J Shoulder Elbow Surg (2020) 29, e416–e433

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Perioperative pain management for shoulder surgery: evolving techniques

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Improving management of postoperative pain following shoulder surgery is vital for optimizing patient outcomes, length of stay, and decreasing addiction to narcotic medications. Multimodal analgesia (ie, controlling pain via multiple different analgesic methods with differing mechanisms) is an ever-evolving approach to enhancing pain control perioperatively after shoulder surgery. With a variety of options for the shoulder surgeon to turn to, this article succinctly reviews the pros and cons of each approach and proposes a potential pain management algorithm.

Keywords: Shoulder surgery; pain management; opioid; nerve block; patient education; pharmacology; multimodal analgesia

Early postoperative pain immediately following shoulder surgery is a major source of concern and distress for patients and orthopedic surgeons.[25,81] Adequate pain control is vital for all aspects of patient recovery, including mental status, nourishment, cost of the episode of care, rehabilitation, patient satisfaction, and the overall outcomes following surgery.[58,175,182] Given the increasing demand and use of shoulder arthroplasty and arthroscopic surgery in the management of various shoulder pathologies, effective pain management must be adaptive to a heterogenous patient population.

Acute perioperative pain is a result of inflammation secondary to tissue trauma and/or direct nerve injury during surgery. Injured tissues release local inflammatory mediators that either lead to oversensitization to stimuli in the local area (hyperalgesia) and/or misperception of pain to non-noxious stimuli (allodynia). Other mechanisms leading to hyperalgesia and allodynia include sensitization of peripheral pain receptors and increased excitability of central nervous system neurons.[90,170,192] These pathways are the targets of various pharmacologic agents aimed at disturbing the pain signal.

Single-analgesic regimens are not always effective in controlling moderate to severe postoperative pain.[81,167] Although opioid medications are the mainstay of pain management, relying solely on them is not advisable given their many short- and long-term effects, for example, constipation, nausea, vomiting, respiratory distress, somnolence, sleep disturbances, urinary retention, dependence, and addiction.[35,58,110,164,189] As such, multimodal pain management has come into favor and is currently recommended for early postoperative pain control. Multimodal analgesia relies on the synergistic effects of different analgesics, through different mechanisms, that are administered during the preoperative, intraoperative, and/or postoperative periods.[81,89] Despite uniform surgeon agreement that multimodal programs are important for optimization of postsurgical pain, there are a multitude of

No institutional review board approval was required for this narrative review.

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https://doi.org/10.1016/j.jse.2020.04.049

interventions with variable efficacy at the shoulder surgeon's disposal.

The complex interplay between patient satisfaction, controlling postoperative pain and opiate stewardship underscores the importance of understanding the evidence behind pain control regimens. The United States is in the midst of an opiate epidemic; 42% of orthopedic surgeon prescriptions are for opiate medications, leaving hundreds of millions of unused (or misused) pills each year. Two independent studies suggest that 8.5%-15% of postoperative rotator cuff patients will be on opiates 180 days after their index surgical procedure.[62,106]

The purpose of this review is to evaluate strategies to enhance patient satisfaction and outcomes and provide guidelines for opiate utilization/minimization after shoulder surgery. It is incumbent upon surgeons to understand the evidence behind the various modalities for controlling pain after shoulder surgery.

Patient risk factors and education

Effective pain management of patients undergoing shoulder surgery begins in the preoperative period. Identifying patients at risk for increased pain, aligning patient and surgeon postoperative expectations, and providing education surrounding pain management is essential.

In addition to the well-established link between preoperative opioid use and increased postoperative consumption, there are other risk factors that might predict increased postoperative opioid consumption and poor outcomes in shoulder surgery patients.[31,141,188] In a cohort database analysis, Rao et al[134] defined many risk factors that were associated with an increased likelihood of being prescribed narcotic pain medications up to a year following shoulder arthroplasty, including age <60 years, and a history of anxiety, opioid dependence, substance abuse, and general chronic pain (Table I). Tokish et al[178] looked at the Brief Resilience Scale to show that patients who were labeled as low-resilience had outcome scores that were 30-40 points lower. Using the Brief Resilience Scale in practice can help identify patients who need more strict attention and pain management following surgery.

A patient history of preoperative use of opiate medication is important to understand. There is a well-established link between preoperative opioid use and increased postoperative consumption and lower patient-reported outcomes in shoulder surgery patients.[31] Patients consuming preoperative opiate medications (>3 months preoperative) are 7-11 times more likely to need prolonged duration of postsurgical medications. In both rotator cuff and arthroplasty cohorts, patients taking opioids uniformly preoperatively did not ultimately reach the same level of functionality as those that did not.[116,188] This risk factor cannot be avoided if the patient has been prescribed opiate medication before surgical consultation. This underscores the importance of physician education regarding the risk of opiate medications. Much like we have developed pathways for optimizing body mass index and glycated hemoglobin (HbA1c) to enhance patient outcomes, surgeons should be empowered to create programs to reduce preoperative use and define postsurgical recovery programs in conjunction with a pain management service for the entire episode of care.

Table I Risk factors associated with increased narcotic use in the postoperative period following shoulder arthroplasty

Risk factor	Max RR
Age <60 yr vs. ≥60 yr	1.40
Race vs. white: Hispanic	1.07
Race vs. white: Other	1.60
ASA class >III vs. I or II	1.33
Preoperative prescriptions: 1-4 Rx vs. 0	2.71
Preoperative prescriptions: ≥5 Rx vs. 0	11.80
Chronic pulmonary disease	1.09
Liver disease	1.11
Rheumatoid/collagen vascular disease	1.16
Neurodegenerative disorders	1.17
Anxiety	1.18
Dementia/psychosis	1.11
Depression	1.08
Opioid dependence	1.29
Post-traumatic stress disorder	1.54
Substance abuse	1.19
Back pain	1.37
Fibromyalgia	1.20
General chronic pain	1.43
Kidney/gall stones	1.37
Migraines	1.16

ASA, American Society of Anesthesiologists; *Rx*, prescription; *RR*, relative risk.
RRs were calculated based on the quarters (ie, the postoperative year was broken down into four 3-month periods). Here is reported the maximum RR that was reported in the study.

Patient education and establishing postoperative expectations are effective, simple, and inexpensive tools in decreasing postoperative pain and opioid consumption.[51,55,94,105,109,137,158,171,172,190,193] Although, studies that used videos, audiotapes, web-based education information, and written materials have failed to show significant impact on postoperative opioid use, a few studies have been successful.[33,153] Sjöling et al[158] showed that in patients undergoing total knee arthroplasty, providing preoperative information led to a more rapid decline in postoperative pain scores and higher satisfaction with pain control. Additionally, these patients experienced lower preoperative anxiety, which influences postoperative pain levels.[77,113,120,145,147,158] Syed et al[171] showed that patients who were educated on recommended postoperative opioid usage, side effects, dependence, and addiction risks, prior to arthroscopic rotator cuff repair (RCR), used significantly less narcotics and were 2.2 times more likely to discontinue use by 3-month follow-up than those who did not receive preoperative education. The ‘‘educated’’ group consumed fewer opiates and simultaneously reported clinically similar VAS pain scores at 2 weeks, 6 weeks, and 3 months.

Being aware of those that might be at increased risk of narcotic consumption and providing patient education before surgery enables patients, in the postoperative period, to achieve pain control and satisfaction while reducing the risks of opioid side effects, diversion, and/or abuse.[40,112,169] Aligning patient and surgeon expectations and education surrounding postoperative pain are foundational elements of enhancing patient outcome.

Pharmcological interventions

Tylenol (intravenous vs. oral)

The exact mechanism of acetaminophen on analgesia has not been completely elucidated. Current theories include inhibition of prostaglandin synthesis in the central nervous system or possible activation of an endogenous cannabinoid (*N*-arachidonyl phenylalanine).[19,67,111,159,160] Standard preoperative dosing in the literature has been 1000 mg (for patients >50 kg)[14,48,122,131] or 15 mg/kg.[91]

Preoperative acetaminophen has the greatest potential in the immediate postoperative period. Khalil et al[91] showed that in hip arthroplasty patients, intravenous (IV) acetaminophen given 1 hour before surgery or before skin closure led to significantly lower pain, lower opioid consumption, and longer time to first analgesia in these patients compared to those that took no acetaminophen. Doleman et al[48] echoed these findings in their systematic review of 7 randomized controlled trials (RCTs) that evaluated Tylenol use preoperatively or post incision, reporting lower pain scores and an overall reduction in opioid consumption in the first 24 hours in patients who received preoperative acetaminophen. However, in the Patterson et al[129] database study with 11,949 total shoulder arthroplasty (TSA) patients who were administered IV acetaminophen on the day of surgery, they actually found a 5% increase in opioid utilization in patients.

In contrast, the use of Tylenol in the postoperative period following orthopedic surgery has not been as successfully established in controlling pain and opioid consumption. Sinatra et al[154] in their RCT showed that IV acetaminophen led to significantly improved pain responses following total knee arthroplasty or total hip arthroplasty, when compared with placebo.

Although IV acetaminophen has been shown to achieve faster and longer analgesic effects than oral formulations,[79,101,157] higher costs of IV acetaminophen compared with oral[60] can preclude widespread use of acetaminophen in the preoperative period. Hip and knee arthroplasty studies have shown that acetaminophen administered orally may be as effective as, if not more so than, IV in terms of immediate postoperative pain and opioid consumption.[80,122,131,168] Stundner et al,[168] in their database study of 245,454 patients who underwent total hip arthroplasty or total knee arthroplasty, showed that the use of more than 1 dose of oral Tylenol on postoperative day 1 (ie, after waking up from surgery) led to a significant 10.7% opioid utilization reduction, compared with a significant 6% reduction when IV Tylenol was used.

The literature supports the use of acetaminophen in the preoperative period, in IV or oral formulations, whereas postoperative acetaminophen has shown promising, yet equivocal, results in the limited studies published.

Gabapentinoids

Several studies involving orthopedic surgery have shown the potential benefits of preoperative gabapentinoids in terms of pain control and opioid consumption in the immediate 24-hour postoperative period (ie, gabapentin and pregabalin).[49,70,71,92,115] These synthetic analogs of γ-aminobutyric acid inhibit the release of neurotransmitters such as substance P, consequently decreasing neural excitability.[152]

Six studies have evaluated gabapentinoid use in the preoperative period for arthroscopic shoulder surgery (Table II).[3,5,15,53,114,163] Ahn et al[5] and Eskandar et al[53] found preoperative use of pregabalin to be leading to significantly less opioid consumption and pain compared to the placebo group up to 24 hours following arthroscopic surgery. Results in studies evaluating gabapentin use before surgery have been varied. Most studies found no significant differences in opioid consumption or pain, whereas Mardani-Kivi et al[114] and Hah et al[69] reported significantly lower opioid consumption and Bang et al found significantly less pain in their gabapentin group.[15]

The use of pregabalin has shown significantly positive effects on pain control and opioid consumption. Apart from 3 separate studies showing significant pain and narcotic control, the majority of studies show no effect of a single preoperative dose of gabapentin on pain control and opioid consumption. Potential benefits are probably related to correct dosage and correct pairing with other modes of multimodal analgesia.[102]

Nonsteroidal anti-inflammatory drugs

Nonsteroidal anti-inflammatory drugs (NSAIDs) assert their analgesic effect by inhibiting cyclooxygenase (COX) 1 and 2 enzymes, leading to decreased prostaglandin production—attenuating the pain response.[26,63] Preoperative NSAID use prior to shoulder surgery has been reported (Table III).[43,138,177] Studies by Toivonen et al[177] and Rouhani

Table II Gabapentinoid use in the preoperative setting in shoulder surgery

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
Mardani-Kivi,[114] 2016	76	2 groups: 1 (38): Gabapentin, 600 mg, 2 h preop 2 (38): Placebo	Arthroscopic Bankart surgery	ns	↑
Spence,[163] 2011	57	2 groups: 1 (26): Gabapentin, 300 mg, 1 h preop 2 (31): Placebo	Arthroscopic shoulder surgery	ns	ns
Bang,[15] 2010	46	2 groups: 1 (23): Gabapentin, 300 mg, 2 h preop 2 (23): Placebo	Arthroscopic rotator cuff surgery	↑	ns
Adam,[3] 2006	43	2 groups: 1 (27): Gabapentin, 800 mg, 2 h preop 2 (26): Placebo	Arthroscopic shoulder surgery	ns	ns
Ahn,[5] 2016	60	2 groups: 1 (30): Pregabalin, 150 mg, 1 h preop 2 (30): Placebo	Arthroscopic shoulder surgery	↑	↑
Eskandar,[53] 2013	80	2 groups: 1 (40): Pregabalin, 300 mg, 12 h preop 2 (40): Placebo	Arthroscopic shoulder surgery	↑	↑

preop, preoperative.
Up arrow indicates significance found in favor of gabapentinoid; down arrow indicates significance in favor of placebo. ns indicates no significant difference was found between experimental groups; the dash indicates that the outcome of interest was not reported by study.

Table III NSAID use in the preoperative setting in of arthroscopic shoulder surgery

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
Demir,[42] 2019	60	2 groups: 1 (30): Dexketoprofen, IV 50 mg with ISB, preop 2 (30): Placebo	Arthroscopic shoulder surgery	↑	↑
Bjørnholdt,[21] 2014	73	3 groups: 1 (25): Dexamethasone, IV 40 mg, preintubation 2 (26): Dexamethasone, IV 8 mg, preintubation 3 (22): Placebo	Arthroscopic shoulder surgery	ns	ns
Rouhani,[138] 2014	60	2 groups: 1 (30): Celecoxib, 200 mg/12 h oral, 48 h prior + 10 d after 2 (30): Placebo	Arthroscopic rotator cuff surgery	↑	↑
Inderhaug,[76] 2014	147	2 groups: 1: NSAIDs, preop 2: No NSAIDs	Arthroscopic rotator cuff surgery	—	—
Assareh,[9] 2007	64	2 groups: 1 (32): Etoricoxib, 120 mg oral, before surgery 2 (32): Etoricoxib, 120 mg oral, after surgery	Arthroscopic shoulder surgery	ns	ns
Toivonen,[177] 2007	30	2 groups: 1 (15): Etoricoxib, 120 mg oral, 1 h before surgery 2 (15): Placebo	Arthroscopic shoulder surgery	↑	↑

NSAID, nonsteroidal anti-inflammatory drug; *IV*, intrvenous; *ISB*, interscalene block; *preop*, preoperative.
Up arrow indicates significance found in favor of NSAID; down arrow indicates significance in favor of placebo. ns indicates no significant difference was found between experimental groups; the dash indicates that the outcome of interest was not reported by study.

et al[138] in which patients undergoing arthroscopic RCR were administered a COX-2 selective inhibitor prior to surgery, 1 hour and 2 days before, and 10 days after, respectively, found significantly lower pain and opioid consumption. Demir et al[42] showed similar results in patients given IV dexketoprofen 15 minutes before RCR.

Table IV NSAID use in the postoperative setting in arthroscopic shoulder surgery

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
Oh,[123] 2018	180	3 groups: 1 (60): Celecoxib, oral 200 mg, twice a day 2 (60): Ibuprofen, 325 mg, 3 times a day 3 (60): Tramadol, 50 mg, twice a day	Arthroscopic RCR	ns	ns
Blomquist,[22] 2014	477	2 groups: 1 (155): NSAIDs, postop 2 (322): No NSAIDs postop	Arthroscopic Bankart surgery	—	—
Axelsson,[13] 2008	40	3 groups: 1 (16): Ketorolac, IV 1 mL, IV 9 mL ropivacaine, IV 10 mL morphine 2 (17): Ketorolac, IV 1 mL 3 (17): Placebo	Arthroscopic Bankart surgery	↑	↑
Hoe-Hansen,[75] 1999	41	2 groups: 1 (21): Ketoprofen, oral 200 mg, once a day for 6 weeks 2 (20): Placebo	Arthroscopic subacromial decompression	↑	—

NSAID, nonsteroidal anti-inflammatory drug; *IV*, intrvenous; *preop*, preoperative; *RCR*, rotator cuff repair.
Up arrow indicates significance found in favor of NSAID; down arrow indicates significance in favor of placebo. ns indicates no significant difference was found between experimental groups; the dash indicates that the outcome of interest was not reported by study.

Use of NSAIDs in the postoperative period to decrease pain and opioid consumption has not shown as positive results compared with preoperative administration (Table IV).[22,37,75,123] Oh et al[123] investigated postoperative administration of celecoxib, ibuprofen, or tramadol in RCR patients. They found no significant difference between groups. However, the retear rate in the celecoxib group (37%) was significantly higher than in the ibuprofen (7%) or tramadol (4%) group ($P = .009$). Hoe-Hansen et al[75] administered 6 weeks of oral 200-mg ketoprofen postoperatively and found significantly better pain control and functional improvements in their NSAID group, whereas Blomquist et al[22] found no functional differences.

Despite beneficial effects on pain control and opioid consumption with NSAID use in the preoperative period, fear of perioperative bleeding[56,136] and negative effects on soft tissue, tendon, tendon-to-bone, and fracture healing reported in animal studies raise concerns about the widespread use of postoperative NSAIDs.[32,45,46,135] Two studies looking at hip arthroplasty found significant increases in perioperative blood loss in those who were on preoperative NSAIDs. However, in both of these studies, patients were also put on thromboprophylaxis with heparin or enoxaparin.[56,136] A systematic review by Teereawattananon et al[174] reported no significant increase in intraoperative or postoperative bleeding events in those treated with preoperative COX-2 inhibitors. Healing concerns seem to be limited to selective COX-2 inhibitors, whereas nonselective NSAIDs administered for a short duration (3-5 days) likely do not have a negative effect on tendon healing, while providing beneficial pain control and decreased narcotic use.[36,108,123]

Regional anesthesia

Regional anesthesia has been increasing in use in shoulder surgery as an effective means of providing anesthesia and postoperative analgesia.[20] The brachial plexus supplies all of the motor and most of the sensory signal (apart from the cephalad cutaneous areas, which are innervated by the supraclavicular nerves) of the shoulder.[25] Given this, shoulder and elbow surgery is ideal for the use of a block without impacting patients' ability to walk postoperatively as seen with epidural or peripheral nerve blocks for lower extremity surgery.[68] To achieve adequate postoperative pain control, blocking the nerve supply to the synovium, capsule, articular surfaces, ligaments, periosteum, and muscles of the shoulder must be achieved.[25,132] Commonly used techniques for shoulder surgery include interscalene blocks (ISBs), continuous ISB (CISB), suprascapular nerve blocks, supraclavicular nerve blocks, local infiltration (LI), and ISB with adjuvants.[164] ISBs are well-studied and established means of providing analgesia following shoulder surgery and are considered the gold standard mode of regional anesthesia.[164] This review will compare different modes of intraoperative analgesia with ISB, which is considered the gold standard.[182]

ISB + adjuvant

Rebound pain, a significant surge in pain when ISB wears off, is reported in the first 8-24 hours following shoulder surgery and leads to a sharp spike in opioid utilization and increase in pain scores.[118,124] Different agents have been tried as adjuvants with ISB to increase the duration of analgesia following surgery such as ketamine, clonidine, dexmedetomidine, epinephrine, buprenorphine, and steroids.[1,17,18,38,39,52,54,59,82,84,148,161,181,191] Of these, steroids have shown the most promise (Table V).

The mechanism by which dexamethasone provides analgesia is thought to be either a result of its vasoconstrictive nature reducing local anesthetic absorption and/or possibly secondary to increased activity of inhibitory potassium channels on nociceptive c-fiber nerves.[10,97] In general, these studies have found prolonged analgesia up to 6-14 hours, with similar or better pain and narcotic use control than ISB alone. An RCT performed by Jadon et al[78] in arthroscopy patients comparing 8 mg of IV dexamethasone added as an adjuvant to ropivacaine vs. ropivacaine alone found significantly less pain at 8 and 24 hours and use of rescue analgesia at 24 hours in the dexamethasone group. Dexamethasone prolonged block duration by 9 hours, with no increase in postoperative nausea and vomiting.

Liposomal bupivacaine

ISBs with long-acting agents such as bupivacaine can provide adequate pain relief for up to 24 hours.[6] However, ISBs have been associated with unpredictable analgesia duration and significant rebound pain.[35] Liposomal bupivacaine (LB) uses a carrier matrix that encapsulates bupivacaine and continuously releases over a longer period of time compared with lidocaine or bupivicaine.[139,195]

Although LB has been studied in multiple studies since 2016 in shoulder surgery (Table VI), definite conclusions have been difficult to draw because of inconsistent formulations and administration of LB in the perioperative period. The 3 most recent published literature found significant benefits in postoperative pain and opioid consumption compared with standard ISB.[57,128,149] All 3 of these studies evaluated the use of LB as a field block before surgery. Ford et al[57] evaluated LB given to 57 patients undergoing arthroscopic shoulder surgery. They found adequate pain control up to 48 hours and a 21% consumption rate of narcotic opioid pills at 1 week postoperation. They also found that time to motor and sensory recovery was on average 26.8 and 34 hours, respectively. Sethi et al[149] performed an RCT in 50 patients undergoing arthroscopic shoulder surgery. Half the patients were administered suprascapular LB injection in addition to standard ISB with bupivacaine and dexamethasone. They found significantly improved pain scores at 1 and 2 days, and significantly less use of narcotics at 5 days in their LB group. Patel et al[128] reported similar findings in their study with 140 patients undergoing open or arthroscopic shoulder surgery in terms of pain and narcotic use differences favoring their LB injection over the ISB only group. They also found significantly improved satisfaction and Overall Benefit of Analgesic scores (a measure of patient satisfaction with pain control) in their LB group, with no differences in length of stay or the complication rate. In contrast, other studies evaluating LB as an intra-articular block prior to incision have found unpredictable results (Table VI).[2,72,118,119,124,142,180,185]

Significantly more investigation is needed to interpret the role of LB in perioperative pain management in shoulder surgery. The literature suggests the use of LB as a field block rather than periarticular use, in the preoperative setting in conjunction with a standard ISB as the most likely methodology to result in beneficial pain and opioid utilization control. Additionally, because of the longer-acting nature of LB, patients should be counseled on effects of the block lasting for 72 hours or longer in order to curb any concerns. Data regarding ISB with LB is forthcoming.

Continuous ISB

The duration of regional anesthesia can be extended with the use of a continuous catheter.[65,73] CISBs can provide postoperative analgesia for multiple days following surgery. They are designed for outpatient pain control, however, safety issues with CISB, increased clinical care required in monitoring, catheter migration, and improper placement are major concerns.[30,66]

Bojaxhi et al,[24] Chalmers et al,[30] Gomide et al,[66] and Hasan et al[73] found significant results in favor of the use of CISB in comparison to ISB in terms of pain control and narcotic consumption. However, Hasan et al noted that 10% of their patients pulled out their catheters and found more adverse effects in their CISB group such as syncope, oversedation, bradycardia, shortness of breath, and hypotension. Hasan et al found increased cost of a CISB and concluded that the modest pain and narcotic control vested by CISB does not justify the additional costs and additional complications.

CISB in shoulder surgery may yield effective pain control and narcotic consumption up to 3-7 days. However, the additional care, complications, and costs need to be considered carefully.

Field blocks

A potential complication of ISB is spread of local anesthetic to the phrenic nerve leading to transient ipsilateral hemidiaphragmatic paresis, Horner syndrome, and hoarseness. This can be particularly concerning for patients with pulmonary pathology, in which any reduction of pulmonary reserve can lead to severe compromise.[146]

One way to provide adequate analgesia while avoiding this adverse effect is by using a field block via a supraclavicular block (SCB) or a suprascapular block (SSB). In an SCB, the brachial plexus is blocked at the level of the plexus divisions, between the anterior and middle scalene

Table V Dexamethasone given as an adjuvant with an interscalene block

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
Kang,[84] 2019	66	3 groups: 1 (22): ISB, injection, 15 mL 0.5% ropivacaine and epinephrine, preop 2 (22): ISB + dexamethasone, injection 15 mL 0.5% ropivacaine and epinephrine + 0.11 mg/kg dexamethasone, preop 3 (22): ISB + dexamethasone + dexmedetomidine, injection, 15 mL 0.5% ropivacaine and epinephrine + 0.11 mg/kg dexamethasone + 1 μg/kg dexmedetomidine, preop	Arthroscopic shoulder surgery	↑	↑
Chalifoux,[29] 2017	69	3 groups: 1 (23): ISB + IV dexamethasone, injection, 20 mL 0.5% ropivacaine + 4 mg dexamethasone, preop 2 (24): ISB + IV dexamethasone, injection, 20 mL 0.5% ropivacaine + 10 mg dexamethasone, preop 3 (22): ISB, injection, 20 mL 0.5% ropivacaine, preop	Arthroscopic shoulder surgery	ns	↑
Sakae,[144] 2017	60	3 groups: 1 (20): ISB + IV dexamethasone, injection, 20 mL 0.75% ropivacaine + 4 mg dexamethasone, preop 2 (20): ISB + perineural dexamethasone, injection, 20 mL 0.75% ropivacaine + 4 mg dexamethasone, preop 3 (20): ISB, injection, 20 mL 0.75% ropivacaine, preop	Arthroscopic shoulder surgery	↑	↑
Webb,[184] 2016	910	2 groups: 1 (574): ISB + IV triamcinolone, injection, 40 mL 0.5% bupivacaine and epinephrine + 25 mg triamcinolone, preop 2 (336): ISB, injection, 40 mL 0.5% bupivacaine and epinephrine, preop	Shoulder surgery	—	—
Watanabe,[183] 2016	44	2 groups: 1 (22): ISB + IV betamethasone, injection, 19 mL 0.375% ropivacaine + 4 mg betamethasone, preop 2 (22): ISB, injection, 20 mL 0.375% ropivacaine, preop	Arthroscopic shoulder surgery	↑	↑
Jadon,[78] 2015	100	2 groups: 1 (50): ISB + IV dexamethasone, injection, 30 mL 0.5% ropivacaine + 8 mg dexamethasone, preop 2 (50): ISB, injection, 30 mL 0.5% ropivacaine, preop	Arthroscopic shoulder surgery	↑	↑
Woo,[191] 2015	144	4 groups: 1 (36): ISB + IV dexamethasone, injection, 12 mL 0.75% ropivacaine + 2.5 mg dexamethasone, preop 2 (36): ISB + IV dexamethasone, injection, 12 mL 0.75% ropivacaine + 5 mg dexamethasone, preop 3 (36): ISB + IV dexamethasone, injection, 12 mL 0.75% ropivacaine + 7.5 mg dexamethasone, preop 4 (36): ISB, injection, 12 mL 0.75% ropivacaine + 8 mg dexamethasone, preop	Arthroscopic shoulder surgery	ns	↑
Kawanishi,[87] 2014	34	3 groups: 1 (10): ISB + IV dexamethasone, injection, 20 mL 0.75% ropivacaine + 4 mg dexamethasone, preop 2 (12): ISB + perineural dexamethasone, injection, 20 mL 0.75% ropivacaine + 4 mg dexamethasone, preop 3 (12): ISB, injection, 20 mL 0.75% ropivacaine, preop	Arthroscopic shoulder surgery	↑	—
Desmet,[43] 2013	144	3 groups: 1 (49): ISB + IV dexamethasone, injection, 30 mL 0.5% ropivacaine + 10 mg dexamethasone, preop 2 (49): ISB + perineural dexamethasone, injection, 30 mL 0.5% ropivacaine + 10 mg dexamethasone, preop 3 (46): ISB, injection, 30 mL 0.5% ropivacaine, preop	Arthroscopic shoulder surgery	↑	—
Cummings,[39] 2011	218	4 groups: 1 (54): ISB + IV dexamethasone, injection, 30 mL 0.5% ropivacaine + 8 mg dexamethasone, preop 2 (54): ISB + IV dexamethasone, injection, 30 mL 0.5% bupivacaine + 8 mg	Shoulder surgery	↑	ns

(*continued on next page*)

Table V Dexamethasone given as an adjuvant with an interscalene block (*continued*)

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
		dexamethasone, preop 3 (54): ISB, injection, 30 mL 0.5% ropivacaine, preop 4 (56): ISB, injection, 30 mL 0.5% bupivacaine, preop			
Tandoc,[173] 2011	86	3 groups: 1 (28): ISB + IV dexamethasone, injection, 40 mL 0.5% bupivacaine and epinephrine + 4 mg dexamethasone, preop 2 (30): ISB + IV dexamethasone, injection, 40 mL 0.5% bupivacaine and epinephrine + 8 mg dexamethasone, preop 3 (28): ISB, injection, 40 mL 0.5% bupivacaine and epinephrine, preop	Shoulder surgery	—	↑

ISB, interscalene block; *preop*, preoperative; *IV*, intravenous.
Up arrow indicates significance found in favor of dexamethasone; down arrow indicates significance in favor of placebo. ns indicates no significant difference was found between experimental groups; the dash indicates that the outcome of interest was not reported by study.

muscles at the first rib using ultrasonographic guidance, accomplishing analgesia to both anterior and posterior divisions, and the suprascapular nerve.[4,164] An SSB block provides local anesthetic to the suprascapular nerve, which is responsible for 60%-70% of the innervation of the shoulder joint. An axillary nerve block can be added to an SSB to deliver analgesia to the other 25%-30% of the shoulder joint that is innervated by the axillary nerve.[196]

Several authors have reported on periarticular injections, locally injected anesthesia (LIA) and local field blocks. Sicard et al,[151] in a prospective randomized controlled study, evaluated the efficacy of LIA compared with ISB in patients undergoing TSA. The LIA group had less severe pain and lower opioid consumption. Further studies have compared multimodal therapies of combining LIA and ISB. Boddu et al[23] evaluated the efficacy of multimodal analgesic protocol associating ISB and LIA in patients who underwent TSA. These reports include local blocks with and without ISB with clinical efficacy and equivalent (and in some cases enhanced) efficacy.[23,149,151] A number of studies have looked at SCB and SSB in comparison to ISB, finding comparable pain control and narcotic utilization between the 2 methods, with higher risks of hemidiaphragmatic paresis in the ISB patients.[8,27,44,47,85,93,95,96,103,140,187] However, these studies have found more pain in field blocks in the immediate 6-8 hours following surgery. Further investigation is needed to directly compare the impact of the axillary nerve block in conjunction with SSB when compared to ISB.

Although ISB is an effective strategy for many patients, regional infiltration or local nerve blocks are an option for patients when regional trained anesthesia is not available (on call/weekends), when time for block is not available, when distal nerve blockage is not desired (previous nerve injury) and in the setting when phrenic nerve compromise is unacceptable (chronic obstructive pulmonary disease or cerebrovascular accident).

Multiple

Few studies have directly compared some of these intraoperative pain management options. Panchamia et al[127] recently evaluated ISB, CISB, and LI in shoulder arthroplasty patients. They reported significantly lower pain up to 12 hours and lower narcotic consumption in the CISB group compared with ISB alone and LI; that is, ISB alone outperformed LI. Singelyn et al[155] compared similar methods in their study that looked at ISB, SSB, and LI in arthroscopic surgery. They found that ISB was the most effective in pain control, narcotic consumption, and patient satisfaction, whereas LI was the least effective. ISB alone did have a higher incidence of postoperative nausea and vomiting, however.

Auyong et al[11,12] performed 2 studies in which they evaluated ISB, SSB, and SCB in arthroscopic surgery in one and CISB, SSB, and SCB in arthroplasty in the other. In both studies, they found similar results in all 3 groups in terms of pain scores and oxycodone consumption at 24 hours; however, the authors reported significantly higher incidence of Horner syndrome, hoarseness, and affected vital capacity in the ISB-only group. Trabelsi et al[179] looked at ISB-only and SSB with SCB groups. They found no differences between the 2 groups in terms of pain scores and narcotic consumption but did find a significantly higher incidence of phrenic nerve block in the ISB-only group.

Postoperative opiates

Opiate medications have been the historic mainstay of postoperative pain management. In fact, pain was once purported to be a (fifth) vital sign in an address by the director of the American Pain Society in 1995, and which physicians were trained to treat accordingly.[28,64,74,133] The

Table VI Use of liposomal bupivacaine use on the day of surgery

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
Ford,[57] 2019	57	1 (57): Injection, 133 mg/10 mL LB + 10 mL 0.5% bupivacaine ISB, preop	Arthroscopic shoulder surgery	—	—
Sethi,[149] 2019	50	2 groups: 1 (25): Injection, suprascapular 20 mL LB + 20 mL 0.5% bupivacaine + 4 mg dexamethasone ISB, preop 2 (25): Injection, ISB only, preop	Arthroscopic shoulder surgery	↑	↑
Patel,[128] 2019	155	3 groups: 1 (69): Injection, 133 mg LB + ISB, preop 2 (15): Injection, 266 mg LB + ISB, preop 3 (71): Injection, ISB only, preop	Shoulder surgery	↑	↑
Namdari,[119] 2018	78	2 groups: 1 (39): Periarticular, 266 mg LB, prior to skin closure + ISB (15 mL 0.5% ropivacaine), preop 2 (39): Injection, ISB only, preop	Shoulder arthroplasty	ns	↓
Abildgaard,[2] 2018	83	2 groups: 1 (36): Periarticular, 20 mL 266 mg LB, intraop into capsule + 30 mL 0.5% bupivacaine, intraop 2 (47): Continuous ISB catheter, 8 mL/h 0.5% ropivacaine, preop	Shoulder arthroplasty	↓	↓
Namdari,[118] 2017	156	2 groups: 1 (78): Periarticular, 20 mL 266 mg LB, intraop 2 (78): Injection, ISB (30 mL 0.5% ropivacaine), preop	Shoulder arthroplasty	↓	ns
Sabesan,[142] 2017	70	2 groups: 1 (34): Injection, 20 mL 266 mg LB, intraop + ISB 20 mL 0.5% bupivacaine, preop 2 (36): Injection, 0.5% bupivacaine, preop + continuous ISB catheter, 6 mL/h 0.125% bupivacaine, postop	Shoulder arthroplasty	ns	ns
Vandepitte,[180] 2017	52	2 groups: 1 (26): Injection, 5 mL 0.25% bupivacaine + 10 mL 133 mg LB, preop 2 (26): Injection, 20 mL 0.25% bupivacaine, preop	Shoulder surgery	ns	ns
Weller,[185] 2017	214	2 groups: 1 (58): Periarticular, 20 mL 266 mg LB + 5% bupivacaine, 2 mg morphine, 30 mg ketorolac, intraop 2 (156): Continuous indwelling catheter, 20 mL 0.5% bupivacaine, preop	Shoulder arthroplasty	ns	↓
Okoroha,[124] 2016	57	2 groups: 1 (26): Periarticular, 20 mL 266 mg LB, intraop 2 (31): Injection, ISB (40 mL 0.5% ropivacaine), preop	Shoulder arthroplasty	↓	↑
Hannan,[72] 2016	58	2 groups: 1 (37): Periarticular, 266 mg LB, intraop 2 (21): Injection ISB 30 mL 0.5% ropivacaine, preop	Shoulder arthroplasty	↑	↑

LB, liposomal bupivacaine; *ISB*, interscalene block; *preop*, preoperative; *intraop*, intraoperative.
Up arrow indicates significance found in favor of NSAID; down arrow indicates significance in favor of placebo. ns indicates no significant difference was found between experimental groups; the dash indicates that the outcome of interest was not reported by study.

premise of eradicating rather than understanding pain has led surgeons to develop prescribing practices that exceed the amount of pain medication ultimately required, leaving behind unused pills that are at risk for misuse and abuse.[171]

Previously, the majority of patients undergoing shoulder surgery received between 60-80 opiate pills (oxycodone, Percocet, dilaudid), that are often refilled.[34] This amount of medication exceeds the Centers for Disease Control and Prevention recommendation of no more than 5 days' duration of opiate medications, a time point that is associated with a sharp increase in the risk of long-term opioid dependence.[150] Furthermore, with current surgeon practices, 20.9% of opioid-naïve patients continued to fill opioid prescriptions beyond 180 days following elective RCR—a higher proportion than patients undergoing any other elective shoulder surgery.[106]

Despite the obvious sequelae of overzealous opiate prescribing, there is very little data that actually guides surgeons on the postoperative use of opiate medications

Table VII Use of cryotherapy following shoulder surgery

Study, year	n	Intervention	Surgery	Pain scores	Opioid consumption
Kang,[83] 2018	30	3 groups: 1 (10): Continuous CT 2 (10): Microcurrent 3 (10): Placebo	Arthroscopic shoulder surgery	ns	—
Alfuth,[7] 2016	52	2 groups: 1 (26): Compressive CT for 24 h 2 (26): Ice pack for 24 h	Arthroscopic shoulder surgery	↑	—
Kraeutler,[98] 2015	46	2 groups: 1 (25): Compressive CT for 1 week 2 (21): Ice pack for 1 week	Arthroscopic surgery	ns	ns
Oshabr,[125] 2002	20	2 groups: 1 (10): Continuous CT for 24 h 2 (10): Placebo	Arthroscopic shoulder surgery	—	—
Singh,[156] 2001	64	2 groups: 1 (32): Continuous CT for 3 weeks 2 (32): placebo	Arthroscopic and open surgery	↑	—
Levy,[107] 1997	15	2 groups: 1 (10): Continuous CT for 90 min 2 (5): Placebo	Arthroscopic shoulder surgery	—	—
Speer,[162] 1996	50	2 groups: 1 (25): Continuous CT for 10 d 2 (25): Placebo	Open surgery	↑	↑

CT, cryotherapy.
Up arrow indicates significance found in favor of CT; down arrow indicates significance in favor of placebo. ns indicates no significant difference was found between experimental groups; the dash indicates that the outcome of interest was not reported by study.

following shoulder surgery. Most of the published data are either expert panel recommendations or anecdotal experience, with virtually no prospective data on opiate requirements following shoulder surgery.

In 2018, using an expert panel, Overton et al[126] recommended a range of 0-20 oxycodone 5-mg pills, or 150 oral morphine equivalents (OMEs), for RCR. Stepan et al[166] developed 2019 opioid-prescribing guidelines through consensus-based methods that recommended 300 to 480 OMEs for arthroscopic RCR. This more than doubles the maximum recommended dose from Overton, and even exceeds the average amount of opioids prescribed at their own center, which was 220 OMEs even before implementation of these guidelines.[50]

Presented at the annual American Shoulder and Elbow Surgeons 2019 meeting, Sethi et al found that patients undergoing rotator cuff surgery require no more than 25 oxycodone 5-mg tablets. This prospective study confirmed Overton's expert panel. In a follow-up multicenter study, Sethi et al[149] later reported that in an RCT using a multimodal approach in elective RCR patients, 73% required 15 or fewer oxycodone 5-mg pills (112.5 OMEs) postoperatively. Moreover, 33% of patients required zero opioids when receiving an ISB using an LB formulation, compared with only 10% in the standard bupivacaine conditions. Median opioid consumption was only 5 oxycodone 5-mg pills (37.5 OMEs) in the LB condition. Even with this marked reduction in the number of opioids prescribed and consumed, the average numeric pain rating scale scores remained lower than 2.5/10 across all patients when using a multimodal analgesic protocol.[149]

There are also notably fewer guidelines for opioid-prescribing practices in TSA. A survey by Welton et al[186] found that physicians continue to prescribe more than 400 OMEs following TSA. Sethi et al[149] reported that 76.9% of arthroplasty patients required fewer than 15 pills and 26.2% required zero opioids. Median consumption was only 6 oxycodone 5-mg pills (45 OMEs). With average numeric pain rating scale scores of only 2.0, it is clear that a vast majority of patients are able to manage their pain sufficiently with a multimodal analgesic protocol, including a low number of narcotic pain medications. Leas et al[102] demonstrated that TSA may be performed without any postoperative opiate medications in a motivated and educated patient population. Although Hamid's cohort self-selected into an opiate avoidance program, this study underscores the importance of patient education, motivation, and surgeon setting of postsurgical expectations as key elements.[102]

These studies suggest that fewer pills (15-25) can be successfully prescribed for RCR and arthroplasty procedures while minimizing postoperative pain and maintaining patient satisfaction.

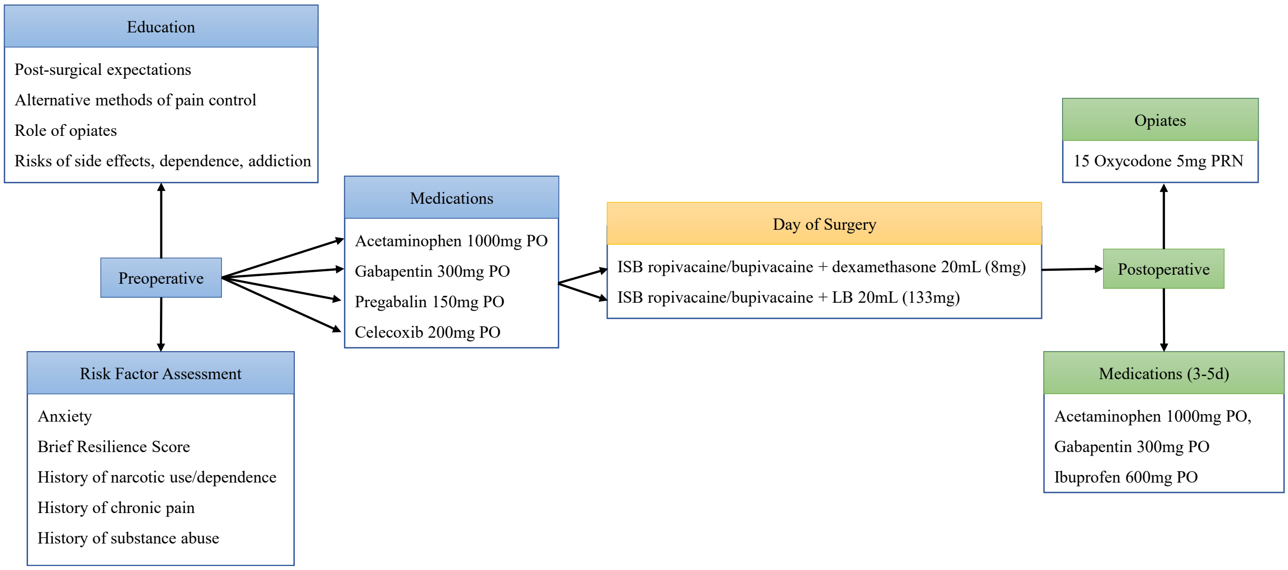

Figure 1 Our recommended multimodal pain management recommendation broken down into preoperative, day of surgery, and postoperative interventions that have been shown in the literature to be effective means of pain and narcotic control. *PO*, oral administration; *ISB*, interscalene block; *LB*, liposomal bupivacaine; *PRN*, as needed.

Cryotherapy

The application of cold to the skin to promote recovery secondary to inflammation following injury has been used in athletic training since the 1960s.[125] During surgery, damaged cells release inflammatory cytokines such as prostaglandins and interleukins that promote vasodilation, increased blood flow, increased temperature, and pain.[86,165] Pain results from direct pressure on nerve endings from the local swelling, as well as from sensitization of these nerves.[88,130] Cryotherapy comes in 3 forms: compressive, continuous flow, and application of ice—all aim to decrease surgical inflammation and pain.

Use of cryotherapy has been widely studied in orthopedic surgeries with varied results. Many studies have shown significant decreases in pain up to 14 days,[16,100,117,143,156,194] whereas others have found no difference.[41,61,98,99,104,156,176] Few that have looked at opioid consumption rates in these patients have found significant decreases in use following surgery.[16,104,117,143]

Speer et al[162] reported better sleep on the night of the operation, significantly less severe pain at 10 days, better tolerance of rehabilitation, decreased desire for opioid analgesics, and decreased perception of swelling in their patients who used compressive cryotherapy for 10 days following open shoulder surgery. In a follow-up study by Singh and Speer,[156] compressive cryotherapy was also used for arthroscopic shoulder procedures with a longer follow-up of up to 21 days; these authors found similar effects as the Speer study. Alfuth et al[7] supported these findings. Other studies have not found such favorable results; however, these studies compared cryotherapy to ice packs (Table VII).[98,121]

Cryotherapy studies performed in shoulder surgery literature lack standardized protocols in analysis, leading to difficulties in making conclusions across studies. Methods of administration of cryotherapy, comparison of cryotherapy to ice packs, and differences in potential benefits between open and arthroscopic surgery patients are all possible factors precluding us from finding a more definite answer. However, studies have shown potential benefit in lowering glenohumeral joint temperature,[125] improving patient pain, sleep, and tolerance for rehabilitation and decreasing patient need for opioids in the postoperative period.

Conclusion

All pain management strategies must begin with patient education and risk factor assessment. Preoperative pharmacology can be used on the day prior to surgery. On the day of surgery, we recommend the use of ISB with LB, as it has shown to be effective, with decreased risk of rebound pain. In the postoperative period, patients should be given a limited number of narcotic pills (we recommend 15 pills) with other pharmacologic interventions for pain control Figure 1.

Disclaimer

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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