MICROBIOLOGICAL PROPERTIES OF AIRBORNE INFECTIONS AND MODERN PROPHYLAXIS STRATEGIES AGAINST THEM

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Abstract: *The microbiological characteristics of airborne infectious diseases, their transmission mechanisms and epidemiological significance are analyzed in this literature review. In particular, the structure, antigenic properties, variability, pathogenesis and resistance to environmental factors of the Influenza virus are scientifically covered.*

The article also considers modern prevention strategies, including vaccines, sanitary and hygienic measures, disinfection measures and comprehensive approaches aimed at strengthening public health. The results of the study show that early diagnosis, regular epidemiological surveillance and effective immunoprophylaxis are important in preventing airborne infections.

Keywords: *airborne infections, influenza virus, microbiology, antigenic variability, prevention, immunization.*

Keywords: *airborne, infection, type, vaccine, air.*

INTRODUCTION

Respiratory infections transmitted by airborne droplets are one of the most important problems for the global health system. Seasonal influenza causes millions of cases of illness every year, causing severe complications and mortality, especially among at-risk populations [5]. The causative agent of influenza, the influenza virus, has a high level of genetic variability, and its antigenic drift and antigenic shift properties lead to the emergence of new strains and an increased risk of epidemic and pandemic spread [6]. The virus is transmitted mainly by aerosol droplets and, due to its short incubation period, exhibits rapid spread.

Therefore, studying the microbiological characteristics of airborne infections and developing effective prevention strategies remains one of the priority areas of modern epidemiology and microbiology. Exposure to droplets produced by coughing and sneezing by infected people or contact with surfaces (fomites) contaminated with droplets is the dominant mode of transmission for respiratory pathogens.[1] Respiratory infections include influenza . Occasionally, a new strain of human influenza virus originates from animals and spreads rapidly through human populations with no previous immunity, causing excessive mortality and morbidity worldwide, a phenomenon known as a pandemic. There have been four influenza pandemics in modern times: the "Spanish" flu of 1918–19, the "Asian" flu of 1957, the "Hong Kong" flu of 1968, and the "swine flu" of 2009. The 1918–19 "Spanish" flu was the most severe pandemic in recent history, causing an estimated 500 million infections and 50–100 million deaths worldwide.[2] Current control measures for influenza infections include vaccines and antiviral drugs. However, influenza viruses have rapidly evolved to evade vaccine immunity and develop drug resistance. New viral variants have reduced the binding of vaccine-derived neutralizing antibodies, leading to vaccine incompatibility or reduced vaccine efficacy. Mutations have been identified that confer resistance to antiviral drugs approved by the US Food and Drug Administration (FDA).[3] Influenza viruses belong to the Orthomyxoviridae family and include four main types: A, B, C, and D. Influenza viruses (IAV) can infect a wide range of birds and mammals, including humans, birds, ducks, chickens, turkeys, pigs, horses, and dogs. Influenza B virus (IBV) infects humans and seals, and influenza C virus (ICV) infects humans and pigs. IAV, IBV, and ICV are human pathogens. Influenza D virus (IDV), identified in 2011, infects pigs and cattle, and no human infections have been reported to date. This review focuses primarily on IAV, as it causes the majority of human and animal influenza infections.[4]

MAIN PART

Airborne infections are a group of diseases that are transmitted through the mucous membranes of the respiratory tract and are rapidly transmitted by aerosols and droplets [7]. The long-term persistence of aerosol particles with a diameter of less than 5 μm in the air and their widespread spread in closed environments increases the epidemiological risk [8].

Viral pathogens play a leading role in the etiology of respiratory infections, with influenza virus in particular being of great importance for the global health system [9]. This virus belongs to the Orthomyxoviridae family and has a segmented, negative-strand RNA genome [10].

In the molecular structure of the virus, hemagglutinin (HA) and neuraminidase (NA) are the main surface antigenic determinants. HA ensures the binding of the virus to sialic acid receptors on the surface of the host cell, while NA is involved in the release of newly formed virions from the cell. Structural variability of these proteins may lead to failure of recognition by the immune system [11].

Unlike many other RNA viruses, influenza virus replication occurs in the cell nucleus [10]. After the virus enters epithelial cells, ribonucleoprotein complexes are transported to the nucleus, where transcription and replication occur [9]. As a result, damage to the epithelial layer, destruction of ciliated cells, and impaired mucociliary clearance are observed [13].

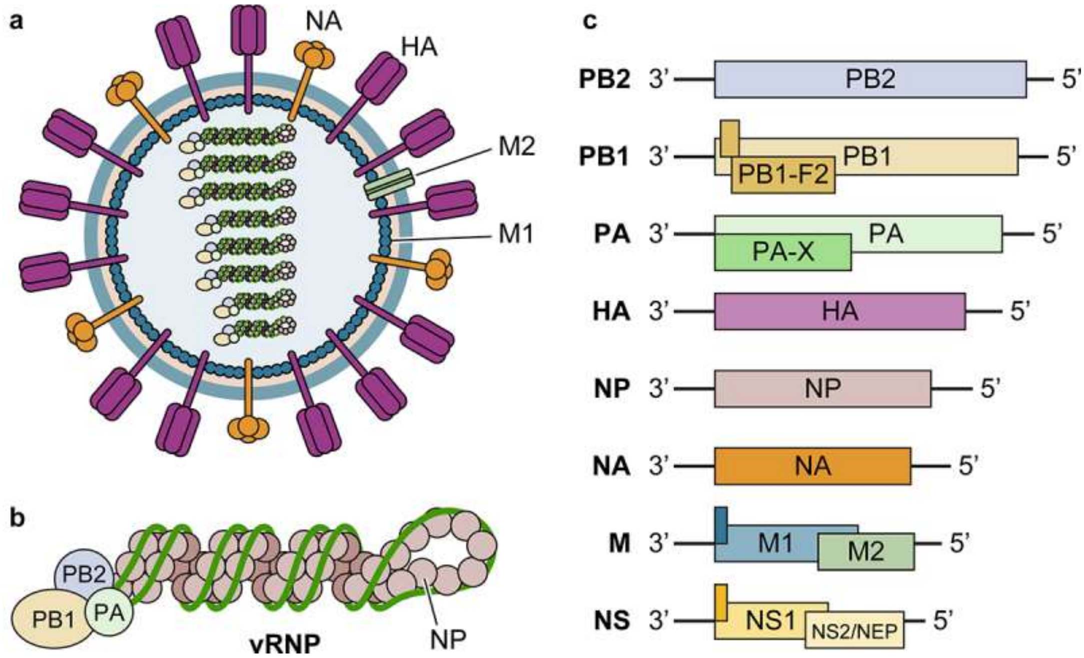
Due to genome segmentation, a reassortment mechanism may occur, which is the molecular basis of antigenic shift [14]. Antigenic drift, which occurs as a result of point mutations, is the main cause of seasonal epidemics [11]. Historical pandemics have been associated with new strains that arose precisely as a result of the exchange of genome segments [15].

The initial phase of the immune response involves the production of interferons and other cytokines, which serve to limit viral replication [7]. Later, a humoral immune response is formed, and neutralizing antibodies are produced [12]. However, the antigenic variability of the virus reduces the effectiveness of long-term protection and requires regular updating of the vaccine composition [16].

In-depth study of the microbiological and molecular characteristics of airborne infections serves as a scientific basis for developing epidemiological control, immunoprophylaxis, and pandemic preparedness strategies [8].

Aerosol transmission, especially in areas with high population density and poor ventilation, sharply increases the spread of infection [17]. Currently, there are a large number of airborne infections, which we will briefly introduce:

The first is Influenza, or the flu virus. Influenza viruses cause about 1 billion infections globally each year, of which 290,000–650,000 deaths are recorded [18]. In the United States, seasonal influenza causes 20,000–50,000 deaths in some years [19]. Transmission occurs by aerosol and direct droplet transmission [17]. Neuraminidase inhibitors (oseltamivir) are effective in treatment [20]. Antibiotics are used only when secondary bacterial pneumonia develops (Figure 1). [21]



1-figure

Illustration of influenza virion components, genomic organization, and viral genes. (a) Influenza virus is an enveloped RNA virus, which has 3 envelope proteins (HA, NA, and M2) on the viral membrane, an M1-formed matrix layer, and eight vRnps. (b) Each vRNP consists of one vRNA segment wrapped with NP and associated with polymerase complex PB2/PB1/PA. (c) Each vRNA segment encodes 1–3 genes, through alternative splicing (NS2/NEP and M2) and frameshifting (such as PA-X and PB1-F2). Accessory proteins expressed through frameshifting are shown as filled dark green bars/boxes.(

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The next is the COVID-19 virus, which caused a global pandemic in 2020–2023, with over 6 million official deaths.

Italy and the United States had high mortality rates in the early stages of the pandemic [22]. The virus enters alveolar cells via the ACE2 receptor [23]. Dexamethasone therapy has been shown to reduce mortality in severe cases [24]. Antibiotics are only recommended if there is bacterial co-infection [21].

Measles is also capable of airborne transmission. Measles virus has the highest infectiousness rate (R0 12–18) [25]. In 2019, over 200,000 deaths were recorded globally, mostly in Africa and Southeast Asia [26]. There is no specific antiviral treatment. Vitamin A administration reduces mortality [25].

Respiratory syncytial virus (RSV) causes severe lower respiratory tract infections in more than 3 million children each year. Treatment is mainly symptomatic; palivizumab is used prophylactically in high-risk groups [26].

Another example is adenovirus. Adenovirus spreads rapidly in closed communities and can cause pneumonia.

Cidofovir is used in cases of severe immunodeficiency [27]. Due to the segmented RNA genome of influenza viruses and the mechanism of antigenic drift, seasonal strains are constantly changing, which necessitates the annual updating of the vaccine composition. The World Health Organization identifies circulating strains through a global surveillance system and determines the recommended vaccine composition for the next season. Clinical studies have shown that seasonal influenza vaccines significantly reduce the risk of severe illness and death [18].

Inactivated and live attenuated influenza vaccines induce a humoral immune response and produce neutralizing antibodies. Vaccination of high-risk groups, especially pregnant women, the elderly, and people with chronic diseases, reduces the risk of hospitalization and respiratory complications [28].

In pandemic situations, in particular, the experience of SARS-CoV-2, has shown that widespread vaccination campaigns dramatically reduce mortality and reduce the burden on the health system. mRNA-based vaccines have been shown to have a high immunogenicity and safety profile [29].

Respiratory viruses are more likely to become epidemic in areas with low vaccination coverage. For example, countries with low vaccination coverage for measles have experienced large outbreaks and increased child mortality. Weakened herd immunity leads to reactivation of the virus [30].

Not vaccinating not only increases individual risk but also allows the virus to circulate widely in the population, increasing the likelihood of new variants emerging. Epidemiological modeling studies have shown that societies with high vaccination coverage are more likely to break the chain of transmission and reduce health care costs [31].

CONCLUSION

In conclusion, the epidemiological, pathogenetic and social significance of airborne microorganisms - viruses, bacteria and some fungi - has been scientifically analyzed. These infections are transmitted mainly through aerosols and droplets released during coughing, sneezing, talking or exhalation, and damage the epithelium of the upper respiratory tract as a primary target. Their rapid spread, short incubation period and, in some cases, severe complications are a serious epidemiological problem for the healthcare system. Airborne microorganisms cause high morbidity and mortality rates globally. Immunoprophylaxis, early diagnosis, effective treatment and improving the sanitary culture of the population are of great importance for their prevention. The spread of these infections can be significantly reduced by using comprehensive preventive strategies.

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