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Intercostal Catheter Analgesia is More Efficient vs. Intercostal Nerve Blockade for Post-Thoracotomy Pain Relief

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A B S T R A C T

A pain after thoracotomy may result in a postoperative hypoventilation and lead to atelectases and pneumonia. This study was aimed to compare two analgesic regimens after posterolateral thoracotomy. 80 patients (40–70 years) undergoing thoracotomy were randomized to intercostal catheter analgesia (group A, n=40) and intercostal nerve block (group B, n=40). Patients in group A were given 20 mL of 0.5% bupivacaine injections twice a day by intercostal catheter. Intercostal nerve blockade was performed using 5 mL of 0.5% bupivacaine. Intercostal nerve in thoracotomy wound, nerves below and above thoracotomy wound was also injected. PaO_2, $PaCO_2$, FVC, FEV1 and visual analog pain scale (VAS) were obtained preoperatively, 24, 48 and 72 hours after operation. Postoperative complications were recorded at the patient discharge. Differences between groups were calculated using Mann-Whitney, KW test and chi square test. The arterial blood gas analyses did not show statistically significant change in any group and time according to the baseline values. FVC and FEV1 decreased significantly in both groups at first postoperative day according to baseline measurements. Patients in B group had significantly higher FEV1 values in the third postoperative day (73.05±11.25 in A vs. 83.50±9.17 in B group, $p<0.05$). Intercostal catheter analgesia resulted in significantly lower postoperative VAS scores and reduced opioid requirement as compared to intercostal nerve blockade. No differences in the postoperative complications were observed between groups.

Key words: *thoracotomy, pain, postoperative, analgesia, anesthetics, local, bupivacaine, catheter, nerve block*

Introduction

Acute pain is one of the major patients' complaints after thoracotomy. It produces significant discomfort, may lead to postoperative complications, prolonged hospitalization and increased cost of medical treatment. In a variety of pain treatment modalities for postthoracotomy pain no one technique proved as superior.

Postoperative opioid medication is commonly associated with nausea, vomiting and dizziness[1]. These adverse effects may be reduced by thoracic epidural analgesia. Epidural analgesia is not free of side effects, like hypotension in patients with limited cardiac function, catheter displacement or urinary retention[2]. Nausea and vomiting are not rare when opioids are used[3]. Other adverse reactions like suppression of respiratory reflexes and hypoventilation that may lead to the atelectases and pneumonia should not be neglected.

Therefore postoperative analgesia with minor influence on cardiac function appears as more appropriate for majority of patients. Local anesthetic techniques may produce less adverse reactions and be more cost effective for postthoracotomy pain relief.[2,4]. Nerve infiltration was confirmed as efficient in some clinical studies, but was mostly used as intraoperative supplementation to other methods of postthoracotomy pain control[5,6].

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Continuous extrapleural intercostal catheter analgesia was suggested as an alternative to the thoracic epidural analgesia for pain control after thoracotomy[7,8]. A systematic review of randomized studies indicates that it is at least as effective as an epidural and significantly better than narcotics alone[9]. Such analgesia using lidocaine and bupivacaine was safe and highly effective in terms of pain relief and recovery of postoperative pulmonary function[8,10,11]. The major disadvantage of this technique is the use of infusion pumps, which may limit patient's mobility and increase costs.

Complications observed in local anesthetic techniques for postthoracotomy pain relief are systemic toxic reactions or complications related to catheter use like wound infections, hypotension and total spinal anesthesia[12,13]. Postoperative respiratory complications like atelectasis and pneumonia may result both from operative trauma and postoperative analgesia[14].

Since infusion of local anesthetic was related to continuous drug delivery, it was not accepted as standard method for postoperative pain relief. Intermittent use of local anesthetics may be more appropriate for patient, allowing better mobility. Therefore this prospective study was aimed to find whether intermittent, twice daily drug application might be sufficient for postthoracotomy pain relief. In this study postoperative analgesic effects of intercostal blockade and intercostal catheter analgesia and ventilatory effects of both techniques were compared. A special attention was focused to complications in both analgesic regimens since that complications were not compared.

Patients

98 consecutive patients 40–70 years undergoing elective thoracotomy due to lung cancer, pulmonary biopsy, thoracic sympathectomy, mediastinal tumor removal or esophageal cancer were enrolled in the study. Exclusion criteria were: obstructive pulmonary disease reducing FEV1 to <70%, diabetes, psychiatric diseases and a history of chronic pain. Patients subjected to major pulmonary resections i.e. pulmectomy and bilobectomy were excluded from study. Finally, 80 patients were randomly allocated into two groups: intercostal catheter analgesia (group A, n=40) or intercostal nerve blockade (group B, n=40). The groups were matched for age, gender and type of operation. Mean age was similar in two groups: 54.3 years in group A and 53.8 years in group B. The most of patients in both groups were male (67.5% in group A vs. 72.5% in group B).

Methods

All patients gave their written informed consent during preoperative visit. Sedative premedication using midazolam 0.03 mg kg^{-1} intravenously was given 30 minutes before anesthesia. All patients were given cefazolin 1.0 g and LMW heparin. Operative procedure was performed through posterolateral thoracotomy without rib resections.

In the group A intercostal catheter was placed by physician on the completion of surgery, such that the tip was within the surgical wound. Sterile 20-gauge multihole epidural catheter with antibacterial filter was used. 20 mL of plain 0.5% bupivacaine was slowly injected. The first bupivacaine wound instillation was performed during general anesthesia, and thereafter twice a day by educated nurse. During and after local anesthetic injection chest drain placed in the axillary line was cross-clamped for 30 minutes. In the group B the first internal intercostal nerve blockade was performed in the operating room at the end of surgery. An intercostal nerve in the thoracotomy wound, nerve below and above was infiltrated using 5 mL of plain 0.5% bupivacaine per each intercostal space. Subsequent blocks were performed by physician using a posterior percutaneous approach.

In the both groups injections of local anesthetics were repeated on the first, second and third postoperative day. Local anesthetic injections were administered twice a day in 12 hours intervals routinely if patients did not ask for the additional analgesia. Patients who complained about insufficient analgesia were administered next local anesthetic after 8 hours.

Pain was objectified by a visual analogue pain scores (VAS) on a numeric scale from 0 (no pain) to 10 cm (worst pain). In cases of subjective mean VAS up to 3 cm at rest or up to 5 cm during coughing, the patients were given additional intravenous analgesics. Rescue drugs were metamizol 0.5 g IV if VAS was 3–5 or meperidine (1 mg/kg IV) if VAS was 5 and more after imposed cough stress.

A respiratory function was evaluated by arterial blood gas analysis and spirometer. Partial pressure of carbon dioxide ($PaCO_2$) and oxygen (PaO_2) were analyzed. Spirometry was performed with a portable spirometer Pneumoscreen II (Jagger). Forced expiratory volume in the first second (FEV1, %), forced vital capacity (FVC, L) and other measurements were obtained preoperatively, 24, 48 and 72 hours after operation.

Chest X-rays and clinical examination were performed every day in all patients from 1^{st}–3^{rd} day after surgery. Postoperative complications were registered at patient discharge. Patients were also examined for toxic effects of local anesthetics (restlessness, nystagmus, tremor, seizures, buzzing or cardiovascular symptoms) during physicians visit. Catheter was removed on 4^{th} postoperative day and chest drain from 1^{st}–3^{rd} day.

Statistical analyses were performed using SPSS 9.0 for Windows software. The normality of distribution was assessed with the Kolmogorov-Smirnov two-sample test. Comparisons of mean ranks between two groups were made using Mann-Whitney exact test. For data where normal distribution was not found (FVC), differences were assessed by a non-parametric Kruskal-Wallis (KW) test. Chi-square test for independent samples was used for comparisons of postoperative complications between two groups. A probability value of less than 0.05 was considered to be statistically significant.

TABLE 1
VENTILATORY PARAMETERS IN PATIENTS UNDERGOING THORACOTOMY. INTERCOSTAL BLOCK GROUP HAD FEV1 SIGNIFICANTLY HIGHER ON 3RD POSTOPERATIVE DAY AND FVC ON 2ND POSTOPERATIVE DAY

		Preoperative	After 24 h	After 48 h	After 72 h
FVC (L)	A	3.37±0.67	1.98±0.59	1.92±0.53*	2.30±0.53
	B	3.27±0.66	1.83±0.57	2.30±0.71*	2.39±0.71
FEV1 (%)	A	81.82±7.02	68.00±8.87	72.00±8.01	73.05±11.25*
	B	83.90±8.82	70.95±15.03	73.95±8.37	83.50±9.17*

* Statistically significant differences between two groups ($p<0.05$). Group A (N=40) – intercostal catheter analgesia, group B (N=40) – intercostal nerve block

Results

No differences were observed between preoperative FVC in group A and in group B (3.27±0.66L vs. 3.37± 0.67L). FVC decreased significantly in both groups 24 hours after surgery according to baseline measurements (1.83±0.57 and 1.98±0.59 L, $p<0.05$ vs. baseline). It gradually rose in both groups (Table 1). After 48 h group A had significantly lower FVC than group B (1.92±0.53 vs. 2.30±0.71, $p<0.05$). On third postoperative day FVC was still significantly lower than preoperative in both groups ($p<0.05$).

FEV1values expressed similar dynamics. FEV1 in A group was still lower 72 hours after operation, both in the comparison to baseline and to group B (73.05±11.25 vs. 83.50±9.17, $p<0.05$)

The arterial blood gases did not show clinically important changes between groups and in comparison to baseline values, as shown on Figure 1. O_2 values were stable, whereas CO_2 showed small but statistically significant increase in B group on second postoperative day (4.9± 0.0.34 in group A vs. 5.38±0.54 kPa).

Subjective pain perception was assessed by VAS and on the basis of rescue drug requirement. Significantly lower postoperative pain scores were observed in group A. Patients in the group A exhibited the highest pain scores on the first postoperative day. An intensity of pain in group A decreased thereafter. In the group B the highest scores were observed on the postoperative day 2 (Figure 2). 7 patients in group A and 11 in group B needed additional metamizol supplementation. 4 in group A and 7 in group B were given meperidine injections (ns; $p<0.05$).

Postoperative complications were observed in both groups (Table 2.). Although more infected haematoma of the wound were observed in group A, and more pleural infections and pneumonia in group B, differences between groups were not significant ($p>0.05$). Clinical signs of systemic toxicity of local anesthetics were not observed in any patient. No one catheter displacement or obstruction was observed during study period.

Discussion

This study confirmed that both intercostal catheter analgesia and intercostal nerve block produced satisfactory pain relief after thoracotomy. Intercostal catheter analgesia was superior in the pain control, resulting in the lower postoperative VAS scores.

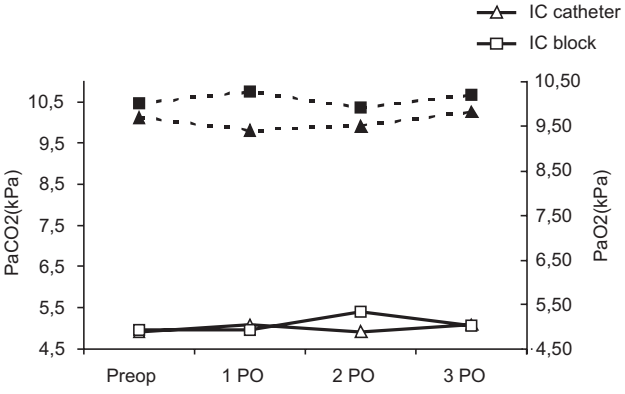

Fig. 1. Arterial blood gas analysis in two groups of patients undergoing thoracotomy. Lower two lines represent values of $PaCO_2$ in four subsequent measurements. Values of PaO_2 are shown in upper, dashed lines. Statistically but not clinically significant differences between groups were observed in PaO_2 on the first postoperative day.

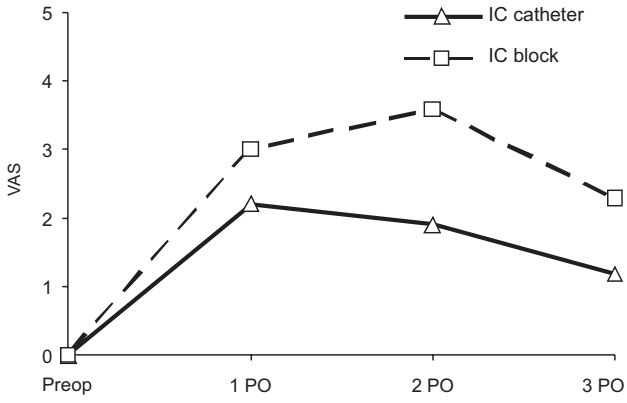

Fig. 2. Pain score in patients after thoracotomy. Pain scores (VAS) observed in the intercostal catheter group (A) were significantly lower than in intercostal block group (B) in the postoperative course.

TABLE 2
POSTOPERATIVE SURGICAL COMPLICATION REGISTERED DURING IN-HOSPITAL STAY IN PATIENTS AFTER THORACOTOMY. NO STATISTICALLY SIGNIFICANT DIFFERENCES WERE OBSERVED IN THE INCIDENCE OF ANY COMPLICATION

Complication	IC catheter	IC block
Local wound infection or haematoma	3	2
Pneumothorax	0	0
Pleural infections	1	2
Pneumonia	3	4
Atelectasis	2	2

Local anesthetic techniques were proven as more efficient as compared to the opioid medication or thoracic epidural in several studies[2,10]. Surprisingly, no one method was widely accepted for postthoracotomy pain relief and intravenous application of opioids is still a principal postoperative pain control method.

A single intraoperative intrapleural intercostal block associated with mini-thoracotomy reduces postoperative pain and improves postoperative outcome after major pulmonary resections[6,15]. This effective method was rarely continued in the early postoperative period, due to the more personnel's engagement, patient discomfort, failed blocks, and other complications. Failed blocks may result in higher postoperative VAS scores, which were observed in our study in the intercostal block group.

The use of local anesthetics via catheter for wound instillation is a promising method of postoperative pain control. It was not able to decrease postoperative pain or opioid requirements after major abdominal surgery[16] but was effective for postthoracotomy pain relief[10]. In our study twice a day catheter applications of bupivacaine attained a better pain control versus intercostal block. Intercostal catheter analgesia proved to be a simple technique, more convenient for postoperative pain control, more comfortable for patients and less painful than repeated injections used in the intercostal blockade.

Luketich and coworkers confirmed that intercostal catheter analgesia significantly reduced opioid requirement and urinary catheter days versus epidural group[2]. Urinary retention and more catheter days may be a consequence of both epidural analgesia and higher opioid requirement. Our study demonstrated that catheter analgesia resulted in lower VAS scores, but was not sufficient for pain control in all study patients. Although the majority of patients in both study groups had satisfactory pain relief, 11 patients in A and 18 in B group needed supplemental intravenous analgesics. Due to the small patient number these differences were not proved as statistically significant. More accurate results should be obtained using enlarged study groups.

Several modifications were undertaken to improve efficacy of catheter analgesia. The epinephrine supplement may prolong the blocking effect of bupivacaine. A continuous drug infusion via intercostal catheter may enable prolonged and balanced postoperative analgesia. It's thus appropriate for application of short acting agents like lidocaine, offering a minor risk of systemic toxicity with effective pain controll[10,11]. Interpleural catheter insertion is a modification of this technique that was not clearly efficient[17]. Silomon demonstrated a lack of efficacy of interpleural analgesia after lateral thoracotomy[17]. Karakaya and colleagues concluded that total fentanyl consumption decreased in patients receiving local anesthetic bupivacaine and/or fentanyl interpleurally for the postoperative analgesia[7]. Since some of local anesthetic injected by intercostal catheter may reach interpleural space, we cross-clamped the thoracic drain to prevent its leak.

A respiratory depression and changes in blood gas analyses were not significant in both groups. A slower return of FEV1 and FVC to baseline values was observed in the intercostal catheter group (the effect of foreign body?). This observation appears to be of only marginal clinical significance and did not produce changes in blood gas values or more postoperative complications. Recent literature reports confirmed that pulmonary function was better throughout the post-operative period in the catheter group versus placebo[10] and similar between intercostal block and thoracic epidural analgesia[5,8]. These results and practical benefits would favor intercostal catheter analgesia over other methods[8].

Intercostal catheter analgesia although efficient is still not widely used, mostly due to the fear from postoperative infective complications. A poor wound healing, local infections and pneumonia are particularly serious. The infection rate associated with intercostal catheter insertion observed by Heng *et al.* was 2.4% in the group of patients with blunt chest trauma not subjected to thoracotomy[18]. In the patients undergoing thoracotomy infection rate is somewhat higher. Rovera *et al.* registered overall postoperative infection rate of 5.0% in patients undergoing videoasisted thoracoscopy. Among the infection risk parameters, COPD was the only parameter associated with a significantly increased incidence of postoperative infection[19].

Complications observed in this study were almost equal in both study groups (table 2). The overall infection rate is a bit higher since more proper postoperative control was undertaken and patients undergoing more invasive procedures were involved. Infections observed in this study should be addressed mostly to the type of surgical intervention and less to the type postoperative analgesia. More invasive procedures like esophageal resections are related to higher postoperative morbidity and mortality. Avendano and coworkers registered some pulmonary abnormality in nearly all patients undergoing esophagectomy. Pneumonia in 19.7% of patients was the most common clinically important complication and required prolonged ventilatory support[20]. In our study two esophageal cancer patients developed severe pneumonia, and one atelecatsis. Two patients with preoperative chronic obstructive pulmonary disease had pneumonia, one

atelectasis and one wound infection. ASA 1 patients and those undergoing minor interventions had no complications. In the intercostal catheter group less pneumonia and pleural infections were observed and in the nerve block less wound infections (ns. $p<0.05$).

A small number of patients is major limitation of this study. An enlargement of both study groups may help to distinguish postoperative complications from these related to the local anesthetic techniques.

Based on the results of this study the use of both anesthetic techniques should be continued and improved. Intercostal catheter analgesia was more comfortable for patient, less traumatic, technically easier to perform with the same rate of postoperative complications. Therefore we encourage it as a routine method of postoperative analgesia, especially in major procedures. Although less effective in pain control in this study, intercostal blockade should not be considered as less valid. It may provide effective pain relief in patients undergoing minor interventions e.g. video-assisted thoracoscopy, especially if day-case procedures are being contemplated[21]. More accurate intercostal nerve blocks might be achieved by ultrasound-guided injections. The addition of vasoconstrictors may prolong analgesic effects of local anesthetics in both groups. Refinements in surgical technique including limited or muscle-sparing thoracotomy, improvements in chest closing, video-assisted thoracoscopic surgery (VATS), and robotic surgery may further reduce the magnitude of postthoracotomy pain[15,19,22,23].

Longer follow up period should prove whether these postoperative pain treatments have an influence on patient outcome. Therefore further study taking into consideration late results should be undertaken.

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MEĐUREBRENA KATETER ANALGEZIJA JE UČINKOVITIJA OD MEĐUREBRENE BLOKADE ŽIVACA KOD UBLAŽAVANJA BOLI NAKON TORAKOTOMIJE

SAŽETAK

Bol nakon torakotomije može uzrokovati poslijeoperacijsku hipoventilaciju i dovesti do atelektaze i upale pluća. Cilj ove studije bio je usporediti dvije metode poslijeoperacijske analgezije nakon posterolateralne torakotomije. 80 bolesnika u dobi od 40 do 70 godine koji su bili podvrgnuti torakotomiji podijeljeno je dvije skupine. Skupina A (n=40) primila je putem katetera u međurebrenom prostoru 20 mL 0.5% bupivakaina. Skupini B (n=40) je injekcijom 5 mL 0.5% bupivakaina u svaki međurebreni prostor učinjena blokada živaca u prostoru u kojem je učinjen operacijski rez, te blok živca iznad i ispod operacijskog reza. PaO_2, $PaCO_2$, FVC, FEV1 i intenzitet boli putem vizualne analogne ljestvice (VAS) su se mjerili prije operacije, 24, 48 i 72 sata iza operacije. Poslijeoperacijske komplikacije zabilježene su pri ot-

pustu. Statistička analiza razlika među skupinama vršila se testom Mann-Whitney, Kruskall-Wallis i χ^2 testom. Vrijednosti analiza plinova u arterijskoj krvi nisu se statistički značajno razlikovale među skupinama i u odnosu na početne vrijednosti. FVC i FEV1 prvog su poslijeoperacijskog dana značajno smanjeni u odnosu na prijeoperacijske vrijednosti kod obje skupine. Trećeg poslijeoperacijskog dana FEV1 bio je značajno veći kod bolesnika u grupi B (73.05±11.25 u skupini A i 83.50±9.17 u skupini B, $p<0.05$). Intenzitet boli statistički značajno je smanjen pri uporabi analgezije putem interkostalnog katetera u odnosu na blok međurebrenih živaca, a smanjena je i potrošnja opioida. Učestalost poslijeoperacijskih komplikacija bila je jednaka u obje skupine.