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Infusion Methods for Continuous Interscalene Brachial Plexus Block for Postoperative Pain Control after Arthroscopic Rotator Cuff Repair

Department of Anesthesia and Pain Medicine, [1]Pusan National University Yangsan Hospital, [2]Pusan National University Dental Hospital, [3]Pusan National University School of Medicine, Yangsan, Korea

Gyeong Jo Byeon[1,3], Sang Wook Shin[1,3], Ji Uk Yoon[1,3], Eun Jung Kim[2,3], Seung Hoon Baek[1,3], Hyun Su Ri[1,3]

Background: Infusion methods during regional analgesia using perineural catheters may influence the quality of postoperative analgesia. This study was conducted to compare the effects of combined or bolus-only infusion of 0.2% ropivacaine on the postoperative analgesia in interscalene brachial plexus block (ISBPB) with perineural catheterization.

Methods: Patients scheduled for arthroscopic rotator cuff repair were divided into two groups, one that would receive a combined infusion (group C, n = 32), and one that would receive intermittent infusion (group I, n = 32). A perineural catheter was inserted into the interscalene brachial plexus (ISBP) using ultrasound (US) and nerve stimulation, and 10 ml of 0.2% ropivacaine was administered. After the operation, group C received a continuous infusion of 4 ml/h, and a 4 ml bolus with a lockout interval of 60 min. Group I received only a 4 ml bolus, and the lockout interval was 30 min. Postoperative pain by the numeric rating scale (NRS) and the forearm muscle tone by the manual muscle test (MMT) were checked and evaluated at the following timepoints: preoperative, and postoperative 1, 4, 12, 24, 36, and 48 h. Supplemental opioid requirements, total consumed dose of local anesthetic, and adverse effects were compared between the two groups.

Results: Sixty-four patients completed the study and the postoperative values such as operation time, time to discharge, and operation site were comparable. There were no differences in NRS scores and supplemental opioid requirements between the two groups. The MMT scores of group I at 4 and 12 h after surgery were significantly higher than those of group C ($P < 0.05$). The total consumed dose of local anesthetic was significantly lower in group I than in group C ($P < 0.05$). The adverse effects were not different between the groups.

Conclusions: The bolus-only administration of 0.2% ropivacaine provided a similar analgesic effect with a lower total volume of local anesthetic and decreased motor weakness compared to combined infusion. Therefore, bolus-only administration is an effective postoperative analgesic method in ISBPB with perineural catheterization after rotator cuff repair. (Korean J Pain 2015; 28: 210-216)

Key Words: Arthroscopy; Brachial plexus block; Patient-controlled analgesia; Ropivacaine; Rotator cuff.

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Correspondence to: Sang Wook Shin
Department of Anesthesia and Pain Medicine, Pusan National University Yangsan Hospital, Geumo-ro 20, Yangsan 626-770, Korea
Tel: +82-55-360-2752, Fax: +82-55-360-2149, E-mail: shinsw@pusan.ac.kr

INTRODUCTION

Shoulder surgery results in significant postoperative pain and many analgesic methods can be tried. Continuous infusion of local anesthetics using a patient-controlled pump has been found to decrease the postoperative pain and the requirements for supplemental analgesics compared to the conventional intravenous patient-controlled infusion of opioid analgesics after arthroscopic shoulder surgery [1]. Postoperatively, local anesthetics are administered into the interscalene brachial plexus (ISBP) continuously until removal of the perineural catheter, and the drugs and doses influence the postoperative analgesic quality and course. Infusion methods including basal-only, bolus-only, or combined administration of local anesthetics into the brachial plexus have been shown to influence the optimization of analgesia and the requirements for oral analgesics [2,3]. The methods used also exert influence on the course of the operation or the occurrence of adverse effects, as prolonged contact of surrounding tissues with local anesthetic may cause changes in those tissues and may lead to the development of toxicity in the surrounding tissues [4].

Even with proper procedural technique, interscalene brachial plexus block (ISBPB) could lead to postoperative neurological complications in certain cases [5,6]. We believe that ensuring an appropriate infusion of adequate concentration, volume, and concentration is mandatory to decrease the occurrence of side effects. Perineural catheters located precisely at the targeted nerves can supply sufficient analgesia with small volume of local anesthetics. In this study, we inserted the perineural catheter into the ISBP with ultrasound (US) guidance and confirmed the placement with nerve stimulation. Our goal was to investigate the infusion methods of 0.2% ropivacaine, and specifically to compare the effects of combined and bolus-only infusion on the postoperative analgesia.

MATERIALS AND METHODS

After the approval of the Institutional Review Board of our hospital (05-2013-062), patients who were scheduled for elective arthroscopic rotator cuff repair (American Society of Anesthesiologists [ASA] physical status I or II) were enrolled in the study. Informed consent was obtained from each patient. Patients who were taking anticoagulants or analgesics, those with allergies to local anesthetics, and those who had neurological deficits, coagulation defects, and severe respiratory disease, as well as patients who could not cooperate during US-guided interscalene perineural catheterization were excluded.

All patients were given midazolam 0.05 mg/kg and glycopyrrolate 0.003 mg/kg intramuscularly. When patients arrived in the operating room, preoperative pain intensity was evaluated with the numeric rating scale (NRS; a score of 0 indicates no pain and a score of 10 indicates the worst pain imaginable). The muscle tone of the arm was also checked with the manual muscle test (MMT) scoring system (0: no palpable or observable muscle contraction, 1: palpable or observable contraction without motion, 2: moves without gravity loading over the full range of motion [ROM], 3: moves against gravity over the full ROM, 4: moves against gravity and moderate resistance over the full ROM, 5: moves against gravity and maximal resistance over the full ROM) with the flexion and extension of the wrist and fingers. A non-invasive blood pressure cuff, electrocardiography, and pulse oximetry were used as standard perioperative patient monitoring instruments.

The ISBP was located with the guidance of ultrasonography (LOGIQ e, GE Healthcare, Princeton, NJ, USA) using the posterior approach technique, and a perineural catheter was inserted. The procedure was performed by a single anesthesiologist as follows. After placing the patient in the lateral decubitus position, the intended insertion area of the brachial plexus catheter was sterilized with chlorhexidine-alcohol, and covered with sterile drapes. Using a linear sonoprobe (5.0-13.0 MHz), the brachial plexus was searched for between the anterior and middle scalene muscles and located. After the administration of local anesthesia using 1% lidocaine, a 18- gauge Tuohy needle was inserted between the C5 and C6 nerve trunks, and electrical nerve stimulation (MultiStim SENSOR; PAJUNK GmbH, Geisingen, Germany) was then applied. When the forearm muscular contractions were confirmed by electrical impulse (1 mA, 2 Hz, and 0.2 ms), a 20-gauge stimulating catheter (StimuLong NanoLine kit; PAJUNK GmbH) was inserted perineurally for 1.5 cm over the tip of needle. The location of the catheter was confirmed again with muscular contraction by electrical impulse (1 mA, 2 Hz, and 0.2 ms). Once a motor response was elicited, the stimulating current intensity was decreased to 0.2 mA.

Then, 0.2% ropivacaine 10 ml was injected through the

catheter. After that, the catheter was firmly fixed at the skin with a needle and thread. A transparent plaster was used as an occlusive dressing. The success of the ISBPB was confirmed with the change of cold sensation at the shoulder area by alcohol swab within 15 min. The procedure was considered a failure when there was no change of sensation after 30 min. For the patients who underwent successful perineural catheterization, general anesthesia was induced as follows. After patients lost consciousness with intravenous thiopental sodium 5 mg/kg, rocuronium 0.08 mg/kg was intravenously injected and the patients were intubated. Desflurane 6 vol% was used and intravenous remifentanil was infused and titrated (0.5–1 μg/kg/min) throughout the operation.

After completion of the operation, the enrolled patients were divided into two groups. In all patients, 0.2% ropivacaine was infused through the catheter using patient-controlled analgesia (PCA) infusion pump systems (Gemstar®, Hospira, Inc., Lake Forest, IL, USA). In group C (n = 32), the following parameters were set: infusion rate 4 ml/h, bolus dose 4 ml, lockout interval 60 min, and 4 h maximum infusion limit 24 ml. For group I (n = 32), the parameters were: bolus dose 4 ml, lockout interval 30 min, and 4 h maximum infusion limit 24 ml. Postoperative pain by NRS and the strength of muscle tone by MMT were evaluated at postoperative 1, 4, 12, 24, 36, and 48 h. The infused dose of the local anesthetic was also evaluated. When the postoperative pain was not controlled with PCA only, meperidine 25 mg was given intramuscularly, and supplemental meperidine requirements were evaluated. The postoperative values such as operation time, time to discharge, and operation site (right or left side) were evaluated. Adverse effects including numbness of the arm, nausea, vomiting, tinnitus, dizziness, catheter dislodgement, local toxicity, and Horner's syndrome were also evaluated.

All results were reported as mean ± standard deviation (SD). NRS and MMT scores were compared with Student's t-tests. The preoperative/postoperative NRS and MMT scores were analyzed by using a paired t-test. The Chi-square test was used to compare genders, ASA classes, and numbers for operation sites. The incidence of adverse effects and the supplemental opioid requirements were analyzed using the Chi-square test and Fisher's exact test. PASW Statistics 18.0 for Windows (SPSS Inc, Chicago, IL, USA) was used for statistical analysis. A difference was regarded as statistically significant at $P < 0.05$.

Pain quality by NRS was the primary outcome variable on which sample size estimation was based. A previous study found that the NRS score on postoperative day 1 was 1.9 ± 2.0 (mean ± SD) [7]. We assumed a 20% difference in the average pain scores over a 48-hour period between the groups to be the minimum relevant difference. The sample size calculation for this study showed a total of 52 patients when we considered type I (α) error = 0.05, type II (β) error = 0.20, a SD = 2.0, and a predicted dropout rate of 10%. Eight patients per group were added to increase the power. Thus, there were 34 patients per group.

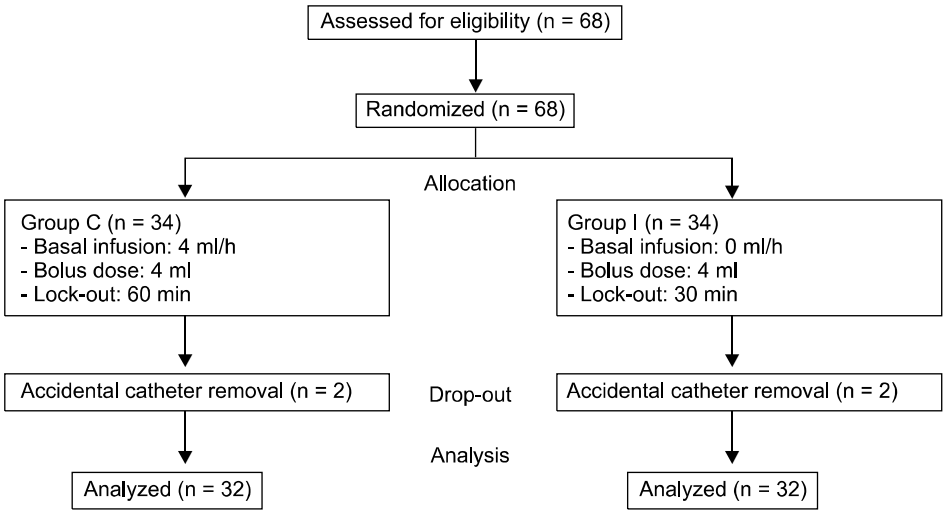

Fig. 1. Patient enrollment and a study flowchart.

RESULTS

Sixty-eight patients were enrolled but the perineural catheters of two patients in each group were accidentally removed within the first 24 h after the operation, and 64 patients completed the study (**Fig. 1**). There were no significant differences in demographic characteristics between the two groups. The postoperative values such as operation time, time to discharge, and operation site were statistically not different between the two groups (**Table 1**).

There were no significant differences in NRS scores at preoperative, or at 1, 4, 12, 24, 36, and 48 h after the operation between the two groups (**Fig. 2**). In addition, 6 (18.8%) patients in group C and 5 (15.6%) patients in group I received additional meperidine, and the supplemental opioid requirements were not different between the groups.

In group I, MMT scores at 4 and 12 h after surgery were higher than those in group C ($P < 0.05$, **Table 2**). The total consumed dose of local anesthetic during the postoperative period was significantly lower in group I than in group C at 12, 24, 36, and 48 h postoperatively ($P <$

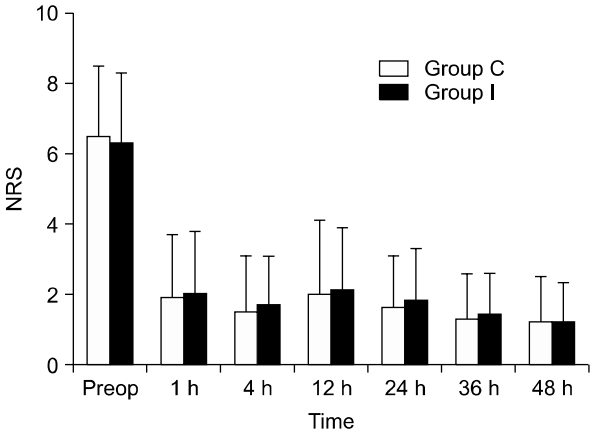

Fig. 2. Preoperative and postoperative numeric rating scale (NRS) for pain was not different between two groups. Group C is combined infusion of 0.2% ropivacaine, and Group I is bolus-only infusion. Preop: preoperation.

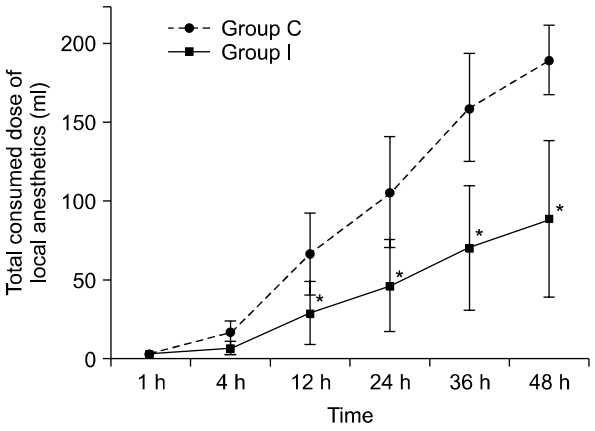

Fig. 3. Total consumed dose of local anesthetics in each group is different between groups. Group C is combined infusion of 0.2% ropivacaine, and Group I is bolus-only infusion. *Total consumed dose of local anesthetics were significantly lower in group I than in group C at 12, 24, 36, and 48 h postoperatively ($P < 0.05$).

Table 1. Demographic Data

	Group C (n = 32)	Group I (n = 32)	*P* value
Age (yr)	56.8 ± 14.7	57.3 ± 11.6	0.903
ASA (I/II)	16/16	14/18	0.317
Gender (M/F)	18/14	13/19	0.802
Height (cm)	161.3 ± 10.6	160.1 ± 9.0	0.624
Weight (kg)	64.5 ± 10.0	64.9 ± 9.6	0.860
Operation Time (min)	165.0 ± 44.1	159.4 ± 34.2	0.571
Time to discharge (d)	5.3 ± 3.3	4.8 ± 2.3	0.461
Operation site (R/L)	21/11	19/13	0.796

All measured values are presented as mean ± standard deviation or numbers of patients. Group C is combined infusion of 0.2% ropivacaine. Group I is bolus infusion only of 0.2% ropivacaine.

Table 2. Manual Muscle Test (MMT) Scoring

Group	Preop	1 h	4 h	12 h	24 h	36 h	48 h
Group C (n = 32)	4.7 ± 0.6	3.9 ± 1.3	3.9 ± 1.1	4.3 ± 1.0	4.6 ± 0.8	4.8 ± 0.6	4.8 ± 0.5
Group I (n = 32)	4.8 ± 0.5	3.9 ± 1.0	4.2 ± 0.7*	4.5 ± 0.6*	4.7 ± 0.5	4.8 ± 0.4	4.9 ± 0.3

All measured values are presented as mean ± standard deviation or numbers of patients. Group C is combined infusion of 0.2% ropivacaine. Group I is bolus-only infusion of 0.2% ropivacaine. *MMT score at 4 h and 12 h were significantly higher in group I than in group C ($P < 0.05$), Preop: preoperation.

Table 3. Adverse Effects

	Group C (n = 32)	Group I (n = 32)	*P* value
Numbness	14 (43.8)	12 (37.5)	0.799
Nausea & Vomiting	4 (12.5)	3 (9.4)	1.000
Tinnitus	1 (3.1)	0 (0.0)	1.000
Dizziness	3 (9.4)	4 (12.5)	1.000
Catheter dislodgement	2 (6.3)	2 (6.3)	1.000
Local toxicity	2 (6.3)	1 (3.1)	1.000
Horner's syndrome	3 (9.4)	2 (6.3)	1.000

Values are number of patients (%). Group C is combined infusion of 0.2% ropivacaine, and Group I is bolus-only infusion.

0.05, **Fig. 3**). The adverse effects did not significantly differ between the two groups (**Table 3**).

DISCUSSION

In this study, we confirmed that bolus-only administration of 0.2% ropivacaine 4 ml showed similar postoperative pain control and early restoration of muscle tone with lower local anesthetic consumption compared to continuous with bolus administration after arthroscopic rotator cuff repair.

Shoulder surgery often causes severe postoperative pain. The repair of rotator cuff tears using mini-open or total arthroscopic surgeries can still be associated with severe postoperative pain, even it is lesser than that of major open surgery [8,9]. The intensity and duration of the postoperative pain might influence the development of chronic persistent pain following surgery [10]. In that case, postoperative analgesia is a very important factor to prevent chronic persistent pain after an operation. Systemic analgesic medications help to relieve postoperative pain, yet many regional methods such as intra-articular injection and epidural block are also used [11,12]. In some operations, as regional anesthesia may provide longer and better analgesia, patients receiving regional anesthesia have been found to have better outcomes in function and movement postoperatively [13]. This could be one of the reasons why regional analgesia is preferred to systemic analgesia in shoulder surgery.

Appropriate regional anesthesia is derived from the accurate injection of local anesthetics to the target nerves. After the introduction of US in regional anesthesia, it has become much easier to find the target nerve and therefore to inject a lesser volume of local anesthetic there. Anesthesia or analgesia may be maintained long enough if a perineural catheter is inserted at the brachial plexus. Not only catheter insertion methods, but the dose, concentration, and volume may matter during continuous peripheral nerve blocks [14,15].

Analgesia with an indwelling perineural catheter has potential complications and risks during the postoperative period due to either the catheter itself or local anesthetic infusion. The complications may involve catheter dislodgement, migration, retention, nerve injury, infection, and local anesthetic toxicity [4,5]. A large amount and prolonged injection of bupivacaine resulted in myopathy in a clinical situation with ISBPB, and myotoxic effects should be a concern if ropivacaine is administered for long periods, though the concern is less than for bupivacaine [16,17]. Intraneural injection of local anesthetics during ISBPB may cause severe plexopathy and neurologic deficits [18]. In the current study, we did not encounter the problem of migration of the perineural catheter in any patients, but this could happen during the postoperative analgesic period [19]. We sutured the catheter to the skin firmly, but still we experienced catheter dislodgements in four of the enrolled 68 patients before the end of the first postoperative day.

In a previous study of open shoulder surgery, continuous ISBP analgesia required a basal infusion to provide effective pain relief, with a basal infusion of 5 ml/h [20,21]. Reducing the basal infusion from 8 to 6 ml/h resulted in similar clinical efficacy in shoulder surgery with ISBPB [7]. A basal infusion of 2 ml/h resulted in postoperative pain, night awakening, and tramadol consumption after rotator cuff surgery similar to that of an infusion of 5 ml/h, and the smaller infusion decreased the frequency of side effects [22]. With reference to the above several basal infusion rates and for comparison of bolus-only administration of 4 ml of 0.2% ropivacaine, we used a basal infusion rate of 4 ml/h in our control group.

As bolus-only infusion of local anesthetics is decreasing the total infused volume of local anesthetics, it may decrease the adverse effects of local anesthetics and the motor weakness of the affected areas, compared to the addition of basal infusions to the bolus infusions. Our results demonstrated that bolus-only administration of 0.2% ropivacaine might result in a similar analgesic effect, a similar adverse effect profile, and decreased motor weak-

ness compared to continuous infusion in ISBPB with a perineural catheter after shoulder rotator cuff repair.

Our study has several limitations. First, unfortunately, we did not evaluate the analgesic quality during the night, in terms of quality of sleep, or in terms of patient satisfaction. Although we enrolled patients who received arthroscopic rotator cuff repair operations, differences might be observed between combined and bolus-only infusions of ropivacaine if we checked the quality of pain control during the night sleep. Second, we also did not check the infused volume of local anesthetic per hour in group C and the total count of bolus administrations. We evaluated and recorded the total infused volume of local anesthetic. The total count of bolus administrations in patients may be able to express the quality of postoperative pain control.

In conclusion, bolus-only injection of local anesthetics in ISBPB might exert a similar postoperative analgesic effect and result in less motor weakness compared to combined infusion after arthroscopic rotator cuff repair.

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