Natural history and treatment of hepatitis B virus and hepatitis C virus coinfection

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Abstract

Hepatitis B virus (HBV) and hepatitis C virus (HCV) coinfection is not uncommon as a result of similar routes of infection. Patients who are coinfected represent a unique group with diverse serologic profiles. Combined chronic hepatitis B and C leads to more severe liver disease and an increased risk of hepatocellular carcinoma. Furthermore, coinfected patients represent a treatment challenge. No standard recommendations exist for treatment of viral hepatitis due to dual HBV/HCV infection, and therefore treatment must be individualized based on patient variables such as serologic and virologic profiles, patient’s prior exposure to antiviral treatment, and the presence of other parenterally transmitted viruses such as hepatitis D virus and human immunodeficiency virus. The natural history and treatment of patients with HBV and HCV coinfection is reviewed.

Introduction

Hepatitis B and hepatitis C viruses are the most common causes of chronic liver disease worldwide. Acute infection with hepatitis B virus (HBV) or hepatitis C virus (HCV) may result in chronic infection, which occurs at a high rate in infants infected with HBV and the majority of individuals infected with HCV. Chronic HBV and/or HCV infection can progress to cirrhosis and be complicated by hepatocellular carcinoma (HCC). Coinfection with both viruses can occur because of shared routes of infection. Patients with dual HBV and HCV infection have more severe liver disease, and are at an increased risk for progression to HCC [1-4]. Coinfected patients represent a diverse group with various viral replication and immunity profiles. Because of their distinct clinical course and heterogeneity, identification of patients who are candidates for therapy and selection of the optimal antiviral therapy is a challenge for clinicians. Herein we review the natural history of HBV/HCV coinfection, current understanding of the interactions between these hepatotropic viruses, and the limited literature on treatment of coinfected patients.

Epidemiology

Approximately 350 million people are infected with HBV worldwide [5], and the World Health Organization estimates that approximately 170 million people are infected with HCV [6]. The exact number of patients infected with both HCV and HBV is unknown. One Eastern European study found a rate of dual infection in 0.68% of a randomly selected healthy population of over 2200 individuals [7]. In patients with chronic hepatitis B, estimates of the rates of HCV coinfection vary from 9% to
with known chronic HBV or HCV infection, especially with chronic hepatitis. In addition, HBV superinfection in patients with chronic hepatitis B have both been reported [11-13]. Therefore, episodes of acute hepatitis in patients with known chronic HBV or HCV infection, especially those with ongoing risk behavior for infection with the alternative virus such as injection drug users, should raise suspicion and prompt screening for superinfection. In addition, as will be described below, silent or occult HBV infection in patients with chronic hepatitis C may alter patients' clinical course and response to therapy [14,15]. However, this phenomenon requires further study regarding its clinical significance before routine screening of HCV patients for HBV DNA can be recommended.

Interaction of Hepatitis Viruses

Several studies have shown that the HBV and HCV interact with each other and affect immune responses. HCV infection can suppress HBV replication, as demonstrated by studies showing that patients with chronic hepatitis B who are coinfected with HCV have lower HBV DNA levels, decreased activity of HBV DNA polymerase, and decreased expression of HBsAg and hepatitis B core antigen in the liver [16-18]. Furthermore, patients with chronic HBV infection who become superinfected with HCV can undergo seroconversion of hepatitis B e antigen (HBeAg) and HBsAg to respective antibodies [19-21]. Shih et al. [22] conducted a longitudinal follow-up study of a large series of HBV infected patients and found that the annual incidence of HBsAg seroconversion was 2.08% in coinfected patients compared to 0.43% in patients with HBV monoinfection, and a subsequent study confirmed these results [23]. Several mechanisms of replicative interference of HBV by HCV have been proposed. Shih et al. implicated the hepatitis C core protein in suppression of HBV [24]. A subsequent study found that the hepatitis C core protein suppressed HBV enhancer activity, thereby affecting transcription [25].

Several authors have reported that HBV can reciprocally inhibit HCV replication as well [27,28]. Specifically, HBV DNA replication has been shown to correlate with decreased HCV RNA levels in coinfected patients [29]. In one Italian study, coinfected patients had a rate of HCV RNA clearance of 71% compared to 14% with HCV monoinfection [26]. HBV replication in coinfected individuals may result in more liver inflammation, as demonstrated by studies in which HBV replication correlated with elevated ALT levels, while HCV replication did not [28,30,31]. Furthermore, coinfected patients have been demonstrated to have lower levels of both HBV DNA and HCV RNA than corresponding monoinfected controls, indicating that concurrent suppression of both viruses by the other virus can also occur [32].

Overall, the available evidence demonstrates that both viruses can inhibit each other simultaneously; either virus can play a dominant role; both viruses have the ability to induce seroconversion of the other; the chronology of infection has a role in determining the dominant virus and HBV and HCV can alternate their dominance [8]. However, the overall dominant effect appears to be HCV suppression of HBV [11,32,33].

Clinical Scenarios

Different scenarios of infection have been described with dual infection with HBV and HCV including acute dual viral hepatitis, occult HBV coinfection of chronic hepatitis C, and superinfection by either virus in patients with pre-existing chronic hepatitis due to the alternative virus. In addition, coinfected patients are often found to have evidence of both HBV and HCV infection without a clear chronology of infection. In areas with high endemic rates of HBV infection due to vertical transmission, coinfection can generally be assumed to be due to HCV superinfection. In other geographic areas, the sequence of infections is less clear. Acute coinfection or superinfection with either virus can lead to fulminant hepatitis, chronic hepatitis, cirrhosis and HCC (Figure 1).

Acute Hepatitis due to Dual Infection

Few studies have been reported on simultaneous acute hepatitis with HBV and HCV, but it appears that HBV and HCV interact in acute infections similar to their interactions in chronic infection. Simultaneous coinfection via an accidental needle stick that resulted in acute hepatitis was first described by Liaw in 1982 [34]. The diagnosis of HBV infection was delayed for 6 weeks, possibly related to HCV interference. Simultaneous coinfection resulting in acute post-transfusion hepatitis has also been described [35]. Mimms et al [36]. studied patients with concurrent
Successful transplantation in infectious scenarios and treatment window for patients coinfected with hepatitis B and hepatitis C viruses. HBV = hepatitis B virus, HCV = hepatitis C virus.

Figure 1
Infectious scenarios and treatment window for patients coinfected with hepatitis B and hepatitis C viruses. HBV = hepatitis B virus, HCV = hepatitis C virus.

Acute infection with HBV and HCV compared to those with acute HBV alone, and reported decreased ALT levels, delayed appearance of HBsAg, and a shorter duration of hepatitis B surface antigenemia in coinfected patients compared to controls, suggesting HCV suppression of HBV activity.

Occult Hepatitis B Infection
Several reports have described the entity of occult or serologically silent HBV infection, particularly as it relates to treatment outcomes [10,14]. Occult HBV infection refers to patients who have low levels of circulating HBV DNA, but who lack both circulating antigens and their corresponding antibodies (i.e. HBsAg, HBeAg, hepatitis B surface antibody [anti-HBs] and hepatitis B e antibody [anti-HBe]). Such patients have been shown to have more severe liver disease [37]. One study found that 33% of patients with chronic hepatitis C and occult HBV infection had cirrhosis, compared to 19% of patients with chronic HCV infection without detectable HBV DNA [38]. Occult HBV may also be associated with more liver inflammation, greater histological activity of hepatitis, and higher ALT levels [14]. The effect of serologically silent infections on response to treatment will be discussed below.

Hepatitis C Superinfection
In areas of high prevalence of HBV infection such as Asian countries, the phenomenon of HCV superinfection is well described [11,13]. Superinfection with HCV can result in suppression of HBV replication, as well as termination of
### Table 1: AASLD Recommendations for Treatment of Chronic Hepatitis B

<table>
<thead>
<tr>
<th>HBeAg</th>
<th>HBV DNA</th>
<th>ALT</th>
<th>Treatment Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
<td>≤2 x ULN</td>
<td>Low efficacy with current treatment. Observe: consider treatment when ALT becomes elevated</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
<td>&gt;2 x ULN</td>
<td>IFN-α, LAM, or ADV may be used as initial therapy. Duration of therapy:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• IFN-α: 16 weeks</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• LAM: minimum 1 year, continue for 3-6 months after HBeAg seroconversion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• ADV: minimum 1 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IFN-α nonresponders/contraindications to IFN-α → LAM or ADV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LAM resistance → ADV</td>
</tr>
<tr>
<td>-</td>
<td>+</td>
<td>&gt;2 x ULN</td>
<td>IFN-α, LAM or ADV may be used as initial therapy. End point of treatment = sustained normalization of ALT and undetectable HBV DNA by PCR assay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• IFN-α: 1 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• LAM: &gt; 1 year</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>• ADV: &gt; 1 year</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IFN-α nonresponders/contraindications to IFN-α → LAM or ADV</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LAM resistance → ADV</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>≤2 x ULN</td>
<td>No treatment required</td>
</tr>
<tr>
<td>±</td>
<td>Cirrhosis</td>
<td>Compensated: LAM or ADV</td>
<td></td>
</tr>
<tr>
<td>±</td>
<td>Cirrhosis</td>
<td>Decompensated: Refer for liver transplant. IFN-α contraindicated.</td>
<td></td>
</tr>
</tbody>
</table>


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Hepatitis B Superinfection

Superinfection with HBV in patients with chronic hepatitis C is less common. Liaw et al. reported a series of 2 patients with chronic hepatitis C with documented HBV superinfection (positive IgM anti-HBc) [12]. One 82-year-old patient who was positive for both HBV DNA and HCV RNA on admission died of fulminant hepatic failure. The second patient was HBSAg positive, but HBV DNA negative. She subsequently recovered from acute hepatitis with normalization of ALT and seroconversion of HBSAg, as well as disappearance of anti-HCV antibody, indicating a possible suppressive role of HBV on HCV infection. It is difficult to draw conclusions from this limited report, but it is reasonable to assume that there may be an increased risk of fulminant hepatitis with HBV superinfection, and that those who recover are at risk for chronic coinfection. The clearance of anti-HCV in this case suggests that superinfection may allow HBV to play the dominant role in suppression of HCV.

**Fulminant Hepatitis**

Several studies have addressed the role of coinfection with HBV and HCV in fulminant hepatitis. Chu et al. [39] conducted a prospective study of patients admitted with acute hepatitis C in Taiwan. Eleven patients had fulminant hepatitis, and of these, 23% had underlying chronic HBV infection, compared to 2.9% for patients without fulminant hepatitis. This corresponded to an odds ratio (OR) for chronic HBV patients developing fulminant hepatitis with HCV superinfection of 10.2 (95% confidence interval 4.7-21.9, p < 0.01). A French study of 40 patients with fulminant and subfulminant hepatitis found that 5 of 40 patients (12.5%) had acute coinfection with HBV and HCV, and 3 of 40 (7.5%) had superinfection of HCV [40]. Another Taiwanese study of 25 subfulminant and fulminant hepatitis cases found similar rates of coinfection (9.4%) and HCV superinfection of chronic hepatitis B (3.1%) [41]. These studies suggest an increased risk of ful-
There are various immune profiles of dually infected patients with chronic hepatitis C and HBV coinfection, and their immune profiles have a bearing on the choice of treatment. One possibility is that these patients are at highest risk of progression to cirrhosis and decompensated liver disease, and therefore, should be considered for treatment. Another possibility is active HCV infection (positive HCV RNA) in the setting of an inactive HBsAg carrier. Such patients behave similar to patients with HCV monoinfection, and likely exhibit HCV viral suppression of HBV activity. Another possibility is active HBV infection in patients with inactive or prior HCV infection (HBV DNA positive/HBeAg positive/HCV RNA negative/anti-HCV positive). This immune profile is less common, and indicates HBV suppression of HCV. The various immune profiles have significance in regards to treatment options as will be discussed below (Table 3).

### Table 2: AASLD Recommendations for Treatment of Chronic Hepatitis C

<table>
<thead>
<tr>
<th>Therapy Widely Accepted</th>
<th>Therapy Contraindicated</th>
<th>Treatment Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Detectable HCV RNA</td>
<td>• Major, uncontrolled depression</td>
<td>Genotype 1 HCV infection:</td>
</tr>
<tr>
<td>• 18 years of age or older</td>
<td>• Renal, heart, or lung transplant recipient</td>
<td>• Peginterferon plus ribavirin (1000-1200 mg daily) for 48 weeks</td>
</tr>
<tr>
<td>• Elevated ALT</td>
<td>• Autoimmune hepatitis or other condition known to be exacerbated by interferon and ribavirin</td>
<td>• In patients who have negative HCV RNA at 48 weeks, retest HCV RNA at 72 weeks to confirm SVR</td>
</tr>
<tr>
<td>• Liver biopsy showing chronic hepatitis with significant fibrosis</td>
<td>• Untreated hyperthyroidism</td>
<td>• Treatment may be discontinued in patients who do not achieve an EVR at 12 weeks</td>
</tr>
<tr>
<td>• Compensated liver disease (total serum bilirubin &lt;1.5 g/dL, INR &lt;1.5, albumin &gt;3.4 g/dL, platelet count &gt;75,000 k/mml; and no evidence of hepatic encephalopathy or ascites)</td>
<td>• Pregnant or unwilling/unable to comply with adequate contraception</td>
<td>• In patients who have negative HCV RNA at 48 weeks, retest HCV RNA at 72 weeks to confirm SVR</td>
</tr>
<tr>
<td>• Acceptable hematological and biochemical indices (hemoglobin &gt;13 g/dL for men and &gt;12 g/dL for women; neutrophil count &gt;1.5 k/mml; and creatinine &lt;1.5 mg/dL)</td>
<td>• Severe concurrent disease such as severe hypertension, heart failure, significant coronary artery disease, poorly controlled diabetes, obstructive pulmonary disease</td>
<td>Genotype 2 or Genotype 3 infection:</td>
</tr>
<tr>
<td>• Not treated previously for HCV infection</td>
<td>• Under 3 years of age</td>
<td>• Peginterferon plus ribavirin (800 mg daily) for 24 weeks</td>
</tr>
<tr>
<td>• History of depression but well controlled</td>
<td>• Known hypersensitivity to drugs used to treat HCV</td>
<td>• In patients who have negative HCV RNA at 24 weeks, retest HCV RNA at 48 weeks to confirm SVR</td>
</tr>
<tr>
<td>• Patient willing to be treated and to conform to treatment requirements</td>
<td></td>
<td></td>
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</tbody>
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Chronic Hepatitis

There are various immune profiles of dually infected patients with chronic hepatitis C, and their immune profiles have a bearing on the choice of treatment. One possibility is that these patients are at highest risk of progression to cirrhosis and decompensated liver disease, and therefore, should be considered for treatment. Another possibility is active HCV infection (positive HCV RNA) in the setting of an inactive HBsAg carrier. Such patients behave similar to patients with HCV monoinfection, and likely exhibit HCV viral suppression of HBV activity. Another possibility is active HBV infection in patients with inactive or prior HCV infection (HBV DNA positive/HBeAg positive/HCV RNA negative/anti-HCV positive). This immune profile is less common, and indicates HBV suppression of HCV. The various immune profiles have significance in regards to treatment options as will be discussed below (Table 3).

Cirrhosis

Cirrhosis refers to the development of fibrous tissue within the liver, leading to the formation of nodules. The two main types of cirrhosis are alcoholic and non-alcoholic. Non-alcoholic cirrhosis is most commonly associated with chronic hepatitis C, although it can also occur in the absence of hepatitis C. The progression of cirrhosis is characterized by the development of fibrosis, which can progress to cirrhosis, a condition in which the liver becomes scarred and hardened. This can lead to liver failure and ultimately death. Treatment options for cirrhosis include medications, such as antiviral agents, and lifestyle modifications, such as戒酒. Early detection and intervention are crucial in preventing complications and improving outcomes.

Hepatocellular Carcinoma

Coinfection with HBV and HCV has been shown in many case-control studies to correlate with an increased risk of developing HCC [4,42]. One study found a rate of HCC in coinfected patients of 63% compared to 15% in HCV monoinfected patients [42]. Benvegnu et al. [1] conducted a prospective study of 290 cirrhotic patients and found that coinfection (detectable anti-HCV and HBsAg) was an independent predictor for development of HCC in a univariate and multivariate analysis (p < 0.02, p < 0.05 respectively). A subsequent longitudinal study confirmed these results, and reported a rate of incidence of HCC (per 100 person years) of 6.4 in dually infected patients, compared to 2.0 in HBV and 3.7 in HCV monoinfected patients, and a 45% cumulative risk of developing HCC at 10 years in coinfected patients, compared with 16% and 28% in HBV and HCV monoinfected controls [2]. Similarly, a South African study reported an 83-fold increased for developing HCC among coinfected patients compared to patients without hepatitis B or C [43]. Because of the likely increased risk of developing HCC, coinfected patients should receive regular 6-month and possible more frequent screening with ultrasound of the liver and serum alpha-fetoprotein levels.

[29] A Saudi Arabian study found that coinfected patients (compared to HCV monoinfected patients) had more decompensated liver disease with a higher proportion of cirrhosis (95% vs. 48.5%) and Child-Pugh class C (37% vs. 0%) [42].

**Table 2: AASLD Recommendations for Treatment of Chronic Hepatitis C**

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</tr>
<tr>
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<tr>
<td>• Patient willing to be treated and to conform to treatment requirements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
There is no currently established standard of care for association for the study of liver diseases (AASLD) recrudescence, adefovir, entecavir, and peginterferon alfa-2a.

with chronic hepatitis B and chronic hepatitis C [44-49].

with chronic hepatitis with detectable serum HCV RNA with chronic hepatitis with elevated ALT and HBV DNA with HBV DNA.

levels or significant findings on liver biopsy associated with infection with the precore or core promoter mutant virus. Currently licensed drugs for chronic hepatitis B in the United States include interferon alfa-2b, lamivudine, adefovir, entecavir, and peginterferon alfa-2a.

Patients with fulminant hepatitis and decompensated cirrhosis are not likely to respond to antiviral agents and are candidates for liver transplantation (Table 1). Patients with chronic hepatitis C with detectable serum HCV RNA are candidates for 24 to 48 weeks of antiviral therapy based on genotype. Currently standard treatment for hepatitis C is peginterferon alfa-2a or 2b plus ribavirin. As with chronic hepatitis B, patients with decompensated liver disease or fulminant hepatitis (rare with acute hepatitis C) are candidates for liver transplantation (Table 2).

There is no currently established standard of care for patients who are coinfected with HBV and HCV. In general, the same treatment criteria should be applied to patients who are HBV/HCV dually infected as are applied to monoinfected patients (Tables 1 and 2). Initiation of treatment, as with both HBV and HCV, is recommended in patients with active chronic hepatitis or cirrhosis prior to decompensation (Figure 1). Given the complex interaction of HBV and HCV both with each other and with the immune system, care must be taken to select the most appropriate antiviral regimen based on serologic markers and levels of viremia. Because of its activity against both viruses, interferon therapy has been the most studied. The published data on the antiviral treatment of HBV and HCV coinfection is reviewed in the following discussion and summarized in Table 4.

*Interferon is an immunomodulating medication with antiviral and antiproliferative effects and has been well studied in patients with chronic viral hepatitis. Interferon alpha (IFNα) is an approved treatment for both chronic hepatitis B and C. In appropriately selected patients with hepatitis C, interferon treatment led to sustained virological response (SVR), i.e. negative HCV RNA 6 months following completion of treatment, in approximately 50% of HCV patients. These results are improved when IFN is used with ribavirin (SVR up to 43%), and when peginterferon plus ribavirin is used (SVR up to 56%) [45]. In chronic HBV infection, IFN is indicated for patients with chronic hepatitis with elevated ALT and HBV DNA levels, and has the benefit of a lack of resistance and a durable response in those who respond to therapy. In studies of HBV patients, interferon is effective in roughly 35% of patients [50]. Peginterferon has also recently shown promise in treatment of hepatitis B [51], and peginterferon alfa-2a was recently licensed in the United States.*

IFN has been the most studied agent in treatment of coinfected patients because of the wealth of experience with this agent in viral hepatitis and its proven activity against both viruses. One of the first case reports of successful treatment with IFN of a coinfected patient (resulting in HBeAg loss and a SVR of HCV infection) was published by Burt et al. in 1993 [52]. Several case series were subsequently reported. In 1995, Gehénot et al. [53] studied 16 patients with histologically proven chronic hepatitis with
Table 4: Medication Trials in Hepatitis B and Hepatitis C Coinfected Patients

<table>
<thead>
<tr>
<th>Author [Ref]</th>
<th>Patients</th>
<th>#</th>
<th>Treatment x Duration</th>
<th>HCY SVR</th>
<th>HBV DNA negative</th>
<th>HBsAg loss</th>
<th>HBeAg loss</th>
<th>SBR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interferon Trials</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gehenot [53]</td>
<td>Anti-HCV+ HCV RNA+ HBsAg+ HBV DNA-</td>
<td>16</td>
<td>INFx 3 MU TIW × 6 mo</td>
<td>N/A</td>
<td>N/A</td>
<td>12.5%</td>
<td>N/A</td>
<td>19%</td>
</tr>
<tr>
<td>Weltman [3]</td>
<td>Anti-HCV+ HBsAg+</td>
<td>8</td>
<td>INFx 3 MU TIW × 6 mo</td>
<td>N/A</td>
<td>N/A</td>
<td>12.5%</td>
<td>N/A</td>
<td>12.5%</td>
</tr>
<tr>
<td>Guptan [54]</td>
<td>Anti-HCV+ HCV RNA+ HBsAg+ HBV DNA+</td>
<td>7</td>
<td>INFx 6 MU TIW × 6 mo</td>
<td>29%</td>
<td>86%</td>
<td>28.6%</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Villa [55]</td>
<td>Anti-HCV+ HCV RNA+ HBsAg+ HBV DNA±</td>
<td>30</td>
<td>INFx 9 MU TIW × 6 mo or 6 MU TIW × 6 mo</td>
<td>16.7% (31%)</td>
<td>66.7% (100%)</td>
<td>3%</td>
<td>N/A</td>
<td>20% (37.5%)</td>
</tr>
<tr>
<td>Utsi [23]</td>
<td>Anti-HCV+ HBsAg+ HCV RNA±</td>
<td>16</td>
<td>INFx 5 MU TIW × 12 mo</td>
<td>43.8%</td>
<td>N/A</td>
<td>N/A</td>
<td>15.4%</td>
<td>50%</td>
</tr>
<tr>
<td>Zignego [10]</td>
<td>Anti-HCV+ HBV DNA+ HBsAg-</td>
<td>14</td>
<td>INFx 3 MU TIW × 12 mo</td>
<td>0%</td>
<td>0%</td>
<td>N/A</td>
<td>N/A</td>
<td>0%</td>
</tr>
<tr>
<td>Liaw [56]</td>
<td>Anti-HCV+ HBV DNA+ HBsAg+</td>
<td>15</td>
<td>INFx 9 MU TIW × 14 wk or 4-6 MU TIW × 12 wk</td>
<td>0%</td>
<td>6.7%</td>
<td>6.7%</td>
<td>6.7%</td>
<td>6.7%</td>
</tr>
<tr>
<td><strong>Interferon plus ribavirin trials</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Liu [57]</td>
<td>Anti-HCV+ HCV RNA+ HBsAg+</td>
<td>21</td>
<td>INFx 6 MU TIW × 3 mo + 3 MU TIW × 3 mo + ribavirin × 6 mo</td>
<td>43%</td>
<td>35%</td>
<td>0%</td>
<td>100%</td>
<td>43%</td>
</tr>
<tr>
<td>Hung [58]</td>
<td>Anti-HCV+ HCV RNA+ HBsAg+</td>
<td>36</td>
<td>INFx 3-5 MU TIW + ribavirin × 6 mo</td>
<td>69%</td>
<td>11%</td>
<td>0%</td>
<td>0%</td>
<td>56%</td>
</tr>
<tr>
<td>Chuang [59]</td>
<td>Anti-HCV+ HCV RNA+ HBsAg+</td>
<td>42</td>
<td>INFx 6 MU TIW + ribavirin × 6 mo</td>
<td>69%</td>
<td>31.3%</td>
<td>14.3%</td>
<td>50%</td>
<td>54.8%</td>
</tr>
<tr>
<td><strong>Interferon plus lamivudine trials</strong></td>
<td></td>
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<td>Marrone [61]</td>
<td>HBsAg+ HBV DNA+ HCV RNA+</td>
<td>8</td>
<td>IFN 5 MU TIW × 12 mo + lamivudine × 18 mo</td>
<td>50%</td>
<td>37.5%</td>
<td>0%</td>
<td>37.5%</td>
<td>50%</td>
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*9 MU arm. Abbreviations: # = number of patients; Ref = reference; SVR = sustained virologic response; SBR = sustained biochemical response; HCV = hepatitis C virus; HBV = hepatitis B virus; Anti-HCV = Antibody to hepatitis C virus; HBsAg = hepatitis B surface antigen; HBeAg = hepatitis B e antigen; mo = month; wk = week; TIW = thrice weekly; INFx = interferon x.

positive anti-HCV, HCV RNA, HBsAg, and anti-HBe (HBV DNA negative), compared to patients with chronic HCV infection alone. Treatment consisted of INFx at 3 million units (MU) thrice weekly (TIW) for 6 months. A similar rate of sustained biochemical response (normal ALT at 6 months following treatment; SBR) was achieved in coinfected patients compared to controls (19 vs. 21%). Two patients treated with IFN seroconverted to HBsAg negative. This study demonstrated that comparable results could be obtained with interferon in coinfected patients who do not have evidence of HBV replication. A subsequent study by Weltman et al. [3] of 8 coinfected patients...
A hepatitis C flare has been described in a coinfected patient. Villa et al. [55] conducted a larger prospective randomized trial of 30 patients with HBV/HCV co-infection (HBsAg positive, Anti-HCV positive, HCV RNA positive), in which patients received either 6 or 9 MU IFN-α TIW for 6 months. This study found that higher dose IFN was more effective in inducing clearance of HCV RNA (31.2% vs. 0%, p = 0.045) and HBV DNA (100% vs. 0%), as well as in inducing a SBR (37.5% vs. 0%, p = 0.019) compared to the lower dose. Histological scores were better in patients in the high-dose arm as well. This was the first study to suggest that higher doses of IFN may be indicated in coinfected patients.

Several studies have reported detectable HBV DNA in patients with chronic hepatitis C but negative HBsAg. This so-called "serologically silent" HBV infection or "inapparent coinfection" has been correlated with impaired response to IFN treatment. Zignego et al. [10] reported significantly worsened results in 14 chronically infected HCV patients with inapparent HCV coinfection (anti-HCV positive, HBV DNA positive, HBsAg negative). Patients were treated with IFN α-2a TIW for 12 months. Four out of 14 patients had normal ALT levels at the end of therapy (28%), but all had relapsed within 6 month post-treatment, and thus none had a SVR. Fukuda et al. [14] also found that silent HBV infection was associated with higher ALT levels, higher histological activity scores and poor efficacy of IFN treatment. Some have proposed that the impaired response to IFN in such patients may be due to HBV-mediated down-regulation of intrahepatic IFN receptor gene expression [15].

A hepatitis C flare has been described in a coinfected patient who had HBeAg/HBV DNA clearance in response to IFN [56]. For this reason, some investigators have raised concern that IFN treatment of coinfected patients carries the risk of a severe hepatitis flare if the suppressive effect of one virus is removed, thereby allowing the other virus to become active.

Though there have been no published studies of the use of pegylated interferon (peg IFN) in coinfected patients, the use of this agent will likely replace standard interferon in treatment of HBV/HCV co-infection, as pegylated interferon is now the standard of care for the treatment of chronic hepatitis C, and has recently been approved for the treatment of chronic hepatitis B.

**Interferon plus Ribavirin**

Several groups have published studies addressing treatment of coinfected patients with antiviral combination therapy with IFN and ribavirin. Liu et al. [57] treated 24 dually infected patients (HBsAg positive/anti-HCV positive) with IFN α-2a (6 MU TIW for 12 weeks) concurrently with ribavirin 1200 mg daily for 24 weeks. Seventeen patients were positive for both HBV DNA and HCV RNA. Results showed a SVR rate of 43% for clearance of HCV RNA, compared to 60% in similarly treated HCV monoinfected controls. Six of 17 patients with detectable HBV DNA at baseline had disappearance of HBV DNA at the end of treatment persisting to 24 weeks post-treatment (35%). A SBR rate of 43% was reported. These results demonstrate the effectiveness of combined IFN and ribavirin in coinfected patients, with a rate of SVR and SBR comparable to HCV monoinfected patients.

Hung et al. [58] treated 36 patients with HBV/HCV co-infection (HBsAg positive/anti-HCV positive/HCV RNA positive) with combination IFN α-2b (3 or 5 MU TIW) and ribavirin (800–1200 mg/day) for 24 weeks. This study reported a SVR rate of 69% and SBR rate of 56%. Loss of HBV DNA was found in 2 of 18 patients with HBV DNA detected at baseline (11%). Interestingly, 53% of patients with negative HBV DNA at baseline had reactivation of HBV DNA at the 48 weeks of follow-up.

Chuang et al. [59] studied combination therapy with high-dose IFN α-2b (6 MU 3 times weekly for 24 weeks) and ribavirin (1000–1200 mg daily for 24 weeks) in 42 coinfected patients, compared to a control group of HCV monoinfected patients. The investigators found comparable rates of SVR in HCV coinfected (69.0%) and monoinfected (67.2%) patients (IFN naïve). Disappearance of HBV DNA occurred in 5 of 16 (31%) patients with positive HBV DNA at baseline. Viral interaction was evident, in that coinfected patients who achieved a SVR (compared HCV nonresponders) were less likely to achieve HBV DNA clearance (8.3% vs. 100%), and more likely to have reactivation of HBV (58.8% vs. 12.5%) or HBV flares (44.8% vs. 8.3%). Of the patients who cleared HBV DNA, 4 of 5 were patients who did not achieve a SVR with undetectable...
The patient's hepatitis improved after discontinuation of the interferon plus ribavirin combination therapy. Nonetheless, the high SVR rate for HCV infection in this population provides further evidence that IFN plus ribavirin combination therapy can be effective in coinfected patients, especially those who have active HCV replication.

As described in the above studies, successful treatment of chronic HCV infection may correlate to HBV reactivation and flaring. Yalcin et al. reported a severe hepatitis B flare in a patient with HBV/HCV coinfection (HBV DNA-negative) undergoing treatment with IFN and ribavirin [60]. This patient's hepatitis improved after discontinuation of therapy, but a relapse of HCV infection with rapid progression to cirrhosis occurred thereafter. Clinicians must exercise caution when treating coinfected patients with combination IFN plus ribavirin given this risk of HBV reactivation.

Interferon plus Lamivudine

One study of lamivudine therapy in addition to IFN for coinfeected patients has been published by Marrone et al [61]. Eight patients with dually active HBV and HCV (HBeAg-positive/HBV DNA-positive/HCV RNA-positive) were treated with 5 MU of IFN and lamivudine 100 mg/day for 12 months followed by lamivudine alone for 6 months. Three patients had clearance of HBeAg, 3 had clearance of HBV DNA (37.5%), and post-treatment ALT levels normalized in 4 of 8 (50%) treated patients. Four patients (50%) also had clearance of HCV RNA that was persistent at 12 months post-treatment (i.e. HCV SVR = 50%). This initial study suggests that the addition of lamivudine to IFN may be effective in coinfectected patients with chronic hepatitis C and active HBV replication. Further studies on this combination therapy in larger groups of patients must be performed in order to confirm these results.

Adefovir and Entecavir

There have been no published studies regarding treatment of coinfectected patients with the newer agents adefovir and entecavir. However, these agents may be useful, particularly in patients with HBV-dominant disease. Studies need to be performed using these agents before they can be recommended for routine usage.

Transplantation

The United Network of Organ Sharing (UNOS) reported that 14 patients were transplanted for combined hepatitis B and C in the United States in 2004, and 434 patients have been transplanted for this indication since 1988 [62]. There are limited data on the post-transplant course of such patients. One small study by Huang et al. [63] reported results of 19 patients with coinfection (either acquired or persistent) following transplantation. This study found that survival of patients with HBV monoinfection was worse than that of dually infected patients, suggesting a possible beneficial role of HCV in the immunosuppressed post-transplant population. Further studies are needed to clarify the clinical course and optimal management of coinfectected post-transplant patients.

Special Populations

Triple Infection with HBV, HCV and Hepatitis Delta Virus

Hepatitis delta virus (HDV) infects only patients with pre-existing HBV infection. Triple hepatotropic viral infections with HBV, HCV and HDV can result in more severe hepatitis, and therefore compel the clinician to offer treatment [8]. Few studies have been published regarding treatment of patients with triple hepatitis virus infection. Weltman et al. [3] studied 7 patients with triple infection who received IFN therapy. One patient had a reported SBR, and 2 patients were withdrawn from treatment due to side effects. Interferon treatment is a reasonable recommendation despite the paucity of data to support its use. Further studies are needed on such patients to determine optimal therapy.

Summary of Treatment Recommendations

Thorough serologic and virologic testing is required in dually infected patients prior to consideration of therapy. Assessment of the "dominant" virus is helpful in determining a treatment strategy. Caution must be taken with
treatment of coinfected individuals, as exacerbations of liver disease after initiation of therapy have been described, likely due to loss of viral suppression from the successfully treated dominant virus. Patients are candidates for therapy if they meet the inclusion criteria for standard treatment guidelines for either HBV or HCV mono-infection (Tables 1 and 2). In coinfected patients with HBV dominant disease, IFN with or without lamivudine is a reasonable option. Further studies of other HBV treatment agents such as adeovir and entecavir are needed before these agents can be routinely recommended, though they may be used on a case by case basis. In addition, future studies are needed to assess the effectiveness of peginterferon as well as triple therapy with lamivudine, IFN, and ribavirin in coinfected patients, though peginterferon should generally be used in place of standard interferon in coinfected patients given its proven efficacy in HBV and HCV mono-infected patients. Referral to a transplant center is indicated for patients with decompensated cirrhosis, fulminant hepatitis, or HCC in appropriate patients. In patients with triple HCV/HBV/HDV infections, few treatment studies have been published, but IFN is a reasonable treatment. Patients who have triple infection with HIV/HBV/HCV should have their care coordinated with an HIV specialist.

Conclusion
 Coinfection with HBV and HCV is not uncommon, especially within areas of high prevalence of hepatitis B. Dual infections present unique management challenges given the complex interaction of HBV and HCV, and the propensity for developing more severe liver disease. Treatment options mostly include IFN with or without lamivudine or ribavirin. Treatment decisions should be made based upon the determination of the "dominant" hepatitis virus. Caution must be exercised in treating coinfected patients, as flares of the untreated virus may occur. No standard of care has been established for treatment of coinfected patients, and larger randomized, controlled trials are needed to clarify the optimal treatment for such patients and the role of newer antiviral agents.

References


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