

EASL 2017 Clinical Practice Guidelines on the management of hepatitis B virus infection[☆]

European Association for the Study of the Liver^{*}

Summary

Hepatitis B virus (HBV) infection remains a global public health problem with changing epidemiology due to several factors including vaccination policies and migration. This Clinical Practice Guideline presents updated recommendations for the optimal management of HBV infection. Chronic HBV infection can be classified into five phases: (I) HBeAg-positive chronic infection, (II) HBeAg-positive chronic hepatitis, (III) HBeAg-negative chronic infection, (IV) HBeAg-negative chronic hepatitis and (V) HBsAg-negative phase. All patients with chronic HBV infection are at increased risk of progression to cirrhosis and hepatocellular carcinoma (HCC), depending on host and viral factors. The main goal of therapy is to improve survival and quality of life by preventing disease progression, and consequently HCC development. The induction of long-term suppression of HBV replication represents the main endpoint of current treatment strategies, while HBsAg loss is an optimal endpoint. The typical indication for treatment requires HBV DNA >2,000 IU/ml, elevated ALT and/or at least moderate histological lesions, while all cirrhotic patients with detectable HBV DNA should be treated. Additional indications include the prevention of mother to child transmission in pregnant women with high viremia and prevention of HBV reactivation in patients requiring immunosuppression or chemotherapy. The long-term administration of a potent nucleos(t)ide analogue with high barrier to resistance, *i.e.*, entecavir, tenofovir disoproxil or tenofovir alafenamide, represents the treatment of choice. Pegylated interferon-alfa treatment can also be considered in mild to moderate chronic hepatitis B patients. Combination therapies are not generally recommended. All treated and untreated patients should be monitored for treatment response and adherence, and the risk of progression and development of complications. HCC remains the major concern for treated chronic hepatitis B patients. Several subgroups of patients with

HBV infection require specific focus. Future treatment strategies to achieve 'cure' of disease and new biomarkers are discussed.

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Introduction

Infection with hepatitis B virus (HBV) remains an important global public health problem with significant morbidity and mortality.^{1–3} New information on the pathogenesis and management of HBV infection has become available since the previous EASL Clinical Practice Guidelines (CPGs) prepared in 2011 and published in 2012.¹ The objective of this manuscript is to update the recommendations for the optimal management of HBV infection. In order to keep the manuscript and particularly the reference list within a reasonable length, only references published after 2012 have been considered, since the readers can find the older supportive references in the 2012 EASL HBV CPGs.¹ The CPGs do not fully address prevention including vaccination. In addition, despite increasing knowledge, areas of uncertainty still exist and therefore clinicians, patients and public health authorities must continue to make choices based on the evolving evidence.

Background

Epidemiology and public health burden

Approximately 240 million people are chronic HBV surface antigen (HBsAg) carriers, with a large regional variation of HBsAg-positive patients between low (<2%) and high (>8%) endemicity levels.^{2,4} The prevalence is decreasing in several highly endemic countries due to improvements in the socioeconomic status, universal vaccination programs and perhaps effective antiviral treatments.⁵ However, population movements and migration are currently changing the prevalence and incidence in several low endemic countries in Europe (*e.g.*, Italy, Germany), owing to the higher HBsAg prevalence rates in migrants and refugees from outside Europe compared with the indigenous population.^{6,7} Even with universal vaccination programs, it has been impossible to substantially prevent acute cases of HBV infection, especially in high risk populations.^{8,9} The number of HBV related deaths due to liver cirrhosis and/or hepatocellular carcinoma (HCC)

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increased between 1990 and 2013 by 33%, relating to >686,000 cases in 2013 worldwide.¹⁰

Virology and immunopathogenesis

The viral life cycle

Human HBV belongs to the *Hepadnaviridae* family of small, enveloped, primarily hepatotropic DNA viruses. In the host, the virus replicates and assembles exclusively in hepatocytes, and virions are released non-cytopathically through the cellular secretory pathway. The viral genome shows an extremely compact organisation. The small (3.2 kb), partially double-stranded, relaxed-circular (rc) DNA features 4 open reading frames encoding 7 proteins: HBeAg (HBV e antigen, secreted dimeric protein), HBcAg (HBV core antigen, viral capsid protein), HBV Pol/RT (polymerase, reverse transcriptase activity), PreS1/PreS2/HBsAg (large, medium, and small surface envelope glycoproteins), and HBx (HBV x antigen, regulator of transcription required for the initiation of infection).^{11,12} Upon viral uptake into hepatocytes, the HBV nucleocapsid is transported to the nucleus to release the rcDNA genome. In the nucleoplasm, the rcDNA is converted into a covalently closed circular DNA (cccDNA), which is wrapped by histones to form an episomal chromatinized structure. It then serves as a transcription template for all viral transcripts that are translated into the different viral proteins.¹³ Besides encoding the capsid protein and the viral polymerase, the pregenomic RNA is reverse transcribed into new rcDNA within the viral capsid. The DNA containing nucleocapsids in the cytoplasm are either recycled into the nucleus to maintain cccDNA reservoir, or enveloped and secreted via the endoplasmic reticulum.¹¹ In addition to complete infectious virions (diameter of 42 nm), infected cells produce a large excess of genome-free, non-infectious sub-viral spherical or filamentous particles of 22 nm.¹¹ Viral genome integration in the host genome can occur randomly; it is not required for viral replication, but is one of the important mechanisms involved in hepatocyte transformation.¹⁴

Genetic variability of HBV

The lack of reverse transcriptase proofreading activity leads to frequent mutations of the viral genome. This results in the coexistence of genetically distinct viral species in infected individuals, also called viral quasispecies, which evolve depending on the pressure from the host environment. The interplay between the virus, hepatocyte and the immune response or antiviral treatment is thought to drive the emergence of HBV mutants that have the capacity to escape immune responses or antiviral treatments. Analysis of genome-wide nucleotide divergence has allowed for the identification of nine genotypes (A-I) and several sub-genotypes.^{12,15}

Immunopathogenesis

In acute resolving infections, the response of the innate and adaptive immune system to HBV is efficient and timely. Viral clearance involves the induction of a robust adaptive T cell reaction inducing both a cytolytic dependent and independent antiviral effect via the expression of antiviral cytokines, as well as the induction of B cells producing neutralizing antibodies preventing the spread of the virus.^{16,17} Hepatocyte turnover resulting from infected cell death leads to cccDNA dilution.

When the acute infection becomes chronic, there is a progressive impairment in HBV specific T cell function. Chronic HBV

infection progresses through distinct disease phases that are strongly associated with age. It has been observed that children and young adults with chronic HBV infection have an immune profile that is less compromised than that observed in older patients, challenging the concept of 'immune tolerance'.¹⁶ Several studies showed that HBV persists with virus-specific and global T cell dysfunction mediated by multiple regulatory mechanisms, but without distinct T cell-based immune signatures for clinical phenotypes (or clinical phase of infection).^{16,17} Genome-wide association studies recently identified the *INTS10* gene at 8p21.3 as a novel locus contributing to the susceptibility to persistent HBV infection among Chinese subjects, and being causative for HBV clearance by activation of *IRF3* and then expression of anti-virus interferons hereby highlighting the role of innate immunity in viral clearance.¹⁸

Natural history and new nomenclature for the chronic states

Chronic HBV infection is a dynamic process reflecting the interaction between HBV replication and the host immune response and not all patients with chronic HBV infection have chronic hepatitis (CHB). The natural history of chronic HBV infection has been schematically divided into five phases, taking into account the presence of HBeAg, HBV DNA levels, alanine aminotransferase (ALT) values and eventually the presence or absence of liver inflammation (Fig. 1). The new nomenclature is based on the description of the two main characteristics of chronicity: infection vs. hepatitis. However, despite this nomenclature, in a significant number of patients, a single determination of HBV replication markers as well as disease activity markers does not allow an immediate classification to one of the phases. Serial monitoring of serum HBeAg, HBV DNA and ALT levels is required in most instances but even after a complete assessment, some subjects fall into an indeterminate grey area and management needs to be individualised. The phases of chronic HBV infection are not necessarily sequential:

Phase 1: HBeAg-positive chronic HBV infection, previously termed "immune tolerant" phase; characterised by the presence of serum HBeAg, very high levels of HBV DNA and ALT persistently within the normal range according to traditional cut-off values [upper limit of normal (ULN) approximately 40 IU/L].¹ In the liver, there is minimal or no liver necroinflammation or fibrosis but a high level of HBV DNA integration and clonal hepatocyte expansion suggesting that hepatocarcinogenesis could be already underway in this early phase of the infection.^{1,19} This phase is more frequent and prolonged in subjects infected perinatally and is associated with preserved HBV specific T cell function at least until young adulthood.²⁰ The rate of spontaneous HBeAg loss is very low in this phase. These patients are highly contagious due to the high levels of HBV DNA.

Phase 2: HBeAg-positive chronic hepatitis B is characterised by the presence of serum HBeAg, high levels of HBV DNA and elevated ALT. In the liver, there is moderate or severe liver necroinflammation and accelerated progression of fibrosis.¹ It may occur after several years of the first phase and is more frequently and/or rapidly reached in subjects infected during adulthood. The outcome of this phase is variable. Most patients can achieve HBeAg seroconversion and HBV DNA suppression and enter the HBeAg-negative infection phase. Other patients may fail to control HBV and progress to the HBeAg-negative CHB phase for many years.

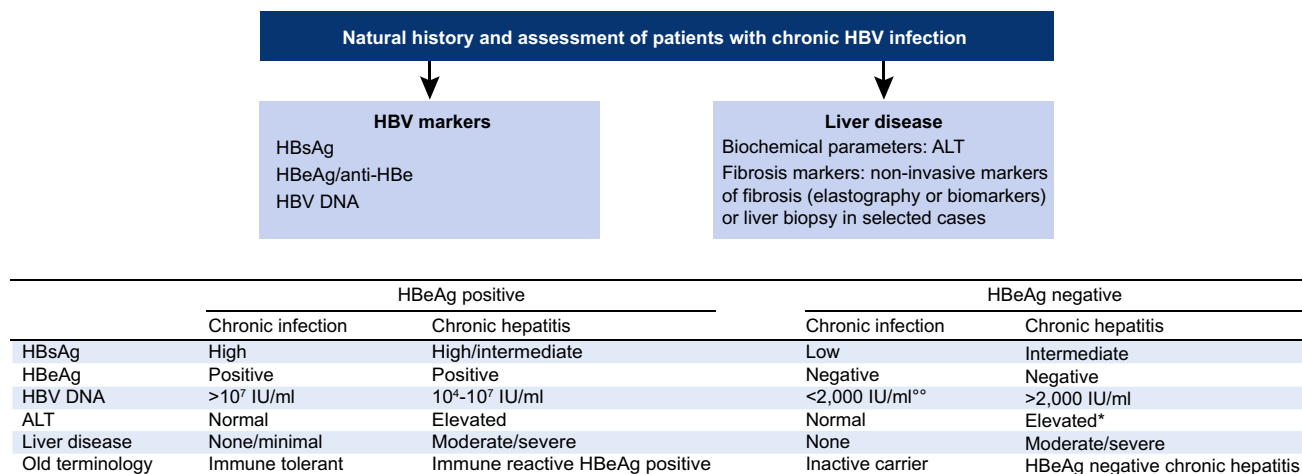


Fig. 1. Natural history and assessment of patients with chronic HBV infection based upon HBV and liver disease markers. *Persistently or intermittently. ^{oo}HBV DNA levels can be between 2,000 and 20,000 IU/ml in some patients without signs of chronic hepatitis.

Phase 3: HBeAg-negative chronic HBV infection, previously termed 'inactive carrier' phase, is characterised by the presence of serum antibodies to HBeAg (anti-HBe), undetectable or low (<2,000 IU/ml) HBV DNA levels and normal ALT according to traditional cut-off values (ULN ~40 IU/ml). Some patients in this phase, however, may have HBV DNA levels >2,000 IU/ml (usually <20,000 IU/ml) accompanied by persistently normal ALT and only minimal hepatic necroinflammatory activity and low fibrosis. These patients have low risk of progression to cirrhosis or HCC if they remain in this phase, but progression to CHB, usually in HBeAg-negative patients, may occur.¹ HBsAg loss and/or seroconversion may occur spontaneously in 1–3% of cases per year.¹ Typically, such patients may have low levels of serum HBsAg (<1,000 IU/ml).²¹

Phase 4: HBeAg-negative chronic hepatitis B is characterised by the lack of serum HBeAg usually with detectable anti-HBe, and persistent or fluctuating moderate to high levels of serum HBV DNA (often lower than in HBeAg-positive patients), as well as fluctuating or persistently elevated ALT values. The liver histology shows necroinflammation and fibrosis.¹ Most of these subjects harbour HBV variants in the precore and/or the basal core promoter regions that impair or abolish HBeAg expression. This phase is associated with low rates of spontaneous disease remission.¹

Phase 5: HBsAg-negative phase is characterised by serum negative HBsAg and positive antibodies to HBcAg (anti-HBc), with or without detectable antibodies to HBsAg (anti-HBs). This phase is also known as "occult HBV infection". In rare cases, the absence of HBsAg could be related to the sensitivity of the assay used for detection.²² Patients in this phase have normal ALT values and usually, but not always, undetectable serum HBV DNA. HBV DNA (cccDNA) can be detected frequently in the liver.¹ HBsAg loss before the onset of cirrhosis is associated with a minimal risk of cirrhosis, decompensation and HCC, and an improvement on survival. However, if cirrhosis has developed before HBsAg loss, patients remain at risk of HCC therefore HCC surveillance should continue. Immunosuppression may lead to HBV reactivation in these patients.¹

Factors related to progression to cirrhosis and HCC

The risk of progression to cirrhosis and HCC is variable and is affected by the host's immune response. The 5-year cumulative

incidence of cirrhosis ranges from 8% to 20% in untreated CHB patients and, among those with cirrhosis, the 5-year cumulative risk of hepatic decompensation is 20%.¹ The annual risk of HCC in patients with cirrhosis has been reported to be 2–5%.²³

HCC is currently the main concern for diagnosed CHB patients and may develop even in patients who have been effectively treated.²⁴ The risk of developing HCC is higher in patients with one or more factors that relate to the host (cirrhosis, chronic hepatic necroinflammation, older age, male sex, African origin, alcohol abuse, chronic co-infections with other hepatitis viruses or human immunodeficiency virus [HIV], diabetes or metabolic syndrome, active smoking, positive family history) and/or to HBV properties (high HBV DNA and/or HBsAg levels, HBV genotype C > B, specific mutations).²⁴ The above factors seem to affect the progression to cirrhosis in untreated CHB patients.¹

Several risk scores have been recently developed for HCC prediction in CHB patients. Most of them, such as GAG-HCC, CU-HCC and REACH-B, have been developed and validated in Asian untreated CHB patients,²⁵ but they do not seem to offer good predictability in most studies including Caucasian CHB patients.^{26,27} A recently developed and validated new score, PAGE-B, offers good predictability for HCC during the first 5 years of entecavir or tenofovir therapy in Caucasian, mostly European, CHB patients and can be easily applied in clinical practice, as it is based on widely available parameters (platelets, age, gender).²⁸ The PAGE-B score appears to predict HCC development even in untreated CHB patients.^{29,30}

Initial assessment of subjects with chronic HBV infection

The initial evaluation of a subject with chronic HBV infection should include a complete history, a physical examination, assessment of liver disease activity and severity and markers of HBV infection (Fig. 1). In addition, all first degree relatives and sexual partners of subjects with chronic HBV infection should be advised to be tested for HBV serological markers (HBsAg, anti-HBs, anti-HBc) and to be vaccinated if they are negative for these markers.

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- (1) The assessment of the severity of liver disease is important to identify patients for treatment and HCC surveillance. It is based on a physical examination and biochemical parameters (aspartate aminotransferase [AST] and ALT, gamma-glutamyl transpeptidase [GGT], alkaline phosphatase, bilirubin, and serum albumin and gamma globulins, full blood count and prothrombin time). An abdominal hepatic ultrasound is recommended in all patients. A liver biopsy or a non-invasive test should be performed to determine disease activity in cases where biochemical and HBV markers reveal inconclusive results.³¹ Of the non-invasive methods, which include liver stiffness measurements and serum biomarkers of liver fibrosis, the use of transient elastography has been mostly studied and seems to offer a higher diagnostic accuracy for the detection of advanced fibrosis. The diagnostic accuracy of all non-invasive methods is better at excluding than confirming advanced fibrosis or cirrhosis.^{31,32} The results of transient elastography may be confounded by severe inflammation associated with high ALT levels.^{31,32}
- (2) HBeAg and anti-HBe detection are essential for the determination of the phase of chronic HBV infection.
- (3) Measurement of HBV DNA serum level is essential for the diagnosis, establishment of the phase of the infection, the decision to treat and subsequent monitoring of patients.
- (4) Serum HBsAg quantification can be useful, particularly in HBeAg-negative chronic HBV infection and in patients to be treated with interferon-alfa (IFN α).
- (5) HBV genotype is not necessary in the initial evaluation, although it may be useful for selecting patients to be treated with IFN α offering prognostic information for the probability of response to IFN α therapy and the risk of HCC.
- (6) Co-morbidities, including alcoholic, autoimmune, metabolic liver disease with steatosis or steatohepatitis and other causes of chronic liver disease should be systematically excluded including co-infections with hepatitis D virus (HDV), hepatitis C virus (HCV) and HIV.
- (7) Testing for antibodies against hepatitis A virus (anti-HAV) should be performed, and patients with negative anti-HAV should be advised to be vaccinated against HAV.

Methodology

These CPGs were developed by a CPG panel of experts chosen by the EASL Governing Board, peer-reviewed by three external experts and approved by the EASL Governing Board. The CPGs have been based as far as possible on evidence from existing publications, and, if evidence was unavailable, on the experts' personal experience and opinion. Manuscripts and abstracts of important meetings published since the last CPG and prior to December 2016 have been evaluated. The evidence and recommendations in these guidelines have been graded according to the Grading of Recommendations Assessment Development and Evaluation (GRADE) system³³ (Table 1). The strength of recommendations (strong: 1, weak: 2) thus reflects the quality (grade) of underlying evidence (I, II-1, II-2, II-3, III). Grades are not provided for statements and definitions. For practical reasons, months and not weeks were used in parts of the manuscript

(e.g. 6 and 12 months instead of 24 and 48/52 weeks, respectively).

Guidelines

Goals of therapy

The main goal of therapy for patients with chronic HBV infection is to improve survival and quality of life by preventing disease progression, and consequently HCC development. Additional goals of antiviral therapy are to prevent mother to child transmission, hepatitis B reactivation and the prevention and treatment of HBV-associated extrahepatic manifestations.

The likelihood of achieving these goals depends on the timing of therapy during the natural course of the infection but also on the stage of the disease and the patients' age when treatment is started. Regression of fibrosis and cirrhosis can be regarded as a further goal of treatment in patients with established advanced fibrosis or cirrhosis, although its impact has not been fully clarified in clinical outcomes. Treatment strategies to prevent HCC development may differ in some ways from those that are needed to prevent fibrosis progression.

In patients with HBV-induced HCC, the goals of nucleos(t)ide analogue (NA) therapy are firstly to suppress HBV replication to induce the stabilisation of HBV-induced liver disease and to prevent disease progression, and secondly to reduce the risk of HCC recurrence after potentially curative HCC therapies. Stabilising the HBV-induced liver disease can be also regarded as a prerequisite for the safe and effective applications of HCC treatments.

In patients with acute hepatitis B, preventing the risk of acute or subacute liver failure is the main treatment goal. Improving the quality of life by shortening the duration of the disease associated symptoms as well as lowering the risk of chronicity may be also regarded as relevant goals of treatment.

Endpoints of therapy

Recommendations

- The induction of long-term suppression of HBV DNA levels represents the main endpoint of all current treatment strategies (Evidence level I, grade of recommendation 1).
- The induction of HBeAg loss, with or without anti-HBe seroconversion, in HBeAg-positive CHB patients is a valuable endpoint, as it often represents a partial immune control of the chronic HBV infection (Evidence level II-1, grade of recommendation 1).
- A biochemical response defined as ALT normalisation should be considered as an additional endpoint, which is achieved in most patients with long-term suppression of HBV replication (Evidence level II-1, grade of recommendation 1).
- HBsAg loss, with or without anti-HBs seroconversion, is an optimal endpoint, as it indicates profound suppression of HBV replication and viral protein expression (Evidence level II-1, grade of recommendation 1).

Table 1. Grading evidence and recommendations (adapted from GRADE system).

Grade evidence	
I	Randomised, controlled trials
II-1	Controlled trials without randomisation
II-2	Cohort or case-control analytical studies
II-3	Multiple time series, dramatic uncontrolled experiments
III	Opinions of respected authorities, descriptive epidemiology
Grade recommendation	
1	Strong recommendation: Factors influencing the strength of the recommendation included the quality of the evidence, presumed patient-important outcomes, and cost
2	Weaker recommendation: Variability in preferences and values, or more uncertainty: more likely a weak recommendation is warranted Recommendation is made with less certainty: higher cost or resource consumption

The level of HBV replication represents the strongest single predictive biomarker associated with disease progression and the long-term outcome of chronic HBV infection. The inhibition of viral replication by antiviral treatment has been shown to achieve the elimination of chronic HBV-induced necroinflammatory activity and progressive fibrotic liver processes in the vast majority of patients, in turn reducing the risk of HCC. It therefore represents the cornerstone endpoint of all our current therapeutic attempts.^{1,25,34–40} The level of HBV DNA suppression that should be attained in order to achieve these benefits is not well defined, but inferred that the lower, the better.

Treatment-induced HBeAg loss and seroconversion to anti-HBe characterises the induction of a partial immune control often leading to a low replicative phase of the chronic HBV infection. Whether this is a durable phase is only proven after treatment cessation. After stopping therapy, HBeAg seroreversion, as well as the development of HBeAg-negative CHB, may also occur (even after NA consolidation treatment), making this endpoint less reliable.^{41,42} Hence, continuing oral antiviral therapy irrespective of the HBeAg response until HBsAg loss has become an alternative strategy.

Suppression of HBV DNA to undetectable levels is normally associated with normalisation of ALT levels. Persistence of elevated ALT levels in patients with complete suppression of viral replication is associated with a lower chance of fibrosis regression and can be a reason for histologic disease progression.⁴³ The most likely explanation for these findings is the presence of concomitant liver injury such as alcoholic or non-alcoholic fatty liver disease.^{34,44} In contrast, transient ALT flares may indicate some level of immune reconstitution and can be associated with favourable outcomes.^{1,45,46}

The loss of HBsAg is regarded as the optimal treatment endpoint, termed 'functional cure', but it is only rarely achieved with our current antiviral armamentarium. Spontaneous HBsAg seroreversion with reactivation of the inflammatory liver process after HBsAg loss is rare and may occur in patients with a significant impairment of their immune function.^{47–52} The main advantage of HBsAg loss is that it allows a safe discontinuation of antiviral therapy. As chronic HBV infection cannot be completely eradicated due to the persistence of cccDNA and integrated HBV DNA,¹ it remains unclear whether HBsAg loss adds to the prevention of the long-term complications of chronic HBV infection beyond what can be achieved by the suppression of HBV DNA replication alone. HCC may still develop even after spontaneous HBsAg loss (annual rate approximately 0.55%).⁵³ The risk, however, is lower if HBsAg

loss is achieved at a younger age and/or in the absence of significant fibrosis.^{1,54} In an Asian cohort followed for 287 patient-years after NA treatment induced HBsAg seroclearance, only two patients with baseline cirrhosis developed HCC or died (0.7% annual risk), which was a significantly lower rate compared with propensity score-matched patients without HBsAg seroclearance (HR 0.09, $p < 0.01$).⁴⁷

Indications for treatment

Recommendations

- All patients with HBeAg-positive or -negative chronic hepatitis B, defined by HBV DNA $> 2,000$ IU/ml, ALT $> \text{ULN}$ and/or at least moderate liver necroinflammation or fibrosis, should be treated (Evidence level I, grade of recommendation 1).
- Patients with compensated or decompensated cirrhosis need treatment, with any detectable HBV DNA level and regardless of ALT levels (Evidence level I, grade of recommendation 1).
- Patients with HBV DNA $> 20,000$ IU/ml and ALT $> 2 \times \text{ULN}$ should start treatment regardless of the degree of fibrosis (Evidence level II-2, grade of recommendation 1).
- Patients with HBeAg-positive chronic HBV infection, defined by persistently normal ALT and high HBV DNA levels, may be treated if they are older than 30 years regardless of the severity of liver histological lesions (Evidence level III, grade of recommendation 2).
- Patients with HBeAg-positive or HBeAg-negative chronic HBV infection and family history of HCC or cirrhosis and extrahepatic manifestations can be treated even if typical treatment indications are not fulfilled (Evidence level III, grade of recommendation 2).

The indications for treatment are generally the same for both HBeAg-positive and HBeAg-negative CHB (Fig. 2). This is based mainly on the combination of three criteria:

- Serum HBV DNA levels
- Serum ALT levels
- Severity of liver disease

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Patients without cirrhosis should be considered for treatment when they have HBV DNA levels above 2,000 IU/ml, serum ALT levels above the traditional ULN (~40 IU/ml) and severity of liver disease assessed traditionally by liver biopsy showing at least moderate necroinflammation and/or at least moderate fibrosis. Patients with HBV DNA >20,000 IU/ml and ALT >2x ULN can start treatment even without a liver biopsy. Liver biopsy may provide additional useful information but it does not usually change the decision for treatment. A non-invasive method for the estimation of the extent of fibrosis and, most critically from a monitoring perspective, to confirm or rule out cirrhosis is useful in patients who start treatment without liver biopsy.

In patients who have HBV DNA >2,000 IU/ml and at least moderate fibrosis, treatment may be initiated even if ALT levels are normal. In patients who cannot or are reluctant to undergo liver biopsy, non-invasive markers of fibrosis may also be used for decisions on treatment indications.

As explained in more detail in the EASL-ALEH CPGs on “non-invasive tests for evaluation of liver disease severity and prognosis”,³² patients with chronic HBV infection either with normal ALT and liver stiffness >9 kPa, or with elevated ALT but below 5x ULN and liver stiffness >12 kPa at a reliable transient elastography can be considered to have severe fibrosis or cirrhosis. Equivalent cut-offs from other elastographic or serological methods of assessment of liver fibrosis may also be used once validated in chronic HBV patients.

Indications for treatment may also take into account the patients' age, health status, risk of HBV transmission, family history of HCC or cirrhosis and extrahepatic manifestations (Fig. 2).

Monitoring of patients currently not treated

Recommendations

- Patients with HBeAg-positive chronic HBV infection who are younger than 30 years and do not fulfill any of the above treatment indications should be followed at least every 3–6 months (Evidence level II-2, grade of recommendation 1).
- Patients with HBeAg-negative chronic HBV infection and serum HBV DNA <2,000 IU/ml who do not fulfill any of the above treatment indications should be followed every 6–12 months (Evidence level II-2, grade of recommendation 1).
- Patients with HBeAg-negative chronic HBV infection and serum HBV DNA ≥2,000 IU/ml who do not fulfill any of the above treatment indications should be followed every 3 months for the first year and every 6 months thereafter (Evidence level III, grade of recommendation 1).

Patients who are not candidates for antiviral therapy should be monitored with periodical assessments of serum ALT and HBV DNA levels as well as for liver fibrosis severity by non-invasive markers (Fig. 2). Patients with HBeAg-positive chronic HBV infection who remain untreated should ideally have ALT determinations at least every 3 months, HBV DNA determinations every 6–12 months and assessment of liver fibrosis every 12 months.¹

Patients with HBeAg-negative chronic HBV infection and HBV DNA <2,000 IU/ml should have ALT determinations every 6–12 months and periodical HBV DNA and liver fibrosis assessments, perhaps every 2–3 years. A quantitative determination of HBsAg levels can be helpful in the decision on the frequency of follow-up in such patients.²¹ Patients can be followed for ALT levels every 12 months and HBV DNA and liver fibrosis assessments every 3 years if they have HBsAg levels <1,000 IU/ml, while follow-up with ALT every 6 months and HBV DNA and liver fibrosis assessment at least every 2 years is advised for patients with HBsAg levels ≥1,000 IU/ml.^{1,21,55}

Patients with HBeAg-negative chronic HBV infection and HBV DNA ≥2,000 IU/ml should be followed with ALT determinations at least every 3 months for the first year and every 6 months thereafter, as well as with assessments of HBV DNA and liver fibrosis by a non-invasive method every year for at least 3 years. If they do not fulfill any treatment indication within the first 3 years of follow-up, they should be consequently followed for life, like all patients in this phase.⁵⁵

Treatment strategies

Currently, there are two main treatment options for CHB patients: treatment with a NA or with IFN α , currently pegylated (PegIFN α) (Table 2).^{1,56} The NAs that have been approved in Europe for HBV treatment include lamivudine (LAM), adefovir dipivoxil (ADV), entecavir (ETV), telbivudine (TBV), tenofovir disoproxil fumarate (TDF) and tenofovir alafenamide (TAF), and can be classified into those associated with low barrier against HBV resistance (LAM, ADV, TBV) and those with high barrier to HBV resistance (ETV, TDF, TAF) (Fig. 3).^{1,56,57}

The main advantage of treatment with a potent NA with high barrier to resistance (i.e., ETV, TDF, TAF) is its predictable high long-term antiviral efficacy leading to undetectable HBV DNA levels in the vast majority of compliant patients as well as its favourable safety profile (Table 2).^{1,56,57} These drugs can be safely used in any HBV infected patient and represent the only treatment option for several patient subgroups including those with decompensated liver disease, liver transplants, extrahepatic manifestations, acute hepatitis B or severe chronic HBV exacerbation.^{57–61} NAs are also the only option for prevention of HBV reactivation in patients under immunosuppression. In addition, preventing HBV transmission in patients with high viremia who do not fulfill the typical criteria for treatment initiation represents further indications in which only NAs should be used.^{1,49,50,52,56,57}

The rationale for a PegIFN α based approach is to induce long-term immunological control with a finite duration treatment. The main disadvantages of PegIFN α treatment is the high variability of response and its unfavourable safety profile making a significant number of patients ineligible or unwilling for this type of treatment (Table 2).^{1,56} Patient selection according to disease activity, HBV genotype, stage of the disease, as well as levels of HBV DNA, HBsAg and HBeAg status can be helpful indicators to predict the individual response probability.^{1,56} Early on-treatment predictors are established and can be used as additional tools (e.g. stopping rules) to individualise the treatment strategy, this helps to discontinue PegIFN α early in those with a low likelihood of long-term response.¹

Theoretically, a combined NA and PegIFN α approach may provide advantages by combining the potent antiviral effect of NA plus the immune modulation of IFN α .^{1,56,62,63} The evidence for

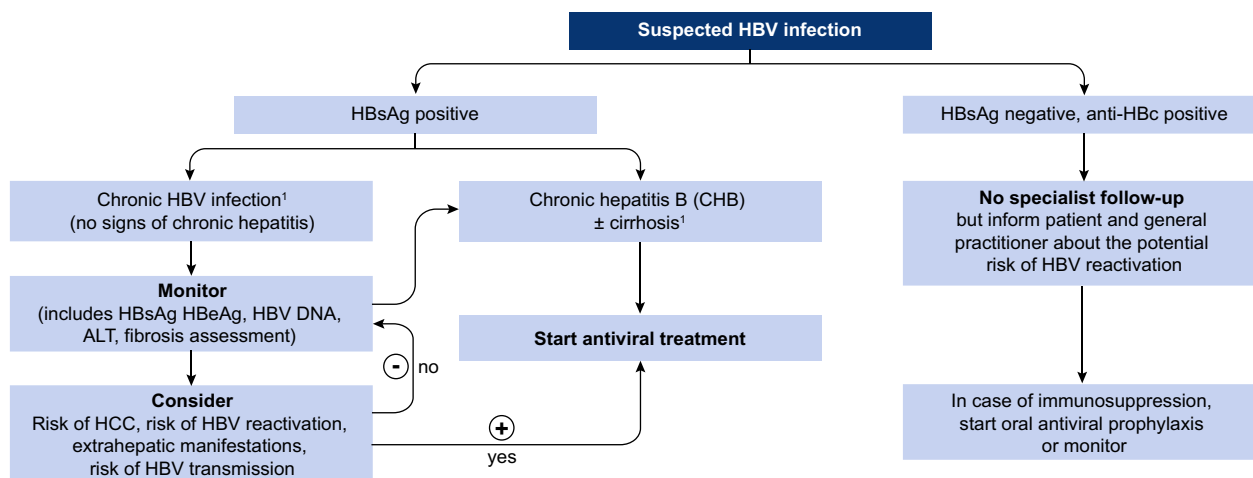


Fig. 2. Algorithm for the management of HBV infection. ¹see definitions in text and Fig. 1.

superiority of such a combined approach, however, is lacking, and there are still many unresolved issues with respect to patient selection, timing, as well as the duration of the combination strategy, which may be addressed in future studies.

Definitions of response

Responses can be divided into virological, serological, biochemical, and histological. All responses can be estimated at several time points during and after therapy. The definitions of virological responses vary according to the timing (on or after therapy) and type of therapy.¹

Virological responses

(1) NA therapy

- Virological response during NA is defined as undetectable HBV DNA by a sensitive polymerase chain reaction (PCR) assay with a limit of detection of 10 IU/ml. Primary non-response is defined by a less than one log₁₀ decrease of serum HBV DNA after 3 months of therapy. Partial virological response is defined as a decrease in HBV DNA of more than 1 log₁₀ IU/ml but detectable HBV DNA after at least 12 months of therapy in compliant patients. Virological breakthrough is defined as a confirmed increase in HBV DNA level of more than 1 log₁₀ IU/ml compared to the nadir (lowest value) HBV DNA level on-therapy; it may precede a biochemical breakthrough, characterised by an increase in ALT levels. HBV resistance to NA(s) is characterised by selection of HBV variants with amino acid substitutions that confer reduced susceptibility to the administered NA(s).
- In patients who discontinue NA, sustained off-therapy virological response could be defined as serum HBV DNA levels <2,000 IU/ml for at least 12 months after the end of therapy.

(2) PegIFNα therapy

- Virological response is defined as serum HBV DNA levels <2,000 IU/ml. It is usually evaluated at 6 months and at the end of therapy.
- Sustained off-therapy virological response is defined as serum HBV DNA levels <2,000 IU/ml for at least 12 months after the end of therapy.

Serological responses for HBeAg are HBeAg loss and HBeAg seroconversion, i.e., HBeAg loss and development of anti-HBe (only for HBeAg-positive patients).

Serological responses for HBsAg are HBsAg loss and HBsAg seroconversion, i.e., HBsAg loss and development of anti-HBs (for all patients).

Biochemical response is defined as a normalisation of ALT levels based on the traditional ULN (~40 IU/ml). Since ALT activity often fluctuates over time, a minimum follow-up of at least 1 year post-treatment with ALT determinations at least every 3 months is required to confirm sustained off-treatment biochemical response. It should be noted that the rates of sustained off-treatment biochemical responses may sometimes be difficult to evaluate, as transient ALT elevations before long-term biochemical remission may occur in some CHB patients within the first year after treatment discontinuation. In such cases, additional close ALT follow-up of at least 2 years after ALT elevation seems to be reasonable in order to confirm sustained off-therapy biochemical remission.

Histological response is defined as a decrease in necroinflammatory activity (by ≥2 points in histologic activity index or Ishak's system) without worsening in fibrosis compared to pre-treatment histological findings.

NAs for naïve CHB patients

Efficacy

Recommendations

- The long-term administration of a potent NA with high barrier to resistance is the treatment of choice regardless of the severity of liver disease (Evidence level I, grade of recommendation 1).
- The preferred regimens are ETV, TDF and TAF as monotherapies (Evidence level I, grade of recommendation 1).
- LAM, ADV and TBV are not recommended in the treatment of CHB (Evidence level I, grade of recommendation 1).

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Table 2. Main concepts and features of current treatment strategies of chronic hepatitis B.

Features	PegIFN α	ETV, TDF, TAF
Route of administration	Subcutaneous injections	Oral
Treatment duration	48 weeks	Long-term until HBsAg loss (stopping NA after some years might be considered in selected cases) ¹
Tolerability	Low	High
Long-term safety concerns	Very rarely persistence of on-treatment adverse events (psychiatric, neurological, endocrinological)	Probably not (uncertainties regarding kidney function, bone diseases for some NA)
Contraindications	Many (i.e., decompensated disease, co-morbidities etc.)	None (dose adjustment according to eGFR ²)
Strategy	Induction of a long-term immune control by finite treatment	Stopping hepatitis and disease progression by inhibiting viral replication
Level of viral suppression	Moderate (variable response pattern)	Universally high
Effect on HBeAg loss	Moderate, depending on baseline characteristics	Low in the first year, increases to moderate during long-term treatment
Effect on HBsAg levels	Variable, depending on baseline characteristics (overall higher as compared to NA)	Low: slowly increases with treatment time in HBeAg-positive patients ³ ; usually very low in HBeAg-negative patients
Risk of relapse after treatment cessation	Low for those with sustained response 6–12 months after therapy	Moderate if consolidation treatment provided after HBeAg seroconversion. High for HBeAg-negative disease
Early stopping rules	Yes	No
Risk of viral resistance development	No	Minimal to none ⁴

PegIFN α , pegylated interferon alfa; ETV, entecavir; TDF, tenofovir disoproxil fumarate; TAF, tenofovir alafenamide; NA, nucleoside/nucleotide analogues; eGFR, estimated glomerular filtration rate.

¹ See section on 'Treatment strategies'.

² Dose adjustments in patients with eGFR <50 ml/min are required for all NA, except for TAF (no dose recommendation for TAF in patients with CrCl <15 ml/min who are not receiving haemodialysis).

³ A plateau in serologic responses has been observed beyond treatment year 4.

⁴ So far no TDF or TAF resistance development has been detected.

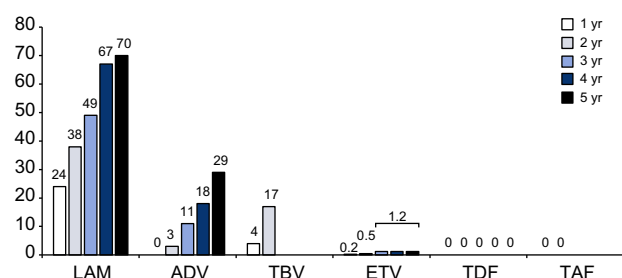


Fig. 3. Cumulative incidence of HBV resistance for lamivudine (LAM), adefovir (ADV), entecavir (ETV), telbivudine (TBV), tenofovir (TDF) and tenofovir alafenamide (TAF) in pivotal trials in nucleos(t)ide-naïve patients with chronic hepatitis B. (Collation of currently available data – not from head-to-head studies). No evidence of resistance has been shown after 8 years of TDF treatment.⁶⁹

The efficacy of all NAs has been assessed in randomised controlled phase III clinical trials (Table 3 and 4). The treatment strategy for non-cirrhotic and compensated cirrhotic HBV patients is identical given the efficacy and long-term safety profile in NA therapy. In HBeAg-positive CHB, 5 years of ETV achieve a 99% cumulative probability of virologic response and 53% probability of HBeAg loss.²⁶ After 5 years of TDF treatment in patients with HBeAg-positive CHB, 97% of those on-treatment had virologic response and 73% had normal ALT,³⁴ while HBeAg loss was present in 49%, HBeAg seroconversion in 40%, HBsAg loss in 10% and HBsAg seroconversion in 8%.

In patients with HBeAg-negative CHB, the 5-year cumulative probability of virological and biochemical responses on ETV was 98% and 95%, respectively, while the rate of resistance to ETV was <1%.^{26,64–68} After 8 years, 99% of HBeAg-negative CHB patients treated with TDF in the registration trial achieved virological response (HBV DNA <400 copies/ml) without evidence of TDF resistance and 88% normalised ALT.⁶⁹ During 3–4 years of TDF treatment in HBeAg-negative CHB patients in real practice, the virological response rates ranged from 92% to 100% without the emergence of TDF resistance, while 75% of patients had normalised ALT.^{70–73} No HBeAg-negative CHB patient cleared HBsAg within the first year of ETV or TDF therapy and very few (~1%) achieved this endpoint during long-term (8 years) therapy.

In patients with HBeAg-positive CHB, the rates of virologic response on TAF were 64% at week 48 and 75% at week 96.^{74,75} HBeAg loss and anti-HBe seroconversion were achieved in 14% and 10% of patients at week 48 and 22% and 18% at week 96, respectively. In the same study, ALT normalisation rates at week 96 by traditional values were higher in patients treated with TAF than TDF (75% vs. 68%), whereas only 1% of patients cleared HBsAg.^{74–76} In HBeAg-negative CHB patients, TAF achieved virologic response in 94% of patients at week 48,⁷⁶ which was maintained in most cases at week 96 (90%). Only one TAF treated HBeAg-negative CHB patient (<1%) cleared HBsAg by week 96.⁷⁷ These virological and serological results are similar to those observed in the TDF arms in both studies. Only 96-week results are available for TAF to date, with the studies still ongoing (Table 3 and 4).

Monitoring of patients treated with ETV, TDF or TAF

Recommendations

- All patients treated with NA should be followed with periodical assessments including ALT and serum HBV DNA (Evidence level I, grade of recommendation 1).
- Patients at risk of renal disease treated with any NA and all patients regardless of renal risk treated with TDF should undergo periodical renal monitoring including at least estimated glomerular filtration rate (eGFR) and serum phosphate levels (Evidence level II-2, grade of recommendation 1).
- Patients on TDF at risk of development and/or with underlying renal or bone disease should be considered for a switch to ETV or TAF, depending on previous LAM exposure (Evidence level II-2/I, grade of recommendation 1).

All patients considered for treatment with a NA with high barrier to resistance (ETV, TDF, TAF) should undergo periodical monitoring. At baseline, full blood count, liver and kidney (eGFR and serum phosphate levels) function tests, serum HBV DNA levels assessed by a sensitive PCR assay should be performed. Appropriate dosing adjustments of ETV and TDF are recommended for patients with eGFR <50 ml/min. TAF dosage remains at 25 mg until eGFR is <15 ml/min, with modeling pharmacokinetics data suggesting no dose change between <15 ml/min and formal renal support, although this is not within the label (Vemlidy® SmPC).⁷⁸ In addition, the baseline renal risk should be assessed for all patients. High renal risk includes one or more of the following factors: decompensated cirrhosis, creatinine clearance (eGFR) <60 ml/min, poorly controlled hypertension, proteinuria, uncontrolled diabetes, active glomerulonephritis, concomitant nephrotoxic drugs, or solid organ transplantation.

During treatment, liver function tests should be performed every 3–4 months during the first year and every six months thereafter. Serum HBV DNA should be determined every 3–4 months during the first year and every 6–12 months thereafter. HBsAg should be checked at 12-month intervals if HBV DNA remains undetectable, while patients who clear HBsAg should be tested for anti-HBs.

Minimal rates of renal function decline have been reported during long-term therapy with ETV and TDF, but the nephrotoxic potential is higher for TDF. Cases of Fanconi syndrome associated with TDF therapy and rescued after a switch to ETV have been reported. In addition, studies using sensitive markers of glomerular and tubular kidney function and of bone mineral density have also reported chronic tubular damage and decline of eGFR and bone mineral density in TDF treated patients.^{70,79–87} Therefore, it seems appropriate for now to monitor all CHB patients treated with TDF therapy for adverse renal effects with serum creatinine (eGFR) and serum phosphate levels. Moreover, CHB patients at high renal risk undergoing any NA therapy should be monitored with serum creatinine (eGFR) levels. The frequency of renal monitoring can be every 3 months during the first year and every 6 months thereafter, if no deterioration. Closer renal monitoring is required in patients who develop

creatinine clearance <60 ml/min or serum phosphate levels <2 mg/dl.

In the two registrational TAF trials, TAF compared to TDF demonstrated superiority in the drug effects on several markers of renal (both glomerular and tubular) function and bone turnover at weeks 48 and 96.^{74–77,88} In both groups of patients there was a significant difference in markers reflecting renal and bone function at week 48. A significant difference was noted in decrease of eGFR in both studies: –0.6 ml/min vs. –5.4 ml/min in HBeAg-positive patients ($p < 0.0001$), –1.8 ml/min vs. –4.8 ml/min in HBeAg-negative patients ($p = 0.004$). Similar mean serum creatinine changes were demonstrated between TAF and TDF treated subjects: HBeAg-positive TAF treated patient's 0.01 mg/dl vs. 0.03 mg/dl in TDF ($p = 0.02$); HBeAg-negative 0.01 mg/dl vs. 0.02 mg/dl ($p = 0.32$). Likewise, a significantly smaller percentage decline in bone mineral density at the hip was reported in TAF patients over TDF treated patients (–0.10% vs. –1.72% in HBeAg-positive patients [$p < 0.0001$], and –0.29% vs. –2.16% in HBeAg-negative [$p < 0.0001$]) and spine (–0.42% vs. –2.29% in HBeAg-positive, –0.88% vs. –2.51% HBeAg-negative. Additional data with biomarkers of renal tubular function and bone turnover suggest less systemic effects in TAF compared to TDF, with less progression of chronic kidney disease and bone effects up to week 96.^{75,77} Long-term clinical data are lacking, however, similar findings of superiority of TAF over TDF have also been found in recent studies in HIV infected patients at risk for or with established renal and bone impairment.^{89–92}

These co-infected data also demonstrate stabilisation in renal parameters (GFR, creatinine) but improvement in proteinuria, albuminuria and tubular proteinuria, ($p < 0.001$) as well as increases in hip and spine bone mineral densitometry from baseline to week 48 (mean percent change +1.47 and +2.29, respectively, $p < 0.05$)⁹¹; with similar findings to 96 weeks.⁹²

Whether these findings translate into improved long-term clinical outcomes in CHB patients remains to be defined, but an optimised safety profile of long-term NA therapy might be preferred, particularly in an ageing CHB population, with accruing co-morbidities. Thus, in CHB patients with deteriorating renal function or low eGFR and/or osteopenia/osteoporosis, particularly in older age, the minimisation of progression of the physiological decline into pathological abnormality should also be considered when choosing NA therapy (Table 5). In such subgroups of CHB patients, both ETV and TAF represent suitable choices with TAF having an advantage in patients with previous exposure to LAM.

Long-term outcome during NA

Recommendations

- Patients under effective long-term NA therapy should remain under surveillance for HCC (Evidence level II-2, grade of recommendation 1).
- HCC surveillance is mandatory for all patients with cirrhosis as well as those with moderate or high HCC risk scores at the onset of NA therapy (Evidence level II-2, grade of recommendation 1).

Long-term ETV or TDF monotherapy has been shown to halt progression of liver disease, and can also result in a significant improvement of histological necroinflammation and fibrosis,

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Table 3. Results of main studies for the treatment of HBeAg-positive chronic hepatitis B at 6 months following 48 or 52 weeks of pegylated interferon alfa (PegIFN α) and at 48 or 52 weeks of nucleos(t)ide analogue therapy.

	PegIFN		Nucleoside analogues			Nucleotide analogues		
	PegIFN α 2a	PegIFN α 2b	LAM	TBV	ETV	ADV	TDF	TAF
Dose ^a	180 μ g	100 μ g	100 mg	600 mg	0.5 mg	10 mg	245 mg	25 mg
Anti-HBe-seroconversion	32%	29%	16–18%	22%	21%	12–18%	21%	10%
HBV DNA <60–80 IU/ml	14%	7%	36–44%	60%	67%	13–21%	76%	64%
ALT normalisation [#]	41%	32%	41–72%	77%	68%	48–54%	68%	72%
HBsAg loss	3%	7%	0–1%	0.5%	2%	0%	3%	1%

References: see EASL CPG 2012¹ for all drugs except for TAF.⁷⁶

PegIFN α , pegylated interferon alfa; ETV, entecavir; TDF, tenofovir disoproxil fumarate; TAF, tenofovir alafenamide; LAM, lamivudine; TBV, telbivudine; ADV, adefovir; ALT, alanine aminotransferase.

^a PegIFN α were given as percutaneous injections once weekly and nucleos(t)ide analogues as oral tablets once daily.

[#] The definition of ALT normalisation varied among different trials (i.e., decrease of ALT to ≤ 1.25 -times the upper limit of normal (xULN) in the ETV or $\leq 1.3 \times$ ULN in the TBV trial). The lower quantification limit of HBV DNA assays was different across studies: <29 IU/ml for TAF studies.

Table 4. Results of main studies for the treatment of HBeAg-negative chronic hepatitis B at 6 months following 48 weeks of pegylated interferon alfa (PegIFN α) and at 48 or 52 weeks of nucleos(t)ide analogue therapy.

	PegIFN	Nucleoside analogues			Nucleotide analogues		
	PegIFN α 2a	LAM	TBV	ETV	ADV	TDF	TAF
Dose ^a	180 μ g	100 mg	600 mg	0.5 mg	10 mg	245 mg	25 mg
HBV DNA <60–80 IU/ml	19%	72–73%	88%	90%	51–63%	93%	94%
ALT normalisation [#]	59%	71–79%	74%	78%	72–77%	76%	83%
HBsAg loss	4%	0%	0%	0%	0%	0%	0%

References: EASL CPG 2012¹ for all drugs except for TAF.⁷⁴

PegIFN α , pegylated interferon alfa; ETV, entecavir; TDF, tenofovir disoproxil fumarate; TAF, tenofovir alafenamide; LAM, lamivudine; TBV, telbivudine; ADV, adefovir; ALT, alanine aminotransferase.

^a PegIFN α was given as percutaneous injections once weekly and nucleos(t)ide analogues as oral tablets once daily.

[#] The definition of ALT normalisation varied among different trials (i.e., decrease of ALT to ≤ 1.25 -times the upper limit of normal [ULN] in the ETV or ≤ 1.3 -times the ULN in the TBV trial). The lower quantification limit of HBV DNA assays was different across studies: for TAF studies it was <29 IU/ml.

often with a regression of established cirrhosis.^{1,34} Moreover, complications of pre-existing decompensated cirrhosis, particularly at an early stage of decompensation, improve or even disappear and the need for liver transplantation is dramatically reduced.¹

HCC may still develop and remains the major concern for CHB patients treated with NAs.^{24,25} Long-term therapy with NAs appears to favourably impact HCC incidence when data from randomised or matched controlled studies are considered.^{24,25} After the first 5 years of ETV or TDF therapy in CHB patients, recent data suggest that the HCC incidence is decreasing further, with the decrease being more evident in patients with baseline cirrhosis.⁹³ In addition, HCC seems to be the only factor affecting long-term survival in ETV or TDF treated CHB patients with or without compensated cirrhosis.⁹⁴ Since NAs are used in the majority of CHB patients because of their favourable effects on the overall long-term outcome, the main clinical challenge is to identify the patients at risk of HCC who require close surveillance. The Asian HCC risk scores, GAG-HCC, CU-HCC and REACH-B, have been validated in treated Asian CHB patients,²⁵ however the PAGE-B score is the only one that offers good predictability for HCC in Caucasian treated CHB patients.²⁸ Based on the HCC risk scores, patients can be classified into those at low, medium and high risk of HCC. Patients in the low HCC risk group have no or negligible probability of HCC development and therefore may not require HCC surveillance.^{25,28}

Despite the remaining risk of developing HCC, the overall survival improves in patients under long-term effective NA(s)

therapy.^{1,39,94–96} Loss of HBsAg during long-term NA therapy may occur in a minority of CHB patients who were initially HBeAg-positive (approximately 10–12% after 5–8 years of therapy) while is rare in patients with HBeAg-negative CHB (<1–2% after 5–8 years of therapy).^{1,83}

NA discontinuation

Recommendations

- NAs should be discontinued after confirmed HBsAg loss, with or without anti-HBs seroconversion (Evidence level II-2, grade of recommendation 1).
- NAs can be discontinued in non-cirrhotic HBeAg-positive CHB patients who achieve stable HBeAg seroconversion and undetectable HBV DNA and who complete at least 12 months of consolidation therapy. Close post-NA monitoring is warranted (Evidence level II-2, grade of recommendation 2).
- Discontinuation of NAs in selected non-cirrhotic HBeAg-negative patients who have achieved long-term (≥ 3 years) virological suppression under NA(s) may be considered if close post-NA monitoring can be guaranteed (Evidence level II-2, grade of recommendation 2).

Table 5. Indications for selecting ETV or TAF over TDF.*

1. Age >60 year
2. Bone disease
Chronic steroid use or use of other medications that worsen bone density
History of fragility fracture
Osteoporosis
3. Renal alteration**
eGFR <60 ml/min/1.73 m ²
Albuminuria >30 mg or moderate dipstick proteinuria
Low phosphate (<2.5 mg/dl)
Hemodialysis

* TAF should be preferred to ETV in patients with previous exposure to nucleoside analogues.

** ETV dose needs to be adjusted if eGFR <50 ml/min; no dose adjustment of TAF is required in adults or adolescents (aged at least 12 years and of at least 35 kg body weight) with estimated creatinine clearance (CrCl) ≥ 15 ml/min or in patients with CrCl <15 ml/min who are receiving haemodialysis.

Since NA therapy does not usually achieve HBV eradication and rarely results even in HBsAg loss,⁸³ long-term therapeutic regimens are given in the majority of NA treated CHB patients. A widely accepted stopping rule exists only for a proportion of patients with HBeAg-positive CHB who can discontinue NAs if they achieve HBeAg seroconversion and HBV DNA undetectability and have completed 6 or preferentially 12 months of ensuing consolidation therapy.^{1,56} According to the existing data, HBeAg seroconversion will remain in the majority (approximately 90%) and virological remission defined as HBV DNA <2,000–20,000 IU/ml will be maintained in ~50% of such patients at 3 years after NAs cessation.⁴¹ Alternatively, clinicians may choose to continue NA therapy until HBsAg clearance, which represents the safest current treatment endpoint.¹

Long-term, perhaps indefinite, NA therapy is usually given in HBeAg-negative CHB patients, who are considered to be able to safely stop NAs only if they achieve HBsAg loss.¹ Recent evidence, accumulating mainly from Asian countries, in which NAs can be discontinued in HBeAg-negative CHB patients who achieve serum HBV DNA undetectability on three separate occasions 6 months apart,⁹⁷ suggests that the discontinuation of NAs might be also feasible in this setting. An important factor affecting the probability of off-NA virological remission appears to be the duration of on-therapy HBV DNA undetectability.⁴¹ According to the existing data, virological remission defined as HBV DNA <2,000–20,000 IU/ml will be maintained in approximately 50% of such patients 3 years after NAs cessation if they have remained for more than two years on virological remission during therapy.⁴¹ Since such findings are based on studies with durations of on-therapy virological remission of >2 to 5 years,⁴¹ the optimal duration of on NAs remission before discontinuation remains unclear. Since overt hepatitis flares and life-threatening episodes have been rarely reported in patients with pre-existing cirrhosis who discontinue NAs,⁹⁸ treatment discontinuation is currently discouraged in patients with cirrhosis. Moreover, NAs may be discontinued only in patients who can be followed closely with ALT and HBV DNA determinations at least during the first year following NAs cessation. Unfortunately, no reliable predictor of post-NAs remission has been identified to date. Retreatment criteria are also important, but have yet to be determined.⁴¹ Based on reasonable clinical judgment, treatment indications for naïve CHB patients may be also applied in patients who discontinue NAs.

Management of patients with NA failure

Recommendations

- Prevention of resistance should rely on the use of first line therapy with high barrier to resistance NAs (Evidence level I, grade of recommendation 1).
- Compliance to NA therapy should be checked in all cases of treatment failure (Evidence level II-1, grade of recommendation 1).
- Management of treatment failure should be based on NAs cross-resistance data (Evidence level II-2, grade of recommendation 1).
- Treatment adaptation should be performed as soon as virologic failure under NAs is confirmed (Evidence level II-1, grade of recommendation 1).

Preventing the emergence of resistance is based on the use of NAs with high barrier to resistance and maximal viral suppression as a first line therapy (Fig. 3). The combination of NAs with low barrier to resistance, such as LAM or TBV with ADV, should be avoided, as this may lead to inappropriate viral suppression and the emergence of multidrug resistant strains. In addition, sequential monotherapies with agents with a low barrier to resistance should be strictly avoided because of the high risk of emerging multidrug resistance strains.⁹⁹

Managing NA failures in CHB patients remains a crucial issue in countries in which ETV, TDF and TAF are not available or fully reimbursed for naïve patients or treatment experienced patients. By contrast, in countries where NAs with a high barrier to resistance have been routinely used for many years, the impact of treatment failures has become minimal. Treatment failure can be defined as primary non-response, partial virological response and virological breakthrough (see section 'Definitions of response').¹⁰⁰

Primary non-response. In patients with primary non-response to any NA, it is important to check for compliance. Poor compliance is now the main cause of primary non-response. In a compliant patient with a primary non-response, genotyping of HBV strains for identifying possible resistance mutations may help in formulating a rescue strategy. Primary non-response is almost exclusively seen with ADV because of suboptimal antiviral potency and should lead to a rapid switch to TDF or ETV.

Partial virological response. Partial virological response may be encountered with all available NAs. It is always important to check for compliance. If patients receive NA with low barrier to resistance (LAM, ADV, TBV), it is recommended to change to a more potent drug without cross-resistance. Most of the time, partial virological response under ETV or TDF is associated with a very high pretreatment viral load and not the result of a lack of efficacy but rather of the potency limit of the antiviral drug. In such patients with a partial virological response at week 48, the HBV DNA levels at week 48 and their kinetics must be taken into account. Patients with declining serum HBV DNA levels may continue treatment with the same agent given the rise in rates of virological response over time and the very low risk of resistance with long-term monotherapy with both agents. It can be assumed that the same applies to TAF. In those with plateauing levels of

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HBV DNA a switch to the other drug or a combination of ETV + TDF/TAF can be envisaged especially in patients with advanced liver disease (see section 'Long-term outcome during NA').

Virological breakthrough. Virological breakthrough in compliant patients is mainly related to the development of HBV drug resistance. The rate of virological breakthrough depends on the barrier to resistance of the NA. Treatment adaptation should be performed as soon as viral breakthrough is identified and confirmed one month apart to prevent a further increase in viral load, subsequent ALT elevation and progression of liver disease including the risk of liver failure.^{99,100}

Management of antiviral drug resistance

Although a concern, antiviral drug resistance has become a manageable issue. The risk of resistance is associated with high baseline HBV DNA levels, a slow decline in HBV DNA and a previous suboptimal NA treatment. Resistance should be identified by HBV DNA monitoring and ideally identification of the pattern of resistance mutations should be used to adapt treatment strategy.

In case of resistance, an appropriate rescue therapy should be initiated with the most effective antiviral agent that does not share cross-resistance to minimise the risk of inducing multiple drug-resistant strains. Table 6 shows cross-resistance data for the most frequent resistant variants. Table 7 shows the recommendations for treatment adaptation.^{99,100} In patients with multidrug resistance, genotypic resistance testing should be performed by a reference laboratory. Combination of TDF with ETV has been evaluated in several clinical studies and appears to be a safe option as a rescue therapy.^{101–104}

PegIFN α monotherapy for CHB patients

Efficacy

Recommendations

- PegIFN α can be considered as an initial treatment option for patients with mild to moderate HBeAg-positive or -negative CHB (Evidence level I, grade of recommendation 2).
- The standard duration of PegIFN α therapy is 48 weeks (Evidence level I, grade of recommendation 1).
- The extension of the duration of PegIFN α therapy beyond week 48 may be beneficial in selected HBeAg-negative CHB patients (Evidence level II-1, grade of recommendation 2).

Only patients with mild to moderate CHB and perhaps selected patients with compensated cirrhosis but no portal hypertension should be considered for PegIFN α therapy (Table 2). In HBeAg-positive CHB patients, response rates at 6 months following 12 months of PegIFN α therapy are 20–30% (Table 3). Although most patients respond with HBeAg loss or seroconversion during the first 6 months of therapy, a 6 month course of PegIFN α and/or a lower dose are inferior to the recommended 12 month course. A combined endpoint of HBeAg loss with HBV DNA <2,000 IU/ml at 6 months post-treatment was achieved in 23% in a meta-analysis of three large trials¹⁰⁵ (Table 3). Among patients who achieved HBeAg loss at 6 months post-treatment,

HBeAg negativity was sustained 3 years post-treatment in 81%. Rates of HBsAg loss following 12 months of treatment are 3–7%. HBsAg loss rates increase after the end of PegIFN α therapy in initially HBeAg-positive CHB patients with sustained virological responses (Table 3). Of the patients with an initial HBeAg loss, 30% experienced HBsAg loss after 3 years of follow-up. The sustainability of HBsAg loss and seroconversion after PegIFN α is good although HBsAg seroreversions have been described.^{62,106}

In HBeAg-negative CHB patients, the 48-week PegIFN α registration trial showed sustained biochemical and virological response rates of 60% and 44% at 6 months and of 31% and 28% at 3 years after the end of therapy.^{1,107} (Table 4). PegIFN α was less effective in HBeAg-negative patients with genotype D or E, who had sustained virological responses in the range of 20%. Few real life studies have addressed the efficacy of PegIFN α in HBeAg-negative CHB patients with genotype B or C. In a retrospective Korean study, approximately 30% of genotype C HBeAg-negative patients achieved virological response at 1 year after the end of PegIFN α .^{1,108}

HBsAg loss rarely occurred during PegIFN α therapy in HBeAg-negative CHB patients, but the rate of HBsAg loss progressively increased after PegIFN α discontinuation, from 3% at month 6 to 9% at year 3 to 12% at year 5 in the registration trial¹ (Table 4). Similar rates were confirmed by real life studies.^{1,107} Overall, among sustained responders, approximately 30% clear HBsAg in the long-term.

Two studies assessed the safety and efficacy of extending the duration of PegIFN α therapy beyond 48 weeks in HBeAg-negative CHB patients. In a European randomised trial with predominantly genotype D patients, 96 compared to 48 weeks of PegIFN α therapy achieved higher rates of sustained virological response (29% vs. 12%, $p = 0.03$) and HBsAg loss (6% vs. 0%).¹⁰⁹ Similarly, a Chinese study including HBeAg-negative CHB patients with genotype B or C showed that 72 compared to 48 weeks of PegIFN α resulted in higher rates of sustained virological response (50% vs. 16%, $p = 0.001$) and HBsAg loss (36% vs. 10%, $p < 0.05$).¹¹⁰

Monitoring of patients treated with PegIFN α

Recommendations

- All CHB patients treated with PegIFN α should be followed with periodical assessments of at least full blood count, ALT, TSH, serum HBV DNA and HBsAg levels (Evidence level I/II-2, grade of recommendation 1).
- HBeAg-positive CHB patients treated with PegIFN α should be also followed with periodical assessments of HBeAg and anti-HBe (Evidence level I, grade of recommendation 1).
- CHB patients with virological response after PegIFN α therapy should remain under long-term follow-up because of the risk of relapse (Evidence level II-2, grade of recommendation 1).

In patients treated with PegIFN α , full blood counts and serum ALT levels should be monitored monthly and TSH should be monitored every 3 months.¹ All patients should be monitored for safety through 12 months of treatment. Serum HBV DNA and HBsAg levels in all CHB patients and HBeAg and anti-HBe in

HBeAg-positive CHB patients should be checked at 3, 6 and 12 months of PegIFN α treatment and at 6 and 12 months post-treatment. Sustained serum HBV DNA <2,000 IU/ml, or even better HBsAg loss, together with ALT normalisation in all CHB patients as well as with HBeAg seroconversion in HBeAg-positive CHB patients are the desired treatment endpoints. Sustained virological response after PegIFN α is usually associated with remission of the liver disease, but all such patients require long-term follow-up because of the risk of exacerbation with development of HBeAg-negative CHB or even of HBeAg seroreversion in initially HBeAg-positive patients. The risk of HBV reactivation seems to diminish over time. In patients with undetectable HBV DNA (and negative HBeAg), HBsAg should be checked at 12 month intervals, as the rate of HBsAg loss increases over time. Patients who become HBsAg-negative should be tested for anti-HBs.

Predictors of PegIFN α response and stopping rules

Recommendations

- In HBeAg-positive CHB patients, HBsAg levels >20,000 IU/ml for genotype B and C, or no decline of HBsAg levels for genotype A and D, at 12 weeks of PegIFN α therapy are associated with a very low probability of subsequent HBeAg seroconversion and can be used as PegIFN α stopping rules (Evidence level II-2, grade of recommendation 2).
- In HBeAg-positive CHB patients with genotype A-D, HBsAg levels >20,000 IU/ml at 24 weeks of PegIFN α therapy are associated with a very low probability of subsequent HBeAg seroconversion and can be used as PegIFN α stopping rules (Evidence level II-2, grade of recommendation 2).
- In HBeAg-negative CHB patients with genotype D, a combination of no decrease in HBsAg levels and <2 log₁₀ IU/ml reduction in serum HBV DNA levels at 12 weeks of PegIFN α therapy predicts no response and should be used as PegIFN α stopping rules (Evidence level II-2, grade of recommendation 1).

Pretreatment. In HBeAg-positive CHB patients, pretreatment predictors of response are low viral load, high serum ALT levels (above 2–5 times ULN), HBV genotype and high activity scores

on liver biopsy. HBV genotypes A and B have been shown to be associated with higher rates of HBeAg seroconversion and HBsAg loss than genotypes C and D.

In HBeAg-negative CHB patients, high baseline ALT, low baseline HBV DNA, younger age, female gender and HBV genotype were independent predictors of response to PegIFN α therapy but the negative and positive values of these variables are low. Patients with genotypes B or C had a better chance of response than genotype D patients.¹ Using pooled data from several studies of PegIFN α therapy in HBeAg-negative CHB patients, a baseline score system (ranging from 0–7) that combined five variables (HBV genotype, HBV DNA, ALT, HBsAg levels and age) identified patients with high and low likelihood of response, but this score has not been validated yet.^{111,112} Baseline host genetic testing to prioritize CHB patients for PegIFN α therapy is not currently recommended in clinical practice, as the initial promising results were not confirmed in subsequent studies.^{113,114}

During treatment. The most important on-treatment predictor of response to PegIFN α is serum HBsAg levels,¹⁰⁵ although they are influenced by HBV genotype.¹¹⁵ In HBeAg-positive CHB patients, a decline of HBsAg levels below 1,500 IU/ml at 12 weeks is a reasonable predictor of HBeAg seroconversion (positive predictive value: 50%), while HBsAg levels >20,000 IU/ml for HBV genotype B and C or no decline of HBsAg levels for HBV genotype A and D are associated with a very low probability of subsequent HBeAg seroconversion¹⁰⁵ (Fig. 4). At week 24 HBsAg levels >20,000 IU/ml predict no response regardless of genotype (Fig. 4). A substantial HBV DNA decrease at 12 weeks has been associated with a 50% chance of HBeAg seroconversion. Also, HBeAg levels and immunologically induced ALT flares followed by a HBV DNA decrease are associated with more frequent HBeAg seroconversion. However, clinically meaningful cut-offs for HBV DNA and HBeAg levels as a tool for on-treatment response prediction have not been reported, these are based on validated studies using adequate outcomes.¹¹⁶

In HBeAg-negative CHB patients, a combination of a lack of decrease in HBsAg levels and <2 log₁₀ IU/ml decline in HBV DNA at 12 weeks of PegIFN α predicts a no response in genotype D patients (negative predictive value: 100%) (Fig. 4). This stopping rule would allow approximately 20% of patients to discontinue PegIFN α .^{1,117,118} No robust on-treatment stopping rules have been developed for HBeAg-negative CHB patients with genotype B or C and very few data are available for those with genotype A and E.¹¹⁸ Some studies have also looked for

Table 6. Cross-resistance data for the most frequent resistant HBV variants.

HBV variant	LAM	LDT	ETV	ADV	TDF/TAF
Wild-type	S	S	S	S	S
M204V	R	S	I	I	S
M204I	R	R	I	I	S
L180M + M204V	R	R	I	I	S
A181T/V	I	I	S	R	I
N236T	S	S	S	R	I
L180M + M204V/I ± I169T ± V173L ± M250V	R	R	R	S	S
L180M + M204V/I ± T184G ± S202I/G	R	R	R	S	S

The amino acid substitution profiles are shown in the left column and the level of susceptibility is given for each drug: S (sensitive), I (intermediate/reduced susceptibility), R (resistant).

ETV, entecavir; TDF, tenofovir disoproxil fumarate; TAF, tenofovir alafenamide; LAM, lamivudine; ADV, adefovir.

* *In vitro* data for tenofovir, *in vivo* data for TDF, no clinical data for TAF.

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Table 7. Management of patients who develop NA resistance.

Resistance pattern	Recommended rescue strategies
LAM resistance	Switch to TDF or TAF
TBV resistance	Switch to TDF or TAF
ETV resistance	Switch to TDF or TAF
ADV resistance	If LAM-naïve: switch to ETV or TDF or TAF If LAM-resistance: switch to TDF or TAF If HBV DNA plateaus: add ETV ^{***} or switch to ETV
TDF or TAF resistance ^{**}	If LAM-naïve: switch to ETV If LAM-R: add ETV [*]
Multidrug resistance	Switch to ETV plus TDF or TAF combination

ETV, entecavir; TDF, tenofovir disoproxil fumarate; TAF, tenofovir alafenamide; LAM, lamivudine; ADV, adefovir; TBV, telbivudine.

^{*} The long-term safety of these combinations is unknown.

^{**} Not seen clinically so far; do genotyping and phenotyping in an expert laboratory to determine the cross-resistance profile.

^{***} Especially in patients with ADV resistant mutations (rA181T/V and/or rN236T) and high viral load, the response to TDF (TAF) can be protracted.

on-treatment positive predictors of sustained response. For HBeAg-negative CHB patients with non-D genotype, a $\geq 10\%$ decline in serum HBsAg from baseline to week 12 of PegIFN α treatment had a higher probability of achieving a sustained response than those with a $<10\%$ decline (47% vs. 16%, $p < 0.01$) but the positive predictive value was low ($\sim 50\%$).¹⁰⁷

Safety of PegIFN α

PegIFN α therapy is associated with considerable side effects although patients with HBV infection seem to tolerate it reasonably well because they are often younger and have less comorbidity than patients who were treated with this agent in the setting of HCV infection.¹ The most frequently reported side effects are flu-like syndrome, myalgia, headache, fatigue, weight loss, depression, hair loss and local reactions at the site of injection. Hepatitis flares may occur which can result in decompensation of liver disease, therefore PegIFN α is contraindicated in patients with decompensated cirrhosis. PegIFN α treatment is also associated with mild myelosuppression, but neutropenia and thrombocytopenia are usually well managed with dose-reduction and only rarely result in clinically significant infection or bleeding. The combination of PegIFN α with telbivudine is contraindicated due to a high risk of neuropathy.

Long-term outcome after PegIFN α

Recommendation

- Patients with sustained responses after PegIFN α therapy and high baseline HCC risk should remain under surveillance for HCC even if they achieve HBsAg loss (Evidence level III, grade of recommendation 1).

The majority of patients who achieve sustained off-treatment responses after IFN α or PegIFN α therapy maintains such responses during long-term follow-up of at least 5 years.¹¹⁹ In sustained responders, there is no progression of liver disease and baseline liver histological lesions improve.¹ HCC may still develop after PegIFN α therapy, even in patients with sustained off-treatment responses, particularly in those with pre-existing

cirrhosis.¹²⁰ The benefit from PegIFN α therapy on the HCC incidence seems to be more clear in Asian patients¹²⁰ and perhaps superior than that of NA therapy.¹²¹ In addition, old cohort studies with standard IFN α and systematic reviews show that the incidence of HCC is decreased in IFN α treated compared to untreated CHB patients, with such an effect being clearer in Asian patients and those with sustained off-treatment responses and/or compensated cirrhosis.^{1,24} Cohort studies in both HBeAg-positive and HBeAg-negative CHB have shown that courses of standard IFN α treatment result in improved overall long-term outcomes including survival in patients with sustained off-treatment responses.¹ Survival data are not available for PegIFN α therapy, but the same favourable outcomes are expected if sustained off-treatment responses are achieved. Rates of HBsAg loss in sustained responders are gradually increasing approaching 50% at 5 years after the end of therapy.¹¹⁹

Combination therapy for CHB

NA plus NA

Recommendations

- *De novo* combination therapy with two NAs with high barrier to resistance (ETV, TDF, TAF) is not recommended (Evidence level I, grade of recommendation 1).
- In treatment-adherent patients with incomplete suppression of HBV replication reaching a plateau during either ETV or TDF/TAF long-term therapy, a switch to the other drug or combining both drugs may be considered (Evidence level III, grade of recommendation 2).

There have been only a few studies evaluating the role of *de novo* combination therapy with potent NAs in treatment naïve chronic HBV infection. In a large prospective multicentre study, HBeAg-positive and -negative CHB patients were randomised to either ETV or ETV plus TDF.¹²² The primary endpoint (HBV DNA <50 IU/ml at week 96) was reached in 76% and 83% of patients treated with mono- or combination therapy, respectively ($p = 0.088$). In the subgroup of HBeAg-positive patients, ETV/TDF combination achieved significantly higher rates of HBV DNA <50 IU/ml (80% vs. 70%, $p = 0.046$), which was entirely attributable to the HBeAg-positive subgroup with baseline HBV DNA levels $\geq 10^8$ IU/ml (79% vs. 62%). However, no difference was found in the rate of HBeAg seroconversions. None of the patients developed resistance, whereas ALT normalisation was observed more frequently in the ETV monotherapy group (82% vs. 69%). This combination did not provide added value in terms of HBsAg kinetics.¹²³

In a second double-blind study, HBeAg-positive treatment naïve patients with high HBV DNA and normal ALT levels were randomly assigned to either TDF plus placebo or a combination of TDF plus emtricitabine for 192 weeks.¹²⁴ At week 192, 55% and 76% of patients in the TDF monotherapy and the combination group respectively reached the primary endpoint, which was HBV DNA <69 IU/ml ($p = 0.016$). Of those who did not meet the primary endpoint, the majority had low levels of ongoing HBV replication, with serum HBV DNA <500 IU/ml. However, HBeAg seroconversion occurred in only 5% of patients (all in the monotherapy group), while no patient developed HBV resistance.

Although both of the above studies showed a higher percentage of complete HBV DNA suppression with NA combination therapy in HBeAg-positive patients with high baseline viral load (HBV DNA $>10^8$ IU/ml), the differences in terms of on-treatment HBV DNA levels and clinical/serological endpoints observed with both strategies are not strong enough to recommend *de novo* combination for this group of patients.

The optimal management of patients with incomplete suppression of HBV replication during long-term treatment with potent NAs (ETV, TDF or TAF) is still a matter of debate. In most of these patients a continuous decline in HBV DNA levels can be observed when continuing the same agent. This approach has been shown to be safe, effective and has not been associated with the development of drug resistance in large prospective long-term studies.^{1,125} So far, there are also no convincing data demonstrating that the presence of a minimal residual viremia with HBV DNA levels <69 IU/ml may have any unfavourable effects with respect to on-treatment disease progression or HCC risk in patients without cirrhosis.¹²⁶ We therefore do not recommend changing the initial treatment strategy in patients with low level and or declining HBV DNA concentrations on a potent NA monotherapy.

However, in patients with decompensated cirrhosis, not achieving a virologic response defined as HBV DNA <20 IU/ml has been shown to be a significant risk factor for developing HCC (HR = 7.74; 95% CI 1.34–44.78; $p = 0.022$) but not in those with compensated cirrhosis ($p = 0.749$).¹²⁷

The long-term consequences of on-treatment HBV DNA levels plateauing above 69 IU/ml but being below 2,000 IU/ml are unclear. As the above mentioned studies showed some advantages of combining NAs in terms of HBV DNA suppression this approach can be considered, and is especially recommended for those with established cirrhosis. A recent retrospective study in ETV (0.5 mg daily dose) treated patients with incomplete HBV

DNA response also showed that adding TDF is superior with respect to viral suppression and ALT normalisation as compared with continuing ETV monotherapy with either 0.5 mg or the higher 1.0 mg daily dose.^{128,129} Switching to another potent NA (i.e., from ETV to TDF/TAF or vice versa) may also sometimes lead to an improved response.

NA plus PegIFN α

Recommendations

- *De novo* combination of NA and PegIFN α is not recommended (Evidence level I, grade of recommendation 1).
- In treatment naïve HBeAg-positive patients, short-term pretreatment with a NA before PegIFN α is not recommended (Evidence level II, grade of recommendation 1).
- In long-term NA suppressed CHB patients, adding PegIFN α or switching to PegIFN α is not recommended (Evidence level II, grade of recommendation 1).

The combination of NA and PegIFN α has been used in treatment naïve and NA suppressed CHB patients. For treatment naïve patients, there is no robust evidence that a *de novo* combination of PegIFN α and NA is superior compared to PegIFN α or NA alone. Previous studies with LAM and or ADV combined with PegIFN α failed to show an advantage of the combination therapy.^{1,130} In a recent randomised controlled trial, the 72-week HBsAg loss rates were superior in the PegIFN α and TDF treated patients compared to those observed in patients receiving PegIFN α alone or TDF alone (9% vs. 3% vs. 0%) but the overall rates were low and mainly confined to genotype A patients.^{62,131} For treatment naïve patients, there is also no robust evidence that short-term

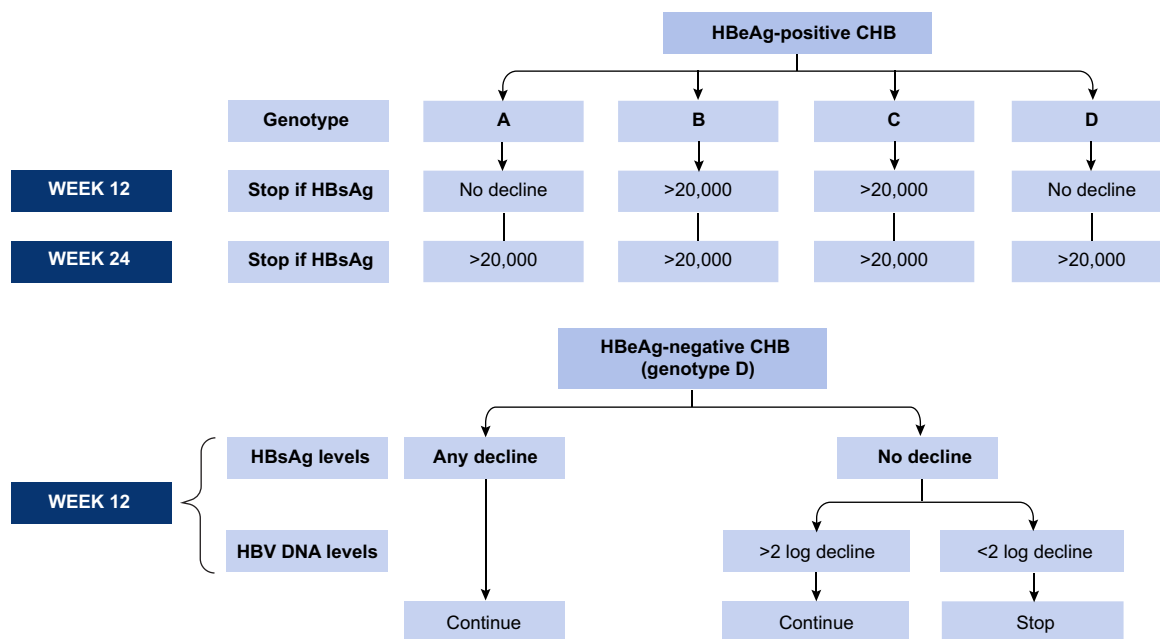


Fig. 4. Week 12 and 24 stopping rules for HBeAg-positive and -negative patients treated with PegIFN α . These rules are based upon viral genotype, HBsAg and HBV levels.

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pretreatment with NA improves the rates of sustained response to PegIFN α .^{130,132,133} The multicentre ARES study demonstrated that a 24-week course of PegIFN α , given to a small group of HBeAg-positive patients who were on ETV therapy for only 24 weeks, can improve the kinetics of HBeAg, HBV DNA and HBsAg, compared to those on ETV monotherapy, but a PegIFN α monotherapy arm was missing.¹³⁴

In CHB patients under long-term effective virological remission by NA treatment, PegIFN α can be used as a 'switch to' or 'add-on' strategy. In HBeAg-positive CHB, two recent Chinese studies assessed the efficacy and safety of switching to PegIFN α for patients on long-term effective NA therapy. Following a 48-week course of PegIFN α , 6–20% of patients cleared HBsAg. Baseline HBsAg <1,500 IU/ml predicted the serological responses.^{135,136} Two additional Asian studies assessed whether a 48-week course of add-on PegIFN α was superior to long-term NA therapy in HBeAg-positive patients.^{137,138} While the HBsAg decline was superior in the combination group, the HBsAg loss rates did not increase significantly.

In HBeAg-negative CHB patients under NA treatment, two multicentre European studies have assessed the safety and efficacy of a 48-week add-on course of PegIFN α .^{139,140} These two studies demonstrated that HBsAg kinetics were fostered by the addition of PegIFN α , but only a few patients cleared HBsAg. HBsAg levels at baseline and week 12 may predict HBsAg decline and/or HBsAg loss. There are no studies assessing the safety and efficacy of switching to PegIFN α monotherapy in HBeAg-negative CHB patients under long-term NA therapy.

As all these studies of PegIFN α therapy in patients under long-term NA therapy increase cost and side effects, this strategy should be carefully assessed in each individual patient weighing up all potential advantages and disadvantages.

Treatment of patients with decompensated cirrhosis

Recommendations

- Patients with decompensated cirrhosis should be immediately treated with a NA with high barrier to resistance, irrespective of the level of HBV replication, and should be assessed for liver transplantation (Evidence level II-1, grade of recommendation 1).
- PegIFN α is contraindicated in patients with decompensated cirrhosis (Evidence level II-1, grade of recommendation 1).
- Patients should be closely monitored for tolerability of the drugs and the development of rare side effects like lactic acidosis or kidney dysfunction (Evidence level II-2, grade of recommendation 1).

Patients with decompensated cirrhosis should be referred for liver transplantation and treated with NAs as early as possible, with the goal of achieving complete viral suppression in the shortest time possible. ETV or TDF are the preferred treatment options and both drugs have been shown to be effective but also generally safe in patients with decompensated disease.^{1,141–145} The licensed ETV dose for patients with HBV decompensated cirrhosis is 1 mg (instead of 0.5 mg for patients with compensated

liver disease) once daily. Less potent NAs are not recommended as they have been demonstrated to have inferior outcomes as compared to potent ones.^{141,146} Despite an overall high safety profile, concerns remain that development of lactic acidosis in patients with decompensated cirrhosis may be a class effect of NAs, and close monitoring for adverse events is especially recommended for patients with a MELD score >22 and impaired kidney function.^{1,147} All NAs must be adjusted to renal function. Because of its favourable safety profile, TAF might be also an interesting treatment option in patients with decompensated disease, especially in those with kidney dysfunction. However, studies concerning the safety and efficacy of TAF in these patient populations are lacking. PegIFN α is contraindicated in patients with decompensated liver disease.

The main goal of NA treatment in patients with decompensated liver disease is to achieve clinical recompensation and to avoid liver transplantation.^{1,57} There is strong evidence that antiviral therapy significantly modifies the natural history of decompensated cirrhosis, improving liver function and increasing survival.^{57,58,148} Meta-analyses demonstrated an overall and transplant-free survival in NA treated patients of more than 80%, respectively.^{58,59} Approximately 35% of treated patients can be delisted for liver transplantation, and an improvement of Child-Pugh Score ≥ 2 observed in at least 40–50%. Patients with early treatment initiation had better clinical outcomes than those with delayed treatment.¹⁴⁸ High baseline Child-Pugh or MELD scores are predictors of poor survival meaning that the disease may have progressed beyond the point of no return.^{58,148–150} In contrast, an improvement in MELD or Child-Pugh score early on-treatment is highly predictive of liver transplant-free survival.^{1,148,149} Undetectable HBV DNA levels can be achieved in >80% after 1 year of treatment, and are associated with a lower risk of HCC development.^{58,127,148} Lifelong treatment is recommended for all patients with decompensated disease. Even under effective NA therapy, the risk of developing HCC is high in these patients, and therefore careful long-term HCC surveillance is mandatory.¹

Prevention of HBV recurrence after liver transplantation

Recommendations

- All patients on the transplant waiting list with HBV related liver disease should be treated with NA (Evidence level II, grade of recommendation 1).
- Combination of hepatitis B immunoglobulin (HBIG) and a potent NA is recommended after liver transplantation for the prevention of HBV recurrence (Evidence level II-1, grade of recommendation 1).
- Patients with a low risk of recurrence can discontinue HBIG but need continued monophylaxis with a potent NA (Evidence level II-1, grade of recommendation 2).
- HBsAg-negative patients receiving livers from donors with evidence of past HBV infection (anti-HBc positive) are at risk of HBV recurrence and should receive antiviral prophylaxis with a NA (Evidence level II-2, grade of recommendation 1).

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Before the advent of NA therapy, recurrent HBV infection in liver transplantation was a major problem.¹⁵¹ All putative patients for liver transplantation should therefore be treated with NA therapy with the aim of achieving an undetectable HBV DNA level.¹ NA therapy in combination with HBIG reduces the risk of graft infection to <5%.^{1,151} Potent NA therapy allows a more efficient combination treatment with synergistic effects and better tolerability with the aim of achieving anti-HBs levels of ≥ 50 –100 IU/L. In selected patients (i.e., HBV DNA negative at liver transplantation), a short course or HBIG free regimens can be considered.¹⁵¹ In selected patients, ETV prophylaxis without HBIG has been shown to be safe and effective in preventing HBV recurrence.¹⁵² Conversely, lifelong combination therapy should be given to patients who are at a high risk for HBV recurrence, namely those who are HBV DNA positive at the time of liver transplantation, who are HBeAg-positive, have HCC, and HDV or HIV co-infection.^{153–155} In the setting of liver transplantation, nephrotoxicity should always be considered and renal function should be carefully monitored because of the concomitant use of calcineurin inhibitors.

When the immune system is therapeutically suppressed in the context of liver transplantation, there is potential for HBV reactivation in HBsAg-negative patients receiving donor organs with evidence of past HBV infection (anti-HBc positive). These patients usually receive receive lifelong LAM prophylaxis.¹⁵⁶

Treatment in special patient groups with HBV infection

HIV co-infected patients

Recommendations

- All HIV-positive patients with HBV co-infection should start antiretroviral therapy (ART) irrespective of CD4 cell count (Evidence level II-2, grade of recommendation 1).
- HIV-HBV co-infected patients should be treated with a TDF- or TAF-based ART regimen (Evidence level I for TDF, II-1 for TAF, grade of recommendation 1).

European and American guidelines on the management of HIV infected patients recommend the initiation of ART in HIV/HBV co-infected patients irrespective of CD4 cell count due to the increased risk of fibrosis progression, cirrhosis and HCC.^{157,158} All persons with HIV/HBV co-infection should receive ART including either TDF or TAF, which have antiviral activity against HIV and HBV. Stopping TDF- or TAF-containing ART should be avoided in persons with HIV/HBV co-infection because of the high risk of severe hepatitis flares and decompensation following HBV reactivation hepatitis. Drug toxicity (renal, bone density, liver) should be closely monitored during ART. ETV represents an alternative anti-HBV treatment without a strong activity against HIV.¹⁵⁷ At present, limited data exists on the use of TAF in HIV/HBV co-infected patients. In 72 HIV/HBV co-infected patients with a stable suppression of HIV and HBV DNA, switching ART from a TDF- to a TAF-containing regimen maintained HIV and HBV suppression in >90% of patients, with improved eGFR and bone

density parameters.¹⁵⁹ Persons with liver cirrhosis and low CD4 count require careful surveillance in the first months after starting ART in order not to overlook immune reconstitution syndrome and subsequent liver decompensation due to flares of liver enzymes.¹⁵⁸ Because TDF, TAF and possibly also ETV monotherapy can cause HIV resistance mutations, all HBsAg-positive patients should be screened for HIV before these drugs are used in the treatment of HBV infection.

HDV co-infected patients

Recommendations

- PegIFN α for at least 48 weeks is the current treatment of choice in HDV-HBV co-infected patients with compensated liver disease (Evidence level I, grade of recommendation 1).
- In HDV-HBV co-infected patients with ongoing HBV DNA replication, NA therapy should be considered (Evidence level II-2, grade of recommendation 1).
- PegIFN α treatment can be continued until week 48 irrespective of on-treatment response pattern if well tolerated (Evidence level II-2, grade of recommendation 2).

At present, PegIFN α is the only available drug that has been proven to have some antiviral efficacy against chronic HDV infection.^{1,160} Studies applying PegIFN α showed on-treatment virologic response rates of about 17–47%.¹ The rate of HDV RNA negativity 24 weeks after treatment cessation was, however, rather low (approximately 25%), and late relapses of HDV replication beyond week 24 after stopping therapy occurred in more than 50% of the responder patients, thus challenging the concept of sustained virologic response in HDV-HBV co-infection.¹⁶¹ Hence, long-term follow-up HDV RNA monitoring is recommended for all treated patients as long as HBsAg is present in serum. HBsAg loss may develop in the long-term follow-up in approximately 10% of PegIFN α patients and can be taken as a marker of cure from HDV infection.^{161,162}

Several studies tried to increase efficacy by increasing treatment duration.^{163,164} However, clear evidence is lacking to confirm that this approach is beneficial for most chronically HDV infected patients. Even after 96 weeks of PegIFN α therapy, alone or in combination with TDF, 24-week post-therapy relapses occurred in 36–39% of the patients with on-treatment response.¹⁶⁵

The likelihood of the long-term response to PegIFN α can be estimated to some extent by HDV RNA and HBsAg kinetics at weeks 12 and 24.^{164,166–169} However, stopping PegIFN α prematurely at this stage is not recommended, if treatment is well tolerated, as the negative predictive values of these markers are not very strong, and late responses may occur in patients with early non-response. Furthermore, long-term follow-up studies suggest that an IFN α based therapy *per se* can be taken as an independent factor associated with a lower likelihood of disease progression, and to develop clinical endpoints.^{162,170}

Neither NAs nor ribavirin showed significant effects on HDV RNA levels in patients with HDV infection.¹ Although HDV is

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often the predominant virus in this co-infection, considerable fluctuating activity of HDV and HBV or both viruses, including alternating predominance can be seen during the natural history of this chronic co-infection.¹ NA treatment is recommended for those patients with HBV DNA levels being persistently above 2,000 IU/ml, and might be considered in order to block residual HBV replication in those with advanced liver disease. In patients with decompensated liver disease, PegIFN α should not be used and these patients should be evaluated for liver transplantation. NA should be considered in all patients with decompensated disease if HBV DNA is detectable.

HCV co-infected patients

Recommendations

- Treatment of HCV with direct-acting antivirals (DAAs) may cause reactivation of HBV. Patients fulfilling the standard criteria for HBV treatment should receive NA treatment (Evidence level II, grade of recommendation 1).
- HBsAg-positive patients undergoing DAA therapy should be considered for concomitant NA prophylaxis until week 12 post DAA, and monitored closely (Evidence level II-2, grade of recommendation 2).
- HBsAg-negative, anti-HBc positive patients undergoing DAA should be monitored and tested for HBV reactivation in case of ALT elevation (Evidence level II, grade of recommendation 1).

In patients with chronic HBV infection, HCV co-infection accelerates liver disease progression and increases the risk of HCC.^{1,171,172} Therefore, all chronic HBV patients should be screened for HCV as well as for other blood borne viruses.^{1,171,173}

With the advent of effective DAA therapy, uptake of antiviral therapy for HCV is increasing rapidly. Sustained virological response rates for HCV in HBV and HCV co-infected patients are comparable with those in HCV mono-infected patients.¹⁷³ There is a potential risk of HBV reactivation during DAAs therapy or after clearance of HCV. It must be noted that most patients with HCV/HBV co-infection, and advanced disease should be on effective NA therapy. Following a series of case reports, the US Food and Drug Administration has now issued a warning about the risk of HBV reactivating in some patients treated with DAAs for HCV. They identified 24 cases of HBV reactivation in HCV/HBV co-infected patients treated with DAAs during a 31-month period from November 2013 to July 2016.^{174–177} More recent data confirms the risk of HBV reactivation associated with DAA therapy. In one publication, out of 103 patients with evidence of previous HBV exposure (HBsAg-negative, anti-HBc positive) undergoing DAA therapy, none experienced reactivation.¹⁷⁸ In another publication, 3 out of 10 patients with HBsAg-positive status demonstrated significant reactivation with two significant clinical events.

Out of the 327 patients treated with DAA therapy, 124 had evidence of anti-HBc with none experiencing any clinical or virological sequelae.¹⁷⁹

Acute hepatitis B

Recommendations

- More than 95% of adults with acute HBV hepatitis do not require specific treatment, because they will fully recover spontaneously (Evidence level II-2, grade of recommendation 1).
- Only patients with severe acute hepatitis B, characterised by coagulopathy or protracted course, should be treated with NA and considered for liver transplantation (Evidence level II-2, grade of recommendation 1).

In patients with acute hepatitis B, preventing the risk of acute or subacute liver failure is the main treatment goal. Improving quality of life by shortening the disease associated symptoms as well as lowering the risk of chronicity can be also regarded as relevant goals of treatment. As outlined in the natural course of disease, acute HBV infection will recover clinically and virologically including seroconversion to anti-HBs without antiviral therapy in more than 95% of adults. A potentially life-threatening disease manifestation is severe or fulminant acute hepatitis B. Characteristics of severe acute hepatitis B are coagulopathy (most studies defined this as international normalised ratio [INR] >1.5), or a protracted course (*i.e.*, persistent symptoms or marked jaundice for >4 weeks), or signs of acute liver failure.^{107,180} Although randomised controlled trials are lacking, several cohort studies indicate that the early antiviral therapy with highly potent NAs can prevent progression to acute liver failure and subsequently liver transplantation or mortality.^{107,181} This effect, however, is not seen if antiviral therapy is initiated late in the course of severe acute hepatitis B in patients with already manifested acute liver failure and advanced hepatic encephalopathy.¹⁸² Data supports the use of TDF, ETV or even LAM. One single-center retrospective analysis from Hong Kong reported a higher short-term mortality in patients with acute exacerbation of chronic hepatitis B (not primary hepatitis B infection) upon treatment with ETV compared to historic controls treated with LAM.¹⁸³ Large case series, however, support that TDF, ETV or LAM can be safely used in acute severe hepatitis B.^{181,184} In principle, TAF should be also effective in this setting, but no data are currently available on the use of TAF in severe acute hepatitis B. The use of glucocorticoids in acute severe hepatitis B is supported by older studies, but these studies in most cases did not include current antiviral drugs.¹⁸⁵ The management of acute liver failure and the indication for liver transplantation are discussed in detail in separate EASL CPGs.^{151,180} Early NA treatment does not increase the risk of chronicity^{181,186}; in fact, observational data from a multicentre cohort even indicated reduced rates of chronicity, if NA treatment was initiated within 8 weeks of acute hepatitis B presentation in genotype A infected individuals.¹⁸⁷

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Children

Recommendations

- In children, the course of the disease is generally mild, and most of the children do not meet standard treatment indications. Thus, treatment should be considered with caution (Evidence level II-3, grade of recommendation 1).
- In children or adolescents who meet treatment criteria, ETV, TDF, TAF, and PegIFN α can be used in this population (Evidence level II-2, grade of recommendation 2).

Chronic HBV infection runs an asymptomatic course in most children, but the lifetime risk of significant clinical complications is not negligible. Since the World Health Organization recommended global HBV vaccination, the incidence of HBV in children has declined worldwide.¹⁸⁸ Issues around the characterisation of the phase of chronic HBV infection, and the indications for treatment, exist in the paediatric population as well, compounded by an enhanced requirement for safety, and thus extrapolation from adult strategies may be unhelpful. Treatment indications should be carefully evaluated,¹ and other co-morbidities, such as non-alcoholic fatty liver disease considered. Overall, a conservative approach is warranted. A joint EASL-ESPHAGN review provides a detailed relevant review.^{189,190}

Conventional IFN α , LAM, ADV, ETV and TDF have been evaluated for safety and efficacy in children, which were comparable to adults.^{1,190} In a study including adolescents 12 to <18 years old with HBeAg-positive and negative chronic HBV hepatitis, 72 weeks of TDF compared to placebo achieved significantly higher rates of virological response (HBV DNA <400 copies/ml: 89% vs. 0%, $p < 0.001$) and ALT normalisation (74% vs. 31%, $p < 0.001$), but similarly low HBeAg clearance rates. TDF proved safe and no patient developed resistance. Another recent study with ETV in adolescents confirmed no improvement in HBeAg seroconversion rates in cases with normal ALT (<30 IU/ml).^{188,189,191} ETV has also been studied in children between the ages of 2–12.¹⁹²

Healthcare workers

Recommendations

- HBV infection alone should not disqualify infected persons from the practice or study of surgery, dentistry, medicine, or allied health fields (Evidence level III, grade of recommendation 1).
- Healthcare workers performing exposure prone procedures with serum HBV DNA >200 IU/ml may be treated with NA to reduce transmission risk (Evidence level II-2, grade of recommendation 2).

According to the recommendations of Center for Disease Control (CDC), HBV infection alone should not disqualify infected

persons from the practice or study of surgery, dentistry, medicine, or allied health fields.¹⁹³ However, percutaneous injuries sustained by healthcare personnel during certain surgical, obstetrical, and dental procedures provide a potential route of HBV transmission to patients as well as providers.¹⁹⁴ Thus, healthcare workers may require antiviral therapy, even if they do not fulfill the typical indications for treatment, to reduce direct transmission during exposure prone procedures to patients. Policies for HBsAg-positive healthcare workers vary among countries. No prospective clinical trials are available to demonstrate the efficacy of antiviral treatment for preventing transmission by healthcare workers, but no HBV transmissions from healthcare workers to patients have been reported, if the healthcare worker has serum HBV DNA levels below 200 IU/ml. Thus, healthcare workers, including surgeons, gynaecologists and dentists, who are HBsAg-positive with HBV DNA >200 IU/ml may be treated with a potent NA (i.e., ETV, TDF, TAF) to reduce levels of HBV DNA ideally to undetectable or at least to <200 IU/ml (CDC recommendation: <1,000 IU/ml; recommendation in many countries: <2,000 IU/ml) before resuming exposure prone procedures.¹⁹⁴ Monitoring for compliance and efficacy in practicing surgeons is required. Healthcare workers performing exposure prone procedures that are not on antiviral treatment might be more frequently retested, especially if they are tested around the HBV DNA threshold, due to fluctuations in viremia.¹⁹⁵ The long-term safety, efficacy, complications and economic implications of such a policy are unknown.

Pregnancy

Recommendations

- Screening for HBsAg in the first trimester of pregnancy is strongly recommended (Evidence level 1, grade of recommendation 1).
- In a woman of childbearing age without advanced fibrosis who plans a pregnancy in the near future, it may be prudent to delay therapy until the child is born (Evidence level II-2, grade of recommendation 2).
- Pregnant women with CHB and advanced fibrosis or cirrhosis, therapy with TDF is recommended (Evidence level II-2, grade of recommendation 1).
- In pregnant women already on NA therapy, TDF should be continued while ETV or other NA should be switched to TDF (Evidence level II-2, grade of recommendation 1).
- In all pregnant women with high HBV DNA levels (>200,000 IU/ml) or HBsAg levels >4 log₁₀ IU/ml, antiviral prophylaxis with TDF should start at week 24–28 of gestation and continue for up to 12 weeks after delivery (Evidence level 1, grade of recommendation 1).
- Breast feeding is not contraindicated in HBsAg-positive untreated women or on TDF-based treatment or prophylaxis (Evidence level III, grade of recommendation 2).

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Family planning should always be discussed with women of childbearing age before initiating HBV therapy. The woman should be informed about the safety data of the HBV drugs on a possible pregnancy.

PegIFN α is contraindicated during pregnancy. There are no adequate and well-controlled studies of LAM, ADV and ETV in pregnant women. Reproduction studies have been performed in animal and in humans with TDF and TBV and revealed no evidence of harm to the fetus due to these drugs.¹ Among the last two agents, TDF should be preferred, because it has a better resistance profile and more extensive safety data in pregnant HBV positive women.^{1,196–198}

In a woman of childbearing age without advanced fibrosis who plans a pregnancy in the near future, it may be prudent to delay therapy until the child is born. In a woman of childbearing age with advanced fibrosis or cirrhosis who agrees for a “planned pregnancy” in the future, PegIFN α therapy may be tried as it is given for a finite duration. It should be noted that effective contraception is required during PegIFN α therapy. If PegIFN α is not possible or has failed, treatment with TDF has to be initiated and maintained even during a future pregnancy.

If female patients become unexpectedly pregnant during HBV therapy, treatment indications should be re-evaluated. The same treatment indications apply to women who are first diagnosed to have CHB during pregnancy. Patients with advanced fibrosis or cirrhosis should definitely continue to be treated, but the treating agent should be TDF.

The prevention of HBV perinatal transmission, which is considered to occur mainly at delivery, and causes the majority of chronic HBV infection is based on the combination of HBIG and vaccination given within 12 h of birth. This prophylaxis reduces the rate of perinatal transmission from >90% to <10%.¹ HBIG and vaccine failures occur almost exclusively in HBeAg-positive women with high HBV DNA levels (>200,000 IU/ml) and/or HBsAg level above 4–4.5 log₁₀ IU/ml.^{198–201} NA prophylaxis could be also useful in the few HBeAg-negative women with high levels of viremia but normal ALT levels.^{198–201} These mothers should be informed that utilising a NA to reduce their viremia levels increase the effectiveness to HBIG and vaccination. LAM, TBV or TDF prophylaxis has been used in this setting during the last trimester of pregnancy. Of them, TDF is the preferred agent due to its characteristics mentioned previously. In a randomised study in pregnant HBsAg-positive women with high HBV DNA levels (>200,000 IU/ml), the rate of mother to child HBV transmission at post-partum week 28 was 0% in those treated with TDF compared to 7% in the placebo control group per protocol analysis having a similar safety profile.¹⁹⁸ If NA therapy is given as prophylaxis, i.e., only for the prevention of perinatal transmission, its duration is not well defined (stopping at delivery or within the first 3 months after delivery). The potential advantage of stopping at delivery is no interference in breast feeding. In addition, TDF ameliorated maternal ALT elevations which can occur during pregnancy or early after delivery in untreated mothers.²⁰²

The safety of NA therapy during lactation is uncertain. HBsAg can be detected in breast milk, but breast feeding may not be considered a contraindication in HBsAg-positive mothers. In women treated with TDF, tenofovir concentrations in breast milk have been reported but its oral bioavailability is limited and thus infants are exposed to only small concentrations.

Patients undergoing immunosuppressive therapy or chemotherapy Recommendations

- All candidates for chemotherapy and immunosuppressive therapy should be tested for HBV markers prior to immunosuppression (Evidence level I, grade of recommendation 1).
- All HBsAg-positive patients should receive ETV or TDF or TAF as treatment or prophylaxis (Evidence level II-2, grade of recommendation 1).
- HBsAg-negative, anti-HBc positive subjects should receive anti-HBV prophylaxis if they are at high risk of HBV reactivation (Evidence level II-2, grade of recommendation 1).

In HBsAg-positive and HBsAg-negative, anti-HBc positive patients receiving chemotherapy or immunosuppressive therapy, including the established and emerging new biological response modifiers, the risk of HBV reactivation can be high, particularly if rituximab is given alone or in combination with steroids.¹ The risk of HBV reactivation can be classified as high (>10%), moderate (1–10%) or low (<1%).^{52,203} Therefore, all candidates for chemotherapy and immunosuppressive therapy should be screened for HBsAg, anti-HBs and anti-HBc prior to immunosuppression treatment.

Vaccination of HBV seronegative patients is recommended. Higher doses or reinforced vaccine may be required to achieve anti-HBs response in immunocompromised patients.^{1,107}

HBsAg-positive patients. All HBsAg-positive candidates for chemotherapy and immunosuppressive therapy should be urgently referred to a specialist for further assessment and diagnosis of the phase of HBV infection. All these patients should start potent NA as a treatment or as prophylaxis.

Patients with chronic hepatitis B should be treated with ETV, TDF or TAF, similarly to the immunocompetent patients. Monitoring and stopping rules for NAs are the same with the immunocompetent patients.

In contrast, the optimal management of patients with chronic HBV infection, but without chronic hepatitis, remains controversial. Prophylactic administration of LAM has been shown to reduce the risk of HBV reactivation and the associated morbidity and mortality,¹ but a residual risk of HBV reactivation remains approximately in 10% of chronic HBV patients with low viremia (HBV DNA <2,000 IU/ml) and in a higher proportion of those with higher viremia levels. As recent studies suggest that ETV or TDF can be successfully used in such patients,²⁰⁴ prophylaxis with ETV, TDF, TAF is recommended in this setting. Prophylaxis should continue for at least 12 months (18 months for rituximab-based regimens) after cessation of the immunosuppressive treatment and discontinued only if the underlying disease is under remission. Liver function tests and HBV DNA should be tested every 3 to 6 months during prophylaxis and for at least 12 months after NA withdrawal as a large proportion of HBV reactivations develops after NA discontinuation.^{205–209}

HBsAg-negative, anti-HBc positive subjects. The risk of HBV reactivation in this group varies widely according to the virological profile, underlying disease and the type and duration of immunosuppressive regimen. These subjects can be tested for serum HBV DNA before immunosuppression. If viremic, they should be treated similarly to HBsAg-positive patients.

In the high risk group (>10%), including anti-HBc positive subjects who need to be treated with rituximab in the onco-hematological setting or those undergoing stem cell transplantation, antiviral prophylaxis is recommended. Prophylaxis should continue for at least 18 months after stopping immunosuppression and monitoring should continue for at least 12 months after prophylaxis withdrawal. LAM may be used safely in this setting although few cases of HBV exacerbation due to LAM resistance have been reported.^{210–212} Prophylaxis with ETV or TDF or TAF can be also considered in HBsAg-negative, anti-HBc positive patients receiving highly immunosuppressive regimens of extended duration.^{213,214}

In HBsAg-negative, anti-HBc positive subjects with moderate (<10%) or low (<1%) risk of HBV reactivation, pre-emptive therapy, not prophylaxis, is generally recommended.^{205,206} The main virological event in these anti-HBc positive patients is HBsAg reappearance (seroreversion), constantly associated with hepatitis flare; by converse HBV DNA detection leads to seroreversion and hepatitis in only 50% of cases.²¹² Pre-emptive therapy is based upon monitoring HBsAg and/or HBV DNA every 1–3 months during and after immunosuppression, and starting ETV, TDF or TAF treatment in case of detectable HBV DNA or HBsAg seroreversion. As HBsAg seroreversion can lead to a severe, even fatal, acute hepatitis, NA should be started as early as possible, independently of ALT levels. For selected clinical settings, characterised by long duration of immunosuppression, limited compliance to monitoring or unknown risk of viral reactivation for new biologicals, universal prophylaxis, rather than pre-emptive therapy, is recommended.

Dialysis and renal transplant patients

Recommendations

- All dialysis and renal transplant recipients should be screened for HBV markers (Evidence level II-2, grade of recommendation 1).
- HBsAg-positive dialysis patients who require treatment should receive ETV or TAF (Evidence level II-2, grade of recommendation 1).
- All HBsAg-positive renal transplant recipients should receive ETV or TAF as prophylaxis or treatment (Evidence level II-2, grade of recommendation 1).
- HBsAg-negative, anti-HBc positive subjects should be monitored for HBV infection after renal transplantation (Evidence level III, grade of recommendation 1).

HBV is still prevalent in dialysis and renal transplant patients and may cause significant morbidity and mortality.¹ All dialysis and renal transplant patients should be screened for HBV markers. Though vaccine responsiveness is impaired, HBV seronega-

tive patients should be vaccinated, preferentially with a reinforced vaccine.^{215,216}

All HBsAg-positive patients should be referred to a specialist for further assessment and diagnosis of the phase of HBV infection.

Dialysis patients. Patients with chronic HBV infection but not chronic hepatitis B should be monitored, as there is no strong evidence to suggest they have increased morbidity and mortality.¹ In contrast, all patients with HBeAg-positive or -negative chronic hepatitis B should receive a NA, as the preferred treatment strategy, independently of the transplantation program.^{205,217,218} ETV is recommended for NA naïve patients.²¹⁹ TAF could be used for both NA naïve and NA experienced/resistant patients but studies are still ongoing.^{74,76} All doses of NAs should be adjusted according to eGFR values in patients with eGFR <50 ml/min (see insert packages), except for TAF which does not require dose adjustment if eGFR is >15 ml/min. PegIFN α could be also used in selected patients. Given that dialysis may reduce ALT levels, caution must be taken to use this marker to assess treatment indications.

HBsAg-negative, anti-HBc positive subjects do not require treatment nor prophylaxis but must be monitored for HBV markers.

Renal transplant recipients. All HBsAg-positive patients should receive anti-HBV prophylaxis or treatment with a NA.^{1,205,217,218} ETV is the preferred option for NA naïve patients. TDF should be avoided because of renal safety issues and may be considered only for patients with NA resistance if TAF is not available.^{74,76,79} TAF could be a good treatment option for both NA naïve and resistant patients, although its efficacy and safety in this setting are currently unknown. Though several studies have used LAM in the past, this drug is not recommended because of the high risk of resistance. NA prophylaxis and treatment should be continued long-term. Long-term NA therapy has been shown to reduce liver complications and improve survival. PegIFN α is contraindicated because of the risk of rejection.

Renal function should be carefully monitored during treatment with a NAs.⁷⁹ Unexpected deterioration of renal function during NA therapy may necessitate a change of treatment or dose adaptation. Arterial hypertension and diabetes mellitus should be optimally controlled in renal transplant recipients.

HBsAg-negative, anti-HBc positive renal transplant recipients do not require prophylaxis or treatment. Monitoring of HBsAg is recommended to identify the few cases of HBsAg seroreversion in which ETV or TAF should be started immediately, irrespectively of ALT levels.

Extrahepatic manifestations

Recommendations

- Patients with replicative HBV infection and extrahepatic manifestations should receive antiviral treatment with NA (Evidence level II-2, grade of recommendation 1).
- PegIFN α should not be administered in patients with immune-related extrahepatic manifestations (Evidence level III, grade of recommendation 1).

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HBV related extrahepatic manifestations include vasculitis, skin manifestations (purpura), polyarteritis nodosa, arthralgias, peripheral neuropathy and glomerulonephritis. Mixed cryoglobulinemias, positive rheumatoid factor or inflammatory markers (complement factors C3/C4, C-reactive protein, blood sedimentation rate) may be found in these patients. HBsAg-positive patients with extrahepatic manifestations and active HBV replication may respond to antiviral therapy. PegIFN α can worsen some immune mediated extrahepatic manifestations and should not be administered in HBV infected patients with immune-related extrahepatic manifestations. Although controlled studies of antiviral therapy in this setting are lacking, case reports suggest that the use of NA is safe and effective.^{61,220} Plasmapheresis, corticosteroids and potentially other immune-suppressive drugs during the initial phase can be useful in addition to NA therapy in special cases.

New biomarkers of HBV infection

Viral cccDNA is the key genomic form that is responsible for the persistence of infection and was shown to persist in the liver of infected patients even after long-term NA therapy and even after HBsAg loss and seroconversion.^{221,222} The regulation of the intrahepatic pool of cccDNA involves several factors including the dynamics of infection in the liver and the intrahepatic antiviral immune response.²²³ Furthermore, cccDNA transcriptional activity is controlled by fine epigenetic regulation which can involve viral and host factors.^{13,224} Besides the need for standardized assays, the main limitation of cccDNA studies is the requirement of liver biopsy; thus surrogate biomarkers are being evaluated (see below). It is noteworthy that not all transcripts are expressed from cccDNA, but can also be expressed from viral sequences integrated in the host genome. Viral genome replication cannot occur from these integrants, but HBsAg expression can occur either from the envelope gene in cccDNA and/or in viral integrants, explaining at least in part why quantification of HBsAg is not a perfect biomarker for intrahepatic cccDNA.²²⁵ Quantification of cccDNA levels and its transcriptional activity will be important in clinical trials evaluating novel treatment concepts to cure HBV infection.

Hepatitis B core-related antigen (HBcrAg) is a composite biomarker comprising several antigens expressed from the precore/core gene: HBcAg, HBeAg, and prec22 precursor protein.²²⁶ The HBcrAg associated proteins can also be detected in circulating hepatitis B virions (Dane particles) as well as in HBV DNA negative Dane particles containing the 22 kDa precore protein and exceeding Dane particles by ~100-fold, and probably also in pregenomic RNA containing virions.²²⁷ The marker does not overlap with HBsAg quantification, and in contrast to HBsAg, HBcrAg quantification might not be influenced by translation from integrated viral sequences. Hence, HBcrAg quantification may provide additional information concerning the translational activity of the HBV infection beyond HBsAg quantification. How to best use this new assay in the management of patients with chronic HBV infection is still a matter of debate. It has been demonstrated that the serum HBcrAg levels may partly reflect the amount of intrahepatic DNA and cccDNA in hepatocytes especially in HBeAg-positive patients.^{228,229} It might also be helpful in defining the phase of chronic HBV infection, especially in HBe-negative patients, as well as predicting the long-term HCC risk.^{228,230-232} Some studies suggest that this biomarker can be

also used to monitor NA or PegIFN α based treatments and predicting therapeutic efficacy including the risk of relapse after stopping NAs.²³³⁻²³⁵ Most of these studies were performed in Japan, and large correlation studies derived from Caucasian patients are lacking. Therefore, further studies are awaited providing clear evidence for a superiority of this marker for clinical decision making over established HBV biomarkers like HBsAg and HBV DNA quantification.

Circulating HBV RNA was first described in 1996 in the serum of HBV infected patients and later as a potential new marker for monitoring NA therapy. HBV RNA can be released into the serum in the form of enveloped pregenomic RNA containing virions,²³⁶ but the full characterisation of these circulating RNAs is ongoing. Because of its strong correlation with intrahepatic cccDNA, serum HBV RNA is an interesting marker to study cccDNA transcriptional activity.²³⁶⁻²³⁸ A strong correlation between quantitative serum HBV RNA dynamics and HBeAg loss in both NA and PegIFN α treated patients²³⁹ was recently demonstrated by using a new rapid amplification of cDNA-ends with polymerase chain reaction (RACE-PCR).²⁴⁰ HBV RNA quantification might be also helpful in predicting viral rebound after discontinuation of NAs.²³⁶ It should be further explored whether the simultaneous testing of different replicative, transcriptional and translational HBV biomarkers will allow for a better definition of the individual "activity" of the chronic HBV infection helping to better predict long-term treatment outcomes.

Future treatment options

Future treatment options for HBV

Many research programs are ongoing to develop new treatment concepts that focus on the clearance of HBsAg in a significant proportion of patients, with the principle aims of: i) stopping treatment with no risk of virological relapse and no risk of liver disease progression and, ii) to further decrease the risk of HCC.

Several definitions of cure have been proposed following several international workshops.^{241,242} A true cure may not be feasible because HBV DNA is integrated into the host genome. Furthermore, among persons who recovered from acute hepatitis B, viral cccDNA can still be detected in the liver explaining the reactivation of HBV replication when these 'recovered' persons are profoundly immunosuppressed. The ability to 'cure' HBV at earlier stages of liver disease would theoretically have a greater impact on reducing the risk of HCC.

The novel treatment options under pre-clinical and early clinical evaluation can be categorized into direct antivirals and immunotherapeutic agents.

Direct-acting antivirals include HBV entry inhibitors, drugs aiming at cccDNA destruction or silencing, approaches targeting viral transcripts by siRNA or anti-sense oligonucleotides, nucleocapsid assembly modulators, approaches to decrease HBsAg release in serum. This list is not meant to be comprehensive as many viral targets are currently being screened for drug discovery. First phase clinical trials are ongoing for several of these agents.^{241,243}

Several potential target mechanisms for immune modulation to engender or restore HBV specific immune responses in conjunction with profound inhibition of HBV replication and HBsAg production to attain immunological control have been suggested.^{241,243} Several approaches are currently being evaluated

in clinical trials to restore innate immunity in CHB patients. Among them, Toll-like receptors 7 (TLR7) agonists have been the most explored, but other strategies that restore IFN α responsiveness or other antiviral innate pathways are under investigation. The lack of a T cell mediated response in chronic HBV is partly due to the expression of co-inhibitory receptors and by the expression of immunosuppressive cytokines. Recent cancer therapies have indicated the potential of check-point inhibitors to restore anti-tumor adaptive immunity. Interesting results have been obtained for HBV in animal models and in *ex vivo* studies in humans. The main concerns of this approach are the potential induction of uncontrolled hepatitis flares and autoimmunity. Several therapeutic vaccines have been evaluated with limited success, but new vaccine formulations are under clinical evaluation.^{241,243}

Combinations of antiviral therapy targeting multiple steps in the HBV lifecycle that suppress viral replication and viral antigen production and immune modulatory therapy to restore immune response to HBV will likely be needed to achieve the goal of a HBV 'cure'.

Given the focused drug discovery effort and the potential of a future 'cure' strategy, it is important to be cognisant, when considering the current clinical management of CHB patients, of the potential evolution of therapy in HBV. Patients who are willing to participate and/or are in phases of the disease that are not eligible for therapy within the current guidelines may be considered for clinical trial participation.

Future treatment options for HDV

At present, patients co-infected by HBV and HDV have to be treated with PegIFN α . The success rate of these treatments is low. Several candidates are being evaluated in clinical trials mainly in combination with PegIFN α and/or NA including HBV/HDV entry inhibitors (Myrcludex-B),^{244,245} drugs inhibiting the release of HBsAg (nucleic acid polymers),²⁴⁶ and inhibitors of the prenylation of the large HDV antigen.^{243,247} Whenever possible, enrollment in these new clinical trials should be considered, either as a rescue of PegIFN α failure or to improve treatment success rate in naïve patients.

Unresolved issues and unmet needs

- When to start antiviral therapy in patients with HBeAg-positive chronic HBV infection
- Stopping rules for HBeAg-negative patients treated with NA
- Retreatment criteria after NA discontinuation
- How to accelerate HBsAg decline in long-term NA treated patients?
- Better baseline or on-treatment predictors of sustained treatment in patients treated with PegIFN α
- Definition of the residual risk of HCC in patients on long-term NA therapy and impact on surveillance
- Unmet need: new treatments with finite duration and high cure rates
- How to define a cure of HBV infection? Definition of novel endpoints
- Biomarkers for the cure of infection and for the cure of the liver disease

Conflict of interest

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