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EXTRAPLEURAL VERSUS EPIDURAL CATHETER TECHNIQUES EMPLOYING ROPIVACAINE ANALGESIA FOR POST-THORACOTOMY PAIN RELIEF

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Abstract

Objective: To assess the effectiveness of the long acting local anesthetic (0.25% ropivacaine) intermittently administered through an extrapleural paravertebral catheter versus a thoracic epidural catheter on postthoracotomy pain relief.

Patients and Methods: Forty patients undergoing elective posterolateral thoracotomy during the period between July 2001 and August 2002 were prospectively studied. They were randomly allocated into two groups (A and B) of 20 patients each. Group A patients received an epidural-type catheter inserted by the surgeon into an extrapleural pocket extending for 2 to 3 intercostal spaces both above and below the thoracotomy incision alongside the vertebral column by the conclusion of operation. A bolus dose of 15 ml of 0.25% ropivacaine analgesia was given during chest closure. Group B patients received a thoracic epidural catheter inserted by the anesthesiologist at T5-6 or T6-7 interspace before induction of anesthesia. A bolus dose of 15 ml of 0.25% ropivacaine analgesia was given after confirming the correct position of the epidural catheter. Postoperatively, patients in both groups were intermittently administered 25 ml of 0.25% ropivacaine analgesia at 6 hourly intervals for 3 successive days. Pain scores (verbal rating scale), requirement of additional analgesia (NSAID), pulmonary function test, shoulder range of motion as well as any complication encountered were assessed and compared in both groups.
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Results: Excluding the immediate postoperative arousal period, the extrapleural analgesia provided better pain control than the thoracic epidural analgesia in the form of less mean values of the verbal rating scale (VRS). Also, the extrapleural analgesia provided more rapid improvement of pulmonary functions, progressive increase of the shoulder range of motion (SRM) as well as less analgesic requirements in comparison to the thoracic epidural analgesia. However, these differences were statistically non-significant (P>0.05). Side effects namely, hypotension, bradycardia, and atelectasis were troublesome only in the thoracic epidural analgesia group. There was no mortality in either group.

Conclusion: Extrapleural paravertebral catheter technique is a valuable alternative to the thoracic epidural technique for post-thoracotomy pain relief. It is easy to perform by the surgeon at the conclusion of operation without complications or side effects. It should be considered as the first choice alternative for post-thoracotomy pain control.

Introduction

Patients undergoing thoracotomy experience severe and intense pain as a consequence of tissue damage to the ribs, muscles, and peripheral nerves that alter chest wall mechanics (Richardson et al 1999). Ineffective chest expansion may predispose to atelectasis, ventilation/perfusion mismatching, hypoxemia, and infection (Kruger and Mc Rae 1999). Effective clearing of secretions with cough and early mobilization can lead to quicker recovery and shorter length of hospital stay (Soto and Fu, 2003).

Various treatment modalities have been introduced for the management of post-thoracotomy pain. These include epidural analgesia, intercostal nerve blockade, cryoanalgesia, systemic use of opioids or nonsteroidal antiinflammatory drugs, and subarachnoid opioid administration (Tetik et al, 2004). Systemic administration of narcotics or nonsteroidal antiinflammatory drugs, either alone or in combination, often do not result in satisfactory pain relief. Furthermore, serious adverse effects may occur at higher doses. The modern strategies therefore aim at improving pain relief by se-
selective administration of drugs to the pain-causing anatomic region rather than by the systemic route (Kavanagh et al., 1994).

Intercostal nerve blocks can be performed either intraoperatively or postoperatively. They provide good pain relief lasting for 6 to 12 hours, however the uncomfortable status of the patients because of serial injections and long-term intercostal neuralgia have been reported as disadvantages of this technique (Peeters-Asdourian and Gupta 1999) and (Dryden et al. 1993). Sabanathan and associates, 1988 have initiated the technique of extrapleural intercostal nerve block that allows the thoracic surgeon to place a catheter into an extrapleural pocket at the conclusion of operation. This indwelling extrapleural catheter allows frequent dosing or continuous infusions of local anesthetic agents and avoids multiple needle injections (Soto and Fu, 2003). No reliable formula has yet been developed to define the dose of local anaesthetic required for paravertebral intercostal blockage, however many investigators assumed in an adult that a volume of 15 ml will spread over and block at least 3 dermatomes (Richardson and Lonnqvist 1998).

Ropivacaïne is a new long acting amide local anesthetic available as a pure S-enantiomer closely related in structure to Bupivacaïne and Mepivacaïne (Behnke et al., 2002). Several Studies have demonstrated that ropivacaïne has a lower CNS and cardiotoxic potential than bupivacaïne and is suitable for epidural anesthesia (Behnke et al., 2002) and (Lemay et al., 2003). Lemay and associates, 2003 reported successful use of a single large bolus dose of 10 ml ropivacaïne 0.75% for thoracic paravertebral analgesia during minor breast cancer surgery without systemic complications. They concluded that the Maximal ropivacaïne plasma concentrations resulting from paravertebral blockade are similar to those reported with equivalent doses of bupivacaïne (Lemay et al., 2003). The present study was designed to assess the analgesic effect of 0.25% ropivacaïne on post-thoracotomy pain when intermittently administered through an extrapleural paravertebral catheter versus a tho-
racic epidural catheter.

**Patients and Methods**

During the period between July 2001 and August 2002, forty consecutive patients undergoing elective posterolateral thoracotomy were prospectively studied. Patients unable to co-operate, those with infection at the proposed site of epidural catheter placement, patients who had FEV1 of less than 60% from the reference value and those with preoperative abnormal shoulder range of motion were excluded from the study. Two randomized groups of 20 patients each were compared regarding the intensity of post-thoracotomy pain, recovery of ventilatory functions, shoulder range of motion as well as any other complication encountered.

**Anesthetic technique:** One day before operation, the use of the hand-held spirometer was explained to the patients and the preoperative baseline ventilatory functions were obtained. The Prince Henry pain scale (Table 1) was also explained. One hour preoperatively, all patients were premedicated with 0.5 mg atropine IM, 2mg midazolam and 100 mcg fentanyl. Before induction of anesthesia, application of standard clinical monitors were done (electrocardiographic leads, automated blood pressure cuff, pulse oximeter and capnography). Anesthetic induction was done by 5mg/kg thiopental and double lumen endotracheal intubation was facilitated by 1 mg/kg succinylcholine. Anesthesia was maintained with Vecuronium 0.1 mg/kg and isoflurane (0.5-0.1% inspiratory) in 100% oxygen. The lungs were ventilated with continuous positive pressure ventilation to maintain normocapnea. No additional opioids were allowed. At the end of operation, neuromuscular blockade was antagonized by using 0.04 mg/kg neostigmine with 0.01 mg/kg atropine IV.

**Epidural catheter technique:** Before induction of general anesthesia, group B patients received an epidural catheter placed at a thoracic level between T5-6 or T6-7. With the patient in sitting position the catheter was introduced by using the paramedian approach and loss of resistance technique and the catheter was
threaded for 4 cm. Three ml of 2% lidocaine with adrenaline 5mcg/ml (1/200000) was injected in the epidural catheter as a test dose. A bolus dose of 15 ml 0.25% ropivacaine analgesia was given after confirming the correct position of the epidural catheter. Postoperatively, patients received intermittent infusion of 25 ml of 0.25% ropivacaine analgesia at 6 hourly intervals for 3 successive days.

**Extrapleural paravertebral catheter technique:**
At the end of the surgical procedure and just before closure of the posterolateral thoraectomy incision, group A patients received an extrapleural paravertebral catheter based on the technique originally described by Sabanathan and coworkers, 1988. The parietal pleura was stripped off the posterior chest wall up to the vertebral bodies for two to three intercostals spaces above and below the level of the thoracotomy, exposing the paravertebral space. A 16-gauge needle was extended out of the thorax in the 7th or 8th intercostals space at the midaxillary line. An epidural-type catheter was passed through the needle tip into the thorax then the needle was removed. The catheter tip was advanced into the paravertebral space, under direct vision, to lie alongside the vertebral column perpendicular to the intercostal spaces. The final position of the catheter was with its lower portion in the inferior part whereas its tip in the superior part of the paravertebral space. The parietal pleura was then re-placed and held in position by absorbable sutures to prevent leakage of the perfusate into the pleural cavity. A bolus dose of 15 ml 0.25% ropivacaine analgesia was given during chest closure. Postoperatively, patients received intermittent infusion of 25 ml of 0.25% ropivacaine analgesia at 6 hourly intervals for 3 successive days. An additional analgesic (75 mg diclofenac sodium) was given by IM injection to any patient in both groups on request and the time and frequency of administrations were recorded.

**Measurements:**
Postoperative pain intensity was assessed just after the patient woke up then at 4 hourly intervals during the first 48 hours and at 6 hourly interval during the next 24
hours by verbal rating scale (VRS-Prince Henry pain scale) (Table 1) (Takamori et al., 2002). Patients were asked their perceived level of pain at rest, on deep breathing and on maximal coughing. Pulmonary function tests, forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) values, were measured before surgery and at hours 24, 48, and 72 and on day 7 postoperatively. These tests were performed with patients relaxed and sitting upright. Postoperative respiratory complications were recorded. Muscle strength and range of shoulder motion (ROSM) were measured before surgery. ROSM were repeated daily by the same examiner during the first 5 days postoperatively by asking the patients to make an abduction of the ipsilateral arm until pain occurred. Arterial oxygen saturation was continuously monitored by a pulse oxymeter (Spo2) using a finger probe until the first postoperative morning. Samples for blood gas analyses were obtained from the radial artery at 6 hourly intervals for the first 24 hours. The frequency and time of requested additional analgesia (NSAI) was recorded for both groups. Untoward effects such as hypotension (decrease of BP by 30% or more compared with the baseline), confusion, nausea, convulsions and vomiting were observed.

**Statistical analysis**

Statistical analysis was performed by the SPSS (version 8) for windows statistical package. Data were presented and analysed using students t-test. The probability (P) less than 0.05 was considered significant.

**Results**

Forty patients were qualified for this study. The characteristics of these patients and their operative procedures were shown in (Table 2). There were no statistically significant differences between the 2 patient groups with respect to age, gender or the procedure performed (P>0.05). Placement of the extrapleural catheters were simple and did not cause any local problems. Positioning of the thoracic epidural catheters were successfully done in all patients.

During the postoperative arou
sal period, pain scores were higher in the extrapleural group than in the epidural group (P<0.05). Subsequently, the extrapleural analgesia provided better pain control than thoracic epidural analgesia. The mean values of the verbal rating scale (VRS) were always less in group A compared to group B (Table 3), however these differences were statistically non-significant (P>0.05). In both groups, no patient had a pain score of four. The average analgesic requirements were always less in group A during the first five days after surgery.

Preoperative pulmonary function values (FVC and FEV1) were similar in both groups (P>0.05%) (Table 4). Although these values fell significantly (P<0.05) when measured at the first postoperative day, no difference could be seen in these changes between both groups (P>0.05). Although FVC and FEV1 values were gradually increased over the subsequent 7 days in both groups, more rapid improvement was noticed in the extrapleural paravertebral group, however these differences were statistically non-significant (P>0.05).

Table 4. There was no statistically significant difference in arterial blood gases between the 2 groups during the first 24 hours postoperatively (P>0.05).

There was no significant difference between the two groups regarding the preoperative range of shoulder motion (P>0.05%). Thoracotomy resulted in a significant reduction (P<0.005) in both groups. Although ROSM progressively increased over the next 5 postoperative days, it was better noticed among group A patients. However, these differences were statistically non-significant (P>0.05; Table 5). Eight patients in group A compared to eleven patients in group B requested additional analgesia (75 mg diclofenac sodium, IM). This difference was statistically non-significant (P>0.05). No mortality was recorded in either group. Morbidity was recorded solely in group B as 3 (15%) patients developed hypotension accompanied by bradycardia that were recovered by IV fluid infusion. Another 2 (10%) patients had atelectasis, one of whom required bronchoscopy and intensive physiotherapy.
Table 1: Prince Henry Pain scale.

<table>
<thead>
<tr>
<th>Pain intensity</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pain on coughing</td>
<td>0</td>
</tr>
<tr>
<td>Pain on coughing but not on deep breathing</td>
<td>1</td>
</tr>
<tr>
<td>Pain on deep breathing, but not at rest</td>
<td>2</td>
</tr>
<tr>
<td>Mild to moderate pain at rest</td>
<td>3</td>
</tr>
<tr>
<td>Sever pain at rest</td>
<td>4</td>
</tr>
</tbody>
</table>

*After Takamori et al. 2002.*

Table 2: Patients characteristics and types of surgical procedures.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average age (years)</td>
<td>52.9 ± 2.5</td>
<td>50.9 ± 1.8</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>13/7</td>
<td>11/9</td>
</tr>
<tr>
<td>Weight (kgm)</td>
<td>70.3 ± 2.2</td>
<td>69.2 ± 2.1</td>
</tr>
<tr>
<td>Disease (benign/malignant)</td>
<td>7/13</td>
<td>7/13</td>
</tr>
<tr>
<td>Lobectomy</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Bilobectomy</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Resection of bullae</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Anti-reflux procedures</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

*Twenty-four patients had right thoracotomy and sixteen patients had left thoracotomy.*

Table 3: Postoperative pain scores during the first 72 hours in both groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>4 H</th>
<th>8 H</th>
<th>12 H</th>
<th>16 H</th>
<th>20 H</th>
<th>24 H</th>
<th>48 H</th>
<th>72 H</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.2 ± 0.4</td>
<td>1.7 ± 0.7</td>
<td>1.4 ± 0.8</td>
<td>1.3 ± 0.7</td>
<td>1.3 ± 0.8</td>
<td>1.2 ± 0.8</td>
<td>0.9 ± 0.7</td>
<td>0.8 ± 0.7</td>
</tr>
<tr>
<td>B</td>
<td>1.9 ± 0.4</td>
<td>1.8 ± 0.6</td>
<td>1.7 ± 0.6</td>
<td>1.5 ± 0.6</td>
<td>1.5 ± 0.7</td>
<td>1.4 ± 0.7</td>
<td>1.2 ± 0.7</td>
<td>0.9 ± 0.7</td>
</tr>
<tr>
<td>( p ) value</td>
<td>&lt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

Table 4: Pulmonary functions before and after surgery in both groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>FVC (A)</td>
<td>28.36 ± 577</td>
<td>1467±334</td>
<td>1629±414</td>
<td>1923±390</td>
<td>2162±427</td>
</tr>
<tr>
<td>FVC (B)</td>
<td>29.19 ± 512</td>
<td>1414±373</td>
<td>1579±266</td>
<td>1871±293</td>
<td>2111±333</td>
</tr>
<tr>
<td>( p ) value</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>FEVI (A)</td>
<td>2.46 ± 412</td>
<td>1248±278</td>
<td>1429±303</td>
<td>1723±321</td>
<td>1987±287</td>
</tr>
<tr>
<td>FEVI (B)</td>
<td>2.29 ± 383</td>
<td>1190±221</td>
<td>1398±227</td>
<td>1693±344</td>
<td>1954±306</td>
</tr>
<tr>
<td>( p ) value</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

\( A \)= group A, \( B \)= group B, \( FEVI \)= Forced vital capacity in one second, \( FVC \)=forced vital capacity.
Table (5): Shoulder range of motion before and after surgery in both groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group A</th>
<th>Group B</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preoperative</td>
<td>166.4 ± 6.5</td>
<td>164.3 ± 6.9</td>
<td>0.12</td>
</tr>
<tr>
<td>Postoperative</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>52.1 ± 11.4</td>
<td>50.3 ± 6.1</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Day 2</td>
<td>71.5 ± 10.6</td>
<td>69.4 ± 6.8</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Day 3</td>
<td>91.8 ± 8.1</td>
<td>89.9 ± 8.9</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Day 4</td>
<td>120.1 ± 7.8</td>
<td>118.3 ± 6.8</td>
<td>&gt; 0.05</td>
</tr>
<tr>
<td>Day 5</td>
<td>137.5 ± 8.1</td>
<td>134.7 ± 8.2</td>
<td>&gt; 0.05</td>
</tr>
</tbody>
</table>

Discussion

Although thoracic epidural analgesia has been shown as the gold standard method for providing highly effective control of postoperative pain, it may not be suitable especially in patients suffering from a coagulation disorder. Furthermore, this technique requires considerable experience (Giebler et al 1997) and may in some patients even be technically impossible (e.g., for anatomic reasons or after spinal operations) (Kaiser et al, 1998). Potential serious complications, such as dural puncture, bleeding, hematoma, and infection at the catheter implantation site need to be taken into consideration with this technique (Liu et al 1995). Therefore, recent interest has reemerged in the management of thoracotomy pain by the extrapleural paravertebral nerve blockade originally described by Sabanathan and colleagues 1988. In this technique a catheter is placed in the extrapleural paravertebral space, under direct vision, by the surgeon before chest closure through which a local anaesthetic is injected. The local anesthetic spread through the paravertebral spaces leading to blockade of the intercostal nerves, their collateral branches, posterior primary rami and the sympathetic chain (Sabanathan et al 1990).

As far as we can ascertain, previous studies comparing ropivacaine analgesia intermittently administered through extrapleural
and epidural routes has not been described before in the literature. However, several investigators have compared extrapleural and epidural analgesia, employing continuous infusion of the structurelessly related local anesthetic bupivacaine (Matthews and Govenden, 1989) and (Richardson et al., 1999).

Deneville and associates, 1993 reported safe extrapleural infusion of bupivacaine after a mean daily dose of 360 mg. Bilgin and colleagues, 2003 have demonstrated the effectiveness of intermittent extrapleural 0.5% bupivacaine administration (0.1 mg/kg) at 4 hourly intervals for 3 days in controlling post-thoracotomy pain and reduction of postoperative complications (Bilgin et al., 2003). In the current study, an average daily ropivacaine dose of 250 mg was safe when administered through the extrapleural route whereas hypotension and atelectasis were troublesome in three and two patients respectively, when ropivacaine administered through the epidural route.

Results of the current study indicate that pain scores were higher in the extrapleural group than in the thoracic epidural group during the postoperative arousal period (P < 0.05). Kaiser and associates 1998 and Eng and Sabanathan 1991 had comparable results. They attributed this variation to the inevitable setup differences between the two study groups as thoracic epidural analgesia was initiated before operation whereas, extrapleural analgesia was started by completion of the operation. Hence, the interval between chest closure and the patient’s arousal might have been too short for the anesthetic agent to diffuse from the catheter to the intercostal and paravertebral spaces, which play a major role for the pain-relieving effect of extrapleural analgesia. Providing analgesia and anesthesia before initiating the pain-causing action (preemptive analgesia) reduced pain sensitization within the central nervous system in the thoracic epidural group.

After the the postoperative arousal period, both techniques provided effective pain control on the Prince Henry pain scale with a statistically non-significant differ-
ences between them (P>0.05). The requirements of nonsteroidal anti-inflammatory drugs (NSAID) were more frequently requested in the thoracic epidural group (P<0.05%). Some investigators (Dau-
phin and associates 1997) and (Richardson and associates 1993) reported similar pain scores in both groups whereas others (Rich-
ardson and associates 1999) reported significantly lower pain scores both at rest and on coughing in the paravertebral group compared to patients in the epidural group.

Many factors are involved in the occurrence of the restriction in lungs following thoracotomy. Changes in pulmonary functions result from lung resection, atelectasis, volume loss due to pneumothorax and also inspiratory muscle dysfunction (Soto and Fu, 2003). We had a similar observation in terms of a decrease in FVC and FEV1 values during the early postoperative period followed by gradual improvements in both groups (P > 0.05). These results correlated with the results of (Peeters-Asdourian and Gupta, 1999 and Richardson and asso-
ciates 1999.) Better postoperative arterial oxygen tension were ob-
served in both groups. It could be attributed to better postoperative pulmonary function, less inhibition of clearance of secretions bac-
cause of less pain on coughing and no use of postoperative opioid analgesics.

Pain relief during the postoperative period may reduce postoperative complications with early ambula-
tion of patients. Despite the range of shoulder motion was im-
proved more in group A however, this difference was statistically non-significant (P > 0.05%). Our patients had an increased self-
信心 over the first postoperative day to the extent that they carried their own chest drainage tubes themselves. A similar better range of shoulder motion was re-
ported by Bilgin and colleagues 2003 among 25 patients who re-
ceived extrapleural bupivacaine analgesia in comparison to an equal group of patients receiving systemic analgesia after thoraco-
tomy.

Despite epidural anesthesia is currently considered the gold
standard for postthoracotomy pain management, hypotension, muscle weakness, and urinary retention are still unwanted effects (Wurnig et al., 2002). None of our epidural analgesia patients developed muscle weakness or urinary retention whereas 3 patients developed hypotension and bradycardia which resolved on IV fluid administration. Atelectasis was developed in two patients in group B. On the other hand, no complication was recorded in any patient in group A.

In conclusion, a comprehensive team approach to post-thoracotomy pain management, involving the surgeon and anesthesiologist, is vital for minimizing pain and improving patient satisfaction. The lack of any technical challenge or complication related to extrapleural paravertebral catheter insertion and better pain relief observed in the present study suggest that intermittent extrapleural infusion of ropivacaine is a safe and effective method for relief of post-thoracotomy pain.

References


Richardson J., Sabanathan S., Eng J., Mearns A., Rogers C.,


