Anesthesia and Medical Practice Journal

Yu JH, et al. Anesth Med Pract J 6: 143.

www.doi.org/10.29011/2637-9953.100143

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Research Article

Efficacy and Prognosis of Ultrasound-guided Stellate Ganglion Block in the Treatment of Idiopathic Sudden Sensorineural Hearing Loss

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Citation: Yu J, Zhen D, Xiaoqiong X, Yalan Z, Meifeng L, et al. (2023) Efficacy and Prognosis of Ultrasound-guided Stellate Ganglion Block in the Treatment of Idiopathic Sudden Sensorineural Hearing Loss. Anesth Med Pract J 6: 143. DOI: https://doi.org/10.29011/2637-9953.100143

Received Date: 16 October, 2023**; Accepted Date:** 23 October, 2023**; Published Date:** 26 October, 2023

Abstract

Objective: To assess the efficacy of the combination of ultrasound-guided stellate ganglion block (SGB) and pharmacological treatment in patients with idiopathic sudden sensorineural hearing loss (ISSNHL) and define patients amenable for SGB combined with pharmacological therapy. **Methods:** Prospective, randomized, trial involving 50 cases with unilateral ISSNHL that were randomly divided into 2 groups: the pharmacological treatment (P) group and SGB+ pharmacological treatment (HBO+P) group, which received additional SGB for 10 days besides the pharmacological treatments. Pure tone audiometry gain larger than 15 dBHL was defined as effective, the total effective rate and prognosis of the two groups were calculated. **Results:** The total effective rates of the two groups were 40% and 72% ($P < 0.05$). The hearing of both groups was improved, compared with the prognosis, after 6 months of treatment, the neutrophil count, lymphocyte count and neutrophil / lymphocyte ratio (NLR) of the two groups were improved, the difference was statistically significant ($P<0.05$), but the prognosis of SGB + P group was better than that of P group. In addition, the effective rate of patients with moderate hearing loss, age ≤ 50 years or without dizziness / vertigo in SGB + P group was higher than that in severe hearing loss, age > 50 years or with dizziness / vertigo ($P<0.05$). **Conclusion:** Ultrasound guided stellate ganglion block combined with pharmacological treatment has better curative effect on hearing recovery than pharmacological therapy alone, and the prognosis is faster, and it is more amenable for patients with moderate hearing loss, age ≤ 50 years or without dizziness / vertigo.

Keyword: Ultrasound; Stellate ganglion block; Idiopathic sudden sensorineural hearing loss; Prognosis

Introduction

Idiopathic sudden sensorineural hearing loss (ISSNHL) is a kind of all or part of hearing loss in a short amount of time due to the characteristics of the disease. Its pathogenesis is not fully understood. The mechanism of ISSNHL includes inner ear microcirculation disturbance, virus infection, labyrinthine window rupture, immune mechanisms, and abnormal cochlear stress reactions.

According to its pathogenesis, there are several traditional

treatment methods: 1. Glucocorticoid therapy, which is the only recognized effective treatment; 2. Spontaneous remission, 3. Steroid hormone therapy, and 4. Combined treatment with vasodilator and hyperbaric oxygen. In the late 70 s, some people thought that inner ear microcirculation disturbance could be the main pathophysiology of ISSNHL [1,2] because arteriae labyrinthi is the only arterial blood supply of the inner ear, and the characteristics of the inner ear system are a slender pipe diameter, walk path winding circuity, hemodynamic change, and easy blood supply conditions. Blood supply disorders of the inner ear can lead to blood supply disorders of the spiral ganglion, cochlear neurons and auditory hair cells, resulting in nutritional deficiency, further causing atrophy, degeneration and necrosis of functional cells and finally leading to a decline in sentosensory function [3]. The postganglionic fibers of the superior cervical ganglion are distributed throughout the cochlear artery, and the sympathetic nerve fibers project to the superior cervical ganglion through the extension of the left and right stellate ganglion. Therefore, as long as the stellate ganglion is completely blocked, inner ear microcirculation disorders can be improved [4]. Therefore, stellate ganglion block (SGB Stellate Ganglion Block) has become a new option for the treatment of ISSNHL. An increasing number of studies have shown that the curative effect of SGB in treating ISSNHL is improved compared with traditional methods, but SGB treatment blind agents easily cause blood vessel and nerve damage, leading to many complications and poor prognosis.

In recent years, along with ultrasonic visualization and the rapid development of nerve block techniques, SGB has been used to treat ISSNHL and has gradually come to the attention of clinical workers. Under the guidance of ultrasound, the blood vessels can be clearly seen so that damage to nerves and blood vessels can be avoided. However, at the moment of drug combination, the curative effect and prognosis of SGB ISSNHL have rarely been reported. Therefore, this study intends to explore the combined effect of ultrasound guided by SGB on ISSNHL drug treatment and prognosis and to ensure that it can be beneficial to the treatment of patients with SGB.

Data and Methods

General Information: This study was approved by the Ethics Committee of Chaohu Hospital Affiliated with Anhui Medical University, and all methods were conducted in accordance with the relevant guidelines and regulations. Informed written consent was given to all patients. From May 2019 to February 2020 in Chaohu Hospital affiliated with the An Hui Medical University ear, nose and throat department, a total of 78 patients with head and neck surgery ISSNHL agreed to participate, and 54 patients were included. Of the 54 participants included, four dropped out of the study. The reasons for dropping out of the study were either loss of contact or incomplete treatment. Overall, 50 participants completed the study. The inclusion criteria were in accordance with the Chinese medical association otolaryngology head and neck surgery branch of the guidelines on the diagnosis of ISSNHL standard [5] and were as follows; (1) age >18 years old, duration ≤14 days; and (2) unilateral disease. The exclusion criteria were as follows: (1) Patients with hemorrhagic diseases, cardiovascular and cerebrovascular diseases or liver and kidney insufficiency; (2) Pregnant or lactating women; (3) Allergic to drugs or poor compliance with treatment and follow-up; and (4) Sound transduction, vestibular function test, head MRI and other indications of organic lesions. Patients were divided into the drug therapy group (group P) and the SGB+ drug therapy group (group SGB+P) by the random number table method.

Methods: All patients received pure tone audiometry and speech-evoked auditory brainstem responses. To rule out the possibility of cerebellar horn tumors, magnetic resonance imaging was performed in patients with a pathologic auditory brainstem-evoked response or severe to severe hearing loss. The average hearing threshold values of six frequencies (250, 500, 1000, 2000, 4000 and 8000 Hz) were recorded as PureToneAverage (PTA). According to the WHO international standard, the patients were divided into four grades of hearing impairment: PTA≤40 dBHL, mild;40 dBHL<pta≤70dbhl, moderate;70dbhl<pta≤90dbhl,="" severe;pta="">90 dBHL, extremely severe. Group P received oral prednisone (30 mg/day for 5 consecutive days, with the dose then being reduced by 10 mg/day after 5 days); flunarizine tablets (5 mg/day for 10 days); vitamin A (25000 IU/day for 10 days); vitamin E (0.1 g/day for 10 days); vitamin B1 intramuscular injection (2 ml every other day for 10 days); mouse nerve growth factor (18 μg/day for 10 days); and intravenous mecobalamine (1 ml/day for 10 days). The SGB+P group received the same drug treatment as group P, but with the addition of SGB therapy.

Noninvasive blood pressure, electrocardiogram, and blood oxygen saturation were routinely monitored. Patients were supine on the operating table, with thin pillows under the shoulders, and the head was tilt back with the mouth opened to slightly to relax the neck muscles. The area was sterilized and covered with sterile towel. Ultrasonic guidance was performed using a MicroMaxx color Doppler ultrasound instrument (SonoSite, USA). First, the base of the transverse process of C6 was located, and a horizontal axis view of the neck was obtained at the level of C6. Anatomical structures such as the common carotid artery, internal jugular vein, thyroid, trachea, esophagus, longus cervical muscle, C6 nerve root and C6 transverse process were identified. An in-plane injection was then applied through the anterior cervical fascia and was stopped when the tip reached the anterior cervical longus muscle. The criteria for the success of SGB were the presence of Horner syndrome on the injection side. The criteria for Horner syndrome were ptosis on the block side, pupil size reduction, facial

vasodilation (redness, elevated skin temperature, nasal congestion, etc). Blood and cerebrospinal fluid were determined to be absent. Seven milliliters of 1% lidocaine was injected slowly. A successful SGB operation was further confirmed by observing the diffusion of local anesthetics in the longus cervical muscle and the expansion of the prevertebral fascia. Patients should be closely observed during treatment. If adverse reactions occur in a patient and there is no improvement after symptomatic treatment, the treatment should be stopped immediately. Both groups were treated once a day for a total of 10 times. Pure tone audiometry was performed 10 days after the start of treatment. The trial was double-blind; that is, the treating physician knew about the grouping, and the audiologist did not. All patients were examined by the same audiologist in the same soundproof room with the same pure tone audiometer before and after treatment. The pure-tone mean hearing threshold (PTA) of the two groups was recorded before treatment, 10 days after treatment and 6 months after treatment. Peripheral venous blood was collected before treatment and 6 months after treatment to monitor neutrophil count, lymphocyte count and neutrophil/lymphocyte ratio in routine blood. The average pure tone hearing threshold, clinical efficacy and prognosis were compared between the two groups before and after treatment, and patients who could benefit from a stellate ganglion block were identified.

Observation index: The curative effect evaluation was [5] in reference to the Chinese journal of otolaryngology head and neck surgery and the Chinese medical association otolaryngology head and neck surgery branch of the curative effect of ISSNHL standard and the categories were as follows: Healed: damage frequency of hearing recovery to normal or healthy ear level, or up to levels before the disease; Obvious effect: the average hearing threshold of damaged frequency increased by more than 30 dBHL; Effective: the average hearing threshold of damaged frequency increased between 15~30 dBHL; and Ineffective: the average hearing threshold of damaged frequency was improved below 15 dBHL. Total effective rate = (number of cured + significant + effective number)/total number of cases ×100%. Prognosis: The neutrophil/lymphocyte ratio (NLR) was used to judge the prognosis of ISSNHL: the lower the NLR, the lower the level of inflammation and the better the prognosis.

Statistical methods: SPSS22.0 statistical software was used for analysis. Normally distributed measurement data were expressed as the mean ± standard deviation（`x±s) and were compared with group t test for comparisons between the groups, the single factor analysis of variance was used for group comparison, and the SNK - q test was used for comparing two groups. The count data were expressed as the adoption rate (%) and were compared using the□2 test, with the difference being statistically significant at $P < 0.05$.

Results

There was no statistically significant difference between the two groups in sex, age, course of disease, ear side, dizziness/vertigo or other general information, as shown in (Table 1).

group	Gender （n）		Age (years)	Course of disease (days)	Side（n）		Dizziness/vertigo（n）
	male	female			left	right	
Group P(n=25)	13	12	42.84±9.52	6.72±3.09	10	15	6
Group SGB+P（n=25）	15	10	45.32±10.03	6.16±2.61	9	16	10
t/□^{2}	0.325		0.896	0.692	0.085		1.471
P	0.569		0.375	0.492	0.771		0.225

Table 1: Comparison of the two groups of patients with general data **(□x□s).**

The changes in the average hearing threshold of the two groups before and after treatment were as follows: there was no statistical significance between the two groups before treatment (P>0.05). After 10 days of treatment and 6 months after treatment, the mean threshold of hearing in the 2 groups was lower than that before treatment, and the difference was statistically significant (P<0.05). The threshold in the SGB+P group was lower than that in the P group, and the difference between the 2 groups was also statistically significant (P<0.05). However, there was no significant difference between the two groups in the average hearing threshold 6 months after treatment and 10 days after treatment (P>0.05), as shown in (Table 2).

Group/mean threshold of hearing	pretreatment	After 10 days of treatment	3 months after treatment
Group P	67.64±10.55	51.24±11.36[a]	52.52±14.45[a]
Group SGB+P	64.48±11.22	42.72±10.66[ab]	43.60±15.02[ab]
Note: Compared with before treatment, [a]*P*<0.05, compared with the P group, [b]*P*<0.05.			

Table 2: The pure tone average threshold comparison in the two groups of patients before and after treatment of（x±s).

Clinical efficacy of patients in the two groups: In the SGB+P group, 72% (18/25) of patients had hearing improvement of more than 15 dBHL, while only 40% (10/25) of patients in the P group had hearing improvement, and the difference between the two groups was statistically significant (P<0.05), as shown in (Table 3).

Group	Cure	valid	effective	Invalid	**total effective rate**	χ^2	*P*
P Group	3（12）	2（8）	5（20）	15（60）	10（40）	5.195	0.023
SGB+PGroup	6(24)	4(16)	8(32)	7(28)	18（72）[a]		

Table 3: Comparison of clinical efficacy between the two groups (n, %).

Prognosis of the two groups: Before treatment, there were no significant differences in neutrophil count, lymphocyte count or neutrophil/lymphocyte ratio (NLR) between the two groups (P>0.05). At 6 months after treatment, the neutrophil count, lymphocyte count and neutrophil/lymphocyte ratio (NLR) in the 2 groups were improved compared with those before treatment, and the difference was statistically significant (P<0.05). The improvement in the SGB+P group was better than that in the P group, and the difference between the 2 groups was also statistically significant (P<0.05). That is, the prognosis of patients in the SGB+P group was better than that of patients in the P group, as shown in (Table 4).

Group	**prior to treatment**			**Post treatment**		
	neutrophil count（10^9/L）	**lymphocyte count**（10^9/L）	**Neutrophil/lymphocyte ratio**（NLR）	**neutrophil count**（10^9/L）	**lymphocyte count**（10^9/L）	**Neutrophil/ lymphocyte ratio**（NLR）
P Group	7.18±2.05	2.11±0.54	3.18±1.81	6.29±1.77[a]	2.26±0.54[a]	3.09±1.48[a]
SGB+P Group	7.28±2.04	2.19±0.53	3.75±1.92	4.72±1.80[ab]	2.38±0.52[a]	2.21±1.27[ab]
Note: Compared with before treatment, [a]P<0.05, compared with the P group, [b]P<0.05						

Table 4: Comparison of neutrophil count, lymphocyte count and neutrophil/lymphocyte ratio (NLR) before and after treatment between the two groups.

To assess which patients would benefit most from SGB treatment, we compared outcomes between subgroups based on the degree of hearing loss (mild to moderate or severe), age (≤50 years or >50 years), and the presence of dizziness/vertigo (yes or no).

In the comparison of the level of hearing loss (P=0.017), age (P=0.017), and presence of dizziness/vertigo (P=0.007) in the subgroups analyzed, the effective rate of the SGB+P group in patients with mild to moderate hearing loss, age ≤50 years old or without dizziness/vertigo was higher than that in patients with severe hearing loss, age >50 years old or with dizziness/vertigo, and the difference was statistically significant (P<0.05); that is, patients with mild to moderate hearing loss, age ≤50 years old or without dizziness/vertigo benefited the most from SGB treatment (Table 5).

	SGB+P Group	*P* Group
subgroup		
Degree of hearing loss		
Mild to moderate	88.2% (15/17)	0.017
severe	37.5% (3/8)	
age		
≤50 years	88.2% (15/17)	0.017
>50 years	37.5% (3/8)	
Dizziness/vertigo		
yes	40% (4/10)	0.007
no	93.3%(14/15)	
Note: The P value was calculated by Fisher's exact test.		

Table 5: Comparison of the response rates in the SGB+P group according to severity of hearing loss, age, and the presence of dizziness/vertigo.

Discussion

Idiopathic sudden sensorineural deafness sexy voice (ISSNHL) is a common form of otology emergency, mainly characterized by sudden onset of acute unilateral deafness, defined as sudden and unexplained within 72 hours of sensorineural hearing loss and hearing loss in at least two adjacent frequencies of 20 dBHL or greater. However, the exact cause of ISSNHL is unknown, and both local and systemic factors can cause ISSNHL. It is generally believed that mental tension, pressure, mood swings, irregular life, and sleep disorders may be the main causes [5-7]. Previous studies have reported that hypertension, diabetes mellitus (DM) and complications, including high blood fibrinogen, are risk factors for ISSNHL [8]. The incidence of ISSNHL has shown a rising trend in China in recent years, and because of its sudden nature and the characteristics of uncertainty, it easily affects the patient's quality of life and causes mental harm to the larger population. Therefore, it has increasingly received the attention of clinicians. Currently, the ISSNHL general treatment method is simple oral corticosteroids and other drugs. However, the treatment effect is not ideal, and a more effective way to compensate for the inadequacy of pure drug therapy is needed.

With the development of medical technology, ultrasound guidance by SGB has gradually been introduced for the treatment of ISSNHL. Based on the theory of inner ear microcirculation, the mechanism of stellate ganglion block is mainly to regulate the vegetative nerve function of the hypothalamus, reduce the excitability of the sympathetic nerve, dilate peripheral blood vessels, block the release of noradrenaline from the postganglionic fibers of sympathetic nerves, regulate the vasomotor function of central blood vessels, increase the blood flow and velocity of the ipsilateral intracranial artery and internal carotid artery, and thus increase the blood flow of the cochlea. It also can improve hypoxia, relieve endolymphatic hydrops and vasospasm, improve inner ear microcirculation,

reduce inner ear lymphatic pressure, enhance neuronutrition, and promote inflammation to subside [9].

In recent years, many studies have found that SGB treatment of ISSNHL has good curative effects; however, the therapeutic effect of SGB is not widely accepted. In 2014, a survey of clinical doctors in Britain showed that 96% of patients did not use SGB in ISSNHL treatment, compared with 99% of clinical doctors who would directly treat patients with oral corticosteroids [10].

To explore the role of SGB in the treatment of ISSNHL and considering that uncertainty and slight improvements in listening can significantly improve quality of life, in this study, the P and SGB + P groups used steroids, vasodilators, and vitamins as conventional treatments. The results showed that both drug therapy alone and SGB combined with drug therapy improved patients' hearing, but SGB combined with drug therapy was more significantly effective than drug therapy alone. In other words, additional SGB therapy significantly improved hearing outcomes. The total response rates of the SGB+P group were 72% and 40%, respectively, and the rates were compared with those of the P group. This suggests that it is necessary for ISSNHL patients to undergo routine SGB treatment.

Viral infection is a possible mechanism of ISSNHL; however, in 2008, Merchant SN questioned the idea of viral infections; for example, ISSNHL found no specific serological response characteristics or antiviral therapy [11]. In recent years, studies have proposed that retrospective analysis can use the neutrophil granulocyte/lymphocyte ratio (NLR) to judge the prognosis of ISSNHL [12,13]. ISSNHL may be due to genetic thrombosis disease susceptibility or cardiovascular risk factors (such as hypertension and diabetes) leading to auricle microcirculation [14,15], and high blood viscosity may lead to auricle microcirculation damage, leading to hearing loss [16,17]. Ciccone et al. calculated carotid intima-media thickness and showed that ISSNHL seems to be related to vascular endothelial dysfunction and preclinical atherosclerosis [18]. Ciccone et al. calculated carotid intima-media thickness and showed that ISSNHL seems to be related to vascular endothelial dysfunction and preclinical atherosclerosis [18]. Capaccio et al. examined high condensation genome polymorphisms and found that patients with ISSNHL were not significantly different in cardiovascular thrombotic disease [19]. White blood cells and their subtypes are inflammatory markers of cardiovascular disease [20]. The NLR is defined as a new potential marker and is used to determine heart and heart disease inflammation. The higher the NLR is, the higher the level of inflammation [21], so the NLR level can be used as a new potential index to predict the prognosis of patients with ISSNHL. In this study, the NLR in the SGB+P group after treatment was lower than that in the P group, and the difference was statistically significant, indicating that the prognosis of SGB combined with drug therapy was superior to that of drug therapy alone.

In addition, our subgroup analysis suggests that certain subgroups may benefit more from SGB treatment than others. The degree of hearing loss is considered an important prognostic factor for ISSHNL [22,23]. In this study, 88.2% (15/17) of patients with mild to moderate hearing loss gained more than 15 dBHL of hearing after treatment, compared to 37.5% (3/8) of patients with severe hearing loss. Some studies have confirmed the initial hearing threshold and the relationship between the recovery rate [23,24] and cannot rule out patients with mild-to-moderate hearing loss ISSNHL itself as the cause of the high spontaneous recovery rate [25].

In a retrospective study of 10 years of data, the highest prevalence of ISSNHL was in the 41- to 50-year-old age group (26.4%), followed by the 51- to 61-year-old age group (19.5%) [26]. It is thought that aging can possibly interfere with ISSNHL recovery factors. The cause is thought to be systemic disease, and microangiopathy increases age consistency [27]. According to our results, patients ≤50 years of age had better hearing recovery than patients >50 years of age. Given that patients >50 years of age may not benefit from SGB treatment, it is worth considering whether it is necessary to combine the health of older patients with SGB treatment when considering possible side effects.

In some studies, dizziness/vertigo is considered an ISSNHL hearing recovery [26] a poor prognostic factor, and people who have conducted multivariate analyses, such as Mosnier, found no final threshold value or correlation with vertigo. Furthermore, given that vertigo is more common in patients with severe hearing loss than in those with mild and moderate hearing loss, they emphasize that the lack of proper statistical analysis may lead to erroneous conclusions [23]. In this study, no correlation was found between the severity of hearing loss and the presence of dizziness/vertigo (b=-0.148, P=0.215, data not specified), which may be partly because the diagnosis of dizziness/vertigo is mainly based on the patient's self-perception. In this study (P=0.007), dizziness/vertigo was a prognostic factor.

There are some adverse reactions and risks associated with SGB treatment, such as local anesthetic poisoning, accidental vascular penetration, bleeding, brachial plexus block, and hoarseness. [28]. In this study, no adverse reactions or risks were found. This may be because this study was performed under the guidance of ultrasound, and the anesthesiologist was skilled and had a clear location of the anatomical structure, which reduced the incidence of adverse reactions and risks.

There are some shortcomings in this study. First, the sample size in this study is relatively small, which may lead to a certain bias in the statistical comparison between the two groups, which

has a certain impact on the accuracy of the research results. In subsequent studies, the sample size can be expanded for further research confirmation. Second, we did not account for the patient's socioeconomic status, which could have affected the etiology of ISSHNL. Third, it is too simple to use only hearing threshold as the treatment outcome and NLR level to assess prognosis. [1] Recent studies have shown that plasma serotonin elevation can be used as a biomarker of SSNHL (specificity: ~96%, sensitivity: ~90%) and may be involved in the pathophysiological process of SSNHL. Therefore, in future research, it is better to take these problems into account and improve the deficiencies as much as possible.

In summary, under the guidance of ultrasound-guided SGB combined with drug therapy in patients with ISSNHL, the hearing restoration effect is better than that of pure drug therapy, and the prognosis is faster, showing that routine application of SGB in ISSNHL is necessary. In addition, patients with mild to moderate hearing loss, age ≤50 years, and no dizziness/vertigo benefit more from an ultrasound-guided stellate ganglion block combined with medication and have a higher chance of hearing improvement.

Conflict of interest: All authors declare no conflict of interest.

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