POST-THORACOTOMY PAIN AND PULMONARY FUNCTION

- Comparison of Intermittent Intercostal Bupivacaine vs Intravenous Pethidine -

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Abstract

Objective and Methods: In a prospective, observer-blind study, 50 patients scheduled for posterolateral thoracotomy were investigated to compare the effects of intermittent intercostal extrapleural bupivacaine (n = 25) and intravenous pethidine (n = 25) on post-thoracotomy pain and pulmonary function. The severity of chest pain (objectified by the use 5-point scale of Prince Henry) and changes in spirometric values [forced vital capacity (FVC), forced expired volume in 1 s (FEV1) and FEV1/FVC] were monitored during the first three postoperative days.Because intravenous pethidine was used to supplement pain relief in the patients who received intercostal analgesia, total pethidine used was compared to that administered to patients in the intravenous pethidine group.

Results: There were no statistical significant differences regarding patient demographics in both groups. No complications occurred. There

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was no significant difference between mean pain scores in the first postoperative day, but in the second and third postoperative days and also in the whole first 72 post-operative hours, pain scores were significantly higher in the intravenous group than the intercostal group. The post-operative decrease in FVC and FEV1 was significantly less with intercostal bupivacaine compared with the intravenous pethidine. There was no significant intergroup difference in the post-to pre-operative FEV1/FVC ratio. The total amount of the pethidine received by the patients was significantly higher in the intravenous group than the intercostal group.

Conclusion: Intermittent intercostal nerve block with bupivacaine appears to be a promising, safe and reliable technique in the management of post-thoracotomy pain. Use of intercostal bupivacaine could significantly reduce or even eliminate the postoperative need for systemic narcotics.

Keywords: Intercostal Analgesia, Thoracotomy, Bupivacaine, Post-operative pain, Ventilatory Function.

Introduction

Insertion of relatively extensive trauma to the thoracic muscles and joints by the posterolateral thoracotomy, often leads to more pain and discomfort than that of other thoracotomic approaches. The intensity of this chest pain is usually exacerbated by ventilation and consequently some degrees of ventilation limitation occur[1]. This postoperative decline in lung function is not obligatory but primarily due to the incisional pain and thus is preventable by effective analgesia[2]. Previous studies indicate that both anesthesia and thoracotomy are associated with significant alterations in pulmonary function and lung mechanics[3] and it has been affirmed that analgesic treatment in thoracotomised patients is the most important factor in preventing the onset of major complications that may negatively influence the results of surgery[4]. Therefore, various methods have been used for the treatment of these post-surgical discomforts, which, with respect to the severity and duration, represent the most severe type of the postoperative

complaints. Although there are various techniques for postoperative pain control after thoracotomy surgeries, it is uncertain which method has better pain control and fewer adverse effects.

Effective postoperative pain relief after elective thoracic surgeries can be obtained with intravenous analgesia using opioids. However, it should be kept in mind that these commonly used systemic opioids are a potential cause of ventilatory depression. Also, the risks of over-sedation have provided the impetus to search for better postoperative pain controlling methods with the emphasis on optimizing the respiratory function.

Epidural analgesia is extensively employed as a means to control post-thoracotomy pain, but is sometimes inadequate[5] and also sometimes may give rise to significant side-effects[6]. Therefore, it has been noticed that other low-risk and cost-effective analgesic treatments are required[6] and the search for more useful analgesic techniques became an interesting and active field of investigation.

Intercostal nerve blockade has been shown to be a reliable method of analgesia used for postoperative pain control and it provides good analgesia after thoracic surgeries[4]. The extra-pleural infusion of local anesthetics is a simple technique, with low risk of complications and provides effective pain relief as well as an improvement in post-operative pulmonary function[7]. Moreover, it has been reported that the addition of intra-operative intercostal nerve blockade to the routine epidural analgesia protocol provides an additive benefit for post-thoracotomy pain relief, especially early after operation[4]. Although intercostal blockade has been reported to be an effective and safe method of analgesia for post-thoracotomy pain, the information about the efficacy of this technique, however, is scarce and it is still unclear whether this method of analgesia is superior to the other analgesic methods used in the posterolateral thoracotomic surgeries.

In this study, we assessed the effects of postoperative thoracic analgesia with intermittent intercostal nerve blockade on post-thoracotomy pain and ventilatory function in comparison to the institutional protocol of intravenous analgesia using systemic opioids.

Materials and Methods

This 24-month study (between March 2002 and March 2004) was conducted on fifty elective posterolateral thoracotomy patients. The study was performed at two university hospitals (Shariati Hospital, Imam Khomeini Hospital-Tehran University of Medical Sciences). The present study is a part of a larger study, in which different methods of analgesia were compared with a same control group using intravenous protocol of analgesia and some results will be published elsewhere. Patients with contraindication for intercostal analgesia or who refused to intercostal analgesia were excluded. None of the patients smoked or took any regular medication during the previous 12 mo. All of the patients abstained from caffeine-containing beverages and alcohol for at least 24 h before the study. The subjects were randomly allocated into two groups. Each group comprised 25 patients who were given either intermittent intercostal analgesia using bupivacaine or intravenous pethidine. All patients underwent a standard posterolateral thoracotomy through the 5^{th} or 6^{th} intercostal spaces, all of which were performed by the same surgeon.

The end points were subjective pain, the total amount of required additional systemic narcotic (i.e. pethidine) and pulmonary function parameters. Pain was evaluated initially at the recovery room and then every six hour. The pain was evaluated after a deep inspiration and its severity was objectified by a 5-point scale (Prince Henry 5-point Pain Scale, Table 1).

Table 1
5-point scale of Prince Henry for postoperative pain assessment

Score	Severity of chest pain
1	No pain on coughing
2	Pain on coughing or movement but not on deep breathing
3	Pain on deep breathing but not at rest
4	Slight pain at rest
5	Severe pain at rest

Pulmonary function parameters, including forced vital capacity (FVC), forced expiratory volume in the first second (FEV1) and FEV1/FVC ratio, were assessed twice: before surgery and on the third postoperative day. Spirometry was performed using a portable spirometer (Micro, Micro Medical Limited, Rochester, UK) by study-blinded medical personnel. Three measurements were taken on each of the two times of pulmonary function assessment, with the patient in a sitting position and breathing room air. The means of these measurements were included in the analysis and the post-operative values were compared with preoperative (control) values for each patient. Opioid use was also measured during this initial 72 hours after the operation.

Intercostal Analgesia Protocol

At the end of the surgery, just before the chest closure, a posterior parietal pleural pocket was created and the surgeon inserted a 16-G polyethylene intercostal catheter by direct visual observation. The tip of the catheter was correctly placed toward the fourth or fifth intercostal space, external to the parietal pleura and alongside the vertebral column. A dressing was applied to prevent kinking and a sterile cap was placed. Commercial ampoules of isobaric bupivacaine 0.125% (in normal saline) (Marcain Spinal®, Astra, Södertelje, Sweden) were used. An intraoperative loading dose of bupivacaine, containing 0.5 ml/kg was injected so as to raise a bleb under the parietal pleura which spread longitudinally to bathe several intercostal nerves in the paravertebral gutter. This fixed dose was repeated every 6 hours and was not changed in response to patients' analgesia requirements. Breakthrough pain was treated with intravenous pethidine (0.5 mg/kg) on demand, given by nurses blinded to group allocation, and the total amount of this additional analgesia was recorded.

Intravenous Analgesia Protocol

In this group of patients, the analgesic protocol consisted of intravenous pethidine every six hour. If analgesia was inadequate and pain

score remained greater than 3 for 30 minutes, 0.5 mg/kg of pethidine was given intravenously and this additional analgesia was recorded.

All patients gave informed consent to participate in this study, which was approved by the Committee on Ethics at the Faculty of Medicine, University of Tehran.

Statistical Analysis

Results were analyzed with a 2-way analysis of variance, student's t-test (for paired data), chi-square, or Fisher exact test. The administration of additional analgesics was analyzed using the Pearson χ^2. SPSS for Windows software package (Release 11.5.0, SPSS Inc, Chicago, IL) was used for statistical analysis. A p value < or = 0.05 was considered significant.

Results

Demographic data are shown in Table 2. Participating in the study were 24 women and 26 men. Mean age and weight were 41.2 (18-60) yr and 71.2 (52-96) kg in the intercostal group, and 39.6 (19-57) yr and 69.1 (51-93) kg in the intravenous group. There were no statistically significant differences in these parameters between the two groups.

Table 2
Demographic data

	Intercostal Group	Intravenous Group
Sex	11 females, 14 males	13 females, 12 males
Age, years (mean range ± SD)	38.2 ± 15.3	39.6 ± 15.2
Bodyweight, kg (mean (range))	73.2 (52-96)	69.1 (51-93)
ASA class (number of patients)		
1	9	7
2	8	10
3	8	8

* Demographic data as shown was comparable.

The range of the procedures was relatively similar in both groups. Mean postoperative hospital stay was 7.2 days for the intercostal group and 6.9 for the intravenous group. No patient died or had a major respiratory complication. There were no complications of catheter placement or bupivacaine administration. Removal of the intercostal catheters was also without incident.

The respective first, second, and third days mean pain scores of the intercostal group were, 2.77/5, 2.42/5, and 2.05/5 and for the intravenous group those were 3.01/5, 2.83/5 and 2.55/5, respectively. There was no significant difference between mean pain scores in the first postoperative day ($p = 0.34$), but in the second and third postoperative days, pain scores were significantly higher in the intravenous group than the intercostal group ($p = 0.037$ and $p = 0.021$, respectively). In the whole 72 post-operative hours, the mean pain score was 2.41/5 in the intercostal group and 2.78/5 in the intravenous group, and the difference was statistically significant ($p = 0.018$).

The decrease in pulmonary function as assessed by FVC and FEV1 (Table 3) was significantly less with intercostal bupivacaine compared to intravenous pethidine ($p = 0.001$ and <0.0001, respectively). However, there was no significant difference ($p = 0.17$) between the post- to pre-operative ratio of FEV1/FVC (Fig. 1, 2 and 3).

Table 3

Comparison of the pre- and post-operative respiratory function parameters in the intercostal analgesia and intravenous analgesia groups.

Respiratory Parameters	Intercostal group	Intravenous group	*P* Value
Postoperative to Preoperative FEV1	0.53 ± 0.37	0.29 ± 0.28	*P* = 0.018
Postoperative to Preoperative FVC	0.55 ± 0.32	0.30 ± 0.31	*P* = 0.01
Postoperative to Preoperative FEV1/FVC	0.77 ± 0.43	0.57 ± 0.53	*P* = 0.17

** FEV1, forced expiratory volume per 1 s; FVC, forced vital capacity; FEV1/FVC, forced expiratory volume per 1 s/forced vital capacity.
** Data are given as mean ± SD.

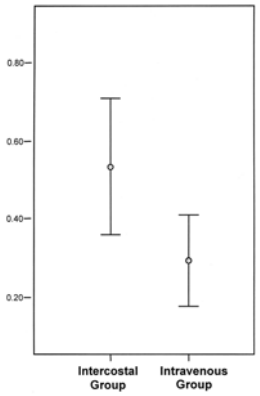

Fig. 1
Comparison of Postoperative/Preoperative FEV1 between two groups

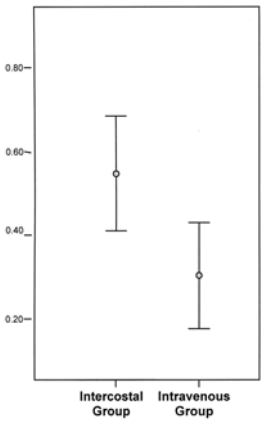

Fig. 2
Comparison of Postoperative/Preoperative FVC between two groups

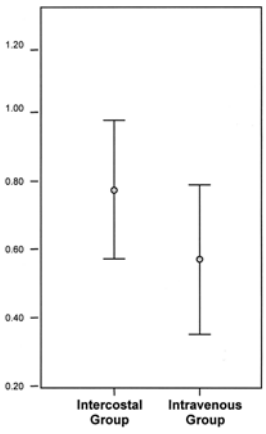

Fig. 3
Comparison of Postoperative/Preoperative FEV1/FVC between two groups

Larger amounts of rescue analgesia (P = 0.001) were used by patients in the intercostal group with bupivacaine than those in the intravenous group (Table 4). The mean additional pethidine requirement during the whole 72 hours of the study was 194.0 mg in the intercostal group and 58 mg in the intravenous group. On the other hand, the patients of the intravenous group received basic and regular intravenous doses of pethidine (25 mg every six hours) as their primary analgesic method. Therefore, the total amount of the pethidine received by the patients (the total amount of basic doses plus the total amount of additional requirements) was significantly higher in the intravenous group than the intercostal group (354 mg versus 194 mg respectively, $P < 0.0001$).

Table 4
Mean additional opiate requirements

	Intercostal Group	Intravenous Group	*P* Value
First day	64.2 ± 41.3	30 ± 23.9	= 0.001
Second day	73.8 ± 47.0	22 ± 26.3	<0.001
Third day	56.0 ± 59.4	6 ± 10.9	<0.001
Total	194.0 ± 136.3	58 ± 48.3	<0.001

** Data are expressed as mean ± SD in milligram.

Discussion

According to our study results it can be concluded that intermittent intercostal analgesia using bupivacaine is an effective method of pain relief after thoracotomies, and in comparison to the more commonly used intravenous analgesia, is more effective in decreasing post-thoracotomy pain-induced ventilatory suppression. Also, it has the ability to reduce additional narcotic demand in these situations.

Continuous extrapleural intercostal block with bupivacaine or lidocaine hydrochloride has been previously reported to be an effective analgesic technique in patients after thoracotomy[8]. However, there are only a few reports concerning the use of intermittent bolus doses of local

anesthetics delivered through an intercostal catheter for the purpose of post-thoracotomy analgesia. In the study of Carretta et al it was concluded that extrapleural intercostal nerve block with intermittent low-dose bupivacaine, allows a significant reduction in the consumption of opioids and could be useful as a low-risk, cost-effective and reproducible treatment when more effective techniques, such as epidural analgesia, are contraindicated[6].

Most, but not all, studies comparing the postoperative analgesic effects of intercostal method have shown a decrease in opioid requirement, pain intensity, or both, despite using of a variety of different drugs, dose regimens and surgical manipulation. For example, the study of Downs and Cooper[9] suggest that continuous intercostal analgesia is a safe technique which minimizes complementary opioid administration and provides adequate analgesia for children post-thoracotomy for lung resection. Similar findings were reported by Dryden et al and the authors conclude that bupivacaine, infused through catheters placed during thoracotomy in the adjacent intercostal spaces, is a useful adjunct to systemic opioid analgesia[10].

In fact, our results are consistent with the above-mentioned findings and also in the recent report of Concha and colleagues. In their study it was found that an intercostal block with bupivacaine plus IV narcotics is a good alternative for post-thoracotomy pain management[11]. Deneuville and colleagues found again that application of intercostal analgesia using 0.5% bupivacaine reduced systemic narcotic demand[12]. However, the power of these data to demonstrate a difference in systemic narcotic requirement is higher than anticipated ($p < 0.001$).

In contrast, some of the other reports are not indicative of the similar results and controversy still remains in this field. In the study of Ohlmer et al, narcotic consumption was reduced by the use of intercostal bupivacaine 0.5% in patients undergoing thoracotomy as compared with systemic opioids, but the authors concluded that in contrast to the more commonly used epidural analgesia, the intercostal method is not adequate alone and has to be supplemented by, or combined with, systemic analgesics in most patients[13]. However, it was emphasized that compared

to epidural analgesia, intercostal analgesia is less invasive and easier to manage on general surgical wards. Leger et al also could not demonstrate a significant reduction in systemic piritramide consumption for the intercostal analgesia in their patients[14]. Possible explanations for this difference include involvement of different surgeons, anesthetists, ward and acute pain nursing staff, and administration of different analgesic agents. In this study continuous intercostal bupivacaine provided similar early pain control as compared with fixed-schedule systemic narcotics but induced better analgesia with fewer complications than on-demand narcotics alone. Even in the pediatric population it has been shown that intercostal analgesia with bupivacaine produces satisfactory and safe analgesia for the early post-thoracotomy period[15].

In the end it should be noted again that the reported researches were almost always done by the use of continuous administration of the drugs and only few reports concerning the use of intermittent administration of intercostal analgesic drugs are available[16]. One of our main targets in this study was to establish the effects of this more practical approach. It seems that this relatively easy to perform method of analgesia is at least more efficacious than the more commonly used intravenous analgesia. Narcotics (regardless of the route of administration) have the capability of inducing respiratory depression (especially in patients with chronic obstructive pulmonary disease) and therefore it is logical to replace them with the effective analgesic method of intercostal local anesthetics in these situations.

Moreover, it should be emphasized that few reports show that following thoracotomy, epidural analgesia is a better pain relieving method than intercostal block[17] and although it was not examined in our study, it seems that whenever possible, epidural analgesia is a more effective method. However, recent studies comparing the effects intercostal analgesia with epidural protocol have found different effects on analgesia or additional systemic narcotic requirement and in fact recent data are not supportive of this approach[11]. Therefore, controversy still remains and larger studies concerning direct comparison of epidural and intercostal analgesia may be required.

Conclusion

We advocate the use of intercostal analgesia with bupivacaine since it appears to be a promising, safe and reliable technique in the management of post-thoracotomy pain. Intercostal blocks significantly reduce systemic opioid demand following thoracotomy.

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