A prospective study of analgesic quality after a thoracotomy: paravertebral block with ropivacaine before and after rib spreading

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Abstract

Objective: Paravertebral block (PVB) is an effective alternative to epidural analgesia in the management of post-thoracotomy pain. Rib spreading (RS) is an important noxious stimulus considered a major cause of post-thoracotomy pain. Our hypothesis was that a bolus of ropivacaine 0.2% through a paravertebral catheter (PVC) inserted before RS could decrease pain during the first 72 postoperative hours. Methods: The methodology employed was to perform a prospective randomised study of 60 consecutive patients submitted to thoracotomy. Patients were divided in two independent groups (anterior thoracotomy (AT) and posterolateral thoracotomy (PT)). A catheter was inserted under direct vision in the thoracic paravertebral space at the level of incision. In each group, patients were randomised to receive a bolus of 20 ml of ropivacaine 0.2% before rib spreading (pre-RS) or after (post-RS), just before closing the thoracotomy. They postoperatively received 15 ml of ropivacaine 0.2% every 6 h combined with methamizol (every 6 h). Subcutaneous meperidine was employed as a rescue drug. The level of pain was measured with the visual analogue scale (VAS) at 1, 6, 24, 48 and 72 h after surgery. The need of meperidine as a rescue drug and secondary effects were also recorded.

Results: We did not register secondary effects in relation to the PVC (paravertebral or cutaneous bleeding or haematoma, respiratory depression, cardiotoxicity, confusion, sedation, urinary retention, nausea, vomiting or pruritus). Seven patients (11.6%) needed meperidine as rescue drug (four pre-RS and three post-RS). The mean VAS values were the following: all cases (n = 60): 4.7 ± 2.0; AT (n = 32): 4.0 ± 2.1; PT (n = 28): 5.6 ± 1.8; pre-RS (n = 30): 4.8 ± 1.9; post-RS (n = 30): 4.6 ± 2.0; AT-pre-RS (n = 16): 4.1 ± 2.0; AT-post-RS (n = 16): 3.9 ± 2.1; PT-pre-RS (n = 14): 5.6 ± 1.6; PT-post-RS (n = 14): 5.4 ± 1.7.

Conclusions: Post-thoracotomy analgesia combining PVC and a non-steroidal anti-inflammatory drug is a safe and effective practice. VAS values are acceptable (only 11.6% of patients required meperidine). It prevents the risk of side effects related to epidural analgesia. Patients submitted to AT experienced less pain than those with PT (4.0 vs 5.6; p < 0.01). PVB with ropivacaine before RS got similar VAS values than the block after RS (4.8 vs 4.6; p > 0.05). The moment of the insertion of the PVC does not seem to affect postoperative pain levels.

Keywords: Post-thoracotomy pain; Paravertebral block; Pre-emptive analgesia

1. Introduction

Pain when experienced after thoracotomy is considered the most intense, acute postoperative pain. It can adversely affect coughing and deep breathing, resulting in respiratory complications such as hypoxia, atelectasis, chest infection and respiratory failure that may delay recovery and, if severe, could be life-threatening [1].

There are many strategies to control post-thoracotomy pain; however, there is no universally accepted strategy, thus accounting for varying management policies among the different groups.

In this setting, epidural analgesia is considered as the gold standard for thoracic analgesia [2]. However, it has been largely demonstrated that a thoracic paravertebral infusion of a local anaesthetic provides similar pain relief with few side effects. This procedure is advantageous because it can be performed under direct vision by the surgeon and permits a simpler postoperative management. It also reduces the occurrence of chronic post-thoracotomy neuralgia and stress responses, and preserves pulmonary function [3].

Recently, there has been a better understanding of postoperative pain pathophysiological mechanisms, and a major emphasis has been on a multi-model approach of pain control. Several groups (including ours) have demonstrated that combining paravertebral block (PVB) and a non-steroidal, anti-inflammatory drug is a safe and effective practice [3–5].

Another interesting concept emerging from this improved knowledge of the basis of pain is the timing of analgesia...
administration. Experimental and clinical studies have shown that neuronal afferent blockade applied before injury can reduce the hyper-excitatory central state and reduce postoperative pain [6]. It has been demonstrated that peripheral tissue injury can lead to hyper-excitability and neuronal plasticity in the spinal cord dorsal horn being responsible for the maintenance of postoperative pain [7]. These findings provide a rational basis for pre-emptive measures that could be undertaken to reduce the peripheral neuronal barrage associated with tissue damage and thus reduce or eliminate postoperative pain.

Rib spreading (RS) is considered one of the most important factors involved in post-thoracotomy pain [8]. Trying to minimise it with a direct local analgesia bolus could be an interesting measure to improve postoperative pain. PVC inserted under direct vision has proven to be an effective and safe procedure in our experience [5]. Although pure pre-emptive analgesia implies analgesia before any noxious event occurs, we hypothesised that trying to block RS with a bolus of local anaesthetic through a PVC could provide a better postoperative pain control by the means of an afferent blockade before a major injury (RS is considered an important cause of postoperative pain). This way, we tried to avoid a hyper-excitatory central state and neuronal plasticity that may affect postoperative pain levels. On this basis, we decided to conduct a randomised controlled trial to determine if infusion of ropivacaine before RS could decrease postoperative pain.

2. Materials and methods

The primary end-point of the study was to check if analgesia through PVC before RS could decrease postoperative pain (first 72 h). Secondary end-point was to find the best subgroup in pain control regarding the type of thoracotomy (anterior (AT) or posteralateral (PL)). Sample size was calculated on the basis of previous similar studies finding adequate statistical power on enrolling 60 cases [3—5].

Included in this study were patients scheduled for an AT or PT thoracotomy for pulmonary resection during 2007. Written informed consent was obtained in all the cases, and the protocol was approved by our institutional ethical committee. The use of visual analogue scale (VAS) for pain measurement was explained to those involved in the study. Patients of each group (AT and PT) were allocated randomly by computer-generated random numbers to receive a bolus of 20 ml of ropivacaine 0.2% before rib spreading (pre-RS) of after (post-RS).

General anaesthesia was induced with 1.5—2 mg kg⁻¹ of propofol, 2 μg kg⁻¹ of fentanyl and 0.6 mg kg⁻¹ of atracurium and maintained with sevoflurane, nitrous oxide and oxygen. All patients were intubated with a double-lumen endobronchial tube for one-lung ventilation.

An AT or PL thoracotomy was implemented in the fourth (AT) or fifth (PT) intercostal space. One tube for wedge resections and two tubes for lobectomies were placed after resection in the seventh or eighth intercostal space; after pneumonec- tomy, the chest tube was removed in the operating room. The same policy of chest tube placement was followed in both the groups to avoid bias in the results of the study. The PVC was placed by the surgeon before or after RS.

The puncture site was situated 2.5—3 cm laterally to the thoracotomy close to the spinous process and an 18-gauge Tuohy needle was inserted perpendicularly to the skin. The needle entering into the paravertebral space was located visually by the surgeon. A catheter was then inserted 2—3 cm. After careful aspiration through the catheter, an initial bolus of 20 ml of ropivacaine 0.2% was infused pre- or post-RS.

The total dose, volume and concentration of ropivacaine were selected with respect to the previous studies, all of which showed the efficacy of plain ropivacaine in concentrations of 0.2%, starting with a bolus dose of 20 ml followed by bolus of 15 ml.

Postoperatively, patients received a bolus of 15 ml of ropivacaine every 6 h with 2 g of endovenous methamizol intercalated every 6 h, and meperidine, a synthetic opioid, as rescue drug (bolus of 50 mg subcutaneous).

Patients’ pain was evaluated with a VAS graded from 0, no pain, to 10, the worst pain imaginable, recorded 1 h after the paravertebral analgesic bolus.

The study period lasted 72 h, and data collection was performed by a third person (the assigned ward nurse) who was blinded to the randomisation and wrote the VAS score in the patient Kardex. Pre- or post-RS bolus was blinded to the nursing staff. Thoracotomy variety was not blinded.

The following data were assessed: (1) 1, 6, 24, 48, 72 h pain scores, (2) any requirement for rescue analgesia (meperidine) and (3) adverse events related to the analgesia technique, respiratory depression (respiratory rate <8 breaths/min), cardiotoxicity, confusion, sedation, urinary retention, nausea, vomiting and pruritus.

SPSS v.13 package (SPSS Inc., Chicago, IL, USA) was used for statistical data analysis. Sigma Plot 11.0 was used for graphics. The data samples were split into four data sets attending to each factor. Adjustment of data sets to a normal distribution was always verified for the applicability of parametric statistics (Kolmogorov—Smirnov test). Subsequently, the comparison of serial measurement (variables) was performed using one-way analysis of variance (ANOVA) test with Bonferroni correction for multiple comparisons.

3. Results

Sixty-four patients were enrolled initially. Four cases were excluded: two required extrapleural resection and two suffered accidental catheter removal.

No pruritus or periods of excessive somnolence were detected in either of the groups. There were no intraoperative or postoperative complications in any of the patients with regard to PVC placement or local anaesthetic infusion.

Patient characteristics and operative data were comparable between the groups (Table 1). Mean VAS values were as follows: all cases (n = 60): 4.7 ± 2.0; AT (n = 32): 4.0 ± 2.1; PT (n = 28): 5.6 ± 1.8; pre-RS (n = 30): 4.8 ± 1.9; post-RS (n = 30): 4.6 ± 2.0; AT-pre-RS (n = 16): 4.1 ± 2.0; AT-post-RS (n = 16): 3.9 ± 2.1; PT-pre-RS (n = 14): 5.6 ± 1.6; and PT-post-RS (n = 14): 5.4 ± 1.7.
Differences between the pre- and post-RS groups and thoracotomy variety (AT/PT) can be seen in Fig. 1a and b. Acceptable postoperative analgesia was provided in both the groups (pre- and post-RS) as shown by the pain scores. There was no statistical significant difference in mean VAS values between both the groups, \( p = 0.401 \) ( \( p > 0.05 \)). No statistical differences were observed on analysis of VAS values per hour (Fig. 1a).

Initial VAS scores (first hour after bolus) were low in both the groups (2.6/2.9) with pain peaking at 6- and 24-h control (VAS values >6). VAS pain scores decreased progressively, being lower after 72 h (3.4/3.6).

VAS scores with regard to the thoracotomy performed (AT or PT) showed lower scores in AT group, which were statistically significant mean and hour (\( p < 0.01 \)), except at the first hour (Fig. 1b).

The subgroups that have less pain at each interval were those with AT: pre-RS with AT (VAS 1 h, VAS 48 h, VAS 72 h) and post-RS with AT (VAS 6 h, VAS 24 h) (Fig. 2).

Seven patients (11.6%) needed meperidine as rescue drug at some moment (four in pre-RS group and three in post-RS), there were no differences in the requirements for rescue analgesia between the two groups (\( p > 0.05 \)).

No complications attributable to postoperative pain (retention of secretions, atelectasis or pneumonia) were recorded. No postoperative bronchoscopies or mini-tracheotomies were performed.

4. Discussion

Thoracotomy produces severe discomfort, with marked respiratory impairment that depends on the quality of pain relief. Appropriate analgesia can reduce this pain-related morbidity [9].

Nociceptive stimuli in thoracotomy arise from skin incision, chest drain incisions, damaged posterior costovertebral structures, fractured or excised ribs and from the parietal pleura. These stimuli are transmitted through small myelinated fibres and the unmyelinated C fibres to the dorsal horn along the somatic intercostal nerves. Pain arising from the visceral pleura is relayed along autonomic afferents [10].

Activation of peripheral nociceptors by tissue damage or localised inflammatory lesions leads to prolonged hyperexcitability in the spinal dorsal horn (central sensitisation) and activation of the whole pain system [11].
As complete pain control cannot be achieved with a single agent or technique without significant serious side effects, a balanced analgesic regime seems more appropriate [12].

Paravertebral infusion of a local anaesthetic effectively produces an afferent unilateral block. Intercostal nerves, their collateral branches and posterior primary rami and the thoracic sympathetic chain all pass through the paravertebral space, making it an ideal site for blockade of the various afferent nociceptive nerve impulses [13]. This has made PVB comparable to epidural block with respect to pain relief, and, as part of pre-emptive analgesia, it is proven to be superior [14].

Pre-emptive analgesia as a strategy to reduce the magnitude and duration of postoperative pain was introduced in 1983 by Woolf, who showed evidence for a central component of post-injury pain hypersensitivity in experimental studies [15].

This concept is based on the intuitive idea that if pain is treated before the injury occurs the nociceptive system will receive less pain than if analgesia is administered post injury. Pre-emptive analgesia would apply well to the situation of elective surgery, since in this situation it is possible to control the series of events and, thus, it is possible to deliver effective analgesia prior to injury [16].

Animal and human volunteer studies have verified this concept. However, despite the use of various pharmacological and regional anaesthetic techniques, it has proven difficult to demonstrate a significant pre-emptive effect and incorporate it into regular clinical practice [17]. Moiniche et al. published a review of randomised controlled trials of pre-emptive analgesia for postoperative pain relief [14]. The overall conclusion of this systematic review was negative with regard to a potential beneficial effect of pre-emptive analgesia on postoperative pain.

However, despite scepticism regarding this general concept, if we focus on PVB, a number of studies, mainly concerning breast surgery [18,19], have shown surprisingly long-lasting analgesia after PVB and have raised the speculation regarding the possible pre-emptive potential of this regional technique.

At the same time, several works have found some evidence to suggest that the peripheral afferent block with a local anaesthetic is more effective in preventing nociceptive impulses from entering the central nervous system than the central block, since local anaesthetics would also reduce neurogenic inflammation of traumatised tissues that is independent on efferent functions of the peripheral nerves [7,20].

In this line, in 1998, Richardson et al. [7] were able to demonstrate a pre-emptive effect of thoracic PVB in thoracotomy patients. Their patients with a preoperative PVB had significantly lower postoperative pain scores.

These results might explain the later finding of the same research group, showing thoracic PVB to be superior to thoracic epidural blocks for thoracotomy patients [21].

Since 2002, in our department, we have been employing a multi-modal treatment of post-thoracotomy pain consisting in a PVB with bolus of ropivacaine intercalated with methamizol and subcutaneous meperidine as rescue drug, with good results [5].

Strict pre-emptive analgesia concept implies analgesia before any noxious stimulus occurs. In our study, all the patients had incisions through the skin and muscles before they received analgesia through the PVC. Therefore, we are aware that we did not employ a pure pre-emptive approach in our study. However, given that RS is considered one of the most important operative injuries involved in post-thoracotomy pain, we hypothesised that analgesia with a PVB prior to this tremendous noxious stimulus could decrease post-operative pain by avoiding a hyper-excitable central state and neuronal plasticity. Finally, our results showed that this strategy alone was insufficient.

Analysing our first-hour VAS values, these were significantly lower (2.6/2.9) in comparison to post-6-h values (6.8/6.6) in both the groups, when the peak of pain was seen. Other authors have showed the peak of pain precisely in the first hour post-thoracotomy [3]. This could be explained by the accumulation of residual anaesthetics given during surgery; most of the procedures were lung resections that precise high dosages of intra-operative anaesthetics that are not completely eliminated in the first postoperative hour.

Analysing our data for the type of thoracotomy, it was remarkable that the difference in mean VAS values between AT and PT (Fig. 1) with a strong statistical significance ($p < 0.01$) in the mean and all hours, except the first hour, might be due to the accumulation of residual anaesthetics. These results confirm the benefits in not only aesthetic but also pain scores of AT over PT, as shown in the other studies [5,22].

The results for the need for rescue analgesia as well as the VAS values mean and per hours were similar for both the groups. No statistical differences were seen. Similarly, in our series, pre-RS PVB brought no extra benefit to post-thoracotomy pain control. Regarding the literature, a number of suggestions have been offered to explain negative results in pre-emptive analgesia studies: outcome measurement problems, too low or too high noxious stimulation induced by the surgical procedure, insufficient afferent blockade analgesia, insufficient central inhibition and insufficient duration of the treatment [14].

The placement of the PVC under direct vision has the advantage of verifying its correct location, assuring that the bolus is administered in the right place. All conditions, dosages and outcome measurements in both analgesia groups were similar. However, the effect of the local anaesthetic bolus pre-RS was not optimal for pre-emptive analgesia.

The lack of pre-emptive effect of pre-RS PVB may be that the pre-RS bolus does not cover other significant nociceptive stimuli such as skin incision and muscle damage. If pre-emptive analgesia concept gains credence, then additional pre-emptive measures would be required to achieve a more intensive multimodal protective coverage. A bolus of local anaesthetic trying to minimise the detrimental effect of RS would be inadequate.

In conclusion, all the patients in the study received satisfactory bolus of analgesia, as assessed by pain scores. Pre-RS PVB did not seem to contribute towards improving postoperative pain scores. The two groups had no differences in the requirement for rescue analgesia. AT proved to be a less-painful incision in comparison with PT with statistically significant values ($p < 0.01$).
There is a need for a large prospective randomised clinical trial with a primary hypothesis of the pre-emptive effect of PVB given before the start of surgery. Until proven, it would remain unclear if thoracic PVB does produce pre-emptive analgesia. Nonetheless, it is clear that PVB does provide excellent postoperative pain relief and does, whether pre-emptive or not, deserve a more widespread use.

References


Appendix A. Conference discussion

Dr H. Kara (Istanbul, Turkey): My simple question would be, were there any iatrogenic rib fractures during the spreading period in both groups of patients?

Dr Fibla: Do you mean during the placement of the needle?

Dr Kara: No, just while performing the thoracotomy and while spreading the ribs. Even showing care, sometimes rib fractures occur.

Dr Fibla: Yes, there were rib fractures but we didn’t analyse them in this study.

Dr Fibla: Do you think that may cause a bias while calculating the VAS score of the two groups?

Dr Fibla: Yes, it may cause a bias however in this study we didn’t take into account this factor.

Dr Kara: Do you use the technique for excision, partial excision of the rib, at the starting time of thoracotomy? To decrease the tension on the ribs, in some clinics, we do as well, on the posterior part, partial rib excision is done.

Dr Fibla: Yes, we do it in posterolateral thoracotomies.

Dr Kara: How about this group?

Dr Fibla: For posterolateral thoracotomies we cut the rib in the posterior part. There is the possibility that other fractures occur while the retractor is open, but we haven’t taken into account this factor for the study. The idea is that we always do the same depending if it is a posterolateral or anterior thoracotomy.

Dr A. Brunelli (Ancona, Italy): You have assessed, in addition to acute pain, also chronic pain or long-term paresthesia in these patients?

Dr Fibla: No. The study just involved until the patient was discharged, until 72 hours.

Dr Brunelli: And what do you think about intercostal muscle preservation before thoracotomy, do you perform it?

Dr Fibla: No. At the moment of closure, we puncture the rib in order to avoid a lesion of intercostal nerve in all the thoracotomies.

Dr Brunelli: So you drill the rib? You puncture and you pass -

Dr Fibla: We drill and pass the suture, yes.

Dr Brunelli: But you don’t save the intercostal bundle?

Dr Fibla: No.

Dr Brunelli: You don’t isolate the intercostal bundle?

Dr Fibla: No.