

## General Thoracic Surgery

# Extrapleural regional versus systemic analgesia for relieving postthoracotomy pain: A clinical study of bupivacaine compared with metamizol

Mehmet Bilgin, MD  
Yigit Akcali, MD  
Fahri Oguzkaya, MD

**Background:** The effects of a local anesthetic delivered through a catheter inserted in the extrapleural region by a surgeon and an analgesic agent given systemically on pain after thoracotomy were assessed.

**Methods:** The patients in group I (n = 25) had a catheter inserted between the parietal pleura and the endothoracic fascia by a surgeon, and 0.5% bupivacaine was given through this catheter. Another 25 patients (group II) had metamizol given intravenously. Respiratory function tests, arterial blood gases, range of shoulder motion, and postoperative pain were evaluated for each group. Bupivacaine and metamizol were given just before finishing the thoracotomy and then repeated every 4 hours for 3 days.

**Results:** There was no statistical difference in arterial blood gases between the groups ( $P > .05$ ). There were statistically significant differences in the respiratory function tests, range of shoulder motion, and visual analogue scale ( $P < .05$ ) between the groups. Group I had fewer complications than group II. There was no mortality in either group.

**Conclusions:** Bupivacaine given through a catheter to the extrapleural region before finishing thoracotomy is substantially beneficial for the prevention of postoperative pain and reduction of postoperative complications.

**C**ontrolling pain after thoracotomy is important for patient comfort and the prevention of possible complications during the postoperative period. Pain after thoracotomy hinders deep breathing and effective cough in patients. Accordingly, lungs cannot expand and this leads to atelectasis and intrapulmonary shunting with complications.

The aim of this study was to assess the analgesic effects of a long-acting local anesthetic (0.5% bupivacaine) given through a catheter inserted in the paravertebral region extrapleurally before finishing thoracotomy versus a systemic analgesic agent (metamizol) and their effects on respiratory functions.

### Material and Methods

This study was performed between January 1998 and December 2001. The patients in group I (n = 25) had a catheter inserted between the parietal pleura and the endothoracic fascia by

From the Department of Thoracic Surgery, Erciyes University Medical Faculty, Kayseri, Turkey.

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Address for reprints: Mehmet Bilgin, Department of Thoracic Surgery, Erciyes University Medical Faculty, 38039, Kayseri, Turkey (E-mail: bilginm@erciyes.edu.tr).

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**TABLE 1. Surgical procedures\***

Surgical procedures	Group I	Group II
Lobectomy	3	2
Bilobectomy	4	4
Pneumonectomy	2	2
Metastasectomy	3	3
Cystotomy plus capitonnage	7	7
Resections of bullae and blebs	6	7
Total	25	25

\*Thirty-two patients had left thoracotomy and 18 patients had right thoracotomy.

a surgeon and 0.5% bupivacaine was given, adjusted according to the weight (0.1 mg/kg) and completed to 10 mL with saline, through this catheter. The other 25 patients (group II) had metamizol (1 g) given intravenously. There were 38 male patients and 12 female patients; their average age was  $46.75 \pm 13.56$  years (range 21-70). The patients were randomly selected.

All these doses were repeated every 4 hours. The catheter was removed after 3 days and systemic analgesic, metamizol, was discontinued.

Forced vital capacity (FVC), forced expiratory volume in 1 second ( $FEV_1$ ), and blood gases were measured preoperatively and postoperatively. Surgical procedures were performed by a standard thoracotomy (Table 1).

Visual analogue scale (VAS) was used for pain scoring. Patients were informed about the procedure before the operation and their consent was obtained. Pain intensity was assessed just after the patient woke up and then at hours 4, 8, 12, 16, 20, 24, 48, and 72. Samples for blood gas analyses were obtained at hours 1, 2, 24, 48, and 72. FVC and  $FEV_1$  values were measured at hours 24, 48, and 72 and on day 7.

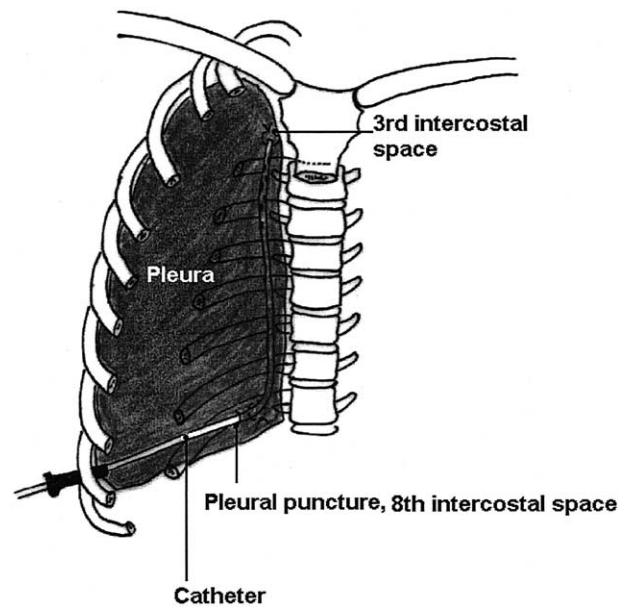
Chest radiographs were obtained in the first 3 days in all patients to evaluate possible complications. Range of shoulder motion (ROM) was measured during the first 5 days.

### Surgical Technique

Before finishing the thoracotomy, a 16-gauge catheter needle was extended out of the thorax through the posterior axillary line in the eighth intercostal space. The catheter was passed through the needle and after moving it into the thorax, the needle was removed. A small hole was opened on the parietal pleura in the paravertebral region through the third intercostal space. Through this hole an extrapleural tunnel was opened to the eighth intercostal space by sterilized biopsy forceps of flexible bronchoscope. The catheter tip was pulled upward with biopsy forceps. The proximal and distal holes in the parietal pleura were deeply closed with 3-0 absorbable sutures to prevent external drug leaks (Figure 1).

### Statistical Analysis

Statistical analyses were made by using Student *t* test (FVC,  $FEV_1$ , ROM, and blood gases), Mann-Whitney *U* test (pain intensity at rest and when coughing), and significance test for the difference between the 2 percentages (age). A *P* value less than .05 was considered significant.



**Figure 1. The schematic illustration of paravertebral catheter insertion.**

### Results

There was no statistically significant difference between the groups in age and sex ( $P > .05$ ). There was no statistical significant difference in respiratory functions between both groups preoperatively ( $P > .05$ ). A decrease in FVC and  $FEV_1$  values was found in both groups when compared to the preoperative values. On the first day when the mean FVC and  $FEV_1$  values were compared with the preoperative values, in group I FVC was 54% and  $FEV_1$  was 55% and in group II, FVC was 42% and  $FEV_1$  was 38% of the preoperative values. In both groups, FVC and  $FEV_1$  values gradually increased in subsequent days. On day 7 postoperatively, group I had 86% and 90% and group II recovered to 70% and 58%, respectively, compared with the preoperative values ( $P < .05$ ; Table 2). Improvement in postoperative respiratory functions was more rapid in the paravertebral analgesia group when compared with the systemic analgesia group.

A statistically significant decrease was observed in these values between the groups for VAS. Pain levels were statistically significant in both groups ( $P < .05$ ; Table 3). In the paravertebral analgesia group the postoperative pain was less than the systemic analgesia group during either the rest or coughing.

When the patients were asked for abduction until the pain occurred during the postoperative 5 days, the degree of abduction angle (range of motion) was found to be significantly higher in the paravertebral analgesia group ( $P < .05$ ; Table 4).

There was no statistically significant difference in arterial blood gases between the 2 groups ( $P > .05$ ).

**TABLE 2. FVC (mL) and FEV<sub>1</sub> (mL) values on postoperative day 1, 2, 3, and 7**

	Preop	Day 1	Day 2	Day 3	Day 7
FVC (paravertebral)	3370.2 ± 543.7	1793.0 ± 564.7	1927.4 ± 374.7	2398.9 ± 713.8	2897.7 ± 683.4
FVC (systemic)	3482.1 ± 324.4	1176 ± 327.9	1339.3 ± 132.8	1943.6 ± 318.6	2216 ± 423.3
P value	>.05	<.05	<.05	<.05	<.05
FEV <sub>1</sub> (paravertebral)	3143.5 ± 745.6	1623.5 ± 375.9	1893.8 ± 436.4	2276.9 ± 653.1	2792.7 ± 618.7
FEV <sub>1</sub> (systemic)	3312.2 ± 516.3	1083 ± 163.6	1280.2 ± 168.5	1872.2 ± 322.5	2143 ± 473.2
P value	>.05	<.05	<.05	<.05	<.05

**TABLE 3. The mean pain scores of the patients at rest and when coughing according to VAS during the first 72 hours**

	Upon rising	Hour							
		4	8	12	16	20	24	48	72
Paravertebral—rest	4.80 ± 1.0	3.76 ± 0.9	3.57 ± 0.8	3.78 ± 0.8	3.16 ± 0.7	2.82 ± 0.9	2.70 ± 0.3	1.89 ± 9.2	1.23 ± 0.1
Systemic—rest	6.93 ± 0.7	6.22 ± 0.3	5.87 ± 0.3	5.01 ± 1.0	4.97 ± 1.0	4.63 ± 1.1	3.80 ± 0.7	3.10 ± 0.9	26.0 ± 0.7
P value	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Paravertebral—cough	5.73 ± 0.4	4.68 ± 0.9	4.01 ± 0.4	4.18 ± 0.9	4.08 ± 0.7	3.57 ± 0.8	3.48 ± 0.8	2.58 ± 0.6	1.89 ± 0.9
Systemic—cough	7.76 ± 0.2	6.96 ± 0.8	6.38 ± 1.1	5.86 ± 0.7	5.53 ± 0.9	4.73 ± 0.7	4.03 ± 1.0	2.82 ± 0.7	2.86 ± 5
P value	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05

**TABLE 4. The mean range of shoulder motion in postoperative 5 days**

	Day 1	Day 2	Day 3	Day 4	Day 5
Group I	56.2 ± 6.8	72.0 ± 17.3	99.5 ± 14.8	131.4 ± 17.8	139.0 ± 17.6
Group II	40.6 ± 0.4	40.2 ± 11.0	70.6 ± 17.7	98.4 ± 18.0	108.3 ± 20.6
P value	<.05	<.05	<.05	<.05	<.05

In group II 3 patients developed atelectasis, 1 patient had atrial fibrillation, and 4 patients had pneumothorax with a ratio of 15% to 20%. One of the patients who had atelectasis required bronchoscopy and intensive physical therapy. In group I 1 patient had hypotension accompanied by bradycardia after the first dose of bupivacaine. No other complications occurred because of the bupivacaine infusion through paravertebral catheter.

## Discussion

Effective analgesia and blockade of perioperative stress response may improve the outcome and accelerate recovery after thoracic surgery.<sup>1</sup> The earliest change in respiratory mechanics during the postoperative period is the decrease in FEV<sub>1</sub> and FVC. These changes may be seen before any change in functional residual capacity is observed. Decreased functional residual capacity and alveolar collapse during anesthesia may be further impaired by restrictive ventilation caused by postoperative pain and abnormal respiration pattern.<sup>2</sup> When airways are obstructed or atelectasis develops, air flow to this region is impaired. Secretions accumulate and a focus for infections may occur. There is a positive correlation between postoperative pulmonary complications and respiratory function tests.<sup>3</sup> Systemic analgesics may be used for pain after thoracotomy.

Currently, epidural anesthesia is the gold standard for postoperative pain management in thoracic surgery but hypotension, muscle weakness, and urinary retention are unwanted effects following epidural blockade.<sup>4</sup>

Intercostal nerve blocks can be performed either intraoperatively or postoperatively. They provide good relief lasting 6 to 12 hours and need to be repeated.<sup>1</sup> An alternate route is the administration of local anesthetic through an intrapleural catheter. This is done by placing a catheter between the parietal and visceral pleura and running the infusion either intermittently or continuously. One of the problems is the loss of local anesthetic solution through the chest tubes; these tubes need to be clamped intermittently for this technique to be effective.<sup>1</sup> It is not safe to clamp chest tubes, which provide drainage of hemorrhage and air and lung patency for expansion, during the postoperative period. Also, there are some reports suggesting that interpleural practices are not safe.<sup>5</sup>

In our study the dose of bupivacaine was less than toxic limits. Patients received a mean daily dose of 38.3 mg bupivacaine, and no systemic side effects were observed except in 1 patient who developed bradycardia and hypotension, which spontaneously resolved within 15 minutes. In the literature no toxicity was found when doses approximately 10-fold higher than ours (360 mg) were adminis-

tered.<sup>6</sup> In the studies where bupivacaine was administered by an interpleural catheter, it was suggested that toxicity resulted from the systemic absorption of bupivacaine because of the rich vascularity of pleura.<sup>7</sup> When blood levels exceed 2.0 to 4.0  $\mu\text{g}/\text{mg}$ , toxic effects involving the central nervous system and cardiovascular system may occur.<sup>7</sup> Dry mouth, reversible myosis caused by stellate ganglion blockade, and ptosis have been reported.<sup>8</sup> Many studies have shown that bupivacaine is fairly effective, with no associated toxicity.<sup>3,6,8,9</sup>

VAS is one of the most reliable methods used for evaluating pain levels.<sup>10</sup> As patients were informed about rating their pain levels in the preoperative period, VAS could easily be used. Administering anesthetic agent during the operation in group I patients provided early pain control and reduced despair and nervousness, which is important for pain control.

Local anesthetics will block the volley of nerve impulses in the unmyelinated C fibers and prevent prolonged widespread increase in the spinal cord dorsal horn. This is known as "windup" phenomenon or central sensitization. Even large doses of opioids alone will not be able to prevent this phenomenon or, once it is established, they will not be able to counteract it effectively.<sup>1</sup> Early pain control avoids the windup phenomenon and central sensitization.<sup>1</sup> Pain relief provided by inserting a catheter in the extrapleural region seems to be more effective compared with metamizol. The pulmonary complications resulted from the lack of effective coughing due to the pain in group II patients.

Another cause of pain after thoracotomy is the organs innervated by sympathetic nerves and visceral pleura.<sup>3</sup> The insertion of the catheter next to the sympathetic nerves reduces these types of pain and avoids an arrhythmic pattern observed in the postoperative period due to sympathetic activation. In this study 1 patient in group I had bradycardia, which resolved spontaneously in 15 minutes.

Many factors are involved in the occurrence of the restriction in lungs following thoracotomy. Changes in pulmonary functions result from lung resection, atelectasis, and volume loss due to pneumothorax and also inspiratory muscle dysfunction.<sup>6</sup> We had a similar observation in terms of a decrease in FVC and FEV<sub>1</sub> values during the postoperative period in both groups. Studies assessing the effects of pain following thoracotomy have shown substantial improvements in postoperative pulmonary functions after intercostal blockade.<sup>1</sup>

The mechanism of action of extrapleural regional anesthesia depends primarily on diffusion of the analgesic agent into the paravertebral region.<sup>11</sup> Local anesthetic agents affect not only ventral nerve roots but also afferent fibers of posterior primary ramus. Posterior ligaments of posterior primary ramus innervate posterior spinal muscles

and skin. These ligaments were traumatized during the posterolateral thoracotomy.<sup>12</sup> The procedure involving intermittent administration of anesthetic agent to this region through a catheter inserted in extrapleural region creates an anesthetic region in the skin due to the blockade of this region by the anesthetic agent. The depth and width of this anesthetic region depend on diffusion of the agent in the extrapleural region. This finding is one of the method's objective criteria for providing pain relief after thoracotomy.

Pain relief during the postoperative period may reduce postoperative complications with early ambulation of patients. The painless arm abduction and the elevation degree were greater in group I compared with group II patients. This observation explains the lack of complications in group I; it also resulted in an increase in the patients' self-confidence because of the fact that they carried their own chest drainage tubes themselves.

This study shows that regional anesthesia provided by a long-acting local anesthetic bupivacaine through a catheter surgically inserted into extrapleural region is effective in postoperative pain control. This safe, cheap, and effective method shows a decrease in possible lung complications and exerts a positive effect on respiratory functions following thoracotomy.

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