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Postoperative pain control after arthroscopic rotator cuff repair

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Arthroscopic rotator cuff repair (ARCR) can provide excellent clinical results for patients who fail to respond to conservative management of symptomatic rotator cuff tears. ARCR, however, can be associated with severe postoperative pain and discomfort that requires adequate analgesia. As ARCR continues to shift toward being performed as an outpatient procedure, it is incumbent on physicians and ambulatory surgical centers to provide appropriate pain relief with minimal side effects to ensure rapid recovery and safe discharge. Although intravenous and oral opioids are the cornerstone of pain management after orthopedic procedures, they are associated with drowsiness, nausea, vomiting, and increased length of hospital stay. As health care reimbursements continue to become more intimately focused on quality, patient satisfaction, and minimizing of complications, the need for adequate pain control with minimal complications will continue to be a principal focus for providers and institutions alike. We present a review of alternative modalities for pain relief after ARCR, including cryotherapy, intralesional anesthesia, nerve blockade, indwelling continuous nerve block catheters, and multimodal anesthesia. In choosing among these modalities, physicians should consider patient- and system-based factors to allow the efficient delivery of analgesia that optimizes recovery and improves patient satisfaction.

Level of evidence: Review Article

Keywords: Rotator cuff repair; arthroscopic; shoulder; postoperative pain; opioids, analgesia; brachial plexus; nerve block

In recent years, the number of arthroscopic rotator cuff repairs (ARCRs) being performed has increased significantly, with some authors reporting population-adjusted increases in procedural volume that range from 163% to 268%.[39,50] The increase in volume has been attributed to the aging population, increased activity level among patients, and significant advancements in arthroscopic techniques and fixation options available to surgeons.[28,39] In addition, there has been a significant shift toward ARCR's being performed at ambulatory surgery centers, where patients are traditionally discharged on the same day of surgery.[50] Despite being characterized as a "minimally invasive" procedure, ARCR is associated with significant postoperative pain in the acute perioperative period.[5,82] As the number of ARCRs being performed at ambulatory centers continues to increase, adequate analgesia associated with rapid recovery and minimal

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postoperative nausea and vomiting (PONV) is necessary to optimize patient outcomes and to reduce health care costs.

Traditionally, postoperative pain after ARCR has been managed with the use of oral opioid medications.[77] The significant pain associated with ARCR often requires large dosages that may have a variety of side effects, such as hypotension, PONV, and sedation, which may result in need for hospital admission and subsequent increased length of stay.[49,53,90] In an effort to minimize postoperative complications, to reduce duration of hospital stay, and ultimately to improve pain control in the acute perioperative period, several different modalities for pain control have been used after ARCR. The authors present a review of these various options, including opioid and nonopioid medications, cryotherapy, intralesional analgesia, suprascapular nerve blocks (SSNBs) with or without an axillary nerve block (ANB), interscalene brachial plexus blocks (IBPBs), and indwelling interscalene catheters.

Opioid analgesia

Opioid agents are widely considered the "gold standard" for postoperative analgesia after orthopedic surgery. Because of their adverse side effect profile and potential for abuse, however, there has been a significant effort to identify alternative methods for relieving postoperative pain, thus reducing risks associated with opioid use.[67,75] Common adverse effects associated with opioids include PONV, constipation, ileus, urinary retention, and pruritus.[77] More significant manifestations of side effects include hypoxia, respiratory depression, hypotension, somnolence, confusion, and dizziness.[49,81,82] As a result of these complications, opioid use after orthopedic procedures has been associated with increased length of hospital stay for a variety of orthopedic procedures.[7,45,90]

As the traditional model of an ambulatory surgery center is to provide surgical treatment and subsequent same-day discharge, postoperative use of intravenous (IV) patient-controlled analgesia (PCA) is a rarely used modality in this setting—although degree of PCA utilization may vary, depending on the insurance system and practice patterns present within specific countries and health care facilities. Patients who ultimately are unable to be discharged on the same day of surgery, however, may often receive a PCA during their hospital admission.

In situations in which a PCA is required, the literature supports its efficacy for postoperative pain management.[29] In addition, when PCA is used in adjunct with a background opioid infusion, patients report better analgesia and can tolerate increased narcotic consumption without a concomitant increase in nausea, vomiting, pruritus, or sedation.[102] Although providing a basal opioid infusion along with a PCA may result in an overall greater dose of opioid delivered, there is no evidence of increased respiratory depression in this setting.[26,91,102] In situations in which obtaining IV access may be difficult, a transdermal fentanyl patch may be used to effectively deliver postoperative opioids. Merivirta et al conducted a prospective, randomized controlled trial demonstrating that patients who used a postoperative fentanyl patch after arthroscopic shoulder surgery had equivalent postoperative pain relief to those who received a subacromial bupivacaine infusion, without demonstrating an increased incidence of respiratory complications.[72] In addition, patients who received a fentanyl patch required 50% less rescue doses of ibuprofen compared with those who received bupivacaine (600 mg vs. 1200 mg; $P = .042$).

Whereas IV PCA and transdermal patches are the most common methods of delivering opioid analgesia after ARCR, the addition of opioids through nerve blocks or intramuscular administration has also been reported. Behr et al reported on 150 patients undergoing ARCR and observed that compared with placebo controls, the duration of sensory block and postoperative analgesia was significantly longer in patients who had opioids either added to their interscalene block or delivered intramuscularly.[9] Candido et al echoed these results, reporting that the addition of opioids to brachial plexus blocks extended the duration of postoperative analgesia 3-fold compared with controls (17.4 ± 1.26 hours vs. 5.3 ± 0.15 hours; $P < .001$) for patients undergoing upper extremity surgery.[18] Although these methods could be highly useful in an inpatient setting, their utility in ambulatory surgery may be limited in considering that addition of opioids would likely delay discharge.

Opioids will likely continue to be an important component in the management of postoperative pain, and in situations that result in hospital admission, PCA or fentanyl patch in addition to oral opioids may be considered. The current paradigm shift and heightened awareness of the potential for opioid misuse, however, warrants a serious consideration of alternative methods of postoperative pain relief after ARCR.[75,76,113]

Nonopioid analgesia

Nonsteroidal anti-inflammatory drugs (NSAIDs) are a cornerstone in the nonoperative management of rotator cuff disease.[14,70] In the acute postoperative period, however, the use of these agents is not as widespread as other modalities. Although studies focusing on NSAIDs after ARCR are limited, NSAIDs can provide significant analgesia for patients in the acute postoperative phase, particularly when they are used as part of a multimodal protocol.[8,54] A level I study by Takada et al compared the analgesic effect of IV flurbiprofen, an NSAID medication, with placebo after ARCR. Results demonstrated statistically significant reductions in visual analog scale (VAS) pain scores at 6 hours, decreased opioid requirements during the first 2 hours postoperatively, and increased time to first request of analgesia in the NSAID group compared with controls.[107] Cyclooxygenase 2 (COX-2)–selective inhibitors are a subclass of traditional NSAIDS, most notable for their ability to reduce the incidence of gastric side effects.[24]

A study of 60 patients by Rouhani et al found that patients who received preoperative COX-2 inhibitors had reduced pain and less sleep disturbance than placebo controls and also demonstrated a quicker functional recovery.[97] Nagasaki et al enrolled 20 patients undergoing shoulder procedures into 2 groups: patients who received IV PCA only and those who received IV PCA along with NSAIDs. The authors found that the addition of NSAIDs resulted in a 50% reduction in need for opioids (15.1 ± 9.0 mg vs. 30.5 ± 21.0 mg; $P < .05$) after shoulder surgery.[78]

Despite these advantages, however, the use of this class of medication is not without potential risk.[70] The adverse effect of NSAID medication on tissue healing, bone metabolism, and fracture healing has been well documented.[21,23] Connizzo et al evaluated the effect of ibuprofen administration on tendon-to-bone healing in the rat model and made biomechanical and histologic assessments at several time points after repair. They reported that early NSAID administration, defined as within the first week after repair, had detrimental effects on overall construct stiffness and resulted in reduced collagen fiber reorganization on histology.[30] Although the data are limited, surgeons should approach the early use of NSAID medication with caution, weighing the potential risks of late failure against early analgesic benefit. Future studies providing long-term longitudinal results of NSAIDs in orthopedics are warranted.

Gabapentin is another adjunct medication used for pain control that has been evaluated in the literature.[19,86] It is widely used for neuropathic pain syndromes, and its mechanism of action involves the GABAergic pathway.[108] In addition to its analgesic properties, it has an anxiolytic effect that could be of additional benefit to patients postoperatively. Despite these potential benefits, it has been associated with sedation and dizziness.[62] Results of gabapentin use in ARCR are equivocal. Bang et al performed a randomized controlled trial examining the effectiveness of perioperative gabapentin compared with placebo and found that although VAS scores were significantly lower at 2, 6, and 12 hours postoperatively, overall opioid administration and side effects were not statistically different.[5] Adam et al performed a similar study to assess the effectiveness of gabapentin as an adjunct to IBPBs and found no significant benefit in regard to overall pain scores or analgesic requirements as a result of the addition of gabapentin.[1] Although the theoretical benefits of gabapentin are promising, the use of gabapentin as an adjunct medication after outpatient ARCR has not yet been validated to recommend routine use.

Cryotherapy

Cold therapy to control pain and swelling has been widely used in ARCR.[36,61,89] Speer et al reported a prospective study showing that cryotherapy was associated with reduced pain and swelling, decreased opioid use, and better overall sleep quality after rotator cuff repair.[106] Similarly, Singh et al performed a randomized controlled trial comparing continuous cryotherapy treatment with age-matched controls and found that the cryotherapy group had lower VAS pain scores and increased sleep on postoperative day 1 in addition to decreased frequency and intensity of pain during postoperative days 7 to 21.[104] The efficacy of cryotherapy involves a reduction in temperature of both the glenohumeral and subacromial spaces, which results in a decrease in detrimental proteolytic enzyme activity that prevents destruction of articular cartilage and subsequent pain.[68,84] Whereas the literature for cryotherapy demonstrates that this joint temperature reduction yields positive results as early as the first postoperative day, additional randomized controlled studies are warranted to determine the long-term utility of this therapy. Although cryotherapy can be an effective component for providing pain relief after ARCR, costs are often not covered by insurance companies, thus limiting widespread access and use by patients.[61]

Intralesional analgesia

Intralesional anesthesia involves either a single injection or the continuous infusion of local anesthesia into the joint space or subacromial region after surgery.[83] Several randomized controlled trials have examined the efficacy of a single subacromial injection. In a study by Boss et al, 42 patients undergoing rotator cuff repair were randomized to receive either a subacromial injection or no injection at all. Their results demonstrated no difference between groups in regard to total morphine consumption and VAS pain scores at rest and during movement.[13] Whereas Harvey et al also reported no difference in overall opioid consumption postoperatively with subacromial injection, they did report decreased pain scores on postoperative days 1 and 2.[47] Fredrickson et al performed a comprehensive review evaluating the efficacy of intralesional anesthesia and reported several studies failing to show significant reduction in postoperative pain in comparing a single bursal injection with continuous intralesional infusion.[41]

Continuous intralesional infusion has gained popularity because of the increasing commercial availability of disposable infusion pumps.[31,32] These pumps allow safe, steady infusion of anesthesia directly into the subacromial space. Although subacromial continuous infusion pumps have been associated with low complication rates, severe chondrolysis has been reported with intra-articular pain pump catheters.[43,94] Matsen and Papadonikolakis found that this risk of glenohumeral chondrolysis is significantly greater with higher doses and higher rates of infusion of local anesthetic ($P = .0029$ and $P = .003$, respectively), suggesting a linear dose-dependent relationship.[71] Considering that several studies have shown unclear analgesic benefit from this modality and that the occurrence of chondrolysis after ARCR has catastrophic potential around the shoulder, the use of continuous infusion pumps in the subacromial space is no longer recommended.[10,56,94]

Suprascapular nerve blocks

The suprascapular nerve (SSN) branches off of the superior trunk of the brachial plexus (Fig. 1). It extends posteriorly through the scapular notch to innervate the supraspinatus and the distal portion of the infraspinatus muscles.[66] Combined with the lateral pectoral nerve, the SSN provides sensation to the posterior shoulder capsule, acromioclavicular joint, subacromial bursa, and coracoclavicular ligament. Blind and ultrasound-guided techniques have been described to target the SSN at the supraspinous fossa or suprascapular notch.[73,88] As an SSNB can be done either with the patient prone through a suprascapular approach or with the patient supine through a supraclavicular approach, it has the potential to provide sufficient anesthetic relief for a large variety of shoulder procedures.[6]

Some studies advocate for the inclusion of an ANB with an SSNB to optimize pain management after ARCR.[64] The axillary nerve originates from the superior trunk of the brachial plexus.[48] After branching from the posterior cord, the nerve passes through the quadrilateral space and divides into anterior and posterior trunks.[74] The posterior trunk innervates the teres minor and posterior deltoid muscle and provides cutaneous sensation to the area overlying the deltoid. The anterior trunk also innervates part of the anterior and middle deltoid muscle as well as the deep subfascial surface of the muscle.[20] ANBs are relatively safe as the site of injection is the posterior upper arm, away from any vital structures (ie, lungs, pleura, cervical spine). After isolation of the axillary nerve within the quadrilateral space, confirmation can be obtained by current stimulation of 0.5 mA with subsequent motor contraction of the deltoid muscle.[96]

Clinical outcomes

A randomized controlled clinical trial performed by Ritchie et al compared the efficacy of an SSNB using 10 mL of 0.5% bupivacaine with a subcutaneous saline injection for patients having arthroscopic rotator cuff surgery.[95] The group receiving the SSNB showed a 51% reduction in demand for PCA and a 31% less consumption of morphine PCA, both of which were statistically significant. The incidence of side effects, such as nausea and vomiting, was reduced 5-fold in the SSNB group, and no complications were observed. Similar findings were obtained in a prospective randomized study by Lee et al for which patients undergoing rotator cuff repair were randomized to SSNB or placebo. Whereas no difference in VAS pain scores was observed, patients with SSNB had statistically significant lower fentanyl consumption than controls did (137.8 ± 212.4 μg vs. 315.1 ± 110.4 μg; $P = .015$).[65]

Multiple studies have documented a statistically significant reduction in total PCA consumption postoperatively (between 0 and 20 hours) in comparing SSNB with adjuvant ANB to control subjects. An additional benefit is that patients who received an SSNB did not require any additional analgesics, opiates, or general anesthesia, and no patient experienced symptoms of full motor blockade.[20,79]

The use of an SSNB is associated with an average 10-hour interval before the onset of significant pain and increased VAS pain scores compared with placebo.[27,34] In addition, times to sit, eat, ambulate, and void were also found to be significantly earlier for patients who received an SSNB, which is particularly useful in the ambulatory surgery setting. SSNB has also been reported to be associated with reduced verbal pain scores at rest and with abduction at all times within the first 24 hours after arthroscopic shoulder procedures.[95] A clinical trial performed by Checcucci et al to investigate SSNB with ANB noted mean satisfaction and comfort scores of 8.4 ± 1.3 and 7.6 ± 0.8, respectively (range of 1 to 10, with 10 being most satisfied or comfortable), with all subjects reporting satisfaction with their experience and no adverse effects. Improved patient satisfaction has been suggested to result in significantly lower VAS pain scores reported in the experimental group at 16 hours after operation.[20]

SSNB with ANB has also demonstrated its effectiveness for patients undergoing arthroscopic procedures of the shoulder, including ARCR.[79] However, certain anatomic structures of the shoulder joint are not fully anesthetized by this technique, including the anterior portion of the glenohumeral capsule, the subscapular muscles, and parts of the acromioclavicular joint.[6] Inability to adequately anesthetize these regions may result in inadequate postoperative analgesia should the surgeon be required to perform additional, unexpected procedures intraoperatively.[20]

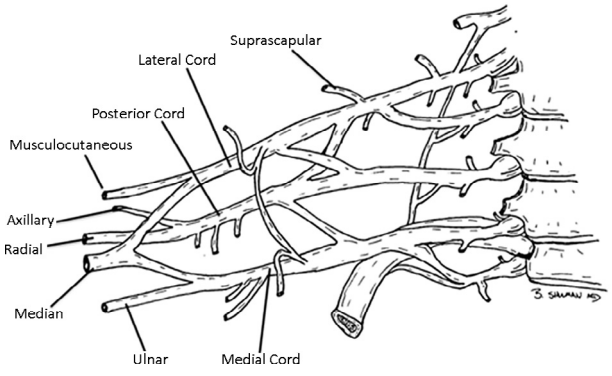

Figure 1 Artist's rendering of the brachial plexus with the major terminal nerves labeled.

Interscalene brachial plexus blocks

The use of ultrasound for guidance has significantly increased the options available to anesthesiologists in performing brachial plexus blocks and also allows a more accurate delivery, resulting in a greater analgesic effect.[42] There are axillary, supraclavicular, infraclavicular, and interscalene approaches to the brachial plexus (Fig. 2), with the method of

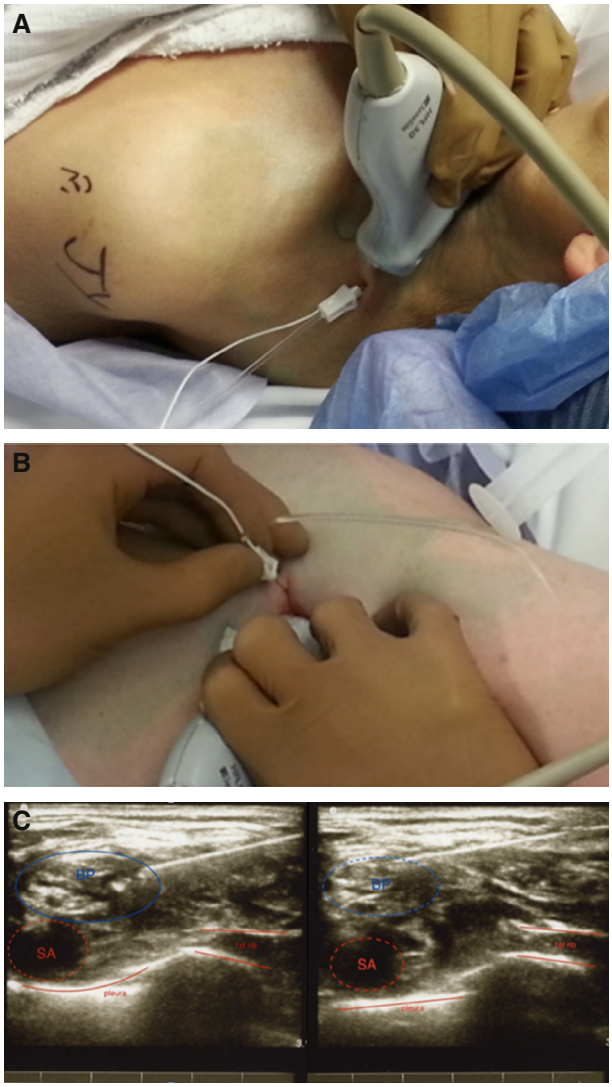

Figure 2 (**A**) Interscalene nerve block performed under ultrasound guidance. (**B**) Axillary nerve block performed under ultrasound guidance. The needle is introduced from anterior near the axillary fold with the arm abducted. (**C**) Ultrasound image of the needle being introduced around the brachial plexus for anesthetic injection. *BP,* brachial plexus; *SA,* subacromial artery.

choice largely depending on the anesthesiologist's preference.[99] Ultrasound guidance allows direct visualization of the needle and associated neurovascular structures and direct observation during anesthetic administration.[105] IBPBs have demonstrated a high level of efficacy in pain management after arthroscopic rotator cuff surgery, particularly because the brachial plexus provides sensory and motor innervation for the entire upper extremity.[105] These blocks can be performed with either 0.5% ropivacaine or bupivacaine, as studies have failed to show any significant difference in either agent with regard to dosage, pain relief, or quality of an IBPB.[58]

Clinical outcomes

D'Alessio et al examined the efficacy of IBPB compared with general anesthesia.[33] They noticed a more efficient operative experience when using the IBPB, citing a mean reduction of 30 minutes in postanesthesia care unit (PACU) time (72 ± 24 vs. 102 ± 40 minutes; $P = .0001$) and also a decrease in nonsurgical intraoperative time (53 ± 12 vs. 62 ± 13 minutes; $P = .0001$). In addition, IBPB resulted in significantly few unplanned hospital admissions (0 vs. 13; $P = .004$). An investigation by Chelly et al reported similar results, including a 64% reduction in readmission rates for nausea and vomiting, severe pain, hypotension, and bronchospasms for IBPB compared with general anesthesia.[22] A comparative analysis of IBPB, subacromial block, and placebo saline injection demonstrated significantly lower pain scores at rest and during movement in the IBPB cohort compared with the 2 other groups.[63] Another study compared IBPB with SSNB and intra-articular infusion. The IBPB and SSNB groups both showed significantly lower pain scores at movement and rest than both the intra-articular local anesthetic and the control groups.[103] Patients in the IBPB group had better pain relief during movement than did those in the SSNB group at 4 hours postoperatively in the PACU, and the IBPB group was the only group with significantly reduced IV acetaminophen consumption in the 24 hours immediately after surgery. Finally, patients in the IBPB group demonstrated a significantly higher rate of satisfaction compared with the other cohorts.[103]

As noted earlier, the use of ultrasound guidance has improved the accuracy and safety of IBPB administration through the years.[69] Despite this, there are significant risks associated with the administration of IBPB. There have been reports of systemic complications including cardiac arrest, respiratory failure, and seizures.[2,10,74,85] Given the proximity of the phrenic nerve to the brachial plexus, there is also increased risk of phrenic nerve injury.[52] Because of this anatomic proximity and relatively high incidence of phrenic nerve injury with brachial plexus blocks, any underlying pulmonary disease is considered to be a relative contraindication to proximal brachial plexus blocks.[110] In addition to systemic complications, there have also been reports of peripheral nerve injury after brachial plexus blocks. These are thought to be secondary to mechanical trauma from needles or catheters, drug neurotoxicity, ischemia, and nerve compression or stretch.[4,35,55] Although the reported rate of neurologic sequelae lasting >1 year after upper extremity regional anesthesia is <1%, complications can drastically affect short-term patient satisfaction.[80] A retrospective review by Weber et al observed that 13% of IBPBs failed to provide adequate analgesic relief, with 1 instance of grand mal seizure, 1 cardiovascular collapse, and 4 cases of severe respiratory distress. Two temporary neurologic injuries were also noted, both of which resolved after approximately 6 weeks.[112] In situations in which an IBPB is contraindicated, an SSNB is a viable alternative.[103]

Indwelling brachial plexus catheters

Continuous infusion pumps can be used to administer analgesia through an indwelling brachial plexus catheter. Patients are sent home with the pump and catheter after discharge from the surgery unit, thus allowing extended analgesia for 48 to 72 hours after surgery.[111] Minimal complications have been reported with these devices, and overall results and patient satisfaction are promising.[10,98]

Clinical outcomes

Compared with other analgesic methods, indwelling interscalene catheters have shown low rates of complication and a reduced need for opioids. Fredrickson et al observed no major complications, such as pneumothorax, spinal or epidural anesthesia, or anesthesia toxicity, associated with indwelling catheters in their study.[40] Borgeat et al reported complete absence of vomiting or pruritus in patients with indwelling catheters compared with a 25% incidence of these effects in patients receiving controlled infusion of morphine.[11]

Koltka et al compared continuous subacromial infusion with a continuous IBPB after arthroscopic rotator cuff surgery and reported lower pain scores at 8 to 48 hours in both groups compared with the control, with the interscalene group having the lowest pain. In addition, they observed that only 16.6% of patients receiving continuous interscalene infusion required additional analgesics compared with 53.3% of those receiving continuous subacromial infusion.[60] Ilfeld et al observed significantly lower oral opioid and NSAID consumption on the first postoperative day in patients with an indwelling interscalene catheter than in those in the saline catheter control,[49] whereas Oh et al found that pain at 16 and 48 hours after surgery was significantly less in patients who had continuous interscalene infusion in addition to an IBPB as opposed to IBPB alone.[82] In addition, patients who received an IBPB and an indwelling brachial plexus catheter required significantly less supplemental analgesia at both 1 hour and 8 hours after surgery compared with those who received just IBPB.

A recent study by Salviz et al prospectively randomized 71 patients undergoing elective ARCR to receive continuous IBPB, single-injection interscalene blockade, or general anesthesia.[98] Whereas continuous IBPB required more time to administer than single-injection blockade (11 ± 11 minutes vs. 6 ± 3 minutes; $P = .03$), patients in this group had lower PACU numeric pain rating scores compared with the single-injection nerve blockade and general anesthesia groups. Continuous IBPB and single-injection blockade were associated with a significantly shorter length of stay in the PACU than in the general anesthesia group (20 ± 31, 30 ± 42, and 165 ± 118 minutes, respectively; $P < .003$). Finally, patients who received continuous IBPB slept significantly longer than patients who received single-injection blockade or general anesthesia during the first 2 postoperative days ($P < .01$).[98] Another study by Shin et al evaluated continuous IBPB vs. IV PCA and found that numeric pain scores and need for supplemental opioids in the PACU were significantly less in the block group than for IV PCA.[100]

Despite these promising reports regarding postoperative pain control with the use of indwelling brachial plexus catheters, not all studies found in the literature support their use. Klein et al reported no significant difference in VAS pain scores either during movement or at rest at 0-, 12-, 24-, and 48-hour intervals after surgery in patients receiving either intra-articular infusion or continuous interscalene infusion.[59] In addition, 50% to 75% of all patients reported insufficient analgesia within the early postoperative period, and similar dosage and time to supplemental opioid analgesia were observed in both groups.[59] Indwelling catheter insertion can also be more technically challenging to perform than a single injection, and catheter failure rate at 24 hours has been reported to be as high as 10% to 20%.[49] Additional risks associated with indwelling catheters include catheter site infection as well as catheter migration or breakage and the concern that continuous infusion has the potential to result in toxic volumes of anesthetic delivery.[3,15,16,92]

Multimodal anesthesia

Multimodal anesthesia (MMA) refers to the use of multiple therapeutic interventions to achieve optimal pain control.[87] The principle of MMA is that appropriate analgesia can be achieved through the judicious use of several classes of analgesics that have additive or synergistic effects, thus requiring lower total doses of individual drugs while providing greater pain relief and a concomitant reduction in opioid-related complications.[17,38,87] Commonly used analgesics in MMA include NSAIDs, COX-2 inhibitors, α_2 agonists, glucocorticoids, *N*-methyl-D-aspartate (NMDA) antagonists, and opioids. The appropriate utilization of MMA protocols has been reported to lead to significant reduction of direct medical costs in orthopedics.[37]

Clinical outcomes

We review 3 prospective, randomized controlled clinical trials that examined the efficacy of MMA in the context of ARCR. MMA protocols varied among the 3 trials, and we encourage referral of the original source for detailed description of analgesics and specific dosages used.

Han et al randomized 70 patients to receive either IV PCA or MMA during ARCR and found that whereas VAS pain scores were better controlled in the MMA group compared with the IV PCA group at 2 hours postoperatively (3.8 ± 2.1 vs. 5.5 ± 2.1; $P < .001$), this benefit did not persist at future time intervals.[46] In addition, the MMA group required more rescue analgesia (IV tramadol) than the IV PCA cohort during 12 to 48 hours after surgery ($P < .001$). The incidence of adverse side effects was not different between groups, with the exception of significantly less PONV in the MMA group

compared with the IV PCA group (5.7% vs. 31.4%; $P = .012$) during 12 to 24 hours postoperatively. Finally, overall costs for the MMA group were significantly lower compared with IV PCA controls ($20.30 vs. $157.80).

Another trial by Jo et al included 54 patients undergoing ARCR who received either MMA or placebo saline injections.[51] Patients in the MMA group had less pain than the placebo group at 5 hours after surgery and at various time points on postoperative day 4 ($P < .001$). Rescue analgesia during the first 24 hours was also significantly less for patients receiving MMA than for placebo controls ($P = .038$), with no significant differences in medication side effects.

Cho et al enrolled 70 patients to receive either MMA or IV PCA after rotator cuff repair and found that VAS scores were lower in the MMA group compared with the IV PCA group on postoperative days 0, 3, 4, and 5, with no differences observed during days 1 and 2.[25] In addition, the MMA cohort required less rescue analgesia throughout the 5-day study period compared with controls and also demonstrated decreased incidence of dizziness and urticaria. The authors defined functional recovery as the ability to perform 120° of flexion and 30° of external rotation after cuff repair and found that patients receiving MMA met this criterion earlier than did patients receiving IV PCA (3.7 days vs. 5.0 days; $P < .013$).

These 3 prospective, randomized controlled trials demonstrate the current benefits of using an MMA protocol after ARCR and emphasize the potential gains that may be achieved through the development of a standardized MMA protocol with proper consideration of patient and hospital characteristics.

Conclusions

The current state of healthcare is shifting towards placing a greater emphasis on delivering safe, patient-centered care in the most cost-effective methods possible. As a result, ambulatory surgery centers are focused on optimizing control of post-operative pain that results in safe and expeditious discharge. Several studies in the total joint literature have already reported on the bundled payment initiative and the costs associated with prolonged inpatient length of stay or re-admissions, with some citing inadequate pain relief as a reason for complication.[12,44,57,93]

Comprehensive long-term analgesia after rotator cuff surgery is an integral component of minimizing the risk of hospital admission, re-admissions and unnecessary office and emergency room visits after discharge from an ambulatory care center. Although advances in arthroscopic surgical techniques have improved outcomes and more allow for faster postoperative recovery, post-operative pain control continues to be a problematic issue faced by surgeons and their patients.[101,109] In our review of postoperative pain control after ARCR, we examined a variety of modalities that offer pain relief in the acute postoperative period and found that each anesthetic option has inherent advantages and disadvantages that should be weighed carefully.

As orthopaedic surgeons, anesthesiologists, and coordinated care teams continue to grow more experienced with various methods of analgesia, we feel that the paradigm of postoperative pain control after ARCR may shift towards a greater delivery of MMA, thus allowing greater delivery of effective analgesia at the patient-specific level. Physicians are encouraged to carefully consider patient-based factors, complexity of surgical procedure, and availability of hospital staff and resources when choosing anesthesia in efforts to improve patient satisfaction and allow for an efficient use of resources, thus providing the greatest benefit to the patient while minimizing costs to the healthcare system.

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