Postoperative Pain Management in the Orthopedic Setting

10

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Objectives

- Provide a comprehensive overview of pain management in the orthopedic patient population.
- Describe multimodal analgesic techniques that help minimize the reliance on opioids in the immediate postoperative period.
- Provide support for the use of regional anesthesia and analgesia and describe newer motor-sparing nerve blocks.
- Discuss the novel formation of the recuperative and transitional pain service.
- Chronic postsurgical pain (CPSP) is a well-known phenomenon after major orthopedic surgery and can partially be addressed by instituting pain management services throughout the perioperative period.

Key Points

- An optimal pain management regimen is critical in order to facilitate rehabilitation, recovery, and discharge in both in- and outpatients.
- Addressing pain through various techniques provides opioid-sparing analgesia.
- Literature supports the use of regional anesthesia over general anesthesia.

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Introduction

Available postoperative pain management modalities vary depending on the surgery type and anesthesia technique utilized. In this chapter, we present the general principles of postoperative pain management and review currently available forms of analgesic approaches including the use of preemptive and multimodal analgesia, local anesthesia infiltration, regional and neuraxial anesthetic and analgesic techniques, and peripheral nerve catheters. We based our review on evidence-based review of the literature whenever possible.

Additionally, we discuss postoperative pain management techniques and regimens used at the Hospital for Special Surgery and highlight some of the successes and limitations we have had with our own patient population.

General Principles of Pain Management

Pathophysiology of Pain

Pain is defined as “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in such damage” [1]. Pain is also subjective, and it may not be a result of potential injury or tissue damage. In the absence of potential injury and involvement of noxious stimuli, pain maybe due to psychological reasons [1]. Given

C. R. MacKenzie et al. (eds.), *Perioperative Care of the Orthopedic Patient*, https://doi.org/10.1007/978-3-030-35570-8_10

that pain is subjective and influenced by emotions and psychologic factors, clinicians are often bound to accept descriptions of pain as reported by the patient.

During surgery, direct tissue damage leads to the release of inflammatory mediators including peptides, lipids, and neurotransmitters [2]. These molecules initiate a cascade of neural processes that encode the noxious stimuli known as nociception [1]. The nociceptive stimulus is transmitted by peripheral somatosensory receptors. Ultimately, these signals are transmitted to the central nervous system via pain neurons. Inflammatory mediators act peripherally and induce local neurogenic inflammation which leads to vasodilatation and plasma extravasation [2]. Pain signals evoked by tissue damage can lead to central and peripheral sensitization, which is defined as increased responsiveness of nociceptive neurons compared to the normal or subthreshold afferent input [1, 3]. According to some literature, such sensitization may be reduced with the use of preemptive analgesia [3].

Pain is further classified as acute or chronic pain. Acute pain is defined as "pain that is present in a surgical patient after surgery" [4]. Chronic pain, per American Society of Anesthesiologists, is defined as pain "extending in duration beyond the expected temporal boundary of tissue injury and normal healing, and adversely affecting the function or well-being of the individual" [5].

Chronic Postoperative Pain

The incidence of chronic postsurgical pain (CPSP) varies depending on the surgery performed and is believed to occur in between 394,000 and 1.5 million cases per year in the USA [6]. After hip replacement procedures, the estimated incidence of CPSP was 12% [6]. The working definition of CPSP proposed by Macrae and colleagues included the following criteria: (i) pain development after a surgical procedure, (ii) at least 2 months of duration, and (iii) exclusion of other causes including malignancy after surgery or chronic infection. The authors suggested further that the possibility of the pain being a continuation from a pre-existing problem should be evaluated and potentially excluded [6]. According to a French cross-sectional cohort study using a survey of 2100 patients who underwent orthopedic procedures, 1292 patients reported suffering from chronic pain after 3 months [7]. Authors noted statistically significant odds ratios for developing CPSP to be associated with arthrodesis, knee arthroplasty, and leg fracture (OR = 2.7, OR = 1.8, OR 1.9, respectively; $P < 0.05$) while noting increased neuropathic pain with elbow surgery, meniscectomy, amputation, and neurolysis [7]. Recent evidence has shown that young age, obesity, female sex, the presence of anxiety, depression, stress, and catastrophizing characteristics have been strongly correlated with CPSP with about one in five patients developing CPSP [8]. A strong risk factor for developing CPSP was found to be severe acute pain, leading the authors to recommend that acute pain should be effectively controlled using regional anesthesia, local anesthetic infiltration, and gabapentin [8].

Variation of Perioperative Pain for Orthopedic Procedures

A patient's experience with perioperative pain can vary dramatically for different orthopedic procedures with different anesthetic and analgesic techniques as well as use of various protocols. A recent meta-analysis that compared adductor canal nerve blocks versus femoral nerve blocks for total knee arthroplasty showed a visual analog scale (VAS) score in various studies ranging from 20 to 48 mm at 48 hours [9]. A recent meta-analysis of patients receiving gabapentinoids for postoperative pain in total knee arthroplasty showed a numerical rating scale (NRS) score in various studies ranging from 3.6 to 5.7 at 72 hours [10]. Other orthopedic procedures can involve a lower level of perioperative pain. A randomized controlled trial of patients receiving periarticular injections in total hip arthroplasty showed mean VAS scores of 2–3 within the first 24 hours, approaching a VAS score of 0–1 by day 5 [11]. The varying pain scores highlight the challenge of knowing when to institute different modalities for the same procedure (i.e., knee replacements). Variable pain scores also underscore that some procedures do not elicit severe pain (i.e., hip replacements) and may not require the same modalities for different procedures. Hence, one protocol may not fit the needs for all procedures and patients. Instead of generalizing orthopedic pain management into one pathway, it is important to understand what differentiates various procedures (pain severity) and tailor the procedure-specific pathways accordingly (e.g., total knee pathways versus total hip pathways).

Preemptive and Preventive Analgesia

Preemptive analgesia describes the concept that the timing of a specific pain intervention can prevent peripheral and central sensitization from noxious nociceptive surgical stimuli [12]. The effectiveness of preemptive analgesia has been studied with mixed results [13, 14]. The concept of preventive analgesia includes a preoperative intervention that may reduce the impact of noxious nociceptive stimuli throughout the perioperative period [12]. Preventive analgesia can include systemic medications and regional anesthesia and analgesia techniques. There is some evidence that hyperalgesia is prevented by regional analgesic techniques [15].

Multimodal Analgesia

Systemic Analgesic Techniques

Opioids

Opioids remain the main systemic analgesic used in the treatment of postoperative pain. Opioids act on multiple receptors in the central nervous system, including the mu, kappa, and delta subtypes. There are multiple receptors within each subtype with some producing analgesia and others producing undesirable side effects such as respiratory depression and reduced gastrointestinal motility. Mu receptors are associated with analgesia, smooth muscle tone, sedation, mood alteration, and nausea and vomiting. Delta receptors are associated with decreased colonic transit time. Kappa receptors have a central analgesic effect, decrease colonic transit time, and have visceral nociception antagonism. Opioids produce effective analgesia and can be administered through multiple different routes with the most common in the postoperative period being the oral and parenteral routes. The parenteral route is ideal for acute postoperative pain due to its rapid onset of action. Morphine and synthetic analogues such as hydromorphone and fentanyl are the most commonly used opioids. Onset of action, half-life, and bioavailability vary by drug and route of administration. Most anesthesiologists have considerable experience with the administration of these drugs. Less commonly used drugs such as methadone which have a long half-life and N-methyl-D-aspartate (NMDA) antagonism have a role in patients on chronic opioids and patients undergoing larger, more painful procedures such as multilevel spine surgeries [16]. While very effective, opioids have significant potential for abuse and misuse contributing to the current opioid epidemic in the USA [17]. Concerns about abuse and misuse of opioids have led to increasing interest in opioid-sparing modalities and enhanced recovery after surgery (ERAS) pathways. These endeavors have shed light on common misbeliefs that NSAID use will increase postoperative bleeding [18, 19].

Intravenous Patient-Controlled Analgesia (PCA)

Intravenous (IV) patient-controlled analgesia (PCA) has become the standard of care for delivery of parenteral opioids on an individualized basis. Typical IV PCA regimens provide patients with autonomy while preventing side effects with "lockout" settings. Successful patient-controlled analgesia requires the availability of special pumps as well as patient and staff education. When compared to staff-administered prn opioids, IV PCA results improved analgesia and patient satisfaction [20, 21]. Dangerous effects such as respiratory depression are not eliminated with IV PCA [21]. Common PCA settings are presented in Table 10.1.

Table 10.1 Common IV PCA settings

Opioid concentration	Demand	Lockout (min)	Basal infusion
Morphine (1 mg/mL)			
Adult	0.5–2.5 mg	5–10	
Pediatrics	0.01–0.03 mg/kg (max = 0.15 mg/kg/h)	5–10	0.01–0.03 mg/kg/h
Hydromorphone (0.2 mg/mL)			
Adult	0.05–0.25 mg	5–10	
Pediatrics	0.003–0.005 mg/kg (max = 0.02 mg/kg/h)	5–10	0.003–0.005 mg/kg/h
Fentanyl (0.01 mg/mL)			
Adult	10–20 μg	4–10	
Pediatrics	0.5–1 μg/kg (max = 4 μg/kg/h)	5–10	0.5–1 μg/kg/h

Nonsteroidal Anti-inflammatory Drugs (NSAIDs)

Nonsteroidal anti-inflammatory drugs (NSAIDs) are widely used agents which inhibit cyclooxygenase (COX) reducing prostaglandin synthesis. Prostaglandins are mediators of inflammation and peripheral nociceptive sensitization. Many NSAIDs irreversibly and nonselectively bind COX, while newer drugs such as celecoxib are selective for COX-2 which is primarily involved in pain and inflammation pathways. NSAIDs are important components of multimodal analgesia and show well-documented opioid-sparing effects [22, 23]. While most NSAIDs are administered orally, ketorolac is an injectable NSAID with excellent analgesic properties [23]. Many of the side effects of NSAIDs including bleeding and disruption of gastric mucosa come from inhibition of COX-1 [24, 25]. Renal dysfunction and disruption of osteogenesis occur with all NSAIDs [26–28]. Bleeding and disruption of osteogenesis may not be of clinical relevance [29, 30].

Acetaminophen

Acetaminophen's analgesic and antipyretic effects are likely mediated through many central mechanisms although its exact mechanism of action remains undetermined. Acetaminophen can be administered orally, rectally, and parenterally. Acetaminophen has been shown to have significant opioid-sparing effects and reduction of side effects when combined with opioids [31, 32]. The main serious side effect of acetaminophen is hepatotoxicity, limiting the maximum dose to

4000 mg/day in adults. The IV formulation has increased bioavailability resulting in a faster onset and avoids first-pass metabolism through the liver which decreases its hepatotoxicity [33]. A recent systematic review showed no clinically significant difference between the IV and oral formulations in postoperative pain management [33].

Tramadol and Tapentadol

Tramadol and tapentadol are synthetic opioids with a unique mechanism of action as a mu agonist and a serotonin-norepinephrine reuptake inhibitor. Tramadol has been shown to be an effective analgesic in the perioperative period [34, 35]. Advantages of tramadol over traditional opioids include decreased respiratory depression and decreased GI side effects. Tramadol can lower the seizure threshold, and there is a risk of serotonin syndrome when it is administered with other pro-serotonergic medications [36]. While previously thought to have a low potential for abuse, tramadol is abused at rates similar to other opioid medications [36]. Tapentadol has similarly been shown to be an effective analgesic in the perioperative period with a reduced side effect profile compared to classical opioids [37, 38]. Tapentadol may have a lower potential for abuse compared to classical opioids [38].

Gabapentinoids

Gabapentin and pregabalin are anticonvulsants that are thought to mediate analgesia through interaction with specific subunits of calcium channels, inhibiting the release of excitatory neurotransmitters. There is evidence that gabapentin decreases postoperative opioid use, but there is conflicting evidence on the degree to which it does [39–41]. Postoperative dosing for 72 hours was shown to promote opioid cessation in a mixed surgical cohort [42]. Pregabalin has a similar method of action to gabapentin but with greater oral bioavailability [43]. Pregabalin has been shown to reduce pain scores and opioid consumption at multiple dosing regimens [43–45]. The main side effect of gabapentinoids is sedation.

Steroids

Systemic corticosteroids such as dexamethasone are primarily used in the perioperative period as antiemetics, but they also have analgesic and anti-inflammatory properties [46]. Dexamethasone acts on the glucocorticoid receptor to suppress the immune response and reduce inflammation. Glucocorticoids can have several side effects including hyperglycemia, immunodeficiency, and adrenal insufficiency if used for an extended period of time. Systemic dexamethasone has also been shown to prolong the duration of action of perineural local anesthetics [47, 48].

Muscle Relaxants

Muscle relaxants are centrally acting drugs used to decrease skeletal muscle tone. These drugs work centrally through different and sometimes poorly understood mechanisms to suppress muscle spasms and relax skeletal muscle. Tizanidine, an alpha-2 agonist, is the only muscle relaxant that has been shown to also be an effective analgesic [49, 50].

Dexmedetomidine

Dexmedetomidine is a centrally acting alpha-2 agonist. Dexmedetomidine is widely used for sedation in critical care and procedural sedation in medically complex patients due to its relative lack of respiratory depression. In a recent meta-analysis, dexmedetomidine was shown to reduce opioid consumption in the postoperative period [51]. Dexmedetomidine has been shown to have an opioid-sparing effect in spine surgery and total knee arthroplasty [52, 53]. This drug is typically administered as a bolus dose followed by an infusion intraoperatively. Dexmedetomidine's most significant side effects is related to its hemodynamic effects leading to bradycardia, hypotension, and hypertension mediated by peripheral alpha-2 receptor stimulation.

Ketamine

Ketamine, originally developed as an anesthetic, is now used in the treatment of postoperative pain, chronic pain, and depression. Ketamine blocks nociceptive stimuli through NMDA receptor antagonism [54]. Ketamine may also act on opioid receptors [55]. A recent systematic review of 39 randomized controlled trials showed that ketamine infusions result in powerful opioid sparing for a variety of surgical procedures [54].

Local Anesthesia Infiltration/ Periarticular Injection

Periarticular Injection

Periarticular injections have become an important part of multimodal analgesia in hip and knee arthroplasty. Typical injection agents include local anesthetics, opioids, NSAIDs, and corticosteroids. A systematic review of 21 randomized controlled trials in hip and knee arthroplasty concluded that PAI improves pain relief, reduces opioid consumption, and results in a larger range of motion and lower rates of nausea and vomiting than placebo [56]. Combining periarticular injection with motor-sparing blocks such as the IPACK and adductor canal blocks may confer further benefits such as earlier ambulation in total knee arthroplasty [57, 58].

Liposomal Bupivacaine

Liposomal bupivacaine is a drug delivery system for the amide local anesthetic bupivacaine that uses lipid bilayers to encapsulate drug resulting in slow release, increased duration of action, and lower plasma concentration than plain bupivacaine [59]. Many of the initial studies in liposomal bupivacaine showed decreased pain scores and opioid consumption when compared to placebo [59]. While there is some evidence of an advantage over traditional pain protocols in the plastic surgery literature, multiple reviews in the orthopedic surgery literature have not shown a difference when compared to plain bupivacaine [60–62]. Moreover, one study looked at over 80,000 total knee arthroplasties done with a peripheral nerve block and showed no clinically meaningful reduction in inpatient opioid prescription, opioid-related complications, and length of stay with liposomal bupivacaine [63].

Regional Anesthesia Techniques

Peripheral Nerve Blockade

Peripheral nerves can be blocked at various sites for upper and lower extremity surgery. The brachial plexus can be blocked via the interscalene, supraclavicular, infraclavicular, and axillary approach. Lower extremity peripheral nerve blocks include the lumbar plexus, femoral, fascia iliaca, adductor canal, sciatic, popliteal, IPACK (interspace between the popliteal artery and the capsule of the posterior knee), saphenous, and ankle blocks. Peripheral nerve blockade provides improved analgesia, side effects, and patient satisfaction when compared to systemic opioids [64–68]. Complications are rare and depend on the site of blockade (e.g., phrenic nerve paresis in interscalene block) [69]. Motor-sparing blocks such as the adductor canal block and IPACK result in similar analgesia to previous peripheral nerve blocks (e.g., femoral and sciatic nerve blocks) with the added advantage of early ambulation and physical therapy due to their motor-sparing effects [58, 70]. Upper extremity motor-sparing blocks such as the superior trunk block and suprascapular block offer similar pain relief yet may spare the phrenic nerve [71, 72] and preserve hand strength. Truncal blocks such as the transversus abdominis plane block and quadratus lumborum block may have a role in postoperative analgesia in orthopedic surgery, including anterior spine surgery [73, 74]. Perineural additives to prolong peripheral nerve blocks include alpha agonists, buprenorphine, and dexamethasone. While each of these additives has been shown to be effective in prolonging the action of local anesthetics when administered perineurally, dexamethasone is by far the most well-studied additive and has been shown to prolong nerve blocks up to 22 hours [75, 76].

Neuraxial Anesthesia and Analgesia

Ambulatory Lower Extremity Procedures

With the increase in the number of ambulatory surgical centers and ambulatory procedures, there is a need for shorter-acting spinal anesthesia to prevent any delays in discharge. Since it has been accepted for spinal use in Europe in 2012, there has been a resurgence in the use of chloroprocaine [77, 78]. Several retrospective and prospective studies demonstrate its safety and efficacy [79–81]. Some studies demonstrated lower risk for transient neurologic symptoms (0–1.9%) and less incidence of urinary retention (0%) [79, 82]. With chloroprocaine dosages of 30–60 mg and length of action ranging from 45 to 90 min, duration is shorter than mepivacaine, lidocaine, and bupivacaine [81]. One randomized controlled trial demonstrated its ability to facilitate earlier discharge and reduce cost in comparison with general anesthesia [83]. To prolong analgesia and spare motor blockade, anesthesiologists are adding opioids (fentanyl, morphine) to their spinal anesthetics [84]. Adding preservative-free morphine has been shown to decrease opioid consumption and pain up to 1 day after surgery [84], but the possibility of delayed respiratory depression precludes its use in the ambulatory setting since all patients require prolonged observation in a monitored setting. Another common side effect of spinal opioids is pruritus which can be debilitating in the immediate postoperative period [84].

Total Hip and Knee Arthroplasty

Recent studies in hip and knee patients comparing general anesthesia to neuraxial anesthesia showed a favorable perioperative outcome in those who underwent neuraxial anesthesia [85]. A database analysis of over 380,000 patients who underwent neuraxial anesthesia had a lower 30-day mortality, shorter length of stay, less cost, and less in-hospital complications compared to general anesthesia recipients [86]. The use of neuraxial anesthesia in hip surgeries has been associated with lower mortality, thromboembolic events, blood loss, cardiopulmonary complications, and infections [87]. A retrospective review of more than 3000 hip and knee replacements showed surgical site infections were less than half as likely if an epidural or spinal was used instead of general anesthesia [88]. It is for these reasons that the primary anesthetic utilized at the Hospital for Special Surgery for lower extremity joint surgeries involves neuraxial techniques.

Peripheral Nerve Catheters

Although multimodal analgesia and motor-sparing blocks have allowed for earlier discharge to home or to rehabilitation centers, there are concerns about possible severe rebound pain and possible readmission for unrelenting pain control or opioid-related adverse effects when the blocks wear off on the day after surgery. Hanson and colleagues [89] compared patients with an ambulatory adductor canal catheter to a control group (sham catheter group) after total knee arthroplasty. Patient satisfaction –which is as high as 94% when the blocks are functioning with the catheter – was notably lower after the resolution of the block while in the hospital.

Rebound pain is a phenomenon first described by Williams and colleagues in 2007 [90]. The study described it as the moderate to severe acute pain a patient encounters after nerve block analgesia resolved. The study was comparing the use of a single-shot femoral nerve block versus a femoral nerve ambulatory catheter after anterior cruciate ligament (ACL) reconstruction. Patients were educated in the use of multimodal analgesia, including NSAID, acetaminophen, and opioids. The study subjects were instructed to keep a pain diary and note the moment when they believed the block did not provide analgesia. A linear regression model identified predictors of rebound pain syndrome (RPS) and only nerve block duration was a predictor. The authors concluded that increased duration of block leads to reduction in rebound pain.

Therefore, the goal of implementing an adductor canal catheter program (as planned at our institution) is not only to prolong analgesia but also prevent rebound pain, further reducing the use of opioids. By sending patients home with an adductor canal catheter, the cost savings to the hospital would be significant. A study done at Virginia Mason in Seattle described how ambulatory adductor canal catheters placed in total knee arthroplasty patients resulted in the ability to discharge of 11.9% of the patients (69 patients) to home on the day after surgery [91]. These patients were educated on home catheter care and were followed closely up to 4 days. Patients removed the catheter after the 50-hour infusion completion on day 3. Remarkably, there were no dislodgments, no major complications such as local systemic toxicity, no infections, and no block attributable falls. No patients had to be seen prior to the 14-day routine follow-up visit with the surgeon. And there was no readmission for pain control. Pain scores were less than 2 at rest and less than 4 out of 10 with activity throughout the infusion period, as well as on postoperative day 4. Most notably, 18.8% of the patients did not take any opioids while at home. This study demonstrated the efficacious use of a catheter with the goal to prevent rebound pain and possibly provide a non-opioid pain regimen at home.

Despite literature suggesting successful use of catheters for managing postoperative pain, there are also studies that show that catheters require more patient education, time for placement, and availability of a healthcare providers for consultation, have higher risk of bacterial colonization, and are prone to dislodgment [92]. With the increased use of additives such as dexamethasone to prolong single-shot nerve blockade, there need to be future studies comparing additive single-shot nerve blocks to those using catheters. If a single-shot block with a dexamethasone additive prolongs the block long enough to minimize rebound pain, the use of a catheters might prove to be unnecessary.

Currently, at the Hospital for Special Surgery, peripheral catheters for certain procedures to prolong the benefits of the block for 2–3 days are used selectively. Placed for elbow surgery, it is used to allow patients to comfortably perform passive range of motion for several days. If it is placed for tissue flap surgeries, the associated sympathectomy promotes vasodilation and improves circulation in the operative site. In the setting of ankle, knee, or hip surgeries, catheters achieve minimization of opioids.

HSS Pain Management for Specific Procedures

Postoperative pain management at the Hospital for Special Surgery is dependent on surgery type, surgeon and patient preference, expected level of pain, the patient's medical history (prior spine fusion surgery, cardiac disease requiring anticoagulation, difficult airway, etc.), planned surgical thromboprophylaxis, and lastly the rehabilitation goals and discharge plans. The postoperative pain management planning for patients without chronic pain or those who do not require a visit (ASA 1 or 2 without history of chronic pain) to our presurgical screening center occurs at the preoperative holding area. Upon discussing the anesthetic plan with the patient, one or more of the following modalities of pain management are provided: epidural PCA, IV PCA, peripheral nerve block, or peripheral nerve catheter. A service to follow the patients is selected to be either the acute pain service (APS), the chronic pain service (CPS), or in straightforward cases the surgical service. Furthermore, when appropriate, incorporation of multimodal analgesia utilization (acetaminophen, NSAIDs, ketamine, dexmedetomidine, etc.) is maximized to reduce systemic use of opioid medication. All patients who receive a regional anesthetic are educated that, once the analgesic effect begins to wear off, the patient will experience pain that will require transitional pain interventions (oral pain medication, IV PCA, redosing of local anesthetic via catheter, etc.). Lastly, close communication with the surgical team is crucial to ensure that there is an adequate postoperative analgesic regimen in place.

Total Joint Replacement

At HSS, more than 90% of hip and knee replacements are performed using regional anesthesia. With the overarching goal of promoting early ambulation postoperatively, there have been attempts to decrease the use of IV PCAs while increasing the use of long-acting, motor-sparing peripheral nerve blocks. For similar reasons, some surgeons have moved away from the use of epidural catheters for postoperative pain management and have relied on the use of peripheral nerve blocks, multimodal analgesia, and periarticular injections to achieve the goal of early ambulation and physical therapy.

Total Hip Arthroplasty

If the total hip arthroplasty is performed using a combined spinal epidural technique (CSE), and the epidural catheter is left in place to be used as a postoperative pain regimen, then the PCEA will be initiated in the recovery room postoperatively. An ifusate of 0.0625% bupivacaine with 0.01 mg hydromorphone at a continuous rate of 4 ml/h with a demand dose of 4 ml every 10 minutes with an hourly maximum of 20 ml is used [93]. On the morning of postoperative day (POD) 1, all the patients with PCEA are followed by the acute pain service, the continuous infusion is stopped, and the demand dose is kept available until noon. Upon encouraging patients to request and use oral pain medication with the use of epidural demand dose as the backup, the patient is transitioned to an oral pain medication regimen (oral acetaminophen, oxycodone, hydrocodone, hydromorphone, NSAIDs, etc.) with discontinuation of the epidural catheter. If the patient cannot tolerate the transition, the epidural may be left in place until the afternoon on POD 1 or the next morning at the discretion of the acute pain service attending physician.

Quadratus Lumborum Block (QLB)

While periarticular injections (PAI) are becoming the standard analgesic regimen for THA, use of novel blocks to supplement the analgesic has been recently reported and since has been adopted for intermittent use at the Hospital for Special Surgery. The successful ultrasound-guided transmuscular quadratus lumborum block (QLB) for postoperative pain management has been previously reported and since has gained popularity for THA procedures [94, 95]. Although there is currently a lack of prospective trials that demonstrates the efficacy of QLB in THA, some anesthesiologists have incorporated the block to optimize the analgesic regimen without compromising the patient's ability to ambulate.

Suprainguinal Fascia Iliaca Block (SIFI)

Another novel block technique that is being used for hip surgery is the SIFI block. The proposed benefit of this block is the ability to provide the same analgesic coverage as a fascia iliaca block but spare quadriceps strength [96], allowing patients to ambulate earlier while consuming less opioids. The literature is scarce on this technique, except for cadaveric dye studies [97] describing the nerves this compartment block may be targeting. There are several retrospective and volunteer studies that validate its potential analgesic benefits, but its motor-sparing capabilities are questioned [98]. Indeed, 2 out of 19 volunteers in one study demonstrated significant quadriceps weakness. Further prospective randomized controlled trials need to be pursued to help elucidate this novel block for hip surgeries.

Total Knee Arthroplasty

Depending on the surgeon's preferences and use of PAI, the postoperative pain regimen may or may not encompass the use of PCEA. Patients whose postoperative anticoagulation regimen allows for use of a PCEA will receive it in the recovery room with similar epidural infusion mixture and settings as aforementioned for THA procedures. However, on POD 1, the basal infusion is started at a higher rate but is still discontinued in the afternoon. Demand dosing is maintained until the POD 1 afternoon, while an oral pain regimen is encouraged to achieve a similar transition. If the surgeon prefers not to use the PCEA, the patients will receive a single-shot spinal anesthetic (usually using an intermediate local anesthetic such as mepivacaine) along with an adductor canal block (ACB) with or without the infiltration between popliteal artery and capsule of the posterior knee (IPACK) block. These non-epidural patients usually have periarticular injections along with their motor-sparing blocks. Most practitioners have changed their practice from performing femoral nerve blocks to using ACB. While femoral nerve blocks were routinely performed in the past [99], recent studies demonstrated similar postoperative analgesia with less quadriceps muscle weakness and perhaps lower risk of neuropraxia with ACB [100–102]. However, the use of large volumes of 0.5% bupivacaine in the ACB has resulted in occasional motor blockade. This is thought to be attributable to proximal spread of local anesthetic to the femoral nerve. The newly developed IPACK block performed under ultrasound guidance has been shown to improve postoperative analgesia by providing improved pain relief to the posterior aspect to the knee without loss of motor function [58, 103]. Prior to its use, however, a close communication with the patient and the surgeon should take place to ensure the discussion of risks and benefits. A foot drop can occur after IPACK or PAI due to anesthetic spread to the peroneal nerve found in the area of injection. Most anesthesiologists do not perform the IPACK block on severely valgus deformed knees, as injury of the peroneal nerve during correction can occur, making early diagnosis difficult.

Shoulder Surgery

Total Shoulder Arthroplasty

Total shoulder surgeries are either done under supraclavicular, interscalene, or superior trunk block. The latter is a novel approach to the brachial plexus that targets the C5–C6 components at the trunk level. This technique not only spares the distal hand but decreases the risk for phrenic nerve blockade or injury [71]. At times, general anesthesia is induced upon block placement at the surgeon's request for additional muscle relaxation. Many practitioners have moved away from using interscalene nerve blocks in favor of supraclavicular or superior trunk approaches as the latter techniques have shown to provide adequate anesthesia and analgesia for surgery with reduced risk of intrathecal injections or phrenic nerve injury due to direct needle trauma. Most patients will require IV PCA as a backup with oral pain medication regimen, as they will experience pain with receding effects of the peripheral nerve block.

Shoulder Arthroscopies

Most shoulder arthroscopies are performed with a supraclavicular or superior trunk block with sedation. Patients are usually ambulatory and are discharged shortly after the procedure; hence, surgeons provide prescriptions for oral multimodal pain medications.

Elbow Surgery

Most procedures are performed with either a supraclavicular or infraclavicular nerve block. Given the high success rate of these techniques under ultrasound guidance, axillary approaches to the brachial plexus have gone out of favor. Supplemental cutaneous nerve blocks are also performed to supplement the brachial plexus block such as the intercostobrachial nerves to aid in tourniquet pain. Patients are usually provided with a prescription for oral pain medications. As with all cases, patients with extensive surgery with expected high postoperative pain levels will be admitted and an IV PCA ordered overnight.

Foot and Ankle Surgery

Depending on the specific case, surgeons may have differing preferences for anesthesia. Close communication with the surgeons ensures that a successful postoperative analgesic plan is implemented. For any procedure involving the forefoot, an ankle block can be performed with or without ultrasound guidance. For any major ankle surgeries such as total ankle replacement, most of the anesthetic plans encompass the use of a single-shot sciatic nerve block in the popliteal fossa, ACB or distal saphenous nerve block (analgesia to medial ankle), as well as a spinal anesthetic. Adjuvants such as clonidine or dexamethasone can be added to popliteal sciatic nerve blocks to lengthen the analgesic duration [104, 105]. Especially with the addition of preservative-free dexamethasone, popliteal nerve blocks have been shown to last as long as 48 hours. Patients will either have an IV PCA and/or oral analgesics for pain once nerve blocks begin to wear off.

Spine Surgery

Patients undergo various types of spine surgery from simple single-level discectomies to multilevel spinal fusion revisions. For nonambulatory spine patients, adequate postoperative analgesia may be difficult to achieve, especially given the limited feasibility for regional anesthesia modalities. Most perioperative pain regimens for spine surgeries encompass the use of opioids. Patients undergoing spine surgery have frequently had chronic low back pain and have been on long-term opioids at home, thus requiring higher than normal doses of perioperative opioid doses. However, every attempt is made to maximize the incorporation of multimodal analgesic approaches including local and regional anesthesia whenever possible. The uses of acetaminophen, NSAIDs, ketamine, gabapentin, and long-lasting local anesthetics injected at the surgical site have been added to protocols in the perioperative setting [106, 107]. The use of NSAIDs, especially ketorolac for spine fusion surgery, varies depending on the surgeons' preference given the concern for increased risk for nonunion at high doses (>120 mg per day) within 14 days of surgery [107]. Although epidural anesthesia above the level of surgery is a feasible option, it impedes neuromonitoring of spinal cord integrity and is rarely performed. Recently, transversus abdominis plane (TAP) blocks have been used for extreme lateral interbody fusion (XLIF) and anterior lumbar interbody fusion (ALIF), with some patients receiving opioid-free anesthesia with adequate analgesia postoperatively.

Recuperative Pain Model

Patients transitioning from IV PCA to oral pain medications may often have difficulty with inadequate pain control. The transition from IV PCA to oral pain medication may also occur on the day of discharge, and patients may find themselves needing additional doses of pain medications at home. Given that the acute pain service does not continue to follow patients after discontinuation of IV PCAs, patients may not be attended to at the time they need it the most to ensure proper and satisfactory analgesic regimen for discharge. For this reason, HSS created a recuperative pain medicine (RPM) service in 2007 with the goal to bridge the gap with specific goals targeted to improve patient and staff satisfaction [108]. After one and a half years of implementing RPM, Press Ganey scores increased from the 87th percentile to 99th percentile among peer institutions. This increase was attributed to the administrative and educational endeavors that focus on providing an adequate oral pain medication regimen in the hospital or at home utilizing in-house staff and telephone helpline services. Furthermore, if a patient continues to have postsurgical pain, the recuperative pain team provides consultations and support for this patient population up to 8 days after surgery. Should longer care be needed, the team initiates a seamless transfer to a chronic pain specialist.

Orthopedic Patients with Chronic Pain

Given the challenges in managing pain in opioid-tolerant patients in the postoperative period, HSS has instituted selection criteria for preoperative chronic pain consultations. Any patient who has been taking opioids daily for more than 6 months or with a current or recent history of substance use disorder, illicit drug use, or use of opioid agonist-antagonists or methadone is required to see one of our chronic pain specialist prior to undergoing surgery. This serves to educate the patient regarding pain expectations for the surgical procedure and the development of a well-outlined plan prior to surgery. This plan usually entails the use of regional, multimodal analgesics and patient-controlled analgesia (intravenous or epidural). Intraoperative and postoperative ketamine and dexmedetomidine infusions have been used to assist in managing patients who were on high doses of opioids prior to surgery. Management usually entails a monitored setting in which increased doses of respiratory depressant medications can be safely titrated.

Transitional Pain Service

The opioid crisis has led clinicians to spearhead several opioid-sparing protocols and pathways for the most painful procedures [109]. HSS is currently piloting a novel home catheter program to assist in transitioning total knee arthroplasty patients from hospital to home through the use of telemedicine. This program will be the first to utilize telemedicine for ambulatory pumps, to continue providing the services of the acute pain service at home via an electronic application that is downloaded on the patient's smartphone or tablet and allows HIPAA-compliant text messaging and voice and video calls. This step is targeted to ease the transition from hospital to home and provide the patient with further guidance and direction in managing and weaning opioids and catheter care as an outpatient [110, 111]. This transitional pain service (TPS) will not only ensure that ambulatory pumps are functioning, and help patients transition off of opioids, but also will help identify patients at risk for chronic postsurgical pain (CPSP). It is postulated that a TPS may even assist in preventing readmissions and CPSP [111, 112].

Summary

HSS postoperative pain management has evolved from primarily focusing on optimizing pain control via peripheral nerve blocks to expanding its attention to not only analgesia but also ambulation (motor-sparing blocks), ambulatory surgery (short acting spinals), and opioid-sparing pathways (long-acting blocks, peripheral nerve catheters). By reviewing the literature, conducting our own studies (retrospective and prospective), and implementing perioperative protocols, HSS has developed a comprehensive understanding for managing all types of patients (both opioid naïve and tolerant) and for several different orthopedic procedures. Focusing not just on the intraoperative anesthetic but also the preoperative education and postoperative analgesic care and long-term outcomes, the goal is to improve patient satisfaction, minimize opioid reliance, and facilitate return to function.

Summary Bullet Points

- Controlling acute postoperative pain will minimize acute and chronic effects of postoperative pain and facilitate physical therapy.
- A multimodal approach to the pain management regimen may include systemic opioids and non-opioids and/or regional analgesics.
- The analgesic agents and techniques chosen will depend on a variety of factors including the type of surgery, patient's comorbidities, and preferences.
- There will be a subset of patients who will require a recuperative pain medicine or chronic pain medicine consult to manage the postoperative pain regimen and to transition to an appropriate outpatient regimen.

Case Study

An 80-year-old woman with a history of Parkinson's disease, dementia, and osteoarthritis sustained a left femoral-neck fracture after a fall. She was scheduled to undergo open reduction and internal fixation (ORIF) of her femur. She weighed 55.8 kg (123 lb.), with a body mass index of 18.7. Her medications taken at home included amantadine and carbidopa–levodopa for Parkinson's disease. The patient had received morphine and hydromorphone prior to hospital transfer, and during her initial assessment at our institution, she was confused, but oriented to person and place. Her son noted that she had underlying dementia and became easily confused during prior hospitalizations. Given concerns for prolonged postoperative delirium related to her age and cognitive dysfunction, the goal of the anesthesia plan was to minimize postoperative opioids. The patient's intraoperative anesthetic plan consisted of spinal anesthesia (1.5% mepivacaine 4 mL). She received mild intravenous sedation with a propofol infusion. At the end of the procedure, an ultrasound-guided suprainguinal fascia iliaca (SIFI) block using 0.25% bupivacaine 30 mL was performed, and a catheter was placed for postoperative analgesia. Postoperatively, a solution of 0.2% ropivacaine at 6–8 mL/hour. was infused through the peripheral nerve catheter, which provided excellent analgesia. The catheter remained in place with a continuous infusion for 2 days, during which time she did not require opioids. The catheter was subsequently removed, and she was transitioned to oral acetaminophen 650 mg (every 6 hours scheduled) and tramadol 50 mg (every 4 hours as needed).

With resumption of her medication and frequent reorientation, her cognitive status improved during the hospitalization, with a return to baseline by POD 2. The patient was discharged on POD 3.

It is well established that postoperative delirium is associated with increased hospital length of stay, morbidity, and long-term neurologic sequelae [113]. In particular, hip fractures are common among the elderly, and the use of psychotropic medications including opioids can predispose patients to postoperative delirium [114]. Therefore, strategies that provide effective analgesia while minimizing exposure to such medications are critical. Our case illustrates how the use of a SIFI catheter can provide prolonged analgesia and reduce opioid consumption after surgery for hip fracture.

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