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Original Research Article

Minimal Volume of Local Anesthetic Required for an Ultrasound-Guided SGB

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Contribution:
Mi Hyeon Lee: Study design, conduct of study, data analysis, manuscript preparation
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Abstract

Background. Compared with the blind technique, ultrasound-guided stellate ganglion block (SGB) reduces the amount of local anesthetic needed for a successful block. The purpose of this study is to determine the minimal, optimal volume of local anesthetic required for successful ultrasound-guided SGB and to reduce its adverse effects.

Methods. Thirty-five patients with postherpetic neuralgia and complex regional pain syndrome of the upper extremity and the facial area were selected. For ultrasound-guided SGB by subfacial method, each patient was injected with 0.5% mepivacaine mixed with contrast media in 2 mL, 3 mL, and 4 mL doses at 2-week intervals. After the procedure, the spread of contrast media in the spine was checked by fluoroscopy. Ptosis and conjunctival flushing were rated and recorded. Adverse effects, such as hoarseness, foreign body sensation, swallowing difficulty, and upper arm weakness, were also recorded.

Results. Out of the 35 initial patients, the results for 33 patients who received all three SGBs were included in this study. The contrast media spread to 4.80 ± 0.82, 4.94 ± 0.86, and 5.09 ± 0.97 total spinal segments in the 2 mL, 3 mL, and 4 mL groups, respectively. The cephalad spread of contrast media was 2.16 ± 0.74, 2.23 ± 0.85, and 2.30 ± 0.78 spinal segments for the 2 mL, 3 mL, and 4 mL groups, respectively, and the caudad spread of contrast media was 2.64 ± 0.51, 2.70 ± 0.61, and 2.89 ± 0.64 segments in the 2 mL, 3 mL, and 4 mL groups, respectively. There were no significant statistical differences in any segments for the three groups ($P > 0.05$). Review of the fluoroscopic images showed spread of the contrast media below the C7–T1 junction in all three groups. Ptosis developed in all three groups after the procedure.

Conclusion. In conclusion, when performing an ultrasound-guided SGB, 2 mL dosage was sufficient for a successful block as the previous, conventional volume. Therefore, when performing an ultrasound-guided SGB, we recommend the 2 mL dosage of local anesthetics for a successful block.

Key Words. Sympathetic Block; Ultrasound

Introduction

Stellate ganglion block (SGB) is a common treatment method for sympathetic-mediated pain of the head, neck, and upper extremities [1]. SGB is also effective in the treatment of phantom pain, postherpetic neuralgia, cancer pain, cardiac arrhythmias, orofacial pain, and vascular headache [2]. The conventional technique for SGB is a blind technique in which the end of the needle is targeted to the C6 transverse process [3]. However, this blind technique can cause various adverse effects, such as epidural, subarachnoid, or intravascular injection, formation of hematomas, and esophageal injury [4–7]. Furthermore, the success rate of the blind technique varies from 16–100% [8–10].

Ultrasound-guided SGB was introduced in 1995 [6]. Ultrasound scanning can image and distinguish the anatomical structure of the neck. Therefore, this technique is advantageous for the proper placement of the needle tip and the visualization of the local anesthetics during SGB [6]. In addition, ultrasound guidance reduces the amount of local anesthetic needed for a successful block [6]. Kapral et al. [6] and Narouze et al. [7] reported the successful effect with 5 mL of local anesthetic in ultrasound-guided SGB. However, there has been a lack of study on the spread of injectant at the vertebrae level or the success rate of the clinical procedure where the dosage was less than 5 mL.

The purpose of this study was to determine the optimal, minimal volume of local anesthetic required for successful ultrasound-guided SGB and to reduce its adverse effects in patients with head and upper extremity pathology.

Methods

This prospective study was conducted as a crossover, blinded, and controlled clinical trial.

After the study protocol was approved by the Institutional Review Board, all subjects received a descriptive explanation of the purpose, procedure, and the method of this study and then submitted written consent forms. This study was conducted from September 2011 to December 2011 on 35 patients, ages 20–75, with postherpetic neuralgia and complex regional pain syndrome of the upper extremity and the facial area. The patients who participated in this study were American Society of Anesthesia Physical Status 1 or 2. All patients with a history of anticoagulant therapy, coagulopathy, or deformities of the neck structures were excluded. The height and weight of the patients were measured. All ultrasound-guided SGB were performed by one anesthesiologist with 6 years of experience. For the ultrasound-guided SGB, each patient received 2 mL, 3 mL, and 4 mL dosages at 2-week intervals to allow a washout period of the injectant. The injectant was 0.5% mepivacaine, composed of isohexol 240 mg I/mL, 2% mepivacaine (emcaine®), and normal saline in a 2-1-1 ratio, respectively (for example, the 0.5% mepivacaine 4 mL was prepared by combining isohexol 240 mg I/mL 2 mL, 2% mepivacaine 1 mL, and normal saline 1 mL.) The order of injected dosages was randomly assigned using a randomization table for the 2 mL, 3 mL, and 4 mL dosages.

The patients were positioned in a supine position with the neck slightly hyperextended. Prior to the procedure, the C6 level was confirmed by the use of a 7–14 MHz liner probe (Xario, Toshiba, Japan). On the short-axis view, the prominent anterior tubercle of the C6 was determined and the C7 transverse process was confirmed by scanning caudally. C7 level was confirmed by the absence of the anterior tubercle. Sonoanatomy of the neck at the C6 level was confirmed by transverse short-axis view. The thyroid, inferior thyroid artery, esophagus, the carotid artery, the internal jugular vein, prevertebral fascia, and Chassaignac's tubercle were also confirmed (Figure 1). Color Doppler imaging was utilized to avoid penetrating the vertebral artery, the carotid artery, and the internal jugular vein during the needle insertion. The neck area was sterilized and the probe was covered with sterilized vinyl. At the C6 level, the probe was placed at the anterior scalene muscle, which is located between the carotid sheath and the brachial plexus. A 25-gauge, 6-cm needle (Kovax®) was inserted laterally 2 mm from the probe. The needle tip was placed posterior to the carotid artery, anterior to the longus colli muscle under the transverse short axis for the in-plane approach (subfascial injection) (Figure 2). The assigned dosage of 0.5% mepivacaine, composed of isohexol 240 mg I/mL, 2% mepivacaine (emcaine®), and normal saline in 2-1-1 ratio, respectively, was injected in the patients. Immediately after the procedure, anterior–posterior and lateral views were taken by fluoroscopy (Figure 3). Each image sequence was randomly numbered and stored on a computer, while the injected dose volume was recorded and saved separately. After all procedures were completed, the stored images were analyzed in batches by a physician who was blinded to the volume of injectate. Finally, the number of each analyzed image was matched to the local anesthetic volume and the data were summarized. Each vertebra was divided into four subsegments, and the spread of the contrast media at the spinal level from the C6 midline was digitized. The level above and below the final spinal level of contrast media spread was then recorded.

After fluoroscopic imaging, the patient was transferred to a recovery room and stabilized for 30 minutes under close monitoring. After an additional 15 minutes, any effects of the sympathetic block, such as ptosis and conjunctival flushing, were recorded. The sympathetic block was categorized into groups from 0–3. Ptosis was classified as 0 (no dropping of the eyelid), 1 (1/4 dropping of the eyelid), 2 (1/2 dropping of the eyelid), and 3 (almost complete dropping), and conjunctival flushing was classified as 0 (no conjunctival flushing), 1 (slight flushing), 2 (1/2 flushing), and 3 (complete flushing). After the procedure, hoarseness, dysphagia, foreign body sensation in the throat, and upper extremity weakness were also recorded by a physician who did not perform the ultrasound-guided SGB.

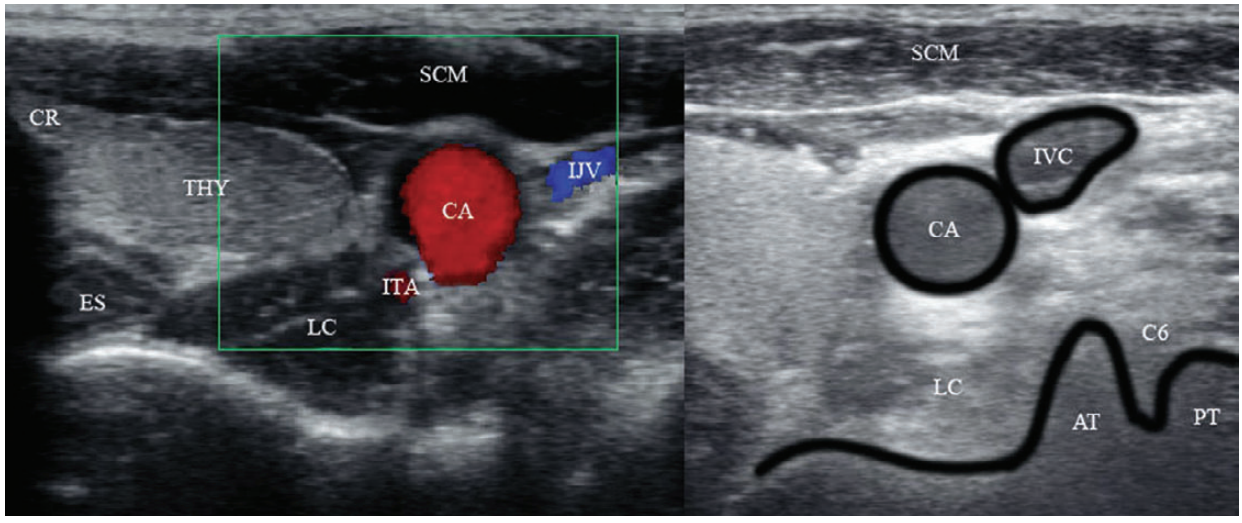

Figure 1 The thyroid (THY), inferior thyroid artery (ITA), esophagus (ES), the carotid artery (CA), the internal jugular vein (IJV), prevertebral fascia, and Chassaignac's tubercle were checked. CR = cricoid cartilage; SCM = sternocleidomastoid muscle; LC = longus colli muscle; C6 = root of C6; AT = anterior tubercle of C6; PT = posterior tubercle of C6.

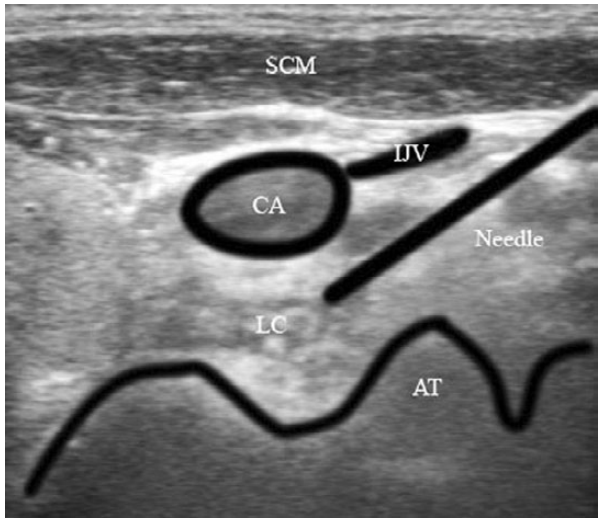

Figure 2 The target point was prevertebral fascia under the carotid artery (CA). Anterior tubercle (AT) of C6, IJV and CA by transverse short axis were revealed. By in-plane approach, needle tip was checked and pushed. When the tip approached the prevertebral fascia, drugs were injected (subfascial injection). IJV = internal jugular vein; LC = longus colli muscle; SCM = sternocleidomastoid muscle.

Sample Size

The spread of contrast media below the C7–T1 junction after the procedure was considered a success. The primary outcome was the success rate in each dosage group (2 mL, 3 mL, and 4 mL). Based on our preliminary study of ultrasound-guided SGB in 30 patients, the expected success rate for the 2 mL dosage group was 97%. Assuming a success rate of 80% for the null hypothesis, calculations to determine the required sample size (with $\alpha = 0.05$ and $\beta = 0.8$) showed that we would need at least 25 patients in each group to demonstrate statistical significance. Taking into consideration the possible elimination of some patients due to the invasiveness of the procedure, 35 patients were initially recruited for this study.

Statistical Analysis

The data were analyzed using SPSS (Version 19.0, SPSS Inc., IBM Company, Armonk, NY, USA) and the results were expressed as means ± standard deviation. The spread of the contrast media was assessed by mixed model analysis. Fisher's exact test was used to assess the difference of the success rate of the three groups based on whether or not there was contrast from T1. Among the three groups, differences between ptosis and conjuctival flushing were assessed by Fisher's exact test. A *P* value of less than 0.05 represented a statistically significant difference.

Results

Out of the initial 35 patients, two patients declined further treatments; the results of the 33 patients (99 SGBs) who

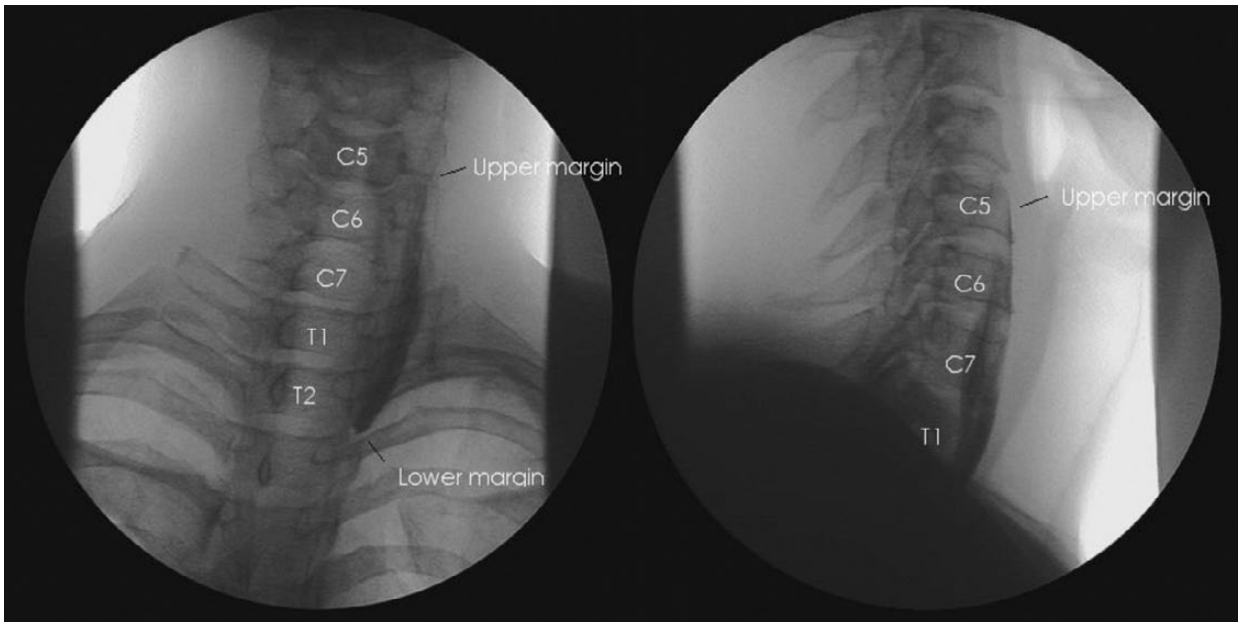

Figure 3 Anterior–posterior view and lateral view. Picture of spread contrast media from C5–T2. The distribution of contrasts, upper margin of contrast and lower margin of contrasts was checked.

received all three SGBs were therefore included in this study. The demographic data of the subjects are listed on Table 1.

The distribution of the contrast media in each procedure is shown on Table 2. The contrast media spread to 4.80 ± 0.82, 4.94 ± 0.86, 5.09 ± 0.97 total spinal segments in the 2 mL, 3 mL, and 4 mL groups, respectively. Statistically, there were no significant differences between the three groups ($P = 0.407$) (Table 2). The cephalad spread of the contrast media was 2.16 ± 0.74, 2.23 ± 0.85, 2.30 ± 0.78 spinal segments in the 2 mL, 3 mL, and 4 mL groups, respectively. Again, there were no statistically significant differences between the three groups ($P = 0.582$) (Table 2). The caudad spread of contrast media was 2.64 ± 0.51, 2.70 ± 0.61, 2.89 ± 0.64 spinal segments in the 2 mL, 3 mL, and 4 mL groups, respectively. There were no statistically significant differences between the three groups ($P = 0.762$) (Table 2). The scopes of the spread of contrast media to spinal segments are charted in Figure 4. There were no statistically significant differences between the three groups ($P > 0.05$) (Figure 4). Spinal segments of cephalad spread of contrast media are charted on Figure 5. The cephalad spread of contrast media was not statistically significantly different between the groups ($P > 0.05$). The contrast media spread

Table 1 Demographic data

	Patients (N = 33)
Age (year)	50.15 ± 13.89
Sex (M/F)	12/22
Height (cm)	163.7 ± 6.9
Weight (kg)	639 ± 10.6

Values are mean ± standard deviation.

Table 2 Spread of contrast media in spinal segment from C6

	Dose (mL)			
	2	3	4	*P* Value
Range (segments)	4.80 ± 0.82	4.94 ± 0.86	5.09 ± 0.97	0.407
Cephalad above C6 (segments)	2.16 ± 0.74	2.23 ± 0.85	2.30 ± 0.78	0.582
Caudad below C6 (segments)	2.64 ± 0.51	2.70 ± 0.61	2.89 ± 0.64	0.762

Values are mean ± standard deviation. Statistically, there were no significant differences between the three groups (mixed model analysis, $P > 0.05$).

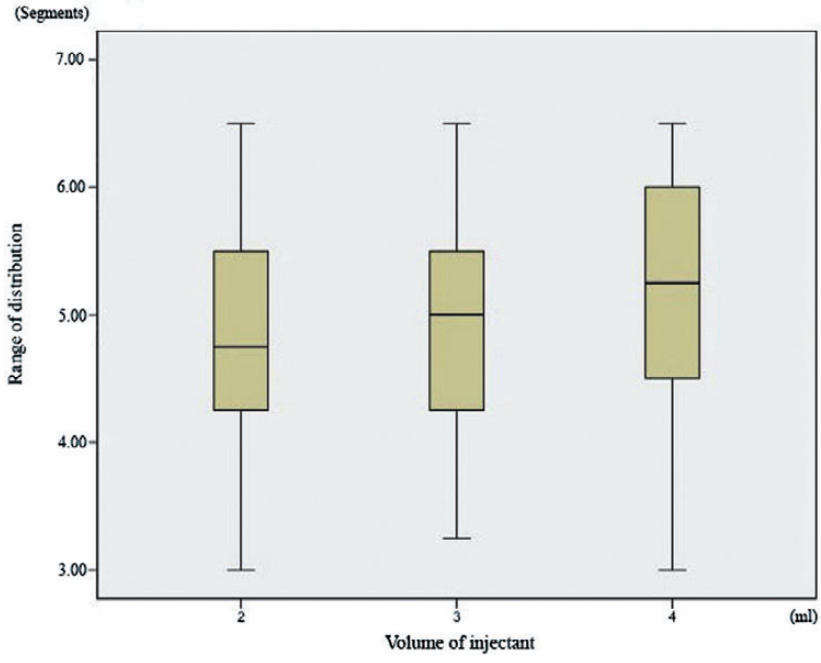

Figure 4 Spread of contrasts from C6 center line. The range is sum of upper (cephalad) distribution and lower (caudad) distribution. There were no differences in three groups ($P > 0.05$).

above the C4 according to the attached graph (Figure 5). The spinal segments of the caudad spread of contrast media are charted on Figure 6. The caudad spread of contrast media showed no statically significant differences between the three groups ($P > 0.05$). The graph shows the contrast media spread below the C7–T1 junction in all procedures (Figure 6). The success rates for the procedure based on the spread of the contrast media are shown on Tables 3 and 4. All of the procedures were 100% successful as seen by the spread of contrast media below the C7–T1 junction (Table 3). The contrast media reached below the center of the T1 vertebra as shown on Table 4. Except in two cases in the 3 mL group, the contrast media spread below the center of the T1 vertebra (Table 4).

After the procedure, to compare the clinical effects, ptosis and conjuctival injections were rated and recorded on Tables 5 and 6. The degree of ptosis was quantified and if

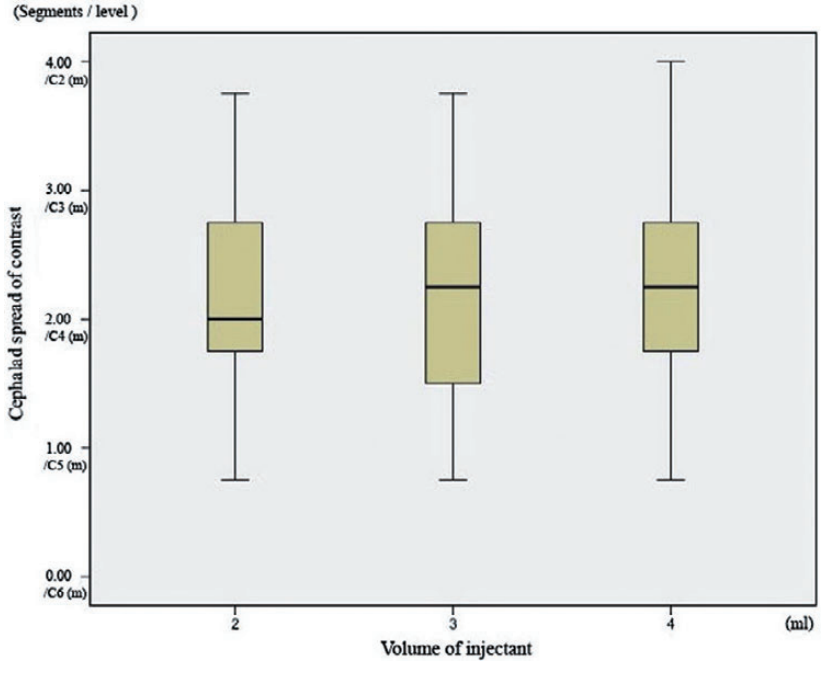

Figure 5 Cephalad spread of contrast media from C6 and cephalad distribution of contrast media. Statistically, there were no significant differences between the three groups ($P > 0.05$). m = mid-portion of vertebrae.

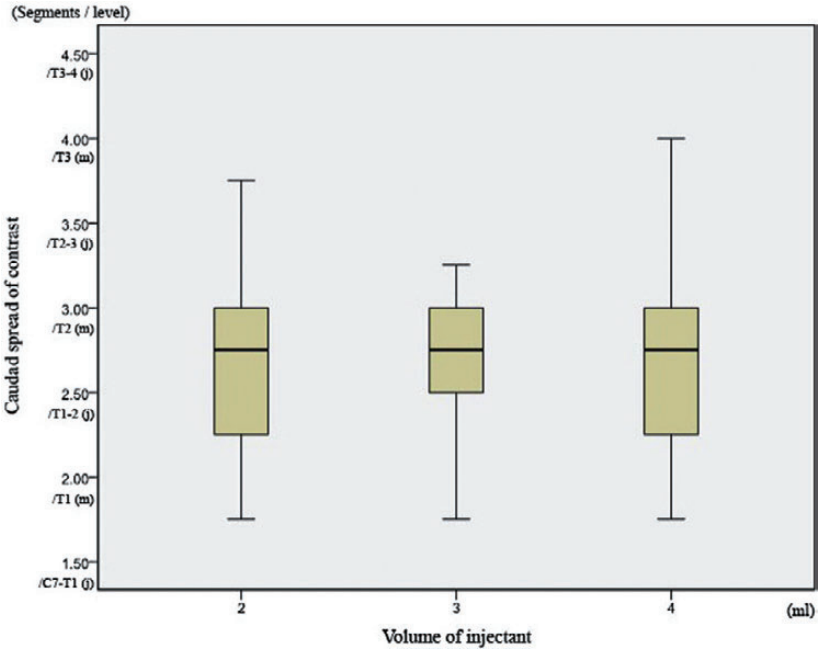

Figure 6 Caudad spread of contrast from C6. There were no differences in the three groups ($P > 0.05$). m = mid-portion of vertebrae; j = junction.

it was greater than 1, ptosis occurred and therefore, all of the procedures obtained ptosis. The quantified degrees of ptosis were compared and there were no statistically significant differences between the three groups ($P = 0.417$) (Table 5). Also, the quantified degrees of conjuctival flushing were compared and there were no statistically significant differences between the three groups ($P = 0.465$) (Table 6).

After the procedure, side effects, such as hoarseness, dysphagia, foreign body sensation in the throat, and upper extremity weakness, did not occur in any group.

Discussion

The stellate ganglion is oval in shape, approximately 2.5 cm long, 1.0 cm wide, and 0.5 cm thick, and normally

Table 3 Success rate of spread of contrast (based at C7–T1 junction)

	Dose (mL)			
Caudad Spread	2	3	4	*P* Value
Above C7–T1 junction	0/33 (0.0%)	0/33 (0.0%)	0/33 (0.0%)	>0.05
Below C7–T1 junction	33/33 (100.0%)	33/33 (100.0%)	33/33 (100.0%)	

Values are number of incidence (%). All of the procedures were 100% successful as seen by the spread of the contrast media below the C7–T1 junction. Statistically, there were no significant differences between the three groups (Fisher's exact test, $P > 0.05$).

Table 4 Radiologic outcome (Based at T1 vertebrae center line)

	Dose (mL)			
Caudad Spread	2	3	4	*P* Value
Above T1 center line	0/33 (0%)	2/33 (5.89%)	0/33 (0%)	0.327
Under T1 center line	33/33 (100%)	31/33 (94.11%)	33/33 (100%)	

Values are number of incidence (%). Except for two cases in the 3 mL group, in all the remaining cases, the contrast media spread below the center of T1 vertebrae. Statistically, there were no significant differences between the three groups (Fisher's exact test, $P > 0.05$).

Table 5 The rate of ptosis after procedure

Degree of Ptosis	Dose (mL) 2	3	4	*P* Value
0	0 (0%)	0 (0%)	0 (0%)	0.417
1	5 (15.2%)	5 (15.2%)	5 (15.2%)	
2	19 (57.5%)	21 (63.6%)	14 (42.4%)	
3	9 (27.3%)	7 (21.2%)	14 (42.4%)	

Values are number of incidence (%). Statistically, there were no significant differences between the three groups (Fisher's exact test, $P > 0.05$).

lies in front of the neck of the first rib and extends to the interspace between C7 and T1 [3]. In 80% of the population, this structure is formed by the fusion of the inferior cervical ganglion and first thoracic ganglion. The traditional method of SGB enforcement uses the anterior tubercle of the C6 vertebra or, less commonly, the C7 vertebra as a landmark. Conventional SGB also requires a large volume of local anesthetic [11]. The large volume of local anesthetic coupled with the complex anatomy of the cervical fascia renders delivery of the injectant unpredictable [9]. Also, the large volume of the local anesthetic can cause upper cervical block (C1–C6) and can spread and block the recurring laryngeal nerve, causing hoarseness [11]. Wulf et al. [12] recommended using minimal volume of local anesthetic for SGB because toxic plasma level was reported in 30% of patients who received 10 mL of 0.5% bupivacaine.

Ultrasound-guided SGB requires a smaller volume of local anesthetic compared with the conventional method [6]. Therefore, the authors of this article sought to determine the optimal, minimal volume of local anesthetic required for ultrasound-guided SGB. As stated earlier, the anatomical location of the stellate ganglion must be considered [3], and if the contrast media spreads below the C7–T1 junction, then it is thought to be a procedural success. Mepivacaine 0.5% mixed with contrast media was injected three times (2 mL, 3 mL, and 4 mL) and the success rate for each group was the primary outcome. The contrast media spread below the C7–T1 junction in all three groups (Table 3). Also, in all groups, except in two cases in the 3 mL group, the contrast media spread below the center line of the T1 vertebra, which was also beyond the stellate ganglion.

The authors compared the clinical outcomes (ptosis, conjunctival flushing) of the three groups, as well as the anatomical success rate based on the contrast images. Ptosis and conjunctival flushing were considered effective if rated more than one point. Ptosis was observed in all three groups; in order to compare the quality of the block, it was quantified, and there were no differences between the three groups. The quality of conjuctival flushing was also compared and there were no differences between the three groups.

Considering both the anatomical and clinical results of this study, ultrasound-guided SGB can be successful with less than 5 mL, specifically 2 mL, of local anesthetic. This is less than the 4 mL volume of local anesthetic that was suggested by Jung et al. [13] who used 0.2% ropivacaine. They used the out-of-plane technique for ultrasound-guided SGB and considered the development of Honer's syndrome as marking a successful procedure. However, aside from the clinical result, the extent and modality of the spread of the local anesthetics were not known. In contrast, in this study, the primary outcome was anatomical success based on the distribution of the contrast media and the visible spread of the local anesthetic. In our study, we used the in-plane technique, which has the advantage of confirming the position of the needle tip; hence, a more precise procedure was possible. We therefore assert that a higher success rate for the procedure can be achieved with a smaller volume of local anesthetic.

The limitations of this study are that dosages less than 2 mL were not studied, the degree of the sympathetic block based on the palm sweat test or a change in skin temperature, the degree of pain relief after the procedure, and the duration of the block were not included in the results. Further studies are therefore needed.

Various imaging devices have been used to improve the accuracy of SGB. Of these, computerized tomography [9] and magnetic resonance image [14] are impractical because they are time consuming and not cost effective. Fluoroscopy is effective in distinguishing bony structures but cannot prevent inadvertent needle placement in major structures, such as the esophagus, vertebral artery, thyroid, and neural tissues [7]. Unlike these other techniques, ultrasound-guided SGB is exceptionally cost and time effective. Also, as the neck structure can be confirmed and the spread of the injectant can be viewed, incorrect placement of the needle tip can be avoided. Ultrasound-guided SGB thus decreases the side effects and improves the safety of the procedure [6]. In this study, side effects, such as hoarseness, swallowing difficulty, foreign body sensation, and upper extremity weakness, were not observed.

Table 6 The rate of conjunctival flushing after procedure

Degree of Conjunctival Flushing	Dose (mL) 2	3	4	*P* Value
0	2 (6.1%)	3 (9.1%)	2 (6.1%)	0.465
1	21 (63.6%)	16 (48.5%)	16 (48.5%)	
2	9 (27.3%)	13 (39.4%)	10 (30.3%)	
3	1 (3.0%)	1 (3.0%)	5 (15.2%)	

Values are number of incidence (%). Statistically, there were no significant differences between the three groups (Fisher's exact test, $P > 0.05$).

In conclusion, this study examined the minimal volume of local anesthetic required during ultrasound-guided SGB. We found that a smaller volume of local anesthetic had the same, sufficient effect compared with the previously recommended larger volume. Therefore, we recommend a volume of 2 mL of local anesthetic for ultrasound-guided SGB as it does not produce adverse side effects and it is sufficient for a successful SGB.

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