



Problems View

Evolution of Mechanisms of Infection Transmission

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Abstract

Infectious diseases represent the outcome of the parasitic interactions between biological species. The mode of transmission of the parasite microorganism to the human hosts represents the mechanisms of infection spreading. Present-day humans have inherited the infectious diseases from their humanoid ancestors. In the course of humanization, pathogenic microorganisms have evolved for invasion of the human species. Hence the mechanism of infection transmission is as well a product of the evolutionary interactions between microbes and men. One basic biological character of *Homo sapiens* is the acquisition of qualities that are missing in animals – consciousness and the capacity to develop a society. The social, intended actions of humans influence the mechanisms of infection transmission in parallel with the biological evolutionary factors and the environmental factors. The biological sense of the infection transmission is the survival in time of the species of pathogenic microorganisms. Dependent on the different characteristics and requirements of the pathogenic microorganisms and the human behavior, different transmission mechanisms are settled. Here we discuss the variety of mechanisms of infection transmission and their evolution under the influence of natural and social factors, as a response to the basic requirement of the species – its survival of the species.

Keywords: infectious diseases, evolution, mechanism of infection transmission

Резюме

Инфекциозните болести са проява на паразитни взаимоотношения между биологичните видове. Начините на прехвърляне на микроорганизмите-паразити върху хората-хазаи представляват механизма на предаване на заразата. Съвременният човек наследява инфекциозните болести от своите предци-хуманоиди. Заедно с очовечаването на хуманоидите патогенните микроорганизми еволюират към паразитиране върху човешкия вид. Следователно механизма на предаване на заразата е също продукт на еволюционните взаимоотношения между микробите и хората. Основен биологичен белег на вида *Homo sapiens* е, че той придобива качества които животните нямат – човек придобива съзнание и развива общество. Социалните, съзнателно предприемани действия на човешкият вид, влияят на механизмите на предаване на заразата съвместно с биологичните еволюционни фактори и факторите на външната среда. Биологичният смисъл на механизма на предаване на заразата е запазването на вида на патогенните микроорганизми във времето. В зависимост от различните свойства и потребности на патогенните микроорганизми и поведението на човешкият вид, се създават различни механизми на предаване. Дискутират се различните механизми на предаване на заразата и тяхната еволюция под въздействието на природните и социални фактори, отговаряйки пак на основната потребност на вида – запазването му.

Communicable diseases are manifestation of the interactions between species - between our species, *Homo sapiens*, and microbial species. They represent a special case of ecological relationships on earth.

Microbes emerged prior to humans and prior to animal life. Soon after their appearance, animal species came into contact and interacted with the world of microorganisms. Thus, certain microbes populated macroorganisms without causing them any harm, while others used the macroorganism's environment in a way that disturbed the eubiotic balance of the host. The relationship became parasitic.

Gradually, over time, parasitic microorganisms increasingly accommodated themselves to the host environment. The relationships created in the adaptation process ranged from nearly complete symbiosis to such that severely damaged the host (pathological manifestations). This was how infectious diseases emerged.

Concurrently, different modes of transfer of microbes from one host to another developed, and the mechanism of infection transmission appeared.

Humans inherit contagious diseases from their ancestors. In the evolutionary process leading to the emergence of modern man, animals, whose existence preceded human life by millions of years, had already been subject to infectious pathology. Hominids became exposed to age-old parasitic relationships with pathogenic microflora, so the process in which the microorganisms pathogenic for animals adapted themselves to the environment of the human body (which was not quite so different) occurred in a natural, evolutionary way. The process also affected the modes by which germs spread from one person to another. Those were the different mechanisms used by pathogens to transmit infection. The mechanism, therefore, by which infection spreads also ensued from the evolutionary relationships between microbes and human beings.

In course of evolution, *Homo sapiens* acquired a key biological quality that animals lack. Humans have consciousness and live in a society (*socium*). That was the basis on which speech developed as a means of expressing consciousness. The need to survive and preserve the species triggered relevant responses both in man and society. Consciously undertaken social actions were reflected on the mechanisms of transfer of infection along with biological evolutionary factors. And while infectious diseases evolved under the influence of both biological and social factors, the epidemic

process never lost its biological essence.

An epidemic process is the spread of communicable diseases in human society. It is founded on the mechanism of infection transmission. An epidemic process is not possible in the absence of a mechanism of infection transmission. The entire evolutionary process of all biological species on earth has involved the evolution of the parasitic relationships between certain species as well as the evolution of infectious diseases and the mechanisms of transmission of infection. The evolution of the latter was driven by the same biological and social factors that brought about the changes in the relationships between micro- and macroorganisms. Depending on the qualities and needs of pathogenic microorganisms and humans, different mechanisms of infection transmission have emerged. They, in turn, also change (evolve) being influenced by natural and social factors, again in response to the basic principle of every species – self-preservation.

Infection spreads by four main mechanisms: airborne, fecal-oral, vector-borne and direct contact. The routes via which these mechanisms occur are countless.

How could the evolution of the mechanisms of infection transmission be characterized?

From the evolutionary point of view, the airborne mechanism of transmission was the last to emerge so it is the most recent one. For person-to-person transmission or animal-to-animal transmission, the infection must come into contact with the respiratory organs. As a physiological function, breathing is crucial for life and in its absence life is only possible for a very short time. A group of microorganisms have found optimal conditions for growth in different parts of the respiratory tract. Owing to the protective role of the physiological and pathological responses (sneezing, coughing, speech), however, the uninvited guests are expelled from the body. This is how aerogenic pathogens leave their host, pass into the air, and enter the next susceptible hosts. For this to happen, the source of infection and the susceptible host need to be within close distance of each other. This transmission mechanism, therefore, is common in human societies. It will rarely occur in wildlife as it will be ineffective there. The airborne transmission mechanism evolved mainly under the influence of social factors. For a group of pathogens the evolutionary process increased the resistance of the causative agents to the external environment and their ability to survive in unfavorable conditions (e.g. the causative agents of diphtheria or scarlet fever).

The survivability of those pathogens became so high that in some cases the infection is transmitted by other mechanisms: alimentary, direct contact. In another group of respiratory infectious agents, social contacts are of primary importance. Closer contacts among people are prompted by natural factors (cold weather and the need to stay indoors), and especially by social factors which cause large numbers of people to gather in small spaces, or overcrowding spaces in poor societies, or bringing people together at cultural, entertainment or similar events in technologically civilized societies (stadiums, discos, rallies, public transport, etc.). This is the case, for instance, with influenza and other seasonal respiratory viral infections. It should be borne in mind that, over time, numerous civilization factors have intensified the evolution of the airborne transmission of infection and this mechanism will certainly keep its leading role in the spread of contagious diseases.

Another group of pathogens most commonly use the fecal-oral mechanism of transmission. In this case, a different vital physiological system of humans is used - the digestive system. An individual can survive much longer without food than without air, but still for only a limited period of time. These infectious agents invade the body through the mouth via different environmental factors (water, food, contaminated hands, etc.). Having resided in the body for some time, they exert varying degrees of pathogenic effect on their host, either causing an infectious disease, or they might not trigger any pathological manifestations at all, in which case there is healthy carriage of infection. Eventually, they exit the host via the faeces. Since it takes much longer for the pathogens to enter a new host, they have developed particularly strong resilience in the external environment.

Social factors have also been instrumental in the evolution of these causative agents. Civilization processes have exposed them to new, previously unknown, adverse impacts - chemicals, antibiotics. The species causing intestinal infections manage to survive by adapting to new conditions and strains by means of increased resistance to antibiotics and other chemicals emerge (e.g. shigella, salmonella, escherichia).

The vector-borne mechanism of infection transmission is the oldest. The causative agents transmitted through this mechanism are poorly resistant to the external environment, which is why the species preservation is ensured by rapid invasion of a macroorganism. The main perpetrators

responsible for the disease transmission are arthropod vectors, carriers of contagious diseases. As they preceded the emergence of mammals on the planet they had had sufficient time to adapt to parasitism in warm-blooded animals. They, in turn, also harbour parasites - microorganisms that most commonly cause no serious harm. By parasitizing animals, they easily became adapted to parasitism in man.

The evolution of the vector-borne mechanism of infection transmission has also been strongly influenced by social factors. Infection occurs after the pathogen is directly introduced into the circulatory system. This naturally occurring transmission mechanism used by blood-sucking arthropods is further complicated by human interference. Human progress has entailed various practices of unnatural, purposeful penetration of the circulatory system - primitive medical manipulations (variolation), injuries incurred during religious rituals (circumcision), etc. The syringe has been known for about 200 years, but its misuse plays the role of a blood-sucking arthropod. Today, from an epidemiological point of view, all invasive procedures are examples of potential routes of transmission of infection.

Epidemiological logic leads to similar conclusions for the fourth group of mechanisms of infection transmission - the mechanism of infection through the outer covers of the body, the skin and mucous membranes, which provide an important protective barrier. Certain pathogenic agents have evolutionally developed an extraordinary resistance in the external environment, awaiting their chance to invade a host through an open wound (anthrax). Other, not highly resistant causative agents of the same group, have developed a more reliable way of invasion through the reproductive system of the host and transmit the infection during copulation (sexually transmitted diseases). A special case of this mechanism are the infections caused by various procedures involving bleeding - medical, religious, domestic, venous drug addicts, etc. It is to be expected that the sexual route of transmission will evolve for other, yet unknown, causative agents, due to its endurance and unresponsiveness to external factors.

The mechanism of disease transmission is at the heart of an epidemic process. Understanding its characteristics will help with taking logical and effective measures for its discontinuation. Ongoing monitoring to detect its changes is the first stage in the fight against epidemic diseases.