Prognostic determinants for chronic hepatitis B in Asians: therapeutic implications


Background: Identifying risk factors for the development of complications of chronic hepatitis B (CHB) is important for setting up treatment criteria.

Aim: To determine risk factors for the development of complications in Asian CHB patients.

Patients and methods: A total of 3233 Chinese CHB patients (mean follow up 46.8 months) were monitored for liver biochemistry, viral serology, hepatitis B virus (HBV) DNA levels, acute exacerbation, hepatitis B e antigen (HBeAg) seroconversion, and development of cirrhotic complications and hepatocellular carcinoma.

Results: Median age for HBeAg seroconversion and development of complications was 35 years and 57.2 years, respectively. Patients with alanine aminotransferase (ALT) levels of 0.5–1 times the upper limit of normal (ULN) and 1–2× ULN had an increased risk for the development of complications compared with patients with ALT levels <0.5× ULN (p<0.001 for both). HBeAg/antibody to hepatitis B e antigen status, and number of episodes, duration, and peak ALT levels of acute exacerbations were not associated with an increased risk of complications. In patients with complications, 43.6% had HBV DNA levels less than 1×10^5 copies/ml. Male sex, stigmata of chronic liver disease, old age, low albumin, and high α fetoprotein levels on presentation were independently associated with increased cumulative risk of complications. Male sex, presence of hepatitis symptoms, old age, low albumin level, and presence of complications on presentation were independently associated with shorter survival.

Conclusion: Prolonged low level viraemia causing insidious and continual liver damage, as reflected by ALT levels of 0.5–2× ULN, is the most likely pathway for the development of complications in Asian CHB patients.

Abbreviations: CHB, chronic hepatitis B; HBV, hepatitis B virus; ALT, alanine aminotransferase; ULN, upper limit of normal; HCC, hepatocellular carcinoma; HBeAg, hepatitis B e antigen; SBP, spontaneous bacterial peritonitis; anti-HBe, antibody to hepatitis B e antigen; AFP, α fetoprotein; PCR, polymerase chain reaction.
The Mann-Whitney U test was used for continuous variables. Differences in paired parameters were tested by the Wilcoxon signed ranks test. The Kaplan-Meier method using the log rank test was applied for calculation of the cumulative risk of development of complications and survival. The Cox hazard proportional model was used to test the associations between different variables and the development of complications and survival.

**RESULTS**

Demographics

A total of 3233 HBV patients were recruited. Demographic data on presentation are shown in table 1. Median and mean duration of follow up were 29 (range 6–291) months and 46.9 (SD 46.6) months, respectively.

HBeAg seroconversion

Among 1274 patients positive for HBeAg on presentation, 512 patients (40.2%) had HBeAg seroconversion at subsequent follow up. Median age at HBeAg seroconversion was 35 years (range 3.6–77.4).

Development of complications

A total of 170 patients (5.3%) developed at least one complication. The number of patients developing each complication was as follows: ascites 96 (3.0%) with 30 patients (0.9%) also having SBP, oesophageal varices 59 (1.8%), encephalopathy 40 (1.2%), and HCC 95 (2.9%). Of the 59 patients with oesophageal varices, 15 had clinical bleeding; the rest were detected by endoscopy. The cumulative risk for the development of complications is shown in fig 1. By the end of 10 years and 15 years of follow up, 8% and 12% of patients, respectively, had developed complications.

### Table 1

Demographic data of the 3233 patients on presentation

<table>
<thead>
<tr>
<th>No of patients</th>
<th>Sex ratio (M:F)</th>
<th>Age (y) (median (range))</th>
<th>HBeAg: anti-HBe</th>
<th>Albumin (g/l) (median (range))</th>
<th>Bilirubin (μmol/l) (median (range))</th>
<th>ALT (U/l) (median (range))</th>
</tr>
</thead>
<tbody>
<tr>
<td>3233</td>
<td>2121:1112 (1.9:1)</td>
<td>38 (1–85)</td>
<td>1274:1959 (1:1.5)</td>
<td>45 (1.5–58)</td>
<td>11.8 (5.5–53)</td>
<td>42 (4–4820)</td>
</tr>
</tbody>
</table>

No of patients with ALT < 0.5 × ULN | ALT > 0.5–1 × ULN | ALT > 1–2 × ULN | ALT > 2–6 × ULN | ALT > 6 × ULN |
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<tbody>
<tr>
<td>714 (22.1%)</td>
<td>1006 (31.1%)</td>
<td>737 (22.8%)</td>
<td>479 (14.8%)</td>
<td>297 (9.2%)</td>
</tr>
</tbody>
</table>

No of patients with AFP < 20 ng/ml | AFP > 20–100 ng/ml | AFP > 100–500 ng/ml | AFP > 500 ng/ml | Duration of follow up (months) |
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<tbody>
<tr>
<td>2861 (88.5%)</td>
<td>243 (7.5%)</td>
<td>97 (3%)</td>
<td>32 (1%)</td>
<td>Median (range) 29 (6–291)</td>
</tr>
<tr>
<td>Mean (SD) 46.9 (46.6)</td>
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</table>

HBeAg, hepatitis B e antigen; anti-HBe, antibody to hepatitis B e antigen; ALT, alanine aminotransferase; ULN, upper limit of normal; AFP, α-fetoprotein.

### Table 2

Median age and hepatitis B e antigen/antibody to hepatitis B e antigen (HBeAg/anti-HBe) status at the time of development of complications of cirrhosis and hepatocellular carcinoma

<table>
<thead>
<tr>
<th>Age (y) at the time of complications (median (range))</th>
<th>HBeAg/anti-HBe (% anti-HBe +ve)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascites (n = 96)</td>
<td>57.7 (29.7–78.1)</td>
</tr>
<tr>
<td>SBP (n = 30)</td>
<td>60.0 (32.2–78.0)</td>
</tr>
<tr>
<td>Oesophageal varices (n = 59)</td>
<td>54.3 (25.4–82.3)</td>
</tr>
<tr>
<td>Encephalopathy (n = 40)</td>
<td>58.5 (27.6–83.1)</td>
</tr>
<tr>
<td>HCC (n = 95)</td>
<td>59 (24.8–82)</td>
</tr>
<tr>
<td>All complications (n = 170)</td>
<td>57.2 (24.8–83.1)</td>
</tr>
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SBP, spontaneous bacterial peritonitis; HCC, hepatocellular carcinoma.
Median age and HBeAg/anti-HBe status at the time of development of each complication are shown in Table 2; 73.5% of patients were positive for anti-HBe when complications developed. As this might be related to the higher prevalence of anti-HBe positivity in the age groups when complications occurred, patients were stratified according to age. For patients under 50 years of age, the prevalence of anti-HBe positivity for patients who developed complications was significantly higher compared with that of patients with no complications (73.1% (38/52) vs 56.4% (1453/2595), respectively; p = 0.016). For patients over 50 years of age, there was no significant difference in anti-HBe positivity between patients who developed complications and patients with no complications (73.7% (87/118) vs 80.1% (374/467), respectively; NS).

Factors associated with the development of complications

Demographics on presentation

Males had a higher cumulative risk for the development of complications than females (p<0.0001). Patients who developed complications, compared with patients without complications, were older (median age 55 years (range 19–82) vs 38 years (range 1–85); p<0.0001), had a higher chance of the presence of stigmata of chronic liver disease (p<0.0001), and were more likely to present with hepatitis symptoms (p<0.0001).

Liver biochemistry on presentation of patients with and without complications of cirrhosis

Table 3

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Liver biochemistry on presentation of patients with and without complications of cirrhosis</th>
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<tbody>
<tr>
<td></td>
<td>Patients who developed complications of cirrhosis</td>
</tr>
<tr>
<td>Albumin (g/l)</td>
<td>34 (17–50)</td>
</tr>
<tr>
<td>ALT (U/l)</td>
<td>59 (11–3370)</td>
</tr>
<tr>
<td>Bilirubin (µmol/l)</td>
<td>18 (3–323)</td>
</tr>
<tr>
<td>AFP (ng/ml)</td>
<td>17.5 (1–32202)</td>
</tr>
</tbody>
</table>

Values are median (range).

ALT, alanine aminotransferase; AFP, α fetoprotein.

The effect of ALT levels during follow up on the cumulative risk for the development of complications was also calculated for patients with at least three ALT readings. Patients were categorised by median ALT levels according to the same criteria adopted above. As there were only nine patients with median ALT levels more than 6×ULN, they were grouped with patients with ALT levels >2–6×ULN. Again, patients with ALT levels >1–2×ULN had the highest risk for the development of complications (p<0.0001 and p = 0.0027 compared with patients with ALT <0.5×ULN and patients with ALT levels 0.5–1×ULN, respectively). Patients with ALT levels of 0.5–1×ULN also had a higher risk for the development of complications compared with patients with ALT levels 0.5–1×ULN and patients with ALT levels 0.5–1×ULN, respectively. Patients with ALT levels of 0.5–1×ULN also had a higher risk for the development of complications compared with patients with ALT levels 0.5–1×ULN and patients with ALT levels 0.5–1×ULN, respectively.
ALT levels <0.5 × ULN (p = 0.0071). There were no significant differences in the risk for development of complications when patients with ALT levels >2–6 × ULN were compared with patients with ALT levels <0.5 × ULN and those with ALT levels 0.5–1 × ULN.

HBeAg status on presentation
There was no significant difference in the cumulative risk for the development of complications between HBeAg positive patients and anti-HBe positive patients (p = 0.12). This was also true when each type of complication was analysed separately.

Effect of exacerbation
The effect of exacerbation on the development of complications was analysed with respect to the number of episodes of exacerbation, duration of exacerbation, peak ALT levels, and peak AFP levels. The only significant risk factor was peak AFP levels of 100 ng/ml or more during or after an exacerbation (p = 0.0001 compared with patients with AFP level less than 100 ng/ml) (fig 3).

HBV DNA levels
HBV DNA levels were measured in 2332 patients. Of these, 112 had paired serum samples before and after HBeAg seroconversion. In addition, 525 HBeAg positive patients and 1695 anti-HBe positive patients had samples at the last follow up for HBV DNA assays. Details of HBV DNA levels measured by Digene Hybrid Capture assay are shown in table 4.

Median HBV DNA levels of the 1695 anti-HBe positive patients, as determined by the Cobas Amplipcr HBV Monitor test, was 7250 copies/ml (range <200–1.7 × 106). Only 386 patients (22.8%) had undetectable HBV DNA levels. HBV DNA levels were <104, >103–104, >104–105, and >105 copies/ml in 183 (10.8%), 320 (18.9%), 259 (15.3%), and 547 (32.3%) patients, respectively.

HBV DNA levels were measured in 110 patients with complications: 21 patients before the complications developed (range 0.2–8.25 months); nine at the time of the complications; 21 patients before the complications developed (range 0.2–8.25 months); and 80 after the complications developed (range 0.2–8.25 months). Median HBV DNA level was 0.323 × 106 copies/ml (range <0.142–1700 × 106 copies/ml). Forty eight patients (43.6%) had HBV DNA levels undetectable by the Digene Hybrid Capture assay. The Cobas Amplipcr HBV Monitor test was performed in 45 of these patients. Thirteen (28.9%) patients had undetectable HBV DNA (that is, <200 copies/ml). HBV DNA levels (copies/ml) of the remaining 32 patients were as follows: <103 in two patients (4.4%); >103–104 in 12 patients (26.7%); >104–105 in 10 patients (22.2%); and >105 in eight patients (17.8%).

Independent factors associated with development of complications and poor survival
Using the Cox proportional hazards model, male sex (p < 0.0001), presence of hepatitis symptoms (p = 0.02), increasing age (p < 0.0001), and low albumin level on presentation (p < 0.0001), and high AFP level on presentation (p = 0.001) were found to be independent factors associated with a higher cumulative risk for the development of complications.

For survival analysis, male sex (p = 0.004), presence of hepatitis symptoms (p = 0.02), increasing age (p < 0.0001), and low albumin level on presentation (p < 0.0001) were found to be independent factors associated with a shorter actuarial survival.

DISCUSSION
The present study was limited by the relatively short period of follow up even though 307 patients (10.0%) were followed up for more than 10 years. Another limitation of the study was the absence of histological assessment. However, the end points of our study, the development of cirrhosis related complications and HCC, are of great clinical and prognostic relevance.

Several findings from the present study have direct implications for criteria for the treatment of CHB in the future. Firstly, the risk of complications increased as ALT levels on presentation increased from >0.5 × ULN to 2 × ULN. In contrast, patients with ALT levels above 6 × ULN had a significantly lower risk for the development of complications (fig 2). These findings were confirmed using median ALT levels of patients during subsequent follow up. Acute exacerbations and high ALT levels (for example, >2 × ULN) probably signify acute injuries to the liver which may not lead to permanent damage. This is probably analogous to the situation in acute viral hepatitis. However, in patients with only mild elevation of ALT, including those with ALT levels in the upper range of normal, the immune attack on the liver might be more insidious and chronic, leading eventually to more severe and permanent damage.

In the study of Kim et al showing an increased risk of mortality from liver disease in patients with ALT levels in the upper range of normal, it was suggested that the normal range of serum aminotransferase concentrations should be lowered in populations in which liver disease are common. Even though the authors did not test their subjects for hepatitis B or C markers, their findings confirm ours. The present guidelines for treatment suggest that only patients with ALT levels >2 × ULN should be treated. This would exclude patients with the highest risks for the development of complications from treatment.

Secondly, in the Asian population, disease activity continues to progress in a proportion of patients after HBeAg seroconversion. Median age for the development of complications in our patients was 57.2 years (table 2). Median age of HBeAg seroconversion was 35 years. More than two thirds of the patients were already anti-HBe positive when they developed complications. The cumulative risk for the development of complications was comparable between patients positive for HBeAg and for anti-HBe on presentation. A Taiwan study by Yang et al. claimed that HBeAg positivity was associated with an increased risk of HCC. HBeAg status of

**Table 4** Hepatitis B virus (HBV) DNA levels of 2332 patients measured by Digene Hybrid Capture assay

<table>
<thead>
<tr>
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<th>112 patients with paired serum</th>
<th>2220 patients with serum at last follow up</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>HBeAg+ve phase (n = 112)</td>
<td>Anti-HBe+ve phase (n = 112)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undetectable HBV DNA (%)</td>
<td>27 (24.1)</td>
<td>73 (65.18)</td>
</tr>
<tr>
<td>HBV DNA level (&lt;10^6 copies/ml) (median (range))</td>
<td>4.15 (&lt;0.142–803.87)*</td>
<td>&lt;0.142 (&lt;0.142–434.58)*</td>
</tr>
<tr>
<td></td>
<td>HBeAg+ve (n = 525)</td>
<td>Anti-HBe+ve (n = 1695)</td>
</tr>
<tr>
<td></td>
<td>102 (19.4)</td>
<td>1271 (75.0)</td>
</tr>
<tr>
<td></td>
<td>&lt;0.142 (&lt;0.142–1700)†</td>
<td>&lt;0.142 (&lt;0.142–1700)†</td>
</tr>
</tbody>
</table>

HBeAg, hepatitis B e antigen; anti-HBe, antibody to hepatitis B e antigen.

*p < 0.001; †p < 0.001
the patients in this study however was checked only at the time of enrolment whereas the development of HCC was observed during the subsequent 10 years of follow up. HBeAg/anti-HBe status at the time of development of HCC was not assessed. This study therefore can provide no clue as to the HBeAg status of patients at the time of HCC development. Another smaller Taiwan study found that although HBeAg seroconversion confers a favourable outcome in some patients, active hepatitis can occur after HBeAg seroconversion, leading to cirrhosis and HCC.13 McMahon et al, in their study, found that ‘‘seroconversion from HBeAg to anti-HBe, and even loss of hepatitis B surface antigen, did not protect patients from development of hepatocellular carcinoma’’.14 These latter two studies confirm the findings of the present study, that the majority of cirrhosis related complications and HCC develop after HBeAg seroconversion. The onset of cirrhosis occurs during the prolonged process of HBeAg seroconversion in Asian patients.15 Cirrhosis will continue to worsen or develop after HBeAg seroconversion.16,18 Thus HBeAg seroconversion should only be regarded as a step towards viral suppression, and therapy may need to be continued after HBeAg seroconversion.

Thirdly, progression of cirrhosis is more likely to be related to the low level of viraemia in a large proportion of patients who are anti-HBe positive. In the current study, only 22.8% of anti-HBe patients had undetectable HBV DNA levels by the PCR based assay; 32.3% had more than 10^{5} copies/ml. (That the wild-type virus is as likely to cause complications as the precore mutants have been analysed in a separate study.)

Among the 56% of patients with complications in whom HBV DNA levels were undetectable by the Digene Hybrid Capture assay, over 70% had HBV DNA levels detectable by the Amplicor HBV Monitor test. Twenty nine per cent of patients had undetectable HBV DNA (that is, <200 copies/ml). This is evidence against the proposal that disease progression is unlikely once HBV DNA levels become less than 10^{5} copies/ml.10 Our findings support the conclusion of Chu and colleagues11 that there is no cut off HBV DNA value for differentiating active from inactive disease in HBeAg negative patients. This implies that prolonged and maximal suppression of HBV DNA to levels below the detection limit of PCR based assays may be necessary to reduce the risk of complications.

In conclusion, prolonged low level viraemia causing insidious and continual liver damage, as reflected by relatively mild elevations in ALT levels, is the most likely pathway leading to the development of complications for Asian patients with CHB. Long term antiviral therapy aiming at maximal suppression of HBV even after HBeAg seroconversion may be required for Asian patients.

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