

The Effect of Intrapleural Analgesia on the External Respiration Function of Patients after Surgical Interventions in the Hepatobiliary Zone

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Abstract The aim of the study was to determine the effect of intrapleural analgesia on the function of external respiration of patients in the postoperative period. **Introduction.** Postoperative pain sensations represent only the visible part of the iceberg, being the root cause of a pathological postoperative syndrome development, which negatively affects the respiratory system. The main trend of clinical research in recent years in this area is the use of the principle of multimodality of pain protection with an emphasis on preventive (before injury and pain) protection. **Material and methods.** We observed 93 patients diagnosed with liver echinococcosis and acute calculous cholecystitis, who were performed traditional liver echinocoectomy and cholecystectomy from 2018 to 2022. The mean age of the examined patients was 52 ± 3.4 years. The patients were divided into 2 groups depending on the type of anesthetic provision. In Group 1, the opioid analgesic promedol, 20 mg IM, was used for the treatment of postoperative pain; in group 2, patients for this purpose were administered intrapleural lidocaine 1% at a dose of 2.5 mg/kg upon request. **Results.** In Group 1, at the stages of surgery, there was an increase in the total peripheral vascular resistance by 15.1% ($P < 0.05$) and a decrease in the indicators of one-time and one-minute heart performance. The main indicators of central hemodynamics of patients in Group 2 of patients at the stages of surgery were stable. **Discussion.** The use of intrapleural analgesia helps to normalize the patency of small bronchi and improves the patency of large and medium bronchi, creates prerequisites for the realization of muscular effort during breathing and coughing. Clinically, this was manifested by the disappearance of pain syndrome, relief of sputum discharge. **Conclusion.** Intrapleural analgesia using local anesthetics lidocaine 1% at a dose of 2.5 mg / kg is the most affordable and adequate method of postoperative anesthesia for surgical interventions in the hepatobiliary zone. Intrapleural administration of lidocaine improves the parameters of respiratory mechanics, which promotes the implementation of patients' active postoperative rehabilitation program.

Keywords Analgesia, Intrapleural analgesia, External respiration, Liver echinocoectomy, Cholecystectomy

1. Introduction

Currently, there has been a significant increase in interest to the problem of postoperative pain and methods of combating it, due to the emergence of modern effective methods of analgesia and awareness of the role of adequate anesthesia in the postoperative rehabilitation of patients. Postoperative pain itself represents only the visible part of the iceberg, being the root cause of the development of pathological postoperative syndrome, which negatively affects the respiratory system [1-4]. The main trend of clinical research in recent years in this area is the use of the principle of multimodal pain protection with an emphasis on preventive (before injury and pain) protection [5-6]. Acute pain increases the rigidity of the chest muscles and anterior

abdominal wall, which leads to a decrease in respiratory volume, vital lung capacity, functional residual capacity and alveolar ventilation. Collapse of the alveoli, hypoxemia and a decrease in blood oxygenation are the consequence of it. Difficulty in coughing due to pain interferes with the evacuation of bronchial secretions, promoting atelectasis with the subsequent development of pulmonary infection [7]. Increased oxygen consumption and carbon dioxide production leads to a corresponding increase in minute respiratory volume. Such an enhancement increases the work of breathing, especially at concomitant lung diseases. Bed rest and immobilization can also cause pulmonary dysfunction, regardless of the pain location. The opioid component remains as the basis of protection against pain at the central (segmental and suprasegmental) level. A preventive approach to the treatment of postoperative pain, based on pathogenetic complex prevention of pain impulses at all levels, is promising.

The aim of the study was to determine the effect of intrapleural analgesia on the function of external respiration of patients in the postoperative period.

2. Material and Methods

We observed 93 patients diagnosed with liver echinococcosis and acute calculous cholecystitis, who were performed traditional liver echinococectomy and cholecystectomy from 2018 to 2022. The mean age of the examined patients was 52 ± 3.4 years. There were 17 males and 76 females. According to their physical status, the patients corresponded to ASA class II-III. All patients received standard premedication 40 minutes before the start of general anesthesia: atropine 0.01 mg/kg, diphenhydramine 0.2 mg/kg, promedol 20 mg were administered intramuscularly.

The patients were divided into 2 groups depending on the type of anesthesia. Group 1 included 49 patients who were performed ataralgesia [8,9]. Group 2 included 44 patients in whom ataralgesia was supplemented by intrapleural analgesia (IPA), which transformed into postoperative IPA. Puncture of the pleural cavity was performed at the level of 6-7 intercostal space along the right middle axillary line in the position of the patient on his back. The skin was anesthetized in the usual way. The "Tuohy" needle was inserted to the upper edge of the underlying rib, then along its upper edge the needle was advanced further until resistance was felt, after identification the catheter was inserted 3 cm further from the tip of the needle upward, the needle was removed, the catheter was fixed on the skin with an adhesive plaster. A fixed catheter was used for postoperative pain relief.

In Group 1, the opioid analgesic promedol, 20 mg IM, was used for the treatment of postoperative pain; in group 2, patients for this purpose were administered intrapleural lidocaine 1% at a dose of 2.5 mg/kg upon request. When deciding on the need for pain relief, we were guided by the international recommendations "Acute Pain Management: Scientific Evidence" (2005), focusing on the criteria for the maximum permissible pain intensity on a visual analogue scale (VAS) [10].

All patients were conducted standard clinical and laboratory tests: measurements were taken before the administration of the analgesic (baseline), and 5 and 15 minutes after its administration. The efficiency of analgesia was assessed by monitoring Mean Arterial Pressure (MAP), Heart Rate (HR), SaO₂, Respiratory Rate (RR) with a Nihon Corden cardiac monitor (Japan); end-diastolic volume (EDV), end-systolic volume (ESV) were assessed by echocardiography; Stroke index (SI), cardiac index (CI), and total peripheral vascular resistance (TPVR) were determined using the generally accepted formula. Pain was assessed using a visual analog scale (VAS).

The study of pulmonary functions was carried out in patients in the pre- and postoperative period using spirometry. Pneumoscreen was done with Chesgraph – Hi-701. The study was carried out in a sitting position before and 24 hours

after surgery. All parameters were automatically calculated as absolute values and as a percentage of the proper values. We studied the dynamics of the following parameters: vital capacity (VC), forced expiratory volume (FEV) in the first second, forced vital capacity (FVC), Tiffno test – FEV₁/VC ratio (%); Parameters of the flow-maximum expiratory volume curve: peak expiratory volume flow rate, maximum volume flow rates (MVf) at 75, 50, 25% (VC) (MVf₇₅, MVf₅₀, MVf₂₅), aerodynamic resistance of the respiratory tract (Raw). Standards and gradations of deviations from the norm were specified according to data from N.N. Kanaev and R.F. Clement. The time of the patient's awakening, the time of tracheal extubation were determined.

The received data were processed on a computer using the Microsoft Excel package. The average indicators were compared using standard methods of variational statistics of the biomedical profile.

3. Results

The analysis of the obtained results of hemodynamic parameters study at various stages of anesthesiological support, depending on the technique used, revealed the following patterns: there was an increase in TPVR by 15.1% ($P < 0.05$) and a decrease in the indicators of one-time and minute heart performance in Group 1 at the stages of surgery. Stroke volume (SV) decreased by 14.4% ($P < 0.05$) compared to the initial stage, HR - by 14.7% ($P < 0.01$), MAP was higher by 10.3% ($P < 0.05$) compared to the initial stage, which increased the myocardial oxygen demand. All this indicated the inadequacy of anesthetic protection in Group 1. The main indicators of central hemodynamics (CH) of patients in Group 2 of patients at the stages of surgery were stable. It was fundamentally important that at the stage of echinococectomy or isolation of the cystic duct, cholecystectomy, HR was lower by 22.2% ($P < 0.05$), TPVR - by 20.3% ($P < 0.01$), EDV was higher by 19.5% ($P < 0.05$) compared with Group 1. Cardiac activity was transferred to a more economical mode of operation.

With the same duration and the same type of surgical intervention, the time for recovery of consciousness and tracheal extubation from the moment of completion of surgical intervention in Group 1 was 43.3 ± 5.6 minutes ($p < 0.01$); in Group 2 it was 22.1 ± 5.2 minutes, which, accordingly, reduced the number of patients of this group requiring intensive monitoring in the ICU. Thus, more than 75% of patients in Group 2 were transferred to a specialized surgical department at the end of the operation, their postoperative period proceeded smoothly, and IPA was used for postoperative pain relief.

The first need for analgesics in the early postoperative period in patients of Group 1 occurred after 65.3 ± 25.2 minutes, in Group 2 - 150.4 ± 20.4 ($P < 0.05$) minutes after the end of the surgery.

After intramuscular administration of promedol, the analgesic effect began at the 10th minute and reached a

maximum after 30 ± 10 minutes. Pain decreased by 55.1% according to VAS (averaging 3.6 ± 1.3 points). 90 ± 15 minutes after administration of the drug, the pain occurred again (increased by 29.4% VAS). In addition, after the use of promedol, hypoventilation syndrome occurred in 2 (4.08%) of 49 patients.

The data presented in Table 1 indicate that in the postoperative period, indicators of external respiratory function (ERF) were statistically significantly reduced from the proper standards.

In Group 1, VC decreased by 41.2% compared to the initial values, FVC decreased by 43.7%. Speed parameters of the spirogram in the postoperative period showed the presence of obstruction in the bronchial tree: FEV - by 55.5%, Tiffno index - by 43.6% ($P < 0.05$). These changes were mainly caused by the pain factor, postoperative inactivity of the patient, i.e. extra-pulmonary component. Pain in the area of the surgical wound after abdominal interventions makes breathing difficult - the patient "spares" the painful area. A decrease in the amplitude of respiratory movements leads to a decrease in tidal volume and functional residual capacity. A decrease in the vital capacity of the lungs does not allow to cough efficiently and remove sputum from the respiratory tract. Normal ventilation-perfusion ratios are disrupted, which increases the risk of developing atelectasis and intrapulmonary shunting. Elastic and inelastic resistance to breathing increases. Besides, the tone of the abdominal wall muscles are reflexively increased, the function of the diaphragm is disrupted, which leads to muscle rigidity and makes deep breathing and coughing impossible. Clinical manifestations of respiratory dysfunction are hypoxemia, hypercapnia, violations of the drainage function of the bronchi, followed by the formation of atelectasis and pneumonia. Tachypnea, in turn, leads to an aggravation of metabolic disorders, negatively affects the activity of the cardiovascular system. Inhibition of pulmonary ventilation causes the occurrence of respiratory and then metabolic acidosis. После обезболивания

наблюдается незначительное увеличение показателей ERF. As it can be seen from the table, the IM introduction of promedol was accompanied by a slight decrease in the index of Tiffno, VC, FVC, FEV [11]. At the same time, there was a slight increase in the level of sedation, which was an early sign of respiratory depression. The sedative effect of opioid analgesics and decreased respiratory rate may promote the development of hypoventilation by suppressing the cough clearing mechanism, which worsens airway obstruction.

In patients of Group 2 (after IPA), the onset of analgesia was developed after 6 ± 1 min on average and was accompanied by the appearance of special sensations, such as numbness of the right half of the chest, a feeling of warmth in the same area. Several patients described the new sensations as numbness of the skin. The detailed picture of anesthesia was observed after 20 ± 5 minutes. Pain was decreased by 64.1% (VAS averaged 2.9 ± 0.7 points). There was a disappearance of pain in the area of the surgical wound or drainage. The resumption of pain syndrome in some patients occurred after 180 ± 30 minutes. The zone of cutaneous analgesia, determined by a needle prick, extended to 3-4 dermatomes and was surrounded by a zone of hypoesthesia, extending to 6-7 dermatomes. IPA, as a rule, relieved the tension of the muscles of the anterior abdominal wall, especially in its upper parts, and patients had the opportunity to breathe with their abdomen. Tachypnea disappeared, breathing became even and deep with the development of analgesia. In addition, patients were more actively able to make movements and turns in bed, torso tilts, which were very limited before the IPA (Fig. 1).

The catheter itself did not cause any discomfort. The course of the postoperative period in the first days was significantly facilitated. The catheter was in the pleural space for 1-2 days. There was no need for IPA by this time.

As it can be seen in Figure 1, the degree of analgesia is more pronounced: at the peak of the IPA action which was confirmed by a higher number of effective analgesias, the number of excellent and good results.

Table 1. Indicators of external respiration function in the examined patients in the postoperative period

Indicators		Group I (n=49)			Group II (n=44)		
		Before surgery	20 min after analgesia	24 hours after surgery	Before surgery	20 min after analgesia	24 hours after surgery
VC	Abs	3.4 ± 0.7	2.04 ± 1.4	2.0 ± 1.2	3.2 ± 0.4	$2.09 \pm 0.03^{**}$	$2.0 \pm 0.07^{**}$
FVC	Abs	3.2 ± 0.4	1.83 ± 0.5	1.8 ± 0.2	2.8 ± 0.7	$2.57 \pm 0.03^{**,*}$	$2.4 \pm 0.06^{**}$
FEV	Abs	3.6 ± 0.6	1.61 ± 0.2	1.6 ± 0.5	2.6 ± 0.8	$1.68 \pm 0.02^{**}$	$1.6 \pm 0.05^{**}$
FEV / VC %		78.4 ± 0.3	$45.35 \pm 1.22^{**}$	$44.2 \pm 1.21^{**}$	74.4 ± 3.3	$55.39 \pm 3.2^{**}$	$53.2 \pm 2.6^{**}$
MVF	25%	58.6 ± 3.5	$37.11 \pm 2.12^{**}$	$36.8 \pm 2.3^{**}$	42.4 ± 3.2	37.29 ± 1.9	36.8 ± 2.4
MVF	50%	58.2 ± 2.2	$34.9 \pm 2.14^{**}$	$34.2 \pm 2.2^{**}$	40.6 ± 2.8	33.63 ± 2.1	$32.4 \pm 1.2^{*}$
MVF	75%	56.8 ± 3.5	$34.92 \pm 3.06^{**}$	$32.6 \pm 3.1^{**}$	50.2 ± 3.0	$39.98 \pm 2.3^{*}$	$36.8 \pm 2.9^{*}$
PEFR	%	56.6 ± 3.1	$33.11 \pm 2.21^{**}$	$30.6 \pm 2.15^{**}$	54.4 ± 3.1	$44.16 \pm 3.4^{*}$	$40.2 \pm 3.19^{**}$

Note: $^{**} P < 0.01$ comparison with the indicator before surgery; $^{*}, * P < 0.05$ comparison with the indicator before surgery

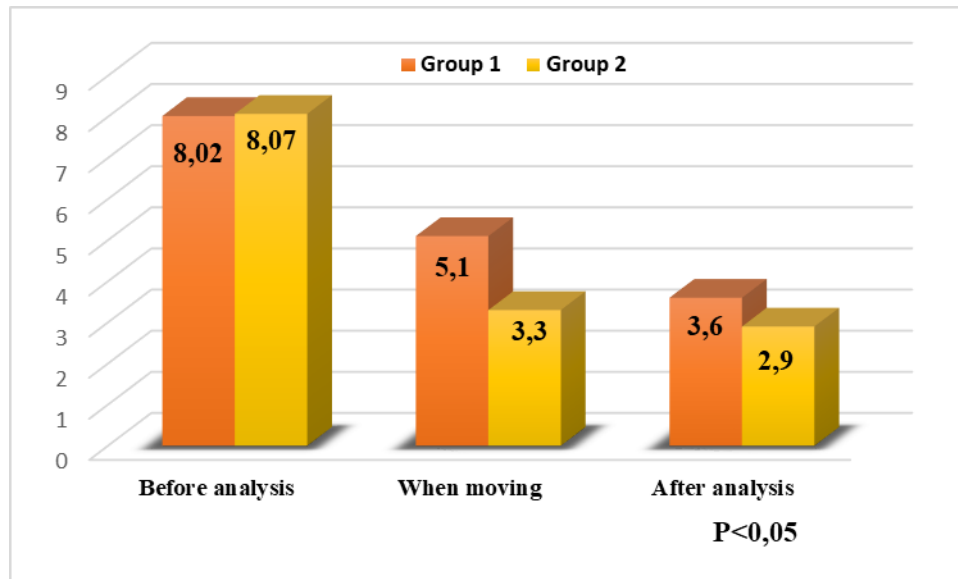


Figure 1. Evaluation of postoperative pain relief efficiency (Visual Analogue Scale)

4. Discussion

The subjective assessment of the analgesic effect of the IPA is undoubtedly positive. In all cases, we managed to relieve pain syndrome on the first day of the postoperative period, without the use of opioid analgesics. Many patients had drowsiness or sleep.

Intrapleural administration of local anesthetics causes unilateral sensory blockade of the chest and anterior abdominal wall. The block also applies to the muscles innervated by the pectoral nerves, including the external intercostal muscles - the muscles of inspiration and the internal intercostal muscles and abdominal muscles, which are also the muscles of inspiration.

IPA was accompanied by an increase of VC by 4.9%, FVC - by 7.09% ($P < 0.05$) and FEV - by 5.3%. The Tiffno index was decreased by 4.1% compared to the pre-analgesic stage, which was associated with the interruption of pain impulses from the surgical area. These data indicate a negative effect of pain syndrome on the tone of the small bronchi in the analyzed type of patients.

The use of IPA helps to normalize the patency of small bronchi and improve the patency of large and medium bronchi, creates preconditions for the realization of muscular effort during breathing and coughing. Clinically, it was manifested by the disappearance of pain syndrome, relief of sputum discharge. All patients noted an improvement in their general condition. It became possible to take a deep breath and forced exhalation. A normal cough with active sputum discharge became possible. The data obtained suggest that external respiration in the postoperative period is significantly affected by surgical trauma, afferent impulses and postoperative pain syndrome. As a result of these changes, adynamia, impaired intestinal motility and cardiovascular insufficiency appear in operated patients. Since the pain of the operated patient inevitably increases with movement, it leads to his immobilization.

IPA had a sufficient analgesic effect while fully preserving the function of the respiratory muscles, which, while maintaining the function of the intercostal muscles, ensures a full act of inspiration, keeping physiological breathing.

Thus, in addition to adequate analgesia, an improvement in ventilation parameters and respiratory mechanics parameters was noted during IPA. As the block is selective, the effect on the motor activity of the respiratory muscles is minimal, and the contractility of the diaphragm is also not impaired. Analgesia is accompanied by an improvement in the component functions of the external respiration system, mechanical properties, and the musculoskeletal system—inspiratory and expiratory muscles. Since the patients we studied did not have a history of chronic pathology of the respiratory system, the results obtained allow us to confirm that postoperative pain syndrome disrupts the mechanical properties of the lungs and airway patency.

5. Conclusions

Our studies confirmed the positive role of regional methods, the use of which begins before and continues during and after surgery. It dramatically reduces the intensity of pain and the need for analgesics of central action, allow to completely abandon the administration of drugs, or use them in moderate doses.

Adequate postoperative analgesia is the main condition for the implementation of an active postoperative rehabilitation program.

Combined IPA is an adequate and safe method of intraoperative protection of patients during surgical interventions in the hepatobiliary area.

Intrapleural administration of lidocaine improves the parameters of respiratory mechanics, facilitating the implementation of an active postoperative rehabilitation

program for patients.

The authors declare no conflict of interest.

This study does not include the involvement of any budgetary, grant or other funds.

The article is published for the first time and is part of a scientific work.

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