HESHAM M. ELGOUHARI, MD
Assistant Professor of Medicine, University of
South Dakota School of Medicine; Avera Center
for Liver Disease/Transplant Institute,
Sioux Falls, SD

TAREK I. ABU-RAJAB TAMIMI, MD
Department of Gastroenterology and Hepatology,
Cleveland Clinic

WILLIAM D. CAREY, MD
Department of Gastroenterology and Hepatology,
Cleveland Clinic

Hepatitis B virus infection: Understanding its epidemiology, course, and diagnosis

■ ABSTRACT

Although hepatitis B virus (HBV) infection is not as common in the United States as in some countries, 5,000 Americans die from it every year. This number can be significantly decreased with proper screening and by vaccinating people at risk. Internists should be aware of the natural history of HBV infection, a vital prerequisite to correctly assessing disease severity and subsequently determining the need for antiviral therapy.

■ KEY POINTS

HBV infection is much more likely to persist and become chronic if it is acquired at birth or in early childhood rather than during adulthood.

Chronic HBV infection is defined as persistence of HBV surface antigen in the serum for more than 6 months.

Although many cases of chronic HBV infection resolve spontaneously, some progress to cirrhosis, hepatocellular carcinoma, and death.
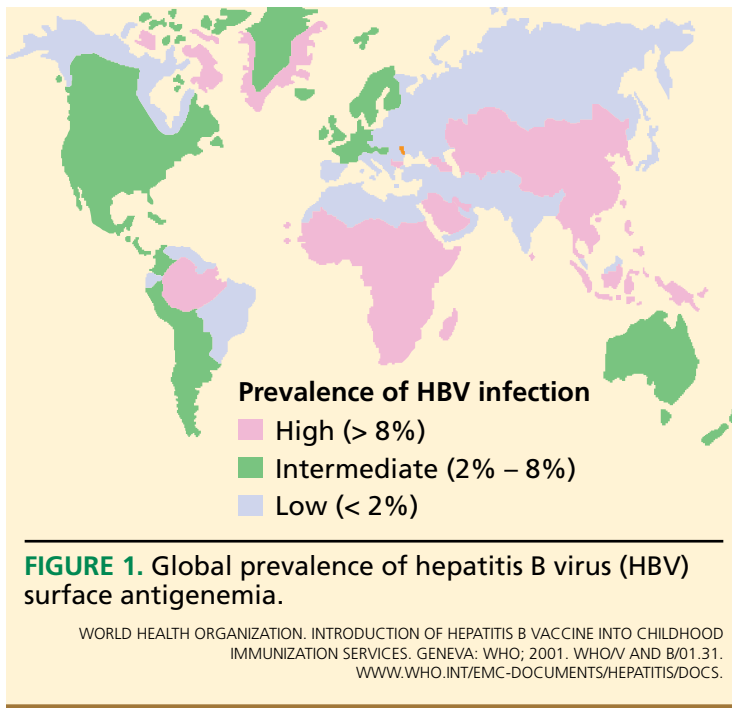
Our knowledge about hepatitis B and related diseases has dramatically increased since the discovery of the causative virus, HBV, in 1963. Despite effective vaccination, hepatitis B still constitutes a major public health problem.

In two parts, this comprehensive review will highlight a practical clinical approach to HBV infection. In this first part, we discuss the epidemiology, natural history, and diagnosis of HBV infection. In the second part, to be published in the next issue of this journal, we will review the general principles of its management, its management in patients on immunosuppressant therapy and in pregnant women, and HBV vaccination.

■ COMMON IN ASIA, LESS SO IN AMERICA

More than 2 billion people—one-third of the world's population—alive today have been infected with HBV at some time in their life, and of these, about 350 million remain infected.[1] Every year, 1 million people die of HBV-related cirrhosis or hepatocellular carcinoma, which means that HBV takes a life every 30 seconds.[2]

HBV infection is highly prevalent in Asia, sub-Saharan Africa, and other parts of the developing world, but less so in the United States, except in Alaskan natives and immigrants from regions of high prevalence (FIGURE 1). By some estimates, 1.25 million carriers, defined as those positive for the HBV surface antigen for more than 6 months, live in the United States, and about half of them are Asian-American.[3,4] Other estimates put the

Prevalence of HBV infection
- High (> 8%)
- Intermediate (2% – 8%)
- Low (< 2%)

FIGURE 1. Global prevalence of hepatitis B virus (HBV) surface antigenemia.

Parenteral or mucosal exposure to infected blood poses a high risk of HBV

number as high as 2 million, taking into account the prevalence of HBV in immigrant populations.

The incidence of acute hepatitis B in the United States has declined from 8.5 per 100,000 population in 1990 to 2.1 per 100,000 population in 2004, with the greatest declines (94%) in children and adolescents, coincident with an increase in hepatitis B vaccination in these age groups.[5] Despite these advances, HBV still causes a considerable number of cases of cirrhosis, cancer, and death—about 5,000 deaths each year in the United States.

HBV HAS FOUR GENES, EIGHT GENOTYPES

HBV is a DNA virus of the Hepadnaviridae family. Its genome is double-stranded with four genes, each one encoding a specific structural protein or proteins[6,7]:
- S gene, for the viral envelope (surface antigen)
- C gene, for both the nucleocapsid (core) antigen and the pre-core (e) antigen
- X gene, for two regulatory proteins required for HBV replication
- P gene, for DNA polymerase.
  Several clinically important mutations in

the HBV genome are known (**TABLE 1**).[7–12]

Eight genotypes of HBV (labeled A though H) have been identified.[13,14] All eight have been found in the United States, but genotype A accounts for 35% of cases, genotype B for 22%, and genotype C for 31%.[15]

The clinical significance of HBV genotypes is not as clear as that of hepatitis C virus genotypes. Although recent data have suggested that different HBV genotypes may be associated with different rates of progression of liver disease and different rates of response to interferon therapy,[13] these data were not enough to recommend routine testing for HBV genotypes in clinical practice.[16]

In HBV infection, the virus itself does not injure liver cells. Rather, the damage of hepatitis is immune-mediated and begins to appear as the host's immune system attempts to clear the virus.

MARKERS OF HBV INFECTION

HBV produces several antigens that can be detected in the blood and that disappear as the body produces antibodies against them. The patterns of these and other markers provide clues to the phase of infection (**FIGURE 2**).

HBV surface antigen and **HBV DNA** are often the first detectable markers of acute infection, appearing before the onset of symptoms or before elevation of **alanine aminotransferase** (ALT) occurs. By definition, an HBV infection is chronic if surface antigen persists longer than 6 months.

HBV e antigen, derived from pre-core protein, is considered a marker of HBV replication and infectivity. In chronic infection, e antigen can persist for years or decades.

HBV core antigen cannot be detected in the serum, but antibodies against it can, first **immunoglobulin M** (IgM) and later **immunoglobulin G** (IgG).

TRANSMISSION: VERTICAL OR HORIZONTAL

Because HBV replicates profusely and produces high titers in the blood (10^8 to 1,010 virions/mL), any parenteral or mucosal exposure to infected blood poses a high risk of HBV acquisition. The risk of HBV transmission from

TABLE 1

Clinically important hepatitis B virus (HBV) mutations

MUTATION	LOCATION IN THE HBV GENOME	RISK FACTORS FOR MUTATION	SIGNIFICANCE
YMDD and multiple others	P (polymerase) gene	Previous treatment with nucleoside analogues (or, rarely, naturally)	Development of drug resistance
Precore or core	C (core) gene	More common in Asia and Southern Europe (30%–90%) than in the United States (10%–40%)	Failure of HBV e antigen secretion but with a remaining risk for progressive liver disease
Vaccine escape	"a" determinant of the S gene	HBV vaccine or immune globulin recipients	Possibly increased risk of hepatocellular carcinoma or prolonged HBV infection
			Occult HBV infection*

*Defined as detectable HBV DNA with undetectable HBV surface antigen. The existence and clinical significance of occult HBV infection with surface mutants remains controversial, however.[12]

a single needlestick is 1% to 6% if the blood is positive for HBV surface antigen but negative for HBV e antigen, and 22% to 40% if positive for both antigens.[17–19] Saliva, nasopharyngeal fluid, breast milk, semen, urine, and cervical secretions can also harbor HBV.[20]

Worldwide, perinatal (vertical) transmission is the predominant mode of HBV transmission, whereas intravenous drug abuse and unprotected sexual intercourse are the main routes of infection in areas of low prevalence, such as the United States. In sub-Saharan Africa, Alaska, and Mediterranean countries, transmission of HBV usually occurs horizontally during childhood, presumably via contact with nonintact skin.[21–24] Saliva has also been thought to be the route of HBV transmission in sporadic cases through human bites.[25]

People at risk of HBV infection include:
- Parenteral drug users
- People with multiple sexual partners
- Household contacts and sexual partners of people who are positive for HBV surface antigen
- Infants born to HBV-infected mothers
- Patients and staff in custodial institutions for the developmentally disabled
- Recipients of certain plasma-derived products (including patients with congenital coagulation defects)
- Hemodialysis patients
- Health and public-safety workers who have

contact with blood
- People born in areas where HBV is endemic, and their children.

These people—as well as all pregnant women, patients infected with hepatitis C virus or human immunodeficiency virus, and patients with chronically elevated ALT or aspartate aminotransferase (AST) levels—should be screened for HBV infection with serologic markers.

■ CLINICAL MANIFESTATIONS VARY

HBV infection, acute or chronic, has variable manifestations. During the acute stage, HBV infection can manifest as anicteric (subclinical) hepatitis, icteric hepatitis, or, rarely, acute fulminant hepatitis. Chronic HBV infection can be asymptomatic (the HBV surface antigen carrier state), or it can be manifested by symptoms and signs of cirrhosis or hepatocellular carcinoma or both. Extrahepatic manifestations, including serum sickness, polyarteritis nodosa, essential mixed cryoglobulinemia, membranous glomerulonephritis, and aplastic anemia, have been reported in patients with HBV infection.[26]
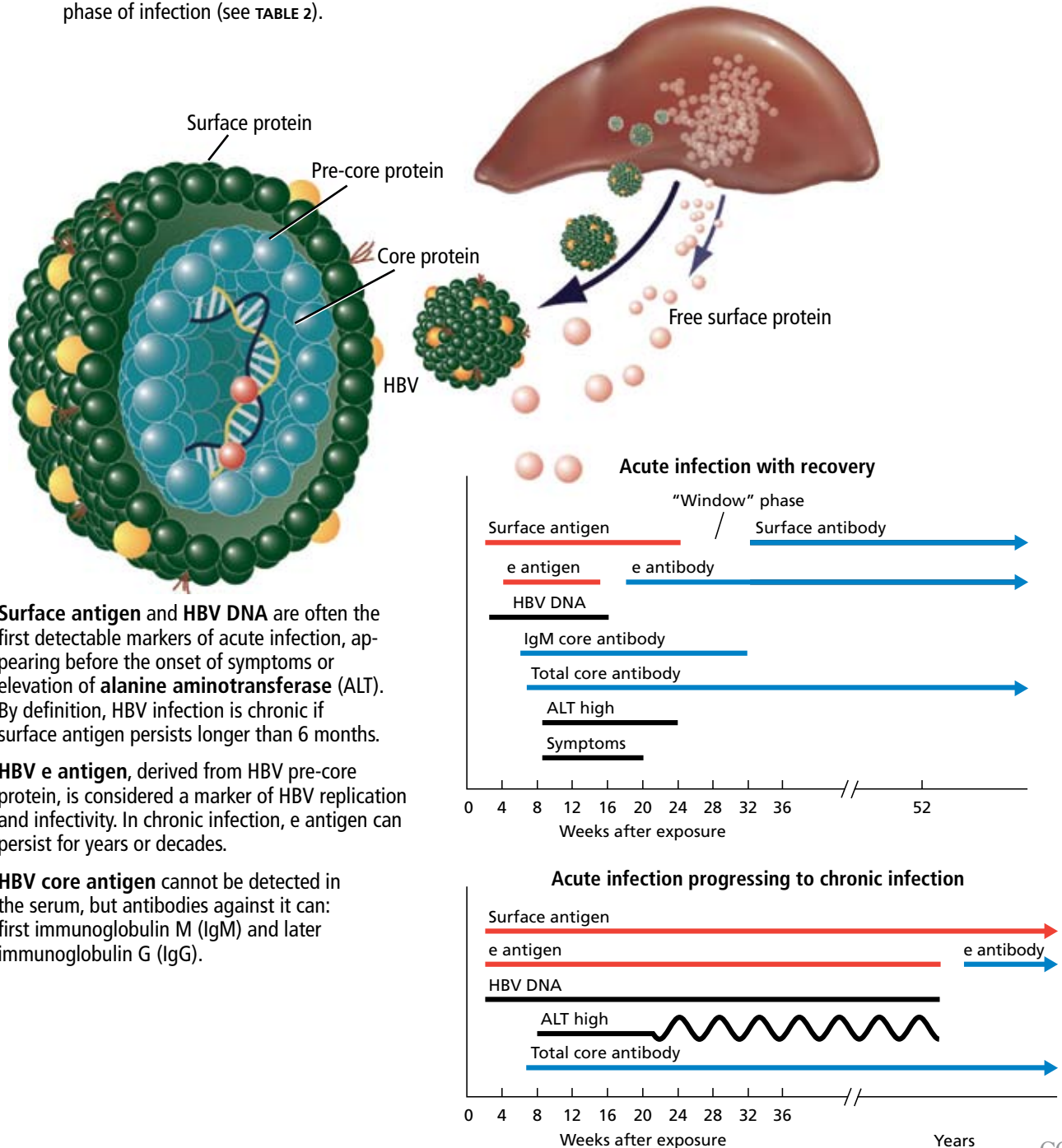
Acute hepatitis B
The incubation period of HBV ranges from 2 weeks to 4 months. Initially, patients complain of fatigue, malaise, anorexia, right upper quad-

In chronic HBV infection, high serum HBV DNA is a strong predictor of cirrhosis

Markers of acute and chronic HBV infection

Most cases of hepatitis B virus (HBV) infection acquired in adulthood resolve spontaneously within 6 months. In contrast, most infections acquired at birth or in early childhood persist and become chronic. HBV produces several proteins (antigens) that can be detected in the blood and that disappear as the body produces antibodies against them. The patterns of these and other markers provide clues to the phase of infection (see TABLE 2).

Surface protein

Pre-core protein

Core protein

HBV

Free surface protein

Surface antigen and **HBV DNA** are often the first detectable markers of acute infection, appearing before the onset of symptoms or elevation of **alanine aminotransferase** (ALT). By definition, HBV infection is chronic if surface antigen persists longer than 6 months.

HBV e antigen, derived from HBV pre-core protein, is considered a marker of HBV replication and infectivity. In chronic infection, e antigen can persist for years or decades.

HBV core antigen cannot be detected in the serum, but antibodies against it can: first immunoglobulin M (IgM) and later immunoglobulin G (IgG).

Acute infection with recovery

"Window" phase

Surface antigen
Surface antibody

e antigen
e antibody

HBV DNA

IgM core antibody

Total core antibody

ALT high

Symptoms

0 4 8 12 16 20 24 28 32 36 // 52
Weeks after exposure

Acute infection progressing to chronic infection

Surface antigen

e antigen
e antibody

HBV DNA

ALT high

Total core antibody

0 8 12 16 20 24 28 32 36 // Years
Weeks after exposure

CCF
Medical Illustrator: Beth Halasz ©2008
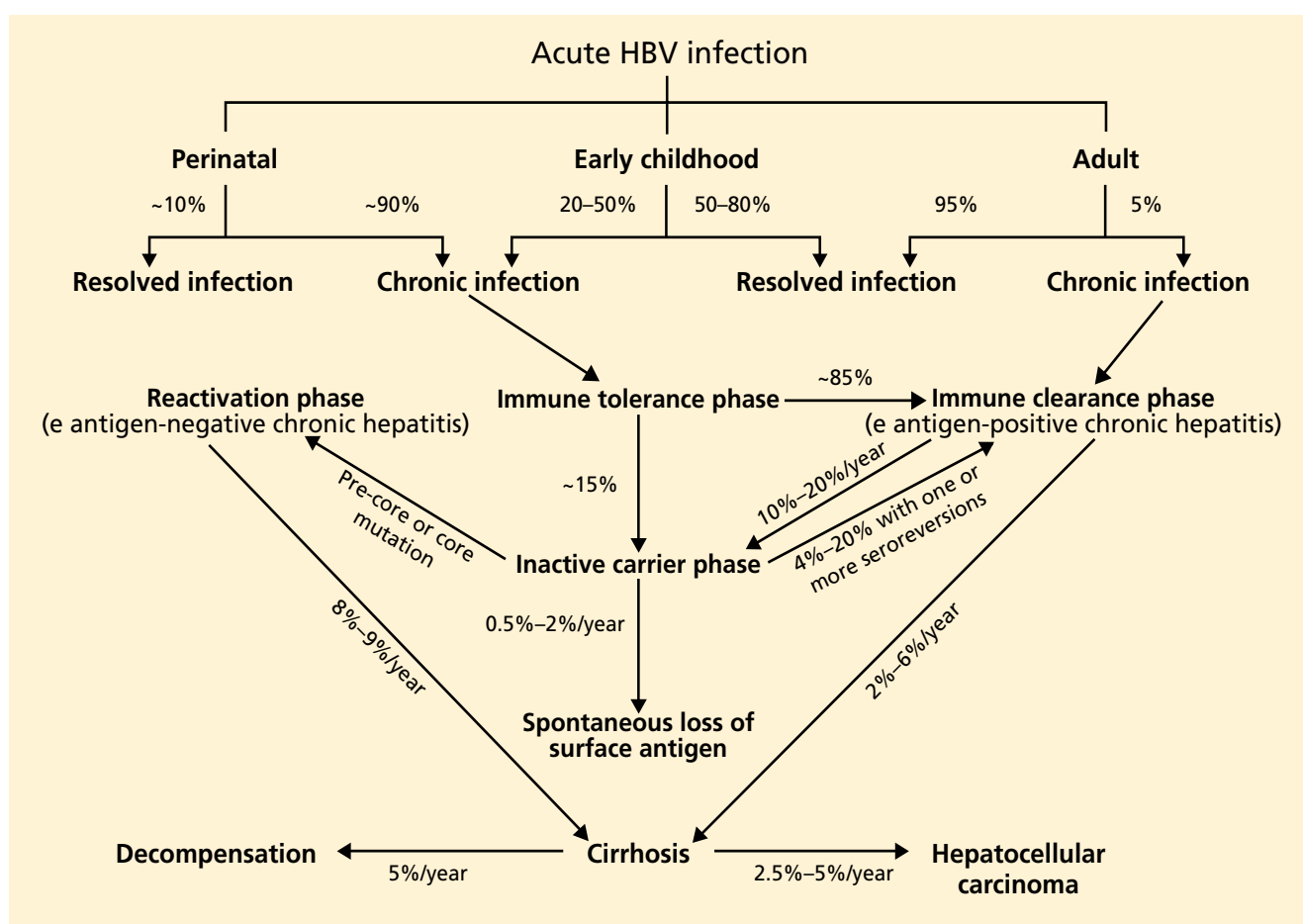
FIGURE 2

FIGURE 3. Natural history of HBV infection.

rant discomfort, or flu-like symptoms (coryza, photophobia, headache, and myalgia); then jaundice becomes apparent, usually within 10 days of the onset of symptoms. Low-grade fever, jaundice, and mildly tender hepatomegaly are the most common signs. Generalized lymphadenopathy is not a feature of acute HBV infection. If the patient also has hepatitis D virus infection or underlying liver disease (eg, alcoholic liver disease), then acute HBV infection may be more severe.

In the acute phase, ALT and AST levels rise, sometimes to values above 1,000 IU/L. In icteric hepatitis, bilirubin levels also rise, usually after the ALT level does. Although the peak ALT level reflects the hepatocellular injury, it has no prognostic value. With recovery, ALT levels normalize in 1 to 4 months.

Acute fulminant hepatitis B occurs in 0.1% to 0.5% of patients, and causes about 10% of cases of acute liver failure in the Unit-

ed States.[27] Patients typically present with rapidly progressive acute hepatitis characterized by signs of liver failure, such as coagulopathy, encephalopathy, and cerebral edema.

In the so-called window phase, laboratory testing may not reveal HBV surface antigen because of early clearance but shows IgM antibody against the HBV core antigen. HBV DNA may be low or undetected.

Chronic hepatitis B

Chronic hepatitis B is usually diagnosed as a result of a workup for abnormal liver function tests or as a result of screening patients at risk for HBV infection. Many patients with chronic hepatitis B have no symptoms or have nonspecific symptoms such as fatigue or right upper quadrant discomfort.

Acute exacerbations due to HBV e antigen seroreversion (ie, in which e antigen reappears) occasionally occur in patients with

TABLE 2

Phases of chronic hepatitis B virus infection

PHASE	E ANTIGEN	E ANTIBODY	HBV DNA	ALT	LIVER BIOPSY FINDINGS
Immune tolerance	Positive	Negative	High	Normal	Normal or nonspecific
Immune clearance	Positive	Negative	Moderately high	Elevated	Chronic hepatitis
Inactive carrier	Negative	Positive	Absent or low	Normal	Nonsignificant hepatitis (usually)
Reactivation	Negative or positive	Positive or negative	Moderate	Elevated	Chronic hepatitis

chronic hepatitis B. Most of these exacerbations are asymptomatic, but occasionally an acute hepatitis-like clinical picture with detectable IgM antibody against the core antigen occurs, leading to misdiagnosis of acute HBV infection in patients not previously known to have chronic HBV infection.[28]

In late cases, signs of cirrhosis such as jaundice, ascites, splenomegaly, pedal edema, encephalopathy, or variceal bleeding can be present.

Hepatocellular carcinoma should be suspected in cirrhotic patients with new-onset right upper quadrant pain, rapidly developing ascites, a palpable liver mass, or hepatic encephalopathy. Other nonspecific features of hepatocellular carcinoma include watery diarrhea, hypoglycemia, and certain cutaneous manifestations such as acanthosis nigricans and the Leser-Trelat sign (multiple pruritic seborrheic keratoses of sudden onset).

In chronic hepatitis B, liver enzyme levels can be normal, even in patients with well-compensated cirrhosis. ALT levels may range from normal to five times higher than normal. Thrombocytopenia, hypoalbuminemia, direct hyperbilirubinemia, and prolonged prothrombin time suggest cirrhosis.

Findings of chronic hepatitis B on liver biopsy range from minimal inflammation to cirrhosis. The most characteristic histologic feature of chronic HBV infection is the "ground-glass hepatocyte," which is due to intracellular accumulation of HBV surface antigen.[29]

People at risk of HBV—and pregnant women—should be screened

■ FEW ADULTS (BUT MANY CHILDREN) REMAIN CHRONICALLY INFECTED

The natural history of HBV infection has become better defined, thanks to extensive epidemiologic studies and highly sensitive HBV DNA assays (**FIGURE 3**). It is crucial for clinicians to understand the natural history of HBV infection to appropriately decide which infected patients need antiviral therapy. This will be discussed in our second article.

HBV surface antigen can be detected in the blood approximately 2 to 4 weeks after inoculation. Simultaneously, HBV DNA, usually in very high levels, is also detectable in the blood. However, in the rare cases of acute fulminant hepatitis, HBV DNA levels can be low or undetectable at the time of presentation because the immune system mounts a robust response with extensive damage to HBV-infected hepatocytes.

The rate of spontaneous recovery from acute HBV infection varies, depending on the patient's age at the time of HBV acquisition and the patient's immune status. Fewer than 5% of immunocompetent adults infected with HBV remain chronically infected, defined as being positive for HBV surface antigen for more than 6 months. On the other hand, 80% to 90% of infected infants and about 20% to 50% of children 1 to 5 years old at the time of acute infection remain chronically infected.[21]

Four phases of chronic HBV infection
Four phases of chronic HBV infection have been outlined (**TABLE 2**),[30] although all patients

TABLE 3

Serologic patterns of hepatitis B virus (HBV) infection

INTERPRETATION	SURFACE ANTIGEN	SURFACE ANTIBODY	E ANTIGEN	E ANTIBODY	IgM CORE ANTIBODY	IgG CORE ANTIBODY	HBV DNA
Acute HBV, early phase	Yes	No	Yes	No	Yes	Yes or no	High
Acute HBV, window phase	No	No	No	Yes	Yes	Yes or no	Low
e antigen-positive chronic hepatitis	Yes	No	Yes	No	No	Yes	High
e antigen-negative chronic hepatitis	Yes	No	No	Yes	No	Yes	Moderate
Inactive carrier state	Yes	No	No	Yes	No	Yes	Absent or low
Resolved hepatitis B	No	Yes or no	No	Yes	No	Yes	Absent

do not go through all phases. HBV surface antigen is detectable in all of them.

The immune tolerance phase, the initial phase of chronic HBV infection, is seen almost exclusively in those who acquired HBV infection vertically or during early childhood. Although patients have high HBV DNA levels, they do not have significant liver disease. This discrepancy is thought to be related to the immune tolerance to HBV; however, the exact mechanism of that tolerance is unclear.[31]

Only 15% of those with immune tolerance have spontaneous HBV e antigen seroconversion (ie, loss of e antigen and appearance of anti-e antibody) within 20 years after infection.[32]

The immune clearance phase (HBV e antigen-positive chronic hepatitis) appears about 20 to 30 years after the onset of the immune tolerance phase in patients who acquire HBV early in life. It is also often seen in patients with infections acquired late in childhood or in adulthood.

This phase marks the start of an immune-mediated process aimed at clearing the viral infection, but it also leads to concomitant hepatocellular injury. Spontaneous clearance of the e antigen increases in this phase to an annual rate of 10% to 20%.[32,33] The strongest predictors of spontaneous e antigen seroconversion are old age, an elevated ALT level, and an acute exacerbation.[26]

Although ALT levels are elevated and there is evidence on liver biopsy of chronic active hepatitis, this phase is usually asymptomatic. Rarely, however, it presents with an acute flare of hepatitis, sometimes accompanied by IgM antibodies against the HBV core antigen (in low titer), leading to an incorrect diagnosis of acute HBV infection.

Depending on the duration of the chronic hepatitis and the frequency and severity of flares, about 12% to 20% of patients in the immune-clearance phase develop serious liver disease within 5 years.[31]

The inactive carrier phase following HBV e antigen seroconversion is characterized by undetectable or low HBV DNA levels (< 1,000 copies/mL), normal ALT levels, and minimal or no necroinflammation on liver biopsy.[30] Such patients should be followed with serial testing, as 4% to 20% of them spontaneously revert to being positive for e antigen at least once.[16] On the other hand, only 0.5% to 2% of surface antigen carriers in western countries clear themselves of surface antigen yearly, but up to half of those who clear the surface antigen have low-level HBV viremia.[34]

The reactivation phase (HBV e antigen-negative chronic hepatitis) is seen in some HBV-infected patients, especially those from Asia and southern Europe, in whom the virus has a spontaneous pre-core or core mutation that makes infected cells unable to secrete the

HBV surface antigen and DNA can be detected 2–4 weeks after inoculation

TABLE 4

Risk factors for cirrhosis and hepatocellular carcinoma in patients with HBV infection

Risk factors for cirrhosis
Longer duration of infection
Male sex
High levels of HBV DNA
HBV genotype C (more than B)
Habitual alcohol consumption
Concurrent infection with hepatitis C or D virus
  or human immunodeficiency virus
Obesity
Diabetes mellitus

Risk factors for hepatocellular carcinoma
High level of HBV DNA
Longer duration of infection
Male sex
Family history of hepatocellular carcinoma
Presence of cirrhosis
Race (Asian, African)
HBV genotype C (more than B)
HBV variant (core promoter)
Reversion from e antibody to e antigen
Hepatitis C virus coinfection
Heavy alcohol consumption
Cigarette smoking
Obesity
Diabetes mellitus

Signs of acute HBV: low-grade fever, jaundice, mildly tender hepatomegaly

e antigen. Although these patients have no e antigen in their blood, they do have intermittent or persistent elevation of ALT, elevated HBV DNA, and histopathologic findings of chronic hepatitis. Compared with those in the immune clearance phase, patients in the reactivation phase tend to be older and to have lower HBV DNA levels but advanced hepatic damage.

Immunity to HBV infection is characterized by loss of HBV surface antigen, DNA, e antigen, and anti-core antigen IgM with development of anti-surface antigen antibody and anti-core antigen IgG (total anti-core antigen antibody). The presence of anti-surface antigen antibody and anti-core antigen IgG together differentiates natural immunity through resolved infection from that which is acquired through vaccination, which is denoted by isolated anti-surface antigen antibody.

FIGURE 2 illustrates the typical serologic course of HBV infection, and **TABLE 3** summarizes how to interpret the various serologic patterns.

Cirrhosis, liver failure, cancer

Cirrhosis, hepatic decompensation, and hepatocellular carcinoma are the major long-term complications of HBV infection. In untreated patients, the annual rate of progression to cirrhosis has been estimated to be 2% to 6% in patients with HBV e antigen-positive chronic hepatitis and 8% to 9% in those with e antigen-negative chronic hepatitis.[30]

The likely explanation for these surprising cirrhosis rates is that e antigen-negative chronic hepatitis usually represents a late stage of the disease, and patients in this phase are usually older and have more advanced liver disease.

Subsequently, the annual rate of progression from compensated cirrhosis to hepatic decompensation has been estimated to be about 5%.[35]

Across all the stages described above, a high serum HBV DNA level has been shown to be a strong predictor of progression to cirrhosis in patients with chronic HBV infection. In a population-based prospective cohort study of 3,582 untreated HBV-infected patients in Taiwan, Iloeje et al[36] found that, compared with patients with serum HBV DNA levels lower than 104 copies/mL, those with levels of 104 or higher had an adjusted relative risk of cirrhosis of 2.5. The relative risk rose to 5.9 with HBV DNA levels of 105 or higher, and 9.8 with levels of 106 copies/mL or higher. More studies in different patient populations are needed for confirmation.

HBV is a strong carcinogen, and the risk of hepatocellular carcinoma is 100 times higher in patients with HBV infection than in uninfected ones.[31]

The most important risk factor for hepatocellular carcinoma in HBV-infected patients is cirrhosis, but this cancer can also develop in noncirrhotic livers.[37] The annual rate of hepatocelluar carcinoma has been estimated to be higher (2.5%–3%) in patients with cirrhosis than in noncirrhotic carriers (0.5%–1%).[30,35–38] Risk factors for cirrhosis and hepatocellular carcinoma are summarized in **TABLE 4**.[16,30] ■

REFERENCES

1. **World Health Organization**. Hepatitis B. www.who.int/csr/disease/hepatitis/whocdscsrlyo20022/en/. Accessed 11/10/2008.

2. **Center for Disease Control and Prevention**. HBV a silent killer. www.cdc.gov/ncidod/diseases/hepatitis/b/hbv_silent_killer. Accessed 2/19/2007.

3. **McQuillan GM, Coleman PJ, Kruszon-Moran D, Moyer LA, Lambert SB, Margolis HS**. Prevalence of hepatitis B virus infection in the United States: the National Health and Nutrition Examination Surveys, 1976 through 1994. Am J Public Health 1999; 89:14–18.

4. **Armstrong GL, Mast EE, Wojczynski M, Margolis HS**. Childhood hepatitis B virus infections in the United States before hepatitis B immunization. Pediatrics 2001; 108:1123–1128.

5. **Mast EE, Weinbaum CM, Fiore AE, et al**. A comprehensive immunization strategy to eliminate transmission of hepatitis B virus infection in the United States: recommendations of the Advisory Committee on Immunization Practices (ACIP). Part II: immunization of adults. MMWR Recomm Rep 2006 Dec 8; 55(RR-16):1–33.

6. **Gish RG, Gadano AC**. Chronic hepatitis B: current epidemiology in the Americas and implications for management. J Viral Hepatol 2006; 13:787–798.

7. **Wei Y, Tiollais PK**. Molecular biology of hepatitis B virus. Clin Liver Dis 1999; 3:189–219.

8. **Seeger C, Mason WS**. Hepatitis B virus biology. Microbiol Mol Biol Rev 2000; 64:51–68.

9. **Hunt CM, McGill JM, Allen MI, Condreay LD**. Clinical relevance of hepatitis B viral mutations. Hepatology 2000; 3:1037–1044.

10. **Allen MI, Deslauriers M, Andrews CW, et al**. Identification and characterization of mutations in hepatitis B virus resistant to lamivudine. Lamivudine Clinical Investigation Group. Hepatology 1998; 27:1670–1677.

11. **Hadziyannis SJ, Vassilopoulos D**. Hepatitis B e antigen-negative chronic hepatitis B. Hepatology 2001; 34:617–624.

12. **Wai CT, Fontana RJ**. Clinical significance of hepatitis B virus genotypes, variants, and mutants. Clin Liver Dis 2004; 8:321–352.

13. **Fung SK, Lok AS**. Hepatitis B virus genotypes: do they play a role in the outcome of HBV infection? Hepatology 2004; 40:790–792.

14. **Norder H, Courouce AM, Coursaget P, et al**. Genetic diversity of hepatitis B virus strains derived worldwide: genotypes, subgenotypes, and HBsAg subtypes. Intervirology 2004; 47:289–309.

15. **Chu CJ, Keeffe EB, Han SH, et al**. Hepatitis B virus genotypes in the United States: results of a nationwide study. Gastroenterology 2003; 125:444–451.

16. **Lok AS, McMahon BJ**. Chronic hepatitis B. Hepatology 2007; 45:507-539.

17. **Mast EE, Alter MJ**. Prevention of hepatitis B virus infection among health-care workers. In: Ellis RE, editor. Hepatitis B Vaccines in Clinical Practice. New York: Marcel Dekker, 1993:295–307.

18. **Werner BG, Grady GF**. Accidental hepatitis-B-surface-antigen-positive inoculations: use of e antigen to estimate infectivity. Ann Intern Med 1982; 97:367–369.

19. **Gerberding JL**. Management of occupational exposures to blood-borne viruses. N Engl J Med 1995; 332:444–451.

20. **Kidd-Ljunggren K, Holmberg A, Blackberg J, Lindqvist B**. High levels of hepatitis B virus DNA in body fluids from chronic carriers. J Hosp Infect 2006; 64:352–357.

21. **McMahon BJ, Alward WL, Hall DB, et al**. Acute hepatitis B virus infection: relation of age to the clinical expression of disease and subsequent development of the carrier state. J Infect Dis 1985; 151:599–603.

22. **Dusheiko GM, Brink BA, Conradie JD, Marimuthu T, Sher R**. Regional prevalence of hepatitis B, delta, and human immunodeficiency virus infection in southern Africa: a large population survey. Am J Epidemiol 1989; 129:138–145.

23. **Bortolotti F, Guido M, Bartolacci S, et al**. Chronic hepatitis B in children after e antigen seroclearance: final report of a 29-year longitudinal study. Hepatology 2006; 43:556–562.

24. **Moreno MR, Otero M, Millan A, et al**. Clinical and histological outcome after hepatitis B e antigen to antibody seroconversion in children with chronic hepatitis B. Hepatology 1999: 572–575.

25. **Hui AY, Hung LC, Tse PC, Leung WK, Chan PK, Chan HL**. Transmission of hepatitis B by human bite--confirmation by detection of virus in saliva and full genome sequencing. J Clin Virol 2005; 33:254–256.

26. **Cacoub P, Saadoun D, Bourlière M, et al**. Hepatitis B virus genotypes and extrahepatic manifestations. J Hepatol 2005; 43:764–770.

27. **Schiodt FV, Atillasoy E, Shakil AO, et al**. Etiology and outcome for 295 patients with acute liver failure in the United States. Liver Transplant Surg 1999; 5:29–34.

28. **Chu CM, Liaw YF, Pao CC, Huang MJ**. The etiology of acute hepatitis superimposed upon previously unrecognized asymptomatic HBsAg carriers. Hepatology 1989; 9:452–456.

29. **Gerber MA, Hadziyannis S, Vissoulis C, et al**. Electron microscopy and immunoelectronmicroscopy of cytoplasmic hepatitis B antigen in hepatocytes. Am J Pathol 1974; 75:489–502.

30. **Yim HJ, Lok AS**. Natural history of chronic hepatitis B virus infection: what we knew in 1981 and what we know in 2005. Hepatology 2006; 43:S173–S181.

31. **Pungpapong S, Kim WR, Poterucha JJ**. Natural history of hepatitis B virus infection: an update for clinicians. Mayo Clin Proc 2007; 82:967–975.

32. **Lok AS, Lai CL, Wu PC, Leung EK, Lam TS**. Spontaneous hepatitis B e antigen to antibody seroconversion and reversion in Chinese patients with chronic hepatitis B virus infection. Gastroenterology 1987; 92:1839–1843.

33. **McMahon BJ, Holck P, Bulkow L, Snowball M**. Serologic and clinical outcomes in 1536 Alaska Natives chronically infected with hepatitis B virus. Ann Intern Med 2001; 135:759–768.

34. **McMahon BJ**. Epidemiology and natural history of hepatitis B. Semin Liver Dis 2005; 25(suppl 1):3–8.

35. **Benvegnu L, Gios M, Boccato S, Alberti A**. Natural history of compensated viral cirrhosis: a prospective study on the incidence and hierarchy of major complications. Gut 2004; 53:744–749.

36. **Iloeje UH, Yang HI, Su J, Jen CL, You SL, Chen CJ**. Risk evaluation of viral load elevation and associated liver disease/cancer in HBV. The REVEAL-HBV Study Group. Predicting cirrhosis risk based on the level of circulating hepatitis B viral load. Gastroenterology 2006; 130:678–686.

37. **Bosch FX, Ribes J, Cleries R, Diaz M**. Epidemiology of hepatocellular carcinoma. Clin Liver Dis 2005; 9:191–211.

38. **Fattovich G**. Natural history of hepatitis B. J Hepatol 2003; 39:S50–S58.

ADDRESS: *William D. Carey, MD, Department of Gastroenterology and Hepatology, A30, Cleveland Clinic, 9500 Euclid Avenue, Cleveland, OH 44195; careyw@ccf.org.*