

An overview of remedial treatment for sudden hearing loss

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Abstract. In the acute phase of sudden hearing loss, in patients for whom two weeks of standardized treatment is ineffective or unsatisfactory, or patients for whom the condition has accumulated for more than three weeks, remedial treatment for about 1 week-1 month can be actively pursued to provide an opportunity for hearing recovery. The mainstay of remedial therapy is intratympanic and retro auricular hormone injections. If the disease has progressed beyond 6 weeks and there is still no significant improvement with local hormone injections, the overall efficacy of the treatment can be improved by a combination of Chinese and Western medicine, such as hyperbaric oxygen chambers, acupuncture, and massage (tui na). However, remedial treatments combining Chinese and Western medicine have not been standardized, and attention should be paid to the diagnosis and treatment during the remedial period.

Keywords: Sudden Hearing Loss, Remedial Treatment, Savage therapy

1. Introduction

Sudden hearing loss refers to sensorineural hearing impairment with at least two consecutive frequencies experiencing a decrease of more than 20dB within 72 hours. China's 2015 guidelines for sudden deafness recommend a 5-day systemic corticosteroid treatment during the acute phase (within 3 weeks) along with a 10-day therapy to improve hemorheology. An average improvement in hearing of less than 15dB after treatment is considered ineffective [1]. Approximately 30-60% of patients show no improvement after treatment [2, 3], necessitating extended treatment duration or remedial interventions [1]. A two-week systemic treatment lays the foundation for improving microcirculation in the body. Subsequently, the condition tends to stabilize, with fewer interfering self-healing factors, making it an opportune time to implement remedial measures [4]. This paper compiles information on remedial treatments for sudden hearing loss from the China National Knowledge Infrastructure and the Web of Science core journal databases in the past 20 years, aiming to serve as a reference for research on remedial treatment for sudden hearing loss.

2. Remedial Treatment for Sudden Hearing Loss

Different types of standard treatment plans are available for acute sudden hearing loss based on various hearing profiles. Cure rates for total deafness, high-frequency decline, and flat decline types are low. In

cases where standard treatment for two weeks is ineffective or unsatisfactory, or when the condition persists for more than three weeks, or when systemic corticosteroid treatment is not suitable, remedial treatment may be considered [1, 5]. Experiments by Zhong et al. [6] indicate an effective rate of over 62.5% for early use of remedial treatment in total deafness-type sudden hearing loss patients, compared to a standard treatment effective rate of only 33.3%. Early and proactive remedial treatment can suppress disease progression in patients with severe hearing loss. Both Chinese and American guidelines [1, 7] prioritize local steroid administration as the primary method for remedial treatment, focusing on intratympanic and retroauricular injections. Methods like tympanic membrane tube perfusion with micro-pump continuous drug delivery are less clinically used due to their complexity and numerous side effects. Approximately 20% - 61.9% [8, 9] of patients exhibit some improvement in hearing after about 1 week to 1 month of remedial treatment, with an average improvement in hearing levels of 18.08 - 24.30dB [10, 11]. However, numerous factors affect the prognosis of sudden hearing loss, potentially overestimating the actual effectiveness rate. Sudden deafness, as an otologic emergency, typically enters a stable phase 1-2 months after onset [11]. If it continues to significantly impact daily life, considering hearing aids, cochlear implants, or other devices may help maintain quality of life.

3. Remedial Treatment Methods for Sudden Hearing Loss

3.1. Local Steroid Administration

3.1.1. Intratympanic Steroid Therapy. Intratympanic Steroid Therapy (IST) is an invasive procedure wherein a physician performs a tympanic membrane puncture under endoscopy, injecting about 0.3ml to 0.5ml of medication into the middle ear cavity. Following the injection, the patient needs to lie with the affected ear upward for approximately 15 minutes to prevent swallowing and subsequent drug reflux through the Eustachian tube. IST achieves high drug concentration, bypasses the blood-labyrinth barrier, directly penetrates into the inner ear, binds with numerous corticosteroid receptors in the inner ear tissues, and exhibits anti-inflammatory, anti-swelling, immunosuppressive, and local microcirculation improvement effects. This approach prolongs drug action while significantly reducing systemic effects, presenting no apparent contraindications and accommodating a wide range of individuals [12]. Initially used extensively by Silverstein et al. [13] for conditions like Meniere's disease and sudden hearing loss, IST gradually evolved into the most classic method for remedial treatment of sudden hearing loss. Ho et al. [14] collected 39 sudden hearing loss cases, with 74% achieving hearing recovery of less than 30dB after systemic steroid therapy (SST) for 10 days. These cases were then divided into SST continuation group and IST group, where after 3 weeks, the IST group showed a 53.3% improvement in hearing compared to only 7.1% in the SST group. For patients with severe hearing impairment, approximately 76% show treatment ineffectiveness during the acute phase [15], yet achieve a 77.42% effective rate after IST administration [16, 17]. Brian et al. [10] observed a 41% improvement and an average hearing improvement of 24.3 dB in patients with failed sudden hearing loss SST after IST administration. Gianoli et al. [18] noted an average hearing improvement of 15.2 dB post-remedial treatment, while Sun et al. [19] clinically observed that only 19.4% of patients achieved a hearing improvement of greater than 15dB after remediation. However, IST involves frequent tympanic membrane punctures, increasing the risk of tympanic membrane perforation and infection, often resulting in symptoms like pain and dizziness. Moreover, it demands strict requirements regarding the operator's skills and the hospital's facility conditions, limiting its acceptance and making its widespread adoption challenging.

Dexamethasone, commonly known for its affordability, safety, and long-lasting effects, is readily absorbed by the cochlear vascular lining. Methylprednisolone, with better permeability through the round window membrane, exhibits quicker action and 1.7 times higher affinity to the inner ear corticosteroid receptors than dexamethasone, maintaining longer durations and higher concentrations with minimal systemic glucose impact [20]. Despite differing pharmacokinetics, both show no significant difference in efficacy [21]. Concerning concentration, clinical observations suggest that

steroid injections at higher than standard concentrations in the middle ear may accumulate better in tissues, potentially making higher-concentration steroid injections more suitable during the remedial period [22]. Chinese guidelines suggest injections every other day for 4-5 times during local administration [1], while American guidelines state that patients should receive a maximum of 3-4 injections, with intervals of 2-4 days per injection [7]. Yang et al. [23] noted that among 160 sudden hearing loss patients receiving IST with different time intervals, the daily injection and every-other-day injection groups showed better efficacy compared to the group receiving injections twice a week, implying that shorter intervals improve patient compliance and stabilize efficacy. However, Liu et al. [24], comparing the efficacy of the same steroid and treatment duration, found no significant difference in hearing recovery among groups receiving local injections every day, every two days, or every three days. Shortening the injection interval does not accelerate recovery or improve efficacy but rather increases costs and aggravates anxiety and fear [25]. Additionally, the US guidelines do not recommend continuing IST treatment beyond 6 weeks [7], as demonstrated by David et al. [26], showing that within 6 weeks of the disease course, 39% of sudden hearing loss patients exhibited a hearing improvement of at least 20 dB, while no significant improvement was observed after 6 weeks.

3.1.2. Retroauricular Steroid Injections. Retroauricular injections are performed subperiosteally in the mastoid process or at the midpoint of the retroauricular groove, penetrating the periosteum posteriorly before advancing approximately 1mm downward and forward to the bony surface behind the external auditory canal [27]. Both retroauricular injections and IST share similarities in rapid onset and low systemic circulation volume. However, they differ in pharmacokinetics [28]: IST directly avoids the blood-labyrinth barrier, resulting in higher peak concentrations at various time points compared to retroauricular injections. The specific mechanism of action for retroauricular injections remains unclear; it may enter the inner ear through various routes such as circulation, permeation, and cerebrospinal fluid [29], achieving shorter peak times in the sigmoid sinus and outer lymphatic fluid with a longer duration of action. While there's no significant difference in overall cure rates [16, 17], retroauricular injections show a more significant improvement in low-frequency hearing loss [30]. Jing et al. [31] found a significant improvement in low-frequency thresholds for patients with conventional treatments ineffective for more than 2 weeks with retroauricular methylprednisolone injections, possibly related to improving inner ear labyrinthine hydrops.

Retroauricular steroid injections serve as a feasible first-choice remedial treatment after standard therapies prove ineffective for mild low-frequency hearing loss, with broad prospects. This method has been listed as one of the local medication approaches in China's sudden hearing loss guidelines [1]. Its unique advantages include simplicity in operation, minimal requirements for equipment and technical expertise, high safety, and ease of promotion. Additionally, compared to IST's limited single-dose administration and susceptibility to reflux, retroauricular administration offers more stable and sustained effects, allowing for larger single doses, reducing the total number of doses, and achieving higher patient acceptance. Although very few patients might experience adverse reactions such as skin atrophy at the injection site, discontinuing the treatment leads to immediate recovery. This approach is less traumatic and causes mild discomfort compared to IST, ensuring higher safety. However, similar to IST, there's ongoing debate around retroauricular injections, with specific protocols adjusted based on the physician's experience, lacking standardization.

3.2. Hyperbaric Oxygen Therapy (HBOT)

The internal auditory artery serves as the sole supplier of blood to the inner ear without collateral circulation. Blood supply to the cochlea is extremely limited, with poor compensatory circulation. Cochlear hair cells have high oxygen consumption and low tolerance to hypoxia [32]. HBOT involves placing patients in a specially designed chamber filled with 100% oxygen and treating them at 1-3 atmospheres for 60-120 minutes. Under 100% oxygen at 3 atmospheres, arterial blood oxygen concentration increases by 6.6-6.8 ml/100 ml, and plasma pressure rises to 2000 mmHg [32]. This rapid elevation in blood oxygen pressure improves blood supply, enhances red blood cell elasticity, reduces

blood viscosity to improve microcirculation, and simultaneously mitigates inner ear inflammation and labyrinth hydrops, lowers vagus nerve excitability, relieves vascular spasm, and alleviates stress [33].

HBOT exhibits overall high safety, with severe adverse reactions being rare. The European consensus conference on hyperbaric medicine in 2016 strongly recommended HBOT as a treatment for this condition [34], and similarly, US guidelines clearly state HBOT can be a salvage treatment for sudden hearing loss within one month of onset [7]. When used in conjunction with other remedial measures, HBOT achieves improvement rates of 59.7-86.67% [32]. However, it cannot rule out spontaneous recovery, mixed effects with steroids, and varying or contradictory conclusions from different clinical studies, leading to substantial debate over its efficacy. For instance, Jiang et al. [35] found that using HBOT as a remedial treatment for refractory high-frequency sudden hearing loss patients did not significantly improve impaired hearing levels, even showing no significant difference compared to the group that did not receive remedial treatment. Similarly, Yeji et al. [36] suggested that in patients with severe hearing loss, cochlear hair cells might suffer irreversible damage, and HBOT only accelerates recovery in patients with hearing loss below 80dB. Conversely, Jakov et al. [37] indicated significant improvement in prognosis for sudden hearing loss patients with hearing loss >61dB post-HBOT, demonstrating considerable effectiveness for remedying severe hearing injuries like complete frequency hearing loss. Moreover, the optimal frequency of HBOT depends on the severity and duration of symptoms and the response to treatment. To maintain adequate blood oxygen levels, each HBOT session is lengthy, with a treatment duration of up to several dozen times, totaling at least 1200 minutes [32]. It is time-consuming, expensive, demands high patient cooperation, and is challenging to widely implement due to its hardware requirements and treatment demands.

3.3. Traditional Chinese Medicine (TCM) Treatment

3.3.1.1. Oral Chinese Herbal Medicine. Sudden deafness falls within the TCM category of “sudden deafness,” (暴聋) first mentioned in the “Su Wen: Jue Lun” (《素问·厥论》): “When the Shaoyang pulse is in excess, sudden deafness occurs.” (少阳之厥则暴聋) The ear is a clear opening and the gathering point of the main vessels. The ear channels are narrow, with small branches prone to stasis and congestion. The “Zheng Zhi Zun Sheng” (《证治准绳》) notes, “Sudden deafness is closely linked to the separation of Yin and Yang, and the channels are almost open but not fully connected; the channels desire to flow but are obstructed.” (暴聋之病,与阴阳隔绝之未甚,经脉欲行而未通) The critical pathological mechanism for sudden deafness is Qi and blood stasis, persisting throughout the disease process. Over time, Qi and blood congeal, exacerbating stasis and deeply affecting the channels [38]. It presents patterns such as Qi stagnation, Qi deficiency, Yang deficiency, Kidney deficiency with blood stasis, and phlegm-stasis obstructing the channels. Based on formulas like Tong Qiao Huo Xue Tang and Tong Qi San, Chinese herbal medicine flexibly combines Qi-tonifying, Yang-augmenting, Kidney-tonifying, and phlegm-dispelling medicines to enhance hearing while improving overall symptoms. Dong et al. [39], applying the principle of opening channels, treated sudden deafness patients with poor initial efficacy or missed optimal diagnosis and treatment times using a combination of kidney-tonifying and channel-opening Huo Xue Tang, achieving an overall effective rate of 76.47%. They highlighted the necessity of re-treatment in the later stages of sudden deafness. Professor Xiong Da Jing proposed that in the later stages of sudden deafness, the primary pathological mechanism is liver-wood stagnation, where the liver Qi doesn’t reach, blood circulation is impeded, and Qi and blood stasis occur in the ear, leading to auditory failure. Thus, the fundamental treatment principle is to soothe the liver, regulate Qi, and unblock channels [40]. Lian et al. [3], focusing on liver treatment, used a formula to clear liver heat and dispel blood stasis in the standard systemic medication for patients with liver yang hyperactivity-type sudden deafness showing inefficacy after 2 weeks. They administered one dose daily and found an efficacy rate of 84.85% in the Chinese medicine group, superior to the pure Western medicine group (33.3%). Therefore, in the later stages of sudden deafness, the emphasis is on the liver, utilizing “opening” as the general treatment principle, with blood-activating and stasis-dispelling to unblock channels being the primary therapeutic methods [40].

3.3.2. Acupuncture Treatment. “Zheng Zhi Zun Sheng” states: “In cases of sudden deafness, many involve channels that are about to open but remain blocked.” Clinically, the proximal acupoints of Tinggong, Tinghui, Ermen, Yifeng, Migen, and Wangu are selected, while distal acupoints are chosen based on the specific diagnosis. The efficacy of acupuncture during the remedial phase is approximately 47.1% [41]. As the nerves and blood vessels around the ears are numerous, a shallow insertion of approximately 15-25mm is generally preferred, without rotation or vigorous manipulation. Bao et al. [42] discovered that deep needling at various ear acupoints in sudden deafness patients was more effective than shallow needling, suggesting increasing the needle depth to 35-40mm during remedial treatment to enhance stimulation. This helps alleviate a highly coagulated state of blood, enhances auditory nerve excitability, and modulates inflammatory responses. However, precise needle manipulation around the ear requires considerable skill, as deep needling may approach the internal jugular vein and should not be blindly attempted.

When basic acupuncture is combined with electroacupuncture, the dual stimulation of electric current and acupoints induces rhythmic contractions in ear and neck muscles. This improves blood flow dynamics, relieves ischemia and hypoxia, accelerates the absorption of inflammatory substances, and promotes the healing of damaged auditory nerves [43]. Different physiological effects are triggered by parameters like waveforms and frequencies, activating different brain regions, resulting in varied therapeutic effects. Wang et al. [44] found that alternating frequencies avoid long-term tolerance, while Jiang et al. [43] compared frequency parameters and found that 2Hz/50Hz sparse-dense waves from electroacupuncture promoted the generation and release of multiple substances, affecting a broader brain area and optimizing effects on blood circulation and reducing edema. Hence, this frequency combination is recommended during the remedial phase.

Hearing is a crucial sensory function, and sudden loss can have a tremendous impact on individuals. In cases of stubborn conditions or poor treatment efficacy, patients are more prone to developing negative emotions like anger and restlessness. During the remedial phase, besides monitoring changes in patients' hearing, assessing their mental state and providing personalized psychological counseling are essential. Acupuncture treatment can alter the body's neurochemical environment and endocrine levels, effectively improving sleep quality, stabilizing emotions, and regulating psychological states [45].

3.3.3. Moxibustion Treatment

The “Bei Ji Qian Jin Yao Fang” (《备急千金要方》) records: “Shaoyang governs the wind-induced deafness in the ear. Insert a needle, leave it for a breath, and perform three moxibustion stimulations.” (商阳主耳中风聋鸣, 刺入一分, 留一呼, 灸三壮) “Jing Yue Quan Shu” (《景岳全书》) states that “wind-induced deafness” should be treated with “Shang Xing” and moxibustion twice with seven stimulations each. (风聋“宜“上星, 灸二七壮) “Wai Tai Mi Yao” (《外台秘要》) innovatively adopts direct moxibustion in the ear canal: “Soak Fructus Eugeniae and Radix Aconiti preparata in water until soft, insert a pointed end into the ear, and perform fourteen stimulations, allowing the Qi to flow through the ear.” (将八角、附子用水浸酥后, 一头削尖置入耳中, 再灸十四壮, 令气通耳中。) Moxibustion can locally warm the area, increase blood flow at the lesion site, enhance parasympathetic activity, improve blood circulation, and achieve the effects of promoting Qi movement and improving blood circulation. However, in current literature, remedial moxibustion treatments are mostly based on individual cases. Moxibustion is seldom used as a standalone remedy. For instance, in a case report by Hee et al. [46], a patient who had undergone seven rounds of ineffective corticosteroid treatment showed significant improvement in hearing and speech recognition after a combined therapy of acupuncture and moxibustion. Similarly, Fan [47] treated a sudden deafness patient who had received continuous medication and high-pressure oxygen treatment for a month without improvement. After only three courses of acupuncture combined with moxibustion, all symptoms were alleviated. Zhu [48] treated a patient with sudden deafness for two months by suspending moxibustion at various acupoints such as Shangxing, Tinggong, Sidù, Zúsānyì, and Zú Sānlǐ for about 10 minutes each, once daily for two weeks, and improved the average hearing threshold from 100dB to 80dB. In reality, it is challenging to

completely remedy hearing back to its initial level using a single treatment method. For patients with no improvement from conventional or singular therapies, moxibustion, being safe, cost-effective, and easy to perform, in combination with other treatments, can enhance overall efficacy.

4. Discussion

In cases where standardized treatment for two weeks in the acute phase is ineffective or unsatisfactory, or when the disease has lasted more than three weeks, initiating remedial treatment lasting about one week to one month can further restore hearing based on the initial treatment's efficacy. Remedial treatments primarily involve intratympanic and postauricular steroid injections, with no significant differences between the two. Medications can be administered every 1-3 days, with a treatment duration of 3-5 times. If local steroid injections do not significantly improve the condition after a total course exceeding six weeks, patients can undergo hyperbaric oxygen chamber treatment. Although not the primary treatment choice, hyperbaric oxygen chamber treatment is a strongly recommended remedial measure. By continuously increasing the stimulus, it offers a possibility of salvaging hearing in the later stages of the disease. Traditional Chinese Medicine believes that long-standing sudden deafness is challenging to treat, with the basic pathological mechanism being liver-wood stagnation and Qi and blood stasis. The treatment principle emphasizes promoting Qi movement and blood circulation, and combination therapies such as acupuncture, tuina, and other external TCM treatments can improve overall efficacy.

5. Conclusion

Sudden deafness progresses rapidly, and missing the optimal treatment time or initial ineffective treatment may lead to lifelong hearing disabilities. Recent guidelines and clinical studies have discovered that combined Chinese and Western remedial treatments offer the possibility of restoring hearing to patients, warranting increased attention and promotion. However, current remedial treatment measures lack standardization, exhibit significant individual differences in efficacy, and often combine multiple approaches during the remedial phase. The practical effectiveness and mechanism of a singular remedial treatment method remain unclear, emphasizing the urgent need for more high-quality, multicenter clinical studies integrating both Chinese and Western medicine.

References

- [1] Yu Lisheng, Yang Shiming. Diagnosis and treatment guidelines for sudden deafness (2015) [J]. Chinese Journal of Otorhinolaryngology Head and Neck Surgery, 2015, 50(06): 443-7.
- [2] Pezzoli M, Magnano M, Maffi L, et al. Hyperbaric oxygen therapy as salvage treatment for sudden sensorineural hearing loss: a prospective controlled study [J]. European Archives of Oto-Rhino-Laryngology, 2015, 272(7): 1659-66.
- [3] Lian Haihong. Clinical observation of clearing liver, heat, and stasis prescription in treating refractory sudden sensorineural hearing loss [J]. Chinese Journal of Clinical Physicians, 2017, 45(04): 103-5.
- [4] Liu Yangyun, Zhang Caixia, Cao Hang, et al. Salvage therapy timing for sudden deafness [J]. Journal of Clinical Otorhinolaryngology Head and Neck Surgery, 2015, 29(08): 719-22.
- [5] Battaglia A, Burchette R, Cueva R. Combination therapy (intratympanic dexamethasone + high-dose prednisone taper) for the treatment of idiopathic sudden sensorineural hearing loss [J]. Otolaryngology - Head and Neck Surgery, 2008, 29(4): 453-60.
- [6] Zhong Zhun, Guo Yunfang, Lei Wen, et al. Efficacy observation of early intratympanic methylprednisolone injection or hyperbaric oxygen in patients with profound sudden sensorineural hearing loss [J]. Journal of Audiology and Speech Pathology, 2021, 29(01): 51-3.
- [7] Chandrasekhar SS, Tsai Do BS, Schwartz SR, et al. Clinical Practice Guideline: Sudden Hearing Loss (Update) Executive Summary [J]. Otolaryngology-Head and Neck Surgery, 2019, 161(2): 195-210.

- [8] Miao Yingzhang, Wei Xin, Song Xiaofei, et al. Comparative study of methylprednisolone intratympanic and retroauricular injection in treating refractory sudden sensorineural hearing loss [J]. *Hebei Medicine*, 2015, 37(24): 3732-4.
- [9] Li Huiqing, He Wenping, Jian Lijuan. Analysis of the therapeutic effect of methylprednisolone tympanic injection in refractory sudden sensorineural hearing loss [J]. *Ningxia Medical Journal*, 2018, 40(02): 153-5.
- [10] Herr BD, Marzo SJ. Intratympanic steroid perfusion for refractory sudden sensorineural hearing loss [J]. *Otolaryngology-Head and Neck Surgery*, 2005, 132(4): 527-31.
- [11] Zhang Yu, Gao Zhong, Liu Yajun, et al. Clinical analysis of intratympanic methylprednisolone rescue treatment for profound sudden deafness [J]. *Chinese Journal of Otorhinolaryngology Skull Base Surgery*, 2017, 23(04): 370-3.
- [12] Jiang Hong, Peng Bingxin, Ma Qiuyan, et al. Research progress on new dosage forms for intratympanic drug administration [J]. *Chinese Journal of Otolaryngology*, 2020, 18(02): 399-403.
- [13] Silverstein H, Choo D, Rosenberg SI, et al. Intratympanic steroid treatment of inner ear disease and tinnitus (preliminary report) [J]. *Ear, Nose & Throat Journal*, 1996, 75(8): 468-71, 74, 76 passim.
- [14] Ho HG, Lin HC, Shu MT, et al. Effectiveness of intratympanic dexamethasone injection in sudden-deafness patients as salvage treatment [J]. *The Laryngoscope*, 2004, 114(7): 1184-9.
- [15] Wilson WR, Byl FM, Laird N. The efficacy of steroids in the treatment of idiopathic sudden hearing loss. A double-blind clinical study [J]. *Archives of Otolaryngology*, 1980, 106(12): 772-6.
- [16] Hou Jiabin, Han Chunji, Liu Di, et al. Meta-analysis of application of glucocorticoids in intratympanic and retroauricular regions for sudden deafness [J]. *Chinese Journal of Otolaryngology*, 2021, 19(05): 747-52.
- [17] Zhai Pu. Comparative study on the efficacy of methylprednisolone rescue treatment for severe sudden deafness by different regional injections [J]. *Medical Theory and Practice*, 2021, 34(17): 3031-3.
- [18] Gianoli GJ, Li JC. Transtympanic steroids for treatment of sudden hearing loss [J]. *Otolaryngology-Head and Neck Surgery*, 2001, 125(3): 142-6.
- [19] Sun Hongcun, Jiang Wenbo, Qiu Xiaowen, et al. Application value of steroid intratympanic injection and hyperbaric oxygen in refractory high-frequency sudden sensorineural hearing loss treatment [J]. *Chinese Journal of Otorhinolaryngology Head and Neck Surgery*, 2018, 25(04): 211-3.
- [20] Wang Ya, Ma Yongming, Wang Yue, et al. Clinical efficacy and prognostic factors analysis of intratympanic methylprednisolone injection in different types of sudden deafness [J]. *Chinese Journal of Otorhinolaryngology Head and Neck Surgery*, 2018, 25(04): 207-10.
- [21] Suzuki H, Mori T, Hashida K, et al. Prediction model for hearing outcome in patients with idiopathic sudden sensorineural hearing loss [J]. *European Archives of Oto-Rhino-Laryngology*, 2011, 268(4): 497-500.
- [22] Fu Y, Zhao H, Zhang T, et al. Intratympanic dexamethasone as initial therapy for idiopathic sudden sensorineural hearing loss: Clinical evaluation and laboratory investigation [J]. *Auris Nasus Larynx*, 2011, 38(2): 165-71.
- [23] Yang Pingli, Zhang Zhiping. Clinical study of different time interval intratympanic dexamethasone infusion in treating sudden deafness [J]. *Journal of Clinical Otorhinolaryngology Head and Neck Surgery*, 2017, 31(11): 822-4.
- [24] Liu Dan, Zhang Yubo, Shan Chunguang, et al. Efficacy of different frequency retroauricular methylprednisolone injections in the treatment of sudden deafness [J]. *Journal of Audiology and Speech Pathology*, 2020, 28(01): 43-6.
- [25] Andrianakis A, Moser U, Kiss P, et al. Comparison of two different intratympanic corticosteroid injection protocols as salvage treatments for idiopathic sudden sensorineural hearing loss [J]. *European Archives of Oto-Rhino-Laryngology*, 2022, 279(2): 609-18.

- [26] Haynes DS, O'Malley M, Cohen S, et al. Intratympanic dexamethasone for sudden sensorineural hearing loss after failure of systemic therapy [J]. *The Laryngoscope*, 2007, 117(1): 3-15.
- [27] Jia Hongguang, Yu Zhan, Huang Xiaobing. Retroauricular injection of methylprednisolone sodium succinate combined with conventional drugs in the treatment of severe sudden deafness [J]. *Chinese Journal of Otorhinolaryngology Head and Neck Surgery*, 2016, 23(02): 69-72.
- [28] Shi Jiao, Han Lin, Li Jingjing, et al. Experimental observation of drug concentration in external lymphatic fluid after retroauricular and intratympanic drug administration [J]. *Chinese Journal of Otolaryngology*, 2016, 14(04): 540-4.
- [29] Li Xinqian, Wang Weihua, Ma Zhaoxin. Basic and clinical research on corticosteroid retroauricular injection in the treatment of sudden deafness [J]. *International Journal of Otorhinolaryngology Head and Neck Surgery*, 2018, 42(06): 345-8.
- [30] Zhao Qun, Wang Yingli, Wang Hongqin, et al. Clinical study of retroauricular methylprednisolone injection in the treatment of sudden deafness [J]. *Chinese Journal of Otolaryngology*, 2015, 13(04): 712-4.
- [31] Jing Yuanyuan, Yu Lisheng, Ma Xin, et al. Efficacy analysis of retroauricular methylprednisolone injection in refractory sudden sensorineural hearing loss [J]. *Chinese Journal of Otolaryngology*, 2014, 12(03): 452-4.
- [32] Olex-Zarychta D. Hyperbaric Oxygenation as Adjunctive Therapy in the Treatment of Sudden Sensorineural Hearing Loss [J]. *International Journal of Molecular Sciences*, 2020, 21(22).
- [33] Shi Dazhi, Tan Juan, Luo Qin, et al. Efficacy and course selection of hyperbaric oxygen in the treatment of sudden deafness [J]. *Journal of Audiology and Speech Pathology*, 2019, 27(04): 395-7.
- [34] Mathieu D, Marroni A, Kot J. Tenth European Consensus Conference on Hyperbaric Medicine: recommendations for accepted and non-accepted clinical indications and practice of hyperbaric oxygen treatment [J]. *Diving and Hyperbaric Medicine*, 2017, 47(1): 24-32.
- [35] Jiang Tao, Sun Hongcun, Hu Jiandao. Application value of hyperbaric oxygen in the treatment of refractory high-frequency sudden sensorineural hearing loss [J]. *Modern Practical Medicine*, 2019, 31(10): 1358-60.
- [36] Ahn Y, Seo YJ, Lee YS. The Effectiveness of Hyperbaric Oxygen Therapy in Severe Idiopathic Sudden Sensorineural Hearing Loss [J]. *Journal of International Advanced Otolaryngology*, 2021, 17(3): 215-20.
- [37] Ajduk J, Ries M, Trotic R, et al. Hyperbaric Oxygen Therapy as Salvage Therapy for Sudden Sensorineural Hearing Loss [J]. *Journal of International Advanced Otolaryngology*, 2017, 13(1): 61-4.
- [38] Wu Yiling. Features and pathogenesis of turbidity disease [J]. *Journal of Intractable Diseases*, 2004, (05): 282-4.
- [39] Dong Guohua, Ren Dengxiao. Clinical efficacy of integrated traditional Chinese and Western medicine in late re-treatment of sudden deafness [J]. *Chinese Journal of Metallurgical Industry Medicine*, 2014, 31(04): 467-8.
- [40] Tian Yuanyuan, Deng Yuanyuan, Man Yinhuan, et al. Professor Xiong Da's treatment of late sudden deafness from the perspective of liver [J]. *Sichuan Traditional Chinese Medicine*, 2014, 32(06): 15-7.
- [41] Yin CS, Park HJ, Nam HJ. Acupuncture for refractory cases of sudden sensorineural hearing loss [J]. *Journal of Alternative and Complementary Medicine*, 2010, 16(9): 973-8.
- [42] Bao Jie, Wang Ying. Treatment of 64 cases of sudden deafness with deep needling at San Cunhao points around the ear [J]. *Famous Doctors*, 2018, (09): 126-7.
- [43] Jiang Siyuan, Hou Wenzhen, Ni Guangxia, et al. Effect of different electrical acupuncture stimulation parameters on clinical efficacy of sudden sensorineural hearing loss [J]. *Chinese Acupuncture*, 2021, 41(10): 1103-7.

- [44] Wang Dongyan, Yang Huinan. Observation on the efficacy of different waveform electroacupuncture in the treatment of sudden sensorineural hearing loss [J]. Journal of Clinical Acupuncture, 2017, 33(01): 24-7.
- [45] Zhang Wanrong, Cai Weiwei, Liang Jiangang, et al. Effect of acupuncture therapy on the quality of life and anxiety-depression status of sudden deafness patients [J]. Chinese Journal of Otolaryngology, 2020, 18(06): 1060-5.
- [46] Kim MH, Kim BH, Kang M, et al. Delayed recovery of pediatric sudden sensorineural hearing loss treated with acupuncture: A case report [J]. Medicine (Baltimore), 2018, 97(51): e13742.
- [47] Fan Yushan, Zhao Caijiao, Yang Jianhua, et al. Slow twirling needle combined with moxibustion for sudden deafness [J]. Liaoning Journal of Traditional Chinese Medicine, 2011, 38(08): 1636-7.
- [48] Zhu Wenlian. Case of sudden deafness after a long day [J]. Chinese Acupuncture, 2012, 32(09): 793.