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Immunological Basis of Viral Hepatitis B and D Co-Occurrence

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Abstract

Chronic infections with human hepatitis viruses continue to be a major health burden worldwide. Despite the availability of an effective prophylactic vaccine against the hepatitis B virus (HBV) and of antiviral agents efficiently suppressing HBV replication, more than 250 million people are currently chronically infected with this hepatotropic DNA virus, and resolution of chronic hepatitis B (CHB) is rarely achieved. Moreover, coinfection with the hepatitis D virus (HDV), a human RNA satellite virus requiring the envelope proteins of HBV for productive viral spreading, substantially aggravates the disease course of CHB. The molecular mechanisms by which these viruses interact with each other and with the intrinsic innate responses of the hepatocytes are not fully understood. While HBV appears to avoid innate immune recognition, HDV elicits a strong enhancement of innate responses. Notwithstanding, such induction does not hamper HDV replication but contributes to liver inflammation and pathogenesis. Intriguingly, HDV appears to influence the ability of T cells to recognize infected hepatocytes by boosting antigen presentation. This review focuses on current knowledge regarding how these viruses can shape and counteract the intrinsic innate responses of the hepatocytes, thus affecting the immune system and pathogenesis. Understanding the distinct strategies of persistence that HBV and HDV have evolved is central for advancing the development of curative therapies.

Keywords: Hepatitis B virus, Hepatitis D virus, Innate immunity, Hepatocytes.

Introduction

In the world, there are more than 350 million people infected with the hepatitis B virus, of which 15-25% (750 thousand) die each year due to the development of complications of liver cirrhosis and hepatocellular carcinoma [1]. The proportion of patients with HBV who have a concomitant delta agent that dramatically complicates its natural history varies from less than 1% to more than 10% in different populations. Worldwide, 20 million people may be infected with hepatitis delta virus [2]. An indicator of the prevalence of chronic hepatitis D is the frequency of detection of anti-HDV antibodies. According to the prevalence of delta infection among patients with hepatitis.

Regions can be conditionally classified into one of four zones: zones of high endemicity - the frequency of anti-HDV antibodies is over 60%; zones of moderate endemicity - the frequency of anti-HDV antibodies is 30–60%; zones of low endemicity—the frequency of anti-HDV antibodies ranges from 10 to 30%; zones of very low endemicity - the frequency of anti-HDV antibodies does not exceed 10%. In general, in developed countries, IOP is reduced, so in Europe and the USA it ranges from 0.2% to 1.0%. The regions of maximum distribution of anti-HDV are the Mediterranean countries, especially Southern Italy and Greece, as well as Romania, a number of countries in Southeast Asia, the Middle East, Africa and South America varies from 15.0 to 20.0%. In Uzbekistan, the prevalence reaches an average of 7.0%. In the post-Soviet space, the most affected regions are Russia, Central Asia, Moldova and Kazakhstan [3,5]. According to expert estimates in the Republic of Uzbekistan, screening studies in risk groups in 2014 revealed the presence of HBsAg in 2.3% of the population. Among pregnant women and blood donors, the prevalence of HBV is 1.3% in 2021 and 1.2% in 2022, respectively.

Materials and Methods

Given the fact that HDV RNA cannot replicate without infection by HBsAg, the endemicity of HDV should directly depend on the prevalence of HBV in the country. However, according to current epidemiological studies, this relationship is not natural and the circulation areas of the delta agent do not correspond to the prevalence of HBV. Thus, in most of South Asia (Taiwan, China), where the incidence of HBV is extremely high, infection with the delta agent is rare. Probably the main factors influencing the prevalence of the delta agent are the processes of globalization and population migration [5,6,10]. Based on the polymorphism of nucleotide sequences of the genomic HDV (differences between genotypes from 19 to 38%), 8 genotypes of the virus are currently distinguished. The wide genotypic profile is probably due to the ability to mutate. HDV genotype 1 is widespread throughout the world, predominant in Europe and the Mediterranean countries, Iran, Turkey, and North America. In East and North Asia genotype 2 predominantly circulates. In the northern part of South America (Brazil, Colombia, Venezuela, Peru, Ecuador) - genotype 3; in Japan, Taiwan and China - genotype 4. In Western and Central Africa, genotypes 5 to 8 are common [11]. The route of transmission of the delta agent is the same as that of HBV; therefore, the risk group includes patients with a rich parenteral history - recipients of donor blood, hematological patients, and injection drug users. Infection through non-medical invasive procedures (manicure, pedicure, tattoo, piercing) is quite widespread. Unfortunately, the hospital route is still relevant, and among medical organizations the leaders are: surgical, tuberculosis departments, dental clinics, and chronic hemodialysis centers. Data on the activity of sexual transmission of the delta agent are at the stage of accumulation. An increased frequency of detection of anti-HDV antibodies is known among homosexuals and commercial sex workers [6]. The vertical variant from mother to fetus also exists, but epidemiologically its role is minimal due to the peculiarities of the clinical course. Chronic hepatitis B with the delta agent is a severe and rapidly progressive form of viral hepatitis, leading to cirrhosis in 70% of cases within 5–10 years. In 15% of patients, cirrhosis can form within 1 to 2 years from the onset of acute hepatitis. The risk of developing liver cirrhosis is three times higher in HDV-infected patients compared with those who have HBV mono-infection only [1,8,11]. The causative agent of HDV, a virion with a single-stranded RNA molecule, is defective due to the low content of genetic material, and

therefore is not capable of independent reproduction. The HDV RNA supercapsid includes significant amounts of HBsAg antigen, so delta infection replicates only in the presence of HBV.

Results

HDV replication begins only after HBV infects hepatocytes and the synthesis of HBsAg is triggered. Anti-HDV IgG occurs in both acute and chronic delta infections and is detected in more than 90% of cases within 3–8 weeks after infection. As a result of the complex interaction between the two viruses, the clinical manifestations of co-infection of hepatitis B with the delta agent vary from mild to severe, in some cases, fulminant hepatitis. It is still unclear what determines the outcome of the disease: the massiveness of viral invasion, the nature of the specific immune response, the genotype of the virus, genetic drift of the surface immune-dominant epitopes of the virus, allowing it to partially avoid the host's immune surveillance, finally, the set of expressed HLA antigens or others, etc. unknown reasons [9]. A higher rate of growth of liver fibrosis was established in patients of the study group, a correlation between TNF-alpha and the rate of growth of liver fibrosis, which allows us to consider tumor necrosis factor-alpha as a genetic marker of the risk of developing viral cirrhosis of the liver. A high correlation coefficient of ALT/IL-1beta was revealed, which allows us to consider the IL-1beta indicator as a genetic marker of the activity of viral liver inflammation. The universal mechanism for the development of inflammation in the liver during viral infections, including co-infection of hepatitis B with the delta agent, is the synthesis of specific chemokines by hepatocytes in response to the introduction of the virus, causing the migration of T-lymphocytes, which through cytokines lead to liver damage [15,16].

Discussion

Currently, there is an opinion that when the delta virus is attached, the synthesis of HBeAg stops. According to Wu J.C., et al (1996), superinfection with HDV RNA can accelerate the process of selection of a mutant form of hepatitis B; treatment options: PEG-IFN-α were introduced into the treatment of HBV with a delta agent in 2006. The HIDIT study 1 showed significant antiviral efficacy of PEG-IFN-2α against HDV RNA in more than 40% of patients, with 25% achieving SVR at 48 weeks of treatment. In June 2009, the second study evaluating the effectiveness of PEG-IFN-2α in combination with Tenofovir (HIDIT II) was launched and is scheduled for completion in May 2017. Patients with chronic HBV with a delta agent (70 people) will receive PEG-IFN - 2α (180 mcg) in combination with Tenofovir (245 mg), and the comparison group was PEG-IFN-2α (180 mcg) in combination with placebo. In the Republic of Uzbekistan, treatment with interferons is provided within the framework of the guaranteed volume of medical care; the effectiveness cannot be considered sufficient (about 30%) and requires further study. A new direction in the treatment of IOP is the development of drugs that inhibit the binding of the delta agent and the hepatitis B virus (Mircludex B), the proposed mechanism of action of which is the ability to firmly bind to specific (however, still not fully studied) receptors for HBV located on the surface hepatocytes, which does not allow viral particles to penetrate into the cell.

In addition, a group of drugs that affect the processes of post-translational modification of delta agent antigens, in particular the processes of prenylation are currently being studied. modification of the cysteine residue at the C-terminus of the L-HDVAg molecule, which enhances the lipophilic properties and ensures stable connection of the HDV RNA nucleocapsid with the virus envelope

(HBsAg) [9]. Nucleoside analogs are ineffective in inhibiting HDV RNA replication. However, this therapy should be considered in patients with active HBV DNA replication (HBV DNA greater than 2000 IU/ml) [8]. IOP is currently poorly studied, but it is the most dangerous and virulent hepatotropic virus, leading to rapid progression and development of liver cirrhosis. However, pairing a delta agent with HBV gives it the same status of a "controllable infection" as a viral one.

Conclusions

Elucidation of the different mechanisms that infected hepatocytes use to unveil the presence of these human hepatotropic viruses to uninfected bystander cells and to different types of resident and circulating immune cells is central to understand key mechanisms determining the resolution of HBV and HDV infection versus persistence. Whereas experimental infection systems and patient analyses support the notion that HBV avoids innate immune recognition, co-infection with HDV appears to cause profound changes in the infected liver. The clear enhancement of various ISGs, the higher production of chemokines and inflammatory cytokines, as well as the increased antigen presentation capabilities determined in HBV/HDV infection may act however as a double sword, boosting the ability of immune cells to recognize infected cells on the one side, but also augmenting liver inflammation and thus accelerating pathogenesis. Through the development of various in vitro and in vivo infection models, as well as of sophisticated technologies enabling the dissection of events occurring at the single-cell level, the role of distinct HBV and HDV proteins in modulating the antiviral responses in infected hepatocytes is gaining recognition, also highlighting the importance of viral activity in counteracting the first line of host defenses. Understanding the interplay between viral proteins and the innate responses remains central for developing curative treatment strategies against HBV and HDV.

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