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Efficiency of Surgical Debridement and Implant Retaining in Treatment of Early Postoperative and Acute Hematogenous Periprosthetic Infections of Hip

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Abstract

Background. Periprosthetic joint infection (PJI) is a devastating complication that influences the duration of treatment and patients life quality. Debridement, antibiotics and implant retention (DAIR) is considered as least invasive surgery patients with stable implant, except cases of chronical periprosthetic infection. ***The aim of this study*** was to evaluate efficiency of surgical debridement and implant retaining in control over infection in group patients with early postoperative and acute hematogenous periprosthetic infections. ***Materials and Methods.*** We performed retrospective monocentral cohort study of treatment early postoperative and acute hematogenous periprosthetic infections of hip in 26 patients. The group included cases with stable implants and period between manifestation of infection and DAIR no more than 4 weeks. We have classified infection as early postoperative in 22 patients (84,2%) and as acute hematogenous in 4 cases (15,8%). ***Results.*** At mean follow-up 42,8±2,3 mounts five patients underwent removal of implant due to reinfection. We performed successful two-stage revision for four of them and had to perform resection arthroplasty in one case. Thus, DAIR protocol was successful in 80,8(%) cases. The mean Harris Hip Score significantly improved compared to preoperative values from 59,2±2,5 to 80,5±1,3 at the last follow-up (p = 0,0002, Z-3,7). ***Conclusions.*** The efficiency of DAIR according to our data was 80,8%. These results allow to consider DAIR as a method of treatment of patients with early postoperative and acute hematogenous periprosthetic infections. Exchange of modular components can decrease the reinfection rate.

Keywords: early periprosthetic infection, acute hematogenous periprosthetic infection, debridement, implant retention, DAIR.

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Introduction

Periprosthetic joint infection (PJI) is one of the most severe complications after total hip arthroplasty (THA) and affects the duration of treatment, mortality and quality of patients life [1, 2, 3, 4].

Surgical treatment and antibiotic therapy with the preservation of the implant (debridement, antibiotics and implant retention — DAIR) is considered by many orthopedic surgeons as the least traumatic intervention, since it allows to save a sta-

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ble and functional endoprosthesis in a significant part of patients, reducing the probability of subsequent surgical interventions and thereby reducing the cost of treatment [1, 5, 6]. Indications for the option of such surgical tactics are early postoperative and acute hematogenic infections, which can be distinguished according to the Tsukayama classification and more accurately determined, taking into account the results of the 2nd International Consensus Meeting on Musculoskeletal Infection [6, 7, 8].

According to modern studies, surgical treatment at the earliest possible time after the appearance of infection symptoms and careful debridement with the replacement of the endoprosthesis modular components are factors that affect the success of treatment [1, 6, 9].

Aims of the study: 1) to determine the effectiveness of surgical treatment with the implant preservation in achieving infection control in patients with acute postoperative or hematogenous infection of the hip joint; 2) to compare the frequency of recurrent PJI in subgroups where debridment was performed with the replacement of modular components and without their replacement.

Materials and Methods

Research design

We conducted a retrospective monocenter cohort study. In the hospital database, all patients (n = 35) who were admitted for treatment after THA with diagnoses of "early postoperative PJI" or "acute hematogenous PJI" for the period from 2013 to 2019 were identified. The diagnosis of "acute hematogenic infection" was established if symptoms occurred a year later or later in the area of a satisfactorily functioning joint.

Patients with stable implants and the absence of fistula were selected for the study cohort. Also, the inclusion criteria were the possibility of long-term antibacterial therapy, the absence of sepsis signs and significant inflammation of soft tissues. If the interval between the manifestation of infection and surgical treatment was more than 4 weeks (for early postoperative and acute hematogenous PJI), or if this case did not meet the above mentioned inclusion criteria and the diagnostic criteria of the 2nd International Consensus Meeting on Musculoskeletal Infection [6], the patients were not included in the cohort. Nine patients were excluded because they did not meet the inclusion criteria. Thus, according to the above mentioned criteria, 26 patients were included in the final analysis (Fig. 1).

The characteristics of the patients are shown in Table 1. In 19 patients, debridment was performed after previously transferred THA, in 7 — after revision. In 22 patients (84.2%), PJI was classified as early postoperative and in 4 (15.8%) — as acute hematogenic [7].

Before performing surgery, the stability of the implants was evaluated according to the radiography of the pelvis and hip joint in AP and lateral projections. Standard laboratory tests were performed.

Treatment

No antibacterial drugs were used before surgical treatment, previously prescribed antibiotics were canceled in 5 patients. Surgical treatment included: arthrotomy with taking tissue samples to identify the pathogen, thorough debridement and removal of necrotic tissues, radical synovectomy, irrigation of the joint with 7-9 liters of solution with antiseptics, replacement of the endoprosthesis modular components in cases where it was possible, as well as drainage. To perform surgical treatment in all patients, an antero-lateral approach was used through which previous THA were performed.

The treatment protocol provided for antibacterial therapy for 3 months, which included an initial course of parenteral antibiotic therapy with a transition to oral administration.

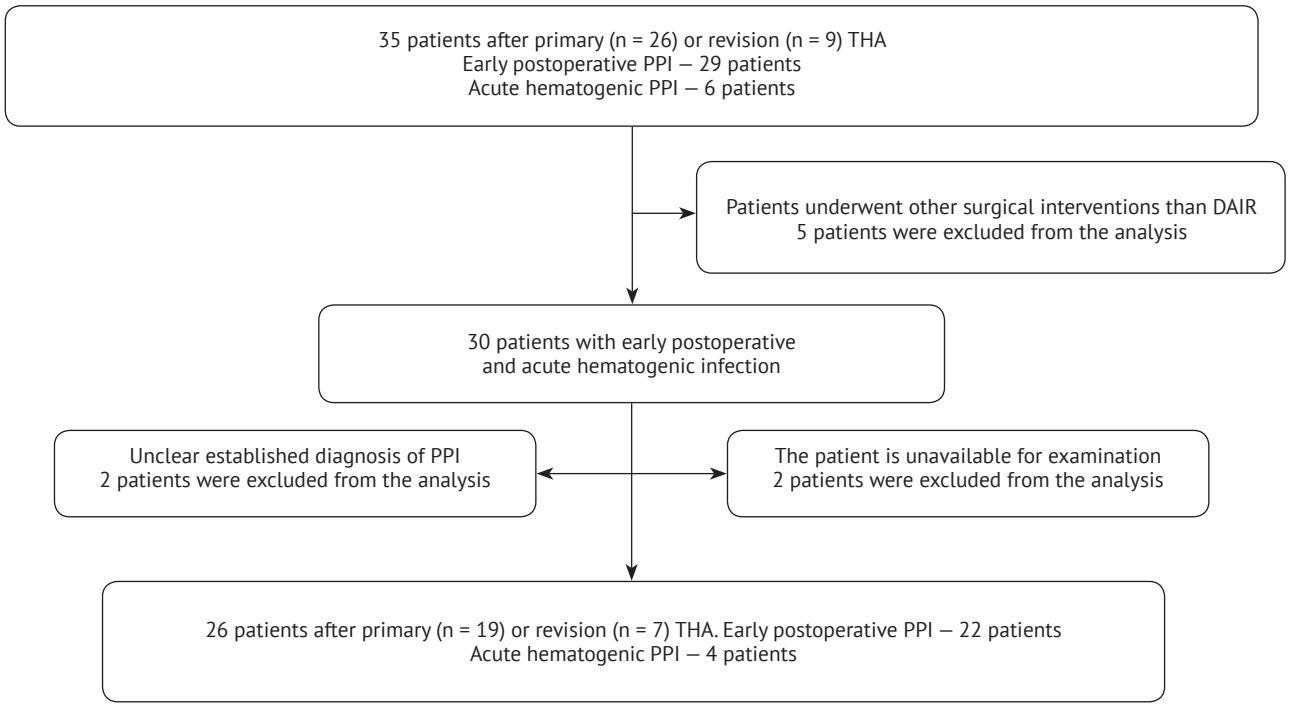

Fig. 1. Study flow chart

Follow-up in the postoperative period

We tracked the treatment results of 26 patients (100% of all observations) in the period from 5 to 60 months, the average follow-up period was 42.8±2.3 months. Infection control was confirmed during the control examination (if it was impossible to arrive for the examination, mail was used) according to the approved criteria of the International Multidisciplinary Delphi Consensus[11]. All cases of repeated hospitalization, infectious complications, aseptic loosening, as well as revision surgeruies on this joint were taken into account. The stability of the endoprosthesis was confirmed on the basis of clinical data and the results of X-ray examination at least 12 months after the surgery. If the patient required repeated surgical treatment (performed according to the protocol described above), which eventually led to infection control and preservation of the implant, then such treatment result was considered successful. The functional state was also assessed on the Harris Hip Score (HHS) scale.

Statistical analysis

Statistical processing was carried out using the program Statistica 13 (Statsoft, USA) and Microsoft Excel 2010. To check the data for normality, the Shapiro-Wilk and Kolmogorov tests were used, in the future, methods of nonparametric statistics were used. The nonparametric Wilcoxon criterion was used to assess the reliability of the difference in the mean values between the dependent samples. The Mann-Whitney test was used to compare independent samples, and the χ^2 test was used for categorical variables. The survival rate of implants was analyzed by the Kaplan-Mayer estimator. The differences in the indicators were considered statistically significant at $p \leq 0.05$.

Results

Preservation of the endoprosthesis during the observation period for at least 12 months in the absence of both clinical and laboratory signs of infection, we considered the treatment to be a successful result. During the follow-up period of 42.8±2.3 months, the endoprosthesis was re-

moved in 5 patients due to the infection recurrence (Table 2). Thus, the protocol of surgical treatment with the preservation of the implant was effective in 80.8% of patients.

Relief of infection was observed in 17 patients out of 22 with early postoperative infection and in all 4 patients with acute hematogenic PJI. Implant survival rate calculated by the Kaplan-Mayer estimator was 76.2% (Fig. 2).

The interval between the manifestation of infection and the implementation of debridement was 2.9±0.19 weeks. The Harris scale score in the study cohort before the

Table 1

Patients charasteristics

Parameter	General group	With replacement of modular components	Without replacement of modular components	p
Number of patients, n	26	11	15	–
Age, years	55,25±2	58±2,5	53±3	0,9
Gender (Male/Female)	13/12	5/6	8/7	0,68
Obesity (BMI>30)	3	2	1	–
Concomitant diseases				
Hypertension	14	5	9	–
CHD	3	2	1	–
Anemia	3	1	2	–
Peptic ulcer of the stomach	2	1	1	–
Gastritis	3	1	2	–
Chronic bronchitis	3	1	2	–
Urolithiasis	2	1	1	–
Rheumatoid Arthritis	2	1	1	–
Viral hepatitis C	6	2	4	–
HIV	1	1	–	–
CRP before DAIR surgery, mg/l	45,25±3	44,2±3,8	45,7±5,5	0,85
ESR before the DAIR operation, mm/h	27,3±5,5	31,9±8,3	26,3±8,9	0,6
Details of surgery				
Primary/revision THA	19/7	8/3	11/4	0,81
Uncemented/ cemented / hybrid	17/6/3	10/1/0	7/5/3	0,12
The interval between THA and DAIR in the group of patients (n = 22) with acute postoperative PPI, weeks.	3,9±0,26			
	2,5±0,24	4,1±0,22	0,015	
Interval between THA and the symptoms occurrence in group of patients (n = 4) with acute hematogenic PPI, years	3,75±0,625	4,91	3,3±0,6	–
Duration of symptoms up to DAIR, weeks.	2,9±0,19	2,5±2,2	3,9±2,3	0,02

BMI — body mass index, CHD — coronary heart disease.

surgical treatment was 59.3±2.5 points, and at the time of the last control examination it was statistically significantly higher — 80.5±1.3 points (p = 0.0002; Z — 3.7).

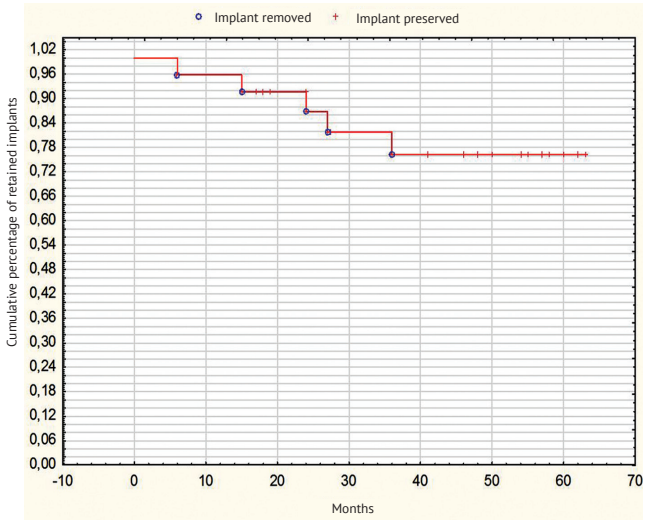

Fig. 2. Kaplan-Meier curve with relapse-free survival of hip prosthesis after DAIR.
Y-axis — cumulative proportion;
X-axis — follow-up in months

A microbiological study of the materials of 26 patients was conducted, the results of which are presented in Table 3.

Isolated gram-positive microflora was detected in more than half of the patients in the study group (of which 3 had a relapse of inflammation), staphylococci prevailed, as well as enterococci and other coagulase-negative staphylococci. Isolated gram-negative flora was identified in 5 (19%) patients. In 2 (7.6%) cases, no growth of the pathogen was detected. Microbial associations were detected in 11 (42%) patients.

In 17 (65%) patients, uncemented fixation implants were used during previously performed THA. In 6 (23%) patients, the type of fixation of the endoprosthesis was cemented, in 3 (11.5%) — hybrid. Replacement of the modular components of the endoprosthesis was performed in 11 (42.3%) cases.

The most commonly empirically prescribed antibiotics after intraoperative tissue sampling for analysis were vancomycin (11 patients) and cefazolin (13 patients). The choice of an antibiotic prescribed empirically did not affect the frequency of infection relapses (p = 0.7). Then an antibiotic was prescribed, taking into account the sensitivity of the pathogen, with a transition to oral administration for 3 months.

Revision surgeries and complications

In 4 patients, a wound revision was performed with repeated debridement for a relapse of infection. In 3 of them, repeated surgical treatment was performed within 2 weeks after the initial debridement with the preservation of the implant, in one patient-after 5 months. In all cases, this made it possible to achieve control over the infection and the absence of relapses during the follow — up period-40, 48, 52 and 57 months, respectively. Among 11 patients who underwent debridement with the replacement of modular components, there was one relapse of infection, whereas in the group without replacement, relapses occurred in 4 patients. In 3 of them, PJI was successfully treated according to the protocol of two-stage revision THA. In one case, we had to perform resection arthroplasty. The successful result of treatment (infection control with the preservation of the implant) was more often observed among patients who underwent surgical treatment with the replacement of modular components, but this difference was not statistically significant (p = 0.1; OR-2.93; 95% CI 0.33-22.7).

One patient in the postoperative period had a dislocation of the hip, which was set closed. The hip joint was immobilized by an orthosis, there were no recurrences of dislocation during the follow-up period of 20 months.

Table 2

Data on patients with PJI treated according to the protocol of surgical treatment with the preservation of the implant: treatment details, results

№	Gender	Age	Primary/ revision THA	The type of the endoprosthesis fixation	PPI by Tsukayama	Interval between THA and DAIR	Duration of symptoms up to DAIR, weeks.	Number of debridments	Observation period, months.	Treatment outcome
1	F	54	Primary	Hybrid	a/h	5 years	3	1	50	Successful
2	f	34	Primary	Uncemented	a/h	3 years	4	1	60	Two-stage treatment
3	m	41	Primary	Uncemented	Early p/o	4 weeks	3	2	48	Successful
4	f	47	Revision	Hybrid	Early p/o	2 weeks.	1	2	58	Successful
5	f	55	Revision	Uncemented	Early p/o	3 weeks.	2	1	17	Successful
6	f	69	Primary	Uncemented	Early p/o	4 weeks	4	1	28	Successful
7	m	49	Primary	Uncemented	a/h	2 years	4	1	62	Successful
8	m	56	Revision	Cemented	Early p/o	4 weeks.	3	1	43	Two-stage treatment
9	m	51	Revision	Hybrid	Early p/o	4 weeks.	3	1	50	Two-stage treatment
10	m	76	Primary	Cemented	Early p/o	5 weeks.	4	1	53	Successful
11	m	56	Primary	Uncemented	Early p/o	3 weeks.	2	2	58	Successful
12	f	66	Primary	Uncemented	Early p/o	3 weeks.	2	1	46	Successful
13	m	56	Primary	Uncemented	Early p/o	2 months.	4	1	15	Two-stage treatment
14	m	62	Primary	Cemented	a/h	5 years	4	1	63	Successful
15	f	59	Primary	Uncemented	Early p/o	4 weeks.	2	1	57	Successful
16	f	72	Primary	Uncemented	Early p/o	4 weeks.	2	1	58	Successful
17	m	46	Primary	Uncemented	Early p/o	3 weeks.	2	1	54	Successful
18	m	34	Primary	Uncemented	Early p/o	5 weeks.	2	1	41	Successful
19	f	65	Primary	Uncemented	Early p/o	4 weeks.	4	1	60	Successful
20	m	58	Primary	Uncemented	Early p/o	2 weeks.	1	2	57	Successful
21	f	71	Primary	Uncemented	Early p/o	6 weeks.	4	1	55	Successful
22	m	36	Primary	Uncemented	Early p/o	5 weeks.	4	1	54	Successful
23	f	79	Primary	Cemented	Early p/o	5 weeks.	4	1	62	Successful
24	f	32	Revision	Cemented	Early p/o	3 weeks.	2	1	36	Resection arthroplasty
25	m	63	Revision	Cemented	Early p/o	3 weeks	2	1	19	Successful
26	m	65	Revision	Uncemented	Early p/o	2 weeks.	2	1	18	Successful

Table 3

Results of microbiological study of intraoperative materials

The microorganism	The studied cohort
No growth was detected	2
Gram-positive	
S. aureus	7+1 MRSA
S. epidermidis	3+6 MRSE
Entherococcus faecalis	4
Другие *CoNS*	4
Corynebacterium spp.	4
Peptostreptococcus magnus	2
S. saprophyticus MR	1
Gram-negative	
Klebsiella pneumoniae	1
Pseudomonas aeruginosa	2
Acinetobacter baumannii	1
Proteus mirabilis	1
Enterobacter cloacae	1
Microbial associations	Identified in 11 patients

CoNS — coagulase-negative staphylococci, *S. saprophyticus* MR-methylene-resistant.

Discussion

In our cohort of 26 patients with early postoperative and acute hematogenous PJI treated according to the protocol of surgical treatment with the preservation of the implant, the frequency of infection control over the follow-up period of 5.5 years was 80.8%. The results of successful treatment of early PJI obtained by us are comparable with the results of modern studies in which the authors used this method of treatment [1, 5, 12, 13, 14, 15, 16].

The analysis of the literature allows us to identify three groups of factors that affect the success of this method in the treatment of early PJI. The first group includes factors that can be determined before surgery: factors related to the patient; factors that depend on symptoms; laboratory results. The second group consists of factors that depend on the microorganism (culture-dependent factors), the third group combines factors related to the details of the treatment [16].

A long interval between the manifestation of infection and the performance of surgical treatment, according to most researchers, increases the probability of unsuccessful treatment [1, 3, 9, 12, 15, 16, 18, 25, 26]. Some researchers attach importance to the duration of the period between THA and debridement [1, 21], however, a number of articles did not reveal a relationship between this factor and the results of treatment [16, 17, 18, 26]. In the works published over the past 10 years, there are active discussions about the permissible duration of the time window between the onset of symptoms and debridement surgery [9, 15]. Thus, according to G.K. Triantafyllopoulos et al., performing DAIR is most effective in the first 5 days after the onset of symptoms [27]. A review of cohort studies conducted by S.-T.J. Tsang showed that in those studies where less than 7 days passed between the appearance of symptoms and infection, the frequency of successful debridments was 72%, and if the duration of symptoms was longer, then only 52% [26]. Y Achermann and a number of orthopedic surgeons are hold the opinion that such surgical tactic is permissible in the first 3 weeks after the manifestation of infection [13, 26, 27]. At the moment, the most authoritative source is the Materials of the 2nd International Consensus Meeting on Musculoskeletal Infection, according to which the DAIR tactic should be applied if no more than 4 weeks have passed after the appearance of symptoms [6].

A wide range of pathogens was detected in patients of the study group. *S. aureus* and coagulase-negative staphylococci were detected most often in both mono-and polybacterial infections. These data are consistent with the data of other authors [1, 3, 15, 16, 28, 29, 30]. According to our data, microbial associations were detected in 46% of patients. After analyzing the risk factors, J.W. Kuiper et al., were unable to show that the presence of a polymicrobial infection, the presence or absence of

a low-virulent pathogen, as well as the addition of a secondary infection, can affect the prognosis in the treatment of patients using the DAIR protocol [25]. According to the literature, patients with detected *S. aureus* and coagulase-negative staphylococci were more likely to develop repeated infections after surgical treatment, and the identification of the pathogen from the *Staphylococcaceae* family was associated with a high frequency of unsuccessful results [9, 25]. In his work, A. M. E Jacobs came to the conclusion that the factors associated with unsuccessful treatment were multiple debridments (more than two procedures) and the presence of the pathogen Enterococcus faecalis [16]. To a certain extent, the results of previous studies are consistent with ours, since reinfection in the study cohort was observed in patients with detected *s. aureus* and *enterococcus faecalis*.

According to S.P. Maier, a high rate of erythrocyte sedimentation before surgery may be an additional predictor of reinfection after DAIR in the group with late chronic infection. In the groups with early postoperative and acute hematogenic PPI, this sign did not demonstrate significant sensitivity and specificity [31].

Extensive radical debridement is an important factor that, in combination with correct antibiotic therapy, affects the eradication of infection [1, 15, 26, 30, 32]. Research data show

Table 4

Results of DAIR in patients with early postoperative and acute hematogenic PJI after THA according to the literature

Author	Number of joints underwent surgery	Observation period, years	The interval between the manifestation of infection and DAIR, days	Success of the DAIR procedure, %
Choi H.R., 2011	28	4,9	No data	68,0
Westberg M., 2012	38	4,0	28	71,0
Buller L.T., 2012	62	2,8	10	57,0
Sukeik M., 2012	26	5,0	20	77,0
Achermann Y., 2014	41	3,1	From 1 to 3 months after surgery (84% in the first month after surgery)	87,0
Duijf S.V., 2015	28	1,9	15	71,5
Bergkvist M., 2016	35	4,2	20	64,0
Grammatopoulos G., 2017	122	7,0	7	85,0
Sendi P., 2017	46	4,0	1,3	91,0
Grammatopoulos G., 2017	82	8,0	28	85,0
Jacobs A.M.E., 2019	51	1,0	No data	86,3
Uriarte I., 2019	26	4,0	No data	26,9
Manrique J., 2019	64	5,8	14	70,3
Barros L.H., 2019	12	3,5	No data	100,0
Svensson K., 2020	575	2,0	3 (от 1 до 8)	71.4 with replacement of modular components, 55.5-without replacement
Clauss M., 2020	57	7,8	No data	93,0

that bacterial biofilms are more often found on polyethylene liners. In addition, the removal of modular components provides better access to the posterior parts of the capsule for performing radical surgical treatment [1, 6]. A meta-analysis of 36 studies (1296 hip joints) showed that surgical treatment with the replacement of modular components allows achieving success in 73% of cases, and without replacement — only in 60% [26]. Despite the fact that most researchers recognize the importance of replacing modular components, we found only a few studies in which the replacement of modular components was performed in 100% of patients [9, 18].

Limitations

The follow-up period for patients after surgery averaged 42.8±2.3 months, so we cannot conclude about long-term infection control. The retrospective design and the small number of patients are the limitations of our work. A small sample size could affect the results: for example, we observed a tendency to increase the number of relapses of infection ($p = 0.1$) that required the removal of the endoprosthesis among patients who did not have the replacement of modular components, but the difference was not statistically significant. In addition, the duration of infection symptoms and the interval between the endoprosthesis and surgical treatment between these samples also differed, which could affect the result.

Conclusion

The effectiveness of surgical treatment with the preservation of the implant in our study was 80.8%, which allows us to consider the proposed tactic as a method of treating patients with early postoperative and acute hematogenous PJI. When replacing modular components, there was a decrease in the frequency of relapses of infection, which was not statistically significant.

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Burtsev A.V. — the concept of the study, the final version.

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Conflict of interest:

The authors declare that there is no conflict of interest.