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ORIGINAL ARTICLE

The influence of interscalene block technique on adverse hemodynamic events

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Abstract
Purpose A hemodynamic event such as hypertension after interscalene block (ISB) is a complication that is often overlooked. The irregular spread of local anesthetic would cause a blockade of carotid sinus baroreceptors leading to the adverse event. The purpose of the present study is to compare ultrasound and neurostimulation technique in preventing hypertension after ISB.
Methods Thirty patients without hypertension history who underwent arthroscopic shoulder surgery for a rotator cuff tear were enrolled. After preoperative administration of the State Trait Anxiety Inventory questionnaire, patients were allocated to receive ultrasound-guided ISB with 20 ml levobupivacaine-HCl 0.5 % (group US) and 40 ml levobupivacaine-HCl 0.5 % with neurostimulation (group NS). The need for antihypertensive drug was recorded. Block onset sensory and motor times were assessed. Systolic and diastolic blood pressures, and heart rate and pulse oximetry (SpO_2), were evaluated before the block as well as 2, 5, 10, 15, 20, and 30 min after.
Results No differences in patient characteristics and anxiety were found in the two groups. Block onset times were similar. At 15 min after block placement, group NS showed significantly higher systolic and diastolic blood pressures compared to group US. No differences in heart rate and SpO_2 were found between the two groups. Three patients of group NS required urapidil administration because of hypertension.
Conclusions Ultrasound-guided ISB permits the use of a low volume of local anesthetic and seems to reduce the incidence of hypertension.

Keywords Hypertension · Nerve stimulation · Ultrasonography · Interscalene brachial plexus block

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Introduction

Interscalene block (ISB) is regarded as an effective anesthetic technique for arthroscopic shoulder surgery [1]. Complications associated with ISB are well documented [2] and include blockade of the phrenic nerve causing diaphragmatic paralysis, recurrent laryngeal nerve block, and blockade of the sympathetic chain causing Horner's syndrome and bronchospasm. However, hypertension after ISB resulting from the inadvertent blockade of nerves innervating the carotid and aortic baroreceptors is underappreciated. The ISB can cause brief hypertension without tachycardia that can require treatment.

The proximity of the carotid sinus baroreceptors to the site of injection can cause a blockade of these receptors, leading to neurogenic hypertension. The carotid sinus baroreceptors are innervated by Hering's nerve, which is a branch of the glossopharyngeal nerve. The glossopharyngeal nerve synapses are in the nucleus tractus solitarius (NTS), and neurons from the NTS project to the nucleus ambiguous where they influence the firing of the sympathetic and parasympathetic nerves.

There are few reports focusing on inadvertent blockade of the nerve innervating the carotid and aortic baroreceptors and its consequences [3, 4]. One case of sustained

hypertension produced by the unilateral section of the glossopharyngeal nerve is reported [5].

Ultrasound (US) guidance for ISB is becoming increasingly common, and it can maximize block quality while minimizing block-related complications by injecting under direct visualization of the target nerve [6, 7]. Moreover, ultrasound ISB allows a reduction in the amount of local anesthetic (LA) necessary for an adequate block of the shoulder surgery [8, 9].

The aim of this study is to test our hypothesis that decreased dose of LA by directed visualization of neural structures under US guidance might reduce the risk of hypertension following ISB.

Materials and methods

This study was conducted on 30 patients 18–50 years of age, ASA physical status I, who were scheduled to undergo arthroscopic shoulder surgery for a rotator cuff tear. This study protocol was approved from the institutional ethical committee of Careggi Hospital (Florence), and written informed consent was obtained from all patients. Patients were excluded from the study if they had a coagulopathy, a cardiothoracic or vascular disease, were allergic to LA, or were taking drugs that could have affected their blood pressure or heart rate.

The day before the surgery, each patient received, by a psychologist, a copy of the Spielberger State-Trait Anxiety Inventory (STAI) to evaluate their anxiety [10]. The STAI clearly differentiates between the temporary condition of "state anxiety" (STAI-S) and the more general and long-standing quality of "trait anxiety" (STAI-T).

This instrument is a tool structured with 20 items for the "trait" and 20 items for the "state anxiety" (each question with 1–4 points answer-score) (Table 1). The overall (total) score for STAI ranges from a minimum of 20 to a maximum of 80; STAI scores are commonly classified as 'no or low anxiety' (20–37), 'moderate anxiety' (38–44), and 'high anxiety' (45–80) [11].

In the preoperative regional anesthesia room, routine monitors including ECG, noninvasive arterial pressure measured with an automatic cuff, and pulse oximetry (SpO_2) were attached, and IV access was established in the nonoperative arm with an infusion of 0.9 % saline at a maintenance rate. Blocks were performed or directly supervised by two anesthetists (L.G. and M.M.) experienced in both NS and US-guided ISB.

Patients were placed in the supine position with the neck rotated slightly to the contralateral side. Using a computer-generated sequence of random numbers, patients were randomly assigned to receive either US-guided ISB with 20 ml levobupivacaine-HCl 0.5 % (Chirocaine; Abbott, Campoverde di Aprilia, Italy) (group US, $n = 15$) or ISB using NS with 40 ml levobupivacaine-HCl 0.5 % (group NS, $n = 15$).

In group US, after adequate skin disinfection with chlorhexidine, nerve location was performed using a MyLab 30 Gold (ESAOTE, Florence, Italy) ultrasound system with a 10–12 MHz linear probe covered with a sterile sheet. The brachial plexus was identified by placing the US probe immediately superior and parallel to the clavicle. The subclavian artery was identified on its short axis and the brachial plexus was identified. While maintaining the brachial plexus in the center of the image, the probe was moved in a cephalic direction until the brachial plexus could be identified between the anterior and middle scalene muscles. After LA skin infiltration with 1 % lidocaine (2 ml), an 18 G, 50-mm short-bevel needle (Stimuplex A; Braun, Melsungen, Germany) was inserted with an in-plane approach and advanced through the middle scalene muscle. The LA (levobupivacaine-HCl 0.5 %, 20 ml) was then injected with intermitted aspiration so that spread was seen between the C5 and C6 nerve roots.

In group NS, skin landmarks were drawn, including the cricoid cartilage, the two heads of the sternocleidomastoid muscle, and the interscalene groove. A horizontal line was drawn at the level of the cricoid cartilage to intersect laterally the interscalene groove, defining the needle insertion point. An 18 G, 50-mm, short-bevel needle (Stimuplex A; Braun) was connected to a nerve stimulator (Stimuplex HNS 12; Braun), initially set up to deliver a 1.0-mA intensity current (2 Hz, 0.2 ms). After a 2-ml 1 % lidocaine skin infiltration, the needle was inserted through the skin with a 45° angle between the anterior and middle scalene muscles just posterior to the sternocleidomastoid muscle according to the Winnie technique [12]. Upon achieving muscle contractions of the deltoid, the position of the needle was adjusted to maintain the proper twitch, while the intensity of stimulation was progressively reduced to a 0.5-mA current. The LA (levobupivacaine-HCl 0.5 %, 40 ml) was injected in increments with aspiration tests intermittently.

At 30 min after block placement, all patients were placed in the "beach-chair" position. Noninvasive blood pressure was measured at the nonoperative side. Pressure monitoring was continued even after the end of the study protocol for a further 30 min.

The systolic arterial pressure (SAP), diastolic arterial pressure (DAP), heart rate (HR), and SpO_2 were measured before block performance (0), and then 2, 5, 10, 15, 20, and 30 min after the block. If hypertension occurred (SAP >140 mmHg), urapidil 10 mg was administered intravenously.

Sensory block of the upper extremity was assessed by pinprick using a 23 G needle testing from C4 to T1

Table 1 The Spielberger State-Trait Anxiety Inventory (STAI) [10]

Part 1. STAY-S

Instructions: A Number of statements which people have used to describe themselves are given below. Read each statement and then circle the response option to the right to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement, but give the answer which seems to describe your present feelings best.

1= not at all
2= somewhat
3= moderately so
4= very much so

1. I feel calm	1 2 3 4
2. I feel secure	1 2 3 4
3. I am tense	1 2 3 4
4. I am regretful	1 2 3 4
5. I feel at ease	1 2 3 4
6. I feel upset	1 2 3 4
7. I am presently worrying about possible misfortunes	1 2 3 4
8. I feel rested	1 2 3 4
9. I feel anxious	1 2 3 4
10. I feel comfortable	1 2 3 4
11. I feel self-confident	1 2 3 4
12. I feel nervous	1 2 3 4
13. I am jittery	1 2 3 4
14. I feel "high strung"	1 2 3 4
15. I am relaxed	1 2 3 4
16. I feel content	1 2 3 4
17. I am worried	1 2 3 4
18. I feel over-excited and rattled	1 2 3 4
19. I feel joyful	1 2 3 4
20. I feel pleasant	1 2 3 4

dermatomes and scored as full sensation = 1 and loss of sensation to touch or pinprick = 0. The motor power was assessed by failure to abduct the shoulder, the so-called deltoid sign [13].

A power analysis estimated that 15 patients would be needed in each group to provide a variation of brachial arterial pressure (systolic and diastolic) of more than 10 % compared with basal values.

All analysis was performed with the statistical package SPSS for Windows (version 11, 0; SPSS, Chicago, IL, USA). Results were presented as the mean ± standard deviation (SD) (continuous variables) or percentage (categorical variables). Comparison between means of continuous variables was done with a two-tailed Student's *t* test and comparison of percentages was made using chi square analysis. A repeated-measures analysis of variance (ANOVA) test, with the Bonferroni correction, was conducted for the systolic and diastolic blood pressures, heart rate, and SpO_2. A *p* value <0.05 was considered statistically significant.

Results

Demographic and surgical characteristics were similar in the groups (Table 2). No differences were seen in onset of sensory and motor block between groups (12 ± 6 vs. 13 ± 5 min and 14 ± 5 vs. 15 ± 6 min). At 20 min after the end of the block, sensory anesthesia to prick test was detected over C4, C5, C6, C7, and T1 dermatomes in 98 %, 98 %, 97 %, 96 %, and 97 % of group US patients and 100 % of group NS patients. At 30 min, sensory and motor block were complete in both groups.

There were no complications such as intravascular injection, persistent motor loss, or persistent sensory loss. Overall, the patients of the two groups had low preoperative anxiety (STAI-S scores lower than 37) (Table 2).

The systolic and diastolic pressures changed more significantly in group NS than in group US ($p < 0.05$) during the first 30 min after block performance (Figs. 1, 2). No significant changes in heart rate and SpO_2 were seen (Figs. 3, 4). None of the patients suffered from dyspnea or alteration of respiratory pattern. In three patients in group NS, hypertension occurred in the first 30 min after ISB placement, requiring urapidil administration (23.3 ± 5.7 mg).

After a further 30 min, all patients had reduced blood pressure values; however, the blood pressure reduction was less evident in patients of group NS than in group US (10 vs. 25 %, $p < 0.05$).

Table 2 Patient characteristics

Variable	Group US ($n = 15$)	Group NS ($n = 15$)
Age (years)	62 ± 19	55.3 ± 17
Male/female (*n*)	9/6	7/8
Height (cm)	168.6 ± 11.8	169.3 ± 10
Body weight (kg)	83.3 ± 10.4	88.6 ± 17.9
BMI (k/m^2)	29.9 ± 8.3	31.1 ± 7.4
Shoulder right/left	8/7	6/9
STAI-T	28 ± 3	27 ± 2
STAI-S	32 ± 3	32 ± 4
Surgical duration (min)	77.5 ± 16.5	70 ± 15.8

Values are mean ± SD or number of patients (*n*)

There were no significant differences between the two groups

BMI body mass index, *STAI-T* State-Trait Anxiety Inventory trait, *STAI-S* State Trait Anxiety Inventory state, *group US* ultrasound-guided ISB with 20 ml levobupivacaine-HCl 0.5 %, *group NS* 40 ml levobupivacaine-HCl 0.5 % with neurostimulation

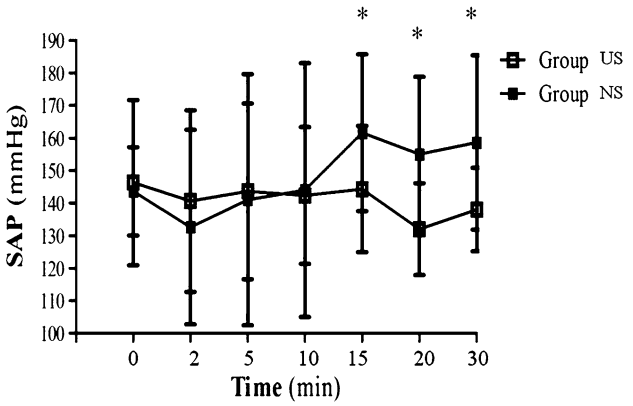

Fig. 1 Systolic blood pressure (SAP) before the block (T0), and then 2, 5, 10, 15, 20, 30 min after. *$p < 0.05$

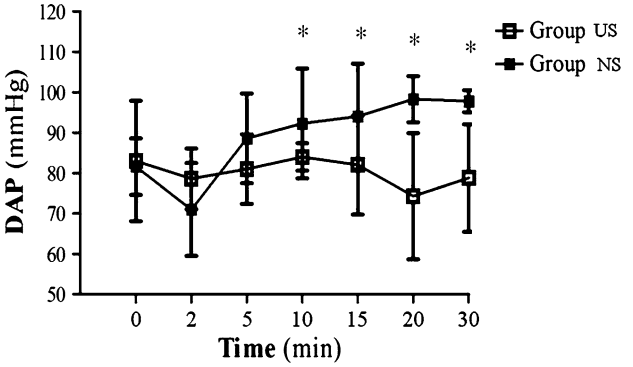

Fig. 2 Diastolic blood pressure (DAP) before the block (T0), and then 2, 5, 10, 15, 20, 30 min after. *$p < 0.05$

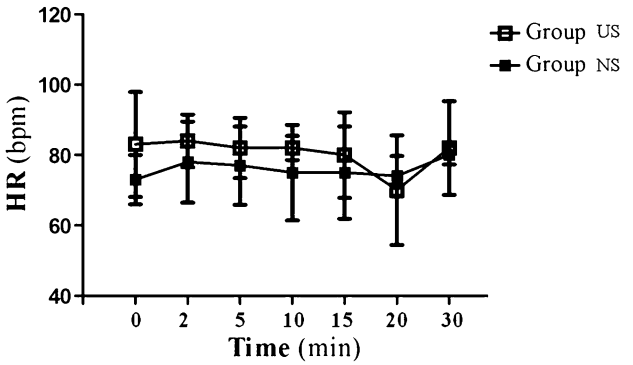

Fig. 3 Heart rate (HR) values before the block (T0), and then 2, 5, 10, 15, 20, 30 min after

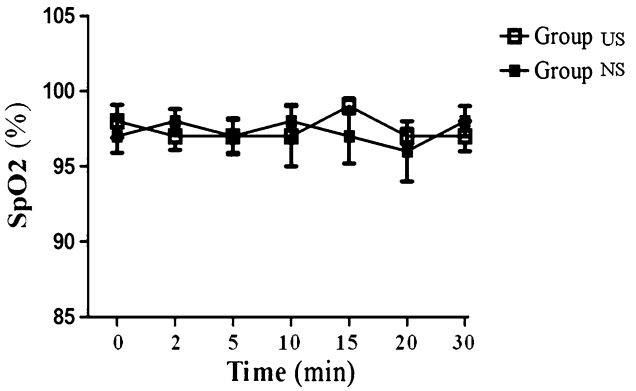

Fig. 4 SpO_2 values before the block (T_0), and then 2, 5, 10, 15, 20, 30 min after

Discussion

In this study, we found that the use of US guidance during ISB can prevent hemodynamic events, such as hypertension, with the same block quality.

Hypertension after ISB is an early complication not yet covered in medical literature. Moreover, the ISB is often realized for shoulder surgery that is commonly performed in the sitting or "beach-chair" position. Significant hemodynamic changes characterized by sudden decreases in heart rate and/or blood pressure caused by activation of the Bezold–Jarish reflex occur in 24 % of patients undergoing ISB anesthesia when the patient's position is changed from supine to sitting [14].

In the literature only two reports have considered hypertension as a complication of ISB. Chakithandy et al. [3] reported a case of hypertension emergency following ISB in a hypertensive lady with unstable angina. Similarly, Hernandez et al. [4] found an increase of blood pressure without tachycardia between 5 and 10 min after ISB in 16 % of patients with normal pressure in preoperative evaluation; 50 % of patients needed hypertension treatment.

The spread of a high volume of LA may reduce the ability of baroreflex receptors to respond to blood pressure variation. Elliot et al. [15] have investigated the incidence of intraoperative hypertension and the need for systemic vasodilator medications intraoperatively in patients undergoing carotid endoarterectomy under general anesthesia who received a local anesthetic injection of their carotid sinus nerve with bupivacaine. The local anesthetic injection was associated with a significant incidence of perioperative hypertension.

The carotid sinus baroreceptor is innervated by the sinus nerve of Hering, which is a branch of the glossopharyngeal nerve. Disorders of the glossopharyngeal nerve are associated with transient hypertension in humans. Kezdi [16] described a patient with the polyneuritis form of porphyria in whom unilateral paralysis of the soft palate was associated with hypertension. Diphtheria and herpes zoster as well as toxic neuropathies causing weakness in the distribution of the ninth motor nerve have been associated with hypertension, coinciding and resolving with the course of paralysis [17]. Ripley and colleagues [5] demonstrated that sustained hypertension resulted from unilateral interruption of the glossopharyngeal nerve, which carries fibers from the carotid sinus.

On the basis of sensory and motor onset time of levobupivacaine-HCl established by a previous study [18], we decided to analyze the phenomenon of hypertension in the first 30 min after the block. From the data of the present study, we can conclude that the increase of blood pressure in patients who received ISB with the NS technique occurs 15 min after block placement. The phenomenon is less evident in the sitting position because of activation of the Bezold–Jarish reflex. We hypothesize that the injection of LA into the brachial plexus sheath using US guidance, in addition to reducing the dose of anesthetic used, prevents the spread of the anesthetic in perivascular tissue and hemodynamic consequences such as early increase of blood pressure.

Hypertension after ISB should be distinguished from hypertension caused by anxiety. Some studies have suggested that anxiety, evaluated by a general scale as STAI, is significantly associated with systemic arterial pressure [19, 20]. In the preoperative period we decided to refer patients to the STAI test to exclude patients with a high level of preoperative anxiety. However, our patient population was found to have a low baseline level of anxiety (STAI-S value lower than 37).

We decided to use a smaller volume of levobupivacaine 0.5 % in group US than in group NS (20 ml vs. 40 ml) on the basis of a previous study that established that US reduces the number of attempts and local anesthetic volume when compared with NS for ISB [8].

Phrenic nerve block following ISB is well described, and frequency can be as great as 100 % [21]. It is therefore described as an inevitable consequence of interscalene brachial plexus block [22]. Even reduction of the volume of local anesthetic and applying proximal digital pressure to the site of injection are not effective in reducing the frequency or intensity of diaphragmatic paralysis during ISB [23, 24]. In our study we used a large volume of LA in group NS. We found no statistically significant differences between groups with regard to oxygen saturation. A limitation of our study was that we did not verify the the incidence of hemidiaphragmatic paresis or impairment in pulmonary function by chest radiograph or ultrasonography.

Another limitation was the exclusion of hypertensive patients because of the risk of hypertensive crisis during

the block. Moreover, it appears prudent for patients with hypertension to use a technique that affects less the modification of blood pressure such as US guidance.

In conclusion, the increase of blood pressure is a potentially harmful consequence of ISB that should be considered when planning ISB, especially in patients with cardiovascular diseases or poorly controlled hypertension. The use of a low dose of LA according to US guidance seems to reduce the incidence of this unintended hemodynamic adverse event.

Conflict of interest None of the authors has a conflict of interest with the submission.

References

1. Singelyn FJ, Lhotel L, Fabre B. Pain relief after arthroscopic shoulder surgery: a comparison of intraarticular analgesia, suprascapular nerve block, and interscalene brachial plexus block. Anesth Analg. 2004;99:589–92.
2. Long TR, Wass CT, Burkle CM. Perioperative interscalene blockade: an overview of its history and current clinical use. J Clin Anesth. 2002;14:546–56.
3. Chakithandy S, Kelly P, Barron J. Hypertension emergency as a complication of brachial plexus block. BMJ Case Rep. 2011;. doi:10.1136/bcr.01.2011.3754.
4. Hernandez A, Salgado I, Agreda G, Botana C, Casas M, Nogueron M. Hypertension crisis after interscalene block for shoulder surgery. Eur J Anaesth. 2006;23:126.
5. Ripley RC, Hollifield JW, Nies AS. Sustained hypertension after section of the glossopharyngeal nerve. Am J Med. 1977; 62:297–302.
6. Marhofen P, Greher M, Kapral S. Ultrasound guidance in regional anesthesia. Br J Anaesth. 2005;94:7–17.
7. Kapral S, Greher M, Huber G, Willschke H, Kettner S, Kdolsky R, Marhofen P. Ultrasonographic guidance improves the success rate of interscalene brachial plexus blockade. Reg Anesth Pain Med. 2008;33:252–8.
8. McNaught A, Shastri U, Camichael N, Awad IT, Columb M, Cheung J, Holtby RM, McCartney CJ. Ultrasound reduces the minimum effective local anaesthetic volume compared with peripheral nerve stimulation for interscalene block. Br J Anaesth. 2011;106:124–30.
9. Choquet O, Morau D, Biboulet P, Capdevila X. Where should the tip of the needle be located in ultrasound-guided peripheral nerve blocks? Curr Opin Anesth. 2012;25:596–602.
10. Spielberger CD, Gorssuch RL, Lushene PR, Vagg PR, Jacobs GA. Manual for the State-Trait Anxiety Inventory. Palo Alto: Consulting Psychologists Press; 1983.
11. Ruffinengo C, Versino E, Renga G. Effectiveness of an informative video on reducing anxiety levels in patients undergoing elective coronarography: an RCT. Eur J Cardiovasc Nurs. 2009;8:57–61.
12. Winnie AP. Interscalene brachial plexus block. Anesth Analg. 1970;49:455–66.
13. Wiener DN, Speer KP. The deltoid sign. Anesth Analg. 1994;79:192.
14. D'Alessio JG, Weller RS, Rosenblum M. Activation of the Bezold-Jarish reflex in the sitting position for shoulder arthroscopy using interscalene block. Anesth Analg. 1995;80:1158–62.
15. Elliot BM, Collins GJ Jr, Youkey JR, Donohue HJ Jr, Salander JM, Rich NM. Intraoperative local anesthetic injection of the carotid sinus nerve. A prospective, randomized study. Am J Surg. 1986;152:695–9.
16. Kezdi P. Neurogenic hypertension in man in porphyria. Transient hypertension and tachycardia by disruption of carotid sinus: review of buffer nerve mechanism. Arch Intern Med. 1954;94:122.
17. Lampen H. Uber Entzugelunschockdruck bei Polyneuritis. Dtsch Med Wochenschr. 1949;74:536.
18. Piangatelli C, de Angelis C, Pecora L, Recanatini F, Cerchiara P, Testasecca D. Levobupivacaine and ropivacaine in the infraclavicular brachial plexus block. Minerva Anestesiol. 2006;72: 217–21.
19. Jonas BS, Lando JF. Negative affect as a prospective risk factor for hypertension. Psychosom Med. 2000;62:188–96.
20. Saboya P, Zimmermann PR, Bodanese LC. Association between anxiety or depressive symptoms and arterial hypertension, and their impact on the quality of life. Int J Psychiatry Med. 2010;40:307–20.
21. Urmey WF, Talts KH, Sharrock NE. One hundred percent incidence of hemidiaphragmatic paresis associated with interscalene brachial plexus anesthesia as diagnosed by ultrasonography. Anesth Analg. 1991;72:498–503.
22. Hadzic A, Vloka J. Peripheral nerve blocks: principles and practice. New York: McGraw-Hill; 2004.
23. Sinka SK, Abrams JH, Barnett JT, Muller JG, Lahiri B, Bernstein BA, Weller RS. Decreasing the local anesthetic volume from 20 to 10 mL for ultrasound-guided interscalene block at the cricoid level does not reduce the incidence of hemidiaphragmatic paresis. Reg Anest Pain Med. 2011;36:17–20.
24. Sala-Blanch X, Lazaro JR, Correa J, Gomez-Fernandez M. Phrenic nerve block caused by interscalene brachial plexus block: effects of digital pressure and a low volume of local anesthetic. Reg Anesth Pain Med. 1999;24:231–5.