

Effects of the prolonged thoracic epidural analgesia on ventilation function and complication rate after the lung cancer surgery

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Key words: lung surgery; thoracic epidural analgesia; lung function; postoperative complications.

Summary. Thoracic epidural analgesia has been considered to have a good anesthetic efficacy and to decrease the postoperative complication rate, while its effect upon the ventilation function is still the topic of many clinical studies. The aim of this study was to evaluate the course of early postoperative period using thoracic epidural analgesia.

Material and methods. A total of 453 patients undergoing the operation due to the non-small cell carcinoma were selected and examined. Their postoperative complications and mortality rate were evaluated. In 79 patients, arterial oxygen saturation (SaO_2), forced vital capacity, forced expiratory volume in the first second, and the efficacy of analgesia were analyzed within the first 7 days after the operation. These patients were divided into subgroups according to the type of the operation – lobectomy or pneumonectomy – and the type of analgesia – thoracic epidural analgesia or opiates administered intramuscularly (control group).

Results. A better statistically significant efficacy of analgesia was observed in thoracic epidural analgesia group than in the control group (visual analog pain scale score 2.5 versus 5.3, $P < 0.01$). There was also a statistically significant lower incidence of postoperative complications (20.5% versus 38.8%, respectively). Thoracic epidural analgesia is a factor decreasing the relative risk of complications ($RR = 0.53$, 95% CI 0.28–0.99, $P = 0.0233$).

In the lobectomy group, 24 hours after the surgery, forced vital capacity was $61 \pm 12\%$ in the group receiving thoracic epidural analgesia and $45 \pm 13\%$ in the control group ($P = 0.0152$); forced expiratory volume in the first second was $56 \pm 17\%$ and $41 \pm 11\%$, respectively ($P = 0.0308$).

In the pneumonectomy group, 24 hours after the surgery, forced vital capacity was $47 \pm 16\%$ in the group receiving thoracic epidural analgesia, $35 \pm 8\%$ in the control group ($P = 0.080$). Forced expiratory volume in the first second was $47 \pm 15\%$ and $36 \pm 7\%$, respectively ($P = 0.0449$).

Conclusion. We conclude that analgesia with intramuscularly administered opioids provides unsatisfactory analgesia, especially in the first days after the operation. Thoracic epidural analgesia is a safe method, which provides a better quality of life for the patient, decreases the postoperative complication rate, and improves the ventilation function after the lung operations.

Introduction

General influence of the epidural analgesia. The epidural analgesia has been known since the beginning of the last century; therefore, its basic effects are considered to be clear (1, 2). The influence on the cardiovascular system is complex and variable, depending on many factors such as the extent of sympathetic denervation, autonomous balance, circulating blood volume, pharmacological effect of the systemically absorbed anesthetic substance – opiate, adrenaline, or a drug for the local anesthesia.

The epidural analgesia particularly acts on the

lower thoracic and lumbar segments (T5–L4) inducing the blockade of peripheral sympathetic nerve, leading to the vasodilatation in the pelvic organs and lower extremities.

Thoracic epidural analgesia (TEA) at the high thoracic level (T1–T5) blocks the afferent and efferent sympathetic innervation of the heart, abolishing chronotropic and inotropic regulation. It leads to a decreased cardiac contractility, decreased heart rate and cardiac output, which, in turn, leads to the diminished oxygen demand of the myocardium. At the same time, the dilatation of the coronary arteries improves the blood

supply to the myocardium.

In relation to better pain relief and less activation of adrenergic system, the vasoconstriction in other organs decreases as well, resulting in better perfusion and higher concentration of oxygen in the tissues. Systematically absorbed local anesthetic decreases the bronchial activity too. TEA also decreases the perioperative stress and endocrine-metabolic reaction to the trauma caused by the surgery (1).

The effect of thoracic epidural analgesia on the respiratory muscles has been shown by several authors. They had used TEA without the operation and found no change in forced expiratory volume in the first second (FEV1), but forced vital capacity (FVC) slightly decreased. They concluded that the influence of TEA on the breathing itself was due to the constant bronchial tone and the motor blockade of intercostal muscles (2). There are also studies showing that TEA can be safely used in patients with chronic obstructive pulmonary disease because it does not impair the ventilatory mechanics and causes the decrease in the pulmonary resistance (3).

TEA clinical effects. All the above-mentioned leads to many positive clinical effects:

- Cardiovascular system: the common TEA influence upon the heart has to be valued as positive because it helps to decrease the incidence of cardiac complications after the lung surgery (4).
- Pulmonary effects: there is a decrease in pulmonary complications (5–8). It has been shown that epidural analgesia decreases pulmonary complications by improvement of deep breathing and coughing (9). Thus, TEA decreases the incidence of pulmonary atelectasis (6, 10).
- TEA improves the tissue oxygenation in the early postoperative period (6).
- Improved wound and tissue blood supply decreases the incidence of pulmonary infections (8).
- Analgesic efficacy: epidural analgesia provides not only a better analgesic effect, but it also allows decreasing the consumption of opiates compared to the administration of them intravenously (11–13).
- Influence on the ventilation function: postoperative pain causes the restriction of ventilation and decreased ventilation function of its own. In 1975, it was shown that even the pain after the upper abdominal operations reduces functional residual capacity and vital capacity up to 78% and 37% as compared to the preoperative measurements. Following the epidural analgesia, the values were 84% and

55%, respectively (9). The ventilation function also similarly diminishes after the lung surgery. The pulmonary function using postoperative anesthesia with intravenously administered opioids has been reported greatly to decrease by 39% of the baseline level in the early postoperative period and to recover by 68% of the baseline only on the eighth day (14). Different papers show that the values of FEV1 are between 30% and 50% of the baseline on the first postoperative day (15, 16).

The positive TEA effect can be seen especially within the first days after the operation (17). Even though many authors have proved that epidural analgesia has a positive impact on the ventilation function (11, 17, 18), some reports show no effect of TEA on it during this particular period (6, 19). Some authors who have concluded that epidural analgesia does not improve the ventilation function, comparing it to other methods of analgesia, have analyzed either different types of operations (laparotomy, Caesarian section) (6, 20) or have compared nearly equivalent methods (paravertebral blockade, introduction of local anesthetic drug into the pleural space, and TEA) (6, 13).

There are only few papers showing no positive effect at all by using the epidural analgesia. M. Concha *et al.* has compared the epidural analgesia with other methods of anesthesia and found no significant difference within the first 48 hours after the operation (21).

There are also several complications associated with the epidural analgesia. It is more painful because it is an invasive manipulation that can sometimes cause neurological complications such as headache, paresis or paralysis, or such systemic problems as pruritus, urinary retention, and transient hypotension (22). H. Nomori *et al.* observed a significant increase in pain on the day after cessation of TEA; however, it was short lasting (23). Other authors did not find more frequent complications in the group receiving epidural anesthesia (24).

In some clinics (8), TEA is used on regular basis if there are no contraindications, patient's resistance, coagulation problems, acute neurological disorders, local or systemic infections, or some particular technical problems.

In many clinics, particularly in the post-Soviet countries, TEA was rarely used. Patients do not prefer this method, being scared of becoming paralyzed, but physicians regard it as an invasive manipulation that will prolong the time the patient spends in the operating theatre and can lead to additional complications,

forgetting about all the positive effects the method can bring.

The aim of this study was to evaluate the course of early postoperative period using TEA under the conditions of our clinic.

Material and methods

A total of 453 patients undergoing the operation due to the non-small cell carcinoma were selected and examined. They were analyzed for the postoperative complications and mortality rate. Of these, 79 patients who had given a written consent for participation were enrolled in this prospective study.

In these patients, arterial oxygen saturation (SaO_2), forced vital capacity, forced expiratory volume in the first second, and the efficacy of analgesia were analyzed within the first 7 days after the operation.

These patients were divided into 4 subgroups depending on the operation – lobectomy or pneumonectomy – and the type of sedation – TEA or opiates administered intramuscularly (control group). In the group of patients receiving TEA, there were 39 patients; lobectomy and pneumonectomy were performed in 20 and 19 patients, respectively. The control group consisted of 40 patients; half of them underwent lobectomy and others – pneumonectomy.

This clinical research was approved by the Ethics Committee of the Clinical Research of Drugs and Pharmacological Products of Latvian Cardiology Institute, statement No. 260504-82.

The type of anesthesia (TEA or conventional intra-

muscular injection of opiates) was chosen by patients themselves. Before the general anesthesia was induced, an epidural catheter was introduced through either T5–T6 or T6–T7 intervertebral space. The catheter was connected to Easy Pump (B. Braun Medical Inc.) filled with 1 mL of *Sol. Morphini hydrochloridi* 1%, 1 mL of *Sol. Clophelini* 0.1%, and *Sol. Marcaini* 0.25% to 100 mL.

Easy Pump provides a constant drug flow into the epidural space at the rate of 2 mL per hour. All the surgeries were made under the general standard anesthesia. By the end of the operation (25), the infusion of analgesic drugs was started and continued in the ward under the supervision of personnel. Epidural infusion was continued for 5 days, or it was stopped if the patient occasionally withdrew the catheter himself. All patients from the control group after the operation received the intramuscular injections of *Sol. Pethidini hydrochloridum* 5% (2.0 mL) given upon request, on an average of three times a day.

During the postoperative period, the patient's cardiac, respiratory functions, and blood oxygenation (SaO_2) were monitored with BSM 2301K monitor (Nihon Kohden Corporation, Japan).

The pain intensity was evaluated using a visual analog pain scale (VAS) (Fig. 1). The pain was classified as follows: 0–2 – insignificant, 3–4 – moderate, 5–7 – severe, 8–10 – very severe. It was measured at rest, during the body movements, and while coughing every 3 to 4 hours within the first 24 hours but later every 6 hours. We taught our nursing staff how to

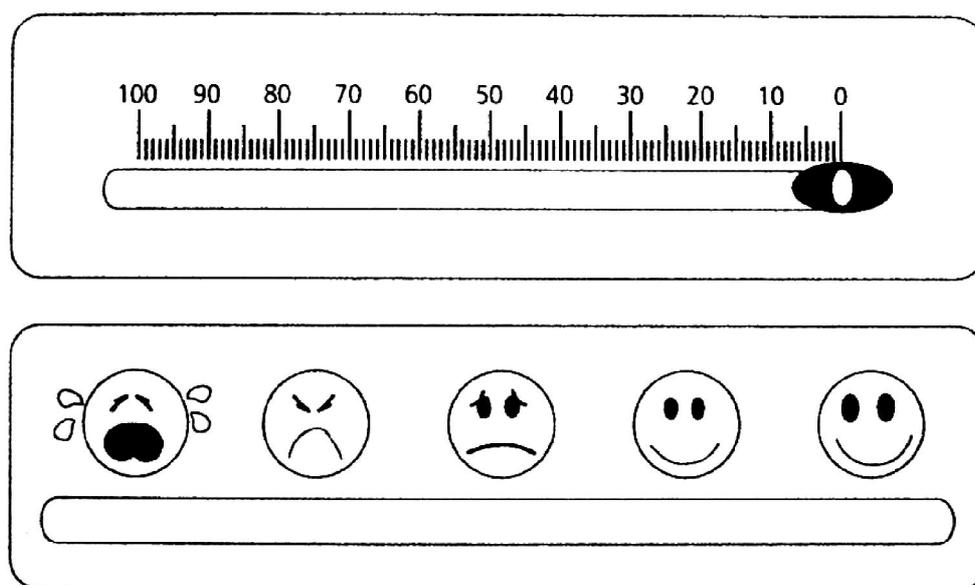


Fig. 1. Visual analogue pain scale

perform these measurements and asked them to register the time when a need for additional analgesia arises or any side effects develop. The efficacy of analgesia during the postoperative period was analyzed by using the t test. The average value of the patient's pain evaluated by VAS was compared between both groups, calculating the standard deviation of the mean value.

The ventilatory function during the postoperative period was evaluated at the patient's bedside, using the portative MicroGP spiograph (Micro Medical Limited P.O. Box 6, Rochester, Kent ME1 2 AZ, England) connected to the COMPAQ 5000 laptop. Spida program version 3.2, provided with spiograph, was used. We collected several measurements and used the best result of the day. For statistical analysis, we used the Microsoft Excel 2000 add-in module pHStat 2 and applied the t test to state the difference between two mean values. Graphs were created using special Statistica 6 program.

When comparing all the results of the postoperative complications and mortality rate, we employed the records of all patients operated on in our Center of Thoracic Surgery within the last 5 years (from January 1, 2000, to December 31, 2004) (26). To state the difference between two proportions, the z test was applied. In order to calculate the relative risk (RR) and the 95% confidence interval (95% CI), we employed the EpiInfo 6 version module StatCalc.

Results

In the analysis of patients' baseline data, we did

not find any differences between both patient groups either in age or ventilatory function, or a concomitant disease.

Mortality in the group of patients receiving TEA was 0% (0 out of 39 observations), but in the group of other patients – 3.4% (14 out of 414 observations). The small number of observations did not allow us to make the statistical analysis.

Efficacy of analgesia. Our observation revealed that analgesia was better in the TEA patient group (statistically significant). Majority (76%) of patients rated their pain control as good; only for some patients, the additional non-narcotic analgesics had to be used. In the opiate group, 30% of patients mentioned the analgesia to be unsatisfactory; others evaluated it as suitable. The intensity of pain determined using VAS scale in both patient groups is shown in Fig. 2.

As seen in Fig. 2, the control group patients suffer from severe pain, which is not allowable. In contrast, patients in TEA group have no pain. The difference between both groups is statistically significant (VAS 2.5 in TEA group and 5.3 in opiate group, $P < 0.05$).

Ventilation function. In all patients, comparing to the preoperative level, the ventilatory function on the first postoperative day decreased dramatically.

However, both groups of patients who underwent lobectomy and pneumonectomy under TEA had significantly better ventilation indices during the first postoperative day as compared to the opiate group.

In the lobectomy group, 24 hours after the surgery, FVC was $61 \pm 12\%$ in TEA group and $45 \pm 13\%$ in the

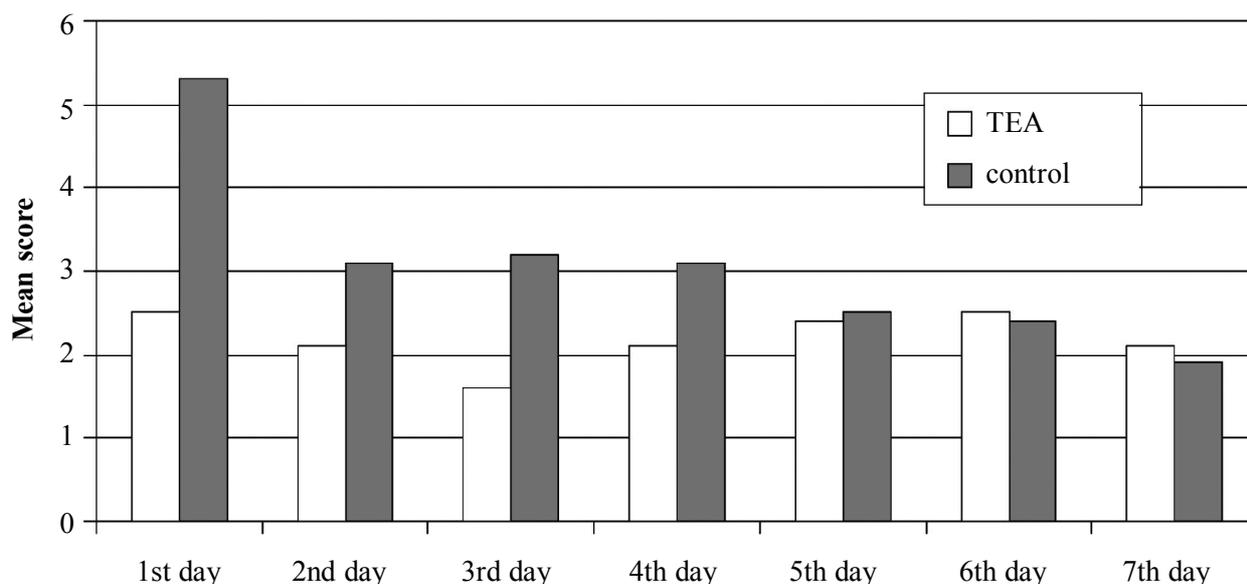


Fig. 2. The intensity of pain measured by visual analogue scale
TEA – thoracic epidural analgesia.

opiate group ($P=0.02$). FEV1 was $56\pm 17\%$ and $41\pm 11\%$, respectively ($P=0.03$). The dynamics in the ventilatory function during the postoperative period in this group is shown in Fig. 3 and 4.

In the pneumonectomy group, 24 hours after the surgery, FVC was $47\pm 16\%$ in TEA group and $35\pm 8\%$ in the opiate group ($P=0.08$). FEV1 was $47\pm 15\%$ and

$36\pm 7\%$, respectively ($P=0.04$). The dynamics in the ventilatory function during the postoperative period in this group is shown in the Fig. 5 and 6.

Postoperative complications. In TEA group, the postoperative complication rate was significantly lower than in the opiate analgesia group (20.5% and 38.8%, respectively). TEA is a factor decreasing the

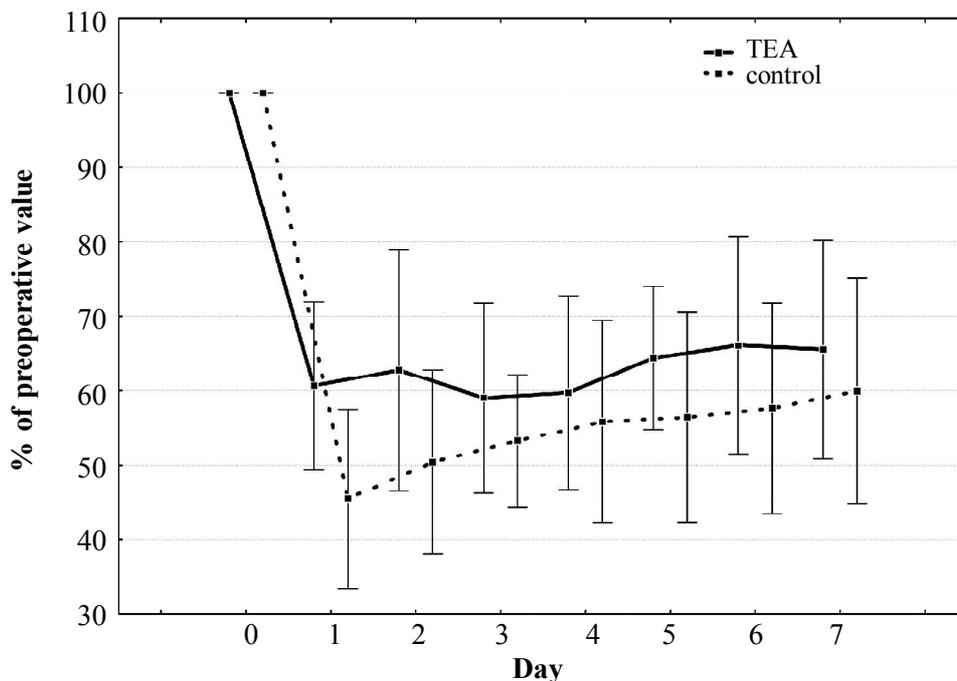


Fig. 3. Changes in forced vital capacity after the lobectomy depending on the method of analgesia
Mean; Whisker: Mean \pm 0.95*SD. TEA – thoracic epidural analgesia.

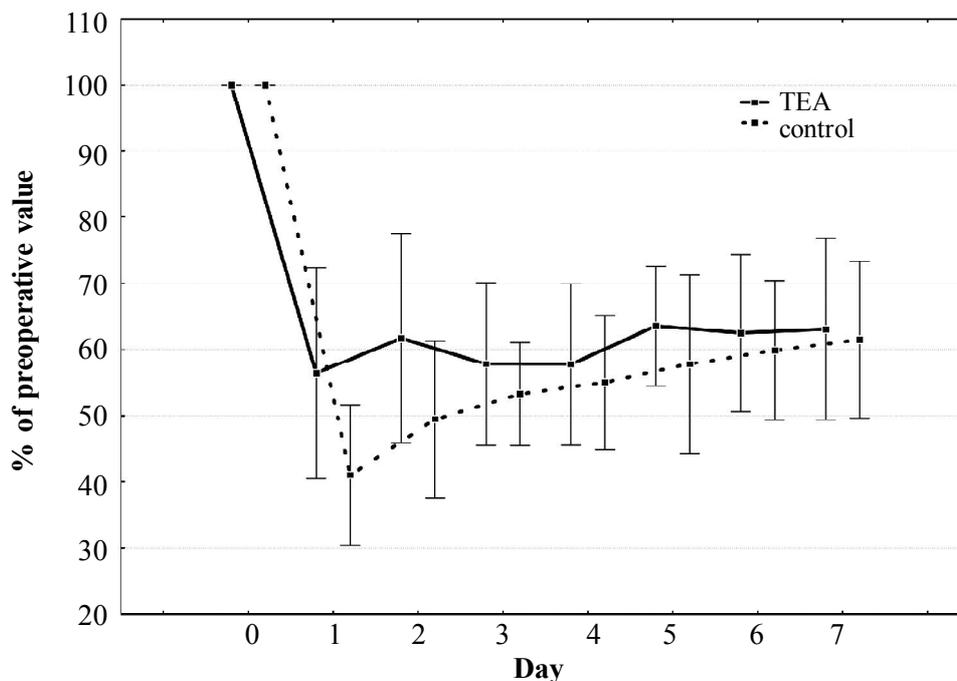


Fig. 4. Changes in forced expiratory volume in the first second after the lobectomy depending on the method of analgesia
Mean; Whisker: Mean \pm 0.95*SD. TEA – thoracic epidural analgesia.

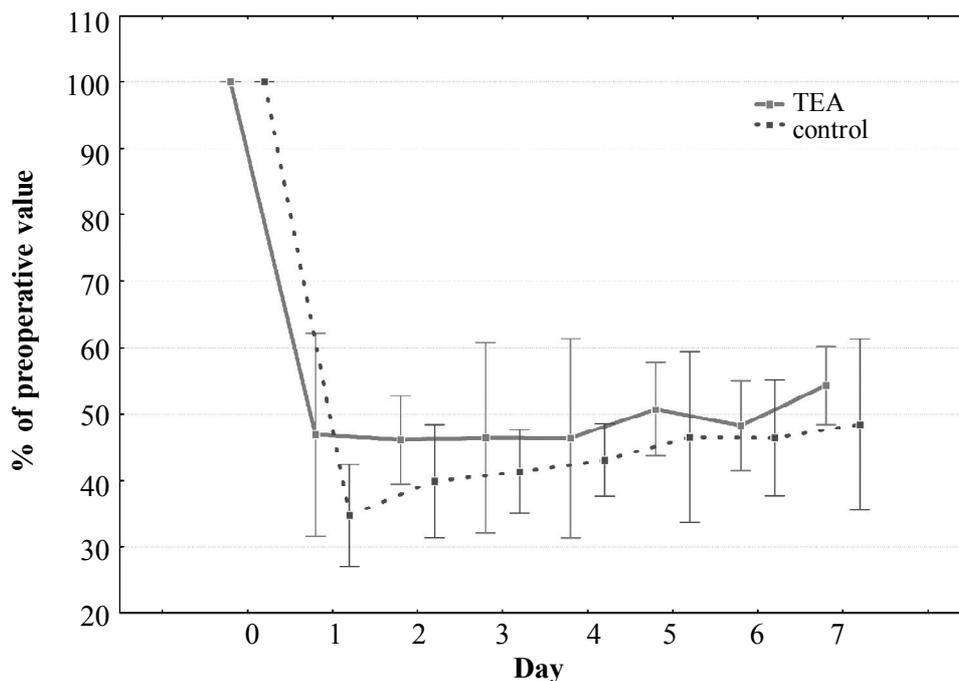


Fig. 5. Changes in forced vital capacity after the pneumonectomy depending on the method of analgesia
Mean; Whisker: Mean \pm 0.95*SD. TEA – thoracic epidural analgesia.

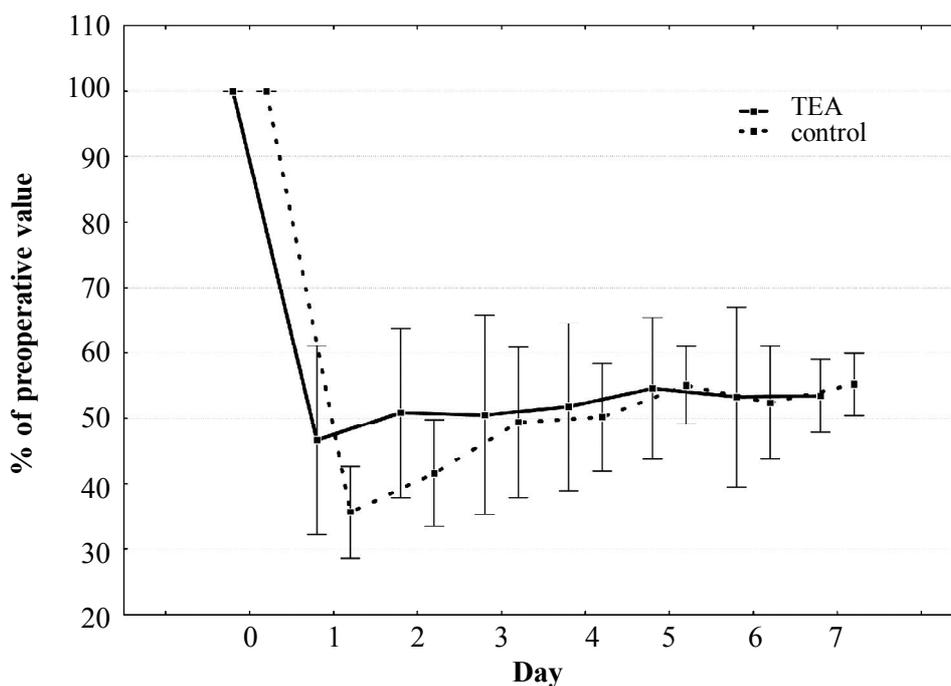


Fig. 6. Changes in forced expiratory volume in the first second after the pneumonectomy depending on the method of analgesia

Mean; Whisker: Mean \pm 0.95*SD. TEA – thoracic epidural analgesia.

relative risk of complications (RR=0.53, 95% CI 0.28–0.99, P=0.02).

In 21.5% of patients (control group), sputum retention occurred, and an extra bronchial cleaning with bronchoscopy was performed. This complication in TEA group developed only in 5.1% of patients

(RR=0.24, 95% CI 0.06–0.93, P=0.01). The list of all complications is showed in Table.

In TEA group, complications were observed in connection with TEA method itself: arterial hypotonia in three patients, vomiting in four patients, and urinary retention in eight patients. Serious, life-threatening

Table. Complication rate in both patient groups

Complication	TEA group (n=39)	All patients (n=414)	P value
Acute coronary syndrome	7.7%	6.2%	NS
Repeated chest tube	7.7%	13%	NS
Atrial fibrillation	5,1 %	21%	NS
Sputum retention	5.1%	21.5%	0.01
Infection	5.1%	9.4%	NS
Bronchial fistula	0%	2.1%	NS
Acute stress ulcer	0%	1%	NS
Exitus letalis	0%	3.4%	NS
All complications together	20.5%	38.8%	0.02

TEA – thoracic epidural analgesia; NS – difference is not statistically significant.

complications in TEA group, like hematoma, paralysis, neuroinfection were not observed.

All other complications, their frequency, and the total number of complications altogether in TEA group were lower if compared to the control group patients. Due to a small number of patients in TEA group and low incidence of complications, the connection between other complication rate and TEA method itself, or the amount of the operations were not possible to state.

Arterial blood oxygenation. We did not observe a significant drop in arterial blood oxygenation measured by the pulse oximeter.

Discussion

A significantly better analgesia in TEA group, comparing it to the group receiving opiates intravenously has been shown also by other authors (12, 19, 27). It has to be noted that the majority of clinics use patient-controlled analgesia, which, unfortunately, is not available in our center. In case of the intensification of pain, the patient receives an additional injection by the nurse on duty. We observed that analgesia with intramuscularly administrated opiates is inadequate; therefore, patients suffer from pain (VAS=5.3 on the first postoperative day).

We observed a significant decrease in the ventilation function in the early postoperative period and, what is more, it greatly depends on adequate analgesia. Other authors have found that there is a decrease in the ventilation function up to 39–50% of the baseline (14–16). In difference to other authors, we have studied just the lung operations, which in itself because of the reduction of lung parenchyma make the ventilation function to decrease. We have as well

concluded that by inadequate postoperative analgesia, the operated side of the thorax practically does not breathe; therefore, to patients, who already have a reduced preoperative ventilation function, it may become fatal after the operation.

It has been noted that there is also a decrease in the ventilation function in case of a deliberate or an accidental removal of the catheter. If a sudden discontinuity of TEA occurs, the staff on duty has to be informed about the action taken in order the patient would not suffer from the pain.

The dispersion of parameters of patients' ventilation function might be explained by the fact that we had considered the preoperative level to be 100%, not taking into account the absolute indices as well as the number of well-functioning and non-functioning segments, which had been resected during the operation.

While using TEA we observed the decrease in sputum retention (4 times), which principally concurs with the observations of other authors who have noticed that TEA decreases the rate of pulmonary complications by 2 to 5 times (5, 8). Besides, there was a 2-fold lower risk of pulmonary atelectasis after the lung operations (6, 10).

We have not observed any statistically significant differences in the oxygenation of the arterial blood, although some papers show that there has been an improvement by 4.56 mmHg on the average in TEA group in the early postoperative period (6). This difference can be explained by the use of pulse oximetry, which is not a very precise method. Besides, we excluded those patients who required the artificial pulmonary ventilation postoperatively, since we were not able to measure lung ventilatory function and the pain intensity.

Conclusions

- Analgesia with opioids administered intramuscularly provides unsatisfactory analgesia, especially in the first days after the operation.
- Thoracic epidural anesthesia, while using Marcaine, morphine, and clopheline, provides an effective analgesia in patients who have undergone the lung surgery.
- Patients who receive thoracic epidural anesthesia have a better statistically significant lung ventilatory function and a lower complication rate.

- B. Braun Medical Easy Pump is a safe and easy to handle device that can be recommended to patients who suffer from postoperative pain and who need a long-term administration of analgesic drugs. Besides, thoracic epidural anesthesia can be used safely in the ward by staff who has undergone a special training.

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Ilgesnēs trukmēs torakalinēs epidurinēs analģezijas ģtaka ventilācijas funkcijai ir komplikāciju daļņui po plauĉių operāciju

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Raktažodĉiai: plauĉių chirurgija, torakalinē epidurinē analģezija, plauĉių funkcija po operācijas, komplikācijas po operācijas.

Santrauka. *Īvadas.* Priimta, jog torakalinē epidurinē analģezija uĉtikrina gerā nejautrā, sumaļina komplikāciju po operāciju daļņi, taĉiau dēļ jos ģtakos plauĉių ventilācijas funkcijai tebediskutuojama.

Metodai. Analizuoti duomenys 79 ligonių, serganĉių plauĉių vēžiu, kuriems atlikta plauĉių lobektomija arba pneumonektomija. 39 ligoniams skirti ilgesnēs trukmēs torakalinē epidurinē analģezija, 40 ligonių sudarē kontrolinē grupē. Pirmāšias septynias dienas po operācijas analizavome komplikāciju daļņi, SaO₂, taip pat analģezijos efektyvumā pagal vizualiai analogiškā skausmo skalē, analizavome ir forsuoĉā iškvēpimo tūri ir forsuoĉā iškvēpimo tūri per pirmajā sekundē, ligonius suskirstydami ģ pogrupius pagal operācijas būdā: pneumonektomija arba lobektomija.

Rezultatai. Torakalinēs epidurinēs analģezijos grupēje nustatēme reikšmingai geresnē nejautros efektyvumā pagal analogiškā skausmo skalē – 2,5, o kontrolinēje grupēje – 5,3 (p<0,01).

Torakalinēs epidurinēs analģezijos grupēje buvo statistiškai reikšmingai maļesnis komplikāciju po operācijas skaiĉius – 20,5 proc., o kontrolinēje grupēje – 38,8 proc. Torakalinē epidurinē analģezija yra reliatyvios komplikāciju rizikos faktorius (RR=0,53, 95 proc. CI=0,28–0,99, p=0,0233).

Lobektomiju grupēje 24 valandas po operācijas forsuoĉas iškvēpimo tūris buvo 61±12 proc. torakalinēs epidurinēs analģezijos grupēje ir 45±13 proc. – kontrolinēje grupēje (p=0,0152). Forsuoĉas iškvēpimo tūris per pirmajā sekundē buvo 56±17 proc. ir 41±11 proc. (p=0,0308).

Pneumonektomiju grupēje 24 valandas po operācijas forsuoĉas iškvēpimo tūris buvo 47±16 proc. torakalinēs epidurinēs analģezijos grupēje ir 35±8 proc. – kontrolinēje grupēje (p=0,080). Forsuoĉas iškvēpimo tūris per pirmajā sekundē buvo 47±15 proc. ir 36±7 proc. (p=0,0449).

Īsvados. Mes konstatavome, jog iki ţiol anestezijai vartoti opioidai neuĉtikrina pakankamos analģezijos (nejautros) laikotarpiu po operācijas. Taigi darome išvadā, kad torakalinēs epidurinēs analģezijos metodas yra saugus, uĉtikrina gerā nejautrā, žymiai pagerina ligonių savijautā, maļina komplikāciju rizikā bei pagerina ventilācijas funkcijā po plauĉių operāciju. Siūlome torakalinē epidurinē analģezijā kasdienēje torakalinēs chirurgijos praktikoje, ypaĉ pacientams, kurių pradiniai ventilācijas duomenys yra prasti, kad neleistų jiems „grēsmingai“ sumaļēti per pirmāšias dienas po operācijas.

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