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Transmission of Hepatitis B Virus (HBV) through Blood Transfusion

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Summary

Hepatitis B virus (HBV) is a DNA virus in the family *Hepadnaviridae* that selectively infects human hepatocytes. Its structural components—an outer envelope and an inner core—facilitate evasion of host immune responses and support its persistence. HBV infection presents as either acute or chronic, with chronic infection leading to severe liver diseases, including cirrhosis and hepatocellular carcinoma. Transmission occurs primarily through contact with infected blood, fluids, or vertical transmission during childbirth. Globally, HBV affects approximately 300 million people, with a significant burden in resource-constrained regions where inadequate blood screening and vaccination coverage exacerbate the issue. HBV remains a challenge to public health due to its high genetic variability and the persistence of covalently closed circular DNA (cccDNA), which complicates treatment. Although vaccination has proven highly effective in preventing HBV infection, challenges remain in achieving universal coverage. Blood transfusion-transmitted HBV is a significant concern in countries with limited resources, where advanced diagnostic technologies, such as nucleic acid testing (NAT), are often inaccessible. Prevention and control strategies are vital to reducing HBV prevalence. These include enhanced blood screening protocols, universal HBV vaccination, public education, and safe medical practices. Supportive care is available for acute HBV infection, while chronic cases are managed with antiviral therapies, though their accessibility remains limited in low-income settings. Recommendations focus on improving diagnostic technologies, expanding vaccination programs, addressing stigma, and ensuring equitable access to treatment. Additionally, hygiene practices and policies to promote safe healthcare settings are essential in reducing HBV transmission. Despite advancements in preventive and therapeutic measures, HBV continues to pose significant challenges globally, particularly in underserved regions, necessitating continued investment in research, policy implementation, and public health interventions.

Keywords: Hepatitis B virus, blood transfusion, liver disease, public health.

Introduction

Hepatitis B virus is a small DNA virus, classified in the family *Hepadnaviridae*, which encompasses similar viruses that infect various animals among others, the woodchuck, ground squirrel, and heron (Mekonnen *et al.,* 2022). The HBV has evolved to infect humans only, and it is consequently well adapted to replicate efficiently in human hepatocytes. Structurally, two major components make up HBV: an outer envelope and an inner core (Bonja *et al.,* 2017). This is known as the hepatitis B surface antigen and is an important marker for diagnosis. Its presence in the blood is detected through one of the most common blood tests available. A positive result indicates a practical infection with HBV (Pessoni *et al.,* 2019). In these ways, the surface antigen considerably allows HBV to be stealthy and avoid immediate host immune detection, generally enabling the virus to proceed with extended asymptomatic carriage (World Health Organization, 2018).

Inside the virus, its outer envelope contains the core constituted of the hepatitis B core antigen. This core houses the viral DNA and all the enzymes necessary for viral replication (Hassan-Kadle *et al*., 2018). As a matter of fact, a double configuration of a core inside an envelope is so important during the processes that keep the virus stable and infectious; therefore, this makes HBV particularly durable and hard to eradicate from the host (Okoroiwu *et al*., 2018).

Hepatitis B Virus Life Cycle

The life cycle of HBV is very complex and starts with entry into a liver cell of a susceptible host (Siraj *et al*., 2018). Entry is mediated by attachment of the virus to receptors on the liver cell membrane. The viral DNA is transported into the cell nucleus, where it is converted into covalently closed circular DNA (CDC, 2024). This cccDNA provides a stable template for replication, enabling the replication cycle of the virus to generate new viral particles. One of the critical features of HBV is the stability of cccDNA. It resides in the nucleus of the liver cell for the lifetime and serves as a continuous template reservoir for future viral production (Apidechkul, 2019). It is this persistence that contributes to chronic HBV infection and complicates treatment efforts (Dasgupta, 2023). In addition, replication of HBV is error-prone and results in genetic variability with the development of distinct HBV genotypes (De Souza *et al*., 2020). This diversity applies a great impact on the virus's response to treatments and vaccines, thus remaining a challenge for the management of HBV (Hussein *et al.,*2022).

Hepatitis B Virus Infection

Hepatitis B remains the most common severe liver disease due to viral causes worldwide (Ishizaki *et al.,* 2017). The infection results from the hepatitis B virus, which selectively attacks and destroys liver cells. Approximately two billion people have, at one time in their lives, been infected with HBV, while about 300 million people live with chronic infection (Abebe *et al.,* 2020). This disease has caused up to one million deaths every year due to complications such as liver cirrhosis and hepatocellular carcinoma.

Despite the existing preventive and therapeutic measures against it, HBV remains one of the most threatening viruses to global health (Bartonjo *et al*., 2019).

Most HBV infections occur through direct contact with infected blood or fluids. Common modes of transmission include: Infection from an infected mother to her newborn infant, together with birth; infection usually occurs via exposure to unsterile medical or dental equipment and through sexual contact without protection and use of needles and personal items such as razors, toothbrushes, and nail clippers passed on from person to person (Jeele *et al*., 2021). The asymptomatic nature of HBV, particularly in its early stage, is what has often been referred to as a "silent epidemic" (Ali *et al.,*2023). Most people infected with chronic HBV infection do not realize that they have the virus and unknowingly continue spreading it in the community. Even in the absence of symptoms, HBV infection can cause liver damage over a long period, resulting in serious liver disease developing latterly among those chronically infected.

Blood Transfusion Transmission of HBV

This includes blood transfusions, especially in instances or countries that have poorly implemented the practice of screening blood (Bancha *et al.,*2020). The estimated risk of acquiring HBV from a blood transfusion is as high as 4.3 per 1,000 units in sub-Saharan Africa when compared with other settings, which have strong measures across the continuum of assuring blood safety. Several studies have highlighted that the prevalence of HBV in blood donors is very high in the Eastern Mediterranean Region (Ismoilova, 2023). Some countries, like Egypt, reported the prevalence of HBsAg among blood donors to be 1.5-4.3%. In Pakistan, this rate is 2.2%, which indicates an enormous risk of HBV transmission through blood transfusion (Hassan *et al*.,2023).

Diagnosis of Transfusion-Transmitted HBV

Detection of HBV amongst Blood Donors

Detection of HBsAg remains the cornerstone of blood screening for HBV. Various methods have been utilized for HBsAg detection including EIAs and CLIAs, with a varied sensitivity of 0.1-

0.62 ng/mL (Ali *et al*.,2024). Newer systems like CLEIAs boast of higher sensitivity thereby shortening the window period for diagnosing HBV infection by as long as 17 days compared to conventional methods (Mohamud *et al.,*2023).

However, these new assays are indeed expensive and depend on major equipment; thus, these tests have limited accessibility in resource-constrained settings (Nimnuch *et al.,*2021). Rapid tests are also available but have lower sensitivity compared to the EIAs, especially for the detection of HBV genotypes possessing antigenic variations (Siraj *et al*., 2018).

Such genetic mutations within the virus may impair the effectiveness of tests aimed at HBsAg. Most of these mutations usually arise in response to immune pressure or antiviral treatments and alter the structure of the surface antigen so that the sensitivity of the tests is reduced. These mutations can be as high as 30% in highly endemic regions and pose a complication in the processes of detecting HBV infection (Mohamud *et al.,* 2022).

Risk and dangers of Hepatitis B Virus

There are two types of HBV infection: an acute, or short-term, and a chronic, which in this case means long-term. Chronic infection with HBV can lead to serious liver diseases namely, cirrhosis and liver cancer, which are both lethal (Mohamud *et al*.,2023). The virus is spread not only in blood but also in other body fluids-saliva and vaginal and seminal fluids-normally through sexual contact, infected transfusions, or mother-to-child. Symptoms of acute HBV infection range from none to jaundice, dark urine, pale-colored stools, fatigue, nausea, vomiting, and abdominal pain (Mohamud *et al.,*2023). Severe forms of acute HBV infection may lead to liver failure, which might be fatal. Most patients recover from the acute infection, but chronic HBV infection can certainly cause progressive liver disease along with life-threatening complications (Okoroiwu *et al.,*2018).

Vaccine for Hepatitis B Virus Infection

Vaccination represents the most efficient form of prevention against HBV infection. In general, the HBV vaccine is safe and available; thus, protocols recommend it for all age groups (Abebe *et al.*,2020). The vaccine is especially crucial for infants, unvaccinated children, and adults with any risk for exposure to HBV (Hassan-Kadle *et al.,*2018). A usual vaccination course consists of three doses that ensure long-term protection from the virus. Antiviral drugs administered to pregnant women with HBV further decrease the rate of mother-to-child transmission (Ali *et al.,*2023).

Treatment of Hepatitis B Virus Infection

Treatment options range from acute to chronic infections. No treatment is allocated for an acute HBV infection, but symptoms can be attended to with supportive care: hydration and nutrition (Pessoni *et al.,*2019). In the case of chronic HBV infection, treatment can be advised using antiviral drugs such as tenofovir and entecavir. These can prevent disease progression, lower the risk of liver cancer, and raise survival rates (CDC, 2024). In long-standing cases, liver transplantation may be deemed necessary, especially for patients in a developed world where access to highly specialized health services is available (Mohamud *et al*., 2022).

Prevention of Hepatitis B Virus Infection

The infection of HBV can be prevented either through vaccination or the use of safety practices (Mekonnen *et al.,*2022). All newborns and people from known risk groups are advised to be immunized against the virus. Other preventive measures include practicing safe sex, not sharing needles, and asepsis in both clinics and hospitals (World Health Organization, 2018).

Conclusion

Chronic HBV infection, as estimated by the WHO, affects nearly 300 million individuals worldwide and results in considerable mortality due to cirrhosis and liver cancer. Despite the serial improvements in blood screening and precautionary measures, HBV still causes a significant risk related to transfusion-transmitted infections and other modes of transmission. Pre-seroconversion windows, viral mutations, and occult infections are the most powerful drivers of continued HBV infection and clearly demand improved diagnostic, preventive, and therapeutic strategies. Vaccination and safe blood practices remain literally the only viable weapons against HBV.

Recommendations

1. **Enhanced Blood Screening Protocols**: All blood donations should be strictly screened for HBsAg using highly sensitive ELISA or CLIA. Screening enhancement in resource-poor countries is also considered or possibly funded by the government or via international health organizations. The introduction of nucleic acid testing for HBV into blood screening would greatly reduce the window period and decrease the risk of transmission of HBV by transfusion. Governments and health authorities in countries with high prevalence should subsidize the NAT costing.
2. **Universal HBV Vaccination Programs**: Ensure complimentary HBV vaccination of all infants and non-immunized children, with expansions into all high-risk adults, including healthcare workers, patients with chronic liver diseases, and populations with high endemicity of HBV infection. Also, the vaccination outreach programs should be extended to the most inaccessible and remotely located parts of towns and countryside where each community has limited access to healthcare and educate them regarding the benefit of taking the HBV vaccination.
3. **Public Awareness and Education**: Investments in educational campaigns on modes of transmission, symptoms, and preventive measures regarding HBV should be pursued by governments. The message outreach can be directed to the most at-risk groups, high-risk healthcare workers, those with high-risk sexual behaviors, and injecting drug users.
4. **Enhancement of Awareness of Personal Protective Measures**: Raise more awareness of personal protective measures by reducing the number of people who share well and sharp razors, nail clippers, and needles. Promote condoms use to protect against sexual transmission.
5. **Promotion of Safe Medical and Dental Practices**: Establish standards and monitor infection control practices for medical and dental facilities. Promote policies of using disposable and sterilized instruments in all healthcare settings to prevent exposure to HBV.
6. **Addressing Stigma, Reducing Barriers to Testing**: Implement policies to reduce stigma associated with HBV testing, particularly within communities that strongly stigmatize persons with infectious diseases. Ensuring privacy and confidentiality of testing and treatment may help to facilitate diagnosis of HBV. Provide free or low-cost screening in high-prevalence areas to increase detection and early treatment of HBV infection.
7. **Support for Chronic HBV Management and Treatment**: Control and improve the spread of chronic HBV infection by improving access to antiviral therapy among people with chronic HBV infection, particularly in resource-poor countries where drug cost is a limiting factor. National policy should negotiate the cost of drugs with pharmaceutical companies.
8. **Environmental Sanitation and Hygiene**: Introduce a policy on cleaning blood spills with the 1:9 ratio of diluted bleach solution. Equip health facilities and public areas with cleaning materials stocked to enable prompt responses in case of blood spill (Centers for Disease Control and Prevention, 2024). Ensure proper hand hygiene after exposure to blood, body fluids, or other contaminated surface exposure-especially in healthcare and childcare settings.

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