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Using linezolid and bedaquiline in patients operated for multidrug-resistant pulmonary tuberculosis

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Abstract:
Objective: to evaluate comprehensive treatment outcomes in patients operated for multidrug-resistant pulmonary tuberculosis (MDR-TB) with the inclusion of linezolid and bedaquiline in the chemotherapy (CTX) regimens.
Materials and methods. We performed a non-randomized continuous single-center retrospective study on 114 patients operated on at the National Medical Research Center for Phthisiology of the Russian Federation Ministry of Healthcare from 2018 to 2022. We conducted a comparative analysis of the effectiveness of CTX regimens in patients with localized and extensive forms.
Results. We detected a statistically significantly wider spectrum of Mycobacterium tuberculosis (MTB) drug resistance (DR) in 41.6% (n=32/77) of patients with tuberculomas and in 18.9% (n=7/37) of patients with fibrous cavernous tuberculosis based on the study of resection specimens vs. respiratory specimens (p=0.03). Inclusion of linezolid and bedaquiline in the CTX regimen for patients with MDR-TB resulted in a reduction in the duration of postoperative treatment by, on average, 14.0±1.3 weeks and 11.1±4.5 weeks, respectively, for localized TB forms and by 14.8±3.2 weeks and 14.9±3.7 weeks, correspondingly, for extensive TB forms vs. CTX regimens without these drugs.
Conclusion. Addition of new antitubercular drugs (linezolid and bedaquiline) to the CTX regimen in patients with MDR-TB can reduce the treatment duration in case of both localized and extensive forms of the disease.

Keywords: tuberculosis, drug resistance, tuberculosis treatment, linezolid, bedaquiline, surgical treatment, resection specimens

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Introduction

The emergence of Mycobacterium tuberculosis (MTB) strains resistant to antitubercular drugs (ATDs) is a major issue preventing a decrease in tuberculosis prevalence [1]. Despite the declining trend in the number of patients with multidrug-resistant (MDR) pulmonary tuberculosis (TB) in Russia, our country remains among the regions with a high burden of multidrug-resistant pulmonary tuberculosis (MDR-TB). In 2023, five countries accounted for more than a half of the total number of MDR-TB cases worldwide: India (27%), the Russian Federation (7.4%), Indonesia (7.4%), China (7.3%) and the Philippines (7.2%) [2].

Patients with TB, without reliably detected MDR based on the study of respiratory specimens, can receive long-term treatment with first-line ATDs without a therapeutic effect [3].

The growing number of patients with common forms of TB associated with MDR triggers the need for surgical treatment methods when it is impossible to achieve a cure exclusively by conservative means [4]. Surgical treatment is an important constituent of comprehensive treatment of patients with MDR-TB, along with chemotherapy (CTX). In this case, the study of resected specimens allows identifying the pathogen and establishing its DR [5]. This is the main condition for a personalized approach to CTX, which will help achieving the desired therapeutic effect [4, 6].

The optimal CTX regimen involves the inclusion of highly effective pharmaceutical drugs. The latter reduce the expected duration of treatment, possess pharmacokinetics ensuring high bioavailability when taken orally, and are well tolerated by patients [7-9].

In recent years, the use of new ATDs, linezolid (Lzd) and bedaquiline (BQ), has become widespread in practical phthisiology. Numerous studies showed high therapeutic efficacy of these drugs in patients with MDR-TB [10].

In this regard, it seems imperative to study the efficacy of CTX regimens with the inclusion of Lzd and BQ in combination with surgical treatment.

Objective: to evaluate the outcomes of comprehensive treatment outcomes in patients operated for MDR-TB with the inclusion of Lzd and BQ in in the CTX regimens.

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Materials and methods

We conducted a nonrandomized continuous single-center retrospective cohort study involving 114 patients with MDR-TB identified based on respiratory and/or resection specimens. All included patients were operated on at the National Medical Research Center for Phthisiology and Infectious Diseases of the Russian Federation Ministry of Healthcare from 2018 to 2022.

Inclusion criteria:

• Men and women over 18 years of age;

• Form of TB: pulmonary tuberculoma or fibrous cavernous tuberculosis (FCT);

• Study subjects underwent lung resections;

• MDR-TB detected in respiratory and/or resection specimens.

Exclusion criterion:

• HIV infection.

Following the 2022 clinical guidelines, Tuberculosis in Adults (current at the time of the study), we defined MDR as resistance of MTB to both isoniazid (isonicotinic acid hydrazide, INH) and rifampicin (R), regardless of the presence of resistance to other ATDs.

To achieve this goal, we identified 6 observation groups:

A) Patients with tuberculomas:

Group Ia, in which CTX regimen included Lzd and/or BQ at the preoperative and postoperative stages;

Group IIa, in which CTX regimen involved the administration of Lzd and/or BQ only in the postoperative period;

Group IIIa, in which CTX regimen did not include the administration of Lzd and BQ at any stage of CTX.

B) Patients with FCT:

Group Ib, in which CTX regimen included Lzd and/or BQ at the preoperative and postoperative stages;

Group IIb, in which CTX regimen involved the administration of Lzd and/or BQ only in the postoperative period;

Group IIIb, in which CTX regimen did not include the administration of Lzd and BQ at all stages of CTX.

For each patient, a comparison of DR in MTB isolated in the respiratory specimen and resection specimen was performed. The former was sampled 4-7 days before surgery; the latter was obtained during surgery. Our study was performed using molecular genetic methods.

The number of ATDs and their combinations in all observation groups were determined on a case-by-case basis by the decision of the medical consilium depending on the DR, the clinical situation preceding CTX, comorbid background, and tolerability of ATDs. There were no significant differences in the list of prescribed drugs among patients of all groups. In the intensive phase of the CTX regimen, a combination of medicines was prescribed including 5-6 ATDs simultaneously. In the continuation phase of CTX, at least 3 ATDs were prescribed. The characteristics of patients within the comparison groups are presented in *Table 1*.

It is obvious that the observation groups of patients with pulmonary tuberculomas are similar in terms of gender and age composition (*Table 1*). Patients aged 25–44 years prevailed in all groups. No statistically significant differences in body mass index (BMI) were detected among the observation groups. Concomitant diseases (hepatitides B and C, chronic obstructive pulmonary disease [COPD] and diabetes mellitus [DM]) were noted in 8 patients (32%) in Group Ia, in 8 patients (33.3%) in Group IIa, and in 10 patients (35.7%) in Group IIIa. Observation groups were similar in terms of the number of patients with bad habits; in each group, more than 25% of cases of active smoking were noted.

The data presented in *Table 2* demonstrate that patients with FCT did not differ statistically significantly in gender and age composition between the observation groups. Each group was dominated by patients aged 25 to 44 years. Statistically significant differences in BMI between the groups were not revealed as well. Concomitant diseases (hepatitides B and C, COPD, DM and hypertension) were recorded in 40.5% (15/37) of patients with FCT: in 38.5% (5/13) of patients in Group Ib, in 33.3% (4/12) of patients in Group IIb, and in 50% (6/12) of patients in Group IIIb. The prevalence of bad habits among patients was similar in these groups, too.

According to the spectrum of MTB resistance upon admission of patients with tuberculomas, at the surgical treatment stage, individuals with established MDR-TB prevailed: 53.2% (41/77). Patients with drug-susceptible TB were less common: 29.9% (23/77). In the groups of patients with FCT, MDR-TB was detected in all of them based on the study of respiratory specimens.

Table 1. Characteristics of patients with pulmonary tuberculomas in observation groups

Parameter		Comparison group, count (%) *			*p*
		Ia (*n*=25)	IIa (*n*=24)	IIIa (*n*=28)	
Gender	Male	12 (48.0)	10 (41.6)	14 (50.0)	>0.05
	Female	13 (52.0)	14 (58.4)	14 (50.0)	
Age, full years	18–24	1 (4.0)	6 (25.0)	5 (17.9)	
	25–44	16 (64.0)	14 (58.3)	19 (67.9)	
	45–59	8 (32.0)	4 (16.7)	4 (14.3)	
BMI, kg/m²		22.5	22.7	22.1	
Concomitant diseases	Hepatitides *B* and/or *C*	3 (12.0)	4 (16.7)	6 (21.4)	
	COPD	2 (8.0)	2 (8.3)	3 (10.7)	
	DM	4 (16.0)	6 (25.0)	5 (17.9)	
Bad habits	Smoking	7 (28.0)	8 (33.3)	7 (25.0)	
	Alcoholism	1 (4.0)	2 (8.3)	2 (7.1)	

* Except for body mass index (BMI); COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.

Table 2. Characteristics of patients with fibrous cavernous tuberculosis in observation groups

Parameter		Comparison group, count (%) *			*p*
		Ib (*n*=13)	IIb (*n*=12)	IIIb (*n*=12)	
Gender	Male	9 (69.2)	8 (66.7)	9 (75.0)	>0.05
	Female	4 (30.8)	4 (33.3)	3 (25.0)	
Age, full years	18–24	2 (15.4)	1 (8.3)	2 (16.7)	
	25–44	8 (61.5)	8 (66.7)	7 (58.3)	
	45–59	3 (23.1)	3 (25.0)	3 (25.0)	
BMI, kg/m²		25.4	21.7	24.4	
Concomitant diseases	Hepatitides *B* and/or *C*	2 (15.4)	2 (16.7)	2 (16.7)	
	COPD	1 (7.7)	1 (8.3)	2 (16.7)	
	DM	3 (23.1)	2 (16.7)	4 (33.3)	
	Hypertension	2 (15.4)	1 (8.3)	1 (8.3)	
Bad habits	Smoking	4 (30.8)	3 (25.0)	4 (33.3)	
	Alcoholism	1 (7.7)	1 (8.3)	2 (16.7)	

* Except for body mass index (BMI); COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus.

Patients in all observation groups underwent planned video-assisted thoracoscopic lung resection. In Groups Ia, Ib, Ic, segmental resection of both lungs was conducted. In Group IIa, there were 8 (61.5%) pneumonectomies, 4 (30.8%) lobectomies and 1 (7.7%) segmental resection of both lungs. In Group IIb, 3 (25%) lobectomies, 3 (25%) pneumonectomies, and 6 (50%) segmental resections on both lungs were performed. In Group IIc, 10 (83.3%) lobectomies and 2 (16.7%) pneumonectomies were executed.

The surgical treatment stage was performed in all cases with the lack of clinical and radiological dynamics (despite conducted CTX), and taking into account current clinical recommendations.

Patients of Groups Ia and Ib received new ATDs according to the instructions for their use. BQ was prescribed to patients of both groups for at least 12 weeks before surgical treatment.

According to the clinical guidelines, Tuberculosis in Adults, treatment was considered effective if, upon its completion, the patient was transferred to Group III of the dispensary register or removed from it, while a persistent absence of bacterial excretion was noted confirmed by the bacteriological method and the TB was assessed as inactive (i.e., favorable outcome) based on clinical and radiological data. Treatment was considered ineffective if the patient continued to have (or resumed signs of) an active TB during the observation period (unfavorable outcome). The treatment results were determined in each case individually, according to the decision of the medical consilium at the place of residence or registration of patients.

Data on the postoperative course of CTX were obtained from the Federal Register of Tuberculosis Patients and based on the results of personalized requests to medical institutions at the place of residence or registration of patients. The duration of patient monitoring in all observation groups was two years.

The processing and analysis of the collected data was carried out using the IBM SPSS Statistics 27.0 software using descriptive and analytical statistics. Confidence intervals for frequencies were calculated using the binomial distribution. One-way analysis of variance (ANOVA) was employed to assess differences in means between the compared groups. Quantitative indicators corresponding to the normal distribution were presented as M±SD, where M is the arithmetic mean and SD is the standard deviation. The Kolmogorov–Smirnov test was used for assessing data for normality. The Kruskal–Wallis test with Bonferroni correction for multiple comparisons was used to compare categorical features between independent samples. In all statistical procedures, differences were considered statistically significant at I<0.05.

Results

In most cases, the postoperative period in the studied patients was uncomplicated. In rare cases, delayed lung expansion was observed in the early postoperative period: in 3 patients in Group Ia, in 2 patients in Group IIa, and in 5 patients in Group IIIa. Besides that, in Group Ib, intrapleural bleeding developed in 1 patient after lobectomy, and a bronchopleural fistula developed in 1 patient after pneumonectomy. In Group IIIb, interpleural bleeding was noted in 3 patients after segmental resection of both lungs, and a bronchopleural fistula was diagnosed in 2 patients after pneumonectomy. The above complications were taken care of in all cases.

In the observation groups, we compared the duration of CTX between the pre- and postoperative periods. The duration of treatment for patients before surgery is shown in *Table 3*.

We found no statistically significant difference in the duration of preoperative CTX: it lasted an average of 31.6 weeks, 25.3 weeks and 29.6 weeks in Groups Ia, IIa and IIIa, respectively. The duration of CTX before surgery in patients with FCT was also similar in different groups: 45.1 weeks, 45.6 weeks and 46.8 weeks in Groups Ib, IIb and IIIb, correspondingly.

Thus, preoperative preparation in the observation groups did not differ between patients with localized and extensive forms of pulmonary TB.

At the next stage, we carried out an analysis of the laboratory study data of the DR spectrum in the respiratory and resection specimens of patients in all groups. As a result, we revealed a discrepancy in the spectrum of MTB-DR in 32 patients with tuberculomas and in 7 patients with FCT.

Table 3. Duration of tuberculosis treatment in the preoperative period

Observation group	Parameter	Duration of treatment before surgery, weeks	*p*
Ia (*n*=25)	*M±SD*	31.6±15.3	0.212
	95% CI	25.3–37.9	
IIa (*n*=24)	*M±SD*	28.7±19.1	
	95% CI	20.6–36.7	
IIIa (*n*=28)	*M±SD*	29.6±12.0	
	95% CI	24.9–34.3	
Iб (*n*=13)	*M±SD*	45.1±14.7	0.85
	95% CI	36.2–53.9	
IIб (*n*=12)	*M±SD*	45.6±14.9	
	95% CI	36.1–55.0	
IIIб (*n*=12)	*M±SD*	46.8±27.7	
	95% CI	29.2–64.4	

The study of resection specimens in patients with tuberculomas exhibited the expansion of the MTB-DR spectrum with additionally revealed resistance to fluoroquinolones in 8% (2/25) of individuals in Group Ia, in 8.3% (2/24) of patients in Group IIa, and in 17.8% (5/28) of study subjects in Group IIIa. In patients with FCT, the MTB-DR spectrum was broader in 15.4% (2/13) of people in Group Ib, in 33.3% (4/12) patients in Group IIb, and in 8.3% (1/12) of patients in Group IIIb. Newly identified MDR of MTB was detected in 45.8% (11/24) of patients in Group IIa and in 42.9% (12/28) of subjects in Group IIIa.

Thus, the revealed differences in the DR spectrum are associated with the form of TB: the expansion of the DR spectrum was recorded in patients with tuberculomas in 41.6% of cases, while in patients with FCT, this was the case in just 18.9% of patients (p=0.03).

The results of our study of the resection specimens revealed the identified latent DR allowed us adjusting the CTX regimen in the postoperative period.

At the next stage, we compared the duration of postoperative CTX until a favorable outcome between the observation groups. The duration of etiotropic therapy in the postoperative period is presented in *Table 4*.

The duration of postoperative CTX in patients in Groups Ia, Ib, IIa, and IIb, the treatment course of which involved the use of Lzd and/or BQ, was statistically significantly shorter than in Groups IIIa and IIIb, in which treatment did not involve these drugs. The inclusion of new ATDs in the CTX regimen made it possible to reduce the duration of postoperative therapy by 14.0 weeks and 11.1 weeks in Groups Ia and IIa, and by 14.8 weeks and 14.9 weeks in Groups Ib and IIb, respectively.

The full course of CTX in patients with localized forms of TB was shorter than in patients with extensive TB forms. E.g., the difference in the duration of the CTX course between patients who received new ATDs at both stages, who took Lzd and/or BQ only after surgery, and who did not receive them at all, was 24.89 weeks, 25.2 weeks, and 29.31 weeks, respectively.

During CTX, adverse reactions (ARs) were noted in 36% (9/25) of patients in Group Ia, 33.3% (8/24) of those in Group IIa, and 42.9% (12/28) of individuals in Group IIIa. In patients with FCT, ARs were detected in 38.5% (5/13) of patients in Group Ib, 33.3% (4/12) of patients in Group IIb, and 50% (6/12) of people in Group IIIb. The nonspecific nature of the detected ARs did not allow us to clearly identify the culprit drug in the complex CTX that directly caused them. The most frequent ARs were gastrointestinal manifestations and arthralgia: they were present in 26% (30/114) and 18.4% (21/114) of patients, respectively. All adverse reactions in all observation groups were stopped by the prescription of pathogenetic therapy and did not lead to a reduction in dosage or to the discontinuation of drugs.

At the end of the observation period, all patients in the groups were removed from the dispensary register or transferred to Group III. At the same time, among patients of Group IIIa, cases of the TB relapse were conformed in 17.9% (5/28) of cases; in 3 patients, this was true up to a year after the completion of the CTX course; and in 2 patients, the relapse occurred after more than 1.5 years.

In 35% (27/77) of patients in Groups Ia and Ib, and in 43.2% (16/37) of patients in Groups IIa and IIb, residual changes were observed within 2-3 lung segments in the form of pleural layers; small (up to 1 cm), dense and calcified foci; and limited fibrosis.

Discussion

Increasing the effectiveness of the combined treatment of MDR-TB remains an unresolved task. The rapid development of MTB-DR to the prescribed ATDs encourages a constant search for more effective drugs and their combinations used for the CTX [12–14]. However, the detection of MDR in MTB is often difficult due to differences in DR strains MTB isolated from different biological specimens. A more reliable biological sample for verifying DR of MTB is a resection specimen [4, 14, 15].

The emergence of MDR-MTB can be associated with a natural change in the natural properties of the bacterial cell, and also occur as a result of the selective action of taken antibacterial drugs. Insufficient adherence to treatment leading to the incorrect duration of administration and daily dosages, as well as the detrimental effects of alcohol and nicotine are quite possible with long courses of CTX [17, 18]. In addition, TB treatment initiated without preliminary testing for susceptibility to anticipated drugs is also one of the main reasons for the formation of DR in MTB. This emphasizes the importance of timely detection of reliable MTB-DR for further selection of a treatment strategy [19].

Table 4. Duration of etiotropic therapy in the postoperative period

Observation group	Parameter	Duration of treatment after surgery, weeks	*p*
Ia (*n*=25)	*M±SD*	30.3±13.9	$p_{Ia–IIa}$=1.0 $p_{Ia–IIIa}$=0.028 $p_{Ia–IIIa}$=0.002
	95% CI	24.5–36.0	
IIa (*n*=24)	*M±SD*	33.2±10.7	
	95% CI	28.7–37.7	
IIIa (*n*=28)	*M±SD*	44.3±15.2	
	95% CI	38.4–50.2	
Iб (*n*=13)	*M±SD*	41.7±11.6	$p_{Iб–IIб}$=1.0 $p_{Iб–IIIб}$=0.031 $p_{Iб–IIIб}$=0.049
	95% CI	34.7–48.7	
IIб (*n*=12)	*M±SD*	41.5±11.2	
	95% CI	34.4–48.6	
IIIб (*n*=12)	*M±SD*	56.5±14.8	
	95% CI	47.0–65.9	

In the observed patients, we revealed differences in the spectra of MTB-DR during the study of respiratory and resection specimens. For example, in 41.6% of patients with tuberculomas and in 18.9% of those with FCT, we noted the presence of latent MTB-DR during the study of resection specimens. This is consistent with the data provided by other studies, in which, when comparing respiratory and resection specimens, a difference in the DR spectra of MTB was established with a frequency of 21.2% to 90% [4, 6, 16]. Thus, the detection of accurate MTB-DR based on the results of the study of the most informative biological sample is a priority task when scheduling a CTX course in the postoperative period.

The goal of this study was to evaluate the efficacy of ATDs in patients with MDR of MTB operated on for pulmonary TB.

When comparing the duration of the CTX course between the observation groups with the inclusion of Lzd and/or BQ, we found a reduction in the mean treatment duration by 14.0 weeks and 11.1 weeks in Groups Ia and IIa, and by 14.8 weeks and 14.9 weeks in Groups Ib and IIb, respectively.

In patients with MDR-TB, the duration of the pre- and postoperative treatment course depends on multiple factors, including the clinical situation preceding CTX, comorbid background, and tolerability of ATDs [4].

High treatment efficacy with the inclusion of Lzd and/or BQ in the CTX regimen will reduce the duration of medicamentous therapy, which can increase patient adherence. Often, long-term use of ATDs may lead to noncompliance with doctor's recommendations by patients, up to and including unauthorized discontinuation of treatment, which may consequently result in relapses and the development of resistant forms of TB [17, 18].

An important criterion for the effectiveness of TB treatment, in addition to its duration, is its safety. The administration of Lzd and/or BQ did not cause severe adverse reactions, and the high frequency of clinical and laboratory response to CTX confirmed the conclusion that Lzd and BQ can be safely used to increase the effectiveness of treatment in patients with MDR-TB [20].

Hence, the use of new ATDs (Lzd and/or BQ) contributes to shortened duration and higher effectiveness of comprehensive treatment in patients operated on for MDR-TB of the lungs.

Conclusion

Our results showed no differences in the duration of preoperative CTX between patients with localized and extensive forms of TB with the inclusion of new ATDs and without their administration. Detection of latent MDR of MTB in the study of paired biological samples helped adjust the etiotropic treatment in the postoperative period. Inclusion of Lzd and BQ in the CTX regimen in patients with MDR TB allowed reducing the time to achieve a favorable treatment outcome by an average of 14.0±1.3 weeks and 11.1±4.5 weeks for localized TB forms and by 14.8±3.2 weeks and 14.85±3.7 weeks for widespread TB forms, respectively. Reducing the duration of the CTX regimen can contribute to better patient adherence to treatment, a reduction in the incidence of adverse reactions and the occurrence of relapses of the TB.

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Conflict of interest: None declared by the authors.

References

1. Mozhokina GN, Samoylova AG, Vasilyeva IA, Russkikh AE. Medications for short-term chemotherapy of drug-resistant tuberculosis and their effect on the host. *Tuberculosis and Lung Diseases* 2022; 100(8): 54-64. (In Russ.) https://www.doi.org/10.21292/2075-1230-2022-100-8-54-64
2. World Health Organization. Global Tuberculosis Report 2024. *Geneva: WHO* 2024. License: CC BY-NC-SA 3.0 IGO.
3. Vasilyeva IA, Samoylova AG, Zimina VN, et al. Chemotherapy for tuberculosis in Russia – The story continues. *Tuberculosis and Lung Diseases* 2023; 101(2): 8-12. (In Russ.) https://www.doi.org/10.58838/2075-1230-2023-101-2-8-12
4. Nekrasov EV, Trusov VN, Tokaev TK. The role of laboratory methods of examining resected specimens in scheduling the regimens of tuberculosis treatment. *Tuberculosis and Socially Significant Diseases* 2019; 2: 40-45. (In Russ.)
5. Borodulina EA, Rogozhkin PV, Olefirov AS. Drug resistance of Mycobacterium tuberculosis obtained from rescted specimens in patients with pulmonary tuberculosis. *Medical Alliance* 2021; 9(1): 6-10. (In Russ.)
6. Uraksina M, Rogozhkin P, Eremenko E. Determination of drug resistance of Mycobacterium tuberculosis in the operating material. *Bull Acad Sci Mold Med Sci*. 2021;69(1). https://www.doi.org/10.52692/1857-0011.2021.1-69.09
7. Konovalova NM, Odinets VS, Vasilenko TI, Zadremaylova TA. Experience of using bedaquiline in the treatment of pulmonary tuberculosis patients with multiple and extensive drug resistance. *Tuberculosis and Lung Diseases* 2017; 95(12): 49-53. (In Russ.) https://www.doi.org/10.21292/2075-1230-2017-95-12-49-53
8. Panova LV, Ovsyankina ES, Khiteva AY, Krushinskaya EA. Experience of using two courses of bedaquiline in an adolescent with fibrous cavernous tuberculosis and extensive drug resistance. *Tuberculosis and Lung Diseases* 2019; 97(7): 56-60. (In Russ.) https://www.doi.org/10.21292/2075-1230-2019-97-7-56-60
9. Nechaeva OB. Socially important infectious diseases posing a biological threat to the population of Russia. *Tuberculosis and Lung Diseases* 2019; 97(11): 7-17. (In Russ.) https://www.doi.org/10.21292/2075-1230-2019-97-11-7-17
10. Ruzanov DY, Skryagina EM, Bujnevich IV. New regimens and new drugs in the treatment of tuberculosis: Are we marching in step? Clinical *Microbiology and Antimicrobial Chemotherapy* 2021; 23(1): 27-42. (In Russ.) https://www.doi.org/10.36488/cmac.2021.1.27-42
11. Shishlova AS. Organizing treatment of patients with drug-resistant forms of tuberculosis. *International Journal for Research* 2024; 9(147): 1-8. (In Russ.)
12. Malik AM, Stancheva MV. Effectiveness of treating patients with multidrug-resistant tuberculosis depending on the treatment regimen. *Smolensk Medical Almanac* 2016; 4. URL: https://cyberleninka.ru/article/n/effektivnost-lecheniya-patsientov-s-tuberkulezom-s-mnozhestvennoy-lekarstvennoy-ustoychivostyu-vozbuditelya-v-zavisimosti-ot/viewer (20 Apr 2025). (In Russ.)
13. Vinokurova MK, Yakovleva LP, Kondakov SN, Petukhova NYu. The effectiveness of treatment and follow-up of newly diagnosed patients with multidrug-resistant pulmonary tuberculosis. *Fundamental Studies* 2013; 7(2): 286-90. (In Russ.)
14. Belousova KV, Kravchenko MA, Berdnikov RB. Comparative analysis of clinically significant biological properties of Mycobacterium tuberculosis isolated from respiratory specimens. *Fundamental Studies* 2014; 9(11): 2452-5. (In Russ.)
15. Belousova KV, Umpeleva TV, Eremeeva NI, et al. Drug sensitivity and genotypic affiliation of Mycobacterium tuberculosis isolated from lung resections of pulmonary tuberculosis patients. *Tuberculosis and Lung Diseases* 2019; 97(7): 11-7. (In Russ.) https://www.doi.org/10.21292/2075-1230-2019-97-7-11-17
16. Borodulin BE, Borodulina EA, Eremenko EP. Outpatient Phthisiology: textbook. *Moscow: KnoRus*, 2022; 418 p. (In Russ.)

17. Sinitsyn MV, Kalinina EM, Belilovsky SE, et al. Tuberculosis treatment in contemporary conditions. *Therapeutic Archive* 2020; 92(8): 86-94. (In Russ.) https://www.doi.org/10.26442/00403660.2020.08.000762
18. Skryagina EM. The effectiveness of tuberculosis treatment in patients with different periods of outpatient and inpatient treatment. *Russian Medical Journal* 2022; 1(79): 106-13. (In Russ.)
19. Zellweger J.-P. Modern possibilities of treating tuberculosis with multidrug-resistant mycobacteria. *Bulletin of the International Scientific Surgical Association* 2017; 6(4): 5-12. (In Russ.)
20. Ivanova DA, Borisov SE, Rodina OV, et al. Safety of treatment regimens for patients with multidrug-resistant tuberculosis according to 2019 WHO recommendations. *Tuberculosis and Lung Diseases* 2020; 98(1): 5-15. (In Russ.) https://www.doi.org/10.21292/2075-1230-2020-98-1-5-15

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