Optimal perioperative pain control for total joint arthroplasty remains a challenge. Whereas traditional regimens have relied heavily on opioids, newer multimodal pathways are increasingly gaining popularity as safer and more effective alternatives. The main premise of multimodal analgesia is decreased consumption of opioids, and hence lesser opioid-related adverse events. Other reported advantages include lower pain scores, faster functional recovery, higher patient satisfaction, and shorter length of hospital stay. Unfortunately, despite the advent of numerous analgesic techniques, the multimodal approach has remained widely variable, making direct comparison between studies difficult to interpret. This article provides an extensive review of traditional and modern perioperative interventions in pain management for total joint arthroplasty, including intravenous patient-controlled analgesia, epidural infusion, oral opioids, nonsteroidal anti-inflammatory drugs, acetaminophen, peripheral nerve blocks, periaxicular infiltration, steroids, anticonvulsants, and long-acting local anesthetics. Emphasis is placed on pathophysiology, clinical evidence, and timing. A standardized multimodal analgesia protocol is also proposed based on best available evidence. In addition to pharmacologic interventions, patient education and interdisciplinary collaboration among the care teams play an important role in the success of any treatment pathway. With a growing demand for total joint arthroplasty in an era of bundled payments and accountable care, there has never been a greater need for a standardized multimodal analgesia pathway. [Orthopedics. 2015; 38(7):e616-e625.]

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The advent of total joint arthroplasty (TJA) is perhaps one of the most important developments in orthopedic surgery. When performed successfully, TJA can afford patients greater independence and improved quality of life. It is no surprise that total hip arthroplasty (THA) has been called the operation of the century.\(^1\) By the year 2030, the demand for THA and total knee arthroplasty (TKA) is projected to grow by 174% and 673%, respectively.\(^2\) Despite the rapidly rising rates of these reconstructive procedures, pain control following TJA remains a well-known clinical challenge. Inadequate postoperative analgesia is an important predictor of poor patient satisfaction and has been associated with slow rehabilitation, prolonged hospitalization, and increased risk of morbidities, including deep venous thrombosis, myocardial infarction, and pneumonia.\(^3,4\) Persistent pain stimulation is also pivotal in the development of chronic pain syndrome.\(^5\)

Traditionally, pain control following TJA has primarily relied on oral opioids, patient-controlled analgesia (PCA), or epidural infusions.\(^6\) Although these modalities provide powerful analgesia, they carry a heavy side effect profile. Sedation, respiratory depression, confusion, constipation, nausea, vomiting, pruritus, and urinary retention are among the most commonly reported adverse effects, often associated with significantly increased length of hospital stay and cost of care.\(^7,8\) Patient-controlled analgesia and epidural infusions also require frequent adjustments, limit ambulation, and may not be appropriate for all patients.

The limitations of opioid-based analgesia, combined with our increased understanding of pain physiology, have led the way to alternative pain management approaches, collectively known as multimodal analgesia. First introduced by Kehlet and Dahl\(^9\) in 1993, the primary goal of multimodal analgesia is to decrease the reliance on opioids and therefore minimize opioid-related side effects. This involves the selection of analgesics that target different but complementary sites of action. Over recent years, there has been a rapid increase in peer-reviewed literature, including prospective randomized trials,\(^10,11\) demonstrating the efficacy of this multimodal approach over the traditional opioid-based analgesia.

The purpose of the current article is to provide an up-to-date review of the current analgesic modalities for TJA and to propose a standardized evidence-based protocol. Although there are numerous reports of multimodal analgesia in TJA, the multimodal approach is widely variable and sometimes loosely defined. A standardized protocol would not only help improve the safety and efficacy of post-TJA analgesia, but also provide an important and necessary common language for designing and comparing future clinical studies.

**Pathophysiology of Pain**

The sensation of pain starts at the site of tissue injury. Specialized nerve endings known as nociceptors sense mechanical, chemical, or thermal changes in the damaged tissue.\(^12\) The noxious stimulus is then transduced by nociceptors into electrical signals (action potentials) and transmitted to the dorsal root ganglion via 2 types of afferent neurons: unmyelinated C fibers and myelinated A fibers.\(^13\) These first-order afferent nerve fibers continue propagating the action potential to the dorsal horn of the spinal cord, resulting in synaptic glutamate release and subsequent activation of second-order afferent neurons. The pain stimulus is then relayed to the thalamus via the ascending spinothalamic tract,\(^3,5\) and from there to the somatosensory and limbic cortices of the brain, where sensory and affective pain discrimination occur, respectively.\(^12\)

Pain sensitization or hyperalgesia can occur in both the peripheral and central nervous systems. Damaged cells at the site of injury release inflammatory pain-inducing agents, such as bradykinin, cytokines, prostaglandins, growth factors, and substance P, that act either directly or indirectly on presynaptic first-order afferent neurons to intensify the noxious stimulus.\(^14\) Among these cytokines, prostaglandins and substance P also mediate central sensitization within the dorsal root ganglion.\(^15-17\) Inhibition of prostaglandin and substance P–mediated glutaminergic activity is thus key in preventing pathological central pain.\(^12-14\) Another focus of pain modulation is at the level of interneurons within the dorsal root ganglion. These interneurons release endogenous opioids that act on both pre- and postsynaptic neurons to inhibit neurotransmitter release and hyperpolarize the membrane potential, respectively. Endogenous opioids also play a role at the level of the midbrain by activating cortical descending antinociceptive pathways.\(^13\)

Normally, inflammatory-mediated hyperalgesia is a transient process that resolves with adequate pain treatment. However, persistent unrelieved pain induces complex structural, chemical, and functional neuronal changes through a phenomenon known as neural plasticity.\(^3,5\) The result is pathological pain that persists even after the abatement of the initial noxious injury. The phenomena of neural sensitization and plasticity emphasize the importance of multimodal analgesia for multifocal modulation of pain.

**Patient-Controlled Analgesia**

In today’s terminology, PCA is assumed to imply the administration of opioids via a programmable intravenous (IV) infusion pump under the patient’s control. This is the most commonly used method of acute pain management.\(^18\) Morphine, hydromorphone, and fentanyl are the frequently used PCA drugs. Hydromorphone is 6 times more potent than morphine, and fentanyl is up to 40 times more potent. As a result, 1 mg of IV morphine is equivalent in analgesic effect to 0.2 mg of IV hydromorphone and 25 to 30 µg of IV fentanyl.\(^18\) Since the development of the first commercially available PCA pump in 1976,\(^18\)
this analgesic modality has revolutionized acute postoperative pain control by minimizing the delays in analgesic administration and the inappropriate pain assessment by health care staff, thus accommodating for interindividual analgesic requirements. A meta-analysis of PCA vs nurse-administered analgesia for postoperative pain found superior patient control and greater patient satisfaction in the PCA group but no difference in hospital length of stay or adverse effects.

Unfortunately, PCA is fraught with problems. With no well-defined dosing schemes, PCA often leads to inconsistent pain relief and requires frequent adjustments to optimize relief or minimize the opioid-associated side effects. Even when the PCA demand dose is optimized, patients often wake up in pain, having not pushed the button while asleep. Programming and medication errors have also been widely reported.

The IV tubing leaves patients susceptible to infection and makes even short trips to the bathroom cumbersome. Patient-controlled analgesia may also not be appropriate for some patients, particularly those with learning difficulties or physical impairment to pushing the button or those unwilling to participate. Most importantly, PCA is associated with significant opioid side effects, including sedation, respiratory depression, confusion, constipation, nausea, vomiting, pruritus, and urinary retention. These adverse effects can often translate into increased hospital length of stay and cost of care.

**Epidural Infusions**

Epidural analgesia is achieved by extradural administration of a local anesthetic, an opioid, or a combination of both. It is available as either continuous or patient-controlled infusions. Compared with PCA, epidural analgesia has been shown to provide superior pain control regardless of the analgesic agent used. However, in patients undergoing TJA, the advantage of the epidural route over PCA becomes insignificant after 18 to 24 hours postoperatively. In addition, although there is a lower incidence of sedation compared with PCA, there are no differences in the rates of nausea, vomiting, or respiratory depression, and there is even an increased incidence of urinary retention, pruritus, and hypotension. The motor and sensory blockade during epidural analgesia poses a hazard to patient ambulation and limits early participation in physical therapy. Severe neurological complications following epidural blockade have also been described. Risk factors for neurological complications include obesity, coagulopathy, diabetes mellitus, peripheral neuropathy, central nervous system disorders, preexisting neurologic deficits, and spinal abnormalities.

Perhaps the most dreaded complication is the development of spinal epidural hematoma (SEH), which has the highest incidence with indwelling catheters, occurring at an estimated rate of 1:150,000. In patients at increased risk of thrombosis, the delayed or temporary interruption in anticoagulation therapy as a result of the indwelling epidural catheter can lead to increased morbidity and mortality. Although guidelines for anticoagulation during epidural analgesia exist, the fine balance between the risk of SEH and the risk of thrombosis make epidural analgesia in high-risk patients a clinical challenge.

**Spinal Anesthesia**

Intrathecal or spinal administration of drugs is common in orthopedic surgery. Spinal anesthesia provides good operating conditions and blood pressure control, thus minimizing blood loss. However, spinal anesthesia for postoperative pain control is limited by duration. Even when using long-acting local anesthetics like bupivacaine, spinal anesthesia wears off within 6 hours. Additives to the spinal solution can extend the duration of analgesia, but hardly beyond 12 hours. The additives to spinal anesthesia over the years are too numerous to mention. Current commonly used additives include vasoconstrictors such as epinephrine, opioids such as fentanyl and morphine, and alpha-2 agonists such as clonidine.

Opioids are the most common spinal analgesic additive and have the advantages of simplicity, reliability, and low dose requirements. Because excellent analgesia can be achieved with a low dose, patients can be alert and more cooperative with physical therapy. Although spinal opioids can prolong the analgesia, they still carry a high incidence of nausea and pruritus. More importantly with spinal administration of morphine, there is a risk of late respiratory depression, even with low doses. Morphine is the most commonly used spinal opioid in major joint surgery because its hydrophilic nature extends its duration of action compared with more lipophilic opioids such as fentanyl. Morphine has been used successfully and safely on regular hospital floors if the nurses are appropriately trained.

Spinal catheters for prolonged postoperative analgesia were at one time common but were implicated as a cause of cauda equina syndrome and have fallen out of use in the United States. For this reason, a single-shot spinal is the preferred anesthetic technique for TJA because it provides good operating conditions and reliable pain relief immediately postoperatively.

**Oral Opioids**

The use of opium for analgesia dates back to ancient times. Opioids bind to opioid receptors present on sensory-afferent neurons. At the level of the damaged tissue, opioid receptors hyperpolarize nociceptors, preventing signal transduction. At the level of the dorsal root ganglion, they mimic the action of endogenous opioids on first- and second-order neurons by preventing the release of neurotransmitters and hyperpolarizing the cell membrane, respectively. At the level of the midbrain, opioids inhibit
GABAergic synaptic transmission in the descending inhibitory pathways, thus facilitating the synaptic currents in these antinociceptive regulatory pathways.

Opioid complications and side effects have been extensively studied. They affect numerous organ functions, including digestive, nociceptive, immune, hormonal, psychomotor, urinary, cardiac, respiratory, and musculoskeletal. This results in a wide array of adverse effects, including nausea, vomiting, constipation, sedation, dizziness, respiratory depression, physical dependence, tolerance, immunosuppression, sexual dysfunction, depression, fatigue, decreased bone mineral density, sleep disturbance, urinary depression, and hypotension.

Compared with the IV route, oral opioids provide equivalent analgesia and time to mobilization in TJA patients but with fewer side effects. Oral opioids are available in immediate- and controlled-release formulations. Morphine, oxycodone, and hydromorphone are among the most commonly prescribed immediate-release opioids. Whereas immediate-release opioids tend to provide inconsistent pain relief due to delays in absorption and failure to reach constant therapeutic plasma concentrations, sustained-release preparations have more consistent bioavailability, thereby providing longer-lasting basal analgesia and minimizing the need for rescue IV narcotics. The Acute Pain Management Guideline Panel currently recommends dosing opioids at a fixed schedule for patients requiring these medications for more than 48 hours.

The efficacy and tolerability of OxyContin (Purdue Pharma LP, Stamford, Connecticut) for postoperative analgesia in elderly patients following TJA has been demonstrated in several studies. In a prospective randomized, placebo-controlled trial of patients undergoing rehabilitation for TKA, those who received OxyContin had better pain control, greater range of motion, and faster discharge compared with those receiving placebo. However, there were no differences in opioid-related side effects between the 2 groups, and the mean age of the treatment group was 65 years. In another 2-stage prospective study comparing OxyContin with PCA and epidural analgesia in TJA patients, the OxyContin group had better pain control and shorter hospital length of stay.

For elderly patients or those who do not tolerate opioids well, tramadol is an alternative. It is a synthetic analog of codeine that binds to opioid receptors and also inhibits reuptake of serotonin and norepinephrine. Tramadol is associated with a low incidence of respiratory and gastrointestinal side effects compared with opioids. However, it is a less potent analgesic and reserved for mild to moderate pain.

ACETAMINOPHEN

Acetaminophen is the most commonly used analgesic in the postoperative setting. Although its exact mechanism of action is not fully understood, acetaminophen is believed to act predominantly in the central nervous system via serotonin, opioid, eicosanoid, and nitric oxide pathways. The safety profile of acetaminophen is well established, with limited contraindications and side effects. Acetaminophen-induced hepatotoxicity is relatively rare and limited to doses exceeding 4 g daily. Although the 650-mg dose is the most commonly available in hospital formulary, the 1000-mg dose has been reported to be more effective in some patients. Since the Food and Drug Administration approval of IV acetaminophen in the United States, randomized, controlled trials have demonstrated the safety and efficacy of repeated administration of 1-g IV acetaminophen every 6 hours in adult inpatients up to 5 days postoperatively. Because the IV formulation bypasses the first-pass metabolism by the liver, its bioavailability is 100% compared with 85% to 95% with the oral route. However, the advantages of IV acetaminophen are offset by its high cost, which limits its wide use in multimodal analgesia. The daily cost of 1 g of acetaminophen given every 6 hours is $43 vs 10 cents for the IV and oral formulations, respectively. To date, there are no randomized, controlled studies directly comparing the efficacy of the IV and oral formulations. A review the national drug monograph of acetaminophen published by the US Veterans Health Administration shows that both formulations have identical pharmacokinetics with regard to metabolism, elimination, half-life, and protein binding, with the exception of bioavailability. Based on available clinical and economic evidence, oral acetaminophen continues to be an integral component of multimodal analgesia, with the IV formulation limited to patients who are unable to tolerate oral medications.

NONSTEROIDAL ANTI-INFLAMMATORY DRUGS

Nonsteroidal anti-inflammatory drugs (NSAIDs) are among the most commonly prescribed medications in the United States, with nearly 70 million prescriptions every year costing more than $7 billion. Although NSAIDs were first introduced into clinical practice in 1899, it was not until 1971 when the mechanism of action was first described by Sir John Robert Vane, a British pharmacologist whose work later earned him the Noble Prize in medicine in 1982. It is now known that NSAIDs reversibly or irreversibly inhibit cyclooxygenases (COX) 1 and 2, which convert arachidonic acid into prostaglandins and thromboxane A2. COX-1 is the primarily constitutive isozyme expressed in most tissues and is involved in renal homeostasis, platelet aggregation, and maintenance of the gastrointestinal (GI) mucosa. However, COX-2 is only constitutively expressed in the brain and kidneys. It is also induced at the site of tissue injury by cytokines and growth factors and produces the prostaglandins responsible for pain modula-
Although prostaglandins can directly activate nociceptors, they largely play a role in inflammatory pain sensitization. At the level of damaged tissue, prostaglandins sensitize first-order afferent neurons to bradykinin. At the level of the dorsal root ganglion, prostaglandins potentiate the release of excitatory glutamate and substance. Prostaglandins also relieve glycineergic inhibition of primary afferent neurons. The suppression of prostaglandin synthesis by COX inhibitors underscores the analgesic effects of these agents. COX inhibition has also been shown to potentiate opioid-mediated inhibition of GABAergic synaptic currents, a mechanism of central synergism between opioids and COX inhibitors.

The superior gastrointestinal safety profile, avoidance of inhibition of platelet function, and direct role in inflammatory pain have prompted significant interest in COX-2 inhibition. Platelets lack COX-2, and even supratherapeutic dosages of COX-2 inhibitors have been shown to not interfere with platelet function or increase the need for transfusion. Currently, celecoxib is the only available US Food and Drug Administration–approved COX-2 inhibitor in the United States. Rofecoxib and valdecoxib, previously available COX-2 inhibitors, were withdrawn following trials showing increased risk of thrombotic events evident after 18 months of treatment. This association could not be established for celecoxib. A large meta-analysis of nearly 32,000 patients showed no difference in cardiovascular events between celecoxib vs placebo or celecoxib vs NSAIDs. Another controversial topic is the deleterious effects of COX-2 inhibition on bone healing; animal and human data have been conflicting. However, with respect to implant fixation following TJA, several studies have failed to establish a deleterious effect in uncemented implants. Interestingly, data from COX-2 knockout mice revealed protective effects of COX-2 downregulation against osteolysis.

Celecoxib, which is metabolized by the liver, reaches peak serum concentration 3 hours after ingestion. While doses of 100 and 200 mg twice daily are equivalent in efficacy, some patients have better relief with the 200-mg twice-daily dose; there is no added benefit beyond this dose. The analgesic benefits of COX-2 inhibition have been demonstrated in multiple randomized, placebo-controlled, double-blind trials. In a trial of rofecoxib vs placebo initiated 24 hours prior to TKA and continued for 2 weeks, the use of rofecoxib was associated with decreased pain levels, decreased consumption of patient-controlled epidural analgesia, and lower rates of vomiting and sleep disturbance. Patients also had higher knee range of motion and greater satisfaction at discharge. Of note, there was no change in hemoglobin levels or bleeding complications between the 2 groups. In another randomized, controlled, double-blind trial of rofecoxib vs placebo initiated 1 hour prior to TKA and continued during the hospital stay, patients in the rofecoxib groups had better pain levels, less knee swelling, reduced morphine consumption, and less incidence of itching.

**PERIPHERAL NERVE BLOCKS**

Peripheral nerve blocks (PNBs) are available as either single injections or indwelling catheters. Their unilateral nature facilitates early ambulation following TJA because patients tend to initially rely on the contralateral limb. The duration of blockade depends on the local anesthetic, with long-acting agents being the most commonly used. Three techniques are available for TJA: psoas compartment block (complete lumbar plexus), fascia iliaca block (femoral, obturator, and partial lateral femoral cutaneous nerves), and femoral nerve block (femoral and partial lateral femoral cutaneous nerves). A supplemental sciatic block may be needed for TKA to block the posterior innervation of the joint capsule. However, sciatic nerve blockade may be a concern in the valgus knee because it can delay the detection of peroneal nerve palsy, a complication variably associated with preoperative valgus deformity. To date, there is no published literature substantiating this concern.

Several studies have demonstrated that continuous femoral nerve block is superior to PCA and as effective as epidural infusion in reducing pain, expediting rehabilitation, and shortening length of hospital stay. These studies have also shown that the femoral nerve block is associated with fewer opioid side effects compared with PCA. Although the incidence of nausea, vomiting, and pruritus is similar among the epidural and femoral nerve block groups, there is significant reduction in the incidence of hypotensive episodes and dysesthesias in the femoral nerve block group.

One disadvantage of continuous PNB is motor weakness, which poses a fall risk and often necessitates the use of a protective brace during ambulation. Nerve palsy has also been reported, with an incidence between 0.22% and 0.5%, although persistent neuropathy is rare. The most severe systemic complications of local anesthetic toxicity are seizure and cardiac arrest; however, the combined incidence of these complications is less than 0.03%. Today, with the emergence of lipid emulsion as a treatment for local anesthetic systemic toxicity, the use of safer local anesthetics such as ropivacaine, and the use of ultrasound to guide the injections, the incidence of PNB side effects is on the decline.

**PERIARTICULAR INJECTIONS**

The role of periarticular injections (PAI) in pain management following TJA—particularly TKA—has increasingly come into the spotlight in recent years. Different cocktails of analgesic agents have been described; all have been shown to reduce postoperative pain, improve functional recovery, and decrease length of hospitalization following TKA. All injections contained a long-acting local anesthetic, and often included a corticosteroid and hyaluronic acid. Some have incorporated local anesthetic and corticosteroid into a gelatin sponge, a solution of local anesthetic and corticosteroid mixed with hyaluronic acid, or a long-acting local anesthetic alone. Despite the variety of formulations, the clinical outcomes of these injections have not been uniformly consistent. Further research is needed to identify the optimal formulation, concentration, and dosage of periarticular injections for TKA.
anesthetic (ropivacaine or bupivacaine) and most contained epinephrine, a steroid (betamethasone or methylprednisolone), and morphine. The most common sites of injection were the posterior capsule, collateral ligaments, quadriceps tendon, subcutaneous tissue, and arthroscopy periosteal edges. This periauricular infiltration cocktail containing multiple synergistic agents injected throughout the traumatized knee likely explains the absence of analgesic benefits of ropivacaine-only injection into only the posterior capsule as demonstrated in a randomized, placebo-controlled, double-blind trial. The addition of a steroid to a local anesthetic not only suppresses local inflammatory mediators, but also prolongs the duration and efficacy of the local anesthetic. The benefits of PAI continue to evolve. A recent prospective study comparing PAI with a combined epidural/femoral nerve blockade showed similar outcomes with respect to readiness for discharge, pain at rest, and pain with daytime ambulation. Therefore, PAI can be used as part of a multimodal approach, particularly when regional analgesia with PNB cannot be performed.

CRYOTHERAPY

The benefits of cryotherapy following TJA are conflicting. Whereas some studies showed improved pain levels, reduced blood loss, and increased range of motion, other studies showed no differences in these parameters. A recent meta-analysis found that the potential benefits of cryotherapy may not be clinically significant to justify its use. As a result, the routine use of cryotherapy is not supported at this time, but it can be still considered as part of multimodal analgesia if it can be provided without excessive cost.

OTHER ADJUVANTS

Steroids and pregabalin have also been used as part of multimodal analgesia. Dexamethasone, a long-acting glucocorticoid widely used for prevention of postoperative nausea and vomiting, has been shown to reduce postoperative pain and opioid consumption at doses above 0.1 mg/kg, especially when given preemptively. In another study, the intraoperative administration of a single 40-mg dexamethasone dose in patients undergoing THA was associated with reduction of pain during physical therapy at 24 hours, but no benefits were noted for morphine consumption, opioid side effects, or pain at rest at any time period.

Recently, randomized, placebo-controlled trials have shown that the use of high-dose preoperative methylprednisolone was associated with significantly lower pain up to 32 hours postoperatively, decreased rescue oxycodone consumption in the first 24 hours, and decreased fatigue throughout the day of surgery, although at the expense of poor sleep quality on the first night. No side effects or complications, including wound infections, were reported in these studies. The use of dexamethasone as part of a multimodal analgesia approach is thus promising and continues to evolve.

Pregabalin, a structural analogue of the neurotransmitter GABA, is a centrally acting agent that inhibits excitatory neurotransmitter release at the level of the dorsal root ganglion. In a randomized, placebo-controlled, double-blind trial of 300 mg of pregabalin administered before TKA and tapered off over 14 days, those in the treatment group consumed less opioids and had better range of motion. However, the study showed a higher incidence of sedation and confusion in the pregabalin group. In another randomized, placebo-controlled, double-blind trial of THA, the use of pregabalin was associated with an increased incidence of sedation despite its significant morphine-sparing effect. Of interest, this study also showed that the combination of pregabalin and dexamethasone provided no additional benefits in the reduction of pain or opioid consumption. A recent meta-analysis of pregabalin in acute postoperative pain confirmed the opioid-sparing effect of pregabalin but failed to show any differences in pain intensity or incidence of opioid-related side effects.

Finally, there is emerging data on the efficacy of liposome bupivacaine (Exparel; Pacira Pharmaceuticals, Inc, Parsippany, New Jersey), a novel, longer-lasting bupivacaine formulation, for post-TKA analgesia. An ultra-long-lasting analgesia achieved by infiltration of a local anesthetic at the traumatized joint is highly appealing.

PREEMPTIVE ANALGESIA

First described by Wall in 1988, preemptive analgesia aims to prevent pain before it starts. This inhibits the transmission of the noxious signal to the central nervous system and limits pain sensitization. The optimal timing of the preemptive analgesia has not been defined, although it has ranged from 1 to 24 hours preoperatively. The essential point is that patients should receive the first dose of the analgesic agent prior the incision, allowing time for the agent to be actively bioavailable. Because most the agents described in this article are quick acting, preemptive analgesia could commence either in the preoperative holding unit or the day before surgery when one considers developing a multimodal pain management protocol.

PATIENT EDUCATION AND MULTIDISCIPLINARY COLLABORATION

Preoperative patient education, including frank discussion about expectations, is an important component of successful surgical outcomes in general and in analgesia in particular. Pain relief is not only one of the most important expectations in patients undergoing TJA, it is also highly correlated with patient satisfaction. A recent prospective study of patients undergoing TJA found that 76% had expectations of complete pain relief. Preoperative discussions should emphasize patients’ proactive role in their pain man-
Feature Article

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TKA: Continuous femoral catheter and single-shot sciatic block

THA: Fascia iliaca block

Abbreviations: IV, intravenous; THA, total hip arthroplasty; TKA, total knee arthroplasty.

*Adjusted based on the total daily requirement of short-acting opioid. Use with caution in elderly patients.*

Figure: Key elements of the pain pathway highlighting the pharmacological rationale of the multimodal approach. Note the different but complementary sites of action, producing the desired synergistic analgesic effects. Abbreviations: DRG, dorsal root ganglion; NSAIDs, nonsteroidal anti-inflammatory drugs.

Modern pain management (calling for pain medication prior to physical therapy or at the early stage of pain, understanding the importance and the synergistic benefits of nonnarcotic medications, asking questions about their pain management and hospital stay, and so on). Information on in-hospital rehabilitation has been shown to decrease length of hospital stay, pain medication use, and anxiety, although a Cochrane review has failed to establish such benefits.

Education should not stop at the patient level but should also include providers who are directly involved in patient care, namely residents, therapists, and nursing staff. A recent needs assessment of pain management for orthopedic patients identified a lack of formal pain management training among residents and nurses, despite being at the front line of patient care. Another equally important concern identified by the same needs assessment study was the need for a consistent and coordinated approach to pain management. Variable preferences among attending physicians can create confusion among members of the health care team and result in suboptimal pain control. A logical solution to this problem is maintaining open communication, a critical aspect that is all too often left out in discussions of multimodal analgesia. A clear communication of the anesthetic/analgesic plan between the surgeon and the anesthesiologist should take place prior to surgery, followed by a clear communication of the analgesic protocol with those directly involved in pain management on a daily basis. This would help eliminate confusion and provide a timely response to pain needs. The effect of com-
munication on patient satisfaction and adherence to treatment has been widely reported.103

**PROPOSED ANALGESIC PROTOCOL**

Multimodal analgesia starts in the pre-operative clinic visit where the surgeon inquires about and discusses the patient’s expectations and fears. The planned analgesic regimen, including its benefits and limitations, together with expected in-hospital rehabilitation goals should be discussed. On the day of surgery, the patient would receive a combination of 200 mg of celecoxib, 1000 mg of acetaminophen, and 10 mg of oral OxyContin in the pre-operative holding unit. A PNB is also performed at that time. For TKA, perform a continuous femoral catheter and a single-shot sciatic nerve block. For TKA, a fascia iliaca block is the technique of choice. In the operating room, a combined spinal anaesthesia and IV sedation is the preferred anesthetic technique. If either a PNB or spinal anaesthesia cannot be performed (eg, lack of expertise, degenerative spinal changes, obesity), perform a periarticular injection, to include a long-acting local anesthetic, a steroid, epinephrine, and an opioid. The injected cocktail should infiltrate the traumatized tissue, including the posterior capsule, collateral ligaments, quadriceps tendon, subcutaneous tissue, and arthroscopy periostial edges.

Postoperatively, the patient should continue to receive 1000 mg of acetaminophen every 6 hours, 200 mg of oral celecoxib every 12 hours, and 10 mg of oral OxyContin every 12 hours. In addition, there should be a standing order for a short-acting oral opioid on an as-needed basis, with the first dose to be administered in the post-anesthesia care unit. The authors prefer opioids with no added acetaminophen to avoid exceeding the daily-recommended acetaminophen dose. The use of immediate-release oxycodone may simplify the calculation of any adjustments needed to the long-acting formulation (OxyContin) based on total daily consumption of as-needed oxycodone. A standing order for a rescue IV opioid is also recommended in the first 24 hours, and its use should be factored in when making adjustments to the OxyContin dose. The use of nonpharmacological analgesic adjuvants, such as cryotherapy, should be weighted against cost and inconveniences.

Finally, it is of paramount importance to start laxatives and antiemetic agents immediately postoperatively, especially for opioid-naïve patients. The Table provides a summary of the protocol. The Figure illustrates the pharmacologic basis of this multimodal approach. Communication of this protocol to members of the health care team directly involved in patient care, together with a formal teaching, is key to success.

**CONCLUSION**

Adequate pain control is a crucial goal of TJA care. There is mounting evidence that multimodal analgesia provides superior pain relief while speeding up functional recovery, minimizing the adverse effects of traditional opioid-based analgesia, increasing patient satisfaction, and reducing length of hospital stay. The wide variability among the multimodal analgesia approaches published to date begs the need for a standardized protocol that will serve as a foundation for clinical efficacy and design of future studies. The proposed postoperative pain management protocol is one step toward standardizing this critical aspect of TJA care.

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