Intrapleural intercostal nerve block associated with mini-thoracotomy improves pain control after major lung resection

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Abstract

Objective: To prospectively assess the impact of intrapleural intercostal nerve block (IINB) associated with mini-thoracotomy on postoperative pain and surgical outcome after major lung resections.

Methods: Between January 2004 and February 2005, we randomly assigned 120 consecutive patients undergoing mini-thoracotomy (10—13 cm) for major lung resections, to receive or not IINB from the 4th to the 8th space at the moment of thoracotomy using 20 ml (7.5 mg/ml) ropivacain injection at the dose of 4 ml for each space. Postoperative analgesia consisted of continuous intravenous infusion of tramadol (10 mg/h) and ketoralac tromethamine (3 mg/h) for 48 h for all patients.

Results: The two groups (60 patients each) were comparable for age, sex, pulmonary function, type and duration of the procedure. Mortality and morbidity were 0% and 10%, respectively, for the IINB group and 3.3% and 15%, respectively, for the non-IINB group (p > 0.05, NS). Mean postoperative pain measured by the ‘Visual Analogue Scale’ were as follows: 2.3 ± 1 at 1 h, 2.2 ± 0.8 at 12 h, 1.8 ± 0.7 at 24 h, and 1.6 ± 0.6 at 48 h for the IINB group; and 3.6 ± 1.4 at 1 h, 3.4 ± 2 at 12 h, 2.9 ± 1.2 at 24 h, and 2.0 ± 1 at 48 h for the non-IINB group. Differences were significant at 1 h, 12 h, 24 h, and 48 h (p < 0.05).

Mean postoperative hospital stay was 5.7 days in the IINB group and 6.5 days in the non-IINB group (p < 0.05).

Conclusion: IINB associated with mini-thoracotomy reduces postoperative pain and contributes to improve postoperative outcome after major pulmonary resections.

Keywords: Intercostal nerve block; Postoperative analgesia; Mini-thoracotomy; Major lung resection

1. Introduction

Postthoracotomy pain control represents a crucial problem in the clinical management after lung resection. Pain strongly limits pulmonary ventilation resulting in a functional lung restriction. Coughing and secretion clearing may be compromised, determining possible bronchial obstruction, atelectasis and/or parenchymal lung infection. Pain is, therefore, considered a major independent factor responsible for increased perioperative morbidity and mortality. Although a number of methods have been proposed for postthoracotomy analgesia [1—6], including systemic use of opioids and non-steroid drugs, epidural analgesia, intercostal nerve block, and cryoanalgesia, the optimal strategy is still to be defined, and pain control remains an open challenge in thoracic surgery.

Increasing knowledge and technical refinements in all surgical disciplines have shown that reduced tissue damage consequent to the use of limited surgical approaches may prove effective in significantly decreasing early postoperative pain [7,8]. In thoracic surgery, the use of muscle-sparing mini-thoracotomies for lung resections has proven to produce more tolerable pain and allow quicker functional recovery and lower postoperative complications [7,9,10].

Following these premises we have associated a minimally uncomfortable analgesic technique such as intrapleural intercostal nerve block (IINB) performed during surgery to the routine use of mini-thoracotomy for major lung resections in order to achieve adequate pain control.

The aim of this study was to assess the impact of IINB associated with mini-thoracotomy on postoperative pain and surgical outcome after major lung resections. Comparisons were made between patients who were randomly assigned to receive or not IINB in addition to continuous intravenous analgesia.

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2. Materials and methods

Between January 2004 and February 2005, we randomly assigned 120 consecutive patients undergoing mini-thoracotomy (10–13 cm) for major lung resections to receive (Group A, 60 patients) or not IINB (Group B, 60 patients). The study was approved by the Institutional Review Board. Informed consent was obtained from each patient.

Baseline analgesia for all patients consisted of continuous intravenous infusion of tramadol (10 mg/h) and ketorolac tromethamine (3 mg/h) starting at thoracotomy and continuing until 48 h after surgery. Subsequent intravenous analgesia was planned according to the patients’ request.

Patients assigned to Group A received IINB from the 4th to the 8th space, performed by the surgeon at the moment of thoracotomy, using 20 ml (7.5 mg/ml) of ropivacain injection, 4 ml for each space. Injection of the local anesthetic in each intercostal space was performed approximately 2–3 cm from the spine.

The surgical approach in all the patients was a muscle-sparing mini-thoracotomy through the 5th intercostal space, usually extended from the posterior to the anterior axillary line for a length ranging between 10 and 13 cm, and applying limited rib retraction.

Patients receiving chest wall resection or exploratory thoracotomy, patients with severe hepatic and/or renal insufficiency, and patients allergic to the drugs employed were not included in the study.

Supplementary intravenous analgesia (propacetamol chlorhydrate, 1 g) was administered upon patient’s request, and the total dose and frequency of additional analgesic intake were recorded and compared between the two groups. Additional analgesic administration was analyzed as an independent factor to exclude possible bias.

Pain level was measured at fixed times in the first two postoperative days. Patients subjectively assessed the level of pain at 1 h \( (T_1) \), 12 h \( (T_2) \), 24 h \( (T_3) \), and 48 h \( (T_4) \) after surgery by a Visual Analogue Scale (VAS) with scores ranging between 1 (pain free) and 10 (the worst imaginable pain).

At the moment of discharge, patients were asked specific questions concerning the efficacy of the pain control achieved in the in-hospital postoperative period. Analgesia was defined as: optimal, good, sufficient, or insufficient according to the patient’s satisfaction. Evaluation of pain intensity was based only on subjective patient-self-assessed parameters. Therefore, postoperative respiratory function data (except pulse oxymetry) were not considered in this study.

Oxymetry was recorded at 24 h \( (T_3) \) and 48 h \( (T_4) \) after surgery.

Duration of the surgical intervention and of in-hospital stay was recorded in all patients. Perioperative complications and the eventual need for postoperative bronchoscopic aspirations were also recorded.

2.1. Statistical analysis

Randomization was performed by sequential allocation of eligible patients to computer-generated random numbers.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squamous carcinoma</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Adenocarcinoma</td>
<td>30</td>
<td>33</td>
</tr>
<tr>
<td>Large cell carcinoma</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Carcinoid</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Metastasis</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Giant granuloma</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Hydatid cyst</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Bronchietiostasis</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1: Pathological diagnosis

All values are expressed as mean ± standard deviation. Statistical analysis of the data expressed as means was accomplished using the Student’s \( t \)-test for comparison of the two groups. Comparisons between proportions were accomplished using the \( \chi^2 \)-test.

Differences in the observed results were considered significant when \( p \) was less than 0.05.

3. Results

One hundred and twenty patients (60 in Group A and 60 in Group B) fulfilled the study criteria and were therefore included in the trial. All patients underwent major lung resection for lung cancer or for benign disease. Pathological diagnosis, reported in Table 1, shows comparable distribution between benign and malignant diseases in the two groups. There were no significant differences between patients of Group A and Group B regarding age, sex, preoperative pulmonary function, and type of surgical procedure (Tables 2 and 3). Major lung resections included lymph node dissection in patients with lung cancer. The mean operative time was 101 ± 39 min in Group A and 98 ± 37 min in Group B (\( p = 0.66, \) NS).

Mean postoperative pain measured by VAS were as follows: 2.3 ± 1 at \( T_1 \), 2.2 ± 0.8 at \( T_2 \), 1.8 ± 0.7 at \( T_3 \), and 1.6 ± 0.6 at \( T_4 \) in Group A; and 3.6 ± 1.4 at \( T_1 \), 3.4 ± 2 at \( T_2 \), 2.9 ± 1.2 at \( T_3 \), and 2.0 ± 1 at \( T_4 \) in Group B. Differences were significant at \( T_1 \), \( T_2 \), \( T_3 \), and \( T_4 \) \( (p\) at \( T_1 \), \( T_2 \), \( T_3 \) < 0.001; \( p \) at \( T_4 = 0.008 \)) (Fig. 1).

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Group A (60 patients)</th>
<th>Group B (60 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (male/female)</td>
<td>47/13</td>
<td>44/16</td>
</tr>
<tr>
<td>Age (mean)</td>
<td>66.6 ± 9</td>
<td>64.8 ± 11</td>
</tr>
<tr>
<td>Preoperative FEV 1 (% predicted)</td>
<td>83.6% ± 20.3</td>
<td>84.2% ± 19.7</td>
</tr>
<tr>
<td>Disease (benign/malignant)</td>
<td>5/55</td>
<td>3/57</td>
</tr>
</tbody>
</table>

Table 2: Patient characteristics

Differences were significant at \( T_1 \), \( T_2 \), \( T_3 \), and \( T_4 \) \( (p\) at \( T_1 \), \( T_2 \), \( T_3 \) < 0.001; \( p \) at \( T_4 = 0.008 \)) (Fig. 1).

<table>
<thead>
<tr>
<th>Type of resection</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lobectomy/bilobectomy</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td>Sleeve lobectomy</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Pneumonecotompy</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Duration of operation (min)</td>
<td>101 ± 39</td>
<td>98 ± 37</td>
</tr>
</tbody>
</table>

Table 3: Type of resection
Oxygen saturation measured at \( T_3 \) and \( T_4 \) were 96% (±4) and 96% (±3), respectively, in the IINB group and 93% (±3) and 94% (±4), respectively, in the non-IINB group. Differences between the two groups were significant in both measurements (\( p < 0.05 \)) at all measurements.

Mean postoperative in-hospital stay was 5.7 ± 0.7 days in Group A and 6.5 ± 0.9 days in Group B (\( p < 0.001 \)). Postoperative complications occurred in six patients (10%) in Group A and in nine patients (15%) in Group B, but this difference was not statistically significant (\( p = 0.5809 \)). Respiratory complications occurred in three patients (5%) in Group A and in six patients (10%) in Group B (\( p = 0.48 \)). Complications are reported in detail in Table 4. Mortality was 0 in Group A and 3.3% (two patients) in Group B (\( p = 0.475, \) NS). The two deaths that occurred in Group B were caused by myocardial infarction in one patient and by respiratory failure in the other patient.

Mean postoperative in-hospital stay of the uncomplicated patients (54 in Group A and 51 in Group B) was 4.2 ± 0.7 in Group A and 4.7 ± 0.8 in Group B (\( p < 0.001 \)).

Chest drain was removed 5.6 ± 0.7 days after surgery in Group A and 6.3 ± 0.9 days in Group B (\( p < 0.001 \)).

Bronchoscopic aspiration was performed because of pulmonary atelectasis or sputum retention in one patient.

### Table 4

<table>
<thead>
<tr>
<th>Complication</th>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atelectasis</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Broncho-pleural fistula</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>Air leak</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Hemothorax</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>6 (10%)</td>
<td>9 (15%)</td>
</tr>
</tbody>
</table>

**Efficacy of pain control.**

(1.6%) in Group A and in eight patients (13.3%) in Group B (\( p = 0.037 \)).

Supplementary analgesia was required during the first two postoperative days in four patients (6.6%) in Group A and seven patients (11.6%) in Group B (\( p = 0.526 \)). Mean additional analgesic consumption (propacetamol chloride) in the 48 h after surgery was 266 mg for patients of Group A and 333 mg for patients of Group B.

The level of patient’s satisfaction regarding the efficacy of postoperative pain control is reported for both groups in Table 5. Patients subjectively reporting an optimal or good efficacy of analgesia in Group A was 65% (39/60 patients); this rate appeared significantly higher (\( p = 0.04 \)) than in Group B (45%; 27/60 patients).

No drug-related problems or complications caused by the analgesic procedures were recorded in the postoperative period.

### Table 5

<table>
<thead>
<tr>
<th>Postthoracotomy analgesia—patient’s satisfaction</th>
<th>Group A (60 patients) (%)</th>
<th>Group B (60 patients) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>Good</td>
<td>40</td>
<td>33</td>
</tr>
<tr>
<td>Sufficient</td>
<td>28</td>
<td>43</td>
</tr>
<tr>
<td>Insufficient</td>
<td>7</td>
<td>12</td>
</tr>
</tbody>
</table>

**4. Discussion**

Adequate pain control in the early postthoracotomy period is one of the most effective ways to prevent respiratory complications and to achieve a quicker functional recovery after lung surgery [11,12]. This is the reason why in this study we have focused our analysis on the evaluation of pain scores in the first two postoperative days and on the comparison of clinical parameters (complications, length of hospitalization, time of chest drain removal, oxygenation, need for bronchoscopic management) that are indicative of the quality of postoperative outcome.

In the development of thoracotomy-related pain, emphasis has been attributed to the extent of muscular severing and to the trauma on costo-vertebral joints and on the anterior costal cartilage due to wide spreading of the ribs [8,13]. Muscle-sparing thoracotomies as an alternative to standard approaches have been advocated as means for reducing perioperative morbidity [7,9,10]. Therefore, our effort in the last years was towards the standardization of a minimithoracotomy muscle-preserving access to be employed for all major pulmonary resection in the attempt to ensure good quality of perioperative pain control associating the less possible patient discomfort related to the analgesic procedure.

IINB is an adequate method, since it is safe, quick, and easy to perform and it can be accomplished intraoperatively without additional discomfort to the patient and with no interference on the operative time. Among the commonly employed long-acting local anesthetics (bupivacaine, levobupivacaine, ropivacaine) we have preferred ropivacaine because it allows lower toxicity in the central nervous system.
and the cardiovascular system [14,15]. The efficacy of intercostal blocks has been largely tested in the literature, even in comparative randomized studies including other analgesic techniques [1,6,16–19].

In some trials, epidural analgesia has been reported to provide better pain control if compared with other currently employed methods [12,17] including intercostal blocks, thus appearing as the gold standard technique in this setting. However, epidural anesthesia is not suitable for all patients and carries risks of potential complications such as bleeding, infection, dural perforation, hypotension, bradycardia, and urinary retention [4,12]. Furthermore, immediate or delayed respiratory depression may occur when opioids are administered epidurally.

Moreover, although there are only few studies in the literature comparing intercostal nerve block (more frequently continuous INB) with epidural anesthesia, the advantages related to the latter technique are not always confirmed. In two studies [18,20], the administration of lumbar epidural morphine was found to have lower efficacy than a continuous intercostal blockade. In another trial [6] comparing continuous epidural infusion at the thoracic level, continuous paravertebral extrapleural block, and single intrathoracic intercostal block, the authors were not able to demonstrate any significant difference. However, all these studies mainly consider patients operated through a posterolateral or a standard lateral thoracotomy and trials comparing the efficacy of these analgesic techniques in association with mini-thoracotomic approaches are not available in literature.

The principal limit reported about single multilevel intercostal analgesia is that even long-acting local anesthetics (such as ropivacaine) are able to provide pain relief only for up to 6–8 h. To achieve longer duration of analgesia a continuous (paravertebral) intercostal nerve block technique has been proposed [1] and largely employed, by using an extrapleural catheter placed percutaneously at the end of the operation. However, the high rate (up to 20%) [21] of ineffective anesthetic administration due to the catheter dislocation seemed excessive and induced us to prefer the single direct infiltration modality.

Another limit usually attributed to the direct intercostal injection technique with respect to the paravertebral technique regards the reduced capacity to anaesthetize the posterior branch of the intercostal nerve that origins very closely to the spine transmitting painful impulses from the posterior part of the intercostal space. The decreased trauma on the costo-vertebral junction related to mini-thoracotomic approach may strongly reduce the component of pain coming from this anatomic district and, therefore, compensate the abovementioned drawback of our analgesic technique. We performed INB always at the time of thoracotomy. Providing analgesia before or right at the moment of the pain-causing action has been reported to reduce pain sensitization within the central nervous system [4,11]. This phenomenon could explain the satisfactory results of intercostal analgesia observed also at longer time intervals from the operation. In our study, subjectively patient-assessed intensity pain scores resulted significantly lower in the group which received INB at all the measurements performed within the first two postoperative days. Moreover, patients included in this group presented significantly shorter in-hospital stay, better oxygenation, and reduced need for bronchoscopic aspiration, thus suggesting a beneficial effect of analgesia on the surgical outcome.

Differences in perioperative morbidity and mortality rates did not reach statistical significance. However, morbidity and, in particular, respiratory complications rate resulted lower in the group of patients who received the more effective pain control (IINB group).

Supplementary intravenous analgesic consumption appeared higher (although with no statistically significant difference) in the group without IINB and this data excluded the possibility of any interference of the additional drug intake on the significance of the results obtained in the group receiving intercostal block.

Although a direct comparison with other analgesic methods is not performed in this study, the pain scores registered when IINB is employed are comparable with historical results obtained in the literature with epidural analgesia and paravertebral blocks [6,16,22].

In conclusion, we have observed that patients undergoing major lung resection through a mini-thoracotomy show reduced postoperative pain and better surgical outcome in terms of time of hospitalization, time of chest drain removal, oxygenation, and need for bronchoscopic management, when IINB is associated. The satisfactory results obtained in our experience with single multilevel intercostal analgesia suggest the opportunity to test the efficacy of this method in comparison with other techniques adopting continuous anesthetic infusion (epidural analgesia, paravertebral block) associated with muscle-sparing mini-thoracotomy.

Acknowledgement

The authors thank Dr Raffaele Masciangelo from the Department of Statistics of the University of Rome “La Sapienza” for his contribution in the elaboration of the statistical analysis.

References

Appendix A. Conference discussion

Dr D. Kim (Seoul, Korea): As you know, postoperative thoracotomy pain originates from three major factors: occasional rib fracture or intentional rib cutting, muscle division, and intercostal nerve damage during the rib spreading or pericostal suture closure. Muscle division and rib fracture are avoidable, as you know, but intercostal nerve damage is still troublesome. So it is very useful to overcome the pain from intercostal nerve damage, but the pain from nerve damage has very long duration, generally.

So my first question is the time duration of the effect of ropivacain. My second question is the early term results of the visual analogue pain scale for 7 days or for 10 days.

Dr Rendina: We have used ropivacain exactly for its prolonged effect. It's usually considered to last for 24 h at least, and the 48-h interval is the most important because it affects the early postoperative outcome of these patients. Usually our patients go out of the hospital in the third to fourth postoperative day and they draw the tubes at that time. So this is why we concentrated on this very early time interval.

I'm sorry, I didn't quite understand your second question.

Dr Kim: You showed the results of visual analogue pain scale within 2 days. My question is whether you have the early term results of pain scale on 7, 10, and 14 days or not.

Dr Rendina: That was beyond the purpose of our study. As I was saying, our purpose was to determine the pain level in the very early postoperative period.

Dr L. Molinas (Barcelona, Spain): Some people are concerned about putting in this anesthesia before the incision is done. Could you comment on that, and also if you use this for videothoracoscopic approaches.

Dr Rendina: It's very simple. The injection in the intercostal muscle is very simple and we do it upon opening the chest. Just after inserting the rib retractor, we do the infiltration with the purpose of covering also the intraoperative time and having a better coverage of the pain overall.

What was your second question?

Dr Molinas: If you use that in videothoracoscopic approaches.

Dr Rendina: No, no, we don’t use it thoracoscopically. We never tried it. In theory, thoracoscopy should be a less painful operation. We concentrated on the standard operation in thoracic surgery.

Dr A. Turma (Istanbul, Turkey): Did you assess neuralgia of the patients who underwent the intercostal block? Neuralgia is a very important problem and very difficult to cope with, and it’s seen after 3 or 4 days and lasts for at least 2 months. Did you look at the neuralgia in these patients?

Dr Rendina: No. Again, as I was saying, the purpose of this study was simply to assess the level of pain and the consequences of the level of pain in the very early postoperative period. We limited our observation to 48 h.