Continuous Extrapleural Intercostal Nerve Block With Continuous Infusion of Lidocaine After Thoracotomy *

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Continuous extrapleural intercostal block (EPIB) with bupivacaine has been reported to be an effective analgesic technique in patients after thoracotomy. We report a retrospective study of EPIB using a continuous infusion of 1% lidocaine hydrochloride at a dose of 1 mg/kg/h. A posterior parietal pleural pocket was created and cannulated with a 16-g polyethylene catheter. Lidocaine was perfused over a 3-day period following surgery. Patients also had access to morphine sulfate via patient-controlled analgesia. Eighteen consecutive posterolateral thoracotomies (in 17 patients) performed during a 6-month period were reviewed. Serum lidocaine exceeded the toxic level of 5 μg/mL in only one patient, a 104.5-kg man who had a level of 5.9 μg/mL on postoperative day 2 but experienced no clinical toxicity. Pain was evaluated by verbal analog scores (0=no pain and 10=worst pain), which averaged 3.02, 3.14, and 2.8 in the 3 days following surgery. Mean total daily MS doses were 24.3, 37.7, and 34.32 mg (range, 0 to 94 mg). Sedation was scored on a 1 to 5 scale. Mean scores were 2.78, 2.56, and 2.6. No patient died or had a major respiratory complication. Continuous EPIB with lidocaine appears to be a promising adjuvant technique in the management of postthoracotomy pain. Effectiveness needs to be confirmed in a prospective randomized study. (CHEST 1995; 108:1718-23)

Key words: analgesia; intercostal nerves; lidocaine; local anesthesia; nerve block; pain measurement; postoperative pain; thoracic surgery; thoracotomy

Pain following surgery is a major cause of morbidity and mortality, and improved pain management results in improvement in postsurgical morbidity and mortality.1,2 The following all contribute to severe pain following thoracotomy: transection of skin, muscle, and pleura; retraction of muscles, ligaments, and intercostal nerves; pleural irritation by chest tubes; and fractured ribs. If pain is not adequately controlled, a series of events, including shallow respiration, chest wall splinting, and avoidance of cough and deep breathing, results in atelectasis, ventilation-perfusion mismatch, hypoxemia, and pneumonitis. The end result can be prolonged ICU and hospital stay or even respiratory failure and death. Traditional treatment with parenteral opioids on demand provides inadequate pain relief and superimposes morbidity secondary to the sedative and respiratory depressant side effects of these drugs. Because of these problems, in recent years, many surgeons and anesthesiologists have been studying new techniques of pain control in the postthoracotomy patient. Local anesthetic intercostal nerve blocks have been tried by many groups in the past and have had some demonstrated benefit, but the problems of multiple daily injections of multiple intercostal nerves and the impracticality of indwelling multiple catheter systems to deliver local anesthetics intermittently to multiple intercostal nerves have resulted in abandonment of these techniques by most groups.

In 1988, Sabanathan et al3 described a simple technique of continuous regional anesthesia via a percutaneous catheter through which continuous bupivacaine could be infused into an extrapleural pocket created by the surgeon at the time of surgery by dissecting the posterior parietal pleura off the chest wall, over a five-rib area, centered on the thoracotomy incision. They reported good analgesia.

We report a pilot study, using a retrospective audit, of the effectiveness of this technique. We have, however, substituted a continuous infusion of 1% lidocaine hydrochloride at a dose of 0.1 mL/kg/h (1 mg/kg/h) for the bupivacaine used by previous investigators.

Materials and Methods

A retrospective, descriptive study was designed to evaluate the effectiveness of postthoracotomy continuous-infusion lidocaine ex-
trapeleural intercostal block (EPIB) in controlling postoperative pain. All consecutive cases of patients who underwent posterolateral thoracotomy during a 6-month period from October 1, 1992, to April 30, 1993, were evaluated. In some thoracotomies performed during this period, the pocket could not be made because of dense adhesions, pleural plaques, or surgical resection of the pleura. In 17 patients (18 thoracotomies), the pocket was dissected. A 16-g, 12-inch long polyurethane, single-lumen central venous catheter with side holes (model AK-04400; Arrow International; Reading, Pa) was introduced percutaneously through a low posterior interspace and was sutured in place (Fig 1). Earlier experience had shown that intermittent dosing and smaller diameter catheters were unsatisfactory because of frequent catheter occlusion. Most patients had 10 mL of 1% lidocaine instilled in the pocket intraoperatively, and all had a continuous infusion at a rate of 1 mg/kg/h for 3 or 4 days after surgery. Intravenous morphine, sulfate (MS) was given on demand until the patient was sufficiently awake to begin using patient-controlled analgesia with MS.

RESULTS

Demographics and Surgical Variables

There were 18 thoracotomies on 12 male and 5 female patients (one male patient had bilateral thoracotomy) with a mean age of 58 years (range, 22 to 82 years). Sixty-seven percent of patients were surgically treated for bronchogenic carcinoma, 22% for other neoplasms, and 11% for benign disease.

Surgical operations included pneumonectomy, 11%; lobectomy, 33%; and wedge or segmental resection, 55% (Table 1). Rib fracture, usually “green stick,” was noted in 28% of patients secondary to retraction. Ribs were reapproximated by figure of eight doubled No. 1 polyglycolic acid sutures placed through drill holes in the lower rib in 83%. This technique is employed to avoid pain consequent to compression of intercostal nerves. Rib resection was performed in 6% (1) of patients, and pleural adhesions were dissected in 41%.

Mean FVC was 3.39 L (range, 1.6 to 5.5 L; predicted mean, 3.93 L); mean FEV₁ was 2.43 L/s (range, 0.92 to 4.58; predicted mean 3.19 L [Table 2]).

Pain Outcomes

Postoperative day (POD) 1 was defined as starting at the completion of surgery and ending at 7 AM the following morning. Each subsequent POD consisted of

| Table 1—Patient Information
| Age, yr | Mean | 57.7 |
| Range   | 2-82 |
| Sex     |      |
| M       | 12   |
| F       | 5    |
| Race, % |      |
| White   | 83.3 |
| Hispanic| 11.1 |
| Black   | 5.6  |
| Diagnosis, %     |      |
| Bronchogenic carcinoma | 67   |
| Lung metastasis   | 22   |
| Benign disease    | 11   |
| Surgical operation, % |      |
| Wedge resection   | 55.3 |
| Lobectomy         | 33.2 |
| Pneumonectomy     | 11.0 |

Figur 1. Spiral CT reconstruction of the thoracic skeleton used to illustrate the position of the catheter (black line) located in a dissected retrapleural pocket (cross-hatched area), overlying five intercostal nerves and the paravertebral sulcus, which is continuously perfused with 1% lidocaine.
3 nursing shifts of 8 h each, from 7 AM to 7 AM.

Serum lidocaine levels were obtained on POD 2 and 3 in 14 and 13 patients, respectively. Mean levels were 2.39 mg on POD 2 (range, 1.2 to 5.9) and 3.7 mg on POD 3 (range, 1.8 to 5.0 [Table 3]). One patient, a 104.5-kg man, had a serum level greater than 5 mg/mL at 5.9 mg. No patient experienced clinical toxicity secondary to administration of lidocaine (Table 3).

The total doses of MS given during each 8-h shift and 24-h day were recorded. Mean daily total doses of MS were 24.3 mg (range, 0 to 88 mg), 37.75 mg (range, 9 to 94 mg), and 34.32 mg (range, 0 to 108 mg) on POD to 1 to 3 (Table 4).

Adequacy of analgesia was documented by multiple assessments by nurses during each shift by verbal analog on a pain rating scale of 0 to 10.2 At the time of this retrospective review, differential pain scores at rest and during movement were not be obtained. Mean daily pain rating scores were 3.02 (range, 0.5 to 8.0), 3.14 (range, 0.4 to 5.1), and 2.8 (range, 0.2 to 6.6) on POD 1 to 3, respectively.

The combination of continuous EPIB and patient-controlled analgesia with MS provided adequate pain relief in most patients. In one patient, a continuous morphine basal rate was required for pain control for 1 day for treatment of unstable angina pectoris. Four patients were given additional MS doses on demand, and one patient received a single dose of ketorolac.

Nurses noted the patient’s state of sedation many times during each shift on a sedation scale of 1 to 5.3 Mean sedation scores (1=alert; 5=comatose) were 2.78 (range, 1 to 4), 2.56 (range, 1.3 to 3.6), and 2.6 (range, 1 to 3.6) on POD 1 to 3. No patient became markedly obtunded or comatose. Four patients had a sedation score of 4 on POD 1 in the hours immediately following administration of general anesthesia. Distribution of sedation scores is shown in Distribution of Table 5.

Complications

One catheter occluded on POD 3. There were no other complications that could be attributed to the catheter.

Fourteen patients were extubated in the recovery room; one patient was extubated in the ICU later on POD 1; two patients were extubated the following morning. Arterial blood gas levels were determined daily. Results in patients following extubation are tabulated in Table 6. Episodes of desaturation below 88% were recorded in 2, 1, and 3 patients on POD 1 to 3, respectively.

Atelectasis was noted on examination or roentgenogram in 3, 2, and 2 patients on POD 1 to 3. No patient required bronchoscopy or reintubation. There were no cases of pneumonia, respiratory failure, or death. One patient, who had undergone previous coronary bypass grafting and multiple coronary angioplasties, developed unstable angina pectoris on POD 3 and required emergency angioplasty. Discharge from ICU was after a mean of 3.29 days (range, 0 to 7). No patient was readmitted to the ICU. Time of hospital discharge was after a mean of 8 days (range, 5 to 12 [Table 7]).

**Discussion**

Many investigators have attempted to utilize the theoretical advantages of regional anesthesia in the management of postthoracotomy pain. Percutaneous intercostal nerve blocks have been demonstrated to be effective in reducing pain, reducing the dosage of opioids, and improving pulmonary function test results.
Findings in well-designed, randomized, double-blind, prospective studies of intercostal nerve block given during surgery\textsuperscript{5,6} and postoperatively.\textsuperscript{6} Although the technique has proven efficacy, logistic considerations and the patient discomfort and risks associated with repeated blocks lead physicians to utilize this technique infrequently in postoperative patients.

A variety of systems of single\textsuperscript{7} and multiple\textsuperscript{8,9} indwelling intercostal catheters have been described to allow serial or continuous regional analgesia. These techniques have not been adopted by thoracic surgeons for general usage.

The difficulty in explaining how a single intercostal injection or catheter can provide wide field analgesia has been explained by studies demonstrating passage of the injected local anesthetic agent retrograde along the subcostal space into the paravertebral space.\textsuperscript{10} While the paravertebral space can be cannulated percutaneously, there is a high failure rate with this technique.\textsuperscript{11}

In an effort to avoid some of the methodologic difficulties inherent in intercostal nerve block, investigators have tried placement of indwelling intrapleural catheters with intermittent or continuous instillation of local anesthetic agents for postoperative pain control.\textsuperscript{12} It is assumed that the anesthetic will diffuse across the pleura to bathe the intercostal nerves, thus providing an equivalent to intercostal nerve blocks, without the need for multiple injections. Three single-arm studies have found this technique to be valuable after thoracotomy in children.\textsuperscript{13-15} Three double-blind, randomized studies have shown improved pain control, reduced narcotic dose, and improvement of various respiratory parameters.\textsuperscript{16-18} Four other studies have found the technique to be ineffective,\textsuperscript{19-22} and in two further studies, intrapleural analgesia was found to be inferior to intercostal block.\textsuperscript{6,23} High measured levels of anesthetic in chest tube effluent help to explain the variable results. It is important to place the patient in a supine position or with the side on which the surgical operation was done down in order to keep the agent in contact with the posterior parietal pleura.\textsuperscript{13}

In 1988, Sabanathan et al\textsuperscript{1} described a technique that combines the advantages of intercostal block with those of intrapleural analgesia. At the completion of thoracotomy, the pleura is stripped off the posterior chest wall over a five-rib area, centered on the incision. A percutaneous plastic catheter is placed in the pocket thus created, and local anesthetic is infused during closure and for a number of days after surgery into the extrapleural pocket.\textsuperscript{1} Three subsequent randomized double-blind studies, two by the same group\textsuperscript{24,25} and one from other investigators,\textsuperscript{26} have shown the technique to be effective, while a fourth study\textsuperscript{27} found no advantage over saline solution infusion.

All of these studies have utilized bupivacaine, presumably because its long duration of action carried an advantage when intermittent injections were used. Toxic plasma levels of bupivacaine are generally considered to be between 2 and 4 µg/mL. Numerous studies have used epinephrine in conjunction with the bupivacaine in a ratio of 1:200,000. Other groups have avoided it because of perceived problems with hypertension and tachycardia.\textsuperscript{28} There is no improvement in analgesia with the use of 0.25 vs 0.5% bupivacaine.\textsuperscript{29}

### Table 5—Patient Distribution of Sedation Scores

<table>
<thead>
<tr>
<th>Sedation Score</th>
<th>POD 1</th>
<th>POD 2</th>
<th>POD 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>7</td>
<td>10</td>
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<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
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</tbody>
</table>

### Table 6—Arterial Blood Gas Levels in Extubated Patients

<table>
<thead>
<tr>
<th>Arterial Blood Gas Value</th>
<th>Preoperative Level (n=12)</th>
<th>POD 1 (n=15)</th>
<th>POD 2 (n=13)</th>
<th>POD 3 (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO\textsubscript{2}, mm Hg</td>
<td>Mean 39.67, Range 34-45</td>
<td>45.27, Range 31-60</td>
<td>44.54, Range 37-52</td>
<td>42.85, Range 41-47</td>
</tr>
<tr>
<td>pH</td>
<td>Mean 7.41, Range 7.35-7.48</td>
<td>7.33, Range 7.23-7.41</td>
<td>7.37, Range 7.28-7.43</td>
<td>7.37, Range 7.31-7.44</td>
</tr>
<tr>
<td>HCO\textsubscript{3} mm Hg</td>
<td>Mean 25.37, Range 21.4-9.1</td>
<td>24.17, Range 19.2-27.9</td>
<td>25.76, Range 21.9-29.4</td>
<td>25.51, Range 23.5-29.6</td>
</tr>
<tr>
<td>Oxygen saturation, %</td>
<td>Mean 95.96, Range 90.6-99.8</td>
<td>97.27, Range 92-99.9</td>
<td>97.54, Range 92-99.3</td>
<td>96.2, Range 88-99</td>
</tr>
</tbody>
</table>

### Table 7—Length of Stay

<table>
<thead>
<tr>
<th>Length of Stay</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>In ICU</td>
<td>3.29</td>
<td>0-7</td>
</tr>
<tr>
<td>In hospital</td>
<td>8</td>
<td>5-12</td>
</tr>
</tbody>
</table>
Initial doses of 100 mg (20 mL of 0.5%) of bupivacaine and total doses of 400 mg/24 h have generally not resulted in serum levels above 2 µg/mL, but higher levels can occur especially in children. In one remarkable case, 20 mL of 0.375% bupivacaine was given intrapleurally every 6 h for 130 days in a cancer patient. Plasma levels remained between 1 and 2 µg/mL at all times.

We were concerned about the cases with high blood levels of bupivacaine in the series cited above, and the relative dearth of information regarding the pharmacokinetics and toxicity of bupivacaine. Since regional anesthetic was to be delivered continuously, there seemed to be little advantage to using a long-acting drug. Accordingly, we elected to utilize lidocaine. Lidocaine, at the dosage used in this study (1 mg/kg/h), is routinely given safely, intravenously in critically ill ICU patients in the management of ventricular premature beats; lidocaine, 300 to 400 mg/h, has been given intrapleurally with minor toxicity, and serum levels were at or below 4.7 µg/mL. Our patients experienced no detectable adverse response to the drug, and measured levels of serum lidocaine remained below the toxic range (>5 µg/mL) in all but one patient. In the future, we will use a reduced dose in patients who weigh greater than 100 kg. Serum levels of lidocaine were not obtained beyond POD 3. We cannot, therefore, recommend use of this technique beyond 3 days at this time.

At our institution, verbal pain rating scores are routinely obtained by nurses in postoperative patients. Optimally, pain scores would have been obtained at rest and with cough and movement, but since this was a retrospective study, these values could not be obtained. Nevertheless, the mean pain scores demonstrated quite good pain control. Nurses and physicians were subjectively impressed by the level of analgesia provided. Although EPIB provides analgesia, it is usually not sufficient in itself to provide adequate pain relief, and adjuvant medications are required.

Mean total MS doses per day were also low. This was true in spite of the fact that the patient who had bilateral thoracotomies had by far the highest MS requirements. Low opioid doses resulted in low sedation scores and an absence of serious morbidity and mortality.

Only one study comparing this technique with epidural methods has been published. It found EPIB to provide equivalent analgesia to continuous epidural infusion of morphine, with a lower rate of complications.

One disadvantage is the technical difficulty of creating the paravertebral pocket in some patients with pleural disease. On the positive side, an anesthesiologist with special skills is not required; it is inexpensive; catheter-related malfunction is rare; pruritus was not seen.

In summary, we have confirmed the favorable experience of Sabanathan et al with the technique of continuous EPIB following thoracotomy. We found continuous EPIB with 1% lidocaine to be a simple, safe, and effective technique in the care of our patients. Relative effectiveness of EPIB needs to be tested in prospective, randomized studies comparing this technique with bupivacaine EPIB and epidural anesthesia.

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REFERENCES


3 Bidwai AV, Cornelius LR, Stanley TH. Reversal of Innovar-associated postanesthetic somnolence and disorientation with physostigmine. Anesthesiology 1976; 44:249-52


8 Dryden CM, McMenemy I, Duthie DJR. Efficacy of continuous intercostal bupivacaine for pain relief after thoracotomy. Br J Anaesth 1993; 70:508-10


12 Kvalheim L, Reiestad F. Intrapleural catheter in the management of postoperative pain. Anesthesiology 1994; 61:A231


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23 van Kleef JW, Burn AGL, Vletter AA. Single-dose interpleural versus intercostal blockage: nerve block characteristics and plasma concentration profiles after administration of 0.5% bupivacaine with epinephrine. Anesth Analg 1990; 70:484-88
28 El-Baz N, Faber LP. Intrapleural infusion of local anesthetic: a word of caution. Anesthesiology 1988; 68:909-10