

# Can Multimodal Analgesia Reduce Postoperative Opioid Consumption in Patients Undergoing Shoulder Arthroscopy? A Retrospective Study

*Ann. Ital. Chir.*, 2024 95, 3: 308–314  
<https://doi.org/10.62713/aic.3324>

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**AIM:** The aim of this study was to investigate whether multimodal analgesia can decrease postoperative opioid usage in patients undergoing shoulder arthroscopy.

**METHODS:** Patients diagnosed with subacromial impingement syndrome who underwent acromioplasty at our institution between October 2022 and November 2023 were retrospectively analyzed. Patients were divided into an observation group and a control group based on postoperative pain management methods. The control group received intravenous self-controlled electronic analgesia (sufentanil injection 1 µg/kg + butorphanol injection 4 mg + 0.9% NaCl injection to 100 mL), while the observation group received multimodal analgesia (ropivacaine subacromial pump 3 mL/h, combined with oral celecoxib and acetaminophen). Visual Analog Scale (VAS) scores were recorded preoperatively and at various postoperative time points, and opioid usage, length of hospital stay, and analgesia-related complications within 1 week postoperatively were compared between groups. The 36-item Short Form Health Survey (SF-36) scores and the Constant–Murley score (CMS), were also assessed 1 day and 1 week after treatment.

**RESULTS:** One hundred thirty-two patients were included in the study, 66 in the observation group and 66 in the control group. In the control group, there were 46 males and 20 females, with a mean age of  $55.47 \pm 11.42$  years and in the observation group 44 males and 22 females, with a mean age of  $56.13 \pm 12.19$  years. The observation group consistently reported significantly lower pain intensity compared to the control group at 8 h (T1), 24 (T2), and 48 h (T3) after surgery ( $p < 0.05$ ). Additionally, the observation group exhibited significantly lower opioid usage and complication rates compared to the control group ( $p < 0.05$ ). SF-36 scores and CMS scores were significantly higher in the observation group 1 week after treatment compared to the control group ( $p < 0.05$ ).

**CONCLUSIONS:** Following shoulder arthroscopy, multimodal analgesia effectively reduces opioid consumption, lowers complication rates, and provides effective short-term pain relief. This approach carries significant implications for improving patient outcomes.

**Keywords:** multimodal analgesia; analgesic pump; opioids; shoulder arthroscopy; morphine equivalent

## Introduction

Subacromial impingement syndrome is a primary cause of shoulder pain, contributing to approximately 44%–65% of all shoulder pain-related conditions [1,2,3]. Acromioplasty plays a crucial role in alleviating patients' pain, alleviating subacromial pressure, and minimizing secondary lesions within the shoulder joint [4]. With the ongoing advancements in endoscopic surgery, shoulder arthroscopy has gained widespread clinical adoption due to its minimally invasive nature, which not only reduces wound size but also enhances patient comfort and reduces the formation of shoulder adhesions. Furthermore, it demonstrates high clinical efficacy and safety [5,6]. Postoperative pain management constitutes a critical aspect of perioperative care for patients undergoing shoulder arthroscopy [7]. Intravenous patient-controlled analgesia (PCA) has emerged

as a more effective and convenient method compared to intravenous analgesia and oral medication in assisting patients to manage pain and enhance satisfaction levels. It has gained increasing popularity among patients following shoulder arthroscopy [8]. Nonetheless, opioids administered via patient-controlled analgesia often precipitate various side effects, ranging from dizziness, nausea, and vomiting to more severe symptoms such as respiratory depression, hypotension, and drowsiness [9]. Enhanced postoperative analgesia and minimized opioid usage serve as integral components of rapid postoperative enhanced rehabilitation [10].

Multimodal analgesia involves the amalgamation of two or more analgesics and analgesic techniques targeting different mechanisms of action. This approach encompasses multiple stages to collectively mitigate pain, thereby amplifying analgesic effects and reducing adverse reactions that may arise from a single drug or therapy [11].

We conducted a retrospective analysis of multimodal analgesia employed in our hospital to alleviate pain following shoulder arthroscopy. Our aim was to investigate whether this approach could effectively reduce opioid dosage in pa-

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tients, with the intention of offering novel methods and insights for clinical pain relief after shoulder arthroscopy.

## Materials and Method

We conducted a retrospective review of patients who underwent acromioplasty treatment for subacromial impingement syndrome at our institution between October 2022 and November 2023. Patients were assigned to either the observation group or the control group, based on the chronological order of their admissions. Specifically, patients who received postoperative analgesia through an intravenous patient-controlled electronic analgesic pump (consisting of sufentanil injection 1 µg/kg + butorphanol injection 4 mg + 0.9% NaCl injection diluted to 100 mL) were included in the control group. Patients who received postoperative multimodal analgesia (comprising a subacromial infusion of ropivacaine at 3 mL/h combined with celecoxib and oral paracetamol) were included in the observation group. This study has obtained the principles outlined in the Declaration of Helsinki and has obtained approval from the ethics committee of Chengyang District People's Hospital (Approval No.: 20230036). The data utilized in this study were extracted from clinical case records, and patient identities were anonymized, thus informed consent was waived.

### Inclusion Criteria

The diagnostic criteria for subacromial impingement syndrome were proposed by Nikolaus and colleagues [12]: ① shoulder arthroscopic acromioplasty was performed in our hospital, and ② age: 18–75 years.

### Exclusion Criteria

The exclusion criteria were: ① Patients who have taken opioid analgesics for a long time; ② patients with shoulder surgery in the past; ③ patients with malignant tumors; and ④ patients with severe cardiovascular and cerebrovascular diseases, as well as those with liver and kidney dysfunction and mental disorders.

### Treatment Methods

Patients in both groups received intravenous-inhalation complex general anesthesia before surgery. Induction of anesthesia involved the administration of propofol (0.1 g/10 mL; code number approved by SFDA of China: H20030115; Manufacturer: Sichuan Guorui Pharmaceutical Co., Ltd., Leshan, China) (2–2.5 mg/kg), fentanyl (1 mL:50 µg; code number approved by SFDA of China: H20054171; Manufacturer: Yichang Renfu Pharmaceutical Limited Liability Company, Yichang, China) (1–2 µg/kg), and rocuronium (5 mL:50 mg; code number approved by SFDA of China: H20103235; North China Pharmaceutical Company Limited, Shijiazhuang, China) (0.6 mg/kg) for intravenous-inhalation complex general anesthesia. Sevoflurane (100 mL; code number approved by SFDA of China: H20080681; Lunan Beite Pharmaceutical and Pharmaceutical Co., Ltd., Linyi, China) was used

to maintain anesthesia depth throughout the surgical procedure. Arthroscopic acromioplasty was performed on all patients. The surgical procedures were performed by a single surgeon, and the approach and technique were consistent across both groups. The same nurse provided perioperative care before and after surgery.

### Postoperative Analgesia

Patients in the control group received postoperative analgesia through an intravenous patient-controlled electronic analgesic pump designed for precise pain management. This pump allowed the patient to self-administer medication via electronic control. The drug formulation within the pump consisted of sufentanil injection (1 mL:50 µg; code number approved by SFDA of China: H20054171; Manufacturer: Yichang Renfu Pharmaceutical Co., Ltd., Yichang Hubei, China) at 1 µg/kg, butorphanol injection (1 mL:1 mg; code number approved by SFDA of China: H20223866; Guorui Pharmaceutical Co., Ltd., Huainan, China) at 4 mg, and 0.9% NaCl injection (10 mL/strike; code number approved by SFDA of China H20043271; China Otsuka Pharmaceutical Co., Ltd., Tianjin, China) to a total volume of 100 mL. The baseline infusion rate was set at 2 mL/h, with an option for patients to administer an additional dose of 0.5 mL as needed. The pump had a locking period of 15 min, and it was removed after 2 days. In cases where patients experienced increased pain, indicated by a Visual Analog Scale (VAS) score of  $\geq 7$ , they were instructed to orally take tramadol hydrochloride sustained-release tablets (50 mg; J20130072, Moody, Beijing, China) at intervals of more than 8 h. The total daily opioid consumption by each patient was carefully recorded.

Patients in the observation group received multimodal analgesia following surgery. A postoperative self-controlled electronic analgesic pump was placed in the subacromial space on the side of the surgery. The baseline infusion rate was set at 3 mL/h of ropivacaine, with a self-controlled dose of 1 mL and a locking time of 15 min. The electronic analgesic pump was removed after 2 days. Additionally, oral celecoxib capsules (200 mg; H20140106, New York, NY, USA) were administered twice daily, along with paracetamol tablets (0.5 g; H20010394, Shanghai Johnson & Johnson Co., Ltd., Shanghai, China.) three times daily. In cases where patients experienced heightened pain with a VAS score  $\geq 7$ , they were instructed to orally take tramadol hydrochloride sustained-release tablets (50 mg; H19980214, Mundipharma (China) Pharmaceutical Co., Ltd., Beijing, China) at intervals of more than 8 h, and the total daily opioid usage was documented.

### Observation Indicators

The severity of patients' pain was assessed using the VAS, a widely recognized tool for pain evaluation [13]. This scale ranges from 0 to 10, with higher scores indicating greater pain intensity. The differences in VAS scores were noted before surgery (T0) and at 8 h (T1), 24 h (T2), 48 h (T3),

**Table 1. Comparison of general data between the two groups.**

Parameter		Control group	Observation group	$\chi^2/t$	<i>p</i>
		(n = 66)	(n = 66)		
Sex (n)	Male	46	44	0.139	0.709
	Female	20	22		
Age (years) mean $\pm$ SD		55.47 $\pm$ 11.42	56.13 $\pm$ 12.19	0.321	0.749
BMI (kg/m <sup>2</sup> ) mean $\pm$ SD		25.43 $\pm$ 6.47	26.33 $\pm$ 7.14	0.759	0.449
Disease duration (months) mean $\pm$ SD		12.57 $\pm$ 2.64	11.79 $\pm$ 2.38	1.783	0.077
Operation time (minutes) mean $\pm$ SD		147.38 $\pm$ 18.75	151.28 $\pm$ 17.49	1.211	0.228

BMI, body mass index; SD, standard deviation.

**Table 2. Comparison of VAS scores at different time points before and after treatment between the two groups.**

Parameter	Control group	Observation group	<i>t</i>	<i>p</i>
VAS at time points mean $\pm$ SD				
T0 (preop)	4.85 $\pm$ 1.42	4.83 $\pm$ 1.23	0.087	0.931
T1 (8 hours postop)	5.95 $\pm$ 0.71	5.17 $\pm$ 0.63	6.676	<0.001
T2 (24 hours postop)	4.88 $\pm$ 0.59	4.14 $\pm$ 0.52	7.644	<0.001
T3 (48 hours postop)	3.57 $\pm$ 0.44	3.01 $\pm$ 0.42	7.479	<0.001
T4 (1 week postop)	1.11 $\pm$ 0.25	1.05 $\pm$ 0.19	1.552	0.123

VAS, Visual Analog Scale.

and 1 week (T4) post-surgery. Postoperative analgesics were converted to oral morphine equivalent doses (4 mg of butorphanol = 5 mg of morphine, 1 mg of morphine = 1  $\mu$ g of sufentanil, and 1 mg of morphine = 10 mg of tramadol [14,15]). The discrepancy in oral morphine equivalent doses within 1-week post-surgery was compared. The occurrence of complications following analgesic administration within 1-week post-surgery, as well as patients' 36-item Short Form Health Survey (SF-36) score [16] and Constant-Murley score (CMS), a shoulder function score [17], were evaluated at 1 day and 1 week after treatment, respectively.

#### Statistical Analysis

Data were subjected to statistical analysis using SPSS 26.0 software (IBM Corp., Armonk, NY, USA). The Shapiro-Wilk test determined whether the data adhered to a normal distribution. Quantitative data, meeting the assumptions of normal distribution and homogeneity of variance, were presented as mean values  $\pm$  standard deviation ( $\bar{x} \pm s$ ). Intra-group comparisons before and after treatment were conducted using the paired *t*-test, while inter-group comparisons utilized the independent samples *t*-test or repeated measures analysis of variance (ANOVA). Qualitative data were expressed as rates or proportions, and inter-group comparisons were made using the chi-square test or Fisher's exact test. A *p* value less than 0.05 was considered statistically significant.

## Results

### General Data

The study population consisted of 132 patients, with 66 individuals in both the control and observation groups. In the control group, there were 46 males and 20 females, with a mean age of 55.47  $\pm$  11.42 years. The observation group consisted of 44 males and 22 females, with a mean age of 56.13  $\pm$  12.19 years. Statistical analysis indicated no significant differences in baseline characteristics between the two groups (*p* > 0.05; Table 1).

### Pain

Before surgery and 1-week post-operation, no statistically significant differences in VAS scores were observed between the two patient groups (*p* > 0.05). However, following surgery, the VAS scores at 8 h, 24 h, and 48 h post-operation were consistently lower in the observation group than in the control group (*p* < 0.05; Table 2).

### Comparison of Opioid Dosage within 1 Week after Surgery between the Two Groups

The mean amount of oral morphine equivalents of opioids used within 1 week after surgery were 23.47  $\pm$  3.16 mg in the control group and 8.35  $\pm$  1.05 mg in the observation group, which was significantly lower in the observation group than in the control group (*p* < 0.05; Table 3).

**Table 3. Comparison of postoperative oral morphine equivalents between the two groups.**

Parameter	Control group	Observation group	<i>t</i>	<i>p</i>
Oral morphine equivalents, (mg) mean ± SD	23.47 ± 3.16	8.35 ± 1.05	36.889	<0.001

**Table 4. Comparison of complications after postoperative use of analgesics between the two groups [n (%)].**

Groups	Control group	Observation group	$\chi^2$ value	<i>p</i>
Number of cases (n)	66	66		
Dizziness	5 (7.6)	2 (3.0)		
Nausea and vomiting	13 (19.7)	3 (4.5)		
Drowsiness	8 (12.1)	1 (1.5)		
Urinary retention	2 (3.0)	0 (0)		
Respiratory depression	1 (1.5)	0 (0)		
Insomnia	8 (12.1)	1 (1.5)		
Total incidence	37 (56.1)	7 (10.6)	30.682	<0.001

**Table 5. Comparison of SF-36 and CMS scores before and after treatment in the two groups.**

Parameter		Control group	Observation group	<i>t</i>	<i>p</i>
SF-36 score (points) mean ± SD	1 day after treatment	38.53 ± 9.36	40.15 ± 9.85	0.969	0.334
	1 week after treatment	68.43 ± 18.54*	79.67 ± 19.89*	3.358	0.002
CMS (points) mean ± SD	1 day after treatment	26.78 ± 7.42	25.62 ± 7.31	0.905	0.361
	1 week after treatment	63.59 ± 13.63*	75.53 ± 15.57*	4.688	<0.001

CMS, Constant–Murley score; SF-36, 36-item Short Form Health Survey; \*Statistically different at 1 week after treatment vs. 1 day after treatment.

*Incidence of Complications after Using Analgesic Drugs within 1 Week Postoperatively in Patients between the Two Groups*

The overall incidence of complications 1 week after treatment was 56.1% for the control group, significantly higher than the 10.6% observed in the observation group. The rate of adverse reactions in the observation group was significantly lower than that in the control group ( $p < 0.05$ ; Table 4).

*SF-36 and CMS Scores 1 Day and 1 Week after Treatment in the Two Groups*

After 1 day of treatment, no statistically significant differences were observed in the SF-36 and CMS scores between the two patient groups ( $p > 0.05$ ). However, after 1 week of treatment, both groups exhibited higher SF-36 and CMS scores compared to those before treatment, with the observation group scoring higher than the control group ( $p < 0.05$ ; Table 5).

**Discussion**

This study showed that the implementation of a multimodal analgesia strategy in patients undergoing shoulder arthroscopy reduced opioid usage, lowered the incidence of complications, and enhanced quality of life and shoulder function. These findings have substantial clinical significance, providing valuable insights and approaches for post-arthroscopy pain management.

The observation group consistently had significantly lower VAS scores compared to the control group ( $p < 0.05$ ). Re-

garding analgesic use, the control group required an oral morphine equivalent of  $23.47 \pm 3.16$  mg within 1-week post-surgery, whereas the observation group’s consumption significantly decreased to  $8.35 \pm 1.05$  mg, marking a substantial difference from the control group ( $p < 0.05$ ). Complication rates also differed markedly between the groups, with the control group experiencing a total incidence of 56.0%, contrasting with the observation group’s rate of 10.5% ( $p < 0.05$ ). After 1 day of treatment, no significant discrepancy was observed in the SF-36 and CMS scores between the two groups ( $p > 0.05$ ). However, after 1 week of treatment, assessments indicated an improvement in both scores for all patients, with the observation group achieving higher scores than the control group ( $p < 0.05$ ), suggesting a more favorable treatment outcome.

In recent years, advances in endoscopic technology have propelled arthroscopic acromioplasty to the forefront as the preferred treatment for patients grappling with subacromial impingement syndrome, particularly when conservative measures are inadequate. This minimally invasive procedure has transformed the management of shoulder impingement, offering patients a pathway to relief and recovery with reduced surgical trauma and accelerated rehabilitation times [18]. Despite the diminished surgical trauma associated with shoulder arthroscopy, patients often contend with local swelling and postoperative pain, challenges that clinicians frequently encounter due to the soft tissue damage surrounding the shoulder joint resulting from arthroscopic surgery [19]. Opioids have conventionally served as postoperative analgesics [20,21], yet their widespread use

has led to the emergence of opioid abuse in clinical practice, a matter of considerable concern within the medical community [22].

From 2009 to 2016, in Israel, there was a 68% increase in the use of five opioids—fentanyl, morphine, levocodone, dolantin, and methadone—with fentanyl witnessing a four-fold surge [23]. Similarly, studies have revealed a fourfold rise in opioid consumption in the United States from 1999 to 2015 [24], accompanied by a corresponding increase in opioid-related complications and mortality. In 2015 alone, over 33,000 individuals tragically lost their lives due to opioid-related overdoses, highlighting the urgent necessity for comprehensive strategies to address this public health crisis [25]. The expenditure on opioid use or abuse in the United States surpasses USD 50 billion annually [26]. Consequently, identifying a novel postoperative analgesic approach emerges as an imperative challenge for clinicians to tackle [27].

With advances in analgesic techniques and scholars' deeper understanding of postoperative pain, methods such as preemptive analgesia and multimodal analgesia have garnered widespread acclaim in clinical practice, yielding favorable outcomes. Preemptive analgesia involves preemptively blocking pain transmission in the spinal cord and brain using analgesic drugs or nerve blocks. This preemptive action inhibits the amplification of pain transmission in the spinal cord and brain by painful stimuli, thereby elevating the pain threshold and preventing peripheral or central pain hypersensitivity [28]. Multimodal analgesia, on the other hand, entails the combined administration of analgesics with diverse mechanisms of action and delivery routes. This approach capitalizes on the synergistic and complementary effects among different drugs to achieve robust analgesic outcomes [29].

Multimodal analgesia offers several advantages, including the reduction of drug dosage and occurrence of adverse drug reactions, enhancement of drug tolerance, and prolongation of analgesic duration, thereby improving overall pain management effectiveness [30]. One study has demonstrated that multimodal analgesia yields minimal adverse reactions and significantly mitigates postoperative pain, establishing it as the most efficacious analgesic regimen available [31]. Our findings indicate that postoperative analgesia utilizing pumped ropivacaine in combination with celecoxib and oral acetaminophen significantly diminishes opioid dosage in patients and notably decreases various complications associated with opioid use compared to intravenous opioid-containing injections.

Celecoxib, a widely used nonsteroidal anti-inflammatory drug (NSAID), is frequently employed in clinical practice due to its therapeutic benefits across various inflammatory conditions. Acting as a selective cyclooxygenase-2 (COX-2) inhibitor, celecoxib exerts anti-inflammatory and analgesic effects by modulating the inflammatory cascade, specifically through the inhibition of prostaglandin synthesis—a pivotal mediator of inflammation. It is also

commonly utilized as a postoperative analgesic [31]. Studies have demonstrated that NSAIDs possess an opioid-sparing effect, enabling reductions in opioid receptor agonist dosages and mitigating the incidence of associated adverse reactions such as nausea and vomiting [32]. Nakata *et al.* [33] discovered that celecoxib administration following orthopedic surgery effectively relieves pain with minimal side effects. Ropivacaine, a local anesthetic agent, induces reversible blockade of impulse conduction along nerve fibers by inhibiting the flow of sodium ions into nerve cell membranes. Research has revealed that dexmedetomidine combined with ropivacaine significantly reduces the total 24-hour consumption of sufentanil in patients undergoing knee replacement surgery, thereby prolonging and enhancing the postoperative analgesic effect [34].

Acetaminophen is an antipyretic analgesic, and its mechanism of action remains unclear. It is believed to be related to inhibiting central prostaglandins, stimulating activity, reducing 5-hydroxytryptaminergic pathways in the spinal cord, or regulating endorphin receptors [35]. Intravenous acetaminophen has been shown to significantly reduce discomfort such as pain and nausea in patients compared to intravenous fentanyl [36]. In our study, we found that oral administration of ropivacaine combined with celecoxib and paracetamol could significantly reduce VAS scores compared to intravenous infusion of opioid-containing drugs. However, the difference in VAS scores at 1 week after surgery between the two groups was not significant. The soft tissue in the shoulder joint may be gradually repaired and improved over time, leading to the gradual subsidence of pain. Furthermore, we observed that both the SF-36 score and CMS score increased after treatment in both groups, with higher scores observed in the observation group compared to the control group. The complications of intravenous opioid infusion can have serious effects on patients, potentially impacting their shoulder joint function during late-stage rehabilitation.

While offering valuable insights, this study had several limitations. Firstly, its retrospective design introduced the potential for selection bias and information bias. Secondly, being a single-center study with a constrained sample size, the generalizability of its findings may be limited. Thirdly, the evaluation of the analgesic effect is subjective. Individual differences and subjective feelings of patients could influence the evaluation, leading to measurement bias of results. Additionally, the short duration of postoperative observation and potential changes in postoperative pain management and medication use habits over time could affect the study outcomes. Therefore, short-term study results may not fully reflect long-term analgesic efficacy and drug use trends. This study provided preliminary evidence on the application of multimodal analgesia in patients undergoing shoulder arthroscopy. To obtain more robust and persuasive evidence, researchers are encouraged to conduct rigorous, multicenter, prospective studies encompassing a broad spectrum of participants.

## Conclusions

The implementation of multimodal analgesia in shoulder arthroscopy procedures not only reduces the need for post-surgery opioid use but also decreases the likelihood of complications. This approach facilitates rapid and significant pain relief in the immediate postoperative period, thereby improving the overall prognosis and recovery of patients.

## Availability of Data and Materials

The datasets used and analysed during the current study were available from the corresponding author on reasonable request.

## Author Contributions

LF and MY designed the research study. LF and MY performed the research. LF and ZT collected and analyzed the data. All authors conducted the study, participated in drafting the manuscript and contributed to critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

## Ethics Approval and Consent to Participate

This study has been approved by the ethics committee of Chengyang District People's Hospital. Approval No.: 20230036. The data utilized in this study were extracted from clinical case records, and patient identities were anonymized, thus informed consent was waived. However, it was approved by Chengyang District People's Hospital.

## Acknowledgment

Not applicable.

## Funding

This research received no external funding.

## Conflict of Interest

The authors declare no conflict of interest.

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