MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SUMY STATE UNIVERSITY
MEDICAL INSTITUTE

Eastern Ukrainian Medical Journal

2, Rymskogo-Korsakova st., Sumy 40007, Ukraine
e-mail: EUMJ@med.sumdu.edu.ua
eumj.med.sumdu.edu.ua
ISSN: 2663-5909 (print)

**DOI: https://doi.org/10.21272/eumj.2019;7(3):257-266**

**Abstract** **УДК 615.55-089.8-036.3-083.98-085:616.151.1**

**O. V. Kravets,**
*State Institution "Dnipropetrovsk Medical Academy of the Ministry of Health of Ukraine", 9, Vernadsky str., Dnipro, 49044, Ukraine*

## INFLUENCE OF DIFFERENT INFUSION THERAPY MODES ON THE DEVELOPMENT OF POSTOPERATIVE PULMONARY COMPLICATIONS IN PATIENTS WITH MEDIUM AND HIGH SURGICAL RISK WITH ACUTE ABDOMINAL PATHOLOGY

**Introduction**. Postoperative pulmonary complications occur in 5–70% of cases in surgical patients and are accompanied by significant short-term and long-term mortality. The purpose is to conduct a comparative analysis of the relationship between the frequency of postoperative pulmonary complications, the degree of surgical risk and the development of interstitial edema in different modes of infusion therapy in patients with moderate and high surgical risk with acute abdominal pathology.

**Materials and Methods**. We examined 200 patients with acute abdominal pathology, operated on urgently by laparatomy access. Patients were divided into groups according to the degree of surgical risk, subgroups were formed taking into account the regimen of infusion therapy. Subgroup 1.1 (n = 50) included patients who received infusion therapy in a liberal regimen; in subgroup 1.2 (n = 50), infusion therapy was performed in a restriction regimen. Subgroup 2.1 (n = 50) consisted of patients who received goal-direct infusion therapy, subgroup 2.2 (n = 50) – restrictive infusion therapy. The non-invasive bioelectric rheography method was used to evaluate the performance of the body's water sectors, sonographically determine the degree of fluid accumulation in the extravascular pulmonary fluid space, postoperative pulmonary complications were verified on the basis of clinical, laboratory and radiological data.

In the total cohort of patients we noted 10.5% of postoperative pulmonary complications. In the postoperative period of the liberal regime of infusion therapy was accompanied by an increase of interstitial volume by 146% ($p<0.04$) and 159% ($p<0.02$) of norm, a moderate degree of accumulation of fluid within the pulmonary space ($R=0,86$, $p=0.04$) and had a strong direct relationship with the development 16% of postoperative pulmonary complications ($R=0.79$, $p=0.002$). The absence of interstitial edema on the background of the restrictive regime of infusion therapy, normal sonographic pattern of light when the frequency of postoperative pulmonary complications 6% in the group of moderate surgical risk of 10% in the group of high surgical risk. Goal-direct infusion therapy generates an increase in the volume of interstices on the first day, the accumulation of fluid within the primary space of mild to 3 days and combined with a 10% development of pulmonary complications after surgery.

**Discussion**. In patients with acute abdominal pathology of middle and high surgical risk the overall incidence of postoperative pulmonary complications is 10.5%, of which 80.9% of all cases are associated with pneumonia. Moderate surgical risk patients had a different infusion therapy's affects to the development of postoperative pulmonary complications; a liberal regime is accompanied by the development of interstitial edema, increased extravascular fluid in the lungs and incidence of pulmonary complications in 16%, restrictive mode preserves the volume of the interstices within the boundaries of the rules during postoperative period and reduces the risks of pulmonary complications to 6%. High surgical risk patients with acute abdominal pathology, postoperative period is complicated by development of pulmonary complications in 10% of cases due to increased interstitial volume and pulmonary extravascular fluid mild in the first day when targeted mode of infusion therapy limits the development of interstitial edema during all the postoperative period in the restrictive mode of infusion therapy.

**Key words:** infusion therapy, acute abdominal pathology, postoperative pulmonary complications, interstitial edema, sonographic diagnosis.

**Corresponding author:** *535951@ukr.net*

**Резюме**

**О. В. Кравець,**
*ДЗ «Дніпропетровська медична академія МОЗ України», вул. Володимира Вернадського, 9, Дніпро, Дніпропетровська область, Україна, 49044*

## ВПЛИВ РІЗНИХ РЕЖИМІВ ІНФУЗІЙНОЇ ТЕРАПІЇ НА РОЗВИТОК ПІСЛЯОПЕРАЦІЙНИХ ЛЕГЕНЕВИХ УСКЛАДНЕНЬ У ХВОРИХ СЕРЕДНЬОГО І ВИСОКОГО ХІРУРГІЧНОГО РИЗИКУ З ГОСТРОЮ АБДОМІНАЛЬНОЮ ПАТОЛОГІЄЮ

Післяопераційні легеневі ускладнення виникають у 5–70 % випадків серед хірургічних пацієнтів і супроводжуються значною як короткостроковою, так і віддаленою летальністю.

**Мета** – провести порівняльний аналіз взаємозв'язку між частотою післяопераційних легеневих ускладнень, ступенем хірургічного ризику і розвитком інтерстиціального набряку при різних режимах інфузійної терапії у хворих середнього і високого хірургічного ризику з гострою абдомінальною патологією.

**Методи і матеріали.** Нами обстежено 200 хворих з гострою абдомінальною патологією, оперованих в ургентному порядку лапаратомним доступом. Хворі розподілялись на групи відповідно до ступеню хірургічного ризику, підгрупи формувались з урахуванням режиму інфузійної терапії. В підгрупу 1.1 (n = 50) увійшли хворі, які отримували інфузійну терапію в ліберальному режимі, в підгрупі 1.2 (n = 50) – інфузійну терапію проводили в режимі рестрикції. Підгрупу 2.1 (n = 50) склали пацієнти, які отримували цілеспрямовану інфузійну терапію, підгрупу 2.2 (n = 50) – рестриктивну інфузійну терапію. Методом неінвазивної біоелектричної реографії оцінювали показники водних секторів організму, сонографічно визначали ступінь накопичення рідини в позасудинному легеневому просторі рідини, післяопераційні легеневі ускладнення верифіцировали на підставі клінічних, лабораторних і рентгенологічних даних.

**Результати дослідження.** У загальній когорті досліджуваних пацієнтів встановлено 10,5 % випадків післяопераційних легеневих ускладнень. Найбільш частою причиною ПОЛ у обстежених хворих була пневмонія з частотою 80,9 %. В післяопераційному періоді

ліберальний режим інфузійної терапії супроводжувався збільшенням інтерстиціального обсягу на 146 % (p < 0,04) – 159 % (p < 0,02) норми, помірним ступенем накопичення рідини в позалегеневому просторі (R = 0,86, p = 0,04) і мав сильну пряму залежність з розвитком 16 % післяопераційних легеневих ускладнень (R = 0,79, p = 0,002). Встановлено відсутність інтерстиціального набряку на тлі рестриктивного режиму інфузійної терапії, нормальна сонографічної картина легенів при частоті післяопераційних легеневих ускладнень 6 % в групі середнього хірургічного ризику, 10 % – в групі високого хірургічного ризику. Цілеспрямована інфузійна терапія формує збільшення обсягу интерстиції в першу добу, накопичення рідини у позалегеневому просторі легкого ступеня до 3 діб і поєднується з 10 % розвитку легеневих ускладнень після операції.

**Висновки:** У пацієнтів з гострою абдомінальною патологією середнього і високого хірургічного ризику загальна частота післяопераційних легеневих ускладнень становить 10,5 %, з них 80,9 % всіх випадків пов'язано з пневмонією. У пацієнтів середнього хірургічного ризику режим інфузійної терапії впливає на частоту виникнення післяопераційних легеневих ускладнень як: ліберальний режим супроводжується розвитком інтерстиціального набряку, збільшенням позасудинної рідини в легенях помірного ступеня і частотою розвитку легеневих ускладнень у 16 %, рестриктивний режим зберігає об'єм інтерстиції в межах норми весь післяопераційний період і знижує ризики легеневих ускладнень до 6 %. У пацієнтів високого хірургічного ризику з гострою абдомінальною патологією післяопераційний період ускладнюється розвитком легеневих ускладнень у 10 % випадків через збільшення інтерстиціального обсягу і легеневої позасудинної рідини легкого ступеня у першу добу при цілеспрямованому режимі інфузійної терапії, обмеження розвитку інтерстиціального набряку весь післяопераційний період при рестриктивному режимі інфузійної терапії.

**Ключові слова:** інфузійна терапія, гостра абдомінальна патологія, післяопераційні легеневі ускладнення, інтерстиціальний набряк, сонографічна діагностика.

**Автор, відповідальний за листування:** *535951@ukr.net*

## Introduction

In the general structure of emergency surgical interventions, more than half of the surgeries are performed regarding acute abdominal pathology. Long-term inpatient treatment and high hospital mortality in patients with this pathology are due to the development of postoperative complications [1, 2]. Postoperative pulmonary complications (PPC) occur in 5–70% of cases and are accompanied by significant short-term and long-term mortality [3]. The development of PPC in surgical patients increases the risks of adverse outcome within 30 days to 14–30%, 90 days to 24.4 %, 1 year to 45.9%, 5 years to 71.4% [4, 5]. The use of the term "postoperative pulmonary complication" in the literature is collective and implies almost any complication of the respiratory system during the entire perioperative period. In 2015, the Committee of the European Society of Anaesthesiology published clear standards for determining perioperative clinical outcome (EPCO). According to these recommendations, "postoperative pulmonary complication" is a clinically significant disorder, negatively affecting the course of the disease, causing a verifiable disease or dysfunction of the lungs [6]. Factors that increase the risks of PPC development are classified into those related to the patient and the procedure. The first ones include age over 60 years, male sex, degree of operational and anaesthesiological risk according to the ASA over II, smoking, chronic obstructive pulmonary

disease or asthma, smoking, morbid obesity, diabetes mellitus, chronic heart, kidney and liver failure. The factors, related with the procedure, are urgent operational conditions, laparatomy surgical access, duration of the operation [4]. Taking into account the described risk factors for the development of PPC, active development of strategies for lung protection in the perioperative period is underway. Most of the recommendations are focused on planned surgical interventions, when preoperative care is aimed at complex optimization of the functional state of the lungs and the patient's nutritional state [4]. Intra- and postoperative programs of lung protection include protective modes of artificial lung ventilation, adequate analgesia and "smart administration of fluid". The optimal infusion therapy (IT) mode remains a controversial issue. Based on the volume of administered infusion solutions there are several IT modes: liberal, restrictive and targeted. It is known that liberal (excessive) fluid administration may increase the initial damage to the lung endothelium, cause damage to the capillaries and is a risk factor of PPC [7]. According to meta-analysis data, the liberal IT mode is associated with high risks of pulmonary oedema, pneumonia and lengthening of hospital stay [7]. Restrictive and targeted IT modes provide replenishment of the required volume of liquid [8,9]. The advantages of the latter are dynamic objectification of the final hemodynamic IT points, such as stroke volume, cardiac output and parameters of sensitivity to infusion [10].

**The aim** is to carry out a comparative analysis of the relationship between the frequency of postoperative pulmonary complications, the degree of surgical risk and the development of interstitial oedema in different modes of infusion therapy in patients with medium and high surgical risk with acute abdominal pathology.

**Methods and materials.** After the approval by the Ethics Committee of SE "DMA" of the MOHU we examined 200 patients with acute abdominal pathology. The prospective observational study was conducted from January 2016 to December 2018. The study was conducted in accordance with the basic bioethical norms of the Helsinki Declaration of the World Medical Association on the Ethical Principles of Scientific and Medical Research as amended (2000, 2008 amendments), the Universal Declaration on Bioethics and Human Rights (1997), the Council of Europe Convention on Human Rights and Biomedicine (1997). Written informed consent was obtained from each participant of the study and all measures were taken to ensure the anonymity of the patients.

All patients were subject to urgent surgery by laparatomy access regarding: acute intestinal obstruction (n=65), perforated gastric ulcer and duodenal ulcer (n=51), strangulated hernia (n=84). The average age of the patients was 61.1±11.5 [45:75] years, of which 106 (53%) were men and 94 (47%) were women.

Inclusion criteria: urgent laparatomy; age over 45 and less than 75 years; degree of volumetric exhaustion more than 10% and less than 30% [11]; degree of surgical risk – medium and high (predicted percentage of postoperative complications and mortality more than 10% based on the P-POSSUM scale) [12, 13]; degree of anaesthetic risk according to ASA-III; informed consent of the patient to participate in the study.

Exclusion criteria: planned surgery; age is less than 45 and more than 75 years; the degree of volume depletion is less than 10% and more than 30%; the degree of surgical risk is mild (predicted percentage of occurrence of postoperative complications and mortality is less than 10% based on the P-POSSUM scale); gastrointestinal bleeding; intraoperative blood loss above the level I according to Bryusov; the degree of anesthetic risk is I-II-IY according to ASA; the refusal of a patient from participation in the study.

According to the degree of surgical risk, patients were divided into 2 groups. The first (n=100) included patients with medium surgical risk, the second (n=100) with high surgical risk [12,13]. The patients of each group were divided into 2 subgroups by the "blind envelopes" method. Subgroup 1.1 (n=50) included patients receiving IT in liberal mode, subgroup 1.2 (n=50) – in restriction mode. The subgroup 2.1 (n=50) included patients who received targeted IT (TIT), subgroup 2.2 (n=50) – restrictive IT. The groups were representative by age, gender distribution, nature of surgical and concomitant somatic pathology.

Preoperative preparation in all patients was carried out in the intensive care unit according to the Protocol of the Ministry of Health of Ukraine No.297 (02.04.2010) [11]. In the first day of the perioperative period in patients of subgroups 1.1, 1.2, 2.2 the volume of IT was calculated taking into account the estimated preoperative fluid deficit, physiological need of the patient per day, surgical injury, intraoperative loss, postoperative pathological losses [8]. Balanced crystalloid solutions were used for infusion (Table 1).

**Table 1 –Calculation of infusion volume depending on IT mode**

| Infusion therapy mode | Degree of volume depletion | Amount of fluid per day (ml/kg*/day) | Average fluid injection rate (ml/kg*/hour) |
|---|---|---|---|
| Liberal | 20% | 100 ±20 | 4.5–5.0 |
| Restrictive | 20% | 50±10 | 1.6–2.5 |

**Note**: kg* – ideal patient body mass

The estimated volume of infusion was divided into three parts and was administered according to the stages: rescue, optimization and stabilization (Table 2) [14].

The stage of de-escalation was initiated on the second day of the postoperative period by combining intravenous and enteral routes of fluid administration, with fluid being administered enterally at a rate of 20 ml/hour, from third day – up to 40 ml/hour, with a maximum volume of up to 70 ml/hour. The volume of intravenous infusion was reduced according to the administered enteral volume. Contraindication to the administration of enteral fluid was the presence of residual gastric volume of more than 300 ml in 6 hours.

In subgroup 2.1, according to the TIT protocol, patients received an intravenous bolus infusion of 500 ml of balanced crystalloid solution over a period of 15 minutes. An increase in the stroke volume (SV) by 10% or more from the baseline was evaluated as a positive response, was the basis for further infusion under the SV control after every 500 ml. After optimization of the SV, patients received IT of the balanced crystalloid solution in a restrictive mode – 2.5 ml/kg/hour. In case of a negative response to the infusion loading, on the background of the restrictive IT mode, dopamine was administered in inotropic doses of 2–10 μg/kg/min to achieve a minimum cardiac index of 2.5 L/min/m2 as an alternative to prevent low SV values [15]. Subsequently, patients were treated according to the restrictive mode of infusion therapy.

**Table 2 – Calculation of infusion volume depending on IT mode and stage**

| Mode stage | Liberal IT mode | Restrictive IT mode |
|---|---|---|
| **Rescue** (administration of 25% of the estimated volume of infusion over a period of 1 hour) | 20–30 ml/kg/hour | 10–15 ml/kg/hour |
| **Optimization** (infusion of the next 25% of the estimated volume over a period of 2 hours (taking into account intraoperative losses)) | 10–15 ml/kg/hour | 5–7.5 ml/kg/hour |
| **Stabilization** (administration of 50% of the estimated volume until the end of the first day of treatment) | 3.5–5.0 ml/kg/hour | 1.6–2.0 ml/kg/hour |

The auscultatory picture of the lungs, the need of substitution oxygen therapy, clinical indicators: basal body temperature ($t^o$), respiratory rate (RR), saturation (SatO2), routine laboratory tests (complete blood count and urinalysis, biochemical blood analysis, coagulogram) were studied, chest x-ray was conducted.

The non-invasive bioelectrical rheography with "Diamond" apparatus evaluated the indicators of the aqueous sectors of the organism: extracellular volume (ECV), volume of intracellular fluid (VICF), volume of intravascular fluid (VIVF). Based on the basic physiology of fluid distribution among the aqueous sectors of the body, we calculated the volume of interstitial space (IS) as the difference between the volumes of extracellular and vascular fluids [16]. The degree of accumulation of fluid in the extravascular pulmonary space (EPS) was quantitatively determined by the linear transducer "Mindray Digi prince DP 6600" by the number of B-lines as a sign of interstitial oedema of lung tissue. Severity of manifestations was estimated according to the data (Table 3) [17].

Control points: before surgery; 6th hour of the perioperative period; 1st, 2nd, 3rd, 5th, 7th and 10th day after the surgery.

**Table 3 – The degree of accumulation of extravascular fluid in the lungs according to sonographic examination**

| Points | Number of B-lines | EPS |
|---|---|---|
| 0 | ≤5 | Absent |
| 1 | 6–15 | Mild degree |
| 2 | 16–30 | Moderate degree |
| 3 | > 30 | Severe degree |

The studied indicators, measured in healthy volunteers (n=40), were accepted as normal values.

Statistical analysis of the results was conducted using the MS Excel 2007 And Statistica v6.1 package (license No. AJAR909E415822FA). The results are shown as M ± m, the statistically significant level was p<0.05. Correlation analysis with calculation of Spearman's rank correlation (R) was used to assess the relationship between the attributes.

**Study results.** In the preoperative period, there was a decrease in the volume of extracellular fluid in all patients with acute abdominal pathology. The decrease of the extracellular volume by 20% (p <0.04) from the norm corresponded to the moderate volumetric depletion and did not significantly differ between the subgroups (Table 4, 5). In the first group of patients there was a deficit of intravascular sector of 17% (p <0.002), interstitial volume of 21% (p <0.01) without significant difference between the subgroups (Table 4). Changes in aqueous sectors in the second group of patients did not significantly differ from the first and were manifested by a decrease in the volume of the intravascular sector by 16% (p<0.05) from the norm, the volume of interstitial tissue – by 21% (p <0.04) (Table 5).

**Table 4 –Indicators of aqueous sectors of the body in different IT modes in patients with moderate surgical risk with acute abdominal pathology**

| Indicator | Norm (n=40) | Baseline (n=100) | 1st day (n=100) | 2nd day (n=100) | 3rd day (n=100) | 5th day (n=100) | 7th day (n=100) | 10th day (n=100) |
|---|---|---|---|---|---|---|---|---|
| **Subgroup 1.1** | | | | | | | | |
| **ECV**(L) | 14.1 | 11.4*±0.3 | 16.0$^{\dagger}$ *±0.5 | 17.8*±0.3 | 19.4*$^{\dagger}$±0.4 | 17.2*$^{\dagger}$±0.3 | 18.6*$^{\dagger}$ ±0.2 | 19.1* ±0.3 |
| **VICF**(L) | 24.9 | 23.8*±0.8 | 22.6*$^{\dagger}$ ±1.3 | 22.1±0.5 | 21.5*±0.9 | 24.0$^{\dagger}$±0.7 | 21.8*$^{\dagger}$ ±0.4 | 20.9* ±0.3 |
| **VIVF** (L) | 4.9 | 4.1*±0.3 | 4.6*$^{\dagger}$±0.2 | 4.4±0.2 | 4.5*±0.1 | 5.4$^{\dagger}$±0.3 | 3.9*$^{\dagger}$ ±0.1 | 4.1*±0.1 |
| **IS** (L) | 9.2 | 7.3±0.3 | 11.4±0.2 | 13.4±0.3 | 14.9±0.4 | 11.8±0.3 | 14.7±0.4 | 15.0±0.4 |
| **Subgroup 1.2** | | | | | | | | |
| **ECV**(L) | 14.1 | 11.4*±0.4 | 13.5$^{\dagger}$ *±0.2 | 12.9*±0.2 | 13.3*±0.1 | 13.6*±0.2 | 13.4* ±0.3 | 13.9* ±0.2 |
| **VICF**(L) | 24.9 | 23.9*±0.8 | 23.9*±1.3 | 23.2*±1.3 | 23.3*±0.9 | 23.7±0.7 | 23.9* ±0.4 | 24.1±0.3 |
| **VIVF** (L) | 4.9 | 4.1±0.2 | 4.9*±0.2 | 4.7*±0.1 | 4.9*±0.1 | 5.0±0.3 | 4.9*±0.1 | 4.8*±0.1 |
| **IS** (L) | 9.2 | 7.3±0.4 | 8.6±0.3 | 8.2±0.2 | 8.4±0.2 | 8.6±0.3 | 8.5±0.2 | 9.1*±0.1 |

**Note:** * p < 0.05 compared to norm, $^{\dagger}$ p < 0.05 compared to previous observation stage

**Table 5 – Indicators of aqueous sectors of the body in different IT modes in patients with high surgical risk with acute abdominal pathology**

| Indicator | Norm (n=40) | Baseline (n=100) | 1st day (n=100) | 2nd day (n=100) | 3rd day (n=50) | 5th day (n=50) | 7th day (n=50) | 10th day (n=49) |
|---|---|---|---|---|---|---|---|---|
| **Subgroup 2.1** | | | | | | | | |
| **ECV** (L) | 14.1 | 11.4*±0.3 | 15.1$^{\dagger}$*±0.3 | 14.8*±0.2 | 12.9$^{\dagger\pm}$0.1 | 12.8*±0.2 | 13.3$^{\dagger\pm}$0.3 | 13.4*±0.3 |
| **VICF** (L) | 24.9 | 23.6±0.7 | 23.7$^{\pm}$1.3 | 24.0*±1.3 | 23.5$^{\dagger}$±0.9 | 24.4*±0.7 | 23.9$^{\dagger\pm}$0.4 | 23.5*±0.3 |
| **VIVF** (L) | 4.9 | 4.1*±0.3 | 4.6±0.2 | 5.2±0.1 | 4.3±0.1 | 5.1±0.4 | 4.5±0.2 | 4.4*±0.1 |
| **IS** (L) | 9.2 | 7.3*±0.5 | 10.5*$^{\dagger}$±0.3 | 9.6*±0.2 | 8.6$^{\dagger}$±0.2 | 7.7*±0.3 | 8.8±0.2 | 9.0±0.3 |
| **Subgroup 2.2** | | | | | | | | |
| **ECV** (L) | 14.1 | 11.4*±0.4 | 12.8$^{\dagger}$*±0.2 | 12.6*±0.2 | 13.6$^{\dagger\pm}$0.1 | 13.1*±0.2 | 13.7$^{\dagger\pm}$0.3 | 13.7*±0.2 |
| **VICF** (L) | 24.9 | 23.7±0.8 | 23.7$^{\pm}$1.3 | 23.5*±1.3 | 24.5$^{\dagger}$±0.9 | 23.3*±0.7 | 24.3$^{\dagger}$±0.4 | 24.3±0.3 |
| **VIVF** (L) | 4.9 | 4.1*±0.2 | 4.6±0.2 | 4.5±0.1 | 4.7±0.1 | 4.6±0.3 | 4.9±0.1 | 4.8*±0.1 |
| **IS** (L) | 9.2 | 7.3*±0.4 | 8.2*$^{\dagger}$±0.3 | 8.1*±0.2 | 8.9$^{\dagger}$±0.2 | 8.5*±0.3 | 8.8±0.2 | 8.7±0.3 |

**Note:** * p < 0.05 compared to norm, $^{\dagger}$ p < 0.05 compared to previous observation stage

In the postoperative period, subgroup 1.1 patients showed exceedence of the IS by 23% (p<0.001) from the norm on the first day after the surgery with a tendency to further increase on the third day, when the IS was 146% (p<0.04) from the norm (Table 4). In the next six days, the IS indicators also exceeded normal values and on the tenth day of the postoperative period corresponded to 159% (p<0.02) of the norm. This coincided with the sonographic signs of a mild increase of the extravascular fluid in the lungs on the 1st day and was confirmed by a direct correlation (R=0.76, p=0.02) (Table 6). From the second to the tenth day, the moderate EPS, established sonographically, had a strong direct correlation with the increased IS (R=0.78–0.86, p=0.02–0.04), respective to the days. The clinical manifestation of interstitial fluid accumulation in the lungs was the development of five cases of pneumonia (10%) on the third day and two cases (4%) on the fifth day of the postoperative period. Patients showed no signs of respiratory failure and did not require replacement therapy. One patient (2%) had a hydrothorax on the tenth day, which required invasive resolution. Rank correlation analysis showed a strong direct relationship between the development of PPC and interstitial oedema (R = 0.79, p=0.002). Medical history of three patients with postoperative pulmonary complications was burdened by concomitant chronic obstructive pulmonary disease.

**Table 6 – The incidence of postoperative complications in patients with moderate surgical risk with acute abdominal pathology in different IT modes**

| Indicator | 1st day (n=100) | 2nd day (n=100) | 3rd day (n=100) | 5th day (n=100) | 7th day (n=100) | 10th day (n=100) |
|---|---|---|---|---|---|---|
| **Liberal IT** | | | | | | |
| **IS, L** | 11.4*±0.2 | 13.4*†±0.3 | 14.9*±0.4 | 11.8*†±0.3 | 14.7*†±0.4 | 15.0*±0.4 |
| **Number of B-lines** | 12±2 | 16±3† | 19±4† | 16±2† | 18±6† | 17±5 |
| **Pneumonia/number of patients** | - | - | +/ 5 | +/2 | - | - |
| **Hydrothorax/number of patients** | - | - | - | - | - | +/1 |
| **Pleuritis/number of patients** | - | - | - | - | - | - |
| **Restrictive IT** | | | | | | |
| **IS, L** | 8.6±0.3 | 8.2*±0.2 | 8.4*±0.2 | 8.6±0.3 | 8.5±0.2 | 9.1 ±0.1 |
| **Number of B-lines** | 5±2 | 4±1 | 3±2 | 3±2 | 4±3 | 3±1 |
| **Pneumonia/number of patients** | - | - | +/1 | +/1 | - | - |
| **Hydrothorax/number of patients** | - | - | - | - | - | - |
| **Pleuritis/number of patients** | - | - | - | - | +/1 | - |

**Note:** *p < 0.05 compared to norm, †p < 0.05 compared to previous observation stage

Patients in subgroup 1.2 did not show an increase in IS throughout the perioperative period, which coincided with the absence of sonographic signs of accumulation of extravascular fluid in the lungs (Table 4, 6). In the postoperative period, pneumonia was verified in two patients with a history of chronic obstructive pulmonary disease: on the third (2%) and fifth (2%) days after the surgery. The clinical course of the disease was not accompanied by signs of respiratory failure and did not require replacement therapy in patients. Rank correlation analysis did not establish a reliable relationship between the development of PPC and the volume of interstitial tissue. The development of infectious fibrinous pleuritis was established after seven days of treatment in one (2%) patient.

The targeted IT mode in subgroup 2.1 was accompanied by a 14% increase in IS (p<0.02) on the first day after surgery. From the second day and during the further postoperative period, interstitial volume did not differ from the norm (Table 5). At the same time, mild accumulation of extravascular

fluid in the lungs was observed up to 3 days after the surgery, accompanied by a direct correlation dependence between EPS and IS (R = 0.86, p = 0.02). The development of pneumonia was established in three cases (6%) on the third day and two cases (4%) on the fifth day after the surgery (Table 7). Treatment of one case of pneumonia was accompanied by the development of compensated respiratory failure and required non-invasive oxygen therapy through nasal cannulas. Rank correlation analysis showed a weak direct relationship between the development of PPC and interstitial oedema (r = 0.49, p=0.0014). Medical history of two patients was burdened with chronic obstructive pulmonary disease, four – with coronary heart disease, II degree hypertension, two – with coronary heart disease, permanent atrial fibrillation.

**Table 7 –The incidence of postoperative complications in patients with high surgical risk with acute abdominal pathology in different IT modes**

| Indicator | 1st day (n=70) | 2nd day (n=70) | 3rd day (n=70) | 5th day (n=70) | 7th day (n=70) | 10th day (n=50) |
|---|---|---|---|---|---|---|
| **Targeted mode** | | | | | | |
| **IS** | 84±0.3 | 10.5*†±0.3 | 9.6*±0.2 | 8.6†±0.2 | 7.7*±0.3 | 8.8±0.2 |
| **Number of B-lines** | 12±2 | 11±4† | 8±3 | 6±2 | 4±1 | 3±1 |
| **Pneumonia/number of patients** | - | - | +/ 3 | +/2 | - | - |
| **Hydrothorax/number of patients** | - | - | - | - | - | - |
| **Pleuritis/number of patients** | - | - | - | - | - | - |
| **Restrictive IT** | | | | | | |
| **IS** | 7.3±0.3 | 8.2*†±0.3 | 8.1*±0.2 | 8.9†±0.2 | 8.5*±0.3 | 8.8±0.2 |
| **Number of B-lines** | 5±1 | 5±2 | 4±1 | 3±2 | 3±2 | 3±1 |
| **Pneumonia/number of patients** | - | - | +/1 | +/3 | - | - |
| **Hydrothorax/number of patients** | - | - | - | - | - | - |
| **Pleuritis/number of patients** | - | - | - | +/1 | - | - |

In subgroup 2.2 patients, the interstitial volume did not exceed the normal value during the entire follow-up period (Table 5). Sonographic examination did not establish the signs of accumulation of extravascular fluid in the lungs (Table 6). In the postoperative period, one (2%) patient was diagnosed with pneumonia on the third day, three (6%) – on the fifth day. Diagnosis of one case (2%) of infectious fibrinous pleuritis was carried out on the seventh day. Rank correlation analysis did not establish a reliable relationship between the development of PPC and the volume of interstitial tissue. Medical history of two patients revealed the presence of chronic obstructive pulmonary disease, four – coronary heart disease, II degree hypertension, three – coronary heart disease, permanent atrial fibrillation.

**Discussion.** The main objective of our study was to determine the frequency of postoperative pulmonary complications and its interrelation with the surgical risk of the patients, the presence of interstitial pulmonary oedema on the background of different (by volume) modes of infusion therapy in patients with acute abdominal pathology.

In the groups of studied patients, there was a medical history of chronic obstructive pulmonary disease, urgent conditions of surgery, endotracheal intubation, postoperative treatment in the intensive care unit, the use of nasogastric probe, which are significant risk factors for the development of PPC [18]. In the total cohort of the examined patients 10.5% cases of PPC were observed. The obtained data coincide with the percentage of PPC occurrence in patients in large planned abdominal surgery and differ from those in urgent conditions [1–8]. Our

results coincide only with the study that investigated the conditions of postoperative respiratory complications in planned and emergency surgery, where the global PPC incidence was 11.7%, while in planned surgery – 11.3% in emergency surgery – 12.3% [19].

The most common cause of PPC in the examined patients was pneumonia with a frequency of 80.9%, followed by respiratory failure (5.9%), pleural effusion (11.8%), which does not differ from the literature data [18].

Correlation analysis of the dependence of the frequency of PPC occurrence based on the group of surgical risk did not reveal significant differences. However, patients with moderate surgical risk with a liberal mode of infusion therapy had the highest percentage of PPC development – 16%. At the same time, in a subgroup of patients with the same surgical risk in the restrictive mode of infusion therapy, the level of pulmonary complications after the surgery was 6%. High surgical risk, regardless of the infusion therapy, was accompanied by 10% of the PPC development.

These data are explained by the correlation between the development of interstitial edema and PPC. So, in a subgroup of patients with the liberal mode of infusion therapy a significant increase in interstitial volume by 146% ($p<0.04$) and 159% ($p<0.02$) from the norm in the perioperative period was accompanied by a moderate degree of EPS accumulation ($R=0.86$, $p=0.04$) and had a strong direct relationship with the PPC development ($R=0.79$, $p=0.002$). The established absence of interstitial oedema on the background of restrictive mode of infusion therapy, regardless of the degree of surgical risk of patients, was confirmed by a normal sonographic picture of the lungs and had no correlation with the PPC development. Apparently, the PPC development was associated with the described perioperative risk factors [18]. Targeted infusion therapy forms an increase in the volume of interstitial tissue by 14% ($p<0.02$) above norm on the first day, sonographic signs of mild accumulation of EPS up to 3 days after the surgery and a weak direct relationship between them ($r = 0.49$, $p=0.014$).

## Conclusions

1. In patients with medium and high surgical risk with acute abdominal pathology:

- the overall incidence of postoperative pulmonary complications is 10.5%;

- the cause of postoperative pulmonary complications in 80.9% of cases is pneumonia.

2. In patients with moderate surgical risk with acute abdominal pathology, the infusion therapy mode influences the incidence of postoperative pulmonary complications:

- the liberal mode is accompanied by the development of interstitial oedema, an increase in extravascular fluid in the lungs to a moderate degree and the frequency of postoperative pulmonary complications by 16 %;

- the restrictive mode keeps the volume of interstitial tissue within the normal limits during the entire postoperative period and reduces the risks of postoperative pulmonary complications up to 6%.

3. In patients with high surgical risk with acute abdominal pathology, the postoperative period is complicated by the development of pulmonary complications in 10% of cases:

- early targeted mode is accompanied by an increase of interstitial tissue volume and mild increase of pulmonary extravascular fluid on the first day;

- the restrictive mode limits the development of interstitial oedema throughout the postoperative period.

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***(received 24.08.2019, published online 29.09.2019)***

***(одержано 24.08.2019, опубліковано 29.09.2019)***