

# The Role of Non-Opioid Analgesic Techniques in the Management of Pain After Ambulatory Surgery

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In describing how patients feel after surgery, Armitage (1) stated that “slapping the patient on the face and telling him or her that it’s all over is a complete inversion of the truth” because as far as the patient is concerned, “it is often just the beginning.” Although the current armamentarium of analgesic drugs and techniques is impressive, effective management of postoperative pain still poses some unique challenges in the ambulatory setting. The increasing number and complexity of operations being performed on an outpatient basis has presented anesthesia practitioners with new challenges with respect to acute pain management. Outpatients undergoing day-care procedures require a perioperative analgesic technique that is effective, has minimal side effects, is intrinsically safe, and can be easily managed away from the hospital or surgery center.

The adequacy of postoperative pain control is one of the most important factors in determining when a patient can be safely discharged from the outpatient facility (2). Because inadequately treated pain is a major cause of prolonged stays or unanticipated hospital admissions after ambulatory surgery, the ability to provide effective pain relief by simple methods that are readily available to an outpatient in his or her home environment will be one of the major challenges for providers of ambulatory anesthesia in the future (3). Unfortunately, there are very few well controlled studies that have carefully examined the optimal approaches to managing postdischarge pain after outpatient surgery.

Perioperative analgesia has traditionally been provided by opioid analgesics. However, the use of large doses of opioids during ambulatory surgery can be associated with an increased incidence of postoperative complications (e.g., ventilatory depression, sedation, postoperative nausea and vomiting, pruritus, difficulty voiding, and ileus), which in turn contribute to

a delayed discharge from the day-surgery facility or to unanticipated hospital admissions. The intraoperative use of large bolus doses or continuous infusions of potent short-acting opioid analgesics (e.g., alfentanil and remifentanil) may actually increase postoperative pain as a result of their rapid elimination and the development of acute tolerance (4). Therefore, anesthesiologists practicing in the ambulatory environment are increasingly using non-opioid analgesics as adjuvants during the perioperative period (Table 1).

To minimize the adverse effects of analgesic medications, “balanced” analgesic techniques involving the use of smaller doses of opioids in combination with non-opioid analgesic drugs (e.g., local anesthetics and nonsteroidal antiinflammatory drugs [NSAIDs]) are becoming increasingly popular approaches during and after ambulatory surgery (5,6). The rationale for the perioperative use of non-opioid analgesic drugs and techniques in the ambulatory setting will be reviewed in this article.

## Local Anesthetic Techniques

Peripheral nerve blocks and wound infiltration with local anesthetics are commonly used adjuvants to both monitored anesthesia care (MAC) and general anesthetic techniques because they can provide intra- and postoperative analgesia (Table 2). As a result, these techniques can decrease the anesthetic and analgesic requirements during surgery and reduce the need for opioid analgesics in the postoperative period. More effective pain relief in the early postoperative period from the residual sensory block provided by local anesthesia can facilitate the recovery process, enabling earlier ambulation and discharge home (i.e., fast-tracking). The use of local anesthetic techniques also decreases the incidence of postoperative nausea and vomiting and thereby decreases the incidence of prolonged recovery stays and unanticipated hospital admissions related to intractable emetic symptoms.

Although additional clinical studies are needed to identify the most cost-effective anesthetic techniques for ambulatory surgery, it would seem that peripheral

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**Table 1.** Commonly Used Non-Opioid Drugs and Nonpharmacologic Techniques for Minimizing Pain After Ambulatory Surgery

Local anesthetics
Lidocaine 0.5%–2% SC/IV
Bupivacaine 0.125%–0.5% SC
Ropivacaine 0.125%–0.5% SC
Levobupivacaine 0.125%–0.5% SC
Nonsteroidal antiinflammatory drugs
Ketorolac 15–30 mg PO/IM/IV
Diclofenac 50–100 mg PO/IM/IV
Ibuprofen 300–800 mg PO
Indomethacin 25–50 mg PO/PR/IM
Naproxen 250–500 mg PO
Celecoxib 100–200 mg PO
Rofecoxib 25–50 mg PO
Miscellaneous analgesic compounds
Acetaminophen 0.5–2 g PO/PR
Propacetamol 0.5–2 g IV
Ketamine 10–20 mg PO, IM/IV
Clonidine 0.15–0.3 mg PO, IM/IV
Non-pharmacologic therapies
Transcutaneous electrical nerve stimulation
Transcutaneous acupoint electrical stimulation
Acupuncture-like transcutaneous electrical nerve stimulation

PO = oral; PR = per rectum; SC = subcutaneous/tissue.

nerve blocks with sedation (i.e., MAC techniques) offer significant advantages over central neuraxis blockade and general anesthesia in the ambulatory setting (7–9). In outpatients undergoing saphenous vein-stripping surgery, use of a femoral/genitofemoral nerve block significantly improved patient satisfaction with the anesthetic experience (7). Blockade of the ilioinguinal and iliohypogastric nerves can significantly decrease the anesthetic and analgesic requirements in both children and adults undergoing inguinal herniorrhaphy, providing 6–8 h of postoperative analgesia (10,11). Similarly, subcutaneous ring block of the penis provides effective perioperative analgesia for circumcision procedures (12). Local anesthetic infiltration of the mesosalpinx significantly decreases the pain and cramping after laparoscopic tubal ligation procedures (13). Pain after arthroscopic shoulder surgery was decreased significantly by a simple suprascapular nerve block (14), and pain after knee surgery was minimized with a femoral nerve block (15). However, more complete perioperative analgesia for shoulder and knee surgery requires the use of an interscalene brachial plexus block (16) and combined femoral, obturator, lateral femoral cutaneous, and sciatic nerve (17) blocks, respectively. Although additional preparation time may be required when these major peripheral nerve blocks are performed before surgery, these block techniques can offer advantages in the postoperative period compared with general or spinal anesthesia (16,17).

**Table 2.** Commonly Used Techniques for Administering Local Anesthesia During Ambulatory Surgery

Peripheral nerve blocks
Ilioinguinal/hypogastric (e.g., herniorrhaphy)
Paracervical (e.g., dilation/curettage, cone biopsy)
Penile (e.g., circumcision)
Peroneal/femoral/saphenous/tibial/sural (e.g., podiatric)
Femoral/obturator/lateral femoral cutaneous/sciatic (e.g., leg)
Brachial plexus/axillary/ulnar/median/radial (e.g., arm or hand)
Peribulbar/retrobulbar (e.g., ophthalmologic procedures)
Mandibular/maxillary (e.g., oral surgery)
IV regional (Bier block) (e.g., arms, legs)
Tissue infiltration and wound instillation
Cosmetic and wound procedures (e.g., blepharoplasty, nasal, septum, endosinus)
Excision of masses and biopsies (e.g., breast, axilla, lipomas)
Field blocks or “splash” technique (e.g., hernia repair, vasovasotomy)
Laparoscopic procedures (e.g., cholecystectomy, tubal ligation)
Arthroscopic procedures (e.g., knees, shoulders)
Topical analgesia
Eutectic mixture of local anesthetics (e.g., skin lesions)
Lidocaine spray (e.g., bronchoscopy, endoscopy, hernia repair)
Lidocaine gel or cream (e.g., circumcision or urologic or oral surgery)
Cocaine paste (e.g., nasal or endosinus surgery)

It has been suggested that performing neural blockade with local anesthetics before the surgical incision may prevent the nociceptive input from altering the excitability of the central nervous system (e.g., preemptively blocking the *N*-methyl-*D*-aspartate-induced “wind up” phenomena and release of inflammatory mediators) (18). The concept of preemptive analgesia (or treating postoperative pain by preventing the establishment of central sensitization) seems very logical (18); however, its clinical relevance has been questioned. Only one well controlled study has demonstrated any benefits of pre-versus postincisional local anesthetic administration in the ambulatory setting (19). A recent qualitative and quantitative review by Møiniche et al. (20) suggested that evidence is still lacking that the timing of single-dose or continuous postoperative pain treatment is important in the management of postsurgical pain. These investigators concluded that there is no convincing evidence that preemptive treatment with centrally or peripherally administered local anesthetics, NSAIDs, opioid analgesics, or ketamine offers any advantage with respect to postoperative pain relief compared with a similar postsurgical analgesic regimen. Nevertheless, preincisional administration offers advantages over infiltration at the end of surgery with respect to intraoperative analgesia.

Preincisional infiltration with local anesthetics in combination with general anesthesia is clearly superior to general (or spinal) anesthesia alone in relieving postoperative pain (21,22). In fact, preincisional infiltration of the tonsillar bed with bupivacaine decreased both constant pain and pain on swallowing for up to 5 days after tonsillectomy procedures in children (22). Preincisional ilioinguinal hypogastric nerve block not only improves intraoperative pain control during inguinal hernia repair, but also reduces the need for oral opioid-containing analgesics after discharge (23). Although preincisional infiltration of the operative site with local anesthetics remains a popular technique for reducing the perioperative opioid analgesic requirement, other more simplified local anesthetic delivery systems (e.g., topical applications) have also been described in the anesthesia literature (24,25). Topical analgesia with lidocaine aerosol was found to be highly effective in decreasing pain, as well as the opioid analgesic requirement, after inguinal herniorrhaphy in adults (24), and instillation of 0.25% bupivacaine before surgical closure provided comparable postoperative pain relief to an ilioinguinal/iliohypogastric nerve block in children undergoing hernia repair (25). Furthermore, the simple application of topical lidocaine jelly or ointment is as effective as peripheral nerve blocks or parenteral opioids in providing pain relief after outpatient circumcision (26).

Intracavitary instillation of local anesthetics is another simple, yet effective, technique for providing pain relief during the early postoperative period after laparoscopic and arthroscopic procedures. Intraperitoneal administration of local anesthetics during laparoscopy was found to be an efficient method of reducing the intensity of postoperative scapular pain (27). However, when bupivacaine was injected at the preperitoneal fascial plane during extraperitoneal laparoscopic hernia repair, it did not reduce postoperative pain (28). Local anesthetics can also be injected into joint spaces to provide analgesia during and after arthroscopic surgery (29). In a placebo-controlled study, intraarticular instillation of 30 mL of 0.5% bupivacaine reduced the opioid requirements and facilitated early mobilization and discharge after knee arthroscopy (30). A follow-up study (31) involving a combination of intraarticular bupivacaine and systemic ketorolac (60 mg IV or IM) further decreased pain in the early postoperative recovery period. A wide variety of adjuvants has also been injected into the intraarticular space to decrease postarthroscopic pain, including morphine, ketorolac, triamcinolone, and clonidine (32-35). Small-dose intraarticular morphine 1-3 mg, in combination with bupivacaine, seems to provide the longest lasting and most cost-effective analgesia after knee arthroscopy (36,37). Although administering the intraarticular morphine before knee surgery was reported to provide a longer

duration of analgesia and greater opioid-sparing effects than when it was given at the end of surgery (37), the clinical advantages of preemptive analgesia remain controversial (20).

Local anesthetic supplementation clearly decreases the severity of incisional pain in the early postoperative period. However, outpatients may still experience significant pain after they have been discharged home because of difficulty in anticipating the degree of pain when the local anesthetic effect wears off. Continuous (38,39) or intermittent perfusion (40) of the surgical wound with local anesthetic solutions is an old-fashioned but highly effective technique for extending incisional pain relief into the postdischarge period. Recently, this technique has been modified to allow for patient-controlled local anesthetic administration after discharge home (41). However, some investigators have failed to find significant differences in pain scores or opioid analgesic requirements when the local anesthetic was instilled or injected at the incision site (42,43). The response to local analgesia appears to be influenced by the location, concentration, and volume of the injected local anesthetic solution. For example, Yndgaard et al. (44) demonstrated that subfascially administered lidocaine was significantly more effective in reducing pain compared with subcutaneous injection after inguinal herniotomy. Finally, combining local anesthetic techniques with other analgesic modalities as part of multimodal (or "balanced") analgesic therapy can improve pain control throughout the perioperative period (45). The concept of balanced analgesia consists of administering several different analgesic drugs to alter the pathophysiologic processes involved in nociception, thereby producing more effective perioperative analgesia with fewer side effects (5,6).

In summary, local anesthetic wound infiltration and peripheral nerve block techniques are simple, safe, and effective approaches to providing perioperative analgesia in the ambulatory setting. Use of major neural blockade techniques involving the upper (e.g., interscalene brachial plexus block) and lower (e.g., femoral nerve block) extremities can facilitate an earlier discharge after major shoulder and knee reconstructive procedures, respectively (46,47). The availability of newer local anesthetic drugs that are alleged to be associated with less toxicity and greater selectivity with respect to sensory and motor blockade (e.g., ropivacaine and levobupivacaine) may further enhance the benefits of local anesthetic supplementation after ambulatory surgery. The addition of adjuvants (e.g., clonidine) can prolong the postoperative analgesia produced by peripheral nerve blocks (48). Recent studies by Klein et al. (49,50) suggest that improved pain control could also be achieved after major shoulder and knee procedures by using a disposable, non-electronic catheter system for continuously infusing

local anesthetic solutions. However, additional studies are needed to document the alleged advantages of these newer local anesthetic drugs and techniques. Future studies are also needed to determine the optimal local anesthetic concentrations and infusion rates with the new catheter systems.

## NSAIDs

NSAIDs have long been used for treating nonsurgical pain syndromes because of their well known antiinflammatory, antipyretic, and analgesic properties. However, with the introduction of parenteral preparations of NSAIDs (e.g., ketorolac and diclofenac), these drugs have become more popular in the management of pain associated with ambulatory surgery. NSAIDs block the synthesis of prostaglandins by inhibiting the enzyme cyclooxygenase (COX), thereby reducing the production of mediators of the acute inflammatory response. By decreasing the inflammatory response to surgical trauma, NSAIDs have been alleged to reduce peripheral nociception. However, more recent studies also suggest that the central response to painful stimuli may be modulated by NSAID-induced inhibition of prostaglandin synthesis in the spinal cord (20).

Early reports suggested that NSAIDs possessed analgesic properties comparable to those of opioid analgesics (51-53) without opioid-related side effects (54,55). When ketorolac was administered as an adjuvant to propofol/nitrous oxide anesthesia, its use was associated with improved postoperative analgesia and patient comfort, which compared favorably to fentanyl (55). Moreover, ketorolac was associated with a decreased incidence of postoperative nausea and vomiting, and patients tolerated oral fluids and were judged fit for discharge earlier than those receiving opioid compounds. Other investigators have also reported that ketorolac provided similar postoperative pain relief to that of fentanyl but was associated with less nausea and somnolence and an earlier return of bowel function after ambulatory surgery (56). Furthermore, it was recently reported that the administration of ketorolac (30 mg) at the incision site to supplement local anesthesia resulted in significantly less postoperative pain, a better quality of recovery, and earlier discharge compared with local anesthesia alone (57). However, when ketorolac was substituted for or combined with fentanyl during outpatient gynecologic and laparoscopic surgical procedures, the beneficial effects of the NSAID were more variable (58-60).

Use of shock-wave lithotripsy to evaluate the effect of NSAIDs on visceral pain, diclofenac produced only a marginal opioid-sparing effect (61). Furthermore, when diclofenac (1 mg/kg IV) was administered before outpatient arthroscopic surgery, it was found to

be associated with similar visual analog pain scores to fentanyl (1  $\mu\text{g}/\text{kg}$  IV) (62). After gynecologic laparoscopy surgery (63), diclofenac decreased pain and analgesic requirements for 24 h postoperatively but had little effect on the recovery profile. Similarly, the administration of ketorolac during the perioperative period in outpatients undergoing laparoscopic cholecystectomy procedures (59) decreased postoperative opioid requirements, but this contributed to only a marginal improvement in ventilatory function at 4 hr after the operation.

When diclofenac was administered preoperatively to pediatric patients, both the incidence of restlessness and crying and the postoperative opioid requirements were lower in the diclofenac-treated (versus acetaminophen-treated) patients (64). Oral ketorolac (1 mg/kg) compared favorably to small-dose acetaminophen (10 mg/kg) for bilateral myringotomy procedures in children, with the ketorolac-treated patients recording lower pain scores and requiring less analgesic medication in the early postoperative period (65). In children undergoing inguinal hernia repair (66), ketorolac (1 mg/kg IV) compared favorably to caudal bupivacaine 0.2% with respect to pain control and postoperative side effects. In fact, the ketorolac-treated patients had an improved recovery profile, including less vomiting, shorter times to voiding and ambulation, and earlier discharge home. Furthermore, the intraoperative administration of ketorolac as an adjuvant to general anesthesia in pediatric patients provided postoperative analgesia comparable to morphine (67). As expected, the ketorolac-treated patients experienced less postoperative nausea and vomiting. When ketorolac or morphine are administered for pain control in pediatric patients, ketorolac-induced analgesia develops more slowly but is longer lasting compared with morphine (68).

Oral or rectal administration of NSAIDs can also be highly effective in the prophylactic management of pain after ambulatory surgery. For example, when oral naproxen was administered before laparoscopic surgery, postoperative pain scores, opioid requirements, and time to discharge were significantly reduced (69). Furthermore, premedication with oral ibuprofen (800 mg) was associated with superior postoperative analgesia and less nausea compared with fentanyl (75  $\mu\text{g}$  IV) (70). However, the more important role for oral NSAIDs is in the postdischarge period. In a recent outpatient study involving the use of a multimodal analgesic technique consisting of alfentanil, lidocaine, ketorolac, and paracetamol (71), oral ibuprofen (800 mg every 8 h) was equianalgesic to paracetamol 800 mg plus codeine 60 mg (every 8 h) when administered during the first 72 h after discharge, and it resulted in better global patient satisfaction and less constipation than the opioid-containing oral analgesic. To achieve the optimal benefit of using NSAIDs in the perioperative period,

these compounds should be continued as prophylactic analgesics for preventive pain management in the postdischarge period (45).

## COX-2 Inhibitors

In an effort to minimize the potential for operative-site bleeding complications, as well as gastrointestinal and renal damage, associated with the classical NSAIDs, the more specific COX-2 inhibitors are being increasingly used as non-opioid adjuvants for minimizing pain during the perioperative period (Table 3). Early studies evaluated the use of celecoxib and rofecoxib for preventative analgesia when administered for oral premedication (72-74). Rofecoxib (50 mg orally [PO]) seems to produce more effective and sustained analgesia compared with celecoxib (200 mg PO) after surgery (72). Preliminary data suggest that celecoxib (200 mg PO) is equivalent to acetaminophen (2 g PO) when administered before outpatient otorhinolaryngology surgery (73). However, rofecoxib (50 mg PO) produced significantly more effective analgesia than acetaminophen (2 g PO), and the pain relief was more sustained in the postdischarge period (74). Premedication with rofecoxib also facilitated the recovery process by reducing postoperative pain and improving the quality of recovery from the patient's perspective.

More recently, a parenterally active COX-2 inhibitor, parecoxib (20-40 mg IV), has been investigated as an alternative to ketorolac and diclofenac (75,76). Parecoxib is a prodrug with an active metabolite (valdecoxib) and is similar both pharmacokinetically and pharmacodynamically to celecoxib. Both preoperative (75) and postoperative (76) administration of this investigational COX-2 drug seems to exert significant opioid-sparing effects, and these preliminary studies suggest that it can improve the quality of recovery and patient satisfaction with postoperative pain management. However, further comparative clinical studies are needed to define the optimal role of COX-2 inhibitors in ambulatory surgery.

## Acetaminophen (Paracetamol)

Of the nonopioid analgesics, acetaminophen is potentially one of the most useful, yet it is vastly underused in the ambulatory setting. When administered in an appropriate oral or rectal dose, acetaminophen can be a very useful adjuvant during the perioperative period and compares favorably to the NSAIDs in children (77). Although Watcha et al. (65) reported minimal analgesic-sparing effects after a 10 mg/kg dose of acetaminophen, Rusy et al. (77) found that a larger dose (35 mg/kg per rectum) was as effective as ketorolac 1 mg/kg IV in reducing pain after tonsillectomy procedures and was associated with less postoperative bleeding than the NSAID. More recently,

Korpela et al. (78) demonstrated that the opioid-sparing effect of acetaminophen was strictly dose related. The optimal dosing regimen for acetaminophen in children consists of a preoperative initial loading dose of 40 mg/kg followed by a maintenance dose of 20 mg/kg every 6-8 h during the early postoperative period (79).

An IV formulation of acetaminophen, known as propacetamol, has been administered to adults as an alternative to ketorolac in the perioperative period (80,81). Propacetamol is a prodrug that is rapidly and completely hydrolyzed by nonspecific plasma esterases to form acetaminophen (also known as paracetamol). Although the future role of this non-opioid parenteral analgesic during the perioperative period is yet to be determined, rectal acetaminophen (1.3 g) has been successfully used as an adjuvant to NSAIDs and local anesthetics in adult outpatients as part of a multimodal fast-tracking protocol (82).

## Ketamine

Ketamine is a unique anesthetic with analgesic-like properties which has been used for both the induction and maintenance of anesthesia and as an analgesic adjuvant during MAC (83). As a result of its well known side-effect profile (Table 4), ketamine fell into disfavor in the anesthesia community in the early 1980s. However, the use of so-called small-dose ketamine (0.1-0.2 mg/kg IV) techniques seems to be associated with a much less frequent incidence of adverse events and with greater patient and physician acceptance (84). Recent studies have described the use of ketamine in combination with propofol for MAC (85,86) and IV anesthesia (87). The administration of ketamine  $4-18 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  in combination with propofol  $30-90 \mu\text{g} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$  can obviate the respiratory depression produced by propofol/opioid combinations while producing positive mood effects after surgery, and it may even provide for an earlier recovery of cognitive function (85,86). In addition, a single bolus dose of ketamine 0.1-0.15 mg/kg during surgery has been reported to produce significant opioid-sparing effects after painful ambulatory surgery procedures (88,89). However, the clinical significance of ketamine's preemptive analgesic effects remains controversial (90,91).

## Nonpharmacologic Techniques

Nonpharmacologic "electroanalgesic" techniques (e.g., transcutaneous electrical nerve stimulation [TENS], acupuncture-like TENS, and percutaneous neuromodulation therapy) can also be used as adjuvants in the treatment of both acute and chronic pain in the ambulatory setting (92). Given the inherent side effects produced by both opioid and non-opioid analgesics (Table

**Table 3.** Dosage Recommendations and Duration of Action of COX-2 Inhibitors

Drug (mg)	Route of administration	Onset (min)	Duration (h)	COX-2/COX-1 activity <sup>a</sup>	Side effects
Celecoxib (100–200)	PO	30–50	4–8	8	Sulfonamide allergy (?)
Rofecoxib (12.5–50)	PO	30–50	12–24	35	Leg edema, hypertension
Paracoxib (20–40) <sup>b</sup>	IM/IV	10–15	6–12	—	Not known
Valdecoxib (40–80)	PO	30–40	6–12	30	Not known
Etoricoxib (30–60)	PO	20–30	≥24	106	Not known

COX-2 = cyclooxygenase-2; PO = orally.

<sup>a</sup> Data on file with Pharmacia (Skokie, IL) and Merck (West Point, PA).<sup>b</sup> IV prodrug of valdecoxib (the active analgesic compound).**Table 4.** Potential Side Effects of Opioid and Non-Opioid Analgesic Drugs

Opioid analgesics
Respiratory and cardiovascular depression
Nausea, vomiting, retching, and ileus
Urinary hesitancy and retention
Pruritus and skin rash
Sedation and dizziness
Tolerance and dependence
Local anesthetics
Residual motor weakness
Peripheral nerve irritation
Cardiac arrhythmias
Allergic reactions
Sympathomimetic effects (due to vasoconstrictors)
Nonsteroidal antiinflammatory drugs
Operative-site bleeding
Gastrointestinal bleeding
Renal tubular dysfunction
Allergic reactions and bronchospasm
Hypertension
Pedal edema
Acetaminophen
Gastrointestinal upset
Sweating
Hepatotoxicity
Agranulocytosis
Ketamine
Hypertension
Diplopia and nystagmus
Dizziness and confusion
Cardiac arrhythmias
Nausea and vomiting
Psychomimetic reactions
Nonpharmacologic techniques
Skin irritation/erythema
Cutaneous discomfort

4), it is possible that nonpharmacologic approaches will assume a more prominent role in the management of pain after ambulatory surgery in the future.

Most studies suggest that TENS produces a 15%–30% decrease in the postoperative opioid requirement (93). In addition to reporting that TENS reduces pain and the need for oral analgesics, Jensen et al. (94) reported a more rapid recovery of joint mobility after outpatient arthroscopic surgery. In reviewing the medical literature, Carroll et al. (95) found conflicting

results regarding the effect of TENS on the requirement for opioid analgesic medication and the quality of postoperative pain relief. Several studies suggest that the location, intensity, and frequency of electrical stimulation are all important factors influencing the efficacy of TENS (and acupuncture-like TENS) therapies (96–98). Moreover, the clinical efficacy of electroanalgesic techniques remains controversial because of the potential sources of bias and difficulty in quantifying the inherent placebo effect of the therapy. Other nonpharmacologic approaches that have also been evaluated as potentially useful analgesic adjuvants in the perioperative period include cryoanalgesia, ultrasound, laser, and even hypnosis (99–101). However, additional well controlled clinical studies are needed to establish the benefits of these nonpharmacologic modalities on patient outcome after ambulatory surgery.

## Summary

As more extensive and painful surgical procedures (e.g., laparoscopic cholecystectomy, adrenalectomy, and nephrectomy, as well as prostatectomy, laminectomy, shoulder and knee reconstructions, and hysterectomy) are performed on an outpatient or short-stay basis, the use of multimodal perioperative analgesic regimens containing non-opioid analgesic therapies will probably assume an increasingly important role in facilitating the recovery process and improving patient satisfaction (3). Optimizing pain management is necessary to maximize the benefits of ambulatory surgery for both patients and health care providers. Additional outcome studies are needed to validate the beneficial effects of these newer therapeutic approaches with respect to important recovery variables (e.g., resumption of normal activities and return to work). Although many factors other than pain *per se* must be controlled to minimize postoperative morbidity and facilitate the recovery process after ambulatory surgery, pain remains a major concern of all patients undergoing surgical procedures (102).

It is clear that the anesthetic technique can influence the analgesic requirement in the early postoperative

period. Although opioid analgesics will continue to play an important role in the management of moderate to severe pain after surgery, the adjunctive use of nonopioid analgesics will probably assume a greater role in the future. Although opioid-free anesthesia may not yet be feasible for major intracavitary surgical procedures, it is becoming increasingly popular for superficial procedures in the ambulatory or office-based setting (103-105). In addition to the local anesthetics, NSAIDs, acetaminophen, and ketamine, nonopioid drugs such as adenosine,  $\beta$ -blockers,  $\alpha_2$ -agonists, and steroids have also been shown to be potentially useful adjuvants during or after surgery (82,106-112). Use of analgesic drug combinations with differing mechanisms of action may provide additive or even synergistic effects with respect to improving pain control and facilitating the recovery process. Finally, safer, simpler, and less costly analgesic drug delivery systems are needed to provide for more cost-effective pain relief in the postdischarge period after ambulatory surgery.

In conclusion, "stress-free" anesthesia with minimal postoperative discomfort should be achievable for the majority of outpatients undergoing ambulatory surgical procedures, with the appropriate use of multimodal analgesic techniques. The aim of the analgesic technique should be not only to lower the pain scores, but more importantly to facilitate earlier mobilization and rehabilitation by reducing complications after discharge home. Recent evidence suggests that clinicians can more effectively prevent postoperative pain and improve the recovery profile after ambulatory surgery by using a combination of preemptive multimodal techniques involving both centrally and peripherally acting analgesic drugs, as well as nonpharmacologic therapies.

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