HBV Immunizations

This is a PDF version of the following document:
Section 3: Prevention of HBV
Topic 1: HBV Immunizations

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Background

Vaccination is the mainstay of hepatitis B virus (HBV) prevention and represents a core intervention in the World Health Organization’s (WHO) efforts to eliminate hepatitis B by 2030.[1] The first hepatitis B vaccine, which was plasma-derived, was first licensed in the United States in 1981 (Figure 1).[2] This vaccine contained purified plasma-derived hepatitis B surface antigen (HBsAg) and was safe and highly successful in preventing HBV infection.[2,3,4] Nevertheless, the first-generation plasma-derived HBV vaccine was tedious to manufacture, and the plasma-derived vaccine led to unsubstantiated concerns regarding the potential for bloodborne pathogen transmission and was eventually discontinued in 1992.[2]

By the mid-1980s, a second generation of hepatitis B vaccines became commercially available. These vaccines utilized recombinant DNA technology to express a nonglycosylated hepatitis B surface antigen in yeast cells, a process that was more cost-effective and scalable than the plasma-derived method.[2,3] Furthermore, yeast-derived vaccines eliminated any concern for vaccine-related bloodborne pathogen transmission.[2]

In the 1990s, mammalian cell-derived HBV vaccines became commercially available. These vaccines contained both the S antigen and either the pre-S2 or the pre-S2 and pre-S1 HBV antigens. Although studies suggested these vaccines were efficacious in conventional HBV vaccine nonresponders and overall more immunogenic than yeast-derived recombinant vaccines, manufacturing costs were higher, and they were not widely used.[5]

In 2017, the newest hepatitis B vaccine, HepB-CpG, was approved by the Federal Drug Administration (FDA). HepB-CpG, also known as Heplisav-B, contains a yeast-derived recombinant HBsAg as well as a novel cytidine-phosphate-guanosine oligodeoxynucleotide adjuvant that binds toll-like receptor 9 and stimulates a more robust immune response to HBsAg than the historical alum adjuvant.[6] HepB-CpG is recommended for use in adults ages 18 years of age and represents the fifth inactivated HBV vaccine recommended in the United States.[6]
Vaccine Uptake

Although acceptance of vaccine is high among adults offered hepatitis B vaccination, adult vaccine delivery and coverage rates have been low.\[7,8,9\] In a recent national survey of physician practices for hepatitis B vaccination, only 31% of primary care physicians reported routinely assessing for and vaccinating adults who reported risk factors for hepatitis B infection.\[7\] Similarly, among men who have sex with men (MSM) surveyed in the Young Men's Health Study, only 17% had received hepatitis B vaccine, despite over 90% of HBV-susceptible MSM in this study reporting access to health care services, including testing for HIV and other sexually transmitted diseases.\[9\] The low rate of HBV immunization in these instances represents missed opportunities to provide vaccination to adults at high risk of acquiring hepatitis B and highlights the need for increased HBV education in primary care.
Indications for Hepatitis B Vaccination

The ACIP has issued recommendations for hepatitis B vaccination in infants, children, adolescents and adults ([Table 1](#)). Universal hepatitis B vaccination is recommended for all infants and all unvaccinated children and adolescents younger than age 19. For adults, the hepatitis B vaccine should be given to persons at risk of acquiring HBV and to any person requesting protection against infection with HBV. The following summarizes the ACIP recommendations for persons who should receive hepatitis B vaccine.

- **Infants**: All infants should receive the hepatitis B vaccine series as part of the routine childhood immunization schedule. The number of hepatitis B vaccine doses and the exact timing of vaccination differ slightly depending on the infant’s birth-weight, the maternal HBsAg status, and the vaccine used. For more detailed information, see the Topic Review on “Preventing HBV Perinatal Transmission”.

- **Unvaccinated Children Younger than 19 Years of Age**: Children and adolescents who have not previously received the hepatitis B vaccine should be vaccinated as part of routine “catch-up vaccination,” regardless of age.

- **Persons at Risk for HBV infection by Sexual Exposure**: Sexual exposure is a well-defined risk factor for HBV acquisition and is likely responsible for more than 30% of incident HBV infections in the United States. The following summarizes groups that should receive hepatitis B vaccine due to risk of HBV acquisition from sexual exposure:
  - Sex partners of HBsAg-positive persons
  - Sexually active persons who are not in a long-term, mutually monogamous relationship (e.g., persons with more than one sex partner during the previous 6 months)
  - Persons seeking evaluation or treatment for a sexually transmitted infection
  - Men who have sex with men

- **Persons at Risk for Infection by Percutaneous Exposure**: Percutaneous exposure is one of the most common risk factors for HBV acquisition in the United States, mainly due to the recent rise in injection drug use. There are, however, several other groups, including health care workers, persons in long-term care facilities, and persons living with someone known to be HBsAg-positive, also known to be at risk for HBV via percutaneous exposure. The following summarizes persons who should receive the hepatitis B vaccine due to risk of percutaneous or mucosal exposure:
  - Persons who currently or recently injected drugs
  - Household contacts of HBsAg-positive persons
  - Residents and staff of facilities for developmentally disabled persons
  - Health care and public safety personnel with reasonably anticipated risk for exposure to blood or blood-contaminated body fluids
  - Hemodialysis, predialysis, peritoneal dialysis, and home dialysis patients
  - Persons with diabetes aged 19-59 years of age
  - Persons with diabetes 60 years of age and older at the discretion of the treating clinician

- **Others at Increased Risk of Acquiring HBV Infection**
  - International travelers to countries with high or intermediate levels of endemic HBV infection, as defined by HBsAg prevalence of 2% or greater ([Table 2](#))
  - Persons with hepatitis C virus infection
  - Persons with chronic liver disease (including, but not limited to, persons with cirrhosis, fatty liver disease, alcoholic liver disease, autoimmune hepatitis, and an alanine aminotransferase [ALT] or aspartate aminotransferase [AST] level greater than twice the upper limit of normal)
  - Persons with HIV infection
  - Incarcerated persons

- **Persons Desiring Protection Against HBV**: All other persons seeking protection from HBV infection, regardless of identified risk factors
Prevaccination Serologic Testing

Potential Role of Prevaccination Serologic Testing

Prevaccination serologic testing has two potential roles: to identify persons with existing immunity to HBV who do not require vaccination and to detect persons with chronic active HBV.[10] If hepatitis B vaccination is administered to persons who are already immune to HBV (or chronically infected with HBV), it does not increase the risk for vaccine-related adverse events.[13] In general, routine prevaccination serologic testing is not recommended in settings where background immunity to hepatitis B is low, as it is not cost-effective.[10, 14, 15, 16] In populations with a high HBsAg prevalence or with a high risk for chronic HBV, prevaccination serologic testing may reduce costs by avoiding unnecessary vaccinations. In these settings, prevaccination serologic testing also offers the opportunity to identify persons with chronic HBV infection and link them to care for management of chronic HBV infection.

Persons Recommended for Prevaccination Serologic Testing

Prevaccination serologic screening for hepatitis B should include the following groups:[10]

- Household, sexual, or needle contacts of hepatitis B surface antigen (HBsAg)-positive persons†
- Persons with HIV infection†
- Persons with elevated alanine aminotransferase / aspartate aminotransferase of unknown etiology†
- Hemodialysis patients†
- Men who have sex with men†
- Persons who inject drugs (past or present)†
- Persons born in countries of high and intermediate hepatitis B virus (HBV) endemicity (HBsAg prevalence ≥2%)
- United States-born persons not vaccinated as infants whose parents were born in countries with high HBV endemicity (≥8%)
- Persons needing immunosuppressive therapy, including chemotherapy, immunosuppression related to organ transplantation, and immunosuppression for rheumatologic or gastroenterologic disorders
- Donors of blood, plasma, organs, tissues, or semen

†Denotes groups that should receive HepB vaccination if nonimmune to HBV and not infected with HBV

Recommended Prevaccination Serologic Tests

If hepatitis B prevaccination serologic testing is performed, the Centers for Disease Control and Prevention (CDC) recommends obtaining the following tests:[10]

- Hepatitis B surface antigen (HBsAg)
- Antibody to HBsAg (anti-HBs), and
- Antibody to hepatitis B core antigen (anti-HBc).

Serologic Testing and Potential Barrier to Hepatitis B Vaccination

Prevaccination serologic testing should be a barrier to vaccination of persons potentially susceptible to HBV infection, especially hard-to-reach populations.[10] If prevaccination serologic testing is indicated, the first dose of hepatitis B vaccine can be delivered at the time blood is collected for serologic testing; if the serologic testing shows the person is immune or has HBV infection, then no further doses of the vaccine should be given. In venues where hepatitis B vaccination is recommended and serologic testing is not feasible, hepatitis B vaccination should simply be provided.[10, 13, 17]
HBV Vaccines and Schedules

HBV Vaccines Approved for Use in the United States

There are currently three single-antigen hepatitis B vaccines approved for use in the United States: Engerix-B, Recombivax HB, and Heplisav-B.[6,10] In addition, there are three FDA-approved combination vaccines that provide hepatitis B immunization in conjunction with other antigens; these include Twinrix (hepatitis A and B combination vaccine), Pediarix (hepatitis B, diphtheria-tetanus-acellular pertussis [DTaP]), and inactivated polio combination vaccine), and Vaxelis (hepatitis B, DTaP, inactivated poliovirus, and Haemophilus influenzae).[10] All of these vaccines utilize recombinant DNA technology to generate purified HBsAg as the hepatitis B vaccine antigen and these vaccines therefore pose no risk for HBV transmission or transmission of other bloodborne viruses. In the United States, none of the hepatitis B vaccines contain thimerosal (or they contain only trace amounts from the manufacturing process). The following provides a brief summary for each of these vaccines.

Single-Antigen Vaccines

- **Engerix-B**: This single-antigen hepatitis B vaccine contains yeast-derived (recombinant) HBsAg combined with an aluminum adjuvant. It is FDA-approved for use in individuals of all ages.
- **Heplisav-B**: This single-antigen hepatitis B recombinant vaccine consists of recombinant HBsAg combined with the synthetic immunostimulatory cytidine-phosphate-guanosine (CpG) 1018 adjuvant; the CpG adjuvant binds to toll-like receptor 9, signaling an innate immune system pathway in response to the HBsAg antigen. This vaccine is FDA-approved for use in persons 18 years of age and older. In addition, at this time, Heplisav-B is not recommended for use in pregnant women.
- **Recombivax-HB**: This single-antigen vaccine contains recombinant HBsAg that is also produced in yeast cells; this vaccine and is FDA-approved for use in individuals of all ages.

Combination Vaccines

- **Twinrix**: This bivalent vaccine contains inactivated hepatitis A virus and recombinant HBsAg. Each 1 mL dose contains a lower quantity of hepatitis A vaccine (720 ELISA units) than the standard 1 mL single antigen hepatitis A vaccine (1440 ELISA units). This vaccine is FDA-approved for use only in persons 18 years of age and older.
- **Pediarix**: This combination vaccine contains diphtheria toxoid, tetanus toxoid, acellular pertussis antigens, recombinant HBsAg, and inactivated poliovirus. This vaccine is FDA-approved as a 3-dose series in infants born of hepatitis B surface antigen (HBsAg)-negative mothers; this vaccine may be given as early as 6 weeks of age and through 6 years of age (prior to the seventh birthday). This vaccine is not approved for children younger than 6 weeks of life and thus should not be given for the birth-dose vaccination for HBV postexposure prophylaxis.
- **Vaxelis**: This combination vaccine contains diphtheria toxoid, tetanus toxoid, acellular pertussis antigens, inactivated poliovirus, recombinant HBsAg, and Haemophilus influenzae type b. This vaccine is FDA-approved as a 3-dose series in children 6 weeks through 4 years of age (prior to the fifth birthday). Although this vaccine is FDA-approved, it is not yet commercially available. Accordingly, it will not be discussed further.

Vaccine Dosing Schedules and Administration

Adults and children have distinct recommended hepatitis B vaccines and recommended vaccine schedules (Figure 2) and (Figure 3).[10] Note that before a potential exposure, such as travel, Twinrix can be administered as an accelerated series at 1, 7, and 21 to 30 days, followed by a fourth dose at 12 months.[10] The vaccine schedules for infants depend on birth weight and maternal HBsAg status (Table 3).[6,10] The amount of HBsAg and volume administered with each vaccine dose varies significantly based on age, which vaccine is used, and whether the individual is receiving hemodialysis (Table 4).[6,10] All hepatitis
B vaccines should be administered as intramuscular (IM) injections, with the deltoid muscle the preferred site for adults, adolescents, and children. For infants less than 1 year of age, the anterolateral thigh should be used for the intramuscular injection. Administration of hepatitis B vaccine in the buttocks or administration subcutaneously is not recommended for any of the FDA-approved hepatitis B vaccines, as administration by these routes is associated with lower levels of protective immune response. At any age, subcutaneous administration is only recommended if intramuscular injection is not an option, such as in persons with hemophilia who have a significant risk of hemorrhage with intramuscular injection. The hepatitis B vaccine should not be given to any persons with a history of a serious allergic response to a prior dose of hepatitis B vaccine, a component of the hepatitis B vaccine, or yeast.

**Vaccine Dosing in Persons Receiving Hemodialysis**

For persons older than 20 years of age and older who are receiving hemodialysis, it is important to note that higher doses of Recombivax-HB (40 µg per dose) and Engerix-B (40 µg per dose) are needed, due to poor vaccine response rates with standard doses of these vaccines in this population; in addition, when Engerix-B is used for persons on hemodialysis, the usual 3-dose vaccine schedule is expanded to four doses (Figure 4). Persons younger than 20 years of age should receive Recombivax-HB (5 µg per dose) or Engerix-B (10 µg per dose). Although limited data suggest Heplisav-B (a 3-dose schedule with standard dosing) and Twinrix (standard schedule and dosing) may lead to higher rates of HBV seroprotection in hemodialysis patients, there are no specific ACIP recommendations for use of either of these vaccines in persons receiving hemodialysis.

**Choice of HBV Vaccine in Adults**

In adults, the ACIP does not preferentially indicate which single-antigen hepatitis B vaccine to use, except in pregnant women, where Heplisav B should be avoided due to lack of safety and efficacy data. Thus, for pregnant women needing hepatitis B vaccine, either Engerix-B or Recombivax-HB should be used. In general, the single-antigen hepatitis B vaccines—Engerix-B and Recombivax-HB—can be used interchangeably in adults. For adults, if a 2-dose series is desired, Heplisav-B is the only option, as all other single-antigen vaccines require three doses. In addition, a 2-dose hepatitis B vaccine series with Recombivax-HB can be used for adolescents 11 through 15 years of age who receive the adult strength dose. If adults require protection against both hepatitis A virus (HAV) and HBV, then Twinrix (combination hepatitis A and hepatitis B vaccine) can be used.

**Choice of HBV Vaccine for Infants, Children, and Adolescents**

For infants, only the single-antigen hepatitis B vaccines (Engerix-B or Recombivax-HB) are recommended for the birth dose vaccine. Pediarix, containing hepatitis B, DTaP, and inactivated polio vaccine, is approved starting at 2 months of age up through age 6 years, and this 3-dose series can be used to complete the hepatitis B vaccination after a single-antigen hepatitis B vaccine birth dose is given. In general, rates of protective immunity are similar across different hepatitis B vaccines in immunocompetent infants, children, and adolescents, and vaccine brands are interchangeable within an immunization series. Due to a lack of data on the interchangeability of acellular pertussis-containing vaccines, the American Academy of Pediatrics recommends vaccines from the same manufacturer be used for the pertussis series.

**Interruption in Schedule**

Longer intervals between dose 1 and 2 or dose 2 and 3 of Engerix-B and Recombivax-HB vaccines have not been shown to diminish efficacy, and if anything, a longer than recommended interval between the last two doses of vaccine may confer higher levels of protection. As such, there is no need to restart the hepatitis B vaccine series in situations where the vaccination schedule has been interrupted. Subsequent doses should be given as soon as possible, making sure the first and second dose are separated by at least 4 weeks, the second and third dose are separated by at least 8 weeks, and the third dose is at least 16 weeks after the first
Minimum Acceptable Intervals Between Doses

For Engerix-B, Recombivax-HB, and Heplisav-B, the minimal acceptable dosing interval between the first and second dose of vaccine is 4 weeks (Figure 5).[6,10] The second and third dose of Engerix-B and Recombivax-HB should be given at least 8 weeks apart, and the first and third dose of vaccine should be separated by at least 16 weeks.[6,10] In infants, the third dose of vaccine (Engerix-B, Recombivax-HB, or Pediarix), should not be administered before 24 weeks of age.[10] For all hepatitis B vaccines and all intervals, doses administered up to 4 days before the minimal acceptable dosing intervals are valid; however, doses administered 5 or more days before the minimum dosing interval must be repeated using the correct schedule.[10] The one exception to these dosing intervals is accelerated administration of Twinrix, which can be given in adults at 0, 7, and 21 days, followed by a fourth dose at 12 months.[10] In the case of accelerated Twinrix, the 4-day grace period does not apply.[10]
Response to HBV Vaccines

The overall response to hepatitis B vaccination is good—after 3 doses of the hepatitis B vaccine, more than 95% of healthy infants and more than 90% of healthy adults younger than 40 years of age achieve protective immunity, defined as an HBsAb level of 10 mIU/mL or greater.\[25,26,27\] Although it is optimal to administer the complete hepatitis B vaccine series, studies have shown that 32 to 56% of persons can achieve protective levels of anti-hepatitis B surface antibody (HBsAb) with a single dose of Recombivax-HB or Engerix-B, and 70 to 75% achieve protective levels with two doses of vaccine.\[25,27\] Similarly, in an open label randomized control trial of Twinrix versus single-antigen hepatitis A vaccine plus single-antigen hepatitis B vaccine in healthy adults 19 years of age and older, HAV seroconversion and HBV seroprotection occurred in 95.1% of subjects in the Twinrix arm versus 92.2% of subjects in the monovalent vaccine arm.\[28\] Response to the two-dose Heplisav-B vaccine is similarly excellent. In phase 3 registration trials that collectively enrolled 9,597 adults aged 18 through 70 years, the rate of seroprotection (SPR) after two doses of Heplisav-B, spaced one month apart, was 90 to 100%, compared with 71 to 90% for standard single-antigen hepatitis B vaccine (Engerix-B) for three doses (Figure 6) and (Figure 7).\[29,30,31,32\] This improvement in seroconversion rates is particularly notable among groups that have historically had lower seroprotective responses to recombinant hepatitis B vaccines, including in persons with older age, diabetes mellitus, tobacco use, and/or obesity.\[6,29,30,33\]

Reduced Response to Vaccine

Despite generally high rates of seroconversion in healthy adults, certain conditions are associated with decreased response to vaccine (Table 5).\[10,19,34,35,36\] A lack of response in healthy individuals has been linked to genetic determinants, specifically HLA haplotypes. In studies from the United States and Sweden, HLA haplotypes B8, SC01, DR3, DBQ1*0604, DQA1*0102, and DRB1*1302 were associated with lower response rates to hepatitis B vaccine.\[37,38\] Nevertheless, the presence of the same haplotypes among some responders in these studies suggests that genetic determinants may be only one factors impacting response to hepatitis B vaccine.\[37,38\]

HBV Vaccine in Persons Receiving Hemodialysis

Among persons with chronic kidney disease, the serologic response rates to Engerix-B and Recombivax-HB vaccines (using standard HBsAg doses and standard dosing schedules) are only about 50 to 60%. To improve the vaccine response in adults receiving hemodialysis, each dose of HBsAg in Engerix-B is increased (from 20 µg to 40 µg) and the dosing schedule is expanded from three doses (0, 1, and 6 months to 4 doses (0, 1, 2, and 6 months). Similarly, when giving Recombivax-HB to adults receiving hemodialysis, each HBsAg dose is increased from 10 µg to 40 µg, but the same schedule is used (0, 1, and 6 months). In an observer-blind, randomized trial in adults receiving hemodialysis, investigators compared a 3-dose Heplisav-B series (0, 1, and 6 months) with the 4-dose series (0, 1, 2, and 6 months) of double-dose (40 µg) Engerix-B in persons receiving hemodialysis; the seroprotective response rates at weeks 28 and 52 were higher with Heplisav-B than with Engerix-B.\[22\] Although this study showed promise with a 3-dose Heplisav B series in persons on hemodialysis, at this time there are insufficient data on the use of Heplisav-B in persons on hemodialysis.

Duration of Immunity

In general, protection generated by a complete vaccine series is believed to last for at least 15 to 20 years in healthy individuals, and immunity in healthy adults and children appears to persist even though antibodies may decline over time, even below the limit of detection.\[39,40,41,42,43\] This is evidenced by a study of seroprotection rates in 423 adolescents who received HBV vaccination as infants. In this study only 24% of participants had protective HBsAb levels of 10 mIU/mL or greater at baseline, but 92% achieved protective levels after a challenge dose of vaccine.\[44\] A similar study of 243 Alaska Natives who were vaccinated in
infancy showed that 51% had HBsAb levels of 10 mIU/mL or greater after 30 years, and among those with HBsAb levels less than 10 mIU/mL, 88% responded to a booster dose of hepatitis B vaccine, achieving HBsAb levels of 10 mIU/mL or greater.[40]
Postvaccination Serologic Testing

Indications for Postvaccination Serologic Testing

Postvaccination testing for levels of HBsAb is not recommended following routine hepatitis B immunization of infants, children, adolescents, or adults.\[10\] The rationale for this recommendation is that most healthy persons have an excellent response to the hepatitis B vaccine series. Postvaccination serologic testing should be considered for persons who have known ongoing risk for hepatitis B exposure, known diminished protective response to vaccine, or whose clinical management depends on knowledge of their HBV immune status. The purpose of testing in these situations is to determine the need for revaccination, and in the case of sex partners, the need for additional protective measures.\[10\] The CDC recommends hepatitis B postvaccination serologic testing to determine vaccine immune response in the following groups:\[10\]

- Infants born to HBsAg-positive mothers
- Infants born to mothers whose HBsAg status remains unknown
- Health care workers and public safety workers at risk for continued exposure to blood and body fluids
- Hemodialysis patients and others who might require outpatient hemodialysis (e.g. predialysis, peritoneal dialysis, and home dialysis)
- Persons with HIV and other immunocompromised persons (e.g. hematopoietic stem-cell transplant recipients or persons receiving chemotherapy)
- Sex partners of HBsAg-positive persons

Timing and Method of Postvaccination Serologic Testing

For persons who have an indication for postvaccination serologic testing, the testing should be performed 1 to 2 months after completion of the hepatitis B vaccine series, regardless of which hepatitis B vaccine was used.\[6,10\] The goal of postvaccination serologic testing is to assess immunity against HBV; performing a quantitative anti-HBs is the recommended test for this assessment. Of note, serologic testing for infants born to HBsAg-positive mothers (or HBsAg-unknown mothers) should also include testing for HBsAg. These infants should have testing performed 1 to 2 months after completing the hepatitis B vaccine series; if the infant received the hepatitis B vaccine on a normal schedule then serologic testing would occur at about 9 to 12 months of age. Deferring the anti-HBs testing until after 9 months of age is important, since these infants may have residual anti-HBs out to 9 months from the hepatitis B immune globulin received at birth.\[10,23,45\] Testing of anti-HBc in infants should be avoided, since maternal anti-HBc may persist for at least 24 months.\[23\] For all ages, following any dose of hepatitis B vaccine, if HBsAg testing is needed to evaluate for active infection, the HBsAg test should be deferred for at least 1 month after receipt of a hepatitis B vaccine dose, since the recombinant HBsAg in the hepatitis B vaccines can cause a transient false-positive HBsAg test (for up to 18 days after vaccination).\[45,46,47,48\]

Interpretation of Postvaccination Serologic Testing

Anti-HBs levels of 10 mIU/mL or greater have been shown to strongly correlate with protection against HBV infection.\[49,50\] As such, those with anti-HBs levels of at least 10 mIU/mL following hepatitis B immunization are considered immune to HBV and protected against infection with HBV.\[10,13,23,50\] For assays that utilize a cutoff different than 10 mIU/mL, it is important to refer to the package insert of the test used to appropriately interpret the results and determine the correct level of anti-HBs antibodies.\[49,50\]

Repeat Postvaccination Serologic Testing

Given the higher prevalence of HBV infection among patients on long-term dialysis, patients undergoing outpatient hemodialysis should have anti-HBs testing yearly.\[10,51\] If anti-HBs levels fall below 10 mIU/mL, a booster dose of HepB vaccine should be administered. In this setting, serologic testing to assess response is not recommended at 1 to 2 months.\[10\] The need for repeat postvaccination serologic testing has not been
established in other high-risk populations, such as persons with HIV infection, hematopoietic stem-cell transplant recipients, and those receiving chemotherapy or other immunosuppressive drugs. In these populations, the ACIP recommends consideration of annual anti-HBs testing with booster dose vaccination for persons at ongoing risk for HBV acquisition.

**Testing Health Care Workers Vaccinated in the Past**

The ACIP suggests health care institutions consider assessing preexposure immunity to HBV in all health care workers at the time of hire, regardless of vaccination status. For health care workers with prior documentation of hepatitis B vaccine, testing for anti-HBs levels should be performed. If anti-HBs levels are 10 mIU/mL or greater, the health care worker is considered immune, and no HBV postexposure prophylaxis is needed following a potential exposure.

Health care workers with previous immunization against HBV and anti-HBs levels less than 10 mIU/mL should receive a one-time dose of hepatitis B vaccine, followed by postvaccination serologic testing 1 to 2 months later. If the anti-HBs level remains less than 10 mIU/mL, administration of 2 additional doses of hepatitis B vaccine is recommended, again followed by postvaccination serologic testing. If, after repeat hepatitis B vaccination, the health care worker fails to mount a protective immune response (defined as anti-HBs levels 10 mIU/mL or greater), they should be counseled on the need for postexposure prophylaxis following exposure.

If a health care institution decides against measuring anti-HBs levels in their health care workers, they should ensure the health care workers seek timely evaluation for postexposure prophylaxis and assessment after any potential occupational exposure to HBV.
Management of HBV Vaccine Nonresponders

Approximately 5 to 10% of immunized individuals fail to develop a protective antibody response (HBsAb level less than 10 mIU/mL) after a complete initial hepatitis B vaccine series. For persons who fail to generate adequate antibody levels in response to a primary 3-dose vaccine series, a fourth dose of vaccine or a second full 3-dose revaccination series can achieve a protective response in half or more of these persons.[49,52,53,54,55] Nonresponders to a second vaccine series are unlikely to develop a protective response to further doses of vaccine.[56] Given the enhanced immune responses to Heplisav-B compared with Engerix-B, there is significant interest in the potential use of Heplisav-B for vaccine nonresponders. Nevertheless, use of Heplisav-B in vaccine nonresponders has not been adequately studied and thus there are no current recommendations to use Heplisav-B for vaccine nonresponders.

Recommended Approach to HBV Vaccine Nonresponders

The following represents recommendations for the approach to persons who do not respond to the initial hepatitis B vaccine series. Most of these recommendations are based on guidance from the CDC and ACIP, and focus on groups for which postvaccination serologic testing is recommended.[10]

- **Infants Born to HBsAg-Positive Mothers:** In most circumstances, the approach to HBsAg-negative infants who were born to an HBsAg-positive mother requires a stepwise approach (Figure 8).[10] If infant serologic testing at 9 to 12 months of age shows the infant did not respond to the initial hepatitis B vaccine series (anti-HBs level less than 10 mIU/mL), they should receive 1 additional dose of hepatitis B vaccine, followed by repeat serologic testing 1 to 2 months later.[10] If, at that point, the infant’s anti-HBs level remains less than 10 mIU/mL, they should receive two additional doses of hepatitis B vaccine to complete a second 3-dose series.[10] Serologic testing (anti-HBs) should be performed 1 to 2 months after completion of the second hepatitis B vaccine series.[10] Alternatively, based on family preference and clinical circumstances, it is reasonable to give a full repeat 3-dose vaccine series to infants who did not respond to the initial vaccine series.[10]

- **Health Care Workers:** All health care workers who receive hepatitis B vaccination should have postvaccination serologic testing; vaccine nonresponders need further management (Figure 9).[10] Previously vaccinated health care personnel with an anti-HBs level less than 10 mIU/mL should receive one additional dose of hepatitis B vaccine followed by repeat serologic testing in 1 to 2 months.[10] If anti-HBs remains less than 10 mIU/mL following a booster dose, two additional doses of vaccine should be administered, followed by repeat anti-HBs serologic screening 1 to 2 months after the final dose of vaccine.[10] As with infants, health care workers with anti-HBs less than 10 mIU/mL may find it more practical to receive a second complete hepatitis B vaccine series followed by repeat serologic testing at 1 to 2 months, as opposed to the stepwise strategy outlined above that begins with giving one dose.[10]

- **Immunocompromised Adults:** Hematopoietic stem-cell transplant recipients, persons with HIV, and persons receiving immunosuppressant medications who are HBsAg-negative and do not respond to initial hepatitis B vaccination (anti-HBs less than 10 mIU/mL 1 to 2 months after completing the initial series) should receive a second complete hepatitis B vaccine series, making certain all doses are given on schedule (Figure 10).[10] Anti-HBs testing should be performed again, ideally 1 to 2 months after completing the second vaccine series.[10] If the anti-HBs concentration remains less than 10 mIU/mL, then HBsAg testing should be performed to determine whether active HBV infection is the cause of vaccine nonresponse.[10] If the HBsAg test is negative, the person should be considered at risk for acquiring HBV infection, and they should receive counseling regarding prevention of HBV infection; persons who test positive for HBsAg should be considered to have HBV infection and should receive further evaluation, management, and counseling.[10] Administering more than two complete hepatitis B vaccine series is generally not recommended for this population. For persons with HIV who do not respond to the initial hepatitis B vaccine series, some experts recommend administering four doses of double-dose vaccine at 0, 1, 2, and 6 months.[57]

- **Hemodialysis Patients:** Hemodialysis patients who do not respond to the hepatitis B vaccine should be managed similar to other immunocompromised adults, with the exception that...
hemodialysis patients who respond to the second vaccine series should undergo yearly anti-HBs screening (Figure 11).[13,21] If anti-HBs levels fall below 10 mIU/mL, a booster dose of hepatitis B vaccine should be administered.[10] In this setting, given the frequency of anti-HBs screening, serologic testing to assess response to additional doses of vaccine is not recommended at 1 to 2 months after the booster dose.[10,13]

Additional Strategies for the Management of HBV Vaccine Nonresponders

Multiple additional strategies have been utilized in managing persons who do not respond to the initial hepatitis B vaccine series, but none of these have been established to have better efficacy than the strategy outlined in the CDC recommendations for hepatitis B vaccine nonresponders.[58] The following summarizes strategies that have been employed in the management of hepatitis B vaccine nonresponders.

- **Use of Different Vaccine Adjuvant:** The Heplisav-B vaccine has a novel synthetic immunostimulatory adjuvant (CpG 1018), which has been shown to confer high levels of immunity in adults.[6,22,29,33,59] Given the enhanced immune response to Heplisav-B compared to other hepatitis B vaccines, some experts have utilized the 2-dose Heplisav-B as the second vaccine series. This strategy is partially supported by one small study comparing one dose of Heplisav-B versus 1 dose of Engerix-B in 59 vaccine nonresponders. In this study, participants who had not responded to 4 to 6 doses of prior hepatitis B vaccines had better immune responses to the 1 dose of Heplisav-B than the 1 dose of Engerix-B, but these differences did not reach statistical significance.[59] There are, however, no published studies addressing the use of the Heplisav-B vaccine series in hepatitis B vaccine nonresponders.

- **Increased Vaccine Doses or Antigen Per Dose:** There are several studies that have evaluated the efficacy of using increased hepatitis B vaccine doses for the management of nonresponders. One study of 48 healthy adult nonresponders showed that revaccination with a double dose of combined hepatitis A and B vaccine (Twinrix) led to protective titers (anti-HBs levels 10 mIU/mL or greater) in 95% of study subjects.[60] A similar study evaluated double- versus single-dose hepatitis B vaccine in health care workers who did not previously respond to hepatitis B vaccination. In this study 97.8% of those receiving the double dose and 89.6% of those receiving the single dose developed anti-HBs titers of 10 mIU/mL or greater; this difference, however, was not statistically significant.[61] Moreover, a systematic review and meta-analysis of vaccine options for adults who did not respond to prior hepatitis B vaccination showed no statistical difference in rates of protective anti-HBs levels between those who were revaccinated with standard dose hepatitis B vaccine versus those who received a double dose of hepatitis B vaccine.[58]

- **Intradermal Administration:** There is some data supporting the enhanced immunogenicity of intradermal versus intramuscular hepatitis B vaccination. In one study of 50 previously vaccinated hemodialysis patients without protective anti-HBs levels, revaccination with intradermal hepatitis B vaccine, in comparison to intramuscular hepatitis B vaccine, yielded statistically higher rates of seroprotection at 1, 12, and 20 months.[62] A similar study of hepatitis B vaccine nonresponders on hemodialysis showed significantly higher seroconversion rates (79% vs 40%) among hemodialysis patients who received weekly intradermal vaccine for 8 weeks versus those who received intramuscular vaccine at 1 and 8 weeks.[63] In addition to patients on hemodialysis, intradermal vaccination has been shown to be effective in patients with chronic liver disease. In one study of 42 patients with chronic liver disease who failed initial intramuscular hepatitis B vaccination, 69% had an immunologic response (anti-HBs10 mIU/mL or greater) after repeat vaccination with up to three doses of intradermal vaccine.[64] It should be noted, however, that intradermal vaccines are challenging to administer, and injection into the subcutaneous tissue yields lower rates of protection. Because of this, their widespread use is limited by the availability of skilled personnel to administer the vaccine.

- **Other Vaccines:** Within the S proteins on the hepatitis B envelope are distinct regions, including the pre-S1 and pre-S2 regions. Certain vaccines, available only in Israel, Western Europe, and parts of Asia, include these protein regions, which have been shown to induce high levels of immunity.[65,66] Studies looking at the use of these pre-S1 and pre-S2 vaccines for prior hepatitis B nonresponders have shown favorable efficacy. In one study of 100 healthcare workers who failed to respond to
conventional hepatitis B vaccine, most responded after a single dose of triple S recombinant vaccine, with rates of seroconversion varying between 60 to 80%, depending on the dose of antigen that was administered (5 to 40 micrograms).[67] Similarly, a phase 3 study of hepatitis B vaccine containing a pre-S2 epitope found seroconversion rates of 68.4% in previous hepatitis B vaccine nonresponders after two doses of vaccine containing pre-S2.[68]
Summary Points

- In the United States, overall hepatitis B vaccine delivery and coverage rates among adults is low, despite high rates of vaccine acceptance among adults who are offered the vaccine.
- All infants, children, adolescents under 19 years of age, healthcare workers, immunocompromised adults, and adults with specific risk factors for HBV acquisition should receive hepatitis B vaccination.
- In general, prevaccination serologic testing is not indicated unless patients are at high risk for HBV infection.
- There are three single-antigen hepatitis B vaccines and one hepatitis A-hepatitis B combination vaccine approved for adults in the United States. The ACIP does not provide preferential guidance on which vaccine to use, with the exception that Heplisav-B should not be used in pregnant women.
- In infants, only single-antigen HBV vaccines (Engerix-B or Recombivax-HB) should be used for the birth dose hepatitis B vaccine, but combination vaccines can be used to complete the hepatitis B vaccine series.
- Overall response to hepatitis B vaccination is good, with greater than 90% of healthy adults achieving protective immunity after three doses of vaccine, defined as a HBsAb level of 10 mIU/mL or greater.
- Age greater than 40 years, male sex, obesity, diabetes, tobacco smoking, chronic hepatitis C infection, alcohol use disorder, renal disease, HIV infection, celiac disease, other immune compromising conditions, and certain genetic determinants have been associated with suboptimal response to hepatitis B vaccination.
- Postvaccination serologic testing is indicated for the following groups: infants born to HBsAg-positive mothers or mothers of unknown HBsAg status, healthcare workers and public safety workers at risk for exposure to blood or body fluids, persons on hemodialysis, persons with HIV, other immunocompromised persons, and sex partners of HBsAg-positive persons.
- For the estimated 5 to 10% of individuals who fail to develop a protective antibody response to an initial 3-dose hepatitis B vaccine series, a fourth vaccine dose or a second full 3-dose revaccination series can achieve a protective response in at least 50% of these persons.
- Novel adjuvants, double dose vaccinations, intradermal vaccines, and vaccines containing proteins in the pre-S1 and pre-S2 regions on the HBV envelope have been used to elicit better immune responses in vaccine nonresponders.
Citations


57. Panel on Opportunistic Infections in Adults and Adolescents with HIV. Guidelines for the prevention and treatment of opportunistic infections in adults and adolescents with HIV: recommendations from the Centers for Disease Control and Prevention, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. Hepatitis B virus infection. Last Updated: November 13, 2018. [AIDSinfo]


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• Propst T, Propst A, Lhotta K, Vogel W, König P. Reinforced intradermal hepatitis B vaccination in
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[PubMed Abstract] -

[PubMed Abstract] -

[PubMed Abstract] -

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Figures

Figure 1 History of Hepatitis B Vaccines Licensed in the United States
Figure 2 Recommended Hepatitis B Vaccine Schedule in Adults

*Before a potential exposure, such as travel, Twinrix can be administered as an accelerated series at days 1, 7, 21-30, followed by a fourth dose at 12 months.

Figure 3 Recommended Hepatitis B Vaccine Schedule in Children

Figure 4 Dosing and Schedule of Hepatitis B Vaccines in Persons Receiving Hemodialysis

Doses administered up to 4 days before the minimal acceptable dosing intervals are valid, but doses administered 5 or more days before the minimum dosing interval must be repeated using the correct schedule.
Figure 5 (Image Series) - Minimal Acceptable Dosing Intervals for Hepatitis B Vaccines
Image 5B: Heplisav-B: Minimal Acceptable Dosing Intervals

Doses administered up to 4 days before the minimal acceptable dosing intervals are valid, but doses administered 5 or more days before the minimum dosing interval must be repeated using the correct schedule.
Doses administered up to 4 days before the minimal acceptable dosing intervals are valid, but doses administered 5 or more days before the minimum dosing interval must be repeated using the correct schedule.
Figure 6 Heplisav-B Vaccine versus Engerix-B Vaccine in Healthy Adults 18-55 Years of Age

In this trial, the primary endpoint was the percentage of persons who achieved seroprotection 8 weeks after the final dose of the Heplisav-B vaccine series or 4 weeks after completing the Engerix-B vaccine series. Seroprotection was defined as an anti-HBs titer of at least 10 mIU/mL.

Figure 7 Heplisav-B Vaccine versus Engerix-B Vaccine in Healthy Adults 40-70 Years of Age

In this trial, the primary endpoint was the percentage of persons who achieved seroprotection 8 weeks after the final dose of the vaccine series. Seroprotection was defined as an anti-HBs titer of at least 10 mIU/mL.

**Figure 8 Recommended Approach to Infants (Born to HBsAg-Positive Mothers) Who Do Not Respond to HBV Vaccine**

*For infants born to HBsAg-positive mothers, anti-HBs and HBsAg testing should be performed at least 1 month after final hepatitis B vaccine dose and 9 months after receipt of hepatitis B immune globulin (HBIG). ^The two additional doses should be given on regular vaccine schedule to complete the second HBV vaccine series. §If anti-HBs remains
^For occupational exposures to hepatitis B, no action for hepatitis B prophylaxis (regardless of source patient hepatitis B surface antigen status). *Health care workers should receive evaluation for all occupational exposures to hepatitis B. Some experts recommend a more practical alternative strategy for very recently vaccinated health care workers with anti-HBs less than 10 mIU/mL that consists of giving a second complete series (instead of the one initial dose of hepatitis B vaccine), followed by anti-HBs testing 1–2 months after the final dose.

Figure 10 Approach to Immunocompromised Hosts Who Do Not Respond to HBV Vaccine

For persons with HIV who do not respond to the initial hepatitis B vaccine series, some experts recommend administering four doses of double-dose vaccine at 0, 1, 2, and 6 months.

Figure 11 Approach to Hemodialysis Patients Who Do Not Respond to HBV Vaccine

This graphic describes the approach to hemodialysis patients who do not respond to the initial HBV vaccine series. ^For adults, the repeat hepatitis B vaccine series should consist of the high-dose (40 µg per dose) HBsAg given as the 3-dose series for Recombivax-HB or 4 doses for Engerix-B. *For persons who respond to the repeat vaccine series and have an anti-HBs titer of 10 mIU/mL or greater, annual testing for anti-HBs is recommended, with administration of a booster dose of hepatitis B vaccine if the anti-HBs titer is less than 10 mIU/mL.

Table 1.  
**Indications for Hepatitis B Vaccination**

<table>
<thead>
<tr>
<th>Groups with Indication for Hepatitis B Vaccination</th>
</tr>
</thead>
<tbody>
<tr>
<td>All infants</td>
</tr>
<tr>
<td>Unvaccinated Children Younger than 19 Years of Age</td>
</tr>
<tr>
<td>Persons at Risk for HBV Infection by Sexual Exposure</td>
</tr>
<tr>
<td>- Sex partners of HBsAg-positive persons</td>
</tr>
<tr>
<td>- Sexually active persons who are not in a long-term, mutually monogamous relationship (e.g. persons with more than one sex partner during the previous 6 months)</td>
</tr>
<tr>
<td>- Persons seeking evaluation or treatment for a sexually transmitted infection</td>
</tr>
<tr>
<td>- Men who have sex with men</td>
</tr>
<tr>
<td>Persons at Risk for Infection by Percutaneous Exposure</td>
</tr>
<tr>
<td>- Persons who currently or recently injected drugs</td>
</tr>
<tr>
<td>- Household contacts of HBsAg-positive persons</td>
</tr>
<tr>
<td>- Residents and staff of facilities for developmentally disabled persons</td>
</tr>
<tr>
<td>- Health care and public safety personnel with reasonably anticipated risk for exposure to blood or blood-contaminated body fluids</td>
</tr>
<tr>
<td>- Hemodialysis, predialysis, peritoneal dialysis, and home dialysis patients</td>
</tr>
<tr>
<td>- Persons with diabetes aged 19-59 years of age</td>
</tr>
<tr>
<td>- Persons with diabetes 60 years of age and older at the discretion of the treating clinician</td>
</tr>
<tr>
<td>Others at Increased Risk of Acquiring HBV Infection</td>
</tr>
<tr>
<td>- International travelers to countries with high or intermediate levels of endemic HBV infection (HBsAg prevalence of 2% or greater)</td>
</tr>
<tr>
<td>- Persons with hepatitis C virus infection</td>
</tr>
<tr>
<td>- Persons with chronic liver disease (including, but not limited to, persons with cirrhosis, fatty liver disease, alcoholic liver disease, autoimmune hepatitis, and an ALT or AST level greater than twice the upper limit of normal)</td>
</tr>
<tr>
<td>- Persons with HIV infection</td>
</tr>
<tr>
<td>- Incarcerated persons</td>
</tr>
</tbody>
</table>

**Persons Desiring Protection Against HBV**

Abbreviations: ACIP = Advisory Committee on Immunization Practices; HBsAg: hepatitis B surface antigen; HBV = hepatitis B virus; ALT = alanine aminotransferase; AST = aspartate aminotransferase

Source:

<table>
<thead>
<tr>
<th>Prevalence Category</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High</strong> (≥8%)</td>
<td>Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Côte d’Ivoire, Djibouti, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Haiti, Kiribati, Kyrgyzstan, Laos, Liberia, Malawi, Mali, Mauritania, Mongolia, Mozambique, Namibia, Nauru, Niger, Nigeria, Niue, Papua New Guinea, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, Sudan, Swaziland, Togo, Tonga, Uganda, Vanuatu, Vietnam, Yemen, and Zimbabwe.</td>
</tr>
<tr>
<td><strong>Intermediate</strong> (5.0-7.9%)</td>
<td>Albania, Bhutan, Cape Verde, China, Democratic Republic of the Congo, Ethiopia, Kazakhstan, Kenya, Marshall Islands, Moldova, Oman, Romania, Rwanda, Samoa, South Africa, Tajikistan, Tanzania, Thailand, Tunisia, Tuvalu, Uzbekistan, and Zambia.</td>
</tr>
<tr>
<td><strong>Low Intermediate</strong> (2.0-4.9%)</td>
<td>Algeria, Azerbaijan, Bangladesh, Belarus, Belize, Brunei Darussalam, Bulgaria, Cambodia, Colombia, Cyprus, Dominican Republic, Ecuador, Eritrea, Federated States of Micronesia, Fiji, Georgia, Italy, Jamaica, Kosovo, Libya, Madagascar, Myanmar, New Zealand, Pakistan, Palau, Philippines, Peru, Russia, Saudi Arabia, Singapore, South Korea, Sri Lanka, Suriname, Syria, Tahiti, and Turkey.</td>
</tr>
<tr>
<td><strong>Low</strong> (≤1.9%)</td>
<td>Afghanistan, Argentina, Australia, Austria, Bahrain, Barbados, Belgium, Bolivia,</td>
</tr>
</tbody>
</table>
Prevalence Category

<table>
<thead>
<tr>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosnia and Herzegovina, Brazil, Canada, Chile, Costa Rica, Croatia, Cuba, Czech Republic, Denmark, Egypt, France, Germany, Greece, Guatemala, Hungary, Iceland, India, Indonesia, Iran, Iraq, Ireland, Israel, Japan, Jordan, Kuwait, Lebanon, Lithuania, Malaysia, Mexico, Morocco, Nepal, Netherlands, Nicaragua, Norway, Palestine, Panama, Poland, Portugal, Qatar, Serbia, Seychelles, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United Arab Emirates, United States of America, and Venezuela.</td>
</tr>
</tbody>
</table>

No data

Andorra, Antigua and Barbuda, Armenia, The Bahamas, Botswana, Chad, Comoros, Cook Islands, Dominica, El Salvador, Finland, Grenada, Guinea-Bissau, Guyana, Honduras, Latvia, Lesotho, Lithuania, Luxembourg, Macedonia, Maldives, Malta, Mauritius, Monaco, Montenegro, North Korea, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, San Marino, Sao Tome and Principe, Timor-Leste, Trinidad and Tobago, Turkmenistan, and Uruguay.

NOTE: This table is based on data from the Centers for Disease Control and Prevention (CDC)

Source:

Table 3.

Hepatitis B Vaccine Schedules for Infants

<table>
<thead>
<tr>
<th>Maternal HBsAg Status</th>
<th>Single-Antigen Vaccine</th>
<th>Single-Antigen + Combination Vaccine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose</td>
<td>Age</td>
</tr>
<tr>
<td><strong>Birth-weight ≥2,000 grams</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Positive | 1 | HBIG  
|  | 2 | Birth (≤12 hours) |
|  | 3 | 1-2 months |
|  | 3 | 6 months † |
| Positive | 1 | HBIG  
|  | 2 | Birth (≤12 hours) |
|  | 3 | 2 months |
|  | 4 | 4 months |
|  | 4 | 6 months † |
| Unknown* | 1 | Birth (≤12 hours) |
|  | 2 | 1-2 months |
|  | 3 | 6 months † |
| Negative | 1 | Birth (≤24 hours) |
|  | 2 | 1-2 months |
|  | 3 | 6-18 months ‡ |
| **Birth-weight <2,000 grams** | | | | |
| Positive | 1 | HBIG  
|  | 2 | Birth (≤12 hours) |
|  | 3 | 1 month |
|  | 4 | 2-3 months |
|  | 4 | 6 months † |
| Unknown | 1 | HBIG  
|  | 2 | Birth (≤12 hours) |
|  | 3 | 1 month |
|  | 3 | 2-3 months |
|  | 4 | 6 months † |
| Negative | 1 | Hospital Discharge or Age  
|  | 2 | 1 month |
|  | 3 | 2 months |
|  | 3 | 6-18 months ‡ |

**Abbreviations:** HBsAg = hepatitis B surface antigen; HBIG = hepatitis B immune globulin

*Mothers should have blood drawn and tested for HBsAg as soon as possible after admission for delivery; if the mother is found to be HBsAg positive, the infant should receive HBIG as soon as possible but no later than age 7 days.

†Pediarix should not be administered before age 6 weeks.

§HBIG should be administered at a separate anatomical site from vaccine.

¶The final dose in the vaccine series should not be administered before age 24 weeks (164 days).
Table 4.

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Recombivax-HB</th>
<th>Engerix-B</th>
<th>Heplisav-B*</th>
<th>Pediari*</th>
<th>Twinrix†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose (µg)</td>
<td>Vol (mL)</td>
<td>Dose (µg)</td>
<td>Vol (mL)</td>
<td>Dose (µg)</td>
</tr>
<tr>
<td>Birth through 10</td>
<td>5</td>
<td>0.5</td>
<td>10</td>
<td>0.5</td>
<td>N/A</td>
</tr>
<tr>
<td>11 through 15</td>
<td>10^3</td>
<td>1.0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>11 through 19</td>
<td>5</td>
<td>0.5</td>
<td>10</td>
<td>0.5</td>
<td>N/A</td>
</tr>
<tr>
<td>≥20</td>
<td>10</td>
<td>1.0</td>
<td>20</td>
<td>1.0</td>
<td>20</td>
</tr>
</tbody>
</table>

Dosing in Hemodialysis Patients and Other Immunocompromised Persons

<table>
<thead>
<tr>
<th></th>
<th>Recombivax-HB</th>
<th>Engerix-B</th>
<th>Heplisav-B*</th>
<th>Pediari*</th>
<th>Twinrix†</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>5</td>
<td>0.5</td>
<td>10</td>
<td>0.5</td>
<td>N/A</td>
</tr>
<tr>
<td>≥20</td>
<td>40^#</td>
<td>1.0^#</td>
<td>40</td>
<td>2.0</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Note: this table is modified from original to include information on Heplisav-B

Abbreviation: N/A = not applicable (not approved for use).

^ Heplisav-B is approved for use in persons aged ≥18; each dose also includes 3,000 µg of CpG 1018 adjuvant.

* Pediari* is approved for use in persons aged 6 weeks through 6 years (prior to the 7th birthday).

† Twinrix† is approved for use in persons aged ≥18 years.

§ The adult formulation approved for ages 11 through 15 and is administered on a 2-dose schedule.

# The Recombivax-HB Dialysis Formulation has 40 µg of HBsAg per 1 mL

Source:

Table 5.

Conditions Associated with Decreases Response to HBV Vaccine

<table>
<thead>
<tr>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age older than 40 years</td>
</tr>
<tr>
<td>Male sex</td>
</tr>
<tr>
<td>Obesity</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Tobacco smoking</td>
</tr>
<tr>
<td>Chronic hepatitis C infection</td>
</tr>
<tr>
<td>Alcohol use disorder</td>
</tr>
<tr>
<td>Chronic kidney disease</td>
</tr>
<tr>
<td>HIV infection</td>
</tr>
<tr>
<td>Celiac disease</td>
</tr>
<tr>
<td>Other immune compromising conditions</td>
</tr>
</tbody>
</table>

Source:
