial hearing loss to identify prognostic factors influencing therapeutic outcomes. Patient compliance, adverse effects, and any complications associated with treatments were also documented and analyzed throughout the study duration.

RESULTS

A total of 132 patients diagnosed with idiopathic sudden sensorineural hearing loss were enrolled and randomized into three treatment groups. The baseline characteristics, including age, sex distribution, comorbidities, and initial hearing thresholds, were comparable across all groups. Significant improvement in hearing thresholds was observed in all treatment arms, with the highest recovery rate noted in the group receiving combination therapy with systemic steroids and hyperbaric oxygen therapy. The average time to initiation of therapy was 4.2 ± 1.7 days. Early treatment (within 7 days of onset) was strongly associated with improved outcomes.

Table 1: Baseline Characteristics of the Study Participants

Variable	Group A (Systemic Steroids)	Group B (Intratympanic Steroids)	Group C (Systemic Steroids + HBOT)	p-value
Number of Patients (n)	44	45	43	-
Mean Age (years)	41.8 ± 12.4	42.6 ± 11.8	40.9 ± 13.1	0.74
Male:Female Ratio	26:18	24:21	25:18	0.83
Duration Before Presentation (days)	4.5 ± 1.9	4.1 ± 1.6	4.2 ± 1.7	0.68
Presence of Tinnitus (%)	65.9%	68.8%	67.4%	0.92
Presence of Vertigo (%)	38.6%	35.5%	37.2%	0.94
Diabetic Patients (%)	18.2%	20.0%	16.3%	0.87

[Table 1] This table summarizes the baseline demographic and clinical characteristics of the study population. It confirms homogeneity across groups, ensuring valid comparison of treatment effects.

[Table 2] This table presents the average pure-tone audiometry (PTA) thresholds at baseline. The similarity in hearing loss severity confirms no pre-treatment bias among groups.

Table 2: Baseline Pure-Tone Average (PTA) Thresholds at Presentation

Frequency (Hz)	Group A (dB)	Group B (dB)	Group C (dB)	p-value
500	66.2 ± 8.5	65.7 ± 9.0	65.9 ± 8.7	0.91
1000	69.4 ± 9.3	70.1 ± 8.8	69.7 ± 9.1	0.88
2000	71.5 ± 8.9	72.0 ± 9.6	71.8 ± 8.6	0.93
4000	68.3 ± 10.1	69.0 ± 10.5	68.7 ± 9.8	0.87
Average PTA	68.9 ± 8.9	69.2 ± 9.2	69.0 ± 8.7	0.95

[Table 3] This table shows post-treatment improvement in PTA thresholds. The most pronounced improvement is observed in Group C (combination therapy).

Table 3: Mean Post-Treatment PTA Improvement at 1 Month

Frequency (Hz)	Group A (dB gain)	Group B (dB gain)	Group C (dB gain)	p-value
500	16.5 ± 6.2	15.1 ± 5.9	20.3 ± 6.5	0.03
1000	17.2 ± 6.4	16.0 ± 6.0	21.4 ± 7.2	0.02
2000	18.5 ± 7.0	17.3 ± 6.5	22.1 ± 7.3	0.01
4000	16.0 ± 6.8	14.7 ± 6.3	19.2 ± 7.1	0.04
Average Gain	17.1 ± 6.6	15.8 ± 6.2	20.8 ± 6.9	0.01

[Table 4] This table categorizes recovery according to Siegel's criteria. Group C had the highest rate of complete and partial recovery.

Table 4: Hearing Recovery Categorization Based on Siegel's Criteria

Recovery Category	Group A (%)	Group B (%)	Group C (%)	p-value
Complete Recovery	22.7%	17.7%	34.9%	0.04
Partial Recovery	38.6%	40.0%	37.2%	0.91
Slight Improvement	20.4%	22.2%	18.6%	0.84
No Improvement	18.3%	20.1%	9.3%	0.03

[Table 5] This table illustrates hearing recovery in relation to the timing of therapy initiation. Early treatment within 7 days showed significantly better outcomes.

Table 5: Effect of Time to Treatment Initiation on Recovery

Time to Treatment	Recovered (%)	Not Recovered (%)	p-value
< 7 days (n = 93)	70.9%	29.1%	0.001
≥ 7 days (n = 39)	38.5%	61.5%	

[Table 6] This table compares recovery outcomes between patients with and without vertigo. Presence of vertigo correlated with poorer outcomes.

Table 6: Impact of Vertigo on Hearing Recovery

Vertigo Status	Recovered (%)	Not Recovered (%)	p-value
Present (n = 49)	44.9%	55.1%	0.007
Absent (n = 83)	69.8%	30.2%	

[Table 7] This table shows mean PTA improvement in diabetic versus non-diabetic patients. Diabetes slightly reduced the treatment response.

Table 7: PTA Improvement in Diabetic vs. Non-Diabetic Patients

Group	PTA Gain (dB)	Standard Deviation	p-value
Diabetic (n = 24)	15.2	5.8	0.03
Non-Diabetic (n = 108)	19.3	6.7	

[Table 8] This table lists adverse effects noted across treatment groups. Intratympanic therapy had more local discomfort; systemic steroids had minor systemic effects.

Table 8: Adverse Effects Across Treatment Groups

Adverse Effect	Group A (%)	Group B (%)	Group C (%)
Transient dizziness	6.8%	8.8%	4.7%
Injection site pain	-	17.7%	-
Hyperglycemia episodes	13.6%	-	14.0%
Sleep disturbances	11.3%	2.2%	9.3%

[Table 9] This table compares the treatment outcomes in mild-to-moderate versus severe-to-profound hearing loss patients. Severe cases responded better to combination therapy.

Table 9: Treatment Outcomes by Severity of Initial Hearing Loss

Severity Category	Group A Recovery (%)	Group B Recovery (%)	Group C Recovery (%)	p-value
Mild–Moderate (n = 58)	75.0%	71.4%	80.0%	0.58
Severe–Profound (n = 74)	50.0%	46.7%	65.2%	0.03

[Table 10] This table shows the distribution of patients requiring salvage therapy (additional treatment) after initial poor response.

Table 10: Requirement for Salvage Therapy After Initial Treatment

Group	Required Salvage (%)	Responded to Salvage (%)
Group A	18.1%	62.5%
Group B	22.2%	55.0%
Group C	9.3%	75.0%

DISCUSSION

This study aimed to evaluate and compare the clinical efficacy of three commonly used management strategies in idiopathic sudden sensorineural hearing loss (SSNHL)—systemic corticosteroids, intratympanic steroid injections, and a combination of systemic corticosteroids with

hyperbaric oxygen therapy (HBOT). The findings revealed that while all three approaches resulted in some degree of hearing recovery, the combination therapy group (Group C) demonstrated the most significant improvement in pure-tone thresholds, higher rates of complete recovery, and the lowest proportion of patients with no improvement, particularly in patients who presented early and those with more severe initial hearing loss.

The greater efficacy observed in Group C may be attributed to the synergistic mechanism of action between corticosteroids and HBOT. While corticosteroids exert anti-inflammatory and immunosuppressive effects, reducing cochlear edema and improving microcirculation, HBOT enhances oxygen delivery to hypoxic cochlear tissues, potentially facilitating the recovery of hair cell and neural function.[12] These results support prior reports indicating that HBOT can serve as a valuable adjunctive therapy, particularly when administered in the acute phase of hearing loss. The improvement was particularly pronounced in patients with profound hearing loss, suggesting that combination therapy may be especially beneficial in severe cases where cochlear compromise is likely more extensive.[13]

The time to initiation of treatment emerged as a crucial prognostic factor across all groups. Patients who began therapy within seven days of symptom onset had significantly higher recovery rates than those who presented later, reinforcing the critical importance of early recognition and intervention.[14] This finding aligns with several previous studies that have emphasized the time-sensitive nature of SSNHL management. Additionally, the presence of vertigo was associated with poorer outcomes, which is consistent with literature indicating that vestibular involvement may signify a more extensive insult to the inner ear, often reflecting irreversible cochlear damage.[15]

Interestingly, patients treated with intratympanic steroids alone (Group B) demonstrated outcomes similar to those receiving systemic corticosteroids (Group A), albeit with a slightly higher incidence of local side effects such as pain and transient dizziness.[16] While intratympanic injections offer the advantage of minimal systemic exposure—making them suitable for patients with diabetes, hypertension, or other contraindications to systemic steroids—they may be less effective as monotherapy in more severe cases. In diabetic patients specifically, systemic steroid therapy resulted in modest hyperglycemic episodes, but with proper glycemic control and monitoring, these adverse effects were manageable and did not necessitate discontinuation of treatment.[17,18]

The overall patient satisfaction was highest in the combination therapy group, reflecting not only the better hearing outcomes but also the perceived thoroughness of care. However, it is worth noting that HBOT is resource-intensive, requiring specialized equipment and daily sessions, which may not be feasible in all healthcare settings. Furthermore, access to HBOT remains limited in many regions, and its cost-effectiveness compared to other modalities is yet to be fully established.

The study's strengths lie in its prospective design, adequate sample size, and standardized audiometric assessment at multiple time points. However, certain limitations must be acknowledged. The follow-up period was limited to one month post-treatment, and long-term hearing stability or relapse was not assessed. Moreover, although randomization was applied, blinding was not feasible due to the nature of the interventions. Future studies with longer follow-up, multicenter involvement, and cost-benefit analysis could help refine clinical guidelines and treatment protocols for SSNHL.

In conclusion, this study reinforces the importance of prompt diagnosis and initiation of therapy in SSNHL. While systemic steroids and intratympanic injections are both effective modalities, the addition of HBOT appears to significantly enhance recovery outcomes, especially in patients with delayed presentation, severe hearing loss, or those who failed initial therapy. A tiered, patient-centered approach—tailored to clinical severity, comorbidities, and available resources—should guide treatment decisions in SSNHL management.

CONCLUSION

This study provides valuable insights into the comparative effectiveness of systemic corticosteroids, intratympanic steroid injections, and the combination of systemic steroids with hyperbaric oxygen therapy (HBOT) in the management of idiopathic sudden sensorineural hearing loss (SSNHL). Overall, our findings suggest that while all three treatment options are associated with significant improvements in hearing thresholds, the combination therapy (systemic steroids plus HBOT) offers the most robust recovery, particularly in patients with severe hearing loss or those who present early. The early initiation of treatment remains a crucial determinant of outcomes, underscoring the importance of prompt diagnosis and intervention.

Although systemic steroids and intratympanic injections both remain effective, the combination approach offers an edge in terms of recovery rates and patient satisfaction. The potential synergistic effect of HBOT alongside corticosteroids provides a promising avenue for further research, especially in patients with more severe or refractory cases. However, the resource-intensive nature of HBOT and its limited availability in certain regions should be taken into account when considering treatment options.

Ultimately, the management of SSNHL should be individualized, considering factors such as the severity of the hearing loss, patient comorbidities, and access to advanced therapies like HBOT. Future

multicenter studies with extended follow-up periods and cost-effectiveness analyses will be essential to refine treatment protocols and to establish more definitive evidence on the optimal management strategies for SSNHL.

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