

Screening of the intensity of post-vaccination immunity to whooping cough in children in 2021–2024 (single-center study)

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Скрининг напряженности поствакцинального иммунитета к коклюшу у детей в 2021–2024 гг. (одноцентровое исследование)

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Another cyclical epidemic rise in whooping cough cases has begun. The fight against this disease remains a serious public health problem worldwide. [1].

Whooping cough is an infectious disease of the respiratory tract caused by the bacteria *Bordetella pertussis*; the disease is characterized by attacks of spasmodic cough, intoxication, and predominant damage to the respiratory tract [2]. About 50 million cases of whooping cough are registered worldwide each year, and about 350,000 people die as a result of the disease [2].

The highest incidence rate is among children under one year of age — 476.6 per 100 thousand children of this age, which makes them one of the most vulnerable groups and confirms the importance of timely immunization [3]. One of the reasons for the increase

in whooping cough in the Russian Federation is the large number of unjustified medical exemptions and parents' refusals and, as a consequence, the untimely implementation of preventive vaccinations against whooping cough infection [4].

On the other hand, the reasons for the persistently high incidence rate are the growth of atypical forms of whooping cough, the increased incidence among adolescents and adults due to short-lived immunity after vaccination with acellular preparations, and the spread of more virulent *B. pertussis* bacteria with antigen mutations that allow the pathogen to evade post-vaccination immunity [5].

Vaccination against whooping cough is carried out according to the following schedule: 3–4.5–6 months, with revaccination at 18 months according to the na-

tional immunization schedule. However, according to Rospotrebnadzor data from the EMISS system, post-vaccination immunity to whooping cough fades on average within 5–8 years after the last vaccination at 18 months [6].

A number of authors have shown the need to introduce additional doses of whooping cough vaccine at the age of 6–7 and 12–14 years, and to vaccinate adults every 10 years [6]. However, there are no changes in the national calendar of preventive vaccinations to date.

Vaccination of children with chronic diseases is of particular and extreme importance in modern conditions. Children receiving immunosuppressive therapy often have deviations from the vaccination schedule or incomplete vaccination [7, 8].

There is a problem with the identification of *B. pertussis* — according to Kostinov A. A., Kostinov M. P., in Russia only 1–36% of all cases of whooping cough are diagnosed [5].

Serodiagnosis using enzyme-linked immunosorbent assay (ELISA) detects IgG, IgM, and IgA antibodies to pertussis toxin and filamentous hemagglutinin, which is crucial in diagnosing whooping cough and assessing the immune response to this disease [4]. IgA and IgM are the antibodies that first respond to infection and are produced at the initial stage of the disease. IgG provides long-term immunity and protection against reinfection; the level of IgG can be used to judge whether a person has persistent immunity to the infection [9].

Thus, the issue of maintaining post-vaccination immunity in adolescence against whooping cough remains relevant for general pediatric practice, both in the species population of children and in groups with immune-dependent diseases, including those on immunosuppressive therapy [10].

STUDY OBJECTIVE: to assess the presence of post-vaccination immunity to whooping cough in adolescents with acute and chronic diseases.

MATERIALS AND METHODS. In 294 children aged from 7.1 to 17 years, $Me = 12.26$ [10.72; 13.58], there was an analysis of the results of laboratory tests for IgG, IgM and IgA antibodies to whooping cough, performed during hospitalizations or outpatient visits to the Federal State Autonomous Institution “National Medical Research Center for Children’s Health” of the Ministry of Health of Russia in the period from 2021 to 2024.

Due to a suspected infectious process, a study of IgM and IgA antibodies to whooping cough was performed in 141 children to exclude acute infectious pathology. Children with positive and questionable IgM and IgA were excluded from further study of post-vaccination immunity. In 153 children, only IgG antibodies to whooping cough were tested to assess the presence of post-vaccination immunity.

Studies of IgG, IgM and IgA antibodies to whooping cough were performed by the enzyme immunoassay method using Savyondiagnostics SeroPertussis IgG, IgM, IgA kits according to the standard methodology recommended by the manufacturer using Tecan Austria Sunrise and Tecan Austria HydroFlex equipment (Austria). A concentration of less than 10 SvU/ml indicates that IgG is not detected, 10–50 SvU/ml indicates a recent or past infection or immunization, and a strictly positive result is an IgG value above 50 SvU/ml.

Statistical processing of the results was performed using the STATISTICA 10.0 program; the results are presented as median (ME) [lower; upper quartile].

RESULTS AND DISCUSSION

It was revealed that in the group of children with suspected infectious pathology ($n = 141$), positive IgM were detected in 38 children (27%), in 11 children IgM was questionable (7.8%), while it was revealed that in children with positive IgM, the IgG concentration was $IU = 64.5$ [43.3; 87.7], in children with questionable IgM, the IgG concentration was $IU = 9$ [4.5; 42.1], in children with negative IgM, the IgG concentration was $IU = 13.3$ [8.2; 51.3]. Thus, in children with positive IgM, the IgG concentration

was significantly higher than in the group with negative ones. This fact is consistent with the literature data on the increase in IgG titer during the acute infectious period [10].

Positive IgA were detected in 25 children (17.7%), borderline in 3 children (2.1%), while in children with positive IgA the IgG concentration was $ME = 88.4$ [72.8; 100], in children with questionable IgA the IgG concentration was $ME = 60.0$ [8.5; 74.7], in children with negative IgA the IgG concentration was $ME = 18.7$ [8.2; 60.0].

Thus, we see that in children with positive IgA, the concentration of IgG was also significantly higher than in the group with negative ones.

To assess the presence of post-vaccination antibodies, children with positive and questionable IgM and IgA were excluded from the total sample. Vaccination status was assessed in 238 children: 30 children with allergic diseases, 9 children with autoimmune pathology, 17 children with other somatic pathologies, 44 children with infectious diseases (with negative IgM and IgA to whooping cough), and 39 children with chronic kidney disease (CKD).

When analyzing the study results in a group of children with allergic pathology ($n = 30$), the concentration of IgG to BP was $Me = 13.5$ [8.2; 37.7], while in 12 children (40%) negative IgG values were determined; when excluding children with negative values, the concentration of IgG was $Me = 30.8$ [19.6; 60.4].

In the group of children with autoimmune diseases ($n = 9$), the concentration of IgG to BP was $Me = 9.25$ [4.95; 25.6], while 4 children (44%) had negative IgG values; excluding children with negative values, the IgG concentration was $Me = 25.6$ [10.15; 54.6]. In the group of children with other somatic pathologies ($n = 17$), the concentration of IgG to *B. pertussis* was $Me = 21.9$ [2.6; 75.0], and 7 children (41%) had negative IgG; excluding children with negative values, the IgG concentration was $Me = 75.0$ [50.3; 75.0]. In the group with infectious pathology, the concentration of IgG to *B. pertussis* was $Me = 18.8$, [8.8; 52.0], also in 9 children (20.5%) negative IgG were determined, when excluding children with negative values, the concentration was IgG $Me = 34.5$ [17.3; 75.0].

In the group of children with CKD ($n = 139$), the concentration of IgG to *B. pertussis* $Me = 18.05$ [8.0; 58.85], of which 49 children (35.5%) had negative IgG; when excluding children with negative values, the IgG concentration was $Me = 47.7$ [20.6; 80.1]. When analyzing the concentration of IgG in children

depending on age, it was found that in children aged 7–14 years, negative IgG was found in 32.1%, and in children over 14 years old, negative IgG was determined in 41.7% of observations. Moreover, the concentration of IgG under 14 years of age was 52 SvU/ml, and in children over 14 years of age 48.5 SvU/ml.

Whooping cough remains one of the most pressing infections despite immunization [11].

In the Russian Federation, whooping cough (pertussis) infection is experiencing a rise in incidence, despite high primary immunization coverage. According to our data, positive IgM was detected in 27% of cases, which is consistent with V.K. Tatchenko's findings that pertussis infection is the cause of a persistent cough in one in three school-age and adolescent patients [12].

Analysis of our sample confirms that with age, the strength of immunity to whooping cough decreases in all groups of patients, this decrease is especially pronounced in patients with autoimmune diseases, which is consistent with global trends [1, 3, 5].

The incidence of whooping cough and the effects of delayed, and sometimes even withdrawals from vaccinations contribute to the development of infections that can not only exacerbate the underlying disease but also threaten the patients' lives. Vaccination is particularly important for children with chronic kidney disease to ensure an adequate quality of life after kidney transplantation [13].

An analysis showed that only 66% of adolescents have IgG. To reduce the incidence of whooping cough, it is necessary to maintain timely vaccination and booster vaccination coverage for children at a level of at least 95% [14].

CONCLUSION

Thus, our study supports the need to consider the feasibility of additional immunization of adolescents against whooping cough.

Particular attention should be paid to vaccination of adolescents with chronic diseases who are on long-term immunosuppressive therapy, due to the risk of developing an exacerbation of the underlying disease and insufficient specific antibody production.

At the same time, to study the formation of the immune response in children of different health groups, it seems important to study not only the titer of specific antibodies, but more in-depth study of the immune status, primarily in individuals with chronic pathology, including immune-mediated one.

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