Successful postoperative pain management after arthroscopic shoulder surgery allows patients to go home earlier, decreases the potential for hospital readmission, and facilitates rehabilitation. Optimal pain control considers the physiological and psychological states of the patient, the resulting alterations due to the surgery, and the technical and economic resources available during recovery. A comprehensive approach to pain control should include preoperative, intraoperative, and postoperative efforts.

Efforts at postoperative pain reduction should begin preoperatively with the establishment of an excellent patient/physician relationship. Preoperative analgesia should be administered. Intraoperative efforts should include the administration of anesthetic medication intra-articularly. Postoperative management should include sleep medication, continuous cold-flow therapy, oral analgesics, and, if necessary, the use of narcotics.

Increasingly, orthopedic surgery is moving from an inpatient setting to an outpatient setting. This is especially true for arthroscopic and mini-open shoulder procedures. Uncontrolled postoperative pain interferes with initial rehabilitation. In a study of >15,000 ambulatory surgical procedures, pain was responsible for 12% of the unplanned hospital admissions, and of these, 60% were orthopedic patients. Acute postoperative pain in an ambulatory surgical setting is frequently undertreated, especially after shoulder surgery, operations for hardware removal, and elbow arthroscopy.

Epidemiologic studies suggest that shoulder pain ranks third among reasons patients visit a doctor, and almost half of patients who seek orthopedic surgical treatment are between 19 and 64 years. This group constitutes most wage earners, and they need to return to work as soon as possible.

Shoulder surgery often results in bone removal, extensive resection of bursal tissue, insertion of hardware, and soft tissue distension from irrigation fluid. Many patients are hospitalized overnight to control pain that results from this intervention. This may be because the postoperative pain is undertreated in the outpatient setting.

Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage. Acute pain results from mechanically, chemically, or thermally induced damage to tissue integrity. With cellular damage, a variety of chemicals are released, including histamine, bradykinin, prostaglandins, serotonin, substance P,
acetylcholine, and leukotrienes, which sensitize nociceptors to other noxious stimuli.⁸⁻¹⁰ These chemical reactions stimulate the sensitive receptors, which are responsible for the pain sensation. If pain is not adequately treated, it can result in the sensitization of the peripheral and central nervous system and lead to the development of chronic pain.¹⁰⁻¹² This article presents the preoperative, intraoperative, and postoperative pain control practices surgeons should apply to treat surgical pain adequately.

**Factors Influencing Analgesic Needs**

Pain is not only a sensory experience, but also a phenomenon with cognitive and affective components. Factors such as gender, age, culture, communication skills, and previous pain experiences may play a role in determining an individual’s perception of pain.¹⁵⁻¹⁶ For example, advancing age is associated with enhanced opioid sensitivity and decreases in opioid consumption.¹⁷ Educating patients about what to expect before, during, and after surgery can decrease anxiety and therefore postoperative pain. Communication between physician and patient is key to a successful outcome.

**Goals of Postoperative Pain Control**

Outpatient surgery offers several advantages: 1) patients have more control of their postoperative care and consequently accept more responsibility for a successful outcome, 2) the stress and expense of a hospital stay are avoided, 3) patients can be hospitalized after outpatient surgery if required, and 4) the surgical team works together to send patients home postoperatively in an adequate condition.¹⁸ The pain management plan should be a collaborative effort among the physician, nursing staff, anesthesiology team, patient, and patient’s family. Optimal pain control considers the physiological and psychological states of the patient, resulting alterations due to the surgery, and technical and economic resources available during recovery. Pain intensity is rarely constant. Movement and physical therapy may increase postoperative pain. Postoperative pain seems to have a circadian cycle, increasing at night,¹⁷ and is usually greatest in the first 24 hours postoperatively. Postoperative pain has a natural history, and the goal of any pain control plan is to modify its course and lessen its development.

**Preoperative Efforts**

A rested state is important preoperatively. A good night’s sleep prior to the day of surgery reduces anxiety. Anxiety causes more pain and may have a detrimental effect by increasing the perception of postoperative pain. Providing patients with sleeping medication one night before and after surgery has been shown to be effective.¹⁹ This medication is an adjuvant to the analgesic protocol.

One approach to pain control is the use of preemptive analgesia. Preemptive analgesia refers to efforts to prevent pain before it starts, therefore reducing central sensitization. Kissin²⁰ reviewed this technique and concluded that the evidence from clinical and basic science studies validated the phenomenon of preemptive analgesia. Orthopedic surgeons are now developing preemptive protocols to achieve better postoperative pain control.
The most frequently used techniques include local wound infiltration, joint inflation, and peripheral nerve blocks.

The routine infiltration of arthroscopic portals and incision sites is commonplace. The most commonly used drugs are lidocaine and bupivacaine. Combining these drugs with epinephrine can provide both adequate analgesia and some control of intraoperative bleeding. Preincisional local anesthetics block the sensitization of peripheral nociceptors and reduce hyperexcitability. This technique provides greater relief than using the same drugs in the postoperative period.\(^\text{1,22}\)

Joint inflation with between 20 and 60 mL of lidocaine or bupivacaine is another option. These drugs have been demonstrated to have a better analgesic effect in the shoulder joint than morphine.\(^\text{23}\)

The third most common technique is a peripheral nerve block such as interscalene and suprascapular nerve blocks. The peripheral nerve block can provide both preemptive analgesia and anesthesia. It has been reported that training in regional anesthesia is inadequate in many residency programs in the United States.\(^\text{24,25}\) Certainly the training and practice of peripheral nerve blocks varies significantly from institution to institution; therefore, not all surgical centers can consistently provide this kind of anesthesia. Advantages of peripheral nerve blocks over general anesthesia in arthroscopic shoulder surgery include the ability to use hypotensive anesthesia with improved hemostasis during shoulder surgery, a reduction in intraoperative narcotic use, earlier patient discharge from the postanesthetic care unit, fewer unplanned hospital admissions, and a faster time to hospital discharge.\(^\text{26}\) However, the disadvantages of peripheral nerve blocks include a longer procedure time and a significant incidence of block failure. Other complications include reflex sympathetic dystrophy\(^\text{27}\) and the possibility of having intense pain (rebound pain) once the block wears off.\(^\text{26}\)

### Interscalene Nerve Block

An interscalene nerve block offers some advantages over general anesthesia for both open and arthroscopic surgical procedures. This block provides excellent intraoperative anesthesia, muscle relaxation, and postoperative analgesia.\(^\text{28,29}\) Although sedation is sometimes needed during block placement, it is well accepted by patients.

However, the interscalene block, even when performed by highly trained and dedicated anesthesiologists, has complications. Bishop et al\(^\text{27}\) reported a 3% interscalene block failure rate, 2.3% short-term complication rate (primarily sensitive neuropathies that resolved in a 9-week period), and 1 case of reflex sympathetic dystrophy. This low complication rate is unusual. Weber and Jain\(^\text{26}\) reported a failure rate of 13%, while 92% of patients required additional opioid medication. The complication rate can be substantially higher if the interscalene block is performed by an inexperienced anesthesiologist.\(^\text{27}\) Lewis and Buss\(^\text{26}\) suggest that while an interscalene block may provide an additional measure of pain control combined with general anesthesia, the increased costs and risks are not justified by the marginal benefit.
Complications related to the interscalene block include recurrent laryngeal nerve block, ipsilateral hearing loss, Horner syndrome, vertebral artery injection, pneumothorax, epidural injection, subarachnoid injection, and phrenic nerve block. Since the phrenic nerve block occurs approximately 100% of the time, an interscalene block should never be done bilaterally, and is contraindicated in patients with severe chronic obstructive pulmonary disease. Other complications reported to occur with interscalene blocks include cardiac arrest, grand mal seizures, high spinal blocks, hematomas, pneumothorax, phrenic nerve palsy, and respiratory distress.

The interscalene nerve block is an effective shoulder anesthetic technique. However, the best results demand a high level of expertise and familiarity. Complications associated with this technique are higher in the community setting, where focused attention to the technique may not be as available as in an academic institution.

**Suprascapular Nerve Block**

The suprascapular nerve block is another type of peripheral nerve block. The suprascapular nerve arises from the superior trunk of the brachial plexus. It innervates up to 70% of the posterior shoulder joint and provides innervation to the acromioclavicular joint, subacromial bursa, and coracoclavicular ligament, along with the lateral pectoral nerve. It does not fully reach some portions of the posterior shoulder joint and the anterior inferior shoulder.

Ritchie et al. reported that preemptive suprascapular nerve blocks improved analgesia and 24-hour quality of life outcomes when used as an adjunct to general anesthesia for arthroscopic shoulder surgery. In contrast, Neal et al. reported that the suprascapular nerve block provided an average analgesia of 220 minutes, with great variation among individuals and no improvement in the 24-hour outcome.

Barber reported a technique consisting of 1 injection with 20 to 25 mL of 0.5% bupivacaine administered before the start of the procedure. Although this technique does not prevent all postoperative pain, it decreases the intraoperative pain and delays the onset of pain for several hours. The reported risks of the suprascapular nerve block are rare (<1%), with pneumothorax being the most frequent.

Regional blockade techniques have a number of common complications. These include persistent paresthesia, nerve damage, inadvertent intravascular injections, and local anesthetic toxicity. Cardiac toxicity with the use of bupivacaine is well documented.

**Intraoperative Efforts**

The extent and duration of surgery can greatly influence postoperative pain intensity and analgesic requirements. The reduction of surgical time and the use of minimally invasive techniques reduce postoperative pain.

Joint infiltration at the end of the procedure is an option for pain control. Although an intra-articular injection of morphine has been found to be beneficial in the knee,
Scoggin et al\textsuperscript{23} did not report any beneficial effect of intra-articular and/or subacromial morphine in the shoulder after arthroscopic surgery. The favorable response to morphine in the knee may be due to tourniquet use (not applicable to the shoulder).

Although bupivacaine appears to have a superior effect when administered intra-articularly inside the shoulder joint in comparison to morphine,\textsuperscript{23} Singelyn et al\textsuperscript{37} reported that a single dose of intra-articular bupivacaine does not provide a significant analgesic effect when compared to peripheral nerve blocks. This can be explained by a rapid washout of the local anesthetic into the adjacent soft tissues or by dilution of irrigating fluid.

**Postoperative Efforts**

Multimodal analgesia techniques may be more effective than a single analgesic, reduce opioid requirements, and decrease undesired side effects.

**Postoperative Oral Medications**

One of the most common postoperative medications is acetaminophen, an over-the-counter analgesic and antipyretic drug. This drug does not cause impaired platelet aggregation, cardiorenal effects, or impairment of bone and ligament healing. It increases the pain threshold by inhibiting the production of central prostaglandins, and it may not be suitable for blocking an inflammatory response. Acetaminophen selectively inhibits COX-3, which is a variant of COX-1 cloned recently from the canine central cortex. This isoform may play a role in the central analgesic and antipyretic effects of acetaminophen.\textsuperscript{38-40} When acetaminophen is compounded with opioid drugs, it effectively relieves moderate to severe postoperative pain.\textsuperscript{17}

Nonsteroidal anti-inflammatory drugs (NSAIDs) have effects on both isoforms of cyclooxygenase (COX-1, COX-2) or selectively block the formation of the isoform type 2 as well as prostaglandin synthesis. They are effective in reducing the sensitization of nociceptors, attenuating the inflammatory pain response, and preventing central sensitization. These drugs can reduce the need for opioid drugs by 20\% to 40\%.\textsuperscript{41-43} The nonspecific forms of NSAIDs have potential adverse effects that make them unsuitable for use in patients with preexisting coagulation defects, preexisting renal dysfunction, myocardial dysfunction, and end-stage liver disease.

The COX-2-specific inhibitors have similar analgesic efficacy, and they offer the advantages of having no effect on platelet function and an improved gastrointestinal tolerability. However, one example of these drugs, celecoxib, is contraindicated in patients with a sulfa allergy. The use of COX-2 inhibitors can be related to other side effects that can make them unsuitable for chronic use, most commonly abdominal pain, diarrhea, and dyspepsia. There is a higher risk of myocardial infarction in some cases, as well as the potential for a rise in systolic blood pressure. Fluid retention and edema have also been observed with the use of COX-2 inhibitors.
Prostaglandin E2, among other protaglandins, is useful in the formation of new bone. Some NSAIDs, therefore, will have an adverse effect on bone formation, at least in part interfering with the bone morphogenetic protein (BMP) signaling system. The use of NSAIDs has resulted in slower healing rates for bone fractures, higher nonunion rates, and weaker fracture unions in animals treated with these medications.\textsuperscript{44,45} The BMP system has also been implicated during early tendon formation.\textsuperscript{46,47} Therefore, disturbing the BMP system by using these drugs can also impair the early phase of tendon repair. These effects seem to be more significant with the use of COX-2 inhibitors. The inflammatory response during the first days after trauma is necessary for adequate and normal bone and soft tissue repair, and should not be inhibited. This acute period may last for the first 10 postoperative days.\textsuperscript{48} After this period has elapsed, it is safer to use COX-2 inhibitors.

Opioids are frequently used to treat moderate to severe pain. They produce their analgesic effect by mimicking the action of endogenous opioid peptides in the central nervous system. Tramadol is a synthetic analog of codeine that acts as a central analgesic drug. Its side effects are vertigo, dizziness, and seizure.\textsuperscript{49} Tramadol is frequently combined with acetaminophen and is effective for pain control.

**Constant Infusion Devices**

Constant infusion devices consist of multiport catheters inserted with a needle into the surgical site (subacromial space or glenohumeral joint) at the end of the procedure. These catheters are attached to pumps that infuse local anesthetics (bupivicaine or ropivacaine are most commonly used) at a constant rate.

Constant infusion pumps provide a consistent medication infusion rate over an extended period. Electric-powered pumps appear to be more consistent than other types. The elastic devices sometimes provide a quicker-than-expected basal rate (100\%-150\%) initially and then achieve the expected rate within 2 to 12 hours. There is an increased rate once again just before medication exhaustion.\textsuperscript{50} Spring-powered pumps initially provide a quicker-than-expected basal rate (115\%-135\%), and this rate decreases to a less-than-expected rate (70\%-75\%) near reservoir exhaustion. However, there are no studies that explore the clinical significance of the variations of different constant infusion systems.\textsuperscript{51-54}

The most effective medication for continuous infusion pumps is not clearly established. Savoie et al\textsuperscript{55} tested bupivicaine 0.25\% in the subacromial space and compared it to saline infusion. They evaluated pain by visual analog scale and tabulated the amount of nonnarcotic and narcotic medication. They concluded that a bupivicaine pain-control infusion pump is an effective means of decreasing postoperative pain. Borgeat et al\textsuperscript{56} reported a trial involving ropivacaine 0.2\% and bupivicaine 0.15\%. They reported a similar analgesic effect, but ropivacaine was associated with better preservation of hand strength and less finger paresthesia. Harvey et al\textsuperscript{57} also reported that the use of subacromial ropivacaine 0.2\% patient-controlled analgesia provided effective postoperative pain control after subacromial arthroscopic decompression. Casati et al\textsuperscript{58}
found ropivacaine 0.2% and levobupivacaine 0.125% equivalent after shoulder surgery, but patients given levobupivacaine consumed less analgesic oral medication.

To date there are no conclusive studies about which is the best anesthetic medication for continuous infusion pumps. Nevertheless, it is important to mention that continuous infusion pumps may not be effective in open shoulder surgery. Boss et al. reported that continuous subacromial infiltration with bupivacaine is ineffective in providing pain relief supplementary to patient-controlled analgesia after open rotator cuff repair and acromioplasty.

Recent evidence of the potential for chondrolysis after continuous intra-articular bupivacaine infusion suggests closer scrutiny of this modality in a joint is needed, although insertion of the infusion devices into areas without articular cartilage should avoid these concerns.

Postoperative Sleep Agents

Pain can cause sleeplessness, which can lead to a vicious cycle of acute pain, anxiety, and additional sleep deprivation. The use of sleeping medication, at least during the first 24 postoperative hours, is advocated. Sleep disturbances may be related to hyperalgesic changes and to alteration of the effect of analgesic or sedative medications via opioidergic and serotonergic mechanisms of action. Sleep disturbances can alter the natural history of pain, so it is important to improve sleep quality and quantity. This improvement is related to an enhancement of patient overall health and quality of life. Thus, the neurobiologic pathways that regulate sleep may also play a role in central pain processing.

Physical Methods

Cryotherapy

The use of cold for analgesia is a practice dating from the time of Hippocrates in the 4th century BC. Ice was also used as a preoperative anesthetic agent in the Middle Ages. Cold therapy in the form of ice bags has been extensively used in athletic training since the 1960s. The mechanism of action of cold is not clear. It is thought to act as an anesthetic agent, raising the pain threshold of the nerve fibers at low temperatures, with its early application reducing the initial hemorrhage, swelling, and inflammation by reflex capillary vasoconstriction. The major benefits of cryotherapy result from altered blood flow and decreased pain, muscle spasm, sensorimotor nerve conduction, and metabolism, as well as increased tissue stiffness. Furthermore, minor elevations in intra-articular temperatures can stimulate proteolytic enzyme activity, which has a detrimental effect on articular cartilage.

Several methods exist for cold application: ice bags, reusable cold packs, and refrigeration devices. In the first 48 hours after shoulder surgery, cryotherapy provides its major benefits by its anesthetic effects and by lowering the metabolic rate of the affected zone and preventing inflammation. Pain reduction has been reported after the
application of cold between 50° and 60°F (10° to 15°C). Singh et al reported that continuous cold therapy was useful for both open and arthroscopic shoulder surgery. They confirmed a significant decrease in postoperative pain and an increase in overall patient comfort and satisfaction. Patients slept longer and more comfortably and were able to reestablish their normal daily patterns.

In contrast, no observed decrease in subacromial and glenohumeral joint temperatures was observed in the immediate postoperative period after 90 minutes of cold therapy. After applying cold therapy for 23 consecutive hours, however, Osbahr et al found significant reduction in skin, subacromial, and glenohumeral temperatures. They observed an increase in temperature in these regions from 4 to 12 hours postoperatively and a relative thermostatic phase from 12 to 23 postoperative hours. The results of cold therapy on the shoulder depend on the tissue depth and the duration of surface cooling. This is because the cold temperature has to overcome a large, muscular mass that surrounds the joint. In contrast to other joints, circumferential cooling cannot be achieved. Although conflicting reports exist, cold therapy after shoulder arthroscopy is a common modality with apparent good subjective results.

**Transcutaneous Electrical Nerve Stimulation**

Transcutaneous electrical nerve stimulation provides a noninvasive method of reducing postoperative pain. While unable to relieve the most intense aspects of pain, it works as an important analgesic adjuvant. Likar et al evaluated the use of transcutaneous electrical nerve stimulation for 3 days after shoulder surgery in a randomized clinical study. Reduced analgesic consumption and significantly lower pain scores were observed.

**Summary**

Efforts at postoperative pain reduction should begin preoperatively with the establishment of an excellent patient/physician relationship. Adequate counseling as to the nature of the condition and what the procedure entails should be provided. A good night’s sleep preoperatively will decrease anxiety and postoperative pain perception. Preemptive analgesia should be administered, including portal and portal track infiltration, joint inflation with an analgesic/anesthetic drug, and peripheral nerve blockade (such as the suprascapular nerve block). Intraoperative efforts should include the administration of anesthetic medication intra-articularly. Postoperative management should include sleep medication, continuous cold-flow therapy, oral analgesics, and, if necessary, the use of narcotics and instillation of a local anesthetic/analgesic agent into the operative site via a pain pump. The use of NSAIDs should be postponed until after the 10th postoperative day in cases of tendon or ligamentous repair. Reduced intraoperative time, elimination of unnecessary bone and soft tissue manipulation, and meticulous surgical technique are also essential for postoperative pain reduction.

**References**


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