ПРОБЛЕМИ ЗАГАЛЬНОЇ ХІРУРГІЇ

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Хірургічні методи профілактики первинної неспроможності кукси бронха

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Surgical methods of prophylaxis of primary insufficiency of the bronchus stump sutures

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Реферат

Мета. Розробити ефективний, малотравматичний, технічно нескладний спосіб профілактики первинної неспроможності кукси бронха (НКБ) за рахунок забезпечення трансторакальної її герметизації та створення умов для зменшення впливу на шов повітряно–хвильового потоку крізь просвіт резектованого бронха.

Матеріали і методи. Проведено комплексний аналіз результатів лікування 123 хворих, яким була виконана резекція легені або пульмонектомія. Усіх хворих розподілили на дві групи: порівняльну (n=66) та основну (n=57). У хворих основної групи застосовували розроблені методики прогнозування ризику виникнення первинної НКБ і хірургічні методи профілактики даного ускладнення.

Результати. Після оцінки ризику розвитку первинної НКБ у 41 хворого основної групи була застосована хірургічна методика, нами запропонована, яка включала два етапи: перший – ендобронхіальна імплантація алотрансплантата до зони резекції та його прошивання механічним швом; другий – укриття кукси бронха біоактивною пов'язкою з додатковим фіксуванням монофіламентними нитками. В основній групі розвиток первинної НКБ спостерігали у 2 (3,51%) хворих, не помер жоден хворий. У порівняльній групі первинна НКБ виникла у 6 (9,09%) хворих, смертність становила 3,03%.

Висновки. Використання оригінального способу хірургічної профілактики НКБ уможливило зменшення частоти її розвитку у 2,6 разу та уникнення смертності.

Ключові слова: резекція легені; пульмонектомія; первинна неспроможність кукси бронха; методи хірургічної профілактики.

Abstract

Objective. To elaborate the effective miniinvasive technically simple method of prophylaxis for primary insufficiency of the bronchus stump sutures (BSS) due to accomplishment of its transthoracic hermetization and creation of conditions for reduction of impact of the air–wave stream through the resected bronchus lumen onto the suture.

Materials and methods. Complex analysis of the treatment results was conducted in 123 patients, in whom pulmonary resection or pulmonectomy was performed. All the patients were divided into two groups: comparative (n=66) and the main (n=57). In patients of the main group the elaborated procedures were applied, concerning determination of the occurrence risk for primary insufficiency of BSS and surgical measures for prophylaxis of this complication.

Results. After estimation of risk for the primary insufficiency of the BSS occurrence in 41 patients of the main group the proposed two–staged surgical procedure was applied: endobronchial implantation of allotransplant into the zone of the resection and its mechanical suturing (stage I), and the bronchus stump covering, using bioactive bandage with additional fixing, using monofilament threads (stage II). In the main group the development of primary insufficiency was observed in 2 (3.51%) patients, no one patient died. In the comparison group primary insufficiency of BSS have occurred in 6 (9.09%) patients, and mortality have constituted 3.03%.

Conclusion. Application of original method of surgical prophylaxis of the BSSI made it possible to reduce its occurrence rate in 2,6 times and escaping of mortality.

Keywords: pulmonary resection; pulmonectomy; primary insufficiency of the bronchus stump sutures; methods of surgical prophylaxis.

Introduction

Despite the development of modern medical science, in particular anesthesiology and technology of surgical operations, complications after lung operations remain an urgent problem in thoracic surgery. One of the terrible complications is the failure of the bronchial stump (FBS) after lung resection or pulmonectomy with the subsequent development of bronchopleural fistulas. According to the literature, FBS occurs in 3 – 15% of cases and there is no tendency to reduce the frequency of development of this complication. After pulmonectomy, the incidence of FBS increases significantly and can reach 34.5%, with mortality in the range of 22 – 57% [1, 2].

Most of the researchers distinguish the immediate causes of the primary FBS as insufficient sealing of the stump or suture divergence, which is associated with the cutting of staples through the thickened or sclerosed bronchus wall by the overlaing of the mechanical suture, which is primarily due to the increasing impact volume on the formed stump without the possibility of its adaptation and compensation of the increasing shock wave action of the air flow. The insufficient coverage of the bronchial stump and its direct contact with the pleural exudate play not the least role, which creates prerequisites for the developing of suture failure [3, 4].

Since 1924, various methods of plastic coverage of bronchial stump were developed and introdused in order to reduce the frequency of FBS development: pedicle flap from the diaphragm, mediastinal or costal pleura, costal pleuro–musculo–periosteal, pericardial and free flap of its own or canned deep fascia of the thigh, canned dura mater. But all these methods of additional strengthening of the suture line and closure of the suture canals against the spread of infection, have not been widely used due to high trauma, lack of effectiveness in the early postoperative period and severe cicatricial deformities in the late postoperative period [5, 6].

There are also known methods of endoscopic (bronchoscopic and thoracoscopic) adduction of fibrinogen–based glue to the bronchial stump, which additionally seals, increases the coagulation activity of the stump and reduces fibrinolytic activity, which creates optimal conditions for healing. Cyacrine glues (cyacrine) in conjunction with a collagen sponge are also used for a defect that has already developed [7, 8].

The disadvantages of these methods are technical difficulties and low efficiency of treatment of bronchial stump with glue compositions, which does not allow to create optimal conditions for healing and, accordingly, they do not exclude the development of FBS and do not reduce the frequency and severity of secondary complications. Therefore, these methods are not widely used.

A known method of bronchial stump coverage, which includes the sanitation of the tracheobronchial tree, bronchus resection, manual and mechanical fased sealing of the bronchial stump. Sealing is carried out by overlaying of sealing suture on the bronchus, then bringing part of the greater omentum on the vascular pedicle through the diaphragm into the chest cavity and fixing with single interrupted sutures, wrapping the line of mechanical sutures.

Clinical evaluation of both the immediate and long–term results of this "method of choice" showed their inconsistency with the rather frequent development of specific complications: hernia along the omentum pedicle with its strangulation, partial and complete necrosis of the omentum, torsion of its pedicle and venous thrombosis of the feeding vessels, ileus, stasis and acute dilatation of the stomach, cecal inversion, damage of the colon arteries, perforation of the stomach after improper ligation of its wall, a variety of infectious and inflammatory complications [9].

In the clinic of the Zaycev Institute of General and Emergency surgery (Kharkiv, Ukraine), the method of preventing the FBS was developed, which includes the sanitation of the tracheobronchial tree, bronchial resection, manual and mechanical fased sealing of the bronchial stump. The sealing of the bronchial stump is carried out with three lines of sutures, one of which is mechanically performed, and the other two are done manually, and first, a mechanical suture is overlaid on the bronchial area, which is intended for resection, then a mattress hand suture is overlaid parallel and proximal to it, and then with the same ligature in the opposite direction – blanket hand suture, capturing the mattress suture and stump defect.

The described method allows to prevent the primary FBC by precluding the eruption of sutures and additional sealing of the stump. However, mattress and blanket sutures not only additionally seal the intersection zone of the bronchus, but also lead to impaired blood flow (additional ischemia) of the stump and increase the number of ways for the spread of infection in the double perforation of these zones.

A comprehensive analysis of the methods of post–resection sealing of the bronchus stump allows us to conclude that there are no uniform approaches to solving this problem, therefore the aim of our work in the development of a low–impact and technologically simple, easily reproducible method of sealing the bronchus stump with an assessment of its effectiveness is very relevant.

The aim of the study: was to develop an effective, low–impact, technically uncomplicated method of sealing the bronchus stump by providing transthoracic hermitization and creating conditions to reduce the impact of an air–wave flow through the lumen of the resected bronchus.

Materials and methods study

The paper presents a comprehensive retrospective analysis of the results of surgical treatment of 123 patients who were treated in the clinic of Zaycev Institute of General and Emergency surgery (Kharkiv, Ukraine) in the period from 2007 to 2018, which underwent lung resection or pulmonectomy.

All patients according to the nature of the pathological process, age, sex, presence of concomitant pathology, volume of pulmonary resection, were divided into 2 representative groups, which allowed us to conduct a comparative analysis of the results obtained.

Group I (comparison group) – 66 patients who used traditional methods of surgical treatment. Group II (main group) – 57 patients in whom the developed methods of predicting the

risk of FBS and prevention of this complication were applied.

Patients of the main group at the stage of preoperative examination and treatment were evaluated by us according to the developed methodology for predicting the risk of developing FBS, which allowed us to apply individual tactics both in preoperative preparation and during surgical intervention [4].

Studying the reasons for the development of the bronchial stump insufficiency (BSI), many authors come to the conclusion that the development of the BSI is a biological problem. On this basis, the presence of comorbidity, which affects the preoperative condition of the bronchial wall, namely its reparative abilities, obtains a great importance. To assess this factor, we additionally studied the nature of the morphological changes in the bronchial wall in the resection area, depending on the accompanying pathology. Comprehensive histological and histochemical studies were subjected to resected lung tissue. The patients included in this stage of the study were divided into 3 groups. The criterion for the distribution of patients into groups was concomitant pathology: I group – 12 patients without concomitant pathology (comparison group); II group – 12 patients with concomitant chronic bronchitis; III group – 12 patients with concomitant systemic atherosclerosis.

The material for the morphological study was the resected lungs or lobes of the lungs of all the studied groups. The material was fixed in 10 % neutral formalin, after which the bronchial slices were excised directly in the resection zone with adjacent tissues about 0.004 m thick. The material was subjected to alcohol impregnation and paraffin embedding, sections were made 5–6 microns thick. Survey specimens stained with hematoxylin and eosin were used for a general assessment of the state of the examined tissues. Staining specimens with picrofuxin according to the Van Gieson's method were used to identify connective tissue structures. Histological and histochemical methods were carried out according to the prescriptions set forth in the manuals of histological technique and histochemistry.

After studying the unfavorable factors of the FBS development in operated patients of the comparison group, a method of preventing primary post–resection FBS was developed and applied in patients of the main group, which includes sanitation of the tracheal–bronchial tree, bronchial resection, mechanical and manual phased sealing of the bronchial stump [3]. Sealing was carried out according to the developed original surgical technique using two allografts in two stages, while at the first stage, the allograft was bronchoscopically injected into the bronchus to the level of resection and a sealing–fixing suture was overlaid, covering the bronchial lumen and fixing the "plug" from the self–absorptive 100% cellulose; and at the second stage, we covered the bronchial stump with an allograft in the form of a bioactive bandage and fixed it with interrupted single sutures with the dissolving monofilament thread.

This method was applied in 41 patients of the main group with moderate and high risk of developing FBS.

Results

After conducting a comprehensive histological and histochemical study of surgical material, the following data were obtained. In patients of group I (without comorbidities): microscopic examination of the morphofunctional components of the lungs showed that their histological pattern is structurally and histochemically close to the normal structure of the examined organ, which allows to consider the study group as the group of comparison (*Fig. 1 – 3*).

In patients of group II (with concomitant chronic bronchitis): microscopic examination of specimens in conditions of chronic inflammation in the bronchial walls and surrounding tissues showed the development of dystrophic, atrophic, disregenerative and destructive changes (metaplasia of the prismatic epithelium, the presence of ulcers and polypoid growth of the mucous membrane, hyperplasia and cystic transformation of bronchial glands), dyscirculatory processes (venous plethora of broncial vessels and surrounding tissues, the presence of blood clots in vessels of peribronchial tissue), marked sclerotic processes in the connective tissue and the vascular

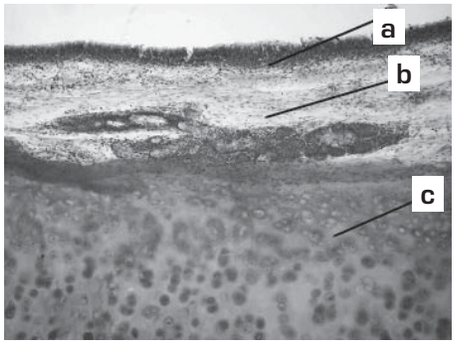

Fig. 1.
The sample of a large–caliber bronchus wall on the cross–section:
a – mucous membrane; b – submucosal layer; c – hyaline plate of the fibrocartilage layer.
Comparison group.
Stained with hematoxylin and eosin, × 100.

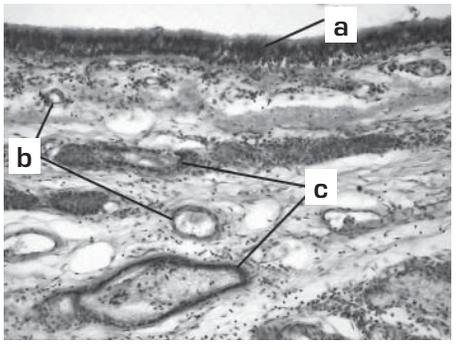

Fig. 2.
The sample of a large–caliber bronchus wall on the cross–section:
a – multi–row ciliated epithelium; b – vessels of the mucous and submucous layers; c – bronchial glands.
Comparison group. Stained with hematoxylin and eosin, × 200.

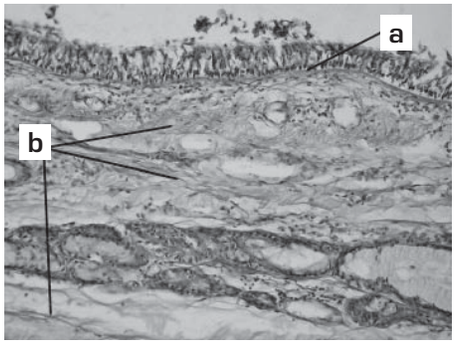

Fig. 3.
The sample of a large–caliber bronchus wall on the cross–section:
a – the basement membrane of the bronchial epithelium; b – moderately pronounced fuchsinophilia of collagen fibers.
Comparison group.
Stained with pikrofuxin by Van Gieson's method, × 200.

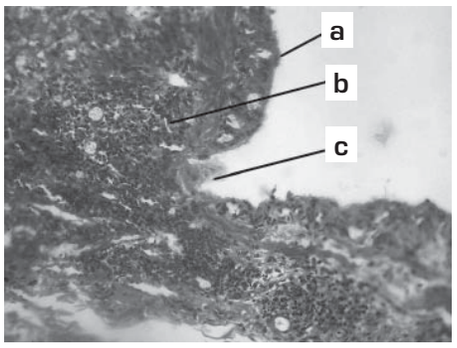

Fig. 4.
The sample of a large–caliber bronchus wall on the cross–section:
a – polypoid growths of the mucous membrane; b – inflammatory infiltration of the bronchial wall; c – ulcerative defect of the mucous membrane.
Group of chronic bronchitis. Stained with hematoxylin and eosin, × 100.

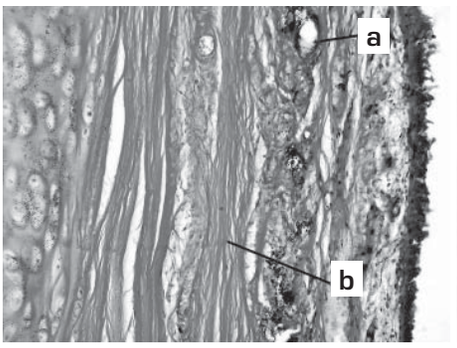

Fig. 5.
The sample of a large–caliber bronchus wall on the cross–section:
a – cystic enlargement of the bronchial gland; b – marked sclerosis of the submucosal layer.
Group of chronic bronchitis.
Stained with pikrofuxin by Van Gieson's method, × 200.

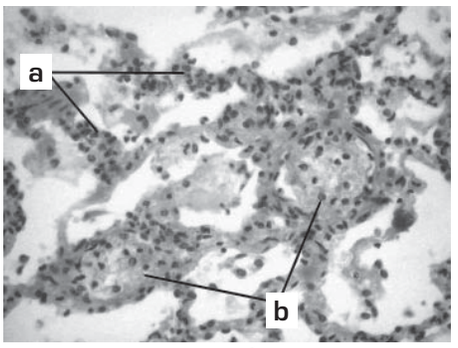

Fig. 6.
The sample of a large–caliber bronchus wall on the cross–section:
a – inflammatory infiltration of the interalveolar septa; b – vascular thrombosis.
Group of chronic bronchitis. S tained with hematoxylin and eosin, x 400.

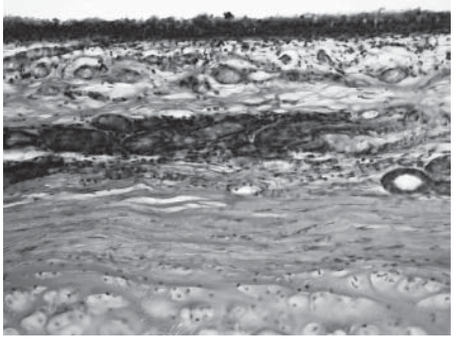

Fig. 7 .
The sample of a large–caliber bronchus wall on the cross–section. Sclerosis of the bronchial wall of with marked fuxinophilia of collagen fibers.
Stained with pikrofuxin by Van Gieson's method, × 200.

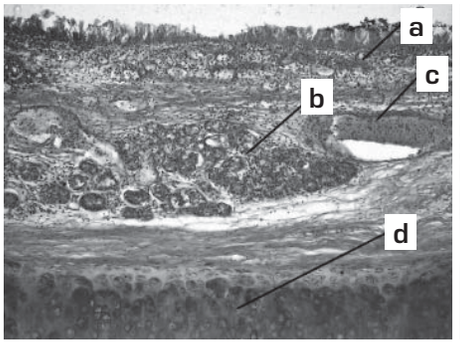

Fig. 8.
The sample of a large–caliber bronchus wall on the cross–section:
a – atrophy, lymphohistiocytic infiltration of the mucous membrane; b – plethora of vessels of the submucosal layer;
c – hyperplasia of the bronchial glands;
d – dystrophy of chondrocytes of hyaline plate.
The group of atherosclerosis.
Stained with hematoxylin and eosin, × 100.

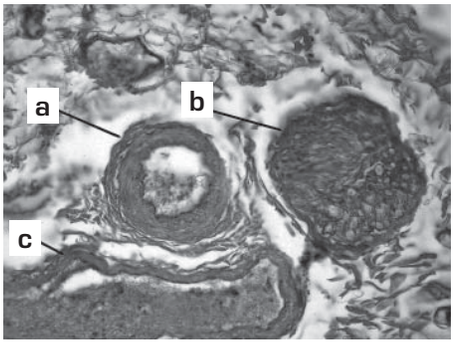

Fig. 9.
Sclerotic changes of artery (a); nervous ganglion (b); venous congestion (c) in the peribronchial tissue at the intersection of the large–caliber bronchus wall.
The group of atherosclerosis.
Stained with pikrofuxin by Van Gieson's method, × 400.

wall with impaired vascularization of the bronchial wall. The revealed pathological processes cause a significant deterioration in the local conditions of bronchial tissue regeneration and contribute to the formation of BSI in the postoperative period (*Fig. 4–6*).

Patients of group III (with concomitant systemic atherosclerosis): the microscopic examination of the specimens of the studied group showed the presence of dyscirculatory, dystrophic, sclerotic and atrophic changes in structural components of all layers of the bronchus wall, peribronchial tissue and adjacent lung tissue, which is due to chronic hypoxia resulting from atherosclerotic lesions in vessels. It can be assumed that the identified pathological changes in the tissues contributed to the inhibition and deterioration of the reparative process in the bronchus stump with the development of its insufficiency in the postoperative period (*Fig. 7–9*).

Based on the data of the morphological study of the surgical material, the intermediate results of surgical treatment in groups with and without concomitant pathology were analyzed. Failure of bronchial stump in the studied groups: group without concomitant pathology (n=12) – 1 (8,3%), group with concomitant chronic bronchitis (n=12) – 1 (8,3%), Group with concomitant systemic atherosclerosis (n=12) – 2 (16,6%). These data suggest that the presence of systemic atherosclerosis as a concomitant pathology has the most unfavourable impact on the healing of the bronchus stump.

After identifying the main factors for the development of BSI and assessing their significance, we conducted a stage of development and introduction of a method of surgical prevention of this complication.

A self–absorbable material based on natural cellulose was chosen as the allograft, while the allograft with predominantly regenerative effect was injected intrabronchially, and with predominantly antibacterial effect – extrabronchially.

The way of the sealing of the bronchus stump (two–stage process, the choice of materials for grafts and the sutures overlaing, as well as their location) made it possible to carry out a more reliable sealing and to prevent its further failure un-

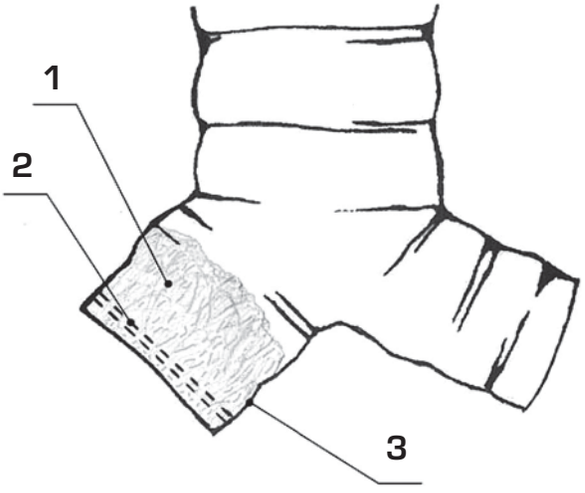

Fig.10.
The first stage of the operation, the bronchial stump is sealed from the inside by a cellulose allograft and mechanical suture.

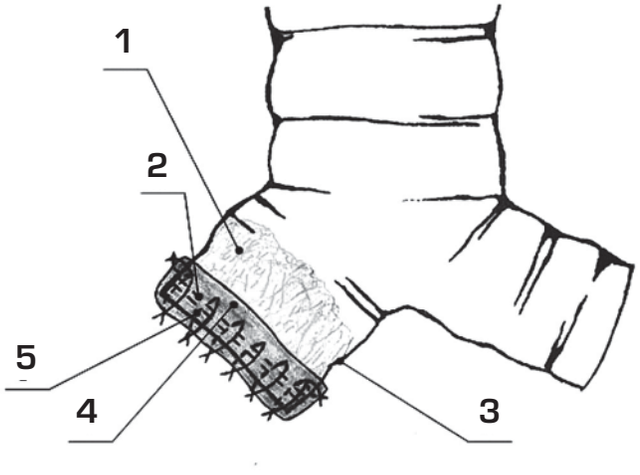

Fig.11.
The second stage of the operation, the bronchial stump is sealed outside by a second allograft.

der the pressure of the air shock wave during breathing. At the same time, the internal allograft significantly reduced the pressure of the air wave on the mechanical suture and promoted more active development of the connective tissue and accelerated guaranteed occlusion of the stump. The allograft, which internally occluded the bronchus stump, prevented the crushing of tissues with staples of mechanical suture and stimulated the accelerated formation of scar tissue until the moment of self–absorption.

The properties of the external allograft allowed, on the one hand, to additionally seal the mechanical suture from the outside, and on the other hand, to prevent the development of infectious processes on its surface. As our clinical experience has shown, the choice of suture material for applying single blanket sutures with atraumatic self–absorbable monofilament thread is significant.

Monofilament thread has the "wick effect", which excludes the possibility of infection penetration through it. Due to the resorption of allografts and suture material, by the time of wound healing, no foreign bodies remain in the pleural cavity, which eliminates the conditions for maintaining the infection.

Thus, this method of prevention of FBS allows to protect the mechanical suture both outside and inside, while softening the pressure of the air shock wave during breathing with all the consequences that follow from this.

The method is illustrated by the *fig. 10, 11*.

In all patients operated with this method, first the sanitation of the tracheobronchial tree was performed with the help of a fibrobronchoscope, and as the initial stage of the surgical intervention, a graft (*1*) was installed in the bronchus, tamponized throughout the subsequent resection zone, and after thoracotomy, a mechanical suture (*2*) was applied with the capture of the allograft tampon. After that, the bronchus was resected within healthy tissue, and the stump (*3*), which was formed during this, was covered with allograft (*4*) in the form of a bioactive bandage with its fixation with a blanket suture (*5*) with a monofilament thread. This monolithic thread was absorbed no earlier than after 3 weeks. It provided an additional hermetic function due to its overlaing, retreating from the mechanical suture (*2*) by approximately 3 – 5 mm. As allografts (*1, 4*), the dissolving materials from regenerated cellulose were used, while the allograft (*1*) with predominantly regenerative effect was injected intrabronchially, and the allograft (*4*) with predominantly antibacterial action, which is provided by its factory–impregnation with antiseptics, was injected extrabronchially.

Discussion

With the same type of pulmonary pathology, as well as the types and volumes of surgical interventions, the accompanying pathology, especially in the absence of its preoperative correction, significantly affects the incidence of postoperative complications, increasing the risk of BSI from 8.3 to 16.6 % of cases. The presence of chronic inflammatory and especially vascular sclerotic changes in the bronchial wall leads to degenerative–destructive changes, which are caused by chronic hypoxia on the background of dyscirculatory disorders, local hypercoagulable syndrome, ischemic atrophy, hypercollagenosis and progressive sclerosis of the external adventive membrane of the bronchial walls. For patients subjected to a surgical treatment (lobectomy, bilobectomy, pulmonectomy) who have chronic bronchitis or marked atherosclerotic lesions of the vessels not only adequate bronchial tree sanation and vascular–thrombolytic preparation for the operation are necessary, but also the development of new methods of resection and management of bronchus stump with its sufficient sealing.

We analyzed the results of surgical treatment of patients who underwent lung resection and pulmonectomy. Two important indicators were evaluated – the frequency of the development of primary FBS and postoperative mortality. In the main group, in which the method of the prevention of pri-

mary post–resection FBS was applied, the primary FBS was observed in 2 (3.51%) patients and mortality was absent. In the comparison group, this complication was observed in 6 (9.09%) patients and mortality due to FBS with the development of secondary empyema and pulmonary heart disease, was observed in 2 (3.03%) cases.

Conclusions

1. The development of the primary FBS according to our data is primarily due to zonal circulatory disorders, trophic tissue disability of the bronchial wall and chronic infectious inflammatory process, reducing the effectiveness of sealing of the bronchus stump and requiring comprehensive prevention by reducing the internal impact on the stitches of increasing shock pressure of inhaled air and limitation of the wound from the pleural cavity.

2. In addition to the preoperative sanitation of the tracheobronchial tree, the surgical intervention in patients with a high risk of developing FBS should be carried out in two stages. At first, a bronchoscopic tamponade of the resection zone with self–absorbable aseptic wipes made from regenerated cellulose, which subsequently performs a "buffer zone", is perfomed; than a sealing–fixing mechanical suture on the stump is overlaid and the lung resection is carried out. The second stage consists of the external sealing of the stump with cellulose wipes impregnated with antiseptics, their fixation with single blanket interrupted sutures by absorbable monofilament thread.

3. The use of the original method of surgical prevention of primary post–resection FBS allowed to significantly reduce the incidence of this complication in patients of the main group from 9.09 to 3.51%, and also to reduce postoperative mortality from 3.03 to 0%.

Acknowledgements

Authors' contributions

All the authors contributed equally to this work. All authors read and approved the final manuscript.

Competing interests

The authors who have taken part in this study declared that they do not have any conflict of interest with respect to this manuscript.

Consent for publication

All the authors have consented for publication of this manuscript.

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