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ORIGINAL PAPER

Post-operative pain control following arthroscopic rotator cuff repair: peri-articular injection versus interscalene brachial plexus block

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Abstract

Purpose To compare post-operative pain relief with peri-articular injection (PI) versus interscalene brachial plexus block (IBPB) after arthroscopic rotator cuff repair (ARCR) surgery.

Methods We retrospectively reviewed 121 consecutive patients undergoing ARCR surgery divided into two groups: the PI group and the IBPB group. We compared complications and self-reported pain score measured using a Numerical Rating Scale (NRS) during the initial 24 hours after surgery.

Results The NRS scores recorded in the recovery room (0), 0.5, and four hours post-operatively were higher in the PI group ($n = 38$) than the IBPB group ($n = 52$) (2.1 vs. 0.8, $p = 0.014$; 1.4 vs. 0.5, $p = 0.0069$; and 1.3 vs. 0.5, $p = 0.012$, respectively). However, the NRS scores recorded at 16, 20, and 24 hours post-operatively were lower in the PI group than in the IBPB group (1.4 vs. 3.1, $p < 0.0001$; 1.4 vs. 3.2, $p < 0.0001$; and 1.7 vs. 3.2, $p = 0.00046$, respectively). The incidences of post-operative nausea and temporary numbness in the upper arm were significantly lower in the PI group than in the IBPB group (7.9% vs. 33%, $p = 0.0052$; and 13% vs. 85%, $p < 0.0001$, respectively).

Conclusions Although IBPB provided superior pain control during the initial few hours after ARCR surgery, PI was superior from 16 to 24 hours post-operatively. The rates of side effects, such as nausea and temporary arm numbness, were also lower in the PI group than in the IBPB group.

Keywords Shoulder · Pain management · Peri-articular injection · Interscalene brachial plexus block · Arthroscopic rotator cuff repair

Introduction

Arthroscopic rotator cuff repair (ARCR) is an increasingly common surgical procedure, which is often associated with severe post-operative pain especially in the immediate post-operative period [1, 2]. Effective pain management is critical not only for early rehabilitation and discharge, but also to reduce healthcare costs [3]. Numerous modalities for post-operative pain management after ARCR have been proposed, including oral and intravenous medications, regional nerve block, intralesional anaesthesia, and multimodal anaesthesia [4]. However, commonly used opioids are associated with risks of nausea and vomiting. Interscalene brachial plexus block (IBPB) has been reported as one of the most effective types of regional block for pain relief after shoulder surgery [5, 6], but it also has some drawbacks with regard to its short duration of effectiveness (10–15 h), technical difficulty, and a concern regarding a pain bounce [7, 8].

Recent studies have reported the effectiveness of intralesional multimodal anesthesia using peri-articular injection (PI) of opioids, non-steroidal anti-inflammatory drugs, steroids, and local anaesthetics for pain control over regional block following major orthopaedic operations, such as

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arthroplasty and anterior cruciate ligament reconstruction [5, 9–11]. In shoulder surgery, such as rotator cuff repair, PI was reported to show improved post-operative pain control compared to sham injection or intravenous patient-controlled anesthaesia [10]. However, there have been no studies comparing the effectiveness of PI with IBPB for post-operative pain control after ARCR.

This study was performed to compare the efficacy and safety of PI and IBPB for pain management following ARCR. We hypothesized that post-operative pain control by PI would exhibit a lower self-reported pain score measured using a Numerical Rating Scale (NRS) in the early post-operative period, and there would be no difference in complication rate between PI and IBPB.

Methods

We conducted a retrospective chart review to identify patients undergoing ARCR surgery with PI or IBPB for post-operative pain control. The study protocol and publication plan were approved by our institutional ethics committee.

Setting and participants

This study used electronic medical records of consecutive patients undergoing ARCR surgery between January 2013 and June 2015 at an academic hospital in Tokyo, Japan.

All surgeries were performed under general anaesthesia maintained with either remifentanil/propofol or remifentanil/sevoflurane. The inclusion criteria were (1) patients with either PI or IBPB after ARCR and (2) ARCR performed by a single surgeon. The exclusion criteria were (1) ARCR combined with other operations, (2) patients using different peri-operative pain control measures, (3) ARCR performed by a different surgeon, and (4) ARCR followed by revision surgery.

Interventions

The study interventions were PI and IBPB. PI consisted of 40 ml of ropivacaine (7.5 mg/ml), 0.8 ml of morphine hydrochloride hydrate (10 mg/ml), 0.3 ml of epinephrine (1.0 mg/ml), 1.0 ml of methylprednisolone (40 mg/ml), 2.5 ml of ketoprofen (20 mg/ml), and 15.4 ml of normal saline solution. PI was performed by the operating surgeon after wound closure. A total of 60 ml of the mixture was injected at the following multiple sites: (A) 20 ml was injected around the portal incision, (B) 20 ml was injected into the subacromial bursa, (C) 10 ml was injected around the axillary nerve, and (D) 10 ml was injected around the suprascapular nerve (Fig. 1). We injected the solution freehand without determining the location of the nerve using ultrasound. The injection procedure took approximately 30 seconds to complete.

Patients received IBPB by experienced anaesthesiologists under general anaesthesia. The injection consisted of 20 ml of ropivacaine under ultrasound guidance, as suggested by Winnie et al. [12]. During insertion of the needle into the interscalene brachial plexus, real-time monitoring with ultrasonographic imaging was used to facilitate accurate local anaesthetic deposition. Ropivacaine was injected around the interscalene brachial plexus just after surgery.

Pre-operative and post-operative medications for both groups of patients

An identical management protocol was used in both groups of patients. Patients did not receive any premedication. Following PI or IBPB and after awakening from anaesthesia, the patients were transferred to and observed in the recovery room until their condition remained stable. Evaluation of pain was carried out by an anaesthesiologist using the NRS score. As rescue analgesia for pain relief in the recovery room, fentanyl (0.1 μg/kg) injection was used if the NRS score was ≥ 4 in both treatment groups.

After patients had left the recovery room, oral celecoxib (400 mg/day) was routinely given in the wards in both groups. In cases with any contraindication for celecoxib, acetaminophen (1800 mg/day) was used according to routine procedures. Pain control in the ward was carried out using oral loxoprofen (60 mg), acetaminophen (300 mg), or intravenous medication (pentazocine hydrochloride, flurbiprofen axetil, or acetaminophen) as necessary. If these arrangements failed, we used intravenous patient-controlled analgesia (IV-PCA) with morphine hydrochloride hydrate (1.0 mg bolus; lockout time, 5 minutes). Antibiotic prophylaxis with 1.0 g of first-generation cephalosporin was administered intravenously 30 minutes before surgery and every eight hours after surgery for 24 hours.

Surgery and rehabilitation

All operations were performed by a single surgeon with the patient under general anaesthesia in the beach chair position. After arthroscopic assessment and subacromial decompression, depending on tear size, we performed double-row fixation or single-row fixation for superior rotator cuff tears (supraspinatus and infraspinatus muscle tendon). Tenodesis was carried out in cases with partial tears or instability of the long head of the biceps tendon. Furthermore, associated subscapularis tendon tears were repaired by single-row fixation. Local icing was applied to the shoulders of all patients during the first 24 hours after surgery.

The same rehabilitation program was applied in all patients. After surgery, the operated shoulder was immobilized for three weeks using a sling immobilizer with an abduction pillow (about 20° of abduction). Range-of-motion exercise was started at three weeks. In the case of large or massive

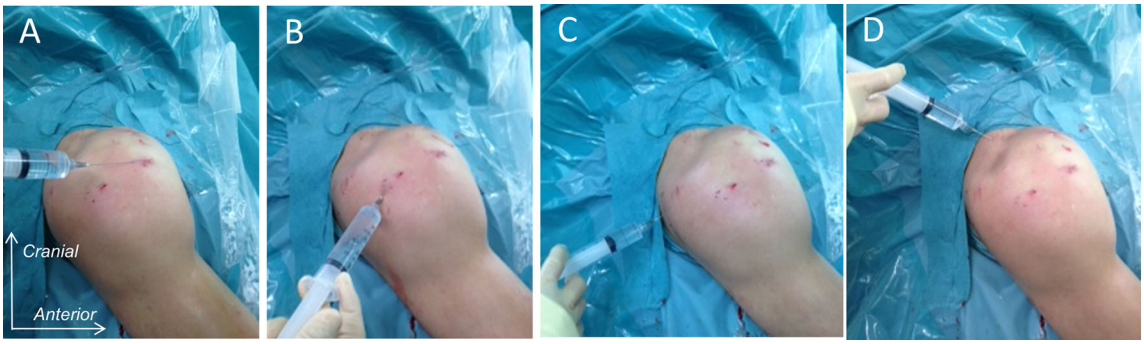

Fig. 1 Peri-articular injection procedure. The right shoulder of the patient in the beach chair position is shown. A total volume of 60 ml of the mixture was injected, consisting of **A** 20 ml around the portal incision, **B** 20 ml into the subacromial bursa, **C** 10 ml around the axillary nerve area, and **D** 10 ml around the suprascapular nerve area

tears, taking off the sling immobilizer and range-of-motion exercises were allowed at four weeks. Six weeks after surgery, the patients started strengthening exercises of the rotator cuff and were permitted to practice light sports activities by three months post-operatively. After six months, full return to sports and heavy labour were allowed.

Outcome measures

The primary outcome was self-rated pain measured using an NRS ranging from 0 (no pain) to 10 (worst imaginable pain). For all patients, NRS score was determined by nursing staff at zero, 0.5, four, eight, 16, 20, and 24 hours post-operatively. Time zero was defined as the time when the patients were moved to the recovery room.

The secondary outcomes were all other post-operative medications used during the initial 24 hours after surgery. We recorded any complications, such as nausea and vomiting, surgical site infections, temporary numbness in the upper arm, delirium, and re-tearing after rotator cuff repair. We also collected data on the mean duration of general anaesthesia and the length of time spent in the operating room, recovery room, overall time in the hospital, rate of surgical site infection, and rate of failed repair.

Sample size calculation

We calculated that 37 patients per group would be required for this retrospective comparative study to detect a clinically relevant 2-point mean difference in the NRS score, with a two-sided 5% significance level and 80% power. For power analysis, we used a standard deviation of 3 in the NRS score based on previous reports [9, 13, 14].

Statistical analyses

Statistical analyses were performed using R (The R Foundation for Statistical Computing). Missing NRS data were replaced by linear interpolation in cases when the missing scores fell between two valid scores, or with the median scores for the other patients in the same treatment group at the same time point. Student's t test or the Mann-Whitney U test was used for continuous variables, and the chi-square test or Fisher's exact test was used for categorical variables. A two-sided p value of < 0.05 was considered statistically significant.

Results

Patient characteristics

A total of 121 ARCRs were performed during the study period, of which 38 patients received PI and 52 patients received IBPB. The flowchart presented in Fig. 2 outlines the methodological process to select the patients for this study. The reasons for ineligibility were another operation combined with ARCR ($n = 13$), usage of a different pain control measure ($n = 12$), operation by a different surgeon ($n = 4$), and revision surgery ($n = 2$). Demographic and major clinical characteristics did not differ between the two groups (Table 1).

Primary outcome

The NRS scores at 0, 0.5, and four hours were significantly higher in the PI group than in the IBPB group (2.1 ± 2.8 vs. 0.8 ± 1.9, $p = 0.014$; 1.4 ± 1.9 vs. 0.5 ± 1.2, $p = 0.0069$; and 1.3 ± 1.6 vs. 0.5 ± 1.4, $p = 0.012$, respectively) (Fig. 3). However, the NRS scores in the PI group were significantly lower than those in the IBPB group at 16, 20, and 24 hours post-operatively (1.4 ± 1.6 vs. 3.1 ± 1.7, $p < 0.0001$; 1.4 ± 1.8 vs. 3.2 ± 1.9, $p < 0.0001$; and 1.7 ± 1.8 vs. 3.2 ± 2.0, $p = 0.00046$, respectively). The NRS score at eight hours post-operatively did not differ between the two groups.

Secondary outcome measures

Use of rescue analgesia

Table 2 shows the frequencies of the different rescue analgesia methods used in the two groups. There was no significant

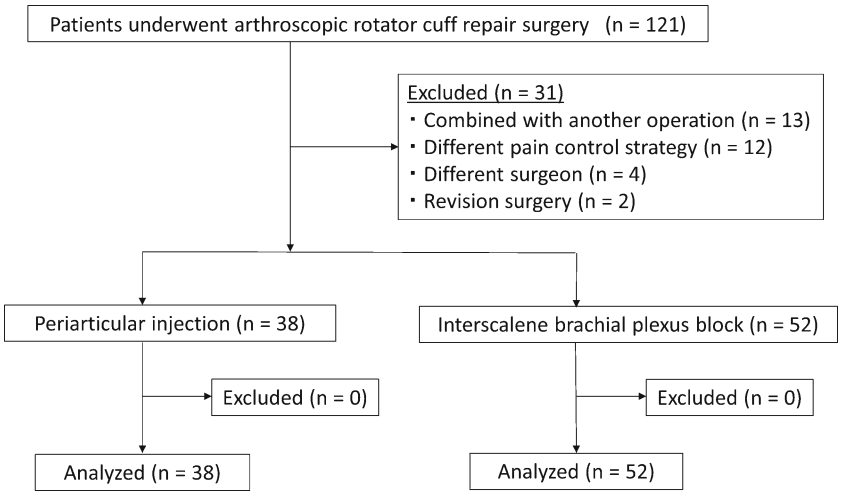

Fig. 2 Patient flow diagram

difference in the usage of rescue analgesia (fentanyl) in the recovery room between the two groups. Significantly fewer patients required IV-PCA in the PI group than in the IBPB group (0% vs. 42%, $p < 0.0001$, respectively). Use of intravenous and/or oral rescue analgesia did not differ between the two groups ($p > 0.05$).

Complications and other relevant characteristics

Significantly fewer patients complained of nausea or temporary numbness in the operated upper arm in the PI group than the IBPB group (7.9% vs. 33%, $p = 0.0052$; and 13% vs. 85%, $p < 0.0001$, respectively) (Table 2). Mean duration of general anaesthesia and the length of time spent in the operating room were significantly lower in the PI group than the IBPB group ($p = 0.0062$ and 0.014, respectively) (Table 3). The length of hospital stay did not differ between the two groups.

Discussion

PI provided superior pain control at 16, 20, and 24 hours following ARCR, whereas IBPB showed better initial pain control at zero, 0.5, and four hours post-operatively. Significantly

Table 1 Patient demographics and baseline clinical characteristics

Demographics and baseline clinical characteristics		Peri-articular injection ($n = 38$)	Interscalene bracial plexus block ($n = 52$)	P value
Age (year)		65.3 ± 10.1	64.9 ± 7.3	0.84*
Male/female		21/17	22/30	0.29†
Height (cm)		162 ± 9	160 ± 10	0.25*
Weight (kg)		63 ± 13	60 ± 13	0.33*
Body mass index (kg/m^2)		23.7 ± 3.1	23.2 ± 3.2	0.44*
History of diabetes mellitus (yes/no)		5/33	3/49	0.28†
Pre-operative Numerical Rating Scale score at rest (point)		1.2 ± 1.8	0.9 ± 1.3	0.44*
Severity of rotor cuff tear (grade 0–4)	Grade 0 (partial)	5	6	0.98**
	Grade 1 (small)	9	18	
	Grade 2 (middle)	15	12	
	Grade 3 (large)	7	10	
	Grade 4 (massive)	2	6	
Double-row/single-row fixation		36/2	45/7	0.29†
Biceps tenodesis (yes/no)		3/35	3/49	0.69†
Repair of the subscapularis tendon (yes/no)		7/31	18/34	0.10†
Duration of surgery (min)		108 ± 31	117 ± 37	0.20*

*P values were determined using Student's t test

† P values were determined using Fisher's exact test

**P values were determined using Mann-Whitney U test

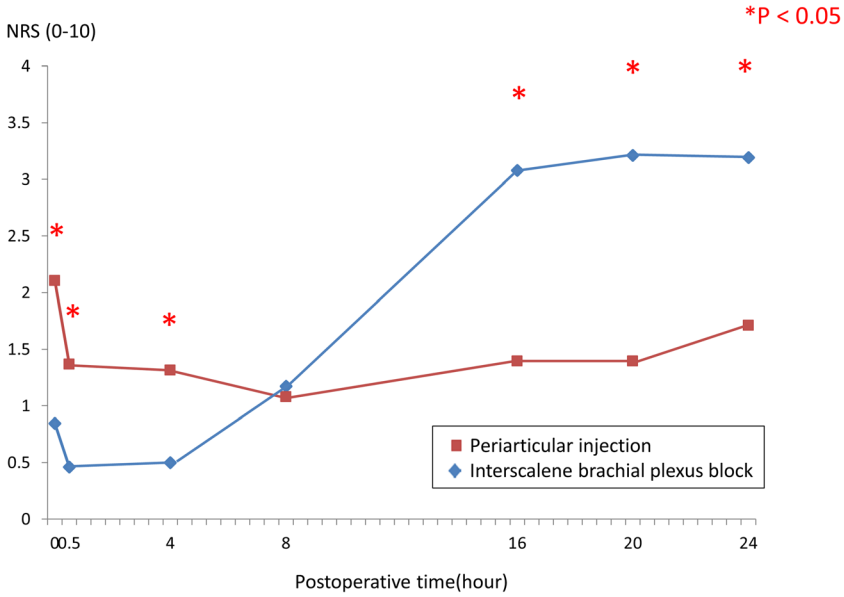

Fig. 3 Numerical rating scale (NRS) scores after arthroscopic rotator cuff repair. The NRS scores at zero, 0.5, and four hours after surgery were significantly lower in the interscalene brachial plexus block group. At post-operative 16, 20, and 24 hours, the NRS scores were significantly lower in the peri-articular injection group. Time zero was defined as the time when patients were transferred from the operation room to the recovery room

fewer patients in the PI group required the use of opioid IV-PCA in the ward and the PI group had fewer complications, such as nausea and temporary numbness in the upper arm of the operated side. To our knowledge, this is the first study comparing the effectiveness of post-operative pain control with PI and IBPB in patients going under ARCR.

Pain control with PI was inferior to that with IBPB for up to four hours post-operatively. Despite the difference between NRS and visual analog scale (VAS) in rating of pain, the scores obtained by PI in our patients were similar to those of VAS in previous reports studying the efficacy of similar injection therapies after ARCR [12, 13, 15]. Perdreau and Joudet reported that PI was beneficial after ARCR in comparison to sham injection [15]. However, 16% of our patients required intravenous fentanyl (Table 2) at zero hours post-operatively, which was consistent with another previous study where the mean VAS score immediately after surgery was 6.9 in patients treated with PI [16]. These results suggest that early pain control after surgery remains challenging in patients with PI. We believe that inadequate initial pain control in the PI group is due to late onset of the drug effect, whereas sensory block with IBPB using ropivacaine has a short onset time (15 minutes) [17]. The precise mechanisms of action of injected drugs in pain management have not yet been clearly defined, and therefore, it is difficult to predict the effectiveness of such therapy. Supplementary methods of pain control would be warranted, especially in the early post-operative period [8, 13].

Table 2 Use of rescue analgesia and complications

Location of using rescue analgesia		Peri-articular injection ($n = 38$)	Interscalene bracial plexus block ($n = 52$)	P value
Recovery room	Intravenous fentanyl (yes/no)	6/32	3/49	0.16†
Hospital room	Intravenous patient-controlled analgesia (yes/no)	0/38	22/30	< 0.0001†
	Intravenous rescue analgesia (times/24 h)	0.42 (0–2**)	0.42 (0–2**)	0.99*
	Oral rescue analgesia (times/24 h)	0.72 (0–3**)	0.31 (0–2**)	0.50*
Complications				
Nausea (yes/no)		3/35	17/35	0.0052*
Surgical site infection (yes/no)		0/38	0/52	NA
Temporary numbness in upper arm (yes/no)		5/33	44/8	< 0.0001*
Delirium (yes/no)		0/38	2/50	0.51*
Re-tear after rotator cuff repair (yes/no)		6/32	6/46	0.76*

† P values were determined with Fisher's exact test

*P values were determined with Student's t test

**Values are expressed as means with ranges in parentheses

Table 3 Duration of general anesthesia, time interval from operation room to recovery room, and length of hospital stay

	Peri-articular injection ($n = 38$)	Interscalene brachial plexus block ($n = 52$)	P value
Mean duration of general anesthesia (min)	167 ± 32	189 ± 41	0.0062*
Time from operation room to recovery room (min)	220 ± 38	242 ± 43	0.014*
Length of hospital stay (day)	3.4 ± 1.5	3.7 ± 1.5	0.42*

*P values were determined using Student's t test

Pain control by IBPB was satisfactory only until eight hours after surgery, necessitating IV-PCA in 42% of patients in the present study. This treatment procedure is technically demanding, unlike PI, which can be carried out within approximately 30 seconds [6, 7]. The effect of IBPB is also known to last for up to 15 hours, and a pain bounce after the analgesic effect had subsided was observed in our study [18, 19]. The reason why there was no similar effect with PI remains to be investigated in future studies. However, our results suggest that PI is an effective method of pain management with significantly fewer complications up to 24 hours post-operatively with the usage of supplementary rescue analgesia compared to IBPB. PI had further advantages of technical simplicity and rapid performance, and the time spent in the operating room was significantly lower with PI, which may also improve the efficiency of operating room usage. The mean duration of general anaesthesia was significantly longer in the IBPB group than in the PI group. As there were no differences between the groups in terms of mean operation time, we speculated that the longer duration of general anaesthesia in the IBPB group was because the time required to complete IBPB was longer than that to complete PI.

PI has been used more commonly for pain relief after major joint surgeries due to its effectiveness and a low prevalence of adverse effects [20–24]. The present study demonstrated the effectiveness of PI after ARCR surgery. Future studies would clarify the optimal timing of injection during ARCR and the better mixtures or concentrations of drugs for PI.

This study had several limitations. A retrospective review of medical records has inherent limitations. Especially, the severity of cuff tears could affect post-operative pain. However, there were no differences in demographic or clinical characteristics, including severity of cuff tears, between our two groups, suggesting that this study would have external validity. However, further randomized controlled trials are necessary to generate a higher level of evidence regarding the superiority of PI over IBPB. Post-operative pain control included oral and intravenous medication, as well as IV-PCA. These additional treatments can distort the effectiveness and necessity of PI and IBPB. ARCR surgery was performed by a single surgeon in a single hospital. We did not review the effect of the PI after 24 hours, unlike previous studies that followed the course until five days after surgery [12, 13, 16]. This was because ARCR is commonly performed as a day surgery, which underscores the importance of pain management in the first 24 h [25].

Conclusions

This study suggested that PI may be preferable to IBPB for pain relief 16–24 hours after ARCR surgery. Patients treated with PI had significantly fewer side effects than those receiving IBPB.

Compliance with ethical standards

The study protocol and publication plan were approved by our institutional ethics committee.

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