

## Original Article

# Ameliorative effects of stellate ganglion lock on stress and inflammation response in patients with traumatic brain injury

Xi Yang<sup>1</sup>, Zhong Shi<sup>2</sup>, Mengchang Yang<sup>1</sup>, Kailan Wen<sup>1</sup>, Jun Li<sup>3</sup>

<sup>1</sup>Department of Anesthesiology, Sichuan Academy of Medical Sciences & Sichuan Provincial People's Hospital, Chengdu 610072, Sichuan, China; <sup>2</sup>Department of Emergency, Xinqiao Hospital, The Third Military Medical University, Chongqing 400037, China; <sup>3</sup>Department of Anesthesia, Chengdu Military General Hospital, Chengdu 610038, Sichuan, China

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**Abstract:** The aim of the present study was to observe the early influence of stellate ganglion block (SGB) on stress and inflammation response on patients with traumatic brain injury (TBI). In this prospective, randomized, controlled research, we chose 60 TBI patients and divided them into SGB treatment group and the control group. We extracted their venous blood at five designed time points namely before- SGB-treatment (T1), 1 h-after-SGB-treatment (T2), 2 d-after-SGB-treatment (T3), 4 d-after-SGB-treatment (T4) and 7 d-after-SGB-treatment (T5), and detected their serum concentration of NO, IL-6, IL-1 $\beta$ , TNF- $\alpha$ , GC, ACTH, NA and AD. In addition, we detected the protein expression of lymphocyte c-Jun, iNOS, GR by Western Blot. We found that the control group exhibited the higher expression of IL-6, IL-1 $\beta$ , TNF- $\alpha$  and NO, while the SGB treatment group exhibited various degrees of reduction. TBI patients had obvious stress reaction and their serum concentration of GC, ACTH, NA and AD after operations reached peak and then went down, the SGB group was always significantly lower than the control group at certain time points except GC ( $P < 0.01$  or  $P < 0.05$ ). In the SGB group the level of GR was significantly higher than that in the control group ( $P < 0.05$ ), and c-Jun and iNOS protein expression were lower than those in control group on the second, the fourth, and seventh day. The patients clinic outcome in the SGB group was better than the control group. These results revealed that SGB could suppress the occurrence of stress and inflammation response, and indicated SGB may participate in the adjustment of nerve-immune system dysfunction after traumatic brain injury.

**Keywords:** Traumatic brain injury, stellate ganglion block, stress response, inflammation response

## Introduction

Traumatic brain injury (TBI) is one of the major diseases that threaten human life in modern society. Although the comprehensive cerebral nerve protection and treatment measures have improved tremendously, there still exists some limitations in the early treatment of brain injury. Choosing what kind of method for early intervention treatment in patients with brain injury to promote brain function recovery as soon as possible is still worth further discussion. Researches shows that in the early period after TBI there are a large number of inflammatory cytokines and immune cells are activated. They are involved in a series of pathological changes after brain injury. As for the positive correlation

between inflammatory cytokines in serum and brain injury, how to adjust its level can create new ways for targeted therapy of brain trauma [1-4]. Recently it has been found that the autonomic nervous system plays an important role on stress and inflammatory response after severe trauma [5]. Severe trauma leads the sympathetic nervous system to be excessively excited, and the secretion of numerous inflammatory cytokine, which leads to the occurrence of systemic inflammatory response syndrome (SIRS). The parasympathetic nervous system can strongly regulate immune inflammatory response through the neurotransmitter acetylcholine [6]. Therefore, exploring effective treatment measures to reduce the mortality and improve outcome after TBI, by inhibiting the

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degree of stress and inflammatory responses, has important clinical significance.

Stellate ganglion block (SGB) is mainly used for the treatment of chronic cerebral spastic pain in the early period. Studies of SGB have shown that SGB could improve immune function, adjust the abnormal changes of the nerve-immune system, restore the destruction of the sympathetic-vagal balance caused by increased sympathetic nervous activity and can reduce systemic sympathetic overstrain [7-11]. In recent years, SGB has been widely used in the treatment of various diseases and has obtained good curative effect [12-15]. SGB can protect the brain function. Studies have shown that SGB could improve the hearing parameters of rats' impaired cochlea [16], which indicated that it might be related to the cerebral blood flow improvement of cochlea. The human study shows that unilateral SGB treatment can increase the lateral cerebral hemisphere cerebral blood flow [17].

Animal studies have found that following removal of the presynaptic input to the superior cervical ganglion of the neonatal rat, promotes recovery following injury[18]. Therefore, we make a bold assumption that SGB inhibit TBI patients with post-traumatic stress and inflammatory response by reducing autonomic nervous excitement. On this basis, this study selected patients with TBI. We use experimental detection to detect patients with the changes of serum NO, IL-6, IL-1 $\beta$ , TNF- $\alpha$ , cortisol (GC), adrenocorticotrophic hormone (ACTH), norepinephrine (NA) and adrenaline (AD) level as well as the protein expression changes of c-Jun, nitric oxide synthase (iNOS), glucocorticoid receptors (GR), aiming to explore the influence of SGB on early stress and inflammation in patients with TBI.

## Materials and methods

### *Ethical issues*

This study was conducted with the approval of the Ethics Committee of our hospital. Written informed consent was obtained from all participants before enrolment. This study was conducted in accordance with the declaration of Helsinki. All the patients were checked and confirmed of no SGB contraindications in pre-operative examination.

### *Inclusion criteria*

① GCS score > 6 points; ② Aged 16 to 60 years; ③ Within 24 hours of injury; ④ Simple TBI, did not meet the indications of craniotomy; ⑤ Without serious associated injuries of neck, chest and abdomen.

### *Exclusion criteria*

① Brain stem injury; ② Intracranial hematoma > 30 ml; ③ With the past history of cerebrovascular disease or other brain disorders; ④ Basal skull fracture combined with cerebrospinal fluid leakage; ⑤ With severe systemic organ diseases; ⑥ Pregnant or lactating women; ⑦ Accompanied with hypoxemia, hypotension and electrolyte imbalance when hospitalized.

### *Treatment*

As for patients who have met the eligible criteria while having no need of surgical treatment we sent them into the ward immediately after admission and administered them with related processing. During the process of treatment, if patient's condition aggravated and needed the surgical treatment, this patient would be excluded from the study. Patients were randomly divided into SGB group and the control group. All patients were given the routine hemostatic, anti-inflammatory, dehydration treatment during the observation period (one week). Patients in SGB group and the control group, on the basis of the fundamental treatment, were performed the unilateral SGB treatment, on the first day of hospitalization, which was performed once every other day for 1 consecutive week. Patients in SGB group were injected 8 ml anesthesia drug that was consisted of 4 ml 2% lidocaine, 1.5 ml 0.75% bupivacaine and 2.5 ml saline [19]. 8 mL dosage of local anesthetics was recommended for a successful block. Patients in the control group were injected 8 ml Saline.

### *Stellate ganglion block*

Block method takes the paratracheal approach, the puncture was performed from the intersection point (2.5 cm above the sternoclavicular joint and 1.5 cm to the lateral side of anterior median line) towards the base of the seventh cervical transverse process. The patient was

laid in the supine position and relaxing the anterior neck muscle, slightly flexing the neck and withdrawing the jaw, with thin pillow padded under the shoulder. When the needle tip touched the sclerotic, the common carotid artery was pushed outwards with the fingers, the withdrawal should not exhibit bleeding, then 8 ml dosage of local anesthetic drugs or contrast media were pushed.

## *Specimen collection*

5 ml venous blood was extracted from the right internal carotid of both the SGB group and the control group at five designed time points, namely before-SGB-treatment (T1), 1 h-after-SGB-treatment (T2), 2 d-after-SGB-treatment (T3), 4 d-after-SGB-treatment (T4) and 7 d-after-SGB-treatment (T5). Then 5 ml heparin-anticoagulated venous blood was put into centrifugal at room temperature at 737.5× g for 5 min. Serum and lymphocytes were separated and obtained.

## *Serum cytokine detection*

The levels of plasma AD, NA, GC, ACTH, IL-6, IL-1 $\beta$  and TNF- $\alpha$  levels were detected with the ELISA method. The reagent kits, Human AD ELISA kit (Jingmei Biological engineering Co.,Ltd, China), Human NA ELISA kit (Jingmei Biological engineering Co., Ltd, China), Human GC ELISA kit (Jingmei Biological engineering Co., Ltd, China), Human ACTH ELISA kit (Jingmei Biological engineering Co., Ltd, China), Human IL-1 $\beta$  ELISA kit (Jingmei Biological engineering Co., Ltd, China), Human IL-6 ELISA kit (Sunbio Biomedical technology Co., Ltd, china) and Human TNF- $\alpha$  ELISA kit (Sunbio Biomedical technology Co., Ltd, china) were used. The wells of ELISA plates were marked, then a 50  $\mu$ l serum sample was added into each well; the detection was performed according to the instructions of the ELISA kit, and the optical density (OD) at 450 nm was read. Then according to the standard OD values, the standard curve was drawn and used to calculate the concentrations. The contents of AD, NA, GC, ACTH, IL-6, IL-1 $\beta$  and TNF- $\alpha$  of each serum sample were calculated based on the standard curve of standard solution. The method of Griess method was performed to determine the total contents of NO $_3^-$  and NO $_2^-$  (which can be used to evaluate the NO levels in serum), based

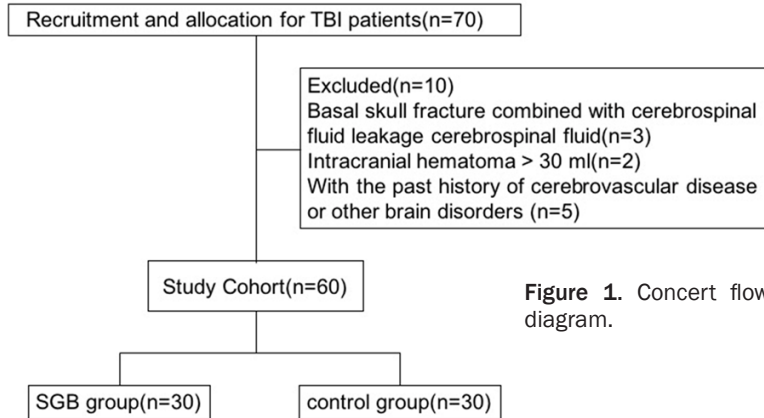
on the instructions of commercial nitric oxide assay kits.

## *Western blotting*

We used the Western Blot method to test the content of lymphocyte c-Jun, iNOS, GR. We extracted proteins of lymphocytes with white blood cell total protein extraction (Pierce products, the United States). And we determined protein content according to the Bradford colorimetric method and took 40  $\mu$ g proteins SDS-PAGE. After electrophoresis was dry, we transferred printing to PVDF membrane for 1 hour. PVDF membrane was closed in fluid (0.5% BSA, 0.01 M PBS) and was stored in 4°C for the whole night. And we joined the dilution of rabbit monoclonal antibody against the iNOS (Santa cruz, USA), Rabbit polyclonal antibody against the c-Jun (Santa cruz, USA), Rabbit polyclonal antibody against the GR (Santa cruz, USA) and Rabbit monoclonal antibody against the GAPDH (Santa cruz, USA) into closed fluid. Then we incubated them at 37°C for 2 hours. And we used PBST to wash the membrane three times and each time washed it five minutes, then we joined the dilution of horseradish tag goat anti rabbit IgG (Chinese fir in jinqiao company products, China) and incubating it at 37°C for 1 hour. After that we used PBST to wash the membrane three times and each time washed it five minutes again. The PVDF membrane was colored through DAB at the room temperature. We terminated the reaction with water the moment that strip appeared. Immunoblot images were obtained and the optical density (intensity)  $\times$  area (mm $^2$ ) of the bands were estimated by a UVP GelDoc 310 Imaging system (UVP, Inc., Upland, CA, USA). The relative target protein expression levels were measured by the ratio of the optical density (intensity)  $\times$  area (mm $^2$ ) of the target band and that of the GAPDH band.

## *Statistical analysis*

Repeated-measures analysis of variance was used and the SPSS 19.0 software was applied. Results showed that data fitted normal distribution, and the overall variance of each sample is equal with homogeneity of variance. The covariance matrix composed of each time point sphericity feature. The experimental data was expressed as mean  $\pm$  standard deviation (



**Figure 1.** Concert flow diagram.

**Table 1.** Baseline characteristics of TBI patients (n=60)

	Control group	SGB group
Male	18 (60.0%)	16 (53.3%)
Age (year)	41.2±9.7	40.3±9.9
Weight (kg)	66.7±12.5	66.4±12.3
GCS scores	11.6±4.8	11.4±5.0
Injury time (hour)	3.8±5.4	3.9±5.4

**Table 2.** Complication and clinic outcome of the patients

	Control group	SGB group
Stress uncer	6 (20.0%)	1 (3.3%)
Headache and dizziness	30 (100.0%)	6 (20.0%)*
Memory dysfunction	3 (10.0%)	0
Hospitalization time (day)	13.8±9.4	9.8±6.4*
Death	0	0

SGB group vs the control group: \* $P < 0.05$ .

$\bar{x} \pm s$ ), the overall level of statistical significance was  $P < 0.05$ .

## Results

### The characteristics of TBI patients

Among 70 patients who underwent TBI, 60 that met the inclusion criteria were randomly allocated into two groups of 30 each and were included in the analysis (**Figure 1**). There was no difference in baseline data, sex or gender, weight, age, GCS scores, and injury time between the two groups (**Table 1**). The clinic outcome with different intervention was seen in **Table 2**. Patients had a headache and dizziness in the control group were more than the SGB group, and hospitalization time in the SGB group was shorter than the control group. No

case died in this experiment. From the data in **Table 2** we inferred that patients clinic outcome in the SGB group was better than the control group.

### Serum IL-6, IL-1 $\beta$ , TNF- $\alpha$ and NO

As the results showed in **Table 3**, in the control group, the IL-6 and IL-1 $\beta$  contents of TBI patients were significantly increased after the injury, and the peak values appeared on the fourth day of injury; TNF- $\alpha$  was increased on second day and fourth day after the injury, and the peak value appeared on the second day of the injury. In the SGB group, TNF- $\alpha$ , IL-1 $\beta$  were reduced after the injury, and the reductions of IL-1 $\beta$  on the second and fourth day were significantly lower than the control group, the reduction amplitude was 127% and 146%, respectively. Furthermore, our study demonstrated that the serum NO levels of both the two groups were increased gradually, and the peak values appeared on the fourth day of injury. The serum concentration of NO in the SGB group was lower than that of the control group at each time point.

### Serum GC, ACTH, NA and AD

The result is shown in **Table 4**. The GC and ACTH of TBI patients were increased after injury and the peak values appeared on the second day in both groups and then went down. At the same time point, the concentration of ACTH in the SGB group was significantly lower than they were in the control group. The concentrations of serum NA and AD were increased rapidly in both groups after TBI injury, and on the second day after operations, the increased extend of the SGB group was significantly lower than that in the control group. The level of serum NA and AD in both groups went back until the seventh day. The serum concentrations of AD and NA in the SGB group were significantly lower than that of the control group at each time point.

### Effect of SGB on protein expression of c-Jun, iNOS, GR in lymphocytes

The protein expressions of GR, c-Jun, and iNOS are shown in **Figure 2**. The protein expression level of GR in the SGB group was obviously

**Table 3.** Impacts of SGB on inflammatory cytokines and NO in the TBI patients (n=30,  $\bar{x} \pm s$ )

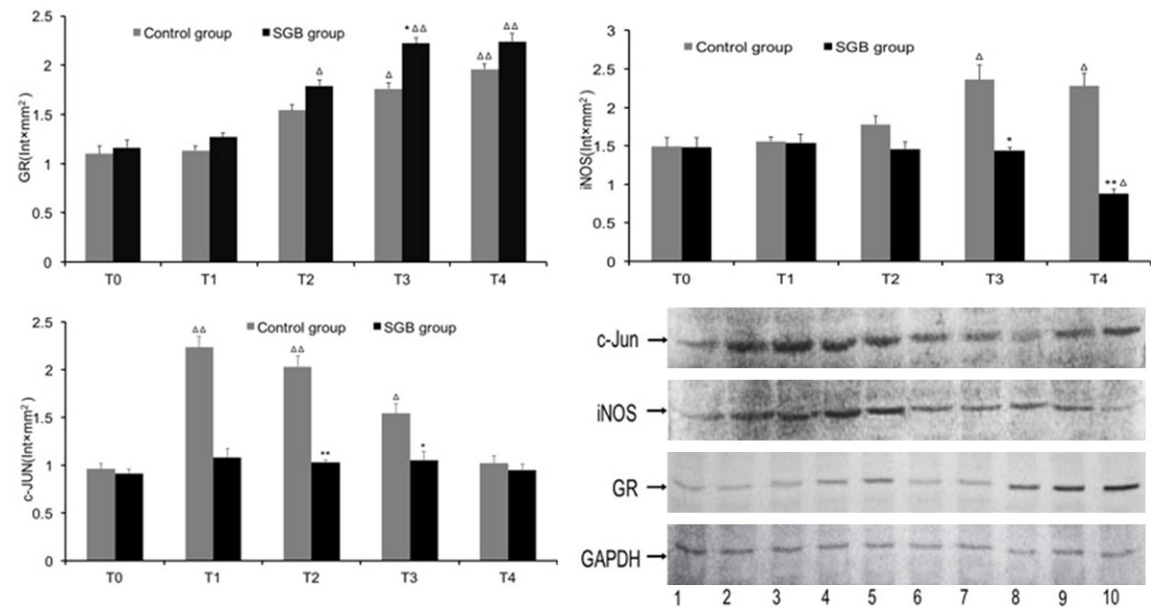
Parameter	Group	Time point				
		T1	T2	T3	T4	T5
NO ( $\mu\text{mol/l}$ )	Control	51.5 $\pm$ 3.4	54.7 $\pm$ 4.7	78.3 $\pm$ 5.7	106.8 $\pm$ 8.8 $\Delta\Delta$	98.6 $\pm$ 7.3 $\Delta$
	SGB	50.6 $\pm$ 4.9	53.9 $\pm$ 4.9	67.8 $\pm$ 5.5	73.4 $\pm$ 5.3 $^{*}\Delta$	73.5 $\pm$ 4.8
TNF- $\alpha$ (pg/ml)	Control	551.5 $\pm$ 26.9	571.7 $\pm$ 25.8	793.8 $\pm$ 73.1 $\Delta$	708.7 $\pm$ 86.1	358.6 $\pm$ 36.1
	SGB	541.4 $\pm$ 25.8	421.6 $\pm$ 50.2	462.9 $\pm$ 69.3 $^{*}$	409.8 $\pm$ 54.3 $^{*}$	345.8 $\pm$ 33.1 $\Delta$
IL-6 (pg/ml)	Control	320.0 $\pm$ 20.1	326.5 $\pm$ 21.0	430.8 $\pm$ 57.5	455.6 $\pm$ 31.6 $\Delta$	427.3 $\pm$ 53.8
	SGB	317.8 $\pm$ 20.3	131.5 $\pm$ 20.4 $\Delta\Delta$	264.7 $\pm$ 28.8 $^{*}$	298.4 $\pm$ 23.2 $^{*}$	405.3 $\pm$ 65.1
IL-1 $\beta$ (pg/ml)	Control	4.1 $\pm$ 0.5	4.1 $\pm$ 0.7	6.0 $\pm$ 0.6 $\Delta$	6.6 $\pm$ 0.5 $\Delta$	5.2 $\pm$ 0.6
	SGB	4.1 $\pm$ 0.3	3.4 $\pm$ 0.4	2.7 $\pm$ 0.5 $^{**}\Delta$	2.7 $\pm$ 0.4 $^{**}\Delta$	4.9 $\pm$ 0.4

SGB group vs the control group:  $^{*}P<0.05$ ,  $^{**}P<0.01$ ; after injury vs during injury:  $\Delta P<0.05$ ,  $\Delta\Delta P<0.01$ .

**Table 4.** Impacts of SGB on serum GC, ACTH, NA, and AD in the TBI patients (n=30,  $\bar{x} \pm s$ )

Parameter	Group	Time point				
		T1	T2	T3	T4	T5
GC (ng/ml)	Control	125.0 $\pm$ 12.4	123.7 $\pm$ 17.5	185.7 $\pm$ 18.3 $\Delta$	144.5 $\pm$ 10.7	132.8 $\pm$ 12.9
	SGB	122.7 $\pm$ 11.7	145.3 $\pm$ 10.0	241.6 $\pm$ 24.1 $^{*}\Delta\Delta$	187.2 $\pm$ 16.6 $^{*}\Delta$	162.6 $\pm$ 16.2
ACTH (ng/ml)	Control	55.5 $\pm$ 2.9	53.4 $\pm$ 2.8	79.8 $\pm$ 7.1 $\Delta$	70.7 $\pm$ 8.1 $\Delta$	65.6 $\pm$ 3.1
	SGB	54.4 $\pm$ 2.8	52.6 $\pm$ 5.2	62.9 $\pm$ 6.3 $^{*}$	60.8 $\pm$ 5.3	54.8 $\pm$ 3.1
AD (pmol/l)	Control	320.0 $\pm$ 20.1	358.8 $\pm$ 20.1	430.8 $\pm$ 57.5	455.6 $\pm$ 31.6 $\Delta$	427.3 $\pm$ 53.8
	SGB	320.8 $\pm$ 20.4	331.5 $\pm$ 20.4	364.7 $\pm$ 28.8 $^{*}$	398.4 $\pm$ 23.2	405.3 $\pm$ 65.1 $\Delta$
NA (nmol/l)	Control	4.1 $\pm$ 0.5	4.3 $\pm$ 0.5	6.0 $\pm$ 0.6 $\Delta$	6.6 $\pm$ 0.5 $\Delta$	5.7 $\pm$ 0.6 $\Delta$
	SGB	4.1 $\pm$ 0.3	4.1 $\pm$ 0.4	4.7 $\pm$ 0.5 $^{*}\Delta$	5.3 $\pm$ 0.4 $^{*}$	4.9 $\pm$ 0.4

SGB group vs the control group:  $^{*}P<0.05$ ; after injury vs during injury:  $\Delta P<0.05$ ,  $\Delta\Delta P<0.01$ .



**Figure 2.** Western blot analysis of lymphocyte c-Jun, iNOS, GR. Lanes 1-5 represented the protein expression before-SGB-treatment (T1), 1 h-after-SGB-treatment (T2), 2 d-after-SGB-treatment (T3), 4 d-after-SGB-treatment (T4) and 7 d-after-SGB-treatment (T5) in the control group, respectively; Lanes 6-10 represented the protein expression before-SGB-treatment (T1), 1 h-after-SGB-treatment (T2), 2 d-after-SGB-treatment (T3), 4 d-after-SGB-treatment (T4) and 7 d-after-SGB-treatment (T5) in SGB group, respectively. SGB group vs control group:  $^{*}P<0.05$ ,  $^{**}P<0.01$ ; after injury vs during injury:  $\Delta P<0.05$ ,  $\Delta\Delta P<0.01$ .



higher than that of the control group ( $P < 0.05$ ). In the control group, the c-Jun level increased significantly after TBI, and the peak appeared on 1 h after SGB treatment ( $P < 0.01$ ). The c-Jun level was significantly higher than that of the SGB group on the second and fourth day ( $P < 0.01$  or  $P < 0.05$ ), and there was no difference between the two groups at 7 days. Similar with the c-Jun, the protein expression levels of iNOS were lower in the SGB group compared to the control group at each time point.

## Discussion

This experiment showed that the values of IL-6, IL-1 $\beta$  and TNF- $\alpha$  in SGB group were lower than the control group, among which IL-1 $\beta$  was significantly lower on the second and fourth day, with the reduction amplitudes as 127% and 146%, respectively. In the early period of post-TBI, a large number of proinflammatory cytokines and immune cells were activated, the post-TBI inflammatory response was one of the main reasons that aggravated the secondary brain injury occurred. The activation of immune cells could cause the release of more inflammatory mediators and free radicals in turn, including interleukins, tumor necrosis factor, and colony stimulating factor. Sharif reported that the human astrocytes could produce TNF- $\alpha$ , IL-1 $\beta$  and IL-6 under stress state [20, 21]. The research revealed that SGB could inhibit the excessive inflammatory response after TBI, help to restore the homeostasis of immune functions, which might be one of the important mechanisms of SGB's protection towards the post TBI brain functions. This experiment also found that the inhibition of SGB towards IL-6 had a time-effect feature: it only exhibited strong inhibitory effect to IL-6 on 1 h-after-SGB-treatment in the SGB group, and on the post-injury seventh day, the IL-6 expression levels of the control group and the SGB group were equal. This meant while the SGB suppressed the expression of IL-6, it still needed to be confirmed that whether it was likely to retain its role in the nerve repairing in the late TBI.

As an important source of cytokines, the excessive activation of lymphocytes is tightly related with the development of SIRS and MODS. NO is one of the effector molecules for activation of the lymphocyte inflammatory response and immunoreaction and is an important proinflam-

matory mediators which plays the promotive effect in the development of inflammation [22-24]. NO is also concerned with several inflammatory signal pathway [25, 26]. Our present study revealed that SGB can not only significantly suppress the production of NO, but also obviously down-regulate the iNOS expressions in the peritoneal lymphocytes.

Neuroendocrine responses refer to the stress process that starts immediately after traumatic brain injury (TBI). Moderate responses to maintain body homeostasis is of crucial importance[27], but post-traumatic systemic inflammatory response syndrome (SIRS) and immune dysfunction can be induced by over-response. The over-stress reaction after severe trauma mainly manifest as the over- activations of the hypothalamus-pituitary-adrenal (HPA) axis and the sympathetic-adrenal medulla (SAM) system. The excitations of HPA axis can be evaluated by the level of serum ACTH and GC. In addition, the excitation of SAM system after TBI makes the persistent increase of the concentration of plasma NA and AD, which leads important organs to hypoxic-ischemic damage and dysfunction. Results show that serum GC and ACTH of patients in both groups reached the peak on the second day after TBI and then went down gradually, but at the same time point, the concentration of ACTH in SGB group was significantly lower than they were in the control group. After TBI, the concentrations of serum NA and AD increased rapidly of patients in both groups. And on the second day after TBI, the increased extension in the SGB group was significantly lower than the control group. The level of serum NA and AD in both groups went back until the seventh day. However, the serum concentration of AD and NA in the SGB group were significantly lower than that of the control group at each time point, which showed TBI excited the sympathetic-adrenal-medulla system and SGB treatment could alleviate significantly the stress response level. All these results above show that SGB help to maintain a stable inner environment after injury. Studies [28, 29] have reported that TBI leads to adrenal cortical dysfunction and the decrease of the level of ACTH and GC, which is incompatible with our results. After analyzing the results, we think it may be related to the differences of patients in the study.

GC reaction is one of the stress reactions of the body, and GR is the key point GC which not only participates in the body's energy metabolism, but also relates with a variety of gene transcriptional regulation. Severe trauma can induce the down-regulation of glucocorticoid receptor (GR) expression and function decline, which can lead to the disorder of the stress response of GR in the body. Our results showed that the GR protein expression in the SGB group was significantly higher than that in the control group after TB. The level of glucocorticoid receptor is related to the prognosis of patients, the higher the level of glucocorticoid receptor, the better the prognosis of patients, conversely, the prognosis is poor. In this study, the level of TNF- $\alpha$ , IL-1 $\beta$  and IL-6 increased and GR decreased in the control group after TBI; while TNF- $\alpha$ , IL-1 $\beta$  and IL-6 was lower and GR was higher than the control group at the same time, which means the negative correlation of GR and inflammatory mediators. This result revealed that increased inflammatory cytokines may inhibit the expression of GR after TBI. At the same time, as the important anti-inflammatory molecules, GR expression may lead to inhibition of generation and release of a large number of inflammatory mediators.

This study aimed to discuss the influence of SGB on early stress and inflammation reaction. The results showed that SGB can effectively inhibit early stress and inflammation reaction and improve clinic outcome, which was the same as our hypothesis and indicated that SGB could help improve the prognosis of patients with acute brain injury. Past study has shown that neural circuits responsible for mediating sympathetic-immune [30]. Furthermore, it is worth considering that early stress response and inflammatory response of TBI patients get touched with each other through which signaling pathways. SGB maybe inhibit early inflammatory response after TBI through inhibiting the euphoria of the autonomic nervous system and through maintaining a moderate amount of stress reaction. There are no in-depth reports published at home and abroad about the treatment effect and mechanism of the improvement made by SGB towards the prognosis of patients with acute brain injury.

Previous studies have shown that in view of the neuro-immune response after traumatic brain

injury management strategy was feasible [31], and could reduce long-term impaired cognitive function caused by trauma-induced and nerve degeneration-caused. Experimental and clinical studies used melatonin, glucocorticoid, tumor necrosis factor (TNF) antibody, endotoxin antibody, interleukin-1 (IL-1) receptor antagonist, bradykinin antagonist, interleukin-6 (IL-6) receptor antagonist, and hemodialysis to inhibit or remove inflammation medium and etc [32-34], and obtained certain effects, but had not reached satisfactory results yet. Because of the complexity of post TBI inflammatory response, the series therapies of anti-inflammatory drug should be limited to be short and in the specific time periods. This study thinks that SGB can provide new thoughts about how to manage the post-TBI neural immune response.

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### Disclosure of conflict of interest

None.

**Address correspondence to:** Dr. Jun Li, Department of Anesthesia, Chengdu Military General Hospital, No. 270 Rongdu Avenue, Jinniu District, Chengdu 610083, Sichuan, China. E-mail: 778267418@qq.com; Dr. Xi Yang, Department of Anesthesiology, Sichuan Academy of Medical Sciences & Sichuan Provincial People's Hospital, No. 32 West Second Section First Ring Road, Chengdu 610072, Sichuan, China. E-mail: 552309660@qq.com

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