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# Efficacy and Safety of Combined Subacromial and Intravenous Patient-controlled Analgesia after Arthroscopic Rotator Cuff Repair

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**Background:** This study investigated the efficacy and safety of combined subacromial and intravenous patient-controlled analgesia for control of postoperative pain after arthroscopic rotator cuff repair.
**Methods:** Between May 2012 and August 2014, 60 patients who underwent arthroscopic rotator cuff repair with acromioplasty and received patient-controlled analgesia were studied prospectively. Cases were divided into 2 groups: combined subacromial and intravenous infusion group (group A, 30 cases) and solitary intravenous infusion group (group B, 30 cases). The visual analogue scale was used to record the patient's level of pain every 12 hours during postoperative 72 hours and the following 48 hours after the suspension of patient-controlled analgesia.
**Results:** The mean preoperative visual analogue scale score was 7.8 in group A and 7.6 in group B, and the immediate postoperative visual analogue scale score was 7.9 and 8.1 for each group. At postoperative time (From 12 hours to 72 hours after operation), the scores of combined subacromial and intravenous infusion were significantly lower than those of solitary intravenous infusion. Significant difference in the frequency of supplemental analgesic injections was observed between group A and group B ($p$=0.008). However, no significant difference in complication rate was observed between the two groups ($p$=0.562).
**Conclusions:** Combined subacromial and intravenous patient-controlled analgesia after arthroscopic rotator cuff repair is more effective than solitary intravenous infusion without significantly increasing complications. Therefore, combined subacromial and intravenous patient-controlled analgesia could be a effective pain control method.
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**Key Words:** Rotator cuff tear; Rotator cuff repair; Patient-controlled analgesia; Postoperative pain control

## Introduction

Acute postoperative pain after arthroscopic shoulder surgery varies from moderate to severe, and intensive postoperative rehabilitation could be interrupted by postoperative pain. Thus, many pain control methods were used in an effort to reduce acute postoperative pain.

Postoperative pain control methods include continuous interscalene infusion of levobupivacaine,[1] intra-articular injection of morphine and bupivacaine,[2] peripheral nerve block,[3] patient-controlled analgesia (PCA) using intravenous injection[4] and continuous-flow cold therapy.[5] Intravenous PCA provided better pain relief, less morphine consumption, and reduced the incidence of complication compared with intermittent injection of pain medication as needed.[4,6] Therefore PCA after shoulder surgery, particularly patient-controlled intravenous injection after open surgery[7] and patient-controlled subacromial infusion after arthroscopic surgery has become more common.[8,9]

Although intravenous PCA has been regarded as a useful pain control device, it would not provide optimal analgesia, so that additional pain therapy might be needed.[10] However, subacromial and intravenous PCA require caution because of complica-

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tions including temporary hypotension, nausea, and vomiting. Few studies of subacromial PCA with intravenous PCA have been reported.

The purpose of our study was to compare the effectiveness, patient satisfaction, and complications between patient-controlled subacromial infusion of bupivacaine combined with patient-controlled intravenous analgesia and solitary patient-controlled intravenous analgesia after arthroscopic rotator cuff repair. The patients were divided into two groups: combined patient-controlled subacromial and intravenous analgesia group and only patient-controlled intravenous analgesia group.

## Methods

Following Institutional Review Board of Dankook University Medical College approval, 60 consecutive patients who underwent arthroscopic rotator cuff repair under general anesthesia for full-thickness rotator cuff tears and PCA were studied prospectively. There were 33 males and 27 female patients, with a mean age of 56.3 years (range, 38–71 years). The size of cuff tear was defined as the length of the greatest diameter measured using a probe during surgery. The tear sizes were categorized as small (<1 cm), medium (1 to 3 cm), large (3 to 5 cm), and massive (>5 cm), according to the classification of DeOrio and Cofield (Table 1).[11]

**Table 1.** Demographic Data

| | Total | Group A* | Group B† | *p*-value |
|---|---|---|---|---|
| Case | 60 | 30 | 30 | |
| Sex (male:female) | 33:27 | 17:13 | 16:14 | 0.842 |
| Age (yr) | 56.3 | 57.2 (40–71) | 56.1 (38–69) | 0.753 |
| Tear size‡ | | | | |
| Small | 8 | 3 | 5 | |
| Medium | 31 | 17 | 14 | |
| Large | 21 | 10 | 11 | |

Values are presented as number only or median (range).
*Combined subacromial and intravenous infusion. †Solitary intravenous infusion. ‡The tear sizes were categorized as small (<1 cm), medium (1 to 3 cm), large (3 to 5 cm), and massive (>5 cm), according to the classification of DeOrio and Cofield.[11]

Those who underwent repair under local anesthesia or had partial or massive tears larger than 5 cm, acromioclavicular arthritis requiring distal clavicle resection, advanced glenohumeral arthritis, anterior instability, stiffness, or nerve damage or those requiring tenotomy or tenodesis of the long head of the biceps were excluded. Also, on preoperative radiographs, a flat-type acromion or no acromial spur cases not requiring acromioplasty were excluded.

Before undergoing operation after being diagnosed with rotator cuff tear, the patients were divided into two groups in random order. On operation day, one of the two PCA methods was selected and the other was used the next time. As such, 30 cases were collected for each group, a combined intravenous injection with fentanyl and ketorolac tromethamine and subacromial infusion with 0.5% bupivacaine (group A) and an only intravenous infusion group (group B). Any case that fell under the exclusion criteria was excluded from the beginning. Only those who received explanations on the study and agreed to it were enrolled. All repairs were performed by the senior author with the arthroscopic technique using suture anchors (double row suture bridge technique) for a full coverage according to tear configuration. Acromioplasty was performed in all cases. All shoulders were immobilized in a brace and pendulum exercises were started one day after the operation.

In the 30 patients in group A, the epidural catheter was inserted through the anterior portal and located in the subacromial space (Fig. 1). The catheter was then connected to the Accufuser-Plus Kit® (Wooyoung Medical, Seoul, Korea), a silicon-balloon infuser, for continuous flow of 100 ml of 0.5% bupivacaine into the subacromial space at a speed of 1.0 ml/h. Patients with se-

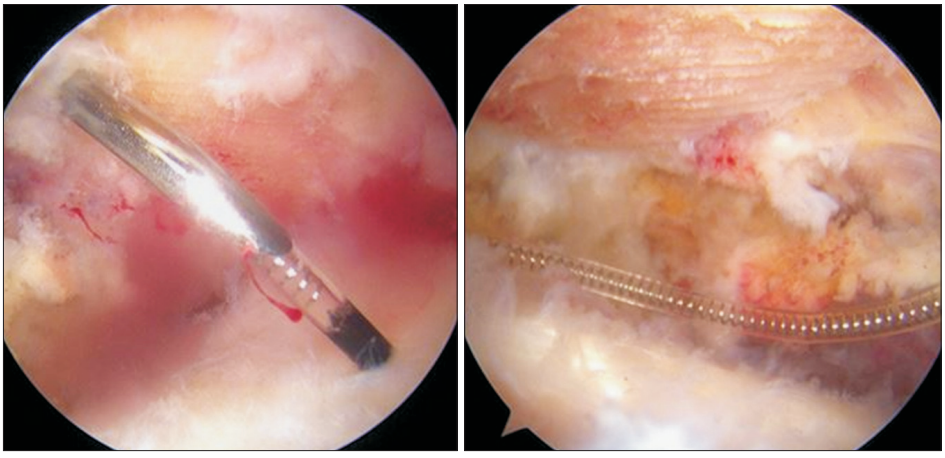

**Fig. 1.** Epidural catheter placed in subacromial space under arthroscopic visualization.

vere pain were able to control the amount of bupivacaine by self-infusing an additional 0.5 ml of bupivacaine, but they were not allowed to repeat the infusion within 15 minutes.

In all patients in group A and group B, 500 to 1,000 μg of fentanyl and 100 ml of ketorolac tromethamine were injected intravenously at a speed of 1 ml/hr. The patients were able to self-infuse an additional 1 ml but had to wait 15 minutes for the next infusion. In both groups, when PCA failed to alleviate pain, uniform supplemental analgesic injections (Tramadol 50 mg/ml, intravenous injection) were administered at the patient's request, and the frequency of injections was recorded for each patient.

Preoperative and immediate postoperative pain at rest was measured using the visual analogue scale (VAS). After PCA began, pain was assessed every 12 hours during postoperative 72 hours. When PCA was stopped after postoperative 72 hours, pain was measured every 12 hours for the next 48 hours. The results according to the frequency of supplemental analgesic injections and complications were analyzed for each group.

The paired Student t-test was used for statistical analysis. The chi-square test was used for the comparison based on the sex and age of patients between the two groups. Statistics were performed using IBM SPSS software ver. 19.0 (IBM Co., Armonk, NY, USA) and the $p<0.05$ were considered significant.

## Results

In group A, there were 17 male and 13 female patients, with a mean age of 57.2 years. In group B, there were 16 male and 14 female patients, with a mean age of 56.1 years. The sex ratio and age were not statistically different between the two groups ($p=0.584$ and 0.732, respectively). According to the classification of DeOrio and Cofield,[11] arthroscopic findings of group A included 3 cases of small-sized tear, 17 cases of medium-sized tear, and 10 cases of large-sized tear. Group B included 5 cases of small-sized tear, 14 cases of medium-sized tear, and 11 cases of large-sized tear.

The mean preoperative VAS score of group A was 7.8, 7.6 for group B ($p=0.865$). Immediately after operation, group A scored 7.9 and group B 8.1 ($p=0.643$). No significant difference was found between groups A and B at preoperative and immediately postoperative time. From postoperative 12 hours to 72 hours, most VAS scores of combined subacromial and intravenous infusion were lower with statistical significance than those of solitary intravenous infusion ($p<0.05$). After PCA was stopped, the VAS score of group A increased from 3.6 to 4.1. However, the VAS score of group B decreased from 4.9 to 4.4. After 72 hours, pain was alleviated over time, with group A scoring 2.6 on postoperative day 5 and group B scoring 2.8. No significant difference was found between the two groups (Table 2, Fig. 2).

The frequency of supplemental analgesic injections for pain control during PCA was 0.4 times in group A and 2.2 times in group B until postoperative day 5. Significant difference in the frequency of supplemental analgesic injections was observed between group A and group B ($p=0.008$) (Table 3).

Among the 30 patients in group A, 7 reported transient nausea, vomiting, and dizziness. Three of them gave up PCA at postoperative 12 hours and the remaining four patients at postoperative 72 hours. Four patients in group B had mild nausea, vomiting, and headache at postoperative 12 hours but did not

**Table 2.** Visual Analogue Scale Pain Scores from Preoperative Day to 5th Postoperative Day

| Time | Group A* | Group B† | *p*-value |
|---|---|---|---|
| Preoperative | 7.8 ± 2.0 | 7.6 ± 2.1 | 0.865 |
| Immediately | 7.9 ± 1.6 | 8.1 ± 1.4 | 0.643 |
| Postoperative (hr) | | | |
| 12 | 6.3 ± 1.9 | 7.3 ± 3.1 | 0.041 |
| 24 | 5.1 ± 1.7 | 6.2 ± 3.4 | 0.016 |
| 36 | 3.7 ± 1.3 | 5.5 ± 2.4 | <0.001 |
| 48 | 3.7 ± 1.4 | 5.3 ± 2.7 | <0.001 |
| 60 | 3.2 ± 2.1 | 5.3 ± 3.1 | <0.001 |
| 72 | 3.6 ± 1.8 | 4.9 ± 2.4 | 0.046 |
| 84 | 4.1 ± 1.3 | 4.4 ± 2.1 | 0.556 |
| 96 | 3.8 ± 2.4 | 4.6 ± 2.8 | 0.074 |
| 108 | 3.4 ± 2.1 | 3.9 ± 1.7 | 0.336 |
| 120 | 2.6 ± 1.2 | 2.8 ± 1.9 | 0.439 |

Values are presented as mean ± standard deviation.
*Combined subacromial and intravenous infusion. †Solitary intravenous infusion.

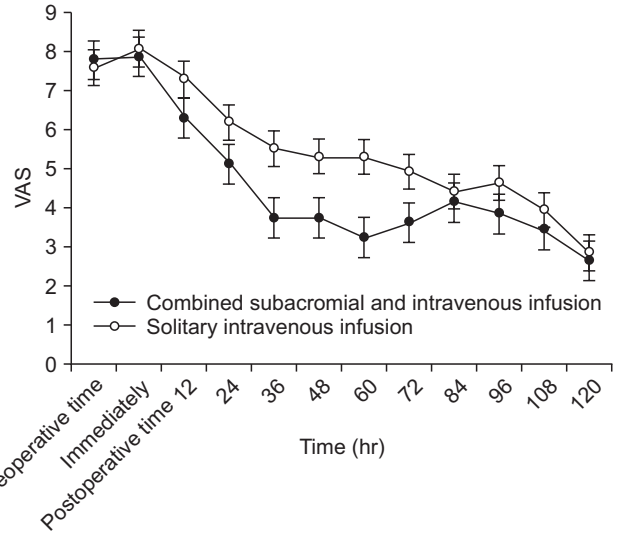


**Fig. 2.** The mean visual analogue scale (VAS) pain score was lower for patients using the combined subacromal and intravenous infusion than those receiving the intravenous infusion.

**Table 3.** PCA-related Adverse Effects and Frequency of Supplemental Analgesic Injections

| Variable | PCA-related adverse effect (n) | | | | | Mean frequency of supplemental analgesic injection (times) |
|---|---|---|---|---|---|---|
| | Nausea | Vomiting | Dizziness | Headache | Total | |
| Group A* | 4 | 2 | 1 | 0 | 7 | 0.4 |
| Group B† | 2 | 1 | 0 | 1 | 4 | 2.2 |
| Total | 6 | 3 | 1 | 1 | 11 | |
| *p*-value | | | | | 0.562 | 0.008 |

PCA: patient-controlled analgesia.
*Combined subacromial and intravenous infusion. †Solitary intravenous infusion.

stop PCA. The complication rate of group A was slightly higher than that of group B, but no statistically significant difference was observed between the two groups ($p=0.562$) (Table 3). In all patients, there were no cases of infection in the operation site.

## Discussion

The introduction of arthroscopic surgery of the shoulder joint has enabled rapid rehabilitation and recovery to activities of daily living and increased interest in postoperative pain control.[8,9,12] Arthroscopic rotator cuff repair, in particular, results in severe pain during the immediate postoperative period. Thus, many studies have focused on direct analgesic injection or infusion into the repaired site instead of intravenous injection for pain control.

The continuous infusion of a subacromial pain pump after arthroscopic subacromial decompression has been shown to minimize use of parenteral opiate analgesia, decrease pain in multiple testing parameters, and in a prospective, randomized, double-blinded controlled study, to decrease pain for the first 2 days after operation and decrease analgesic use.[13-15] A study of patient-controlled subacromial pain pumps showed a 34% reduction on the VAS, but no change in the amount of oral opioid use.[16] In another study, use of the subacromial infusion pump resulted in shorter recovery room stays but made no difference in pain, narcotic use, or postoperative range of motion of the shoulder joint.[17] Therefore authors suggested that patients with continuous infusion of a subacromial pain pump require less additional analgesia for more effective pain alleviation.

Fentanyl and ketorolac tromethamine move to the central nervous system through blood and interact with the receptor in the system to reduce postoperative pain. PCA with fentanyl and ketorolac tromethamine has been widely accepted not only in orthopaedic surgery but also in other operations and has proven its efficacy.[18-20] Results for gender related difference in intravenous PCA for postoperative pain control after rotator cuff repair were also reported.[21] However, no study on results of combined subacromial infusion with intravenous analgesia have been reported, and reports analyzing complications of combined analgesia are even harder to find.

In our series, preoperative and immediate postoperative pain was not significantly different between group A and group B. At postoperative 12 hours, the group with combined subacromial and intravenous infusion showed better results in pain alleviation compared with the group with solitary intravenous infusion. From postoperative 12 hours to 72 hours, significant differences were found between group A and group B ($p<0.05$). Therefore, we reached the conclusion that combined subacromial and intravenous infusion might be more effective in pain alleviation than solitary intravenous infusion in the initial stage after the operation. After PCA was stopped, pain increased slightly in group A and gradually reduced over time. The frequency of supplemental analgesic injections was significantly lower in group A than in group B ($p=0.008$) without increasing complication rate, implying that the effects of combined subacromial and intravenous PCA were better than those of solitary intravenous PCA.

Our study has the following limitations: first, subjects were limited to those with rotator cuff tears, making it difficult to apply the results to other patients with different shoulder disorders; second, long-term outcome was not evaluated for detection of complication and male and female patients were not compared; third, we only investigated VAS at rest but did not evaluate VAS during motion of the shoulder and physiotherapy performances; fourth, the patients were not evaluated for chondrotoxicity of bupivacaine. Bupivacaine is known to have a chondrotoxicity.[22] However a study by Busfield et al.[23] using subacromial bupivacaine found no evidence of chondrotoxicity in the early period. We supposed that subacromial infusion would not or would show minimized leakage to the glenohumeral joint followed by coverage of the tendon tear. These limitations could represent areas of future research.

## Conclusion

Combined subacromial and intravenous PCA after arthroscopic rotator cuff repair is more effective than solitary intravenous infusion without significantly increasing complications in the short term postoperative period. Therefore, combined subacromial and intravenous PCA could be an effective pain control method. However it is important to use caution regard-

ing adverse effects of this pain control method.

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