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The effect of a bilateral stellate ganglion block guided by ultrasound on postoperative cognitive function in elderly spinal patients

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Objective: Post-operative cognitive dysfunction (POCD) is a prevalent consequence of general anesthesia in older individuals (≥60 years) undergoing spine surgery. Factors associated with spinal surgery (prone positioning, prolonged length, and increased bleeding) along with general anesthesia elevate the risk of postoperative complications. Stellate ganglion block (SGB) exhibits neuroprotective effects via enhancing cerebral microcirculation and decreasing inflammation. This study intends to investigate the influence of bilateral SGB on POCD in these patients. **Methods:** One hundred fourteen elderly spine surgery patients were randomly assigned to a control group (standard general anesthesia) and a study group (ultrasound-guided bilateral SGB 2 hours pre-anesthesia plus general anesthesia). Cognitive function was evaluated by the MMSE/MoCA at T0 (pre-SGB), T1 (one day post-operation), and T3 (three days post-operation); POCD was categorized by severity. **Results:** One hundred patients were analyzed (14 excluded). Baseline characteristics were similar between groups ($p > 0.05$). At 2 hours post-op, no difference was found in cognitive impairment between groups. However, the SGB group had fewer moderate and severe cognitive dysfunction cases ($p < 0.05$). At 72 hours, no difference in mild cognitive impairment was observed, but the SGB group had lower POCD incidence ($p < 0.05$). **Conclusions:** Ultrasound-guided bilateral SGB before anesthesia successfully diminishes moderate-to-severe postoperative cognitive dysfunction within 3 days post-operation in elderly spine surgery patients.

Keywords: Post-operative cognitive dysfunction (POCD), Stellate ganglion block (SGB), Spinal surgery, MMSE, MoCA

Introduction

Post-operative cognitive dysfunction (POCD) is a problem frequently observed in the elderly, particularly in individuals over 60 years of age. The primary signs are diminished memory function, impaired concentration, and various emotional alterations.[1] The investigations have

showed that the incidence of POCD in elderly individuals over 60 years is 25.8% within 7 days and 10% within 3 months following surgical treatment. In compared to postoperative patients devoid of POCD, the likelihood of older patients getting POCD ranges from 25% to 40%, and the death rate is double that of patients without POCD.[2-4] There are considerable individual variations in the prevalence and severity of POCD. Some people endure for several days, weeks, or even months, while others may persist for an extended duration, losing the capacity to work and live.[1,5] Consequently, the presence of this disease signifies not only the progression of the ailment but also the degradation of quality of life, which has numerous detrimental impacts on society.[6-7] Currently, each domain of POCD study possesses its own systematic investigation. The objective is to swiftly identify reliable screening methods and countermeasures. Anti-inflammatory measures, suppression of microglial activation, and enhancement of cerebral microcirculation are prominent treatments for addressing POCD in contemporary medicine; nevertheless, a cohesive and meaningful approach has yet to be established.[8-10] The fast POC examination is primarily based on the neuropsychological testing group. These comprised a Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), Frontal Assessment Battery (FAB), and Wechsler Intelligence Scale (WIS).[11-13]

These neuropsychological tests can rapidly assess patients' cognitive status, thereby identifying individuals at high risk who require treatment.

Factors closely associated with postoperative cognitive dysfunction (POCD) encompass preoperative age, physical condition, and additional variables; of these, age is the sole risk factor for long-term POCD (exceeding three months post-surgery).[1] Wei et al, C demonstrated that older individuals undergoing orthopedic surgery are often more predisposed to developing POCD.[14]

Spinal surgery is a prevalent procedure in orthopedic surgery. It encompasses spinal fractures, intervertebral disc herniation, spinal stenosis, and spondylolisthesis, which typically necessitate surgical intervention. Spinal surgery encompasses discectomy, decompression, laminectomy, and foraminotomy. Special spinal surgery, prone positioning, prolonged operation duration, increased bleeding, and other factors may contribute to the risk of postoperative cognitive damage.[15-16] Indeed, general anesthesia is a significant risk factor. Factors such as anesthesia, inflammation, and multiclock therapy may contribute to the development of cognitive impairment, although the precise involvement remains uncertain. A SGB can enhance cerebral microcirculation and diminish cerebral hypoxia and inflammation. We hypothesize that the SGB may influence older individuals undergoing spine surgery and intraoperative cerebral microcirculation alterations. We designed the experiment to examine the effects of the block and to generate insights for the clinical prevention of postoperative cognitive impairment. This study intends to investigate the influence of bilateral SGBs on POCD in these patients.

Materials and Methods

Inclusion and Exclusion

The study was done at the Second Affiliated Hospital of Inner Mongolia Medical University from July 2022 to October 2024. Informed written consent was acquired from all patients enrolled in the trial. In this single-center, double-blind, placebo-controlled, randomized clinical trial, older patients over 60 years of age undergoing spinal surgery (ASA physical status II to III) were enrolled. Exclusion criteria encompassed cervical spine surgery, neck surgery, people diagnosed with Alzheimer's disease, and a history of mental disorder.

This study constitutes exploratory clinical research, with sample size determination mostly reliant on the following factors:

Applicable Clinical Scenarios:

Given the challenges in recruiting patients for spinal surgery (who must satisfy criteria including specific age, ASA classification, and type of surgery), the study duration (from July 2022 to October 2024, encompassing 27 months), and the patient throughput at the research facility, the initial objective was to enroll 114 patients. This is to guarantee that an adequate quantity of genuine samples is ultimately accessible for statistical analysis, following the exclusion of patients who do not fit the requirements or withdraw prematurely.

Source for the occurrence of POCD:

Based on literature reports[2-4] and the hypothesis of this study that stellate ganglion block (SGB) may diminish the incidence of postoperative cognitive dysfunction (POCD), it is estimated that if the incidence of POCD in the SGB group is 15-20% lower than in the control group, the necessary sample size for each group

is approximately 40-50 cases, resulting in a total sample size of 80-100 cases, assuming $\alpha = 0.05$ and test power $(1 - \beta) = 0.8$. Consequently, the original strategy was to recruit 114 patients to mitigate any attrition issues.

Randomization

The randomization procedure was organized using the EXCEL function ROUNDUP and enclosed in sealed envelopes by individuals not involved in the study to disclose random entries. Patients were randomly assigned to one of two groups (SGB or control groups). In the control group, the patient underwent merely an ultrasound scan and received a saline injection. In the SGB group, individuals received bilateral SGBs under ultrasound supervision.

Block Method

Upon entering the operating room and establishing venous access during anesthesia preparation, patients underwent a bilateral SGB, which was finalized within two hours prior to the primary procedure. The patient was positioned supine with the neck slightly extended. Following skin cleaning, a high-frequency ultrasonic sensor probe is positioned laterally at C6 and C7. Broad double nodules were found using ultrasound imaging of the neck anatomy at the C6 level and at the C7 level by the absence of anterior nodules. Color Doppler imaging was employed to prevent damage to blood vessels. At the intervertebral junction of C6 and C7, the tip was positioned superior to the long cervical muscle by an in-plane approach. Subsequently, after withdrawal and indicating no, the vessel was entered, with one side receiving a single 5 ml dosage of 0.1% ropivacaine and 5 mg of compound betamethasone to the stellate ganglion, while The control group was bilaterally administered an equivalent dosage of 0.9% saline. As participants could not be blinded to transient Horner's syndrome (ptosis, reduced sweating, hoarseness) resulting from the SGB, clinicians notified all participants about the symptoms associated with Horner's syndrome, irrespective of the intervention group.

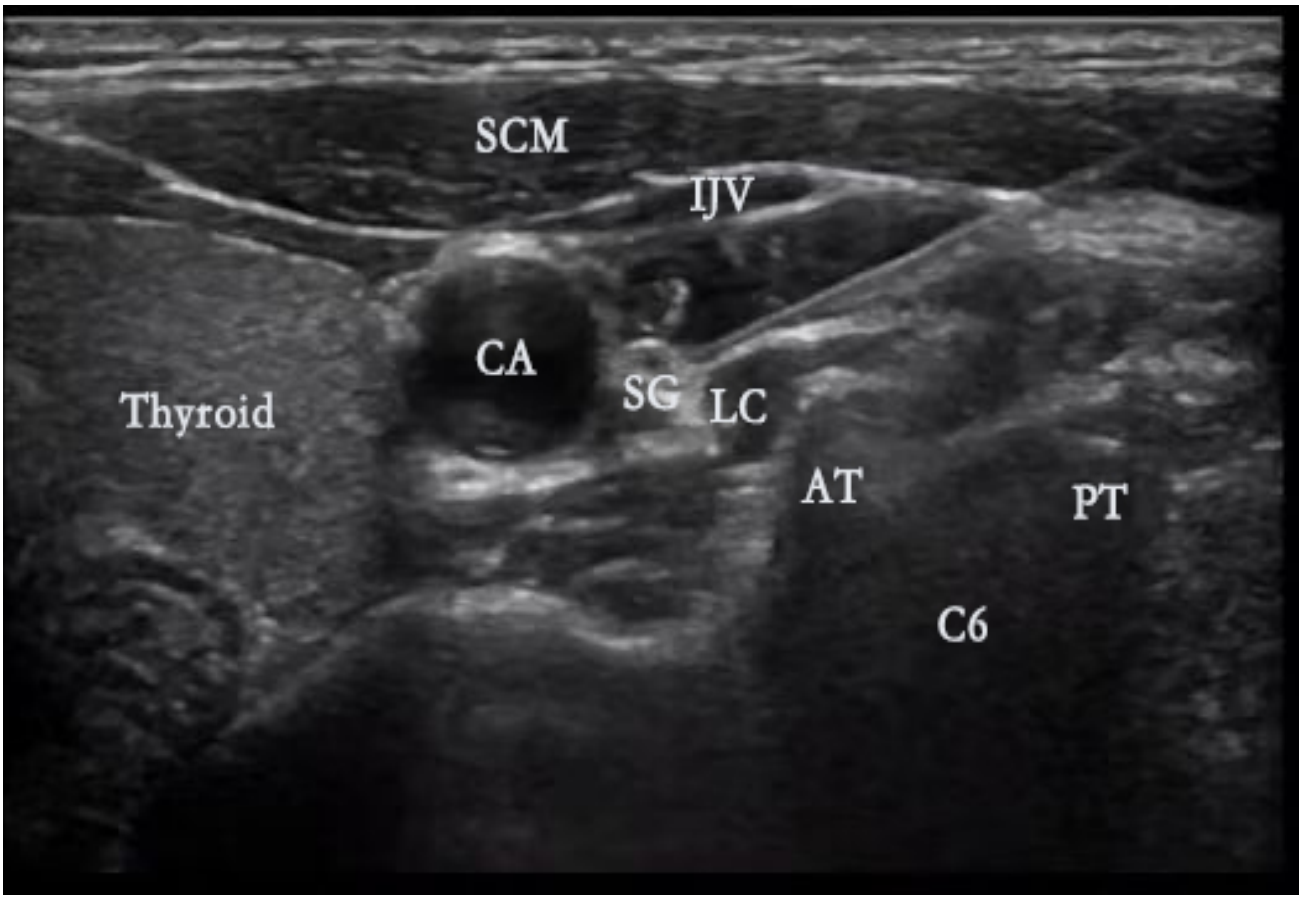

Figure 1. Sonogram of the stellate ganglion on c6 CA: Carotid artery, SCM: Sternocleidomastoid Muscle, IJV: Internal Jugular Vein, AT: anterior tubercles of the transverse process, PT: posterior tubercles of the transverse process, SG: Stellate Ganglion, LC: longus colli muscle

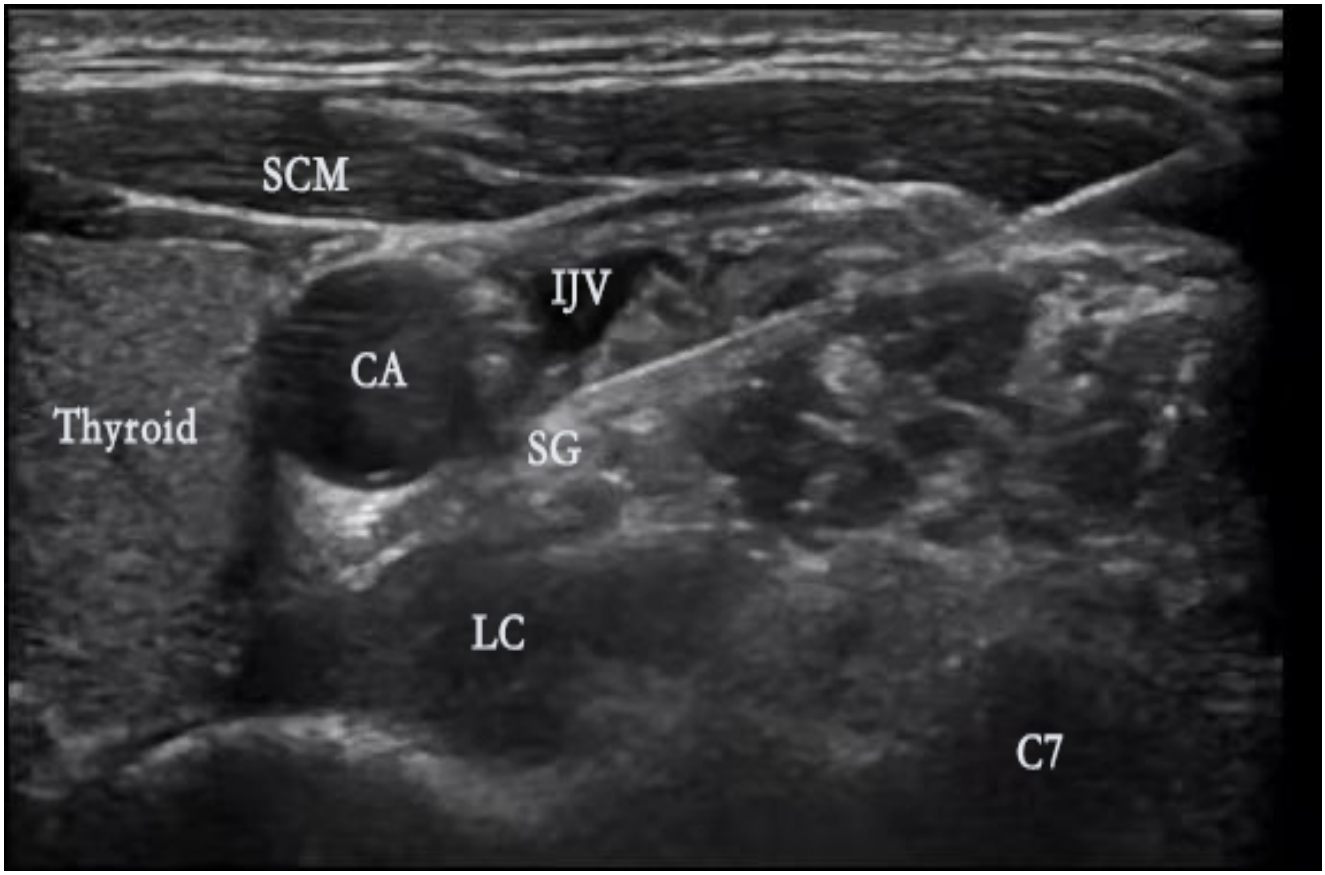

Figure 2. Sonogram of the stellate ganglion on c7 CA: Carotid artery, SCM: Sternocleidomastoid Muscle, IJV: Internal Jugular Vein, AT: anterior tubercles of the transverse process, PT: posterior tubercles of the transverse process, SG: Stellate Ganglion, LC: longus colli muscle

Detection Standard

Monitoring include non-invasive blood pressure measurement, electrocardiography, and pulse oximetry. Post-injection, vital signs and Horner's syndrome were monitored to confirm the efficacy of the block.

Anesthesia

Two hours post-block, patients were relocated to the operating room for anesthetic induction. After three minutes of preoxygenation, the induction regimen (sufentanil 0. 4 micrograms kg^{-1} and propofol 1. 0 to 2. 0 mg kg^{-1}) was administered, followed by rocuronium 0. 1 mg kg^{-1}. Insert a suitably reinforced tracheal catheter under visual laryngoscopy guidance; anesthesia was maintained with 1 to 1. 5% sevoflurane and 0. 8 to 3. 0 ng/ml, supplemented by occasional injections of rocuronium. The objective is to maintain the BIS index within the range of 40 to 60, ensure the ventilator sustains normal $PECO_2$ pressure, and achieve muscle relaxation in the patient to facilitate a smooth process.

Intraoperatively, hypotension was defined as mean arterial pressure (MAP) falling below 30% of baseline, managed by administering ephedrine or norepinephrine, and atropine for severe bradycardia. At the conclusion of the procedure, she received 0. 5% (0. 2 ml kg^{-1}) of ropivacaine administered under local anesthesia.

Analysis of the Mental Scale

All patients underwent assessments for MMSE, MoCA, word fluency, and digit span at T0, T1, and T2 (where T0 denotes pre-surgery, T1 represents the first day post-surgery,For the patients, the test was conducted by two residents with standardized training, executed in a tranquil environment, and the interference was carried out independently by the patient himself. These two residents conducted all perioperative assessments and data collecting, unaware of the group assignment.

Statistical Method

All data were statistically examined using SPSS 25. 0 software, and the one-sample Shapiro-Wilk normality test was conducted for all measurement data. Measurement data conforming to a normal distribution are represented by mean ± standard deviation, with independent sample t-tests employed for group comparisons. Conversely, non-normally distributed measurement data are characterized by median and quartiles, with group differences assessed using independent samples.

Mann-Whitney U test; count data are represented by frequency or rate (%), x^2 test or Fisher's exact probability method; and ordinal data are expressed by frequency or rate (%) and independent samples. Mann-Whitney U test. α=0. 05 was the significance level, and $p<$ 0. 05 was deemed statistically significant.

Ethical Statement

This study received approval from the Ethics Committee of the Second affiliated hospital of Inner Mongolia Medical University (No. EFY20230008). And be approved in Mongolian National University of Medical Sciences School of Medicine (2023/3-08)

Result

Between July 2022 to October 2024, 114 participants were evaluated for eligibility; 14 persons fulfilled the exclusion criteria, resulting in the recruitment of 100 participants for the study. Three patients in the SGB group withdrew due to their inability to complete the scale, and five patients withdrew.

One patient was excluded from the group due to their refusal to engage in the scale evaluation post-surgery, and another patient withdrew from the group following a sudden myocardial infarction after surgery. One patient in the control group withdrew due to her refusal to participate in the scale assessment following surgery. Consequently, 90 patients participated in the experiment and completed the analytical investigation, comprising 41 patients in the SGB group and 49 patients in the control group.

Baseline Data

The fundamental characteristics of the patients in the two groups were equivalent (Table 1).

The primary results and selected secondary outcomes

The primary results and selected secondary outcomes were presented by group. The primary finding indicated no statistically significant difference in mental scale scores between the two patient groups prior to surgery ($p>$ 0.05). On the first and third days post-surgery, a substantial statistical difference in mental scale ratings was seen between the two patient groups, with the scores of patients getting SGBs significantly diminished ($p<$ 0.05). Secondary results indicated that patients undergoing SGB had considerable improvements in postoperative dizziness, nausea, and pain (Table 2).

Cognitive impairment was classified according to the scores. There was no statistical difference between the two groups of patients without cognitive impairment and those with mild cognitive impairment. Nonetheless, a substantial statistical difference was observed in individuals with moderate to severe cognitive impairment, as the scores of those getting SGBs were dramatically diminished ($p<$ 0.05). (Table 3, Table 4, Table 5)

Discussion

The SGB is a method of blocking the cervical sympathetic ganglion, characterized by rapid onset, noticeable results, and minimal adverse effects.[17-18] It is particularly effective in treating many disorders. It efficiently enhances cerebral microcirculation and diminishes the inflammatory response. Research has demonstrated that SGB can significantly enhance inflammatory response and neurological function in diabetic rats following ischemic stroke, and bilateral SGB can successfully reduce the incidence of migraine and residual pain perception.[19-21] Nonetheless, the application of bilateral SGB in spinal patients has not been documented; therefore, we hypothesize that bilateral SGB may also significantly reduce the incidence of postoperative ischemic cognitive dysfunction in patients undergoing spine surgery. We examined alterations in cognitive function within three days post-surgery in elderly spinal patients having bilateral SGB, as evidenced by the patients' cognitive abilities, short-term memory, and linguistic organization and retrieval capabilities.

This study is the first to assess the efficacy of bilateral SGB in avoiding postoperative cognitive impairment in elderly adults following spine surgery.

The SGB is a safer routine block technique. It is frequently utilized on the right side due to the right central nervous system's characteristic neuroanatomical connections and its role in sustaining persistent sympathetic responses.[22-23] Traditional

Table 1. The basic characteristics of the patients in the two groups

Variable	SGB group (n = 41)	Control group (n = 49)	*p*-value
SEX			0.539
male	16 (39.02)	15 (30.61)	
female	25 (60.98)	34 (69.39)	
ASA			
2	37 (90.24)	45 (91.84)	
3	4 (9.76)	4 (8.16)	
Age	67.37 ± 5.43	66.84 ± 5.99	0.661
Operation time	180.88 ± 53.5	160.14 ± 66.35	0.104
BMI	24.93 ± 3.65	24.39 ± 3.45	0.476
Education			0.413
Illiteracy	13 (31.71)	19 (38.78)	
Primary school	13 (31.71)	14 (28.57)	
Middle school	11 (26.83)	15 (30.61)	
University or above	4 (9.76)	1 (2.04)	
SGB			0.001**
None	0 (0)	49 (100)	
Yes	41 (100)	0 (0)	
Hypertension			
None	20 (48.78)	23 (46.94)	
Yes	21 (51.22)	26 (53.06)	
Diabetes			0.273
None	37 (90.24)	39 (79.59)	
Yes	4 (9.76)	10 (20.41)	
Old myocardial infarction			0.590
None	39 (95.12)	48 (97.96)	
Yes	2 (4.88)	1 (2.04)	
Cardiovascular disease			
None	29 (70.73)	34 (69.39)	
Yes	12 (29.27)	15 (30.61)	
Cerebrovascular diseases			0.799
None	36 (87.8)	41 (83.67)	
Yes	5 (12.2)	8 (16.33)	
Pulmonary diseases			0.283
None	39 (95.12)	43 (87.76)	
Yes	2 (4.88)	6 (12.24)	
Osteoporosis			0.727
None	36 (87.8)	45 (91.84)	
Yes	5 (12.2)	4 (8.16)	
Thyroid dysfunction			0.371
None	40 (97.56)	45 (91.84)	
Yes	1 (2.44)	4 (8.16)	

*Indicates the use of Fisher's exact test *p<0.05, **p<0.01, ***p<0.001*

Table 2. Comparison of secondary outcomes between the two groups, including postoperative nausea, vomiting, pain, and other conditions.

Variable	SGB group (n = 41)	Control group (n = 49)	*p*-value
Headache and dizziness			
None	41 (100)	40 (81.63)	0.003*
Yes	0 (0)	9 (18.37)	
Nausea and vomiting			
None	34 (82.93)	38 (77.55)	0.711
Yes	7 (17.07)	11 (22.45)	
Weak			
None	40 (97.56)	47 (95.92)	
Yes	1 (2.44)	2 (4.08)	
Gastrointestinal reactions			
None	41 (100)	47 (95.92)	0.498
Yes	0 (0)	2 (4.08)	
Pain			
None	41 (100)	43 (87.76)	0.030*
Yes	0 (0)	6 (12.24)	
Others			
None	35 (85.37)	33 (67.35)	0.083
Yes	6 (14.63)	16 (32.65)	

*Indicates the use of Fisher's exact test *p<0.05, **p<0.01, ***p<0.001*

Table 3. Comparison of cognitive scales between the two groups.

Variable	SGB group (n = 41)	Control group (n = 49)	*p*-value
MMSE			
T0	23.9 ± 3.48	21.9 ± 4.49	NA
T1	24.34 ± 3.07	22.38 ±4.24	0.014*
T2	24.29 ± 3.2	22.04 ±4.75	0.009*
MoCA			
T0	19.73 ±3.31	17.27 ± 5.69	NA
T1	20.29 ±4.15	16.3 ± 4.99	0.001*
T2	19.39 ±3.97	16.27 ± 4.87	0.001*
Word fluency			
T0	33 ± 9.73	30.2 ±11.17	NA
T1	35.95 ± 9.62	28.91 ±9.42	0.001*
T2	32.32 ± 9.64	27.82 ±9.93	0.032*
Reverse order of digital breadth			
T0	2.85 ± 0 .76	2.53 ±1.06	NA
T1	2.95 ± 0.92	2.46 ±1.11	0.026*
T2	2.98 ± 0.72	2.45 ±1.21	0.013*

**p<0.05, **p<0.01, ***p<0.001, NA-Not Applicable.*

Table 4. Cognitive impairment was classified.

Cognitive impairment	SGB group (n = 41)	Control group (n = 49)	*p*-value
T0			
None	16 (39.02)	15 (30.61)	0.067
Mild	20 (48.78)	17 (34.69)	0.081
Moderate	5 (12.2)	17 (34 .69)	0.052
T1			
None	16 (39.02)	12 (24.49)	0.074
Mild	22 (53.66)	22 (44.9)	0.073
Moderate	3 (7.32)	13 (26.53)	0.01*
Severe	0 (0)	2 (4.08)	0.01*
T2			
None	20 (48.78)	16 (32.65)	0.029*
Mild	18 (43.9)	20 (40 .82)	0.087
Moderate	3 (7.32)	12 (24.49)	0.01*
Severe	0 (0)	1(2 .04)	0.01*

**p<0.05, **p<0.01, ***p<0.001*

Table 5. Postoperative cognitive dysfunction (POSD) occurs.

Cognitive impairment	SGB group (n = 41)	Control group (n = 49)	*p*-value
T0			0.539
None	16 (39.02)	15 (30.61)	
Yes	25 (60.98)	34 (69.39)	
T1			0.21
None	16 (39.02)	12 (24.49)	
Yes	25 (60.98)	37 (75.51)	
T2			0.18
None	20 (48.78)	16 (32.65)	
Yes	21 (51.22)	33 (67.35)	

**p<0.05, **p<0.01, ***p<0.001*

SGB is conducted unilaterally, administering one block per day while rotating between the left and right sides. This method extends the treatment period and diminishes patient adherence. Consequently, we implemented simultaneous bilateral ganglion block, which markedly diverges from prior reports. Precise localization with ultrasound guidance can significantly decrease the risk of adverse effects. Conducting an SGB block without fluoroscopic or ultrasound guidance, the most prevalent significant adverse event is systemic seizures resulting from unintentional endovascular administration of local anesthetic. Currently, under ultrasound supervision, adverse events occur infrequently, and the bilateral application of local anesthetics can result in diaphragmatic nerve block, potentially leading to respiratory difficulties. Nonetheless, we employ the procedure

administered prior to general anesthesia, so mitigating harmful outcomes even in the event of a diaphragmatic nerve block. In contrast to the frequently employed unilateral SGB block, we interpret the bilateral block as the variable block modification. Our data indicates that the bilateral SGB block can significantly enhance postoperative cognitive function. In the selection of enrolled individuals, we excluded those diagnosed with Alzheimer's disease but did not exclude patients with initially impaired cognitive function. This is because we aim to observe the major index, bilateral SGB, to enhance the incidence of postoperative cognitive impairment. rather than preventive treatment.

Our findings corroborate our hypothesis. The objective of the study is to ascertain if bilateral SGB can significantly diminish the occurrence of POCD. In patients who received bilateral SGB, the incidence of POCD markedly diminished, likely due to the concurrent bilateral SGB enhancing cerebral microcirculation and alleviating POCD resulting from inadequate cerebral blood flow. Indicating that postoperative cognitive dysfunction may be linked to intraoperative alterations in cerebral microcirculation. This modification can be accomplished by executing a bilateral SGB before anesthesia.

Therefore Ultrasound-guided bilateral SGB can significantly enhance the incidence of moderate to severe postoperative cognitive dysfunction, demonstrating both safety and efficacy.

Constraints of the Experiment and Prospective Research Avenues

This study validated the short-term efficacy of ultrasound-guided bilateral stellate ganglion block (SGB) in ameliorating postoperative cognitive dysfunction (POCD) in elderly patients undergoing spine surgery; nevertheless, it possesses the following limitations:

Constraints on Sample Size and Scope: A total of 90 patients were included. The limited sample size results in inadequate statistical power; the single-center design introduces geographical selection bias, so constraining the external validity of the findings.

Brief Follow-Up Period: Cognitive function was assessed solely within three days post-surgery, with no long-term follow-up (e.g., 1–6 months or beyond) done, rendering it unable to elucidate the impact on long-term postoperative cognitive dysfunction (POCD).

Considering the constraints of this study and the deficiencies in the domain of POCD, future research may be pursued from three perspectives:

Augmenting Sample Size and Executing Multi-Center Research Conduct multi-center, large-sample randomized controlled trials (RCTs) including patients from hospitals across various regions and tiers to enhance the external validity of the findings.

Prolonging Follow-Up Evaluation: Prolong the follow-up duration to 3–12 months post-surgery. Assess the long-term efficacy and safety by integrating neuropsychological assessments (MMSE, MoCA), the Activity of Daily Living Scale (ADL), along with metrics such as duration of hospital stay and mortality, while also considering delayed adverse effects such as cervical nerve injury.[24-25]

Enhancing Mechanism Investigation: Assess the concentrations of serum inflammatory markers (IL-6, TNF-α, IL-1β), brain metabolic indicators (S100β, NSE), and neurotrophic factors (BDNF) prior to, during, and after to operation. Examine the "anti-inflammatory + enhancing cerebral metabolism" mechanism and elucidate the correlation between biological indicators and POCD.[26.27]

This study presents a fresh and useful research avenue for treatment interventions aimed at preventing POCD, affirming that cervical sympathetic trunk block may function as a preventive measure. Subsequent investigations should concentrate on the fundamental mechanisms, long-term impact rates, and the extent of improvement for this condition.

Conclusion

Final Assessment Bilateral SGB under ultrasound guidance can successfully diminish the incidence of postoperative cognitive impairment in elderly patients undergoing spine surgery. It can successfully diminish the incidence of moderate and severe cognitive impairment within three days post-surgery. Moreover, it can significantly diminish the occurrence of dizziness, nausea, vomiting, and discomfort.

Conflicts of Interest

All authors have no potential or non-potential financial conflicts of interest.

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None

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