ISSN: 0975-833X

*Available online at http://www.journalcra.com*

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

*International Journal of Current Research*
*Vol. 13, Issue, 04, pp.17120-17125, April, 2021*

**DOI: https://doi.org/10.24941/ijcr.41247.04.2021**

RESEARCH ARTICLE OPEN ACCESS

# MICROBIOLOGICAL EFFICIENCY OF INTRAVENOUS IMMUNOGLOBULINS IN THE COMPLEX TREATMENT OF "VENTILATOR-ASSOCIATED" PNEUMONIA IN PREMATURE INFANTS

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**ARTICLE INFO**

***Article History:***
Received 15th January, 2021
Received in revised form
19th February, 2021
Accepted 20th March, 2021
Published online 30th April, 2021

***Key Words:***
Infants, Immunoglobulin, Respiratory Distress Syndrome, Ventilator-Associated Pneumonia, Microorganisms.

**ABSTRACT**

***Aim:*** To investigate the microbiological effectiveness of intravenous immunoglobulins in the complex treatment of "ventilator-associated" pneumonia (VAP) in premature newborns. ***Material and methods:*** We conducted a microbiological study of tracheo-bronchial aspirates (TBA) in 98 premature newborns with respiratory distress syndrome complicated by the development of "ventilator-associated" pneumonia (VAP). The 16 infants received intravenous immunoglobulins (IVIG) from the second day of life. The 47 infants received IVIG in the acute period of VAP from 5 to 8 days from the onset of the disease. The comparison group consisted of 35 infants with VAP who were not given IVIG. Infants from all groups received antibacterial therapy. ***Results:*** The content of microorganisms in TBA in the amount of lg3 colony-forming units in 1 ml or more is an unfavorable sign for the development of VAP in premature newborns. The use of IVIG in infants with VAP is characterized by high microbiological efficiency, which occurs in most patients within a day from the start of treatment. The greatest inhibition of growth is observed against *bacteria, Mycoplasma pneumonia, Mycoplasma hominis, Ureaplasma urealyticum* and *Chlamidia trachomatis*. The effect was weaker against Candida spp. The best effect was with the early administration of IVIG: the respiratory tract was sanitized faster and secondary infection developed less frequently.



***Citation: Maria Vasilievna Kushnareva, Ekaterina Vitalievna Vetrova and Elena Solomonovna Keshishyan.*** "Microbiological efficiency of intravenous immunoglobulins in the complex treatment of "ventilator-associated" pneumonia in premature infants*", 2021. International Journal of Current Research, 13, (04, 17120-17125.*

# INTRODUCTION

Currently, much attention is paid to the problem of treating infectious and inflammatory diseases in premature newborns. The use of artificial lung ventilation (ALV) in infants with respiratory distress syndrome (RDS) often leads to the development of severe infection, in particular ventilator-associated pneumonia (VAP) (Cernada *et al*., 2014).

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Treatment with antibiotics does not always allow you to get a quick and lasting effect, since many pathogens, mainly hospital strains, have multiple resistance to antibiotics (Maltezou HC, *et al*, 2013; Kolls, JK. 2017; Kushnareva MV, *et al*, 2019). The etiology of VAP is represented often in newborns by a combination of bacteria and intracellular microorganisms: *Mycoplasma pneumonia, Mycoplasma hominis (M. hominis), Ureaplasma urealyticum (U. Urealyticum), Chlamidia trachomatis (Ch. trachomatis)*. However, the intracellular localization of microorganisms significantly limits the effect of antibiotics on them (Rakovskaya, 2008; Kohlhoff *et al*, 2015). Intravenous immunoglobulins (IVIG) are used for the treatment of severe infection in newborns, but their

effectiveness and expediency in such patients is controversial (Antonov, A G, *et al*, 2007; Aronskind, E V, *et al*, 2007; Zwiers, C *et al*, 2018). In particular, the question of the use of IVIG for the treatment and prevention of pneumonia in infants with RDS receiving a hardware ventilator remains open.

**Aim**: To investigate the microbiological effectiveness of intravenous immunoglobulins in the complex treatment of" ventilator-associated" pneumonia in premature newborns.

# MATERIAL AND METHODS

We conducted a microbiological study of tracheobronchial aspirates in 98 premature newborns with RDS, which was complicated by the development of VAP. The body mass at birth was from 870 to 2,750 g, and the gestational age was from 27 to 36 weeks. Group I included 16 infants with VAP, who were prescribed IVIG from the second day of life. The 47 infants with VAP formed group II. They received IVIG in the acute period of VAP from 5 to 8 days from the onset of the disease. The study of TBA was carried in this group out on 1-2 days of life before the development of pneumonia, on 5 – 8 days from the onset of the disease to the administration of IVIG, one day after the first infusion of IVIG and 3 days after the end of the course of immunotherapy. The comparison group (III) in this study consisted of 35 infants with VAP who did not receive IVIG immunotherapy. The microbiological study of TBA was carried in this group out on 1-2 days of life before the development of pneumonia, on the day of diagnosis of pneumonia (4-8 days of life), on the next day from the start of treatment and after 6 days in the dynamics of antibiotic therapy. We performed additional inoculations of TBA to establish a possible change in the pathogen in addition to the above-mentioned examination dates, in the absence of positive clinical dynamics from the treatment or deterioration of the condition. The immunoglobulins (octagam in 6 infants, pentaglobin – in 5, intraglobin – in 5) were prescribed on the 2nd day of life before the onset of the disease in 16 infants with VAP (group I). The IVIG treatment (in 27 infants – pentaglobin, in 20 - intraglobin) was started in the acute period of pneumonia on the 5th - 8th day from the onset of the disease in 47 newborns with VAP (group II). The immunoglobulin transfusion was performed for 3 consecutive days. Octagam was administered at a dose of 500 mg / kg, pentaglobin-250 mg/kg, intraglobin at the rate of 6-8 ml/kg of weight.

The VAP was combined with localized infection in the examined infants. The omphalitis was diagnosed in 23 newborns, the tracheobronchitis was in 36 infants, the rhinitis was in 4 infants, the urinary tract infection was in 14, the asymptomatic bacteriuria was in 13, the conjunctivitis was in 8, the otitis was in 1, meningitis was in 1 infant. Indicators of gestational age, body weight and body length at birth did not have significant differences in all groups. The groups were representative in terms of body weight, gestational age, and perinatal pathology. All infants were on ALV and received syndromic and etiotropic antibacterial therapy. The microbiological cultures of TBA were carried out by qualitative and quantitative methods using a standard set of nutrient media (Waites KB, *et al*, 1999; Labinskaya, A S,, *et al*, 2015; Rakovskaya IV, 2008). The determination of the sensitivity of bacteria to antibiotics was carried out by the method of standard disks (Methodological instructions, 2004), and of *Mycoplasma hominis (M. hominis)* and *Urealplasma urealyticum (U. urealyticum)* in a liquid nutrient medium (Waites KB. *et al*, 1999; Rakovskaya IV. 2008). The causative agents of the disease were those strains of conditionally pathogenic microorganisms whose microbial number exceeded lg3 colony-forming units in one ml of TBA (CFU / ml), and the accompanying microflora included strains with a microbial number less than lg4 CFU/ml (Labinskaya, A S, 2015). S***tatistics***. Statistical processing of the results was carried out using the Statistica 7 computer software package. The indicators $\chi^2$ and percent (%) of the occurrence of the trait in the groups were calculated. A significant difference between the compared indicators was considered indicators $p \leq 0.05$. The percentage of small numbers is given for compaison in groups.

# RESULTS AND DISCUSSION

Conditionally pathogenic microorganisms were isolated from TBA in the first two days of life in all premature newborns who subsequently developed VAP. The study of TBA in the first two days of life allowed us to establish that the content of microorganisms in the amount of lg3 CFU / ml or more is an unfavorable sign for the development of pneumonia in premature newborns. This massive colonization of the respiratory tract resulted in the development of pneumonia in 75% of infants (80% of newborns with a birth weight of less than 1500 g and 70% of newborns with a birth weight of more than 1500 g). The pathogens isolated from TBA were representatives of various groups of gram-positive and gram-negative bacteria, intracellular microorganisms, and *Candida spp*. The table 1 shows the various VAP pathogens that were isolated from TBA in etiologically significant amounts (lg4-9).As can be seen from Table 1, the etiology of VAP is represented by a wide range of microorganisms with a predominance of gram – negative pathogens-representatives of *Enterobacteriaceae* (*E. coli* and *Klebsiella spp*.) and *Ps. aeruginosa*. *Staphylococcus spp*. (mainly *S. epidermidis* with hemolytic properties, h+) and *Enterococcus spp*. are more common, and *Streptococcus spp* was much less common among gram-positive microorganisms. *Candida albicans* was seeded along with bacteria from the respiratory tract in some newborns. Attention is drawn to the high frequency of mixed infection (75-85%), which is very diverse in its spectrum. There are associations of bacteria with *Candida albicans* quite often. The most frequent bacterial associations were in group III. They were 3.3 and 2.2 times more common than in group I and group II ($p<0.05$, respectively).

A high frequency of associations of bacteria and intracellular microorganisms (*M. pneumoniae*, *M. hominis*, *U. urealyticum* and *Chlamidia trachomatis*) was found in groups (from 56.5 to 68%). The study of the sensitivity of pathogens of VAP to antibiotics showed that the strains that are polyresistant to antimicrobial drugs predominated. These microorganisms remained sensitive to 2-6 antibiotics out of 10-18 studied. Thus, all *E. coli* strains were sensitive only to amikacin and gentamicin, 70% - to kanamycin, neomycin and streptomycin, 56% - to cefotaxime and ceftazidime, 89% - to carbapenems, 44% - to chloramphenicol, azithromycin and azlocillin, 22% - to ampicillin. All *Klebsiella pneumoniae* strains were resistant to ampicillin and carbenicillin, while maintaining sensitivity to amikacin. The 70% strains of *Klebsiella pneumoniae* strains were sensitive to other aminoglycosides (netilmycin, gentamicin, kanamycin, streptomycin), 50% strains were

**Table 1. The etiological structure of VAP in premature infants**

| N | Pathogen (lg4 CFU / ml and higher) | The group I (n=16) | | The group II (n=47) | | The group III (comparison group, n=35) | |
|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % |
| 1 | *E.coli* | 5 | 31 | 9 | 19 | 12 | 34 |
| 2 | *K.pneumoniae* | 1 | 6 | 11 | 23 | 6 | 17 |
| 3 | *K.ozenae* | 1 | 6 | 0 | 0 | 1 | 3 |
| 4 | *Ps.aeruginosa* | 4 | 25 | 6 | 13 | 2 | 6 |
| 5 | *S.epidermidis (h+)* | 7 | 44 | 5 | 11 | 5 | 14 |
| 6 | *S.aureus* | 0 | 0 | 2 | 4 | 3 | 9 |
| 7 | *Streptococcus A* | 0 | 0 | 2 | 4 | 3 | 9 |
| 8 | *Streptococcus B* | 0 | 0 | 2 | 4 | 1 | 3 |
| 9 | *Pneumococcus* | 0 | 0 | 3 | 6 | 3 | 9 |
| 10 | *Enterococcus spp.* | 5 | 31 | 4 | 8.5 | 5 | 14 |
| 11 | *H.influenzae* | 1 | 6 | 0 | 0 | 2 | 6 |
| 12 | *Bacteroides sp.* | 0 | 0 | 6 | 13 | 1 | 3 |
| 13 | *Fusobacterium spp.* | 1 | 6 | 0 | 0 | 0 | 0 |
| 14 | *Candida albicans* | 9 | 56 | 6 | 13 | 3 | 9 |
| 15 | *M.pneumoniae* | 0 | 0 | 10 | 21 | 7 | 2 |
| 16 | *M.hominis* | 2 | 12.5 | 10 | 21 | 5 | 14 |
| 17 | *U.urealyticum* | 3 | 19 | 3 | 15 | 9 | 26 |
| 18 | *Chlamidia trachomatis* | 2 | 12.5 | 7 | 15 | 6 | 17 |
| 19 | Monoinfection | 4 | 25 | 7 | 15 | 7 | 20 |
| 20 | Mixed infection (2 or more pathogens)) | 12 | 75 | 40 | 85 | 28 | 80 |
| 21 | Bacteria + *Candida spp.* | 2 | 12.5 | 4 | 8 | 1 | 3 |
| 22 | Bacteria + *Candida spp.* and / or intracellular pathogens | 9 | 56.5 | 32 | 68 | 20 | 57 |
| 23 | Combination of bacteria | 1 | 6 | 4 | 9 | 7 | 20 |

**Table 2. Microbiological efficacy of IVIG in premature infants with VAP one day after the first infusion of drugs (I test) and 3 days after the course (II test) of Immunotherapy**

| № | Treatment effectiveness indicators | The group I | | The group II | | The group III * | |
|---|---|---|---|---|---|---|---|
| | | n=16 | % | n=47 | % | n=35 | % |
| 1 | Reducing the titer of pathogens (test I) | 13 | 81 | 39 | 83 | 5 | 14 |
| 2 | Complete eradication (Test I) | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | No effect (test I) | 3 | 19 | 8 | 17 | 30 | 86 |
| 4 | The titer of the pathogen did not change (test I) | 2 | 12.5 | 5 | 11 | 26 | 74 |
| 5 | Increasing the titer of the pathogens (test I) | 1 | 6 | 3 | 6 | 4 | 11 |
| 6 | Reducing the titer of pathogens (test II) | 12 | 75 | 39 | 83 | 18 | 51 |
| 7 | Complete eradication (Test II) | 4 | 25 | 3 | 6 | 0 | 0 |
| 8 | No effect (test II) | 0 | 0 | 10 | 21 | 18 | 51 |
| 9 | The titer of the pathogen did not change (test II) | 0 | 0 | 5 | 11 | 17 | 49 |
| 10 | Increasing the titer of the pathogens (test II) | 0 | 0 | 5 | 11 | 17 | 0,09 |
| 11 | Secondary infection (after eradication) | 2 | 12.5 | 7 | 15 | 14 | 40 |

Note. * The elimination of pathogens and the development of secondary infection occurred in the second – third week of antibacterial treatment in group III (comparison).

**Table 3. Pathogens of secondary infection isolated from TBA in premature newborns with pneumonia**

| N | Pathogens | The group I (n*=2) | | The group III (n*=7) | | The group III (n*=14) | |
|---|---|---|---|---|---|---|---|
| | | n | % | n | % | n | % |
| 1 | *E.coli* | 1 | 6 | 0 | 0 | 4 | 11 |
| 2 | *Enterobacter liquefaciens* | 0 | 0 | 1 | 2 | 0 | 0 |
| 3 | *Ps.aeruginosa* | 0 | 0 | 3 | 6 | 7 | 20 |
| 4 | *Enterococcus faecalis* | 1 | 6 | 2 | 4 | 3 | 9 |
| 5 | *Bacteroides fragilis* | 0 | 0 | 1 | 2 | 0 | 0 |
| 6 | *Candida albicans* | 0 | 0 | 2 | 4 | 2 | 6 |

Note. "n*" - the number of infants with the development of secondary infection.in the group. The percentage is calculated from the total number of infants in the group.

sensitive to cephalosporins of the 3rd-4th generation (cefotaxime, ceftazidim, cefaclor, cefepim), 80% strains were sensitive to carbapenems and 20% to chloramphenicol. *Ps. aeruginosa* was sensitive to amikacin and colistin in most cases (in 80% and 100%, respectively). Some strains (10% - 30%) were sensitive to ceftazidime, imipenem/cilastatin, meropenem. All strains of *Ps. aeruginosa* were resistant to carbenicillin, chloramphenicol, netromycin, streptomycin, and kanamycin. The *Acinetobacter baumanii* strain was sensitive to aminoglycosides and colistin. All *Enterococcus faecalis* strains were susceptible to vancomycin and linezolid, 30% of the strains were susceptible to chloramphenicol, 60% to ampicillin and rifampicin, and 40% to cefotaxime and imipengem/celastatin. *Enterococcus faecium* remained sensitive only to vancomycin and linezolid. *Streptococcus strains* of groups *A*, *B*, and *Pneumococcus* were sensitive to benzylpenicillin, oxacillin, macrolides, cefazolin, cephalexin, azlocillin, linezolid and vancomycin, but resistant to aminoglycosides and weakly sensitive to 3rd generation cephalosporins. All strains of *S. epidermidis* with hemolytic properties were sensitive to vancomycin and linezolid, 82% - to amikacin and gentamicin, 64% - to kanamycin, streptomycin and chloramphenicol, 55% - to cephalexin and cefazolin, 45% - to macrolides (erythromycin, oleandomycin, azithromycin), 33% - to fusidine, 20% - to benzylpenicillin and oxacillin.

All isolated *S. epidermidis* strains were resistant to ampicillin and lincomycin. *S. aureus* was sensitive to vancomycin, linezolid, macrolides, and fusidine. H. *influenzae* remained sensitive to aminoglycosides (amikacin, gentamicin, and kanamycin), cephalexin, ceftazidime, cefotaxime, azithromycin, erythromycin, and chloramphenicol. The trains of *Bacteroides spp*. were sensitive to metronidazole, imipenem/cilastatin, and cefoxitin. It should be noted, that *M. hominis* and *U. urealiticum* strains were multi-resistant to antibiotics. These microorganisms remained sensitive to 2 or 3 antibiotics: all strains were sensitive to midekamycin, 20% of the strains were sensitive to amikacin and gentamicin. In addition, *M. hominis* strains were selectively highly sensitive to josamycin, and *U. urealitycum* to clarithromycin. Most strains of *Klebsiella pneumoniae*, *S. epidermidis*, *S. aureus* (60% - 75%) and all strains of *Ps. aeruginosa* were classified as hospital-acquired based on the study of their biological properties (biochemical, genetic, serological, and antibiotic resistance spectrum). The identification of microorganisms identical in their properties in several patients, as well as from environmental objects, served as a reason to consider them hospital. As can be seen from the above results of the study, most bacterial pathogens had acquired (*Enterobacteriaceae, Pseudomonas spp*., *Staphylococcus spp*.) or natural (*Enterococcus spp*., *Bacteroids spp*.) resistance to antibiotics. *Mycoplasma pneumonia, Mycoplasma hominis, Ureaplasma urealyticum* and *Chlamidia trachomatis*, in addition to their natural resistance to antibiotics, are poorly accessible to their effects due to intracellular localization. These circumstances, as well as the limited range of antibacterial drugs allowed for use in newborns, significantly complicate the treatment of infectious and inflammatory diseases in this category of patients. In this regard, the use of intravenous immunoglobulins, which have a broad antimicrobial effect, in infants with VAP and tracheobronchitis, increases the possibility of successful treatment.

The accompanying conditionally pathogenic microflora in the amount of 10 – 100 CFU/ml was seeded from the TBA, along with the pathogens of pneumonia. It was mainly represented by *S. epidermidis*, *Enterococcus spp*, *Str. viridans*, *Candida spp*, non-pathogenic species of *Neisseria spp*. and *Corynebacterium spp*. The low titer of pathogens, the absence of pathogenicity factors, and a single detection did not allow them to be attributed to the pathogens of the disease. The frequency of occurrence of these microorganisms did not significantly differ in the study groups ($p>0.05$) and ranged from 6 to 14%. The dynamics of changes in the respiratory tract microflora in infants with VAP is presented in Table 2. There was a significant decrease in the total microbial count (total number of microbial cells in 1 ml of TBA - TMC) for the causative agents of pneumonia in the vast majority of the examined infants in groups I and II already on the 2nd day after a single infusion of immunoglobulin in TBA. The most pronounced sanitizing effect was observed for bacterial microflora, *Mycoplasma honinis*, *U. urealyticum* and *Chlamydia spp. (*8 – 100 times), and less pronounced effect was for *Candida spp*., the number of which decreased by 1.5-2 times ($p<0.05$). At the same time, the greatest quantitative reduction of pathogens (10 – 100 times compared to the baseline level) was observed in group I than in the second group and was found in 75% and 58% of infants, respectively. The number of pathogens decreased by 1.5-8 times in the remaining infants of these groups. A decrease in the content of microflora in TBA was observed only for 5 pathogens (3 bacteria and 2 *Mycoplasma*) in 4 infants (11%) ($p<0.05$), which was significantly lower than in groups I and II during the same period of examination in the comparison group, The degree of decrease in TMC was insignificant-by 2-8 times in group II.The positive effect was observed in all newborns 3 days after the end of the course of immunoglobulins in group I. However, 2 infants had a secondary infection of the respiratory tract (1 infant had *Enterococcus faecalis* and 1 infant had *Escherichia coli*) with the development of superinfection. It was later (a week after the disease). Every fourth infant had the elimination of the pathogen. There was also a good microbiological effect in group II. However, it was less pronounced than in group I. Thus, the absence of positive bacteriological dynamics with the preservation of high titers of pathogens was observed in 11% of infants in the group II, and the elimination of microorganisms without secondary infection was 4 times less frequent than in group I ($p<0.005$). The development of secondary infection was observed in 7 newborns of group II on the 4th – 8th day after the end of the course of immunotherapy, including 1 infant on the 3rd day after returning to the ventilator.

Secondary infection in this group II was caused by *Ps. aeruginosa* in 3 infants, *Enterococcus spp*. in 2 infants, *Bacteroides fragilis* in 1 infant, *Enterobacter liquefaciens* in 1 infant. *Candida spp* was seeded in high titers (lg4 and lg6) along with bacterial pathogens, in 2 infants. A decrease in microflora (bacteria, *mycoplasma*, *Chlamydia spp. and Candida spp*.) was observed only in half of the examined infants in the comparison group III after 6 days of antibacterial treatment, in the remaining infants pathogens were present at the same high level (lg4-7). A gradual decrease in the microflora to normal or to complete absence in TBA was observed in 21 infants (including 6 infants with mycoplasma-bacterial infection), in the course of further antibacterial treatment for 2-3 weeks. However, the elimination of primary pathogens was noted in 14 infants (including 6 with mycoplasma-bacterial infection), followed by massive colonization with other bacterial microflora and *Candida spp*., the development of secondary infection, the frequency of which exceeded this indicator in groups I and II by 3 times ($p<0.05$). Replacement of antibacterial therapy, additional administration of intravenous immunoglobulins (1 or 2 doses) was required in these infants. The change of pathogens was observed once in 12 infants, twice in 2 infants and was caused by *Ps. aeruginosa* in 7 infants, *E. coli* in 4 infants, *Enterococcus faecalis* in 3 infants, and *Candida albicans* in 2 infants. Airway sanitation occurred by the end of 4-6 weeks of treatment in infants with superinfection.

Secondary respiratory tract infection after elimination of primary pathogens against the background of antibacterial therapy occurred in 23 infants with VAP (in 21 infants once and in two infants twice). The respiratory tract was populated by microorganisms, that were resistant to previously used antibiotics. The spectrum of pathogens of secondary infection is presented in Table 3. As can be seen from Table 3, these were a hospital strain of Ps.aeruginosa (in 10 infants - 10%), strains of Enterococcus faecalis (in 6 infants – 6%), strains of E. coli (in 5 infants – 5%), strains of Candida albicans (in 4 infants - 4%), a strain of Enterobacter liquefaciens (in 1 infant – 1%) and a strain of Bacteroides fragilis (in 1 infant – 1%). There was a selection of microorganisms with acquired multiple resistance to antibiotics (hospital strains of Ps.aeruginosa and E. coli) or with natural resistance to many

antibacterial drugs (auto strains of Enterococcus faecalis, Bacteroides fragilis, Candida albicans) in almost all cases. These are "problematic" infectious agents, for which it is difficult to choose an antibacterial treatment. A special role belongs to additional alternative methods of treatment in the fight against them. These include immunosubstitution and immunomodulatory therapy. Our study showed that the use of intravenous immunoglobulins significantly (3, 4 times) reduced the frequency of secondary infection compared to infants who received only basic therapy. The positive clinical and microbiological effects of IVIG can be associated with an increase in the content of immunoglobulins in the lumen of the respiratory tract, where they have an antimicrobial effect (Volodin *et al*, 2008), and also stimulate phagocytosis in the focus of inflammation (Kushnareva and Vetrova, 2021).

**Conclusion**

Thus, the use of intravenous immunoglobulins in infants with VAP is characterized by high microbiological efficiency, which occurs quickly and is registered in most patients within a day from the start of treatment. The greatest inhibition of growth is observed in relation to bacterial microflora and intracellular microorganisms. The effect is manifested in relation to Candida spp. to a lesser extent. The respiratory tract sanitation was more effective and secondary infection was less likely to develop with early immunoglobulin administration at the beginning of the inflammatory process than in infants who were prescribed IVIG at the height of the disease.

**The bulleted key points**

- The IVIG inhibit the growth of VAP pathogens (bactria, *M. hominis* and *U. urealiticum*, *Candida spp*.) in the respiratory tract actively a day after the first administration of the drug.
- The antimicrobial effect of IVIG is long-lasting. A low titer of microorganisms or their complete eradication is observed for at least three days after the course of immunotherapy.
- The IVIG reduces the incidence of mixed bacterial infection and secondary infection in infants with VAP.

**Acknowledgement**

The authors thank the administration of the Institute for the opportunity to perform this scientific research.

**Authors contribution**

M.V.Kushnareva (microbiological research, material analysis, statistics, text writing, manuscript design), E.V.Vetrova (clinical observation of infants, treatment, material analysis), E.S.Keshishyan (literature analysis).

**Glossary of Abbreviations**

*Escherichia coli - E. coli*
*Chlamydia trachomatis – Ch. Trachomatis*
*Haemophylus influenzae - H. influenzae*
Hardware artificial lung ventilation - HALV
Iintravenous immunoglobulins - IVIG
*Klebsiella ozenae - K. ozenae*
*Klebsiella pneumonia – K. pneumoniae*
*Mycoplasma hominis – M. hominis*
*Mycoplasma pneumoniae – M. pneumonia*
Respiratory distress syndrome – RDS
*Staphylococcus aureus – S. aureus*
*Staphylococcus epidermidis - S. epidermidis*
Total microbial count - TMC
Tracheobronchial aspirate - TBA
Ventilator-associated pneumonia – VAP
*Ureaplasma urealyticum – U. urealyticum*

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