Perioperative Pain Control: A Strategy for Management

Mitchell Jay Cohen, MD, William P. Schecter, MD, FACS*

University of California, San Francisco, San Francisco General Hospital, 1001 Potrero Avenue, San Francisco, CA 94110, USA

A thorough understanding of the anatomy and neurophysiology of the pain response is necessary for the effective treatment of perioperative pain. Pain begins with stimulation of specialized nerve endings called nociceptors. Nociceptors exist throughout the body and serve as the proximal end of the sensory nerves. Most prevalent in highly sensate areas, such as the fingertips, extremities, and face, these receptors are most often stimulated directly by injury and surgical incision. In addition to responding to direct stimulation, these receptors also respond to mediators released during surgical trauma, inflammation and stress, leading to impulse formation and pain [1–4]. These mediators, which include prostaglandins, bradykinins, histamine, and serotonin, act by two mechanisms to cause pain [1,5,6]. First, they act on nerve endings to cause pain impulse formation. Second, they amplify other pain signals caused by direct stimulation. These mediators have also been implicated in prolonged up-regulation of nociceptors, which leads to chronic pain, phantom pain, and hypersensitization [1,4].

Nociceptor stimulation causes depolarization of the nerve, creating an all-or-nothing response. The nerve impulse travels from the periphery to the dorsal horn of the spinal cord via Lissauer’s tract. Myelinated A-δ nerve fibers conduct nerve impulses rapidly. Relatively slow conduction takes place in unmyelinated C fibers in the viscera, which join autonomic nerves as they travel to join somatic nerves entering the central nervous system. This union of visceral and somatic nerves is responsible for the phenomena of referred pain. Because the visceral nerves enter the cord at the level of the somatic nerves with which they travel, the pain is perceived to be originating from the area innervated by the somatic nerves.

* Corresponding author. 1001 Potrero Avenue, Ward 3A33, San Francisco, CA 94110. E-mail address: bschecter@sfgsurg.ucsf.edu (W.P. Schecter).
The sensory fiber nerves enter the dorsal horn. Pain and temperature fibers cross the midline and ascend to the brain in the lateral spinothalamic tract. Substance P is the primary neurotransmitter at the synapse between the afferent peripheral and ascending spinothalamic tract nerves. Interestingly, substance P has also been well described as a primary mediator in the neuroinflammatory cascade providing a connection between inflammation and chronic pain. The ascending fibers in the spinothalamic tract terminate primarily in the brain stem and thalamus, which then relay the information to the perceptive cerebral cortex. Signal transmission to and within the cerebral cortex causes perception and localization of pain. Other signals are sent to the limbic system, further processed in the emotional centers, and are thereby responsible for the emotional response to pain.

**Inflammation and pain**

Inflammation is itself painful. Often this simple fact is not recognized and patients are undertreated. Inflammation causes pain through the up-regulation of stimulated nociceptors and the recruitment of nonstimulated or dormant receptors [1,3,4]. Proinflammatory mediators, including TNF-α, IL-1, IL-6, and the interferons, decrease the threshold for impulse generation, and raise the intensity of the nociceptive impulse. Additionally, the basal rate of discharge of peripheral nociceptors increases in a proinflammatory state [7]. These mechanisms make pain control in the patient with inflammatory conditions both complicated and difficult. These mediators explain why the pro-inflammatory state is itself painful. Patients with inflammation generally require analgesia at levels equal to or greater than levels required by patients with more direct and obvious sources of pain [7].

Inflammation can generate pain, but pain in turn also generates inflammation. As described above, nociceptor stimulation and the resultant generation of the nerve impulse take place in an all-or-nothing fashion. Several factors modulate pain intensity. These factors include the number of receptors stimulated, the duration of stimulation, and how efficiently the central nervous system processes the impulses. When the pain response is sufficiently intense or prolonged, the pain impulse is further amplified by neurogenic inflammation [6]. Neurogenic inflammation is mediated by the release of substance P, which is also the primary central neurotransmitter at the presynaptic nerve ending. During intense or prolonged pain, substance P acts peripherally to induce inflammation, vascular permeability, and other tissue injury, causing both nociceptor stimulation and amplification of nerve impulses [5].

Pain and subsequent neurogenic inflammation have the same physiologic effects as direct tissue injury or surgical stress. These effects include elevation of the heart rate, higher blood pressure, increased O₂ consumption, myocardial ischemia, lung injury, and release of adrenocorticotropic hormone (ACTH), antidiuretic hormone (ADH), cortisol and proinflammatory
mediators, including IL-1, Il-6 and TNF-α [6,8,9]. Intense pain leads to changes that can reorganize the dorsal horn ultra structure. Dorsal horn changes result in new feedback loops, causing central sensitization and precipitating the onset of chronic pain [5,7].

Along with the inflammatory and structural changes, which are responsible for sensitization and chronic pain, a change in gene expression takes place with intense painful stimuli. Previous pain and ongoing chronic pain modulate the pain experienced with each new painful stimulus. Painful stimuli have been shown in animal studies to produce gene expression changes that precipitate changes in pain perception and impulse formation in as little as 1 hour [5]. Posttranslational modification causes inflammatory amplification of painful stimuli and pain perception. Preemptive analgesia and balanced analgesia become especially important in patients who have been previously sensitized [5,6,10,11].

Certain receptors may be especially important for the transformation from acute to chronic pain. N-nitrosodimethylamine (NDMA) is the primary receptor involved in chronic pain and sensitization, but substance P and protein kinase C have been implicated as well [12,13]. Acute pain leads to sensitization of these receptors, decreasing the threshold for future impulse as well as increasing the baseline impulse level in much the same manner as described above for neurogenic inflammation [5].

**Descending modulation of pain**

Descending pain fibers from the cerebral cortex and midbrain modulate the afferent nerve stimuli that transmit nociceptive impulses to the central nervous system. Other molecular neurotransmitters, including enkephalin, noradrenaline, serotonin, and gamma aminobutyric acid (GABA), also modulate and inhibit the frequency and degree of nociceptive impulses, thereby attenuating the pain response [11]. These substances, including the endogenous opioids and endorphins, are released from the central nervous system, bind to opioid receptors, and prevent presynaptic release of neurotransmitters, including substance P, thereby inhibiting the perception and response to painful stimuli [11].

**Nerve anatomy**

Peripheral nerves are made of millions of axons bundled into fascicles. At the end of each of these nerves are the nociceptors. Multiple fascicles are then bundled into nerves. This bundling is brought about by the Schwann cell, which is also responsible for myelination.

Myelin provides some structure for the nerve and increases the speed of conduction of the nerve impulse. A protective sheath, called the endoneurium, surrounds each axon. Each fascicle is in turn surrounded and protected by the perineurium and each nerve by epineurium. Each of these
layers serves to protect the nerve from trauma and allows the nerve to flex and move without injury. Pharmacologically, the layers are important because they inhibit the penetration, slow the diffusion, and prolong the duration of local anesthetic.

At the cellular level, each nerve cell membrane is made of a phospholipid bilayer, which separates the nerve into hydrophobic and hydrophilic domains. Bridging these domains are transmembrane channels, including the sodium channels necessary for depolarization and conduction. In the nerve cell, the principle extracellular cation is sodium, while potassium is the principle intracellular cation. Active transport of sodium and potassium maintains a transmembrane gradient of −70 to −90 mV thereby creating a polarized, charged electrical potential for nerve signaling.

Peripheral nerves are further classified into myelinated and unmyelinated fibers. Myelin is a lipid-based substance made by Schwann cells. It is found on larger sensory and motor nerves. Myelin serves to increase the speed of impulse conduction by salutary conduction. In unmyelinated nerve fibers, conduction proceeds by sequential opening of closely spaced sodium channels. In all myelinated nerves, however, transmembrane sodium channels are found only intermittently along the nerve axon at specialized nodes called the nodes of Ranvier. In a myelinated axon, transmembrane sodium channels are widely spaced at the nodes of Ranvier, allowing electric potential to “jump” from node to node, thereby increasing the velocity of impulse conduction.

**Pharmacology of nonopioid analgesia**

Nonopioid analgesics can be separated into two categories: nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen. Acetaminophen has long been the gold standard for mild to moderate pain control and is often used for its antipyretic effects. It has an excellent safety profile at standard dosing of 325 to 1000 mg every 4 to 6 hours. Unlike most opioids, dose escalation does not provide greater drug effect. Acetaminophen’s only major side effect is hepatotoxicity. Although hepatotoxicity has been reported at the recommended dose of 325 to 1000 mg every 6 hours, hepatotoxicity at doses less than 4 g over 24 hours is unlikely [10].

Acetaminophen is a metabolic product of phenacetin, an analgesic that has a significant risk of nephrotoxicity and, as a result, is no longer available for prescription. Prolonged use of large doses of acetaminophen is associated with an increased risk of renal insufficiency, although this event is considered unlikely at normal doses. Unlike many NSAIDs, acetaminophen is not associated with platelet dysfunction and, as a result, does not increase bleeding risk [10,14].

Making up the class of NSAIDs are the salicylates, proprionic acids, acetic acids, oxylates, and fenamates, all of which act through the blockage of cyclooxygenase (COX). COX is an enzyme that converts arachidonic acid to
prostaglandin, which is necessary for neurosensitization to painful stimuli and subsequent hyperalgesia. Cellular injury leads to release of phospholipids, which are an important component of the cell membrane. Phospholipids are then metabolized to arachidonic acid in the presence of the enzyme phospholipase. Arachidonic acid is metabolized in the presence of COX, resulting in the formation of prostaglandin. Prostaglandins are molecular signals that stimulate nociceptive nerve impulse transmission from the site of injury. By blocking prostaglandin synthesis, NSAIDs block transduction of the physical stimulus to the nociceptors [3,10,14].

The alternative pathway for COX metabolism is the production of leukotrienes. Inhibition of COX can theoretically increase leukotriene production, accounting for rare asthmatic and anaphylactic reactions to NSAIDs [14].

COX exists in two isoforms, which have markedly different physiologic effects. COX-1 influences platelet function, gastric mucosal protection, and hemostasis, while the COX-2 isozyme affects the inflammatory cascade and pain [14]. Aspirin and most of the NSAIDs are nonselective and block both isoforms, resulting in analgesia along with varying degrees of side effects, including injury to the gastric mucosal barrier, coagulopathy, and platelet dysfunction [15,16]. The inhibition of prostaglandin synthesis is the prime cause of the side effects of COX inhibitors. Prostaglandins influence the creation and maintenance of the gastric mucosal barrier and NSAIDs have long been implicated in the destruction of this barrier and subsequent ulceration. NSAIDs also act directly on the gastric mucosa, causing direct mucosal injury and ulceration [5,10,14]. Although the risk of bleeding from NSAID use is small, the risk increases with older patients, higher drug dosages, and longer periods of therapy.

COX-1 is present in the stomach, intestines, kidneys, and platelets, and helps produce prostaglandins, which have a role in regulating gastrointestinal function and platelet aggregation. COX-2 is produced during inflammatory states and serves as an enzyme for production of prostaglandins that mediate inflammation pain and fever. Theoretically, a drug that inhibits only COX-2 would, as a result, be primarily anti-inflammatory, without incurring the adverse risks of gastrointestinal ulceration and bleeding [16].

Despite great hope that the selective COX-2 inhibitors would provide analgesia without gastrointestinal side effects, little evidence supports that claim. Additionally, recent evidence shows the COX-2 inhibitors to be associated with adverse cardiovascular events, including myocardial infarction and cerebrovascular accident (CVA). A study testing the efficacy of rofecoxib in preventing colonic polyps showed that patients treated with rofecoxib had a higher rate of cardiovascular events. As a result of this data, Merck withdrew rofecoxib from the market in September 2004. Similarly, a National Institutes of Health trial examining celecoxib was ended because of the unexpected finding of cardiovascular toxicity. At the time of this writing, celecoxib and valdecoxib have also been withdrawn [17–23].
NSAIDs alone are useful for mild to moderate pain. For perioperative pain they are useful adjuncts to opioids and local anesthetics [10,24]. NSAIDs can reduce perioperative opioid dose requirements by up to 50% [25]. NSAIDs help modulate and treat the inflammatory milieu and attenuating the pain caused and heightened by inflammation. NSAIDs are most often given orally. Ketorolac is a nonselective COX inhibitor that can be given intramuscularly or intravenously in the perioperative period [14,26,27].

**Pharmacology of opioid analgesia**

Because of its potency, opioid analgesia is the gold standard for perioperative pain control. Opioid receptors exist in the periphery, spinal cord, and central nervous system. Recently, opioid receptors have also been identified on inflammatory and immunologic cells. Opioids act by binding to presynaptic receptors and preventing the release of substance P at the presynaptic vesicle, thereby preventing impulse transmission. The three opioid receptors are μ, κ, and δ. Each receptor is in a different location and produces different effects. The μ receptor is responsible for spinal and supraspinal analgesia and also mediates undesirable opioid side effects, such as respiratory depression, bowel dysmotility, urinary retention, and pruritus. The κ receptor also provides spinal and supraspinal analgesia while mediating miosis, sedation, and dysphasia. The δ receptor mediates spinal and supraspinal analgesia.

While some opioid receptors exist in the periphery, most are located centrally. To function, the opioids must cross the blood-brain barrier. The opioids have differing partition coefficients and lipid solubilities, which determine distribution, onset, and duration of action. Opioids with greater lipid solubility have a faster onset of action because of their rapid distribution and ability to cross the blood-brain barrier. Fentanyl is an example of a lipid-soluble drug with a high potency and a rapid onset of action.

Unlike acetaminophen and the NSAIDs, opiates do not have a ceiling effect and escalating doses will stop pain once enough drug is given. Often, as doses escalate, respiratory depression and other less serious side effects make it imprudent to further escalate doses [28]. Careful monitoring of opioid administration in the opioid naïve and elderly patient is essential.

Opioids are divided into two categories. In one category are the μ agonists, which include morphine, hydromorphone, fentanyl, oxycodone, codeine, methadone, and meperidine. In the other category are the agonist/antagonists. The agonist/antagonists are further divided into the mixed agonist/antagonists, because they bind at both the μ and κ receptors, and partial agonists, so called because of their limited efficacy.

Morphine is the model opioid to which all others are compared. Intravenous morphine is most commonly used in the perioperative period, although it is also available for oral, rectal, intrathecal, and epidural use. Subcutaneous or intramuscular morphine administration is an option but inconsistent
uptake and distribution of the drug from these sites make intravenous use a better choice in the perioperative period. Intravenous morphine has an onset of action at approximately 5 minutes, a peak effect within 20 minutes, and duration of action of 3 to 4 hours. Unfortunately, morphine has a relatively high incidence of associated nausea and vomiting, which can delay discharge from the recovery room or same-day surgery unit [10,29].

Fentanyl is a highly potent lipophilic drug with an onset of action of approximately 30 seconds after intravenous administration and a short duration of action because of rapid redistribution from fat stores. The short duration of action of fentanyl is ideally suited to outpatient surgery and makes for easy rapid titration in the inpatient setting. Fentanyl remains an ideal drug for drip titration in the ICU. In addition to offering the benefits of rapid titration, fentanyl has a lower incidence of nausea and vomiting compared with morphine, making fentanyl a better choice for analgesia in outpatient surgery.

Meperidine is another opiate available for perioperative use. Meperidine has a similar time-to-onset but only one tenth the potency of morphine. In addition, it has atropine-like side effects, including tachycardia and ampullary dilatation. Meperidine has a toxic metabolite (normeperidine), which is excreted in the urine. Normeperidine causes anxiety, tremor, and seizures. While meperidine should be avoided in patients with renal insufficiency, the drug is effective in the treatment of postoperative shivering when given in small doses.

Oxycodone and hydrocodone are opiates available orally and often used in conjunction with acetaminophen. These drugs are effective for mild to moderate pain and the dose can be increased if the pain is more severe. Oxycodone is also available in sustained release form, which can provide analgesia for up to 12 hours.

Codeine is a weak opioid that is also often combined with acetaminophen. The maximum recommended analgesic dose of codeine is 60 mg every 6 hours. Codeine is not very effective for severe pain but can be a useful adjunct to reduce other opioid requirements. Once the patient is ready to transition from the ICU to the floor or hospital to home, codeine usually provides well-tolerated analgesia [10,14].

Tramadol is a relatively new analgesic drug. Both tramadol and meperidine have a similar efficacy [30–32]. Tramadol works through two mechanisms. First, as a weak opioid agonist, the drug acts on μ receptors [30–32]. Second, tramadol inhibits monoamine neurotransmitter re-uptake, which weakly hinders norepinephrine and serotonin re-uptake in a manner similar to an antidepressant. Tramadol has two enantiomers, which lead to better efficacy. Safety and efficacy are similar to other opioids and meperidine. Tramadol may be given in doses of 50 to 100 mg orally every 4 to 6 hours in adult patients. Concomitant use of antiemetics may be necessary in outpatient surgery when tramadol is used because of the increased risk of nausea and vomiting [33].
Over the past 5 years, ketamine has seen increasing use as an analgesic/sedative drug outside the operating room. Ketamine owes its increased use to its opioid-sparing effect. Ketamine works through NDMA modulation and has been effective in preemptive analgesia and reduction of narcotic requirements [34–36].

Pharmacology of local anesthesia

While local anesthetics vary widely in their applicability, onset, and duration, they all eliminate conduction of nociceptive impulses along the nerve axon. Local anesthetics bind to receptors in the sodium channel, blocking sodium influx, arresting depolarization, and interrupting conduction. All local anesthetics are made up of a lipophilic aromatic ring linked by either an amide or ester group to a hydrophilic amino group. This tertiary amine structure allows the anesthetic to penetrate the nerve and diffuse into its lipid-rich environment. All local anesthetics are weak bases with Pkas that range from 7.6 to 8.9 [33].

Ester-linked local anesthetics are metabolized by cholinesterase produced in the synaptic nerve endings. The anesthetics are then broken down into para-aminobenzoic acid (PABA), a common ingredient in many healthcare products, lotions, and creams. Because most patients are already sensitized to PABA, cross-reaction and allergy can take place [33].

The potency of local anesthetics depends on their lipid solubility, which is measured by the oil-water partition coefficient. The more lipid soluble an anesthetic is, the more binding takes place, resulting in increased potency. The potency additionally depends on vasodilatation and redistribution in the particular tissue bed. Potency is not based on the characteristics of the anesthetic alone but also on the distribution and washout of the drug. Duration of action is based on the degree of binding of the drug. Duration of action can be prolonged by adding epinephrine to the anesthetic, thereby causing vasoconstriction and slowing washout of the drug [33].

There are six major adverse reactions to local anesthetics: cardiac arrhythmias, hypertension, direct tissue toxicity, central nervous system toxicity, methemoglobinemia, and allergic reactions. Of all local anesthetics, bupivacaine is associated with the most serious cardiac arrhythmias. Bupivacaine depresses conduction of cardiac tissue, which can result in reentrant arrhythmias. These arrhythmias can in turn rapidly degenerate into ventricular fibrillation [37,38]. Great care must be taken to avoid intravascular injection of bupivacaine. In addition, recommended doses of bupivacaine should not be exceeded.

All local anesthetics have central nervous side effects, which include dizziness, lightheadedness, paresthesias, nervousness, and disorientation. Severe toxicity can result in seizures, coma, and even respiratory arrest. For this reason, care must be taken to avoid intravascular injection when doing a field block or nerve block. Intraneural injection can result in neurotoxicity.
All local anesthetics in high concentrations are neurotoxins. Injection of a drug into a nerve can result in nerve injury because of the needle. Finally, the direct injection of a drug into a nerve sheath can result in a compartment syndrome occurring within the epineurium, resulting in nerve injury from increased pressure.

An unusual but potentially fatal complication of local anesthesia is methemoglobinemia. Prilocaine is the drug most commonly associated with methemoglobinemia. Methemoglobinemia occurs as a result of oxidation of the iron in hemoglobin from the ferrous to the ferric form. This oxidation can take place as a result of exposure to prilocaine, resulting in increased affinity of oxygen to the hemoglobin molecule. Because of this affinity, oxygen does not dissociate from the hemoglobin molecule in peripheral tissues, thereby causing decreased oxygen delivery. Tachypnea, cyanosis and spuriously increased hemoglobin oxygen saturation are the clinical signs of methemoglobinemia. Supplemental oxygen will not increase oxygen saturation. A high index of suspicion is essential to make the diagnosis. Methemoglobinemia is easily treated by the administration of methylene blue intravenously in doses of 1 to 2 mg/kg [39]. Methylene blue reduces the ferric ion to the ferrous form, thereby allowing hemoglobin molecules to release oxygen to the peripheral tissues. Methemoglobinemia usually results when prilocaine is used as either a topical anesthetic in the oral pharynx or in the eutectic mixture local anesthetic (EMLA) cream [39,40]. Methemoglobinemia is most commonly associated with this form of prilocaine administration because of the difficulty in controlling the amount of drug administered in a spray or in a topical cream.

Assessment of pain

Assessment of pain depends on level of consciousness and degree of cooperation. In patients who are awake and able to communicate, pain and sedation are best assessed by a good history and physical examination [41]. Multiple objective scales have been developed to measure the severity and nature of pain. These scales can be further broken down into unidimensional and multidimensional scales. Unidimensional scales are the simplest and most widely used. They measure only the intensity of pain. The two most common scales are the visual analog scale (VAS) and the numeric rating scale (NRS). The VAS consists of a straight line with the words “no pain at all” written on one end and the words “the worst pain” written at the other end. Patients indicate their level of pain by placing a mark along the scale. Measurement improves when a standard 10 cm line is used. The VAS is most useful when it tracks the changing pattern of a patient’s pain, and less useful for comparing the level of pain between different patients [10].

The NRS is a numerical scale to evaluate the level of pain. The most commonly used scale is between zero and 100. Zero represents no pain and 100 represents the worst pain imaginable. With all these scales, patient
self-reporting is the most reliable indication of the existence and the intensity of pain [42].

There are a variety of multidimensional scales. However, these scales are most useful in evaluating chronic pain and have limited use in the management of perioperative pain [43–45].

Balanced perioperative analgesia

The concept of balanced analgesia implies that pain is treated with the least amount of the most specific drug necessary. Balanced analgesia treats all aspects of the pain axis, including stimulation, modulation, inflammation, and psychology with a combination of drugs and therapies each aimed at creating a synergistic pain-control regimen.

Balanced analgesia begins before the onset of stimuli with the preoperative interview. This interview is critical to the notion of balanced analgesia and effective pain control. Careful interrogation regarding baseline pain, previous painful stimuli, and treatment methods, both effective and failed, guides both the choice and application of analgesia while also comforting the patient. This preoperative interview can rate discomfort and separate pain from anxiety while providing careful assessment of the emotional lability of the patient. In the preoperative setting, a careful explanation of the details of the anesthetic and pain-control strategy combined with medication before the beginning of surgery reduces anxiety and modulates pain perception. The interview sets the stage for attenuation of pain and identifies emotionally labile individuals who may benefit from modifications in the anesthetic technique and perioperative pain-treatment regimen.

After the preoperative interview, preemptive medication also is essential to attenuate the pain response. Preoperative sedation helps to achieve a state of conscious sedation and amnesia. The sedation allows the patient to cooperate without fear or anxiety. Short-acting drugs with anxiolytic and amnestic properties, such as midazolam, can be used because they have proven benefits with limited hemodynamic effects and a good safety profile. Preoperative opiates and anxiolytics can reduce intraoperative anesthesia and postoperative analgesia requirements. Attention to preemptive pain control reduces central sensitization, hyperexcitability, and inflammation [46]. Effective preoperative analgesia with a combination of agents reduces perioperative morbidity, shortens hospital stays, and improves patient satisfaction [17,47–49].

Continuous epidural catheters are another useful adjunct to traditional pain control. They are most appropriate in orthopedic, abdominal, and thoracic procedures and in the treatment of blunt chest injury. When placed before induction of anesthesia, continuous epidural analgesia reduces intraoperative and postoperative anesthetic requirements [50–54]. In addition, epidural analgesia reduces ileus and postoperative nausea and vomiting. In appropriate circumstances, continuous epidural analgesia with
local anesthetic, opioids, or clonidine will attenuate the perioperative neuroendocrine response. Single-dose neuraxial anesthetics will reduce the incidence of postoperative pulmonary complications, myocardial infarction, and thromboembolism [51,52,54,55].

Early and continuous attention to analgesia incorporating a combination of techniques and drugs is essential. Insufficient analgesia at any point in the perioperative period, even for a short time, will predispose the patient to sensitization, inflammation, and chronic pain at levels similar to those seen with long-term untreated pain [6,56].

Pain assessment is mandatory. While assessment is relatively easy in the patient who is awake, oriented, and able to communicate, many postoperative patients are unable to accurately assess and communicate their level of pain. Careful monitoring of vital signs, levels of agitation, and other clues allows proper titration of analgesia. Patients who are in pain may show objective signs such as tachypnea, tachycardia, and sweating similar to the signs of hypovolemia. A careful assessment should allow appropriate management of both pain and volume status [5,6,27,41].

A balanced analgesia approach should continue into the postoperative period. Sedation does not provide proper analgesia and should not be used as a substitute for adequate analgesia. This rule is sometimes forgotten in the ICU where sedated patients in pain are often undertreated behind the cover of sedation. Aberrant vital signs, increased oxygen consumption, tissue injury, and a perpetuation of the pro-stress, pro-inflammatory milieu are all consequences of pain when undertreated, even if it is masked by sedation [4,11,48,54,55,57].

Opiates are the mainstay of a postoperative analgesic program. As a general rule, the intravenous route is the most accurate method of opiate administration. Whenever possible, we prefer to administer opioids using patient-controlled analgesia. This improves patient satisfaction, reduces patient anxiety, and provides more effective analgesia when compared with standard nurse-provided intravenous administration [58–62]. However, no evidence shows that postoperative cardiac pulmonary or thromboembolic complications are reduced with patient-controlled anesthesia compared with intermittent opioid administration. NSAIDs should be used with the opioids if possible. The concomitant use of NSAIDs with opioids provides moderate analgesia and has an opioid-sparing effect.

A recent development in perioperative pain control is the use of continuous regional infusions of local anesthetic. These infusions are administered through small catheters, which are placed directly into the surgical wound at the time of surgery. Small infusion pumps are filled with local anesthetic (usually bupivacaine), which is infused at a continuous rate directly into the wound site. At the end of the acute pain period the catheter is removed by the patient or in the doctor’s office.

A number of studies have shown the efficacy and safety of these new devices. One study conducted on 80 patients who underwent inguinal hernia
repair showed that use of a continuous bupivacaine pump was closely associated with reduced time in the recovery room, reduced worst-pain score on postoperative day 1, and higher patient satisfaction. No differences in pain score were seen from days 2 to 5. Additionally, there was no difference in narcotic analgesia use between the group that used the pumps and the group that did not. Another recent double-blind study of 52 patients undergoing open hernia repair showed a statistically significant decrease in VAS-scored pain and daily narcotic use for patients using the continuous bupivacaine pump. One additional study of patients undergoing median sternotomy for cardiac surgery showed a significant decrease in VAS pain score and higher patient satisfaction among pump users. This study showed no difference in patient-controlled morphine use between the group that used the pump and the group that did not [63,64]. Meanwhile, patients using the pump required less time before ambulation and experienced shorter hospital stays than patients not equipped with the pump [65]. None of the studies reported catheter related complications. The use of direct-wound anesthetic infusion seems to provide a useful adjunct to opioid and nonopioid analgesia in the postoperative setting.

The most recent Practice Guidelines for Acute Pain Management in the Perioperative Setting were published in 2004 and provide additional evidence-based recommendations from the American Society of Anesthesiologists Task Force on Acute Pain Management [66]. The US Department of Veterans Affairs offers Clinical Practice Guidelines for the Management of Postoperative Pain [67]. These guidelines include useful and practical treatment algorithms.

Summary

Balanced analgesia employs different drugs in a complementary fashion to target different points in the afferent and efferent pain pathway. Effective perioperative analgesia is an important responsibility of the surgical team, which includes the surgeon, anesthesiologist, nursing staff, patient, and the family. Careful attention to perioperative analgesia improves the patient experience, resulting in a higher quality of care.

References


