Оригинальное исследование | Original study article
DOI: https://doi.org/10.35693/SIM546106

Dynamics of ventilation parameters in patients with bilateral destructive tuberculosis after staged surgical treatment using extrapleural pneumolysis with silicone plombage and contralateral lung resection

Darya V. Donchenko[1], Mikhail I. Chushkin[1], Elena V. Krasnikova[1], Ruslan V. Tarasov[1, 2], Georgii V. Chitorelidze[1], Mammad A. Bagirov[1, 3]

[1]Central Tuberculosis Research Institute (Moscow, Russian Federation)
[2]Moscow Medical University "Reaviz" (Moscow, Russian Federation)
[3]Russian Medical Academy for Continuous Professional Education (Moscow, Russian Federation)

Abstract

Aim – to study the dynamics of respiratory function indicators in patients with bilateral widespread destructive tuberculosis during staged surgeryt using extrapleural pneumolysis with silicone plombage on the side of the smallest lesion.

Material and methods. The main study group consisted of 14 patients with widespread bilateral destructive tuberculosis who underwent extrapleural pneumolysis with silicone plombage (EPSP) in combination with lung resection on the opposite side. The control group included 29 patients who underwent lung resections on both sides. All patients underwent spirometry before and 3–5 weeks after each stage of surgery: FVC (forced vital capacity of the lungs) and FEV1 (forced expiratory volume in 1 second) were registered.

Results. The dynamics of the spirometric study values after staged surgery in the EPSP group was a decrease in FVC by 1.05±0.47, FEV1 by 0.95±0.6 l, and in the control group – by 1.74±0.76 l and 1.33±0.5 l, respectively ($p < 0.05$).

Conclusion. The staged surgery with the use of EPSP was accompanied by a significantly smaller decrease in functional parameters and can be used in patients with widespread bilateral destructive tuberculosis with low respiratory function.

Keywords: tuberculosis, extrapleural pneumolysis with silicone plombage.
Conflict of interest: nothing to disclose.

Citation
Donchenko DV, Chushkin MI, Krasnikova EV, Tarasov RV, Chitorelidze GV, Bagirov MA. **Dynamics of ventilation parameters in patients with bilateral destructive tuberculosis after staged surgical treatment using extrapleural pneumolysis with silicone plombage and contralateral lung resection.** *Science and Innovations in Medicine.* 2024;9(2):149-153. DOI: https://doi.org/10.35693/SIM546106

Compliance with ethical standards
The authors received the patient's voluntary consent in writing for the publication of medical data.
Ethics expertise: Protocol No. 2/2 dated 22.02.2022 of the Local Ethics Committee.

Information about authors
Darya V. Donchenko – a postgraduate student of the Department of Surgery.
ORCID: https://orcid.org/0009-0003-0965-6882
E-mail: 25260790@mail.ru
Mikhail I. Chushkin – PhD, leading researcher of the Center for Diagnostics and Rehabilitation of Respiratory Diseases.
ORCID: https://orcid.org/0000-0001-8263-8240
E-mail: mchushkin@yandex.ru
Elena V. Krasnikova – PhD, leading researcher of the Department of Surgery.
ORCID: https://orcid.org/0000-0002-5879-7062
E-mail: el.krasn@gmail.com
Ruslan V. Tarasov – PhD, surgeon, junior researcher of the Department of Surgery; Associate professor of the Department of Surgical Diseases.
ORCID: https://orcid.org/0000-0001-9498-1142
E-mail: etavnai@yandex.ru
Georgii V. Chitorelidze – PhD, junior researcher of the Department of Surgery.
ORCID: https://orcid.org/0000-0001-5062-9788
E-mail: chitorelidze2015@yandex.ru
Mammad A. Bagirov – PhD, thoracic surgeon, chief researcher of the Department of Surgery; Professor of the Department of Thoracic Surgery.
ORCID: https://orcid.org/0000-0001-9788-1024
E-mail: bagirov60@gmail.com

Corresponding Author
Darya V. Donchenko
Address: Central Tuberculosis Research Institute, 2, bld. 1a Yauzskaya alley, Moscow, Russia, 107564.
E-mail: 25260790@mail.ru

Received: 13.07.2023
Accepted: 27.01.2024
Published: 03.02.2024

Динамика вентиляционных показателей у больных двусторонним деструктивным туберкулезом легких после этапного хирургического лечения с использованием экстраплеврального пневмолиза с пломбировкой силиконовым имплантом в сочетании с контрлатеральной резекцией легкого

Д.В. Донченко[1], М.И. Чушкин[1], Е.В. Красникова[1], Р.В. Тарасов[1, 2], Г.В. Читорелидзе[1], М.А. Багиров[1, 3]

[1]ФГБНУ «Центральный научно-исследовательский институт туберкулеза» (Москва, Российская Федерация)
[2]Московский медицинский университет «Реавиз» (Москва, Российская Федерация)
[3]ФГБОУ ДПО «Российская медицинская академия непрерывного профессионального образования» Минздрава России (Москва, Российская Федерация)

Аннотация

Цель – изучить динамику показателей функции внешнего дыхания у больных двусторонним распространенным деструктивным туберкулезом легких при проведении этапного хирургического лечения с применением экстраплеврального пневмолиза с пломбировкой силиконовым имплантом на стороне наименьшего поражения.

Материал и методы. Основная группа состояла из 14 больных распространенным двусторонним деструктивным туберкулезом, которым выполнен экстраплевральный пневмолиз с пломбировкой силиконовым имплантом (ЭПСИ) в сочетании с резекционными операциями легких на противоположной стороне. Контрольная группа включала 29 пациентов, которым выполнены резекционные операции легких с обеих сторон. Всем больным выполняли спирометрию до и через 3–5 недель после каждого этапа хирургического лечения: определяли функциональную жизненную емкость легких (ФЖЕЛ) и объем форсированного выдоха за 1 секунду (ОФВ1).

Результаты. Динамика показателей спирометрического исследования после этапного хирургического лечения составила в группе ЭПСИ снижение ФЖЕЛ на 1,05±0,47 л, ОФВ1 – на 0,95±0,6 л, а в группе сравнения на 1,74±0,76 л и 1,33±0,5 л соответственно (p<0,05).

Заключение. Этапное хирургическое лечение с применением ЭПСИ сопровождается значительно меньшим снижением функциональных показателей и может быть использовано у больных распространенным двусторонним деструктивным туберкулезом с дыхательной недостаточностью и низкими показателями функции дыхания.

Ключевые слова: туберкулез, экстраплевральный пневмолиз с пломбировкой силиконовым имплантом.

Конфликт интересов: не заявлен.

Для цитирования:
Донченко Д.В., Чушкин М.И., Красникова Е.В., Тарасов Р.В., Читорелидзе Г.В., Багиров М.А. **Динамика вентиляционных показателей у больных двусторонним деструктивным туберкулезом легких после этапного хирургического лечения с использованием экстраплеврального пневмолиза с пломбировкой силиконовым имплантом в сочетании с контрлатеральной резекцией легкого.** *Наука и инновации в медицине.* 2024;9(2):149-153.
DOI: https://doi.org/10.35693/SIM546106

Соответствие нормам этики
Авторы в письменной форме получили добровольное согласие пациентов на публикацию медицинских данных.
Этическая экспертиза: протокол ЛЭК 2/2 от 22.02.2022.

Сведения об авторах
Донченко Д.В. – аспирант отдела хирургии.
ORCID: https://orcid.org/0009-0003-0965-6882
E-mail: 25260790@mail.ru
Чушкин М.И. – д-р мед. наук, ведущий научный сотрудник центра диагностики и реабилитации заболеваний органов дыхания.
ORCID: https://orcid.org/0000-0001-8263-8240
E-mail: mchushkin@yandex.ru
Красникова Е.В. – д-р мед. наук, ведущий научный сотрудник отдела хирургии.
ORCID: https://orcid.org/0000-0002-5879-7062
E-mail: el.krasn@gmail.com
Тарасов Р.В. – канд. мед. наук, врач-хирург, младший научный сотрудник отдела хирургии; доцент кафедры хирургических болезней.
ORCID: https://orcid.org/0000-0001-9498-1142
E-mail: etavnai@yandex.ru
Читорелидзе Г.В. – канд. мед. наук, младший научный сотрудник отдела хирургии.
ORCID: https://orcid.org/0000-0001-5062-9788
E-mail: chitorelidze2015@yandex.ru
Багиров М.А. – д-р мед. наук, врач – торакальный хирург, главный научный сотрудник, руководитель отдела хирургии; профессор кафедры торакальной хирургии.
ORCID: https://orcid.org/0000-0001-9788-1024
E-mail: bagirov60@gmail.com

Автор для переписки
Донченко Дарья Валерьевна
Адрес: Центральный научно-исследовательский институт туберкулеза, Яузская аллея, 2, стр. 1а, г. Москва, Россия, 107564.
E-mail: 25260790@mail.ru

Список сокращений
ЭПСИ – экстраплевральный пневмолиз с пломбировкой силиконовым имплантом; ФЖЕЛ – функциональная жизненная емкость легких; ОФВ1 – объем форсированного выдоха за 1 секунду; МБТ – микобактерия туберкулеза; МЛУ – множественная лекарственная устойчивость; ШЛУ – широкая лекарственная устойчивость.

Получено: 13.07.2023
Одобрено: 27.01.2024
Опубликовано: 03.02.2024

INTRODUCTION

Currently, the Russian Federation has seen an increase in cases of tuberculosis with multidrug-resistant (MDR) and extensively drug-resistant (XDR) Mycobacterium tuberculosis, leading to the formation of a severe patient group with widespread destructive pulmonary tuberculosis [1–3]. Typically, these patients are characterized by a long duration of the disease, often bilateral localization of lung lesions, and severe respiratory dysfunction. Due to the insufficient effectiveness of drug therapy in these patients, surgical treatment methods are increasingly being employed [4–7]. There is often a need for multi-stage surgical treatment due to the extensive nature of the disease. According to many researchers, resections involving one lobe or more than three segments lead to overexpansion of the remaining parts of the lung and increase the risk of postoperative pulmonary-pleural complications and tuberculosis reactivation [8–10]. Additionally, a significant reduction in the respiratory surface of the lungs increases the risk of respiratory disorders, necessitating the avoidance of resection procedures and requiring the use of collapse surgery. The primary method of collapse surgery to date has been therapeutic extrapleural thoracoplasty. This procedure involves extensive trauma to the chest muscles, leading to impaired respiratory mechanics and upper limb function, and is also accompanied by prolonged pain syndrome [11]. Due to the poor cosmetic effect, characterized by chest deformity, patients often refuse this type of surgical treatment. This has led to the search for and development of new minimally invasive methods of surgical collapse.

The least traumatic method of collapse surgery is considered to be extrapleural pneumolysis with plombage. Various types of plombage materials have been proposed: collagen, thoracore, displaced autologous skeletal muscles, methacrylate beads, and others [12–15]. All plombage types had a number of drawbacks, the most common of which were the short-term effect of collapse due to the resorption of the material and suppuration of the filling due to its biological incompatibility with the organism [14–17]. Currently, the search for the ideal plombage for extrapleural pneumolysis continues, one that would provide a stable and long-lasting collapse of lung cavities while preserving the integrity of the chest wall.

The clinics of the Federal State Funded Research Institution "Central Research Institute of Tuberculosis" (FSFRI CRIT) has a vast experience of using extrapleural pneumolysis with silicone plombage (EPSP) in collapse surgery treatment of tuberculosis (mainly, as an alternative to thoracoplasty). The satisfactory tolerability and preservation of lung tissue integrity have allowed for the successful application of EPSP in patients with low functional reserves, including those with bilateral destructive pulmonary tuberculosis.

AIM

Study the dynamics of respiratory function indicators in patients with bilateral widespread destructive tuberculosis during staged surgery using extrapleural pneumolysis with silicone plombage on the side of the smallest lesion and resections of various volumes on the side of the largest lesion.

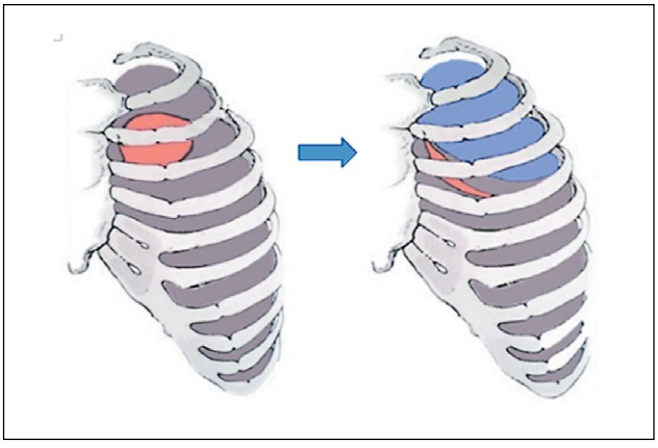

Figure 1. *Extrapleural pneumolysis plombage using a silicone implant.*
Рисунок 1. *Экстраплевральный пневмолиз с использованием силиконового импланта.*

MATERIAL AND METHODS

Since 2010, staged surgical treatment using EPSP in combination with lung resections has been performed on 14 patients at FSFRI CRIT. These patients, included in the main study group, had a very high risk of postoperative complications due to the widespread nature of the disease and low functional indicators. The extrapleural pneumolysis using a silicone implant was performed according to the original technique (patent No. RU 2448658). The surgery was conducted with a modified approach and without resection of the rib segment.

For plombing, a round silicone breast implant with a high profile, textured shell, and dense cohesive gel was used, intended for lifelong presence in the body and not causing rejection reactions, with a volume corresponding to the volume of cavities in the lung (**Fig. 1**).

The comparison group included 29 patients with extensive destructive pulmonary tuberculosis who underwent bilateral sequential lung resection surgeries. The majority of patients in both groups were women: 8 (57%) in the main group and 15 (52%) in the comparison group. The average age was 43.5±0.8 years in the main group and 38±0.4 years in the comparison group. Drug resistance of the tuberculosis mycobacterium (MTB) was detected in the main group in 8 patients (57.1%), while in the comparison group it was noted in 19 patients (65.4%). All patients received anti-tuberculosis therapy according to the spectrum of sensitivity of MTB in accordance with the order of the Ministry of Health of Russia No. 951 prior to the start of surgical treatment.

All patients underwent computed tomography of the chest organs before surgical treatment. Spirometry was performed before surgery and 3–5 weeks after each stage of the operation, in compliance with the standards of the Russian Respiratory Society study [18]. The study used the proper values of the European Coal and Steel Community [19]. To assess lung function impairments, a modified qualification of the Global Initiative for Chronic Obstructive Lung Disease (GOLD) was used.

In the main group, the average value of respiratory parameters before staged surgical treatment was as follows: FVC 66.2±8.1% d. v., FEV1 53.8±7.3% d. v.; in the comparison group: FVC 95.5±12.2% d. v., FEV1 109.2±37.7% d. v.

Volume of operation	EPSP + resection (n=9)	Resection + EPSP (n=5)
Combined resection	Resection + EPSP	4 (80%)
Lobectomy	1 (11%)	1 (20%)

Table 1. *Distribution of resection operations using extrapleural pneumolysis with a silicone plombage depending on the sequence of the stage (n=14)*
Таблица 1. *Распределение резекционных операций с использованием экстраплеврального пневмолиза с пломбировкой силиконовым имплантом в зависимости от очередности этапа (n=14)*

Statistical processing was performed using the Medcalc v. 18.2.1 software suite. For respiratory function indicators, the arithmetic mean and standard deviation of the indicators (M±σ) were calculated; for the average age, the arithmetic mean and error of the arithmetic mean (M±m) were calculated. The reliability of differences in the same quantitative indicators was determined using Student's t-test. Differences were considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSION

The choice of tactics for staged surgical treatment using EPSP was determined depending on the extent of the process and the presence of complications in the lung subject to resection. The distribution of options for the volume of resection operations depending on the choice of staged surgical treatment in the main group is presented in **Table 1**.

The table data demonstrates that the majority of patients in the main group underwent resection interventions in the volume of combined resection. In 9 (64%) patients, the first stage included the EPSP operation. In 5 (36%) patients, the first stage was the lung resection to ensure sanation: these were patients with hemoptysis and a high risk of pulmonary hemorrhage.

In the comparison group, the operations were distributed as to the sequence of staged resections; the data follows in **Table 2**.

It follows from the table, in the comparison group 15 (51.7%) patients underwent resection on the side of the smaller lesion on the first stage in order to ensure a minimal decrease of functional indicators, and 14 (48.3%) patients underwent large volume resections on the first stage (more than 3 segments), also due to a high risk of pulmonary hemorrhage.

The dynamics of lung function indicators in the main group after the surgery is shown in **Table 3**.

Volume of operation	Large volume resection + resection (n=14)	Resection + large volume resection (n=15)
Combined resection	2 (14%)	11 (73%)
Lobectomy	12 (86%)	4 (27%)

Table 2. *Options for the volume of resection interventions in the comparison group (n=29)*
Таблица 2. *Варианты объема резекционных вмешательств в группе сравнения (n=29)*

Subgroup	1 (n=9)	2 (n=5)	1 (n=9)	2 (n=5)	1 (n=9)	2 (n=5)		
	After stage 1		After stage 2		After 2 stages of surgery treatment		t	p
FVC, l	-0,02±0,5	-1,02±0,15	-1,08±0,4	-0,17±0,17	-0,96±0,55	-1,2±0,2	1,1	0,3
FEV1, l	-0,24±0,3	-1,13±0,5	-0,73±0,25	-0,16±0,09	-0,75±0,56	-1,3±0,5	1,7	0,1

Table 3. *Dynamics of respiratory parameters after surgery in the main group*
Таблица 3. *Динамика респираторных показателей после хирургического лечения в основной группе*

Subgroup	1 (n=14)	2 (n=15)	1 (n=14)	2 (n=15)	1 (n=14)	2 (n=15)		
	After stage 1		After stage 2		After 2 stages of surgery treatment		t	p
FVC, l	-0,75±0,65	-1,11±0,5	-1,02±0,45	-0,9±0,4	-1,66±0,8	-1,83±0,72	0,6	0,5
FEV1, l	-0,6±0,4	-0,75±0,27	-0,76±0,4	-0,63±0,2	-1,3±0,6	-1,38±0,25	0,5	0,6

Table 4. *Dynamics of respiratory parameters after surgery in the control group*

Таблица 4. *Динамика респираторных показателей после хирургического лечения в группе сравнения*

	Main group (n=14)	Comparison group (n=29)	t	p
FVC, l	-1,05±0,47	-1,74±0,76	3,74	0,005
FEV1, l	-0,95±0,6	-1,33±0,5	2,16	0,037

Table 5. *Dynamics of absolute values of FVC and FEV1 before and 3-5 weeks after staged surgery in patients of the compared groups*

Таблица 5. *Динамика абсолютных величин ФЖЕЛ и ОФВ1 до и через 3–5 недель после этапного хирургического лечения у больных сравниваемых групп*

In the subgroup where the EPSP was performed on the first stage, a lesser decrease of FVC and FEV1 was seen, by 0.96±0.55 l and 0.75±0.56 l respectively, than in the subgroup where the EPSP was performed on the second stage. The changes in respiratory parameters were as follows: FVC 1.2±0.2 l and FEV1 1.3±0.5 l respectively. In the individual complex assessment of the dynamics of respiratory functions in the main group after the EPSP stage, in 10/14 (70%) patients opposite changes of the respiratory function: in 5/14 (35%) – deterioration, and in 5/14 (35%) patients, improvement of functional indicators was identified.

In the comparison group, an analysis of the dynamics of respiratory parameters after staged surgical treatment was performed; the data follows in **Table 4**.

In the comparison group, regardless of the order of the surgical treatment stage, a moderate decrease in respiratory parameters was observed, the degree of which was practically the same for all options.

A comparative analysis of dynamics of absolute values of FVC and FEV1 in patients in the main and comparison groups before and after the staged surgery. The data follows in Table 5.

According to the data from the table, patients of the main group showed a decrease of the FVC after staged surgery by 1.05±0.47 l, whereas the patients of the comparison group showed a decrease of this parameter by 1.74±0.76 l (p<0,05). The FEV1 in the patients from the main group decreased by 0.95±0.6 l, and in the patients from the comparison group it decreased more, by 1.33±0.5 l (p<0.05).

In graphic form, the dynamics of absolute values of FVC and FEV1 before and 3-5 weeks after the staged surgery in patients from the two groups is presented in **Figures 2, 3**.

It is clearly shown that in both groups, the decrease in respiratory parameters was moderate, but in the main group, patients initially had lower functional reserves; therefore, the degree of decrease in indicators was less than in the compared group of patients.

The decrease of FVC and FEV1 (liters) is seen both in the main and the comparison group, which is accounted for by the removal of the lung parenchyma. Even affected by the tuberculosis, it was still involved in the respiratory function. In the group of patients that underwent the EPSP method, the degree of decrease of indicators was significantly less.

Analysis of the results showed that the dynamics of FVC and FEV1 values in the main group were significantly less than in the control group (p<0.05), which indicates a more functionally preserving nature of extrapleural pneumolysis with silicone implant plombage.

Therefore, when choosing surgical treatment tactics using extrapleural pneumolysis with silicone implant plombage, it is advisable to perform EPSP at the first stage in order to maximize the preservation of the ventilation function, which is safer for anesthesia during resection surgery.

CONCLUSION

Extrapleural pneumolysis with silicone implant plombage allows to achieve a significantly smaller decrease in respiratory function (p<0.05) than resection surgery. The use of EPSP in staged surgical treatment of patients with advanced destructive tuberculosis makes it possible to expand the functional operability of patients with limited respiratory reserves.

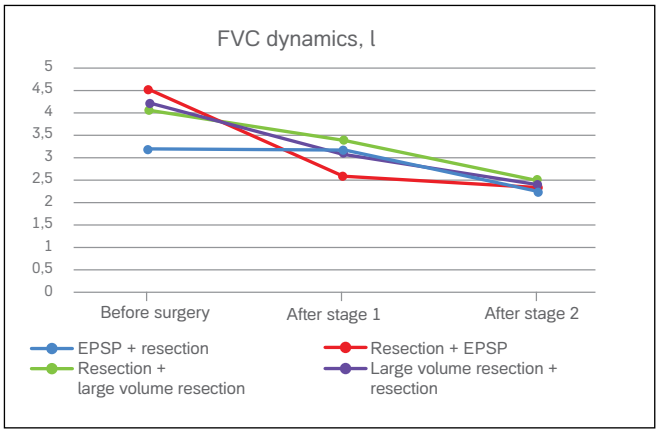

Figure 2. *Dynamics of FVC absolute values before and 3–5 weeks after surgical treatment in patients of the compared groups.*

Рисунок 2. *Динамика абсолютных величин ФЖЕЛ до и через 3–5 недель после хирургического лечения у больных сравниваемых групп.*

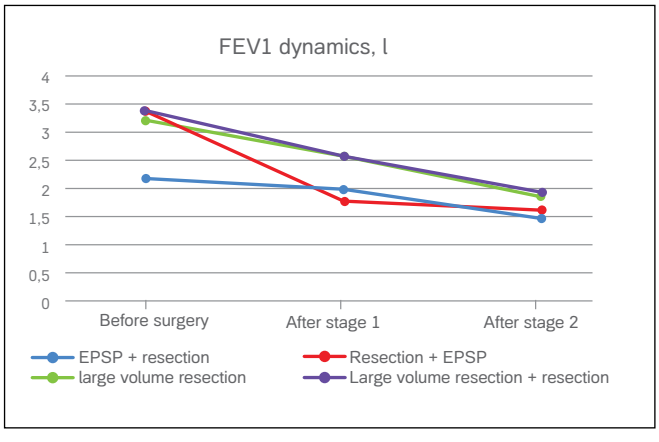

Figure 3. *Dynamics of absolute values of FEV1 before and 3-5 weeks after surgical treatment in patients of the compared groups.*

Рисунок 3. *Динамика абсолютных величин ОФВ1 до и через 3-5 недель после хирургического лечения у больных сравниваемых групп.*

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
Study funding. This research received no external funding. The study is the part of research project YH FURE-2022–0012 "Functionally saving and personalized approach to surgical treatment of widespread tuberculosis of the respiratory and musculoskeletal systems".	***Источник финансирования.*** Исследование проводилось без спонсорской поддержки. Работа выполнена в рамках темы НИР «Функционально сберегающий и персонализированный подход к хирургическому лечению распространенного туберкулеза органов дыхания и костно-суставной системы YH FURE-2022–0012».
Conflict of Interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Contribution of individual authors. D.V. Donchenko – has been responsible for scientific data collection, its systematization, statistical processing and analysis, wrote the first draft of the manuscript. M.I. Chushkin – provided scientific expertise, detailed manuscript revision and editing, approved its final version. E.V. Krasnikova – prepared the illustrations, provided manuscript editing. R.V. Tarasov – was engaged in data statistical processing and analysis. G.V. Chitorelidze – was engaged in data collection and manuscript editing. M.A. Bagirov – has developed the study concept, coordinated the study. All authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	***Участие авторов.*** Д.В. Донченко – сбор материала, подсчет, статистическая обработка, анализ полученных данных, подготовка текста работы. М.И. Чушкин – научный консультант, проверка критически важного содержания, утверждение окончательного варианта статьи. Е.В. Красникова – подготовка иллюстраций работы, редактирование текста статьи. Р.В. Тарасов – статистическая обработка, анализ полученных данных. Г.В. Читорелидзе – сбор материала, редактирование текста статьи. М.А. Багиров – формулировка цели, выводов, контроль за проведением работ. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.

REFERENCES / ЛИТЕРАТУРА

1. Strelis AK, Strelis AA, Anastasov OV, et al. Efficiency of surgical treatment of multidrug-resistant pulmonary tuberculosis within the DOTS-PLUS program. Bulletin of Siberian Medicine. 2009;8(1):85-91. (In Russ.). [Стрелис А.К., Стрелис А.А., Анастасов О.В., и др. Эффективность хирургического лечения туберкулеза легких с множественной лекарственной устойчивостью в условиях программы dots-plus. Бюллетень сибирской медицины. 2009;6(1):85-91]. DOI: 10.20538/1682-0363-2009-1-85-91

2. Xu HB. Pulmonary resection for patients with multidrug-resistant tuberculosis: systematic review and meta-analysis. Journal of antimicrobial chemotherapy. 2011;66(8):1687-1695. DOI: 10.1093/jac/dkr210

3. Sheyfer YuA, Gelberg IS. Analysis of treatment outcomes for destructive pulmonary tuberculosis in patients with multiple drug resistance of M. tuberculosis. Tuberculosis and lung diseases. 2020;98(10):23-27. (In Russ.). [Шейфер Ю.А., Гельберг И.С. Анализ результатов лечения деструктивного туберкулеза легких у пациентов с множественной лекарственной устойчивостью M. tuberculosis. Туберкулез и болезни легких. 2020;98(10):23-27]. DOI: 10.21292/2075-1230-2020-98-10-23-27

4. Pomerantz BJ, Cleveland JrJC, Olson HK, et al. Pulmonary resection for multidrug resistant tuberculosis. The Journal of thoracic and cardiovascular surgery. 2001;121(3):448-453. DOI: 10.1067/mtc.2001.112339

5. Das S. Changing Trend of Surgery in Pulmonary Tuberculosis. Journal of Pulmonary & Respiratory Medicine. 2015;5(1):225. DOI: 10.4172/2161-105X.1000225

6. Sabirov ShYu, Nematov ON, Abdulkasimov SP, et al. Effectiveness of the surgical treatment of patients with pulmonary tuberculosis and multidrug resistance of its causative agent. Tuberculosis and socially significant diseases. 2015;3:65-66. (In Russ.). [Сабиров Ш.Ю., Нематов О.Н., Абдулкасимов С.П., и др. Эффективность хирургического лечения туберкулеза легких с множественной лекарственной устойчивостью возбудителя. Туберкулез и социально значимые заболевания. 2015;3:65-66].

7. Kral'ko VYa, Gurevich GL, Skryagina EM. Basic principles of surgical treatment of tuberculosis in patients with multidrug and extensive drug resistance in modern conditions. Meditsinskaya panorama. 2014;9:34-36. (In Russ.). [Кралько В.Я., Гуревич Г.Л., Скрягина Е.М. Основные принципы хирургического лечения туберкулеза у пациентов с множественной и широкой лекарственной устойчивостью в современных условиях. Медицинская панорама. 2014;9:34-36].

8. Belov SA, Grigoryuk AA, Shapovalov AS. Corrective thoracoplasty to achieve aerostasis after volumetric lung resections. Modern problems of science and education. 2021;2. (In Russ.). [Белов С.А., Григорюк А.А., Шаповалов А.С. Корригирующая торакопластика для достижения аэростаза после объемных резекций легких. Современные проблемы науки и образования. 2021;2]. URL: https://science-education.ru/ru/article/view?id=30699 DOI: 10.17513/spno.30699

9. Fu Y, Duanmu H, Fu Y, et al. Surgery for pulmonary tuberculosis and its indications. Handbook of Global Tuberculosis Control. Springer: Boston, MA; 2017;225-34.

10. Motus IYa, Golubev DN, Bazhenov AV, et al. Pulmonary tuberculosis surgery. Tuberculosis and lung diseases. 2012;89(6):14-20. (In Russ.). [Мотус И.Я., Голубев Д.Н., Баженов А.В., и др. Хирургия туберкулеза легких. Туберкулез и болезни легких. 2012;89(6):14-20].

11. Barker WL. Thoracoplasty. Chest surgery clinics of North America. 1994; 4(3):593-615.

12. Bogush LK. A new technique for closing apical caverns by extrapleural pneumolysis with fixation of the exfoliated apex with a rib on a muscular pedicle. Problems of Tuberculosis. 1945;4:42-50. (In Russ.). [Богуш Л.К. Новая методика закрытия верхушечных каверн путем экстраплеврального пневмолиза с фиксацией отслоенной верхушки ребром на мышечной ножке. Проблемы туберкулеза. 1945;4:42-50].

13. Malov AA. Extrapleural pneumolysis with filling in the treatment of widespread destructive pulmonary tuberculosis. Tuberculosis and lung diseases. 2011;88(12):22-27. (In Russ.). [Малов А.А. Экстраплевральный пневмолиз с пломбировкой в лечении распространенного деструктивного туберкулеза легких. Туберкулез и болезни легких. 2011;88(12):22-27].

14. Khrushcheva TN. Extrapleural pneumothorax and oleothorax in the treatment of destructive forms of pulmonary tuberculosis. Problems of thoracic surgery. 1952;4:275-276. (In Russ.). [Хрущева Т.Н. Экстраплевральный пневмоторакс и олеоторакс при лечении деструктивных форм туберкулеза легких. Вопросы грудной хирургии. 1952;4:275-276].

15. Bertin F, Labrousse L, Gazaille V. New modality of collapse therapy for pulmonary tuberculosis sequels: tissue expander. Ann Thorac Surg. 2007;84(3):1023-5. DOI: 10.1016/j.athoracsur.2007.04.013

16. Peppas G, Molnar TF, Jeyasingham K. Thoracoplasty in the context of current surgical practice. Ann Thorac Surg. 1993;56(4):903-9. DOI: 10.1016/0003-4975(93)90353-j.01350190083024

17. Calado T, Alvoeiro M, Cabral D, et al. Surgical Treatment of Complications 55 Years After Extraperiosteal Lucite Ball Plombage for Pulmonary Tuberculosis. Rev Port Cir Cardiotorac Vasc. 2017;24(3-4):139. PMID: 29701371

18. Chuchalin AG, Avdeev SN, Aysanov ZR, et al. Russian respiratory society. Federal guidelines on diagnosis and treatment of chronic obstructive pulmonary disease. Pulmonologiya. 2014;(3):15-54. (In Russ.). [Чучалин А.Г., Авдеев С.Н., Айсанов З.Р., и др. Федеральные клинические рекомендации по диагностике и лечению хронической обструктивной болезни легких. Пульмонология. 2014;(3):15-54]. DOI: 10.18093/0869-0189-2014-0-3-15-54

19. Quanjer PH, Tammeling GJ, Cotes JE, at al. Lung volumes and forced ventilatory flows. Report Working Party Standardization of Lung Function Tests, European Community for Steel and Coal. Official Statement of the European Respiratory Society. Eur Respir J Suppl. 1993;16:5-40.