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ASSESSMENT OF POST-VACCINATION COLLECTIVE IMMUNITY AGAINST NEW CORONAVIRUS INFECTION (COVID-19) AMONG SERVICEMEN OF THE ARMED FORCES OF THE RUSSIAN FEDERATION

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ABSTRACT: The recent vaccination campaign targeting the new coronavirus infection (COVID-19) carried out in the Armed Forces of the Russian Federation, on the background of the current unstable global pandemic situation, makes it necessary to study post-vaccination population immunity to the SARS-CoV-2 virus and thus identify key features of immunity in organized military collectives. In the future, this will make it possible to objectively assess the risks of a worsening pandemic situation, effectively adjust the ongoing sanitary and anti-epidemic measures aimed at preserving and strengthening the health of military personnel, as one of the main conditions for maintaining the combat readiness of the Armed Forces of the Russian Federation. During a study conducted on epidemic indications, it was found that vaccination with Gam-Covid-Vac contributes to the formation of collective immunity with 95% effectiveness. A gender-based analysis of the immune response showed that the proportion of persons who lack class G immunoglobulins to SARS-CoV-2 among females is twice than that among men (9.3% and 4.7%, respectively). Seroprevalence indicators, classified by blood group, range from 94.4% (AB (IV) Rh–) to 97.4% (A (II) Rh–). There were no significant differences in seroprevalence between groups of people with different blood groups; however, the highest value of seroprevalence was seen among military personnel with blood group A (II) Rh–. In this context, it is advisable to continue monitoring the formation of immunity in individuals with various blood groups. The results obtained made it possible to form a primary medical and social "portrait" of a serviceman with the most adequate immune response to the introduction of the Gam-Covid-Vac vaccine (a man under the age of 20 with blood type A (II) Rh–) and to draw a conclusion about the high effectiveness of vaccination in military units (formations) staffed by conscripts and military educational organizations.

Keywords: new coronavirus infection; collective immunity; seroprevalence; organized collective; military personnel; vaccination; military educational organizations; blood type.

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ОЦЕНКА ПОСТВАКЦИНАЛЬНОГО КОЛЛЕКТИВНОГО ИММУНИТЕТА ПРОТИВ НОВОЙ КОРОНАВИРУСНОЙ ИНФЕКЦИИ (COVID-19) СРЕДИ ВОЕННОСЛУЖАЩИХ ВООРУЖЕННЫХ СИЛ РОССИЙСКОЙ ФЕДЕРАЦИИ

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Резюме. Проводимая в Вооруженных силах Российской Федерации прививочная кампания против новой коронавирусной инфекции (COVID-19), на фоне сохраняющейся в мире неустойчивой эпидемической ситуации, обусловливает необходимость изучения поствакцинального коллективного иммунитета к вирусу SARS-CoV-2 с целью выявления особенностей формирования иммунорезистентности в организованных воинских коллективах. В дальнейшем это позволит объективно оценивать риски ухудшения эпидемической ситуации, эффективно корректировать проводимые санитарно-противоэпидемические мероприятия, направленные на сохранение и укрепление здоровья военнослужащих, как одно из главных условий сохранения боеготовности Вооруженных сил Российской Федерации. В ходе проведенного по эпидемическим показаниям исследования было установлено, что вакцинация Гам-КОВИД-Вак способствует формированию коллективного иммунитета со степенью эффективности 95%. Анализ иммунного ответа в зависимости от полового признака показал, что доля лиц, у которых отсутствуют иммуноглобулины класса G к SARS-CoV-2, среди женского пола в 2 раза больше, чем среди мужчин (9,3 и 4,7% соответственно). Показатели серопревалентности в зависимости от группы крови колеблются от 94,4% [AB (IV) Rh–] до 97,4% [A (II) Rh–], существенных различий серопревалентности среди групп лиц с разными группами крови не выявлено, однако среди военнослужащих с группой крови A (II) Rh– этот показатель максимальный, в связи с чем целесообразно продолжать наблюдения за формированием иммунитета у лиц с различными группами крови. Полученные результаты позволили сформировать первичный медико-социальный «портрет» военнослужащего с наиболее адекватным иммунным ответом на введение вакцины Гам-Ковид-Вак [мужчина в возрасте до 20 лет с группой крови A (II) Rh–] и сделать вывод о высокой эффективности вакцинации в воинских частях (соединениях), комплектуемых военнослужащими по призыву и в военных образовательных организациях.

Ключевые слова: новая коронавирусная инфекция; коллективный иммунитет; серопревалентность; организованный коллектив; военнослужащие; вакцинация; военные образовательные организации; группа крови.

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BACKGROUND

Two years have passed since the emergence of the coronavirus disease 2019 (COVID-19) pandemic in Russia. During this time, medical specialists have managed to gain profound experience and knowledge in preventing this infection. The pandemic has affected nearly all human activities. The population has learned to live with the "coronavirus," which requires strict adherence to restrictions and other measures that make up a set of sanitary and antiepidemic (preventive) measures [1–3].

Despite the progress made in controlling COVID-19, the epidemic remains unstable. The pandemic has an undulating course with a downward trend. Thus, a consistent and purposeful set of evidence-based measures aimed at removing restrictions and returning society to prepandemic living is necessary [4–7].

One of the main activities is the creation of stable collective immunity to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which is developed after an illness and artificially through specific prophylaxis. The use of modern Russian vaccines is a scientific way of prolonging protection mechanisms in people who had COVID-19 [8–13].

In the epidemic process of COVID-19, the state of collective immunity to SARS-CoV-2, which can predict the emergence of an epidemic, is of great importance [14–17]. Collective immunity develops in a cohort of patients who had recovered and those who were vaccinated. The immune response of the body to SARS-CoV-2 develops according to this scenario: by days 5–7 from the onset of the infection, in 40%–55% of the cases, virus-neutralizing antibodies begin to form in the blood of those who had the infection, and by the end of week 3, they are detected in 100% of the patients. The intensity of immunity in patients who had recovered from COVID-19 decreases within 6–12 months after the infection. At present, the duration of postvaccination immunity, according to various expert estimates, can be up to 1 year [18–21].

According to Russian researchers in various regions of the Russian Federation (RF), 82.4%–95.2% were asymptomatic (inapparent) carriers among seropositive individuals for the entire monitoring period (2020–2021). However, no sex differences could be identified. The highest seroprevalence was detected among children aged 1–17 years [22–25].

Currently, data are limited on the formation of collective immunity in military personnel postinfection and postvaccination [26, 27]. Thus, an assessment of specific collective immunity to SARS-CoV-2 in organized military groups is necessary to identify the characteristics of its formation among military personnel. Owing to social contacts in such groups, data obtained can be used to predict the emergence of an epidemic among comparable population groups [28–31].

The study aimed to analyze population immunity to SARS-CoV-2 during the COVID-19 pandemic following immunoprophylaxis in organized military groups.

MATERIALS AND METHODS

The study was conducted from April 1 to April 30, 2021, according to the order of the Minister of Defense of the RF. The study participants were military servicemen and members of the civilian staff of the Ministry of Defense of the RF who received a full course of vaccination with Gam-COVID-Vac (component 2 of the vaccine).

The total sample was distributed into several groups according to territory (belonging to the military district and Central Authorities of the Military Administration), blood types and Rh factor, sex, and age. In total, 7586 people took part in the study, including 1721 patients from the Central Authorities of the Military Administration (CAMA), 2016 from the Western Military District, 991 from the Central Military District, 1394 from the Southern Military District, 973 from the Eastern Military District, and 491 from the Northern Fleet (NF).

One month after receiving the full vaccination course, 3–5 mL of blood was taken from the cubital vein and placed in vacuum tubes with a coagulation activator. The samples were sent to the laboratories of military medical organizations on a territorial basis in accordance with the generally accepted methodology[1]. Blood serum was examined using a set of reagents for the determination of class G immunoglobulins (IgG) to SARS-CoV-2 in human serum (plasma) by the enzyme-linked immunosorbent assay (a set of reagents was used for enzyme immunoassay detection of class G immunoglobulins to SARS-CoV-2 "SARS-CoV-2-IgG-ELISA-BEST"). The immunological efficacy of vaccination was analyzed based on the assessment of positivity ratio (PR) levels and IgG titers to SARS-CoV-2. A PR of ≥ 1.1 (specific antibody titer 1:100) was considered positive.

Seroprevalence was assessed by the following equation:

$$S = (s^{+} \times 100\%) / N,$$

where S is the seroprevalence index, s^{+} is the number of seropositive participants, and N is the sample size.

The geometric mean titer of antibodies was calculated according to the generally accepted method[2].

The results were statistically analyzed using standard tools of Statistica 10.0 package in accordance with the rules of descriptive and analytical statistics. When comparing group differences, a two-sample Student's *t*-test was used for variables with a normal distribution. Nominal data were analyzed and described in absolute terms, and derivatives were analyzed and described in percentages. A p value < 0.05 was considered statistically significant.

[1] Sanitary rules SP 1.2.036–95. The procedure for accounting, storage, transfer, and transportation of microorganisms of I–IV pathogenicity groups.

[2] MU 3.1.3490–17. Epidemiology. Prevention of infectious diseases. The study of population immunity to influenza in the population of the Russian Federation (approved by the Chief Public Health Officer of the Russian Federation on October 27, 2017).

Table 1. Seroprevalence rates in military personnel of various military districts, %
Таблица 1. Показатели серопревалентности у военнослужащих различных военных округов, %

Parameter	Proportion of individuals with IgG to SARS-CoV-2+, % (*M* ± *m*)
Central Authorities of Military Administration (CAMA)	97.9 ± 0.3
Western Military District (WMD)	95.1 ± 0.4
Central Military District (CMD)	96.0 ± 0.6
Southern Military District (SMD)	95.1 ± 0.5
Eastern Military District (EMD)	92.1 ± 0.8
Northern Fleet (NF)	88.6 ± 1.4

Table 2. Distribution of antibody titers in the examined groups, pers.
Таблица 2. Распределение титров антител в обследуемых группах, чел.

IgG titer to SARS-CoV-2	CAMA	WMD	CMD	SMD	EMD	NF
1 : 100	61	91	29	52	53	38
1 : 200	566	322	63	621	106	397
1 : 400	253	138	24	19	33	0
1 : 800	65	56	7	8	17	0
1 : 1600	137	98	6	26	61	0
1 : 3200	268	225	5	40	71	0
1 : 6400	334	988	817	560	555	0
Geometric mean antibody titer	1 : 722	1 : 1342	1 : 2899	1 : 692	1 : 1334	1 : 103

RESULTS AND DISCUSSION

The results revealed that vaccination with Gam-COVID-Vac promotes the development of collective immunity with an efficiency of 95%. No statistically significant differences were found in the total proportion of seroprevalence in the examined samples, with Student's *t*-test of 0.02 ($p > 0.05$) (Table 1); however, the maximum indicators were registered in the CAMA group, and the minimum ones were recorded in the NF group. An indirect influence on the formation of collective immunity in this group of negative factors in military service under the conditions of the Far North (geographical and climatic factors, vitamin deficiency, etc.) cannot be ruled out; however, this hypothesis requires additional verification.

Of the overall participants, the proportion of seropositive individuals with the maximum antibody titer (1:6400) was 57.1% ($n = 3254$). The distribution of titers, including the geometric mean antibody titer (GMT), in the examined groups is presented in Table 2. For this indicator, the minimum values were also detected in the NF group. This is most likely due to the short time interval between the vaccination and the subsequent blood sampling for laboratory testing for the presence of IgG to SARS-CoV-2 (at the time of the study, no more than 1 month had passed). However, when evaluating these results, the influence of the above factors on the extent of the formed immune response cannot be excluded.

Moreover, no significant differences were found in the distribution of seropositive individuals according to blood groups and Rh factor. Their relatively even distribution was noted, with the highest rates in the group with blood type A (II) Rh–, and the lowest rates were revealed in those with AB (IV) Rh– (Table 3).

However, the distribution of GMT characterizing the degree of immunity to SARS-CoV-2 in the corresponding samples revealed significantly ($p < 0.05$) that servicemen with blood type A (II) Rh– produce the highest levels of antibodies, twice as high as those of servicemen with the AB (IV) Rh– type, with the lowest level of this indicator. This finding led to the hypothesis that individuals with blood type A (II) Rh– form the strongest immune response to Gam-COVID-Vac, whereas individuals with blood type AB (IV) Rh– demonstrate the least immunogenicity (Table 4).

Considering that the number of male participants in the study was 20 times higher than that of female participants, which is quite typical for military personnel of the Armed Forces of the RF, differences in seroprevalence by sex were analyzed. Nevertheless, statistical processing of data revealed that the proportion of seroprevalence in male military personnel was 4.6% higher than in female military personnel. Indicators characterizing the degree of intensity of the formed immune response (GMT) were nearly two times higher than similar indicators in women (Table 5).

Table 3. Seroprevalence indicators depending on blood type and Rh factor
Таблица 3. Показатели серопревалентности в зависимости от группы крови и резус-фактора

Blood type and Rh factor	0 (I)		A (II)		B (III)		AB (IV)	
	Rh+	Rh–	Rh+	Rh–	Rh+	Rh–	Rh+	Rh–
Quantity, pers.	1361	1656	967	343	306	347	262	107
Proportion of individuals with IgG to SARS-CoV-2+, % ($M \pm m$)	95.4 ± 0.6	95.1 ± 1.2	95.9 ± 0.5	97.4 ± 0.9	95.2 ± 0.7	94.7 ± 1.4	95.3 ± 1.1	94.4 ± 2.2

Table 4. Distribution of antibody titers in samples
Таблица 4. Распределение титров антител в выборках

IgG titer to SARS-CoV-2	0 (I)		A (II)		B (III)		AB (IV)	
	Rh+	Rh–	Rh+	Rh–	Rh+	Rh–	Rh+	Rh–
1 : 100	62	11	68	16	30	12	15	4
1 : 200	411	85	513	104	301	100	111	48
1 : 400	77	15	92	22	52	5	19	8
1 : 800	31	14	26	4	20	3	6	0
1 : 1600	63	13	75	16	53	14	19	3
1 : 3200	134	23	144	31	94	20	28	4
1 : 6400	520	130	670	145	371	94	129	34
Geometric mean antibody titer	1 : 883	1 : 970	1 : 941	1 : 1073	1 : 899	1 : 718	1 : 834	1 : 538

Table 5. Distribution of the examined individuals, antibody titers depending on gender
Таблица 5. Распределение обследуемых лиц, титры антител в зависимости от пола

Indicator	Men	Women
IgG titer 1:100	311	13
IgG titer 1:200	1967	108
IgG titer 1:400	442	25
IgG titer 1:800	141	12
IgG titer 1:1600	313	15
IgG titer 1:3200	574	35
IgG titer 1:6400	3139	115
No IgG to SARS-CoV-2, pers.	343	33
Quantity, pers.	7230	356
Proportion of individuals with IgG to SARS-CoV-2+, % ($M \pm m$)	95.3 ± 0,3	90.7 ± 1,5
Geometric mean antibody titer	1 : 991	1 : 575

Table 6. Seroprevalence indicators in different age groups
Таблица 6. Показатели серопревалентности в различных возрастных группах

Age, years	≤ 20	21–30	31–40	41–50	51–60	≥ 61
Proportion of individuals with IgG to SARS-CoV-2+, % (*M* ± *m*)	96.7 ± 0.5	95.2 ± 0.6	94.2 ± 0.4	93.4 ± 0.8	92.9 ± 1.6	90.9 ± 4.4

By age, all examined servicemen were distributed into six groups, and despite statistically insignificant differences, the highest seroprevalence rate was registered in servicemen aged ≤ 20 years (Table 6). Objectively, this group includes conscripted servicemen, contracted servicemen in the first 2 years of service, and cadets of military educational organizations in the first 3 years of the study. In this regard, it is reasonable to assume that the overwhelming majority of servicemen of these categories have A1 military service eligibility, that is, they are apparently healthy people without chronic diseases. A clear trend was found toward a decrease in seroprevalence as age increases. Therefore, we can assume a direct relationship between the formation of immune protection and age indicators in the population.

CONCLUSION

The efficiency of Gam-COVID-Vac vaccination in military personnel contributes to the development of 95% of collective immunity to SARS-CoV-2, which fully corresponds to the vaccine characteristics declared by the manufacturer. Thus, the maximum vaccination coverage of all categories of military personnel will contribute to the formation of effective collective immunity and will reduce significantly the incidence of COVID-19 in organized military groups.

The results of the analysis of seroprevalence indicators in various samples, formed by blood types and Rh factor, as well as sex and age characteristics, enable to generate primary medical and social "portrait" of a serviceman who can develop the most adequate immune response to Gam-COVID-Vac, i.e., a male serviceman aged < 20 years with blood type A (II) Rh–. Thus, the vaccination of conscripts and cadets of military universities can be considered an exhaustive and effective medical and sanitary measure and antiepidemic (preventive) activity performed in military units (formations) and military educational organizations.

The lower seroprevalence rates in comparison with other samples in the NF group require additional verification. However, even now, the vaccination of military personnel in northern regions can be recommended during additional nonspecific immunoprophylaxis using immunomodulators and multivitamin preparations.м

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