Control of Postoperative Pain
Nonnarcotic and Narcotic Alternatives and Their Effect on Pulmonary Function
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Control of postoperative pain traditionally has been achieved using intramuscular narcotics. In recent years, new techniques, in addition to intramuscular narcotics, have been utilized in the postoperative period in an attempt to provide adequate analgesia. Patients undergoing intrathoracic or intraabdominal procedures or both have been treated with intercostal block therapy, transcutaneous electrical nerve stimulation, or cryotherapy. Spinal narcotics and patient-controlled narcotic analgesia have also been used to treat postoperative pain. Each of these techniques will be reviewed with special emphasis on their analgesic efficacy and their role in modifying postoperative pulmonary function.

**INTERCOSTAL BLOCKS**

Intercostal blocks can be used to provide postoperative analgesia for surgical procedures involving the thorax or abdomen. The intercostal nerves arise from the ventral division of the first through 12th thoracic nerves. The first, second, and 12th intercostal nerves have unique anatomy. The first intercostal nerve contributes to the inferior trunk of the brachial plexus. The second intercostal nerve contributes to the intercostobrachial nerve of the arm. The 12th intercostal nerve is really subcostal and contributes to the iliohypogastric and ilioinguinal nerves. Intercostal nerves communicate with the sympathetic ganglia via the grey rami communicans and give rise to posterior, lateral and anterior cutaneous branches (Fig 1). Although intercostal nerves five through 11 can be blocked anywhere along their anatomic course, intercostal blocks are usually performed 7 to 9 cm lateral to the posterior midline, at the angle of the rib, because it is at this point that the rib becomes easily palpable. In addition, this posterior location is chosen to ensure that the lateral cutaneous branch, which arises in the midaxillary line, is also blocked. The lateral cutaneous branch supplies sensory innervation to a major portion of the anterior and posterior thorax and abdomen.

The intercostal nerve courses under the inferior margin of each rib. It moves in close association with the intercostal vein and artery. When intercostal blocks are performed postoperatively from the skin surface, the rib is used as a bony landmark to facilitate performing the block without eliciting paresthesia.

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FIGURE 1. A typical intercostal nerve gives rise to the posterior, lateral and anterior cutaneous nerve. (Reproduced with permission.)
After anesthetizing the skin and subcutaneous tissue, the needle and syringe of local anesthetic are cautiously walked along the rib in a caudal direction until the needle walks off the inferior border of the rib. After advancement of the needle 2 to 3 mm and careful stabilization, the syringe is first aspirated to prevent intravascular injection, and then, the local anesthetic solution is injected. Intercostal blocks can also be performed by the surgeon under direct vision prior to wound closure in the patient undergoing a thoracotomy.

Intercostal blocks may be used to provide postoperative analgesia in patients undergoing upper abdominal procedures. Pain relief lasting up to 18 hours after a single dose of local anesthetic has been observed, although in many clinicians’ experience, pain relief is commonly of four to six hours’ duration. Continuous infusion intercostal blocks have resulted in longer pain-free intervals. The interval between cholecystectomy and first required supplemental dose of narcotic, as well as the total dose of narcotic required, has also been shown to be decreased in patients receiving intercostal blocks when compared to patients not receiving them.

Postoperative decrements in pulmonary function have been shown to be attenuated in patients receiving intercostal blocks after undergoing cholecystectomy. The observed decrease in one-second forced expiratory volume (FEV₁), forced vital capacity (FVC), and peak expiratory flow rates were less after intercostal blocks. However, comparison of different analgesic regimens has yielded conflicting results.

In patients undergoing cholecystectomy, Rawal and colleagues demonstrated that those patients receiving intercostal blocks had a smaller decrease postoperatively in peak expiratory flow rates than those patients receiving intramuscular narcotic analgesia alone. However, patients receiving intercostal blocks still had a greater decrease in peak expiratory flow rate than those receiving epidural morphine analgesia. Rosenberg and colleagues compared intramuscular narcotic, intercostal blocks, epidural morphine, and continuous infusion plus demand infusion of fentanyl for control of postoperative pain after various upper abdominal procedures, including cholecystectomy. No difference in peak expiratory flow rate measured at two and 24 hours postoperatively was detected among the four regimens. In addition, postoperative chest x-ray findings did not differ among the four regimens.

When used to provide postoperative analgesia after thoracotomy, intercostal blocks have also been shown in some studies to decrease supplemental analgesia requirements and lessen the usual observed decrement in arterial PaO₂, peak expiratory flow rate, and FEV₁. However, de la Rocha and Chambers could not demonstrate a statistically significant difference in FEV₁ after thoracotomy between control patients and those receiving intercostal blocks. Similarly, Galway and colleagues showed no difference in postoperative peak expiratory flow rate or vital capacity after thoracotomy in patients receiving intercostal blocks compared to control subjects.

The most common complication after intercostal blocks is pneumothorax. At an institution where 95 percent of the intercostal blocks are performed by residents, Moore reported only eight pneumothoraces in 10,941 patients receiving intercostal blocks for an incidence of 0.073 percent. However, other authors report the incidence of pneumothorax after intercostal blocks to range from 0.33 to 19 percent. In addition, other less common complications following intercostal blocks include total spinal block and severe hypotension. Systemic absorption of local anesthetic from the site of administration is greater with intercostal blocks compared to epidural administration.

Cryanalgesia

Cryanalgesia is a specialized block of the intercostal nerves which can be performed under direct vision at the conclusion of a thoracotomy prior to wound

![Figure 2. Cryanalgesia is achieved by freezing the intercostal nerve. (Reproduced with permission.)](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21567/)
wound closure. Cryoanalgesia is achieved by freezing the intercostal nerve using a cryosurgery probe (Fig 2).[^22]

The exposure to freezing temperature results in local damage to the nerve which in experimental animals is reversible over time.[^34]

Cryoanalgesia decreases postoperative pain and narcotic requirement.[^19,20,22] In patients receiving cryoanalgesia, pain that did occur was usually not incisional but was related to shoulder and arm pain from irritation of the pleura by the chest tube.[^19,20] The effect of cryoanalgesia on postoperative pulmonary function is unclear. Katz and colleagues[^30] found that postoperative FEV₁ and FVC in nine thoracotomy patients treated with cryoanalgesia were no different from control patients who received either intercostal blocks with long acting local anesthetic or no nerve block therapy. Rooney and colleagues[^39] found that FEV₁, FVC, and negative inspiratory pressure were more decreased at 24 hours postoperatively in thoracotomy patients receiving cryoanalgesia compared to untreated control subjects.

Anesthesia from cryotherapy to the intercostal nerves lasts longer than the apparent time required for wound healing. Sensation may begin to return as early as two to three weeks post procedure[^39] or as late as six to eight months after surgery.[^19] Return of normal sensation may take over one year.[^19]

**Transcutaneous Electrical Nerve Stimulation**

The use of transcutaneous electrical nerve stimulation (TENS) to provide postoperative analgesia has become increasingly popular in recent years. The patient is instructed preoperatively about the technique and about the use of the stimulus generator. Initial settings for stimulus frequency, current output, and pulse duration may be determined at this time. In the operating room after wound closure, sterile gelled electrodes are applied to the skin on either side of the incision. Sterile dressings are then applied to the wound site, and the electrodes are connected to the battery-operated stimulus generator. TENS may be applied on a continuous[^35-38] or intermittent basis.[^30]

The mechanism by which TENS therapy results in analgesia is unclear. In 1965, Melzack and Wall[^31] proposed the gate theory of pain. This theory proposes that afferent pain signals are modified by a gating mechanism located in the substantia gelatinosa of the dorsal spinal cord. The relative amount of TENS stimulation of large myelinated A-beta nerve fibers and of pain stimulus to the small A-delta and C nerve fibers determines whether the gate is open, facilitating afferent transmission of pain signals, or closed, inhibiting transmission. TENS may result in analgesia because the delivered stimulation of the large peripheral nerve fibers results in a closing of the gate.

The efficacy of TENS in reducing postoperative analgesia requirements is controversial. VanderArk and McGrath[^50] showed that analgesia could be achieved and narcotic requirements decreased in patients undergoing abdominal or thoracic procedures when TENS was applied on an intermittent basis after pain occurred. Soloman et al[^22] demonstrated that patients undergoing hip arthroplasty, transabdominal gynecologic procedures, or lumbar spine surgery achieved a significant reduction in postoperative narcotic use while receiving continuous TENS therapy only if they were naive users of narcotics. However, this study relied on historical controls and did not employ a sham stimulator group. Control groups that received sham stimulators were employed in studying the effect of TENS in patients undergoing cholecystectomy[^19] and in patients undergoing a variety of intraabdominal surgeries.[^30] Both of these studies demonstrated a decrease in narcotic requirement when patients received TENS therapy. Other studies have also demonstrated a decrease in postoperative narcotic requirement in patients receiving TENS therapy after surgery for spinal fusion with Harrington rod,[^34] laminectomy,[^35] intraabdominal surgery,[^36] and thoracotomy.[^36]

However, three recent studies employing control groups that received sham TENS therapy failed to demonstrate any decrease in narcotics requirement.[^38,37,38] In one of these studies, patients undergoing cholecystectomy who received TENS therapy complained of less severe pain but required the same number of narcotic injections as the control group.[^37] In another study, patients undergoing various intraabdominal procedures who received TENS therapy had the same severity of pain and the same daily narcotic requirement as those patients in the sham group.[^38] Finally, Warfield and colleagues[^38] demonstrated that although the pain score of patients undergoing thoracotomy who received TENS therapy was less than control subjects, the narcotic requirement was not different.

TENS therapy frequently requires supplementation with parenteral narcotics. In one study, only 22 percent of 22 thoracotomy patients treated with TENS therapy requested no narcotic in the first 24 hours postoperatively,[^38] and in two other studies only 25 to 33 percent of patients undergoing thoracic or abdominal surgery and treated with TENS requested no narcotic during the period of study.[^30,31] Finally, some patients receive no pain relief from TENS.[^30,31]

Whether TENS therapy results in an attenuation of the usual postoperative decrement in pulmonary function is also controversial. Stratton and Smith[^38] applied TENS therapy after pain was present on the second postoperative day in patients undergoing thoracotomy and found that FVC improved after ten minutes of TENS therapy. However, the control group did not
receive sham stimulator therapy. Ali and colleagues,27 in a sham controlled study of TENS therapy in patients undergoing cholecystectomy, demonstrated that the postoperative decrease in FRC, VC, and arterial Po, was present but significantly less than in the control groups. However, other sham controlled studies of TENS therapy failed to demonstrate any improvement in the observed decrease in peak expiratory flow rates in patients undergoing cholecystectomy,27 or in arterial blood gas values of patients undergoing various intraabdominal procedures.28

Additional benefits attributed to TENS therapy include a decrease in the occurrence of postoperative atelectasis and pneumonia in patients undergoing cholecystectomy27 or various intraabdominal procedures,29 and a shorter recovery room stay and better tolerance of chest physical therapy in patients undergoing thoracotomy.30 Other studies of patients undergoing various intraabdominal procedures have failed to demonstrate any benefit from TENS therapy with respect to length of hospital stay,30 length of intensive care unit stay,31 or the occurrence of postoperative pulmonary complications.32

Few complications have been associated with TENS therapy. Some patients have experienced skin irritation from the gel or adhesive on the electrodes.33 Presence of a cardiac pacemaker and pregnancy in the first trimester are considered contraindications to the use of TENS therapy.40

NONNARCOTIC ALTERNATIVES

Each of these three techniques of nonnarcotic control of postoperative pain, intercostal blocks, cryotherapy, and TENS, have deficiencies in addition to those discussed above. Intercostal blocks may need to be repeated at frequent intervals and may not always result in complete analgesia of the injected segments,41 therefore requiring supplementation with parenteral narcotics. None of these three techniques provides analgesia for wounds or irritation outside of the specific segments to which they are applied, and patients treated with any one of the three techniques frequently require supplemental therapy with narcotics. Sufficient data are not available to determine whether patients receiving cryotherapy may ultimately be at risk for developing a deafferentation pain syndrome. Therefore, at the present time, cryotherapy is best viewed as an experimental procedure.

PARENTERAL NARCOTIC THERAPY

Because each of these alternative techniques of nonnarcotic control of postoperative pain has failed to eliminate the need for narcotic therapy, there has been continued interest in the use of narcotics to achieve postoperative analgesia. Traditionally, narcotic analgesia has been administered to the patient by intramuscular (IM) injection on an as needed basis. This approach presents logistic and pharmacologic obstacles to overcome in order to achieve adequate patient analgesia.

Graves and colleagues42 have described the usual cycle of events that a patient experiences after making a request for pain medication (Fig 3). The logistics of each step in the cycle are such that a significant time interval may pass between the patient request and the administration of the IM injection.

Once the drug is administered, it must be absorbed from the injection site. After absorption, the patient experiences pain relief only if the blood concentration of the drug is above a minimum effective analgesic concentration, a pharmacologic limitation.43-44 Blood concentrations of narcotics administered by intramuscular injection vary according to the period of time since injection.45 Austin and colleagues45 studied ten patients who underwent either cholecystectomy or abdominal hysterectomy and found that in the immediate postoperative period, meperidine, 100 mg IM every four hours, resulted in blood concentrations of drug associated with complete pain relief during a minority of the first eight hours of time. They estimated that meperidine blood concentrations after IM administration were elevated above the minimum effective analgesic concentration for only 35 percent of

Figure 3. The cycle of events that occur following a patient request for pain medications. (Reproduced with permission.43)
each four hour time interval studied. Tammisto retrospectively evaluated the effectiveness of IM oxycodone administered to 100 patients postoperatively on the general surgical and urological services. Over 75 percent of the patients described their analgesia as good. However, of the remaining patients experiencing poor or only moderate analgesia after IM oxycodone, 80 percent of these complained that the duration of analgesia they experienced was too short, and 20 percent complained that the maximal effectiveness of a single injection was inadequate.46

There is a large amount of interpatient variability in the minimum effective analgesic concentration. Austin and colleagues44 demonstrated the minimum effective concentration for meperidine to vary from 0.24 to 0.76 \( \mu g/ml \) in nine patients who underwent intraabdominal or orthopedic surgical procedures. These investigators also found that the dose response curve for effective analgesia was steep; the concentration that resulted in moderate pain relief compared to effective analgesia differed by only 0.05 \( \mu g/ml \). Tamsen and colleagues46 determined that the minimum effective concentration of meperidine, just prior to a patient request for additional analgesia, varied from 0.094 to 0.754 \( \mu g/ml \) in 20 patients who underwent major intraabdominal surgical procedures.

In addition to the large amount of interpatient variability in the minimum effective analgesic concentration, the amount of administered narcotic required to provide adequate analgesia varies widely from person to person. Ranges of administered doses have varied over fivefold.47 Bennett and colleagues47 demonstrated that morphine sulfate requirements in morbidly obese patients after gastric bypass surgery varied from 0.33 to 1.74 mg/kg in the first 36 hours. When expressed as mg/m², the requirements still exhibited the same degree of variation (16.4 to 90.2 mg/m²). Chakravarty and colleagues48 found similar results using either meperidine or buprenorphine after upper abdominal surgery. In the first 24 hours, the meperidine doses varied from 2.9 to 23 mg/kg and the buprenorphine doses varied from 4.2 to 57 mg/kg. Tamsen and colleagues46 showed that hourly demand for meperidine after upper abdominal surgery varied from 12 to 50 mg/hour and was directly correlated with mean plasma concentrations of meperidine and the minimum effective concentration for the individual patients and was unrelated to age, gender, body weight or body surface area. Similar results have been obtained using morphine sulfate.49 Currently, though, there is no effective way to predict a given individual's hourly analgesic needs.

Because of individual variability in minimum effective analgesic concentrations, and the large variation in drug doses necessary to achieve effective analgesia, techniques have been developed for narcotic administration that allow greater individualization of therapy than presently available using intermittent IM injections. One such technique is on-demand intravenous bolus therapy or patient controlled analgesia (PCA).

**Patient-Controlled Analgesia**

Patient-controlled analgesia (PCA) is administered intravenously by using an infusion pump that is programmed to deliver a set dose of drug to the patient when he or she activates a control button. The size of the dose and the shortest time interval between doses—or the lockout interval—is programmed into the pump. Some infusion pumps have the capability of providing a continuous background infusion as well as demand dose of narcotic.

Compared to treatment with IM narcotics, treatment with PCA for postoperative pain has been reported by Bennett and colleagues50 to decrease the disturbance of nighttime sleep and increase the amount of spontaneous activity that patients undertake following laparotomy while achieving superior pain control. In addition, Bennett and colleagues51 have shown that PCA with morphine maintained analgesia without excessive sedation more frequently than maintained by IM morphine in patients after gastric bypass surgery. However, Welchew51 has found that mean scores of pain, sedation, and nausea were the same for patients treated with either intramuscular morphine sulfate or demand infusion fentanyl after upper abdominal surgery. Sedation in the IM treatment group was noted to increase immediately after each intermittent injection.

Bennett and colleagues52 have reported that PCA results in less of a decrement in peak expiratory flow rates on days two and three following upper abdominal surgery than occurs in patients treated with IM injections. However, Welchew51 was unable to demonstrate

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**Table 1—Administration of Patient-Controlled Analgesia**

<table>
<thead>
<tr>
<th>Surgical Procedure</th>
<th>Lockout Interval (min)</th>
<th>Bolus Dose†‡</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphine analgesia:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gastric bypass</td>
<td>6</td>
<td>0.30-0.75‡</td>
<td>55</td>
</tr>
<tr>
<td>Gastric bypass</td>
<td>6</td>
<td>0.60 (± 0.20)‡</td>
<td>47</td>
</tr>
<tr>
<td>Intraabdominal</td>
<td>6</td>
<td>0.30-0.50‡</td>
<td>53</td>
</tr>
<tr>
<td>Intraabdominal</td>
<td>15</td>
<td>2-3‡</td>
<td>49</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>5</td>
<td>2‡</td>
<td>57</td>
</tr>
<tr>
<td>Meperidine analgesia:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intraabdominal</td>
<td>15</td>
<td>15-30†</td>
<td>56</td>
</tr>
<tr>
<td>Intraabdominal</td>
<td>NA</td>
<td>20,25,30†</td>
<td>58</td>
</tr>
<tr>
<td>Intraabdominal</td>
<td>NA</td>
<td>20,25,30†</td>
<td>46</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>5</td>
<td>30†</td>
<td>57</td>
</tr>
</tbody>
</table>

*Abbreviation: NA indicates not available.
†Milligrams.
‡Mg/m² BSA.
a difference in FEV₁, FVC, or peak expiratory flow rates 12 or 24 hours after upper abdominal surgery between the two treatment groups.

Decreasing requirements for PCA during the first two to three days after the surgical procedure have been demonstrated in patients undergoing laparotomy for various intraabdominal procedures and in patients undergoing gastric bypass procedures. This suggests that during this time period, tolerance does not develop.

Disadvantages of PCA include the potential for complications resulting from the use of narcotics. However, respiratory depression has been reported uncommonly with the regimens used (Table 1). When respiratory depression has occurred, it has in general been associated with either hypovolemia or supplemental doses of narcotic, in addition to those from the PCA device. PCA also requires specialized equipment: infusion tubing with one-way check valves, and infusion pumps or syringes.

Patient acceptance of on-demand intravenous bolus therapy or PCA has been high. Bennett and colleagues report the impressions of three patients who received conventional intermittent IM injections for analgesia after a prior intraabdominal operation and PCA after current gastric bypass surgery. Each of the three preferred PCA. Their reasons were as follow: (1) there is no delay between perception of pain and administration of analgesia; (2) there is no feeling of helplessness because of too much analgesia; and (3) the patient, not the doctor or nurse, controls the use of the analgesic.”

The future for patient-controlled narcotic analgesia remains to be determined. Whether it is safer or more efficacious than conventional intermittent IM narcotic therapy still remains to be proven. Its role in relation to other alternatives such as continuous infusion narcotic therapy, will also require investigation.

**Spinal Narcotics**

Spinal administration of narcotics for postoperative pain control has become a more commonly used technique in recent years. Narcotics have been administered by either the intrathecal or epidural routes. Cousins and Mather have recently reviewed in detail the use of intrathecal and epidural narcotics for postoperative pain control. They note that both techniques are effective for relieving postoperative pain, that no neurotoxicity has been noted, that neither technique appears to induce sympathetic blockade or postural hypotension, and that respiratory depression, urinary retention, itching, and nausea and vomiting are the most commonly observed complications.

Respiratory depression after spinal narcotic analgesia is more likely to occur in the elderly, in subjects without preexisting tolerance to narcotics, and in subjects given supplemental parenteral narcotics. In addition, respiratory depression occurs more commonly as the dose of the administered narcotic is increased.

After receiving either intrathecal or epidural narcotics, respiratory depression is maximal six to ten hours after administration and may persist for nearly 24 hours. Therefore, all postoperative patients who receive either intrathecal or epidural narcotics must be cared for the first 24 hours in an environment where monitoring and nursing care are oriented to early detection and treatment of respiratory depression.

At Moffitt-Long Hospital of the University of California, San Francisco, all patients who have received epidural or intrathecal narcotics for postoperative pain therapy are cared for on nursing units where all personnel have received detailed instruction about the technique. Respiratory rate is monitored every 30 minutes for the first 16 hours after administration of the spinal narcotic and hourly until 24 hours have elapsed. Naloxone is readily available as is airway resuscitation equipment. The anesthesiologist who administered the spinal narcotic takes responsibility for evaluation of the patient’s requests for supplemental analgesia until 24 hours have elapsed. In addition, the anesthesiologist is available for consultation concerning other complications such as respiratory depression, urinary retention, excessive nausea, and vomiting, itching, or unexpected somnolence.

In more recent studies, attempts have been made to determine if epidural analgesia results in improvement in postoperative ambulation or pulmonary function in patients undergoing either abdominal or thoracic surgery. Rawal and colleagues compared the efficacy of postoperative intramuscular and epidural morphine in obese patients (Broca index ≥1.5) undergoing gastoplasty. All patients had an epidural catheter placed preoperatively, and in a randomized double-blind fashion, patients received either morphine intramuscularly and saline solution per the epidural catheter, or morphine per the epidural catheter and saline solution intramuscularly. Pain relief was the same in both groups; however, the patients receiving intramuscular morphine required more injections. Patients receiving epidural morphine were able to stand with assistance, walk with assistance, and walk freely without assistance significantly sooner than patients receiving intramuscular morphine. The decrement in postoperative vital capacity, FEV₁, and peak expiratory flow rates was the same in both groups. As discussed earlier, Rosenberg and colleagues compared intramuscular narcotic, intercostal blocks, continuous infusion/plus demand infusion fentanyl, and epidural morphine for control of postoperative pain after various intraabdominal procedures. The mean pain intensity score and the peak expiratory flow rate measured at two and
24 hours did not differ among the four regimens, nor did postoperative chest x-ray findings.

Bonnet and colleagues\(^7\) compared the efficacy of postoperative epidural morphine and intramuscular baralgine, a nonnarcotic anticholinergic analgesic, in patients undergoing colonic or rectal resection. Postoperatively, patients receiving epidural morphine suffered less pain. No difference was observed in postoperative vital capacity, FEV\(_1\), or PaO\(_2\).

Larsen and colleagues\(^8\) evaluated the clinical efficacy and occurrence of respiratory depression in patients who underwent abdominal surgery and received postoperative epidural morphine administered at either the thoracic 6-7 interspace or one of the interspaces between L3-S1. Postoperative pain scores, pulmonary function test results (FEV\(_1\), FVC, peak expiratory flow rate), and arterial blood gas determinations did not differ between the two sites of administration.\(^7\)

Shulman and colleagues\(^9\) evaluated patients undergoing thoracotomy, predominantly for lobectomy, and evaluated the efficacy of epidural morphine and intramuscular morphine. All patients had an epidural catheter placed preoperatively, and in a randomized double blind fashion, patients received either morphine intramuscularly and saline solution per the epidural catheter, or morphine per the epidural catheter and saline solution intramuscularly. Pain relief during the first eight hours postprocedure was better for the patients receiving epidural morphine; however, by 24 hours, the pain relief was similar in both patient groups. Likewise, the degree of patient somnolence was not different between the two groups. The usually observed decrement in some of the measures of pulmonary function was significantly less during the first 24 hours in the patients who received epidural morphine. The reduction in the FVC and FEV\(_1\) were significantly less at two, eight, and 24 hours postoperatively; however, the decrease in the peak expiratory flow rate was less in the patients receiving epidural morphine only at 24 hours. The relative preservation of FVC and FEV\(_1\) was on average 500 to 600 and 300 to 400 ml. The clinical significance of these changes is not known.

The use of intermittently administered epidural narcotic has raised concerns similar to those discussed earlier with respect to the use of intermittent intramuscular narcotics. Techniques are being developed for epidural narcotic administration that allow greater individualization of therapy than presently available using intermittent injections. Continuous epidural infusion of morphine for treatment of postoperative pain following thoracotomy,\(^10\) and continuous plus on-demand epidural infusion of morphine for treatment of postoperative pain following intraabdominal procedures\(^11\) are promising new techniques. The role of other agents such as somatostatin by continuous epidural infusion\(^12\) or of combinations of agents such as morphine and the local anesthetic bupivacaine by continuous epidural infusion\(^7\) remains to be more fully evaluated.

Conclusions

The choice of which modality to employ to provide patients with analgesia and improved outcome after either intraabdominal or intrathoracic surgery is difficult. The choice depends in part on the available monitoring facilities and the skill and experience of the patient's physicians. More comparative studies, composed of larger numbers of patients, and designed to alleviate as much of the heterogeneity of patient populations, anesthetic regimens, surgical procedures, and supplemental analgesic therapy will be necessary. In addition, assessment of outcome with respect to significant cardiopulmonary complications and length of recovery room, intensive care and hospital stay will need to be emphasized. The most realistic approach to postoperative pain control may indeed be one that combines one or more therapies.

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