tients with genotype 1b and low virus load. Additionally, the relationship between attainment time of negativity of serum HCV RNA after the initiation of combination therapy and the continuance of negative HCV RNA in patients with genotype 1b and low HCV-RNA load of <100 KIU/mL were also evaluated.

Materials and Methods

Patients

Eligibility criteria for entry into the study included the following: 1) HCV genotype 1b; 2) serum level of HCV RNA of <100 KIU/mL before treatment; 3) no corticosteroid, immunosuppressive agents, or antiviral agents used within 6 months; 4) no hepatitis B surface antigens (HBsAg), antinuclear antibodies (ANA), or antimitochondrial antibodies (AMA) detectable in serum, determined by radioimmunoassay; 5) leukocytes >2,000/mm^3, platelet count >80,000/mm^3, and bilirubin <2.0 mg/mL; 6) follow up for >6 months before treatment. We excluded from the study all of the patients with the following: 1) a history of alcohol abuse; 2) advanced liver cirrhosis of encephalopathy, bleeding esophageal varices, or ascites. The physician in charge explained the purpose and method of the combination therapy as well as the potential adverse reactions to each patient and informed consent was obtained from each patient.

From December 2004 to May 2007, 60 HCV patients were enrolled in this retrospective cohort study at the study hospital.

Patients were classified into three groups according to their response to combination therapy: rapid virological response (RVR), defined as undetectable HCV RNA at week 4 after the initiation of combination therapy; early virological response (EVR), defined as undetectable HCV RNA at week, 5 to 12 of combination therapy; and late virological response (LVR), defined as undetectable HCV RNA at week 13 to 24 of combination therapy. A SVR was defined as clearance of HCV RNA by commercial amplicor HCV qualitative assay (Amplicor HCV; Ver.2.0, Roche Diagnostic Systems, Basel, Switzerland) at 6 months after the cessation of combination therapy (19).

Next, predictors of SVR in patients with undetectable HCV RNA in serum during treatment were assessed by the multiple logistic regression analysis. Finally, SVR rate based on the attainment time of negativity of HCV RNA and continuance of negative HCV RNA during combination therapy were examined.

Combination therapy of pegylated-IFN and ribavirin

For the treatment regimen, the peginterferon (Peg-intron, Schering-Plough Pharmaceutical Co., Osaka, Japan) and ribavirin (Rebetol, Schering-Plough) were given at the dose described based on body weight. At the initiation of combination therapy, patients received peginterferon at a median dose of 1.4 μg/kg (range, 1.3-1.7 μg/kg) subcutaneously each week and oral ribavirin at a median dose of 12.0 mg/kg (range, 9.9-14.9 mg/kg) daily. The peginterferon dose was adjusted according to body weight (60 μg for ≤40 kg, 80 μg for >40 kg and ≤60 kg, 100 μg for >60 kg and ≤80 kg, 120 μg for >80 kg and ≤100 kg, and 150 μg for >100 kg). The ribavirin dose was adjusted according to body weight (600 mg for ≤60 kg, 800 mg for >60 kg and ≤80 kg, and 1,000 mg for >80 kg). The regimen or treatment period was decided by the physician. A total of 39 patients were treated with a 48-week regimen and 16 patients were given combination therapy for a 24-week regimen. Treatment for the remaining five patients was discontinued because of treatment-related side effects within 26 weeks after the initiation of combination therapy.

Blood samples were obtained just before and 6 month after combination therapy. The samples were stored at -80℃ until analyzed. Using these blood samples, HCV-RNA level before IFN therapy was analyzed by quantitative PCR assay (Amplicor GT-HCV Monitor Version 2.0, Roche Molecular Systems) (20). HCV-genotype was examined by polymerized chain reaction assay, using a mixture of primers for the six subtypes known to exist in Japan, as reported previously (21). Serum alanine aminotransferase (ALT), aspartate aminotransferase (AST) concentrations, and HCV RNA were measured at least once per month during therapy. Negativity of serum HCV RNA was defined as clearance of serum HCV RNA by commercial amplicor HCV qualitative assay (19). Clinical evaluation and biochemical and hematological tests were performed at 4 weekly intervals.

Liver histology before IFN therapy

Liver biopsy specimens were obtained percutaneously under the observation by laparoscopy using a modified Vim Silverman needle with an internal diameter of 2 mm (Tohoku University style, Kakinuma Factory, Tokyo), fixed in 10% formalin, and stained with Hematoxylin and Eosin, Masson's trichrome, silver impregnation, and periodic acid-Schiff after diastase digestion. The biopsy specimens were diagnosed according to the system of Desmet et al (22).

Statistical analysis

Nonparametric procedures were employed for the analysis of background features of the patients with SVR and without SVR, including the Mann-Whitney U test. Independent factors that might have influenced SVR were studied using multiple logistic regression analysis, and the following variables were evaluated as prognostic factors: sex, age, body mass index, liver staging, a history of interferon therapy, a history of HCV load of ≥100 KIU/mL, HCV RNA level, biochemical factors (AST, ALT), platelet count, HCV RNA 4, 8, 12 week after the initiation of IFN therapy, continuous negative period of HCV RNA during IFN therapy and period of IFN therapy. The SPSS software package (SPSS Inc., Chicago, IL) was used to perform statistical analysis. A p value of <0.05 was considered to indicate a significant difference.

Table 1. Clinical Backgrounds before Combination Therapy of Peginterferon and Ribavirin in Chronic Hepatitis C Patients

	Total	Response			
		RVR	EVR	LVR	p
Patients, n*	60	18	31	6	
Sex, male (%)†	42 (70%)	15 (83%)	23 (74%)	2 (33%)	0.063
Age (yrs)‡	51.9±10.1	50.8±9.3	52.1±10.8	53.9±10.9	0.713
BMI‡	21.9±3.1	23.2±3.6	21.2±2.9	21.9±2.3	0.177
A history of IFN†, (%)	28 (47%)	7 (39%)	13 (42%)	4 (67%)	0.085
History of maximum HCV RNA level of >100KIU/mL (+/-)†	43/17	13/5	21/10	4/2	0.498
HCV RNA(KIU/mL)§	52 (<5-99)	43(8-93)	58(<5-99)	72(21-90)	0.498
AST (IU/L)‡	58±32	61±47	56±24	51±18	0.480
ALT (IU/L)‡	73±52	80 ± 62	69 ± 37	82±59	0.456
FPG(mg/dL)‡	93.1±13.6	93.2±13.0	92.5±12.2	97.5±24.6	0.182
Triglyceride (mg/dL)‡	92.5±35.2	94.5±27.8	90.6±42.9	93.9±30.2	0.887
Platelet(10^4/mm^3)‡	18.7±6.3	20.9±4.7	19.6±5.9	13.7±5.6	0.106
Fibrosis staging† (Non-LC/LC)	54/6	18/0	26/5	5/1	0.067

*ALT, alanine aminotransferase; AST, aspartate aminotransferase; BMI, body mass index; EVR, early virological response; FPG, fasting plasma glucose; HCV, hepatitis C virus; IFN, interferon; LC, liver cirrhosis; LVR, late virological response; RVR, rapid virological response

Normal reference ranges 6-50 IU/L for ALT, 11-38 IU/L for AST,

†Data expressed as number of patients (percentage)

‡Data expressed as mean ± standard deviation

§Data expressed as median (range)

Result

Clinical characteristics of the patients

A total of 60 patients were enrolled on present study. Table 1 shows the characteristics of the patients who received combination therapy. Clinical profiles were as follows: mean age =52 years, male/female =42/18, and median (range) HCV-RNA=52 (<5-99) KIU/mL. Two of the patients treated with 48-regimen and three out of five discontinued combination therapy due to side effects had positive HCV RNA during combination therapy. Patients with negativity of serum HCV RNA during combination therapy were classified into three groups according to the difference of response: RVR (n=18), EVR (n=31), and LVR (n=6). There were no significant differences in several factors in three groups as shown in Table 1.

Safety and tolerance of IFN

Of the 60 patients included in this study, five discontinued combination therapy because of IFN-related adverse events: one patient each with thrombocytopenia, general fatigue, psychiatric disorder, poor appetite, and cholecystitis. The onset of IFN-related side effects ranged from one to 11 weeks after initiation of IFN therapy. These side effects in five patients disappeared one month after cessation of IFN therapy.

Next, ten of the remaining 55 patients had dose reduction of interferon and/or ribavirin because of side effects: 5 cases of thrombocytopenia, 3 cases of general fatigue, and 2 cases of poor appetite. The onset of dose reduction due to IFN-related side effects ranged from 1 to 26 weeks after initiation of IFN therapy.

Efficacy of treatment

Out of 60 patients enrolled in the present study, 47 patients (78.3%) had SVR by the intention-to-treat analysis. Table 2 shows the differences in the clinical background between patients with SVR and those without SVR. The SVR was significantly associated with the attainment time of negativity of serum HCV RNA and continuance period of negative HCV RNA. Multivariate analysis indicated that non-relapse occurred when serum HCV RNA at week 8 was negative (p=0.004) and continuance of negative HCV RNA during treatment was $\geq$30 weeks (p=0.016) (Table 3).

Table 2. The Difference of Clinical Backgrounds between Patients with SVR and Those without SVR

	SVR (n=47)	Non-SVR (n=13)	p value
Age (years old) †	52.2 ± 10.1	53.4 ± 8.9	0.346
Sex (male/female) †	35/12	8/5	0.488
BMI	21.8 ± 3.2	22.2 ± 3.0	0.732
Liver staging (non-LC /LC)	42/5	12/1	1.00
a history of interferon (+/-)	22/25	6/7	1.00
a history of HCV load of ≥100KIU/mL (+/-)	31/16	7/6	0.520
HCV-load (KIU/mL) *	58 (<5-99)	46 (6-93)	0.375
AST (IU/L) *	49 ± 34	54 ± 22	0.102
ALT (IU/L) *	70 ± 55	83 ± 39	0.082
Platelet (10^4/mm^3) *	19.0 ± 6.5	17.6 ± 3.8	0.230
HCV RNA (-) 4W	17/46 (37%)	0/10 (0%)	0.023
HCV RNA (-) 8W	35/46 (76%)	1/10 (10%)	0.002
HCV RNA (-) 12W	44/46 (96%)	3/10 (30%)	<0.001
Continuous negative period (week)	34.9 ± 11.6	10.4 ± 12.1	<0.001
Period of IFN therapy (week)	41.6 ± 12.6	28.8 ± 19.6	<0.001

Data are number of patients, median (range) or mean±standard deviation. p value calculated by the Mann-Whitney U test

*ALT, alanine aminotransferase; AST, aspartate aminotransferase; HCV, hepatitis C virus; IFN, interferon; SVR, sustained virologic response

Table 3. Multivariate Analyses Identifying Predictors of SVR

Factor	Category	Odds ratio	95% Confidence interval	p value
HCV RNA week 8*	+ /-	1/69.1	4.0-1201.4	0.004
Continuance period of negative HCV RNA during treatment (week)	<30 / ≥30	1/34.5	1.9-500.0	0.016

HCV, hepatitis C virus

*HCV RNA at week 8 after the initiation of treatment

SVR based on the attainment time of negativity of serum HCV RNA and continuance of negative HCV RNA

All fifty-five patients with negativity of HCV RNA after the initiation of combination therapy had continuance of negative HCV RNA during combination therapy. SVR rate based on the attainment time of negativity of serum HCV RNA and continuance of negative HCV RNA during combination therapy are shown in Table 4. In the RVR group, all of seven patients with continuance of negative HCV RNA of 20 to 29 week during treatment had SVR. In the EVR group, patients with continuance of 30 to 39 week during treatment had SVR of ≥90%. In the LVR group, patients with continuance of 30 to 39 week during treatment had SVR of 50%.

Discussion

We have described the efficacy of combination therapy of peginterferon and ribavirin in patients infected with HCV genotype 1b and low virus load. The present study was limited to patients with genotype 1 and HCV-load of <100 KIU/mL. Another limitation is that the present study was not a randomized controlled study; thus, the treatment period was varied. Moreover, half of the patients had a history of IFN monotherapy and two-thirds of the patients had a history of maximum HCV RNA level of >100 KIU/mL. Clinical backgrounds of the enrolled patients were varied.

However, several findings from the present study have direct implications for combination therapy for chronic hepatitis C in the future. First, SVR was primarily associated with attainment time of negativity of serum HCV RNA and continuance of negative HCV RNA. The period of combination

Table 4. SVR Based on the Attainment Time of Negative HCV RNA and Continuance Period of Negative HCV RNA during Combination Therapy

Response*	Continuance period of negative HCV RNA (week)					Total
	<10	10-19	20-29	30-39	40-49	
RVR	100% (1/1)	ND	100% (7/7)	ND	100% (10/10)	100% (18/18)
EVR	ND	63% (5/8)	ND	90% (9/10)	100% (13/13)	87% (27/31)
LVR	0% (0/2)	ND	ND	50% (2/4)	ND	33% (2/6)
Total	33% (1/3)	63% (5/8)	100% (7/7)	79% (11/14)	100% (23/23)	85% (47/55)

EVR, early virological response; HCV, hepatitis C virus; LVR, late virological response; ND, not done; RVR, rapid virological response

*Response of HCV RNA means attainment time of negativity of serum HCV RNA after the initiation of combination therapy

therapy is statistically significant by univariate analysis. However, multivariate analysis showed that early undetectable HCV RNA and prolonged negativity of serum HCV RNA during treatment were associated with the SVR. In the RVR group, all seven patients with continuance of negative HCV RNA for 20 to 29 week during treatment had SVR. This result suggests that a short course regimen of 24 or < 24 week in combination therapy may be suitable for patients who have genotype 1, low virus load, and RVR. Earlier studies have reported higher SVR rates in patients with undetectable HCV RNA at week 4 compared to those with detectable HCV RNA (7-9, 23). Jensen et al (8) has reported that patients with RVR should be treated for a short course regimen. On the contrary, it may be necessary to treat patients without RVR with a long course regimen. The present results coincided closely with these earlier results.

Secondly, in the EVR group, patients with continuance of negative HCV RNA of ≥30 weeks during treatment had SVR of ≥90%. However, one-third of the patients with continuance of negative HCV RNA of 10 to19 weeks relapsed after the termination of therapy. This result suggests that patient with EVR should be given combination therapy for a year. Third, in LVR group, half of the patients with continuance of negative HCV RNA of 30 to 39 weeks during treatment had SVR. This indicates that patients with delayed undetectable HCV RNA should be treated to continue the negativity of serum HCV RNA for a prolonged period of ≥ one year to obtain a high rate of SVR.

A previous study (24) indicates that the suitable treatment period of combination therapy for chronic hepatitis C should be determined based on the time of attainment of negative HCV RNA in patients with genotype 1b and a high virus load of ≥100 KIU/mL. Similarly, the present study suggests that in patients with genotype 1b and low-virus load, the period of combination therapy should be determined based on the attainment time of negativity of serum HCV RNA.

It is desirable to expose patients with chronic hepatitis C to the shortest duration of treatment possible to reduce the likelihood of adverse events and minimize costs. Long-term treatment can be associated with serious side effects and is costly. HCV treatment of combination therapy is expensive; a 24-week treatment course costs approximately 20,000 dollars. Thus, the results of this study underscore the importance of changing the duration of treatment based on the difference of attainment time of negative HCV RNA. To attain SVR rate of ≥90% in patients with undetectable HCV RNA and continuance of negative HCV RNA during treatment, it is desirable to give a short course regimen of ≤20-29 weeks in the RVR group, 30-39 week in the EVR group. Moreover, in LVR, prolonged combination therapy regimen of >48 weeks may be recommended.

In conclusion, the period of combination therapy for chronic hepatitis C should be determined based on attainment time of negativity of serum HCV RNA and continuance of negative HCV RNA in patients with genotype 1b and low-virus load.

Acknowledgement

The present work was supported in part by grants-in-aid from Okinaka Memorial Institute for Medical Research and the Japanese Ministry of Health, Labour and Welfare. The authors acknowledge the editorial assistance of Thomas Hughes.

References

1. Manns MP, McHutchison JG, Gordon SC, et al. Peginterferon alfa-2b plus ribavirin compared with interferon alfa-2b plus ribavirin for initial treatment of chronic hepatitis C: a randomised trial. Lancet **358**: 958-965, 2001.
2. Fried MW, Shiffman ML, Reddy KR, et al. Peginterferon alfa-2a plus ribavirin for chronic hepatitis C virus infection. N Engl J Med **347**: 975-982, 2002.
3. Hadziyannis SJ, Sette H, Morgan TR, et al; PEGASYS Interna-

tional Study Group. Peginterferon-alpha2a and ribavirin combination therapy in chronic hepatitis C: a randomized study of treatment duration and ribavirin dose. Ann Intern Med **140**: 346-355, 2004.

4. McHutchison JG, Manns M, Patel K, et al. Adherence to combination therapy enhances sustained response in genotype-1-infected patients with chronic hepatitis C. Gastroenterology **123**: 1061-1069, 2002.
5. Shiffman ML, Di Bisceglie AM, Lindsay KL, et al; Hepatitis C Antiviral Long-Term Treatment Against Cirrhosis Trial Group. Peginterferon alfa-2a and ribavirin in patients with chronic hepatitis C who have failed prior treatment. Gastroenterology **126**: 1015-1023, 2004.
6. Shiffman ML, Ghany MG, Morgan TR, et al. Impact of reducing peginterferon alfa-2a and ribavirin dose during retreatment in patients with chronic hepatitis C. Gastroenterology **132**: 103-112, 2007.
7. Schalm SW, Weiland O, Hansen BE, et al. Interferon-ribavirin for chronic hepatitis C with and without cirrhosis: analysis of individual patient data of six controlled trials. Eurohep Study Group for Viral Hepatitis. Gastroenterology **117**: 408-413, 1999.
8. Jensen DM, Morgan TR, Marcellin P, et al. Early identification of HCV genotype 1 patients responding to 24 weeks peginterferon alpha-2a (40 kd)/ribavirin therapy. Hepatology **43**: 954-960, 2006 (Erratum in Hepatology **43**: 1410, 2006).
9. Bronowicki JP, Ouzan D, Asselah T, et al. Effect of ribavirin in genotype 1 patients with hepatitis C responding to pegylated interferon alfa-2a plus ribavirin. Gastroenterology **131**: 1040-1048, 2006.
10. Dalgard O, Bjøro K, Hellum KB, et al. Treatment with pegylated interferon and ribavarin in HCV infection with genotype 2 or 3 for 14 weeks: a pilot study. Hepatology **40**: 1260-1265, 2004.
11. Mangia A, Santoro R, Minerva N, et al. Peginterferon alfa-2b and ribavirin for 12 vs. 24 weeks in HCV genotype 2 or 3. N Engl J Med **352**: 2609-2617, 2005.
12. Bruno S, Cammà C, Di Marco V, et al. Peginterferon alfa-2b plus ribavirin for naïve patients with genotype 1 chronic hepatitis C: a randomized controlled trial. J Hepatol **41**: 474-481, 2004.
13. Lindahl K, Stahle L, Bruchfeld A, et al. High-dose ribavirin in combination with standard dose peginterferon for treatment of patients with chronic hepatitis C. Hepatology **41**: 275-279, 2005.
14. von Wagner M, Huber M, Berg T, et al. Peginterferon-alpha-2a (40 KD) and ribavirin for 16 or 24 weeks in patients with genotype 2 or 3 chronic hepatitis C. Gastroenterology **129**: 522-527, 2005.
15. Krawitt EL, Gordon SR, Grace ND, et al; for the New York New England Study Team. A study of low dose peginterferon alpha-2b with ribavirin for the initial treatment of chronic hepatitis C. Am J Gastroenterol **101**: 1268-1273, 2006.
16. Ferenci P, Fried MW, Shiffman ML, et al. Predicting sustained virological responses in chronic hepatitis C patients treated with peginterferon alfa-2a (40 KD)/ribavirin. J Hepatol **43**: 425-433, 2005.
17. Iwasaki Y, Ikeda H, Araki Y, et al. Limitation of combination therapy of interferon and ribavirin for older patients with chronic hepatitis C. Hepatology **43**: 54-63, 2006.
18. Arase Y, Suzuki F, Suzuki Y, et al. Side effects of combination therapy of peginterferon and ribavirin for chronic hepatitis-C. Intern Med **46**: 1827-1832, 2007.
19. Doglio A, Laffont C, Caroli-Bosc FX, et al. Second generation of the automated Cobas Amplicor HCV assay improves sensitivity of hepatitis C virus RNA detection and yields results that are more clinically relevant. J Clin Microbiol **37**: 1567-1569, 1999.
20. Albadalejo J, Alonso R, Antinozzi R, et al. Multicenter evaluation of the COBAS AMPLICOR HCV assay, an integrated PCR system for rapid detection of hepatitis C virus RNA in the diagnostic laboratory. J Clin Microbiol **36**: 862-865, 1998.
21. Dusheiko G, Schmilovitz-Weiss H, Brown D, et al. Hepatitis C virus genotypes: an investigation of type-specific differences in geographic origin and disease. Hepatology **19**: 13-18, 1994.
22. Desmet VJ, Gerber M, Hoofnagle JH, et al. Classification of chronic hepatitis: diagnosis, grading and staging. Hepatology **19**: 1513-1520, 1994.
23. Davis GL, Wong JB, McHutchison JG, et al. Early virologic response to treatment with peginterferon alfa-2b plus ribavirin in patients with chronic hepatitis C. Hepatology **38**: 645-652, 2003.
24. Arase Y, Suzuki F, Sezaki H, et al. Suitable treatment period in patients with virological response during combination therapy of peginterferon and ribavirin for chronic hepatitis C. Intern Med **47**: 1301-1307, 2008.

Journal of Viral Hepatitis, 2009, 16, 437–443 doi:10.1111/j.1365-2893.2009.01085.x

Occult hepatitis B virus infection increases hepatocellular carcinogenesis by eight times in patients with non-B, non-C liver cirrhosis: a cohort study

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Received and accepted for publication February 2008

SUMMARY. An impact of serum hepatitis B virus (HBV) DNA on hepatocarcinogenesis has not been investigated in a cohort of patients with non-B, non-C cirrhosis. Eighty-two consecutive Japanese patients with cirrhosis, who showed negative hepatitis B surface antigen and negative anti-hepatitis C virus, were observed for a median of 5.8 years. Hepatitis B virus core (HBc) region and HBx region were assayed with nested polymerase chain reaction. Both of HBc and HBx DNA were positive in 9 patients (11.0%) and both were negative in 73. Carcinogenesis rates in the whole patients were 13.5% at the end of the 5th year and 24.6% at the 10th year. The carcinogenesis rates in the patients with positive DNA group and negative DNA group were 27.0% and 11.8% at the end of the 5th year, and 100% and 17.6% at the 10th year, respectively ($P = 0.0078$). Multivariate analysis showed that men ($P = 0.04$), presence of HBc and HBx DNA (hazard ratio: 8.25, $P = 0.003$), less total alcohol intake ($P = 0.010$), older age ($P = 0.010$), and association of diabetes ($P = 0.005$) were independently associated with hepatocellular carcinogenesis. Existence of serum HBV DNA predicted a high hepatocellular carcinogenesis rate in a cohort of patients with non-B, non-C cirrhosis.

Keywords: hepatitis B virus, hepatocellular carcinogenesis, liver cirrhosis, occult hepatitis B virus infection, proportional hazard model.

INTRODUCTION

Hepatocellular carcinoma (HCC) is a leading cause of death in many parts of sub-Saharan Africa and Asia [1,2]. It is also one of the most common neoplasms in Japan [3]. Hepatitis B virus (HBV) infection is the primary cause of cirrhosis and HCC and one of the major causes of death globally [4]. Needless to say, a cohort of patients with HBV-related chronic hepatitis and cirrhosis has a significantly high risk for HCC development [5–7]. In our retrospective cohort studies concerning HBV-related disease, cumulative hepatocellular carcinogenesis rates in chronic hepatitis ($n = 610$) and cirrhosis ($n = 180$) were 2.1% and 7.2% at the end of the 5th year, and 4.9% and 27.2% at the 10th year, respectively [5,7]. Abundant epidemiological and molecular biological evidence shows that HBV is an important factor in the development of HCC [8–10], but the precise role of HBV in the oncogenesis is still unknown.

HBV infection is usually diagnosed when the circulating hepatitis B surface antigen (HBsAg) is detected. However, the availability of highly sensitive molecular biology techniques has allowed the identification of HBV infection in HBsAg-negative individuals with or without circulating antibodies to HBsAg and/or hepatitis B core antigen (anti-HBc) [11–16]. Much evidence suggests that this so-called occult HBV infection is highly prevalent in a number of patient subgroups including those with HCV infection [16,17], cryptogenic advanced liver fibrosis [18] and HCC [17,19–27]. Although Marusawa *et al.* [28] and Uetake *et al.* [29] described the relationship between anti-HBc and HCC appearance rate in each study, impact of occult HBV infection on carcinogenesis cannot be evaluated because of lack of HBV DNA assay. As all the previous studies were performed as a pilot study or a case-controlled one, actual risk ratio of occult HBV infection for hepatocellular carcinogenesis has not been reported in a cohort study until now.

Abbreviations: AFP, alpha-fetoprotein; ALT, alanine transaminase; AST, aspartic transaminase; HBsAg, hepatitis B surface antigen; HBV, hepatitis B virus; HCC, hepatocellular carcinoma; HCV, hepatitis C virus; PCR, polymerase chain reaction.

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We, therefore, analysed a retrospective cohort of consecutive patients with cirrhosis for a long period, in order to elucidate the influence of occult HBV infection on the carcinogenesis rate from non-B, non-C cirrhosis.

PATIENTS AND METHODS

Patients

Among 103 consecutive patients diagnosed as having non-B, non-C cirrhosis by peritoneoscopic liver biopsy at Toranomon Hospital, Tokyo, Japan in the period from 1976 to 1998, initial frozen sera at the time of the diagnosis of cirrhosis were available for the assay of HBV DNA in 82 patients (79.6%). The cohort of 82 patients was retrospectively observed for a long period. All the patients showed negative HBsAg, negative anti-hepatitis C virus (HCV) and negative HCV RNA. Patients with a possible association of HCC at the time of the diagnosis of cirrhosis were strictly excluded from this study. No patient received interferon or other antiviral therapy after the diagnosis of cirrhosis.

Background and laboratory data of the patients

There were 67 men and 15 women aged 34–80 with a median age of 58 years. A total of 47 patients (57.3%) had a history of alcohol intake of more than 500 kg until the diagnosis of liver cirrhosis. Fifteen patients (18.3%) had decompensated cirrhosis with ascites, a history of encephalopathy, or both. The median value of indocyanine green retention rate at 15 min (ICG R15) was 33% (range, 7–75%), and total bilirubin concentration was 1.3 mg/dL (range 0.4–20.9 mg/dL).

Measurement of hepatitis virus markers

Hepatitis virus markers were assayed using frozen sera at −80 °C. All sera were tested for HBsAg (radioimmunoassay, Dainabot, Tokyo, Japan), anti-HCV (second-generation anti-HCV, enzyme-linked immunosorbent assay, Dainabot), and HCV RNA with reverse transcription-nested polymerase chain reaction (PCR).

HBV DNA was analysed for the region of HBc and HBx by sensitive nested PCR according to Yotsuyanagi *et al.* [30]. Fifty microlitres of STE solution [100 mmol/L Tris–HCl (pH 8.0), 100 mmol/L NaCl, 2 mmol/L ethylenediaminetetraacetic acid (pH 8.0), and 0.2% sodium dodecyl sulphate] with 20 μg of proteinase K (Boehringer, Mannheim, Germany) were added to serum samples. Mixed samples were then incubated for 2 h at 55 °C. DNA was extracted twice with phenol/chloroform, once with chloroform, and precipitated with ethanol. The DNA pellet was dissolved in 25 μL of TE buffer [10 mmol/L Tris–HCl (pH 8.0) and 1 mmol/L ethylenediaminetetraacetic acid (pH 8.0)].

Prepared DNA was subjected to amplification using nested PCR technique. HBV DNA was amplified using two independent pairs of primers, with each primer complementary to sequences in the X or core region of the HBV genome [30]. Amplification was performed using a thermal cycler for a total of 40 cycles, with each cycle consisting of 94 °C for 1 min, 55 °C for 1 min and 72 °C for 1 min, in 100 μL of reaction mixture containing 200 mmol/L of each dNTP, 1X PCR buffer [50 mmol/L KCl, 10 mmol/L Tris–HCl (pH 8.3), 1.5 mmol/L $MgCl_2$ and 0.001% (w/v) gelatine], and 2 units of Ampli-Taq polymerase (Perkin Elmer Cetus Corp., Norwalk, CT, USA). The PCR products were separated in a 2% agarose gel and transferred to a nylon membrane (Schleicher and Schuell, Dassel, Germany). The membrane was then probed with digoxigenin-labelled oligonucleotides, which hybridize specifically with the core or X gene. Results were considered valid only if the same results were obtained in at least two separate experiments.

We considered the cases with positivity in at least two different viral genomic regions as HBV DNA positive. Appropriate negative controls were included in each PCR. The limit of sensitivity of our nested PCR methods ranged from 10 to 1 genome equivalents/mL.

Follow-up of patients

Follow-up of the patients was made on a monthly or bimonthly basis after diagnosis of cirrhosis by monitoring alpha-fetoprotein (AFP) and other biochemical data. Imaging diagnosis was made at least once a year for each patient with CT or US. After 1988, in order to detect HCC earlier, imagings were done three or more times per year in a majority of patients.

No patient underwent interferon therapy after the diagnosis of cirrhosis, but some of the patients received an oral or intravenous administration of medicinal herbs during the follow-up period.

All patients were finally evaluated in November 2004. The cases lost to follow-up were 13 (15.9%). The median observation period of the total patients was 5.8 years with a range of 0.1–34.8 years.

Statistical analysis

Differences of background features and laboratory data between the patients with and without HBV DNA were analysed by chi-square test, Fisher's exact test and Mann–Whitney's *U*-test. The time between diagnosis of cirrhosis and appearance of HCC was analysed using the Kaplan–Meier technique [31] and differences in curves were tested using log-rank test [32]. Those patients who had been lost to follow-up were regarded as censored data at the time of missing in the statistics. Independent risk factors associated with the appearance rate of HCC were studied using the stepwise Cox regression analysis [33]. Potential risk factors

assessed for hepatocellular carcinogenesis included the following 18 variables: age, sex, association of diabetes mellitus, total alcohol intake, history of cigarette smoking, family history of liver disease, history of blood transfusion, state of cirrhosis (presence of ascites and/or a history of encephalopathy), HBc DNA, HBx DNA, aspartic transaminase (AST), alanine transaminase (ALT), albumin, bilirubin, globulin, AFP, platelet, and ICG R15. A probability less than 0.05 was considered as significant. Data analysis was performed using computer program SPSS version 11 [34].

RESULTS

HCC appearance rate in all the patients

During the observation period, HCC appeared in 16 patients (19.5%). Median interval between the diagnosis of cirrhosis and HCC was 5.6 years (range 0.7–15.6 years) in the patients with HCC development. The cumulative HCC appearance rate in the 82 patients was 13.5% at the end of the fifth year after the diagnosis of cirrhosis, 24.6% at the end of tenth year, 33.3% at the 15th year, and 41.6% at the end of 20th year.

HCC appearance rates according to serum HBV DNA

Among the 82 patients, 9 patients (11.0%) showed positive serum HBV DNA and 73 (89.0%) negative HBV DNA. The former 9 patients had both HBc DNA and HBx DNA, and the latter 73 had neither of them. Table 1 summarizes the profiles and laboratory data of each group. There was no demographic difference between the two groups. There was also no statistically significant difference between them except for ALT value, which was lower in the patient group with positive HBV DNA ($P = 0.028$).

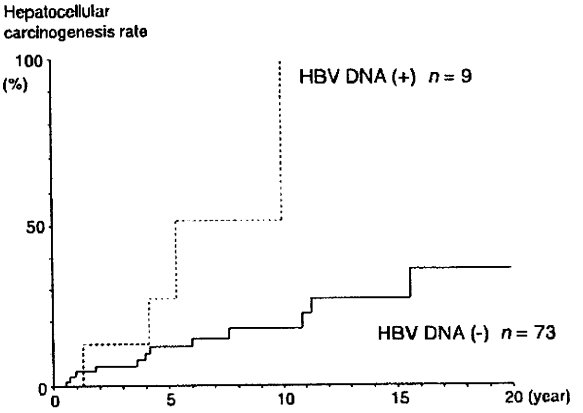

Fig. 1 Hepatocellular carcinogenesis curves of the patients with and without serum hepatitis B virus DNA. Carcinogenesis rates were 12.5% and 6.0% at the end of the third year, 27.0% and 11.8% at the fifth year, and 100% and 17.6% at the tenth year, respectively.

Figure 1 shows the curves of crude HCC appearance rate in the two patients group with and without serum HBV DNA. The third-year HCC appearance rates in the patients with and without DNA were 12.5% and 6.0%, the 5th-yr rates 27.0%, 11.8%, the tenth-yr rates 100% and 17.6%, respectively. The HCC appearance rate of the patient group

Table 1 Demography and laboratory data of patients with and without serum hepatitis B virus DNA

	HBV DNA*		
	Positive ($n = 9$)	Negative ($n = 73$)	P
Demographic and background features			
Sex – men/women	8/1	59/14	0.55
Age (median, range)	51 (45–68)	58 (34–80)	0.44
History of transfusion	1 (11.1%)	14 (19.4%)	0.55
Alcohol intake of 500 kg or more	5 (55.6%)	42 (58.3%)	0.87
Diabetes mellitus	3 (33.3%)	15 (20.8%)	0.40
Observation period (years)	5.7 (1.0–21.0)	6.1 (0.1–34.8)	0.92
Laboratory data (median, range)			
ICG R15 (%)	34 (12–51)	32.5 (7–75)	0.78
AST (IU/L)	32 (17–86)	40.5 (14–184)	0.26
ALT (IU/L)	16 (9–43)	28.5 (4–160)	0.028
Albumin (g/dL)	3.8 (2.6–4.5)	3.6 (1.7–5.2)	0.20
Bilirubin (mg/dL)	0.9 (0.5–2.8)	1.3 (0.4–20.9)	0.14
Platelet ($\times 1000/mm^3$)	142 (67–232)	104 (27–647)	0.18
AFP (ng/mL)	5 (3–9)	6 (1–98)	0.38

ICG R15, indocyanine green retention rate at 15 min; AST, aspartic transaminase; ALT, alanine transaminase; AFP, alpha-fetoprotein. *HBV DNA was assessed for HBc and HBx DNA using polymerase chain reaction

of positive HBV DNA was slightly higher than that of negative DNA ($P = 0.0078$, log-rank test).

Significance of serum HBV DNA in hepatocellular carcinogenesis

Cox proportional hazard model was performed for analysis of risk factors for liver carcinogenesis, using the 18 variables as mentioned above.

In the last step of stepwise regression analysis, the following five variables entered the model and could not be removed: sex ($P = 0.005$), serum HBV DNA ($P = 0.003$), past history of alcohol intake ($P = 0.003$), age ($P = 0.035$), and association of diabetes mellitus ($P = 0.022$) (Table 2). Accordingly, these five factors were significantly associated with hepatocellular carcinogenesis in the patients with non-B, non-C cirrhosis. Among them, gender was the strongest predictor of future HCC occurrence rate, indicating that male patients had 15.4 times as high carcinogenesis hazard as women patients. Similarly, positive HBV DNA (hazard ratio, 8.25) and little alcohol consumption of less than 500 kg (hazard ratio, 7.19) were the second and third strongest predictors for carcinogenesis, respectively. When the background factors of the cases were adjusted with the other significant factors, positive test for HBV DNA was significantly associated with the hepatocellular carcinogenesis rate.

Curves of carcinogenesis rates were generated from the multivariate analysis in an imaginary positive DNA group and an imaginary negative DNA group, with average sex ratio, average alcohol intake, average age and average association rate of diabetes (Fig. 2). The difference of the carcinogenesis curves indicated 'pure' impact of positive serum HBV DNA upon the carcinogenesis, which was adjusted with significant covariates assuming a standardized study group.

Table 2 Independent factors associated with liver carcinogenesis in the patients with non-B, non-C cirrhosis

Factors	Category	Hazard ratio (95% confidence interval)	*P*
Sex	Women	1	
	Men	15.4 (2.24–111.1)	0.005
Serum HBV DNA*	Negative	1	
	Positive	8.25 (2.01–33.93)	0.003
Total alcohol intake	≥500 kg	1	
	<500 kg	7.19 (1.98–26.32)	0.003
Age	<60 years	1	
	≥60 years	3.98 (1.10–14.42)	0.035
Diabetes mellitus	No	1	
	Yes	3.89 (1.22–12.47)	0.022

*Positive HBV DNA: positive for both HBc DNA and HBx DNA.

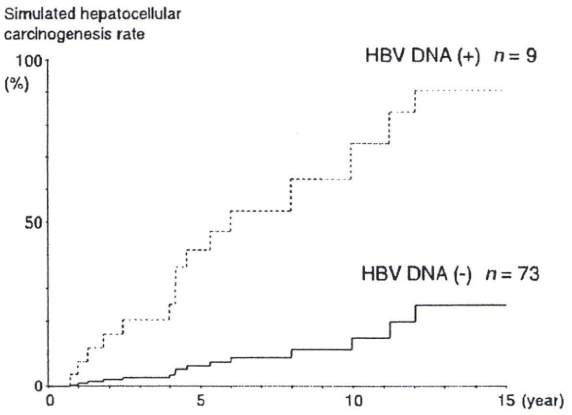

Fig. 2 'Adjusted' hepatocellular carcinogenesis rates in the positive HBV DNA group and the negative DNA group. Cox proportional hazard analysis showed that the carcinogenesis rate in the positive DNA group was significantly higher than that of the negative DNA group, when the other significant covariates were substituted with the same average parameters in the two groups.

Mortality and causes of death

During the observation period, 36 (43.9%) of 82 patients died: 5 (55.6%) of 9 patients in the positive DNA group and 31 (42.5%) of 73 patients in the negative DNA group. Cumulative survival rates in patients with and without HBV DNA were 78.8% and 74.1% at the end of the fifth year, 54.4% and 44.4% at the tenth year, 38.4% and 29.6% at the 15th year, and 33.6% and 29.6% at the 20th year, respectively. Although the survival rate in the positive HBV DNA group was lower than in the negative group, statistical significance was not shown.

Causes of death included liver failure due to liver cirrhosis in 21 (4 in positive DNA group and 17 in negative DNA group), progression of HCC in 7 patients (all in negative DNA group), and other causes in 8 (one in positive DNA group and 7 in negative DNA group).

DISCUSSION

Epidemiological and molecular virological studies in the 1970s and early 1980s established a strong aetiological association between chronic HBV infection and the hepatocellular carcinogenesis [35]. We also estimated annual carcinogenesis rates as 0.5% in chronic hepatitis and 3% in cirrhosis, from cohorts of biopsy-proven HBV disease [5,7].

Integration of HBV DNA has been reported in the majority of HBsAg positive HCCs since 1980s, and the fact suggested HBV might be oncogenic. Up to now, there is no evidence

that HBV DNA is directly oncogenic and the mechanism by which chronic HBV infection leads to carcinogenesis remains unclear. Integration of HBV DNA may stimulate cellular pro-oncogenes or suppress growth-regulating genes [36]. Integration of HBV DNA, however, has been found in varied regions of the host chromosomes and no preferential and specific site has been identified until now. The other authors suggested that integration of HBV DNA could also induce carcinogenesis via transactivation of other oncogenes [37]. Both HBx protein and the truncated pre-S/S protein are potent transactivators and are commonly found in HCC tissue but their precise role in hepatocarcinogenesis remains unknown.

Occult HBV infection is generally defined as the detection of HBV DNA in the serum or liver tissue of patients who test negative for hepatitis B surface antigen [38–41]. Occult HBV infection was first reported in the early 1980s when hybridization techniques for the detection of HBV DNA became available. These studies showed that HBV DNA could be detected in HBsAg negative patients with HCC [42]. Recent studies using more sensitive techniques confirmed the close correlation between chronic occult HBV infection and carcinogenesis. Many authors demonstrated the relationship between occult HBV infection and hepatocellular carcinogenesis, mainly by a pilot study or a case–control study [17,19–27]. Shiota *et al.* [24] reported in their case studies without control group that serum of 18 out of 26 HCC patients without HBsAg and anti-HCV were positive for either S, C, or X region on PCR and southern blotting. Pollicino *et al.* [26] described that viral DNA was detected in 68 of 107 cases of HCC tissue (63.5%) and in 63 of 192 cases of chronic hepatitis tissue (32.8%), and concluded that occult HBV is a risk factor for development of HCC. The other authors also emphasized the high incidence of HBV DNA in either serum or HCC tissue compared with that of cases without HCC development. All the literatures, except one [43] from Taipei where HBV infection was endemic and prevalent, concluded that occult HBV infection was closely associated HCC development. However, precise risk or hazard ratio for carcinogenesis has not been reported.

Current study on this topic provided strong evidence of an association between occult HBV infection and HCC. In the patient cohort of non-B, non-C cirrhosis, occult HBV infection increased the future carcinogenesis rate with a hazard ratio of 8.25 (95% confidence interval, 2.01–33.93). It has been proposed that diagnosis of occult HBV infection be made only when HBV DNA can be detected using at least two sets of primers from different areas of the HBV genome in duplicate assay [38,39]. Appropriate negative controls must be included in each assay and specificity of the amplification reaction confirmed by sequencing of the amplicons. Using this strict criterion, occult HBV infection was found in 9 (11.0%) of 82 Japanese patients with non-B, non-C cirrhosis. Background features of the nine patients with serum HBV DNA showed a slightly younger age, a lower ALT, a slightly lower bilirubin, and a slightly higher platelet count (Table 1). Although all these demographic and laboratory findings were considered to favour low carcinogenetic risk, the patients with cryptic HBV DNA infection developed HCC more frequently. After adjustment of these background covariates in the multivariate analysis, positivity of serum HBV DNA proved to be an independent risk factor for hepatocarcinogenesis (Table 2).

As this retrospective cohort consisted of only cirrhosis as an advanced liver disease, and as it included both alcoholic and non-alcoholic cirrhosis, the hazard ratio of 8.25 could not be applied for varied stages and varied aetiologies of liver disease. In order to elucidate the impact of occult HBV infection on carcinogenesis, future studies should be performed also in the other cohort of chronic liver disease, such as HCV-related disease. Although anti-HBc and anti-HBs antibody were measured in a small numbers of the patients, an exact relationship between serum HBV DNA and serum positivity of anti-HBc antibody was not analysed in this study. When we tested anti-HBc antibody in a small part of subjects, 3 of 6 patients (50.0%) with positive HBV DNA had serum anti-HBc antibody and 7 of 19 patients (36.8%) without HBV DNA had anti-HBc (Fisher's exact test, $P = 0.69$). For the convenience of clinical circumstance and practical usefulness, significance of positive anti-HBc on carcinogenesis risk should be elucidated through a large-scale cohort study with an identical assay for anti-HBc antibody.

Although a lot of epidemiological and clinicopathological evidence of the relationship has been published, precise role of occult HBV in this setting has been still unclear. Patients with occult hepatitis B overlap with those who previously have been classified as having recovered [44]. In fact, the distinction between recovery and occult hepatitis B is likely to be somewhat arbitrary, as recovery does not necessarily imply eradication of infection in all cases [30], but includes the possibility of complete suppression in some cases by a broad and vigorous immune response [44]. One of the most important clinical questions is whether occult hepatitis B merely represents a marker of past infection, or whether HBV genome persistence contributes to liver disease. It is very likely that occult HBV is a cofactor in the development of HCC. Several studies found that patients co-infected with HBV and HCV have increased risks of HCC compared with those with mono-infection. Our cohort studies [45] also showed that a risk factor of a history of heavy drinking interacted with HBV or HCV subtypes in a characteristic manner from the viewpoint of carcinogenesis in cirrhosis. The other important problem is whether occult HBV infection alone causes HCC. To address this question, studies on occult HBV infection in patients with HCC might provide details on other causes of chronic liver disease including nonalcoholic fatty liver disease, which may masquerade as cryptogenic cirrhosis, hemochromatosis, alfa-1-antitrypsin deficiency, and autoimmune liver disease [46]. Recently,

Castillo *et al.* [47] reported a clinical state of occult HCV infection, which shows negative serum anti-HCV, negative serum HCV RNA, and positive HCV RNA in liver biopsy specimen. Although we did not tested the possibility of occult HCV infection in this study, future studies should be also aimed at the influence of latent HCV infection on hepatocarcinogenesis.

In conclusion, occult HBV infection significantly increased the incidence of hepatocellular carcinogenesis in patients with non-B, non-C cirrhosis. Although non-B, non-C cirrhosis seemed to include varied aetiology of liver disease, cryptic HBV infection should be taken account in the prediction of future HCC development.

ACKNOWLEDGEMENT

This study was supported in part by a research grant of Ministry of Health, Labor and Welfare, Japan.

REFERENCES

1 Parkin DM, Stjernsward J, Muir CS. Estimates of worldwide frequency of twelve major cancers. *Bull World Health Organ* 1984; 62: 163–182.
2 Okuda K. Early recognition of hepatocellular carcinoma. *Hepatology* 1986; 6: 729–738.
3 The Liver Cancer Study Group of Japan. Primary liver cancer in Japan: Clinico-pathological features and results of surgical treatment. *Ann Surg* 1990; 211: 277–287.
4 Maynard JE. Hepatitis B: global importance and need for control. *Vaccine* 1990; 8: S18–S23.
5 Ikeda K, Saitoh S, Koida I *et al.* A multivariate analysis of risk factors for hepatocellular carcinogenesis – a prospective observation of 795 cases with viral and alcoholic cirrhosis. *Hepatology* 1993; 18: 47–53.
6 Tsukuma H, Hiyama T, Tanaka S *et al.* Risk factors for hepatocellular carcinoma among patients with chronic liver disease. *N Engl J Med* 1993; 328: 1797–1801.
7 Ikeda K, Saitoh S, Suzuki Y *et al.* Disease progression and hepatocellular carcinogenesis in patients with chronic viral hepatitis: a prospective observation of 2215 patients. *J Hepatol* 1998; 28: 930–938.
8 Prince AM, Szmuness W, Michon J *et al.* A case–control study of the association between primary liver cancer and hepatitis B infection in Senegal. *Int J Cancer* 1975; 16: 376–383.
9 Ohnishi K, Iida S, Iwama S *et al.* The effect of chronic habitual alcohols intake on the development of liver cirrhosis and hepatocellular carcinoma. Relation to hepatitis B surface antigen carriage. *Cancer* 1982; 49: 672–677.
10 Lam KC, Yu MC, Leung JWC, Henderson BE. Hepatitis B virus and cigarette smoking: Risk factors for hepatocellular carcinoma in Hong Kong. *Cancer Res* 1982; 42: 5246–5248.
11 Kaneko S, Muller RH, Feinstein SM *et al.* Detection of serum hepatitis B virus DNA in patients with chronic hepatitis using the polymerase chain reaction assay. *Proc Natl Acad Sci U S A* 1989; 86: 312–316.
12 Wang JT, Wang TH, Sheu JC, Shih LN, Lin JT, Chen DS. Detection of hepatitis B virus DNA by polymerase chain reaction in plasma of volunteer blood donors negative for hepatitis B surface antigen. *J Infect Dis* 1991; 163: 397–399.
13 Zhang YY, Hansson BG, Kuo LS, Widell A, Nordenfelt E. Hepatitis B virus DNA in serum and liver is commonly found in Chinese patients with chronic liver disease despite the presence of antibodies to HBsAg. *Hepatology* 1993; 17: 538–544.
14 Liang TJ, Baruch Y, Ben-Porath E *et al.* Hepatitis B virus infection in patients with idiopathic liver disease. *Hepatology* 1991; 13: 1044–1051.
15 Koike K, Kobayashi M, Gondo M, Hayashi I, Osuga T, Takada S. Hepatitis B virus DNA is frequently found in liver biopsy samples from hepatitis C virus-infected chronic hepatitis patients. *J Med Virol* 1998; 54: 249–255.
16 Cacciola I, Pollicino T, Squadrito G, Cerenzia G, Orlando ME, Raimondo G. Occult hepatitis B virus infection in patients with chronic hepatitis C liver disease. *N Engl J Med* 1999; 341: 22–26.
17 Takeuchi M, Fujimoto J, Niwamoto H, Yamamoto Y, Okamoto E. Frequent detection of hepatitis B virus X-gene DNA in hepatocellular carcinoma and adjacent liver tissue in hepatitis B surface antigen-negative patients. *Dig Dis Sci* 1997; 42: 2264–2269.
18 Chemin I, Zoulim F, Merle P *et al.* High incidence of hepatitis B infections among chronic hepatitis cases of unknown aetiology. *J Hepatol* 2001; 34: 447–454.
19 Sheu JC, Huang GT, Shih LN *et al.* Hepatitis C and B viruses in hepatitis B surface antigen-negative hepatocellular carcinoma. *Gastroenterology* 1992; 103: 1322–1327.
20 Paterlini P, Driss F, Pisi E, Franco D, Berthelot P, Brechot C. Persistence of hepatitis B and hepatitis C viral genomes in primary liver cancers from HBsAg-negative patients: a study of a low-endemic area. *Hepatology* 1993; 17: 20–29.
21 Lee DS, Huh K, Lee EH, Lee DH, Hong KS, Sung YC. HCV and HBV coexist in HBsAg-negative patients with HCV viraemia: possibility of co-infection in these patients must be considered in HBV-high endemic area. *J Gastroenterol Hepatol* 1997; 12: 855–861.
22 Brechot C, Jaffredo F, Lagorce D *et al.* Impact of HBV, HCV, and GBV-C/HGV on hepatocellular carcinomas in Europe: results of a European concerted action. *J Hepatol* 1998; 29: 173–183.
23 Shintani Y, Yotsuyanagi H, Moriya K *et al.* The significance of hepatitis B virus DNA detected in hepatocellular carcinoma of patients with hepatitis C. *Cancer* 2000; 88: 2478–2486.
24 Shiota G, Oyama K, Udagawa A *et al.* Occult hepatitis B virus infection in HBs antigen-negative hepatocellular carcinoma in a Japanese population: involvement of HBx and p53. *J Med Virol* 2000; 62: 151–158.
25 Tamori A, Nishiguchi S, Kubo S *et al.* HBV DNA integration and HBV-transcript expression in non-B, non-C hepatocellular carcinoma in Japan. *J Med Virol* 2003; 71: 492–498.
26 Pollicino T, Squadrito G, Cerenzia G *et al.* Hepatitis B virus maintains its pro-oncogenic properties in the case of occult HBV infection. *Gastroenterology* 2004; 126: 102–110.

27 Yotsuyanagi H, Hashidume K, Suzuki M, Maeyama S, Takayama T, Uchikoshi T. Role of hepatitis B virus in hepatocarcinogenesis in alcoholics. *Alcohol Clin Exp Res* 2004; 28: 181S–185S.
28 Marusawa H, Osaki Y, Kimura T *et al.* High prevalence of anti-hepatitis B virus serological markers in patients with hepatitis C virus related chronic liver disease in Japan. *Gut* 1999; 45: 284–288.
29 Uetake S, Yamauchi M, Itoh S, Kawashima O, Takeda K, Ohata M. Analysis of risk factors for hepatocellular carcinoma in patients with HBs antigen- and anti-HCV antibody-negative alcoholic cirrhosis: clinical significance of prior hepatitis B virus infection. *Alcohol Clin Exp Res* 2003; 27(8 Suppl.): 47S–51S.
30 Yotsuyanagi H, Yasuda K, Iino S *et al.* Persistent viremia after recovery from self-limited acute hepatitis B. *Hepatology* 1998; 27: 1377–1382.
31 Kaplan EL, Meier P. Nonparametric estimation for incomplete observation. *J Am Stat Assoc* 1958; 53: 457–481.
32 Harrington DP, Fleming TR. A class of rank test procedures for censored survival data. *Biometrica* 1982; 69: 553–566.
33 Cox DR. Regression models and life tables. *J R Stat Soc* 1972; 34: 248–275.
34 SPSS Inc. SPSS for Windows Version 11.0 Manual. Chicago, IL, USA: SPSS Inc., 2001.
35 Beasley RP. Hepatitis B virus: the major etiology for hepatocellular carcinoma. *Cancer* 1988; 61: 1942–1956.
36 Matsubara K, Tokino T. Integration of hepatitis B virus may contribute to hepatocarcinogenesis. *Mol Biol Med* 1990; 7: 243–260.
37 Koshy R, Hofschneider PH. Transactivation by hepatitis B virus may contribute to hepatocarcinogenesis. *Curr Topics Microbiol Immunol* 1989; 144: 265–281.
38 Brechot C, Thiers V, Kremsdorf D, Nalpas B, Po S, Paterlini-Brechot P. Persistent hepatitis B virus infection in subjects without hepatitis B surface antigen: clinically significant or purely "occult"? *Hepatology* 2001; 34: 194–203.
39 Conjeevaram HS, Lok AS. Occult hepatitis B virus infection: a hidden menace? *Hepatology* 2001; 34: 204–206.
40 Hu KQ. Occult hepatitis B virus infection and its clinical implications. *J Viral Hepatitis* 2002; 9: 243–257.
41 Torbenson M, Thomas DL. Occult hepatitis B infection. *Lancet Infect Dis* 2003; 2: 479–486.
42 Brechot C, Degos F, Lugassy C *et al.* Hepatitis B virus DNA in patients with chronic liver disease and negative test for hepatitis B surface antigen. *N Engl J Med* 1985; 312: 270–276.
43 Kao JH, Chen PJ, Lai MY, Chen DS. Occult hepatitis B virus infection and clinical outcomes of patients with chronic hepatitis C. *J Clin Microbiol* 2002; 40: 4068–4071.
44 Guidotti LG, Chisari FV. To kill or to cure: options in host defense against viral infection. *Curr Opin Immunol* 1996; 8: 478–483.
45 Ikeda K, Kobayashi M, Someya T *et al.* Influence of hepatitis C virus subtype on hepatocellular carcinogenesis: a multivariate analysis of a retrospective cohort of 593 patients with cirrhosis. *Intervirology* 2002; 45: 71–78.
46 Marrero JA, Lok ASF. Occult hepatitis B virus infection in patients with hepatocellular carcinoma: innocent bystander, cofactor, or culprit? *Gastroenterology* 2004; 126: 347–350.
47 Castillo I, Pardo M, Bartolome J *et al.* Occult hepatitis C virus infection in patients in whom the etiology of persistently abnormal results of liver-function tests is unknown. *J Infect Dis* 2004; 189: 7–14.

Hepatology Research 2009; 39: 439–447 doi: 10.1111/j.1872-034X.2008.00481.x

Original Article

Effectiveness of combination therapy of splenectomy and long-term interferon in patients with hepatitis C virus-related cirrhosis and thrombocytopenia

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Aim: To elucidate the effectiveness of combination therapy of splenectomy and long-term interferon (IFN) on survival and hepatocarcinogenesis, we retrospectively analyzed 180 patients with hepatitis C virus (HCV)-related cirrhosis and thrombocytopenia.

Methods: Group A consisted of 121 patients who received neither splenectomy nor IFN therapy. Group B consisted of 11 patients who underwent splenectomy only. Group C consisted of 32 patients who underwent IFN therapy only. Group D consisted of 16 patients who received the combination therapy splenectomy followed by IFN therapy.

Results: The viral response in group D estimated at least 6 months after IFN therapy showed sustained viral response in four patients, biochemical response in one and no response in six. Multivariate analysis using time-dependent variables showed significant improvement of survival rate in patients on the combination therapy,but no effect on the appearance rate of hepatocarcinogenesis relative to the findings in group A.

Conclusions: In this study, the splenectomy did not directly improve the prognosis, but increased the ability for patients to undergo IFN. As a result, we considered that the combination therapy of splenectomy and long-term IFN significantly improved survival rate in patients with advanced HCV-related cirrhosis and thrombocytopenia.

Key words: cirrhosis, hypersplenism, interferon, splenectomy, thrombocytopenia

Abbreviations:
AFP, Alpha-fetoprotein; ALT, Alanine aminotransferase; AST, Aspartic aminotransferase; BR, biochemical response; CT, Computed tomography; HCC, Hepatocellular carcinoma; HCV, Hepatitis C virus; ICG R15, Indocyanine green retention rate at 15 min; IFN, Interferon; MELD score, Model for End-Stage Liver Disease score; NR, No response; PLT, platelet; SVR, Sustained virological response; TTT, Thymol turbidity test; US, Ultrasonography; ZTT, Zinc sulfate turbidity test.

INTRODUCTION

THE PRESENCE OF severe thrombocytopenia in patients with cirrhosis associated with hepatitis C viral (HCV) infection limits the use of interferon (IFN) therapy. The different treatment modalities for hepatocellular carcinoma (HCC), such as hepatic resection, radiofrequency ablation, or percutaneous ethanol injection, are also limited by low platelet (PLT) counts. In patients with compensated cirrhosis and low model for end-stage liver disease (MELD) score, liver transplantation is not warranted and the use of antiviral therapy to slow down the progression to liver failure is not recommended. In other words, such patients are too healthy for transplantation and too thrombocytopenic to treat with antiviral agents. Splenectomy has been suggested for the treatment of secondary hypersplenism and thrombocytopenia as a means to improve PLT count.[1]

If patients with HCV-related cirrhosis and thrombocytopenia could receive the benefits of splenectomy[2,3] and IFN therapy,[4,5] such therapy would clinically be very useful. The combination therapy of splenectomy and long-term IFN administration may improve survival rate and reduce the incidence of hepatocarcinogenesis.

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Received 2 February 2008; revised 4 November 2008; accepted 17 November 2008.

However, there are only a few reports that have examined the usefulness of this combination therapy in patients with advanced HCV-related cirrhosis and low PLT count.[6] In this study, we retrospectively analyzed 180 patients with compensated cirrhosis and thrombocytopenia who had received the combination therapy of splenectomy and long-term IFN to determine the effects of such treatment on the survival rate and incidence of HCC.

PATIENT AND METHODS

Study population

A TOTAL OF 180 Japanese patients with cirrhosis, hypersplenism and low PLT count ($\leq 80 \times 10^3/\mu L$) were examined between 1990 and 2006. Their initial sera were positive for antibodies to HCV (anti-HCV; second-generation anti-HCV kit; ELISA, Dainabot, Tokyo, Japan), positive HCV-RNA (Amplicor HCV monitor assay version 2.0; Roche Diagnostics, Tokyo, Japan), and negative for hepatitis B surface antigen (HBsAg; radioimmunoassay, Dainabot). Anti-HCV was assayed using stored frozen sera at -80°C. They were diagnosed with liver cirrhosis between 1990 and 2006 at Toranomon Hospital, Tokyo, Japan. In addition to liver biopsy and/or peritoneoscopy, liver cirrhosis was also diagnosed utilizing clinical findings (e.g. presence of esophageal varices), and with computed tomographic (CT) or ultrasonographic (US) findings. The following protocol was applied in our hospital until 2000: Patients with a platelet count of less than $50 \times 10^3/\mu L$ are eligible for HCC surgery (such as hepatic resection, radiofrequency ablation, or percutaneous ethanol injection) provided they receive platelet transfusion. The decision to pursue splenectomy was individualized and based on the presence thrombocytopenia and/or intractable gastric varices, and discussed with the patients.

We retrospectively analyzed the effect of splenectomy on cirrhotic patients with low PLT count ($\leq 80 \times 10^3/\mu L$). Of the total 180 patients, 121 (67.2%) patients received neither antiviral therapy nor splenectomy (group A). Thirty-two (17.8%) patients received only IFN therapy (group C). The remaining 27 (15.0%) patients underwent splenectomy (11 patients underwent only splenectomy [group B] and 16 received IFN therapy after splenectomy [group D]). Splenectomy was performed for the following reasons; (i) low PLT count in 20 patients (six [54.5%] of group B and 14 [8.5%] of group D), (ii) low PLT count and part of treatment of gastric varices in three (one [9.0%] of group B and two [12.5%] of group D), and (iii) low PLT count and refractory esophageal varices in four (four [36.4%] of group B). None of the patients required emergency splenectomy (e.g. bleeding gastric varices or other bleeding complications related to low platelet count). Our institution does not require informed consent for retrospective analysis.

Patients background and laboratory data

Table 1 summarizes the profiles and patients of groups A, B, C and D at the time of diagnosis of liver cirrhosis. Indocyanine green test was conducted in 91.2% of the patients. Patients of group D had significantly lower PLT count ($P = 0.01$) and AST ($P = 0.01$) than patients in others groups. The proportion of group A patients who regularly consumed alcohol at ≥ 80 g/day was significantly higher than other groups. Patients of group C had significantly lower TTT ($P = 0.08$) than others.

Splenectomy

Splenectomy was performed through midline or left subcostal incision depending on body habitus and previous incisions. For group B, five patients underwent splenectomy and six underwent Hassab's operation.[7] In group D, 13 patients underwent splenectomy and three underwent Hassab's operation.

IFN treatment

Thirty-two patients received IFN therapy (group C). In group C, 21 patients received 3 million units of IFN-α (natural or recombinant) intramuscularly three times per week to maintain a low alanine aminotransferase (ALT), 11 patients received 6 million units of IFN-α to eradicate HCV. Patients of group C received IFN therapy for a median period of 0.5 years (range, 0.0–9.7 years).

Sisteen patients received the combination therapy (group D). Of these, 12 (75%) patients underwent splenectomy for the purpose of induction of antiviral therapy with IFN. The other patients (25%) had undergone splenectomy pre dating this study. In group D, 11 patients (Cases 1–4, 8, 10–13, 15–16) received 3 million units of IFN-α (natural or recombinant) intramuscularly three times per week to maintain a low ALT, 3 patients (Cases 6, 7, and 9) received 6 million units of IFN-α to eradicate HCV. For the other two patients; one (Case 5) received pegylated IFNα2b (50 μg) monotherapy and the other patient (Case 14) received pegylated IFNα2b (50 μg) plus ribavirin (400 mg) combination therapy to maintain low ALT (Fig. 1). Patients of group D received IFN therapy for a median period of 1.4 years (range, 0.2–12.4 years).

Table 1 Patient profiles and laboratory data at the time of diagnosis of cirrhosis

	Group A (Neither splenectomy nor IFN)	Group B (splenectomy)	Group C (IFN)	Group D (splenectomy + IFN)	P*
Demography					
No. patients	121	11	32	16	
Sex (M/F)	64/57	6/5	13/19	13/3	0.07
Age (years)†	61 (32–82)	61 (42–66)	59 (36–72)	52 (36–60)	0.41
Alcohol intake of 80 g/day or more	29	0	10	0	0.03
Diabetes mellitus	12	1	4	2	0.96
Laboratory data†					
Platelet count ($\times 10^3/\mu L$)	61 (17–80)	64 (42–75)	66 (25–80)	44 (27–78)	0.01
Prothrombin activity (%)	73 (50–101)	79 (58–94)	80 (66–100)	74 (47–100)	0.88
Albumin (g/dL)	3.5 (1.7–4.8)	3.5 (2.0–4.3)	3.4 (2.5–4.1)	3.3 (2.7–4.5)	0.64
ZTT (Kunkel)	12.3 (0.7–23.3)	10.3 (3.3–18.2)	10.8 (4.4–21.0)	12.0 (6.1–17.1)	0.29
TTT (Kunkel)	14.1 (0.4–37.2)	12.0 (4.4–16.9)	7.8 (1.2–34.0)	12.7 (2.7–34.1)	0.08
Bilirubin (mg/dL)	1.5 (0.4–7.7)	1.2 (0.7–5.3)	1.1 (0.6–2.7)	1.2 (0.8–4.4)	0.03
AST (IU/L)	64 (21–652)	83 (31–157)	75 (28–216)	60 (30–154)	0.17
ALT (IU/L)	53 (11–239)	72 (24–191)	71 (18–298)	46 (14–182)	0.01
ICG R15 (%)	38 (12–96)	41 (15–64)	32 (6–62)	32 (8–53)	0.44
Alpha-fetoprotein (ng/mL)	23 (2–909)	40 (3.9–165)	29 (5–631)	11 (4–190)	0.28

ALT, alanine aminotransferase; AST, aspartic aminotransferase; ICG R15, indocyanine green retention rate at 15 min; TTT, thymol tubidity test; ZTT, zincsulfate tubidity test.
*Kruskal-Wallis test or χ^2-test. †Expressed by median (min, max).

The effect of IFN therapy was classified according to elimination of HCV-RNA and ALT value 6 months after the end of treatment. Sustained virological response (SVR) was defined as persistent disappearance of HCV RNA after therapy, biochemical response (BR) as normal ALT values without elimination of HCV RNA for at least 6 months after therapy, and no response (NR) as persistently elevated or transiently normalized ALT levels without loss of HCV RNA.

Follow up of patients

Patients were followed up on a monthly basis after the diagnosis of cirrhosis by monitoring hematologic, biochemical, and virologic data. Imaging studies were conducted three or more times per year in the majority of patients by using computerized tomography (CT) or ultrasonography (US). Angiography was performed only when HCC was highly suspected based on CT or US. When angiography detected a typical hypervascular nodule, it was considered a specific finding for HCC in these follow-up patients, and histological confirmation was usually not required in the majority of patients. If the angiographic study did not show any hypervascular staining in a small hepatic nodule, a fine needle biopsy was performed. In this cohort, 18 (12.2%) patients were lost to follow up [14 patients (11.6%) from group A, two patients (18.2%) from group B, one patient (3.1%) from group C and two patients (12.5%) from group D]. The date of the last follow-up in this study was 31 March 2007, and the median observation period of studied patients was 5.9 years (range, 0.1–19.6 years).

Statistical analysis

Non-parametric procedures were used for the analysis of background characteristics of the patients, including Kruskal–Wallis and χ^2 test. Changes in laboratory tests values after splenectomy were evaluated by using Wilcoxon signed-rank test. Survival rate was calculated from the period between diagnosis of liver cirrhosis and death in each group, by using the Kaplan–Meier method.[8] HCC appearance rate was calculated from the period between diagnosis of liver cirrhosis and appearance of HCC in each group, by again using the Kaplan–Meier method. Differences in slopes of survival and carcinogenic curves were evaluated by log-rank test. The median waiting period between diagnosis of cirrhosis and splenectomy was 1.6 months (range, 0.0–199.5 months) for groups B and C. To compensate for wait-time bias in the splenectomy groups, curves of survival and HCC appearance were also drawn from the time of diagnosis

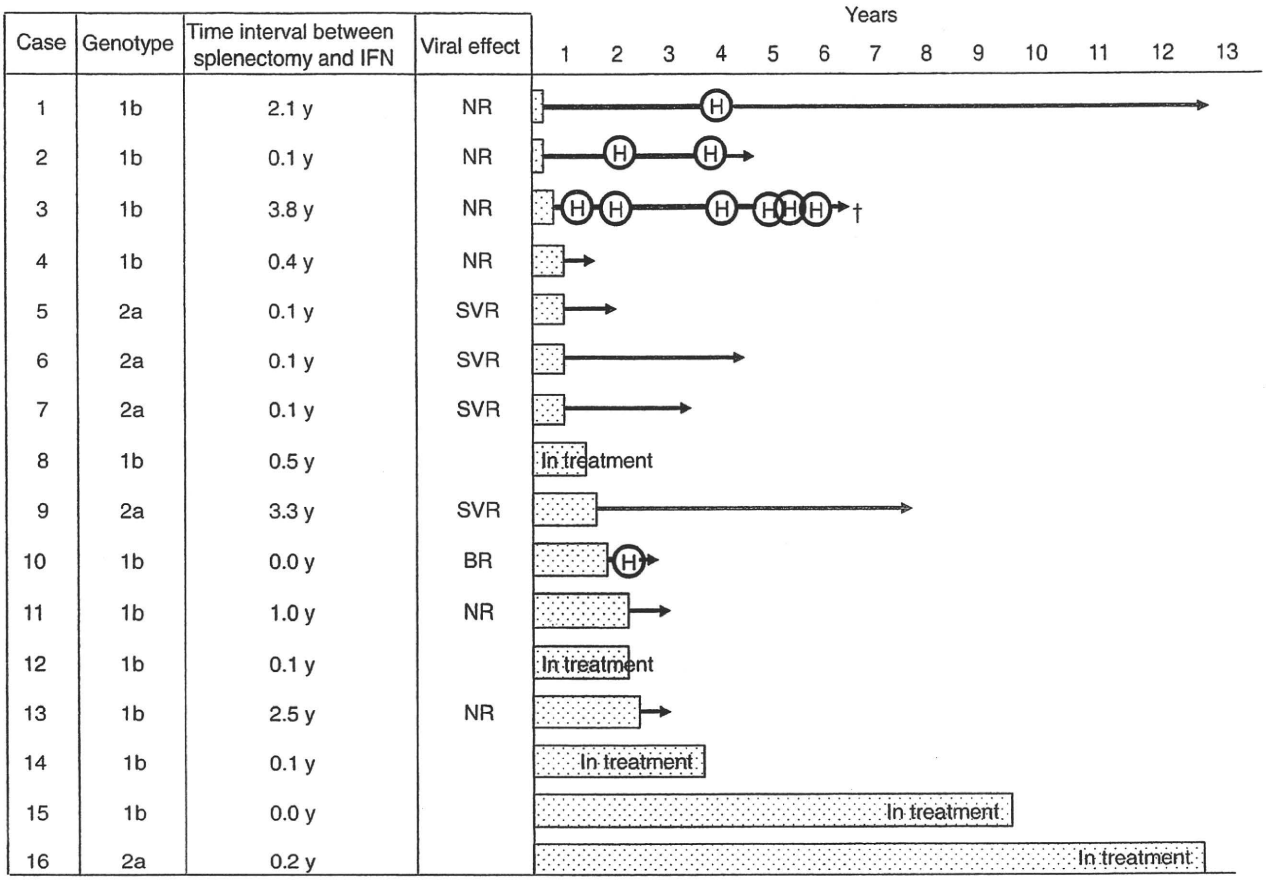

Figure 1 Individual patients who underwent splenectomy followed by long-term IFN therapy (group D). Hepatocellular carcinoma (HCC) developed in five of 16 patients. The dotted bars and arrows represent IFN therapy and follow-up period. H, appearance of HCC; SVR, sustained virological response; BR, biochemical response; NR, no response; †, death.

of cirrhosis in the groups. Independent factors associated with survival and HCC appearance were studied by using time-dependent Cox regression analysis.[9] The following 14 variables were analyzed for potential covariates for survival and liver carcinogenesis at the time of the diagnosis of cirrhosis: age, sex, habitual alcohol intake (80 g/day or more), association of diabetes, albumin, zinc sulfate turbidity test (ZTT), thymol turbidity test (TTT), bilirubin, aspartic aminotransferase (AST), ALT, PLT count, prothrombin activity, indocyanine green retention rate at 15 min (ICG R15), and alpha-fetoprotein (AFP). In addition to these variables, an interaction term of "waiting time" from the diagnosis of liver cirrhosis to splenectomy was introduced in the analysis as a time-dependent covariate. Several variables were transformed into categorical data consisting of two or three simple ordinal numbers in order to estimate the hazard ratio. All factors found to be at least marginally associated with survival and liver carcinogenesis ($P < 0.10$) were entered into multivariate Cox proportional hazard model. A P-value of less than 0.05 was considered to be significant. Statistical analyses were performed using the SPSS software (SPSS, Chicago, IL, USA).

RESULTS

Effects and complications of splenectomy

THE SPLENECTOMY GROUP consisted of 11 patients with Child–Pugh Class A (group B = 2, group D = 8), 15 with Child–Pugh Class B (group B = 8, group D = 7) and 1 with Class C (group D = 1) at operation. The median weight of the removed spleen was 430 g (range, 190–1600 g). Leukocyte count, PLT count and total bilirubin improved in most patients after sple-

nectomy. Leukocyte count increased about 1.6 times at 6 months after splenectomy [before splenectomy, median = 3200/mm³ (range 1800–5600); after splenectomy, 5200 (3700–9000); $P < 0.001$). PLT count increased about 2.3 times at 6 months after splenectomy [before splenectomy, median = $47 \times 10^3/\mu L$ (range, $26–77 \times 10^3$); after splenectomy, 110×10^3 ($79–275 \times 10^3$); $P < 0.001$). Total bilirubin decreased about 0.6 times at 6 months after splenectomy [before splenectomy, median = 1.2 mg/dL (range, 0.6–4.4); after splenectomy, 0.7 (0.4–1.8); $P = 0.001$). Leukocyte and PLT counts reached peak levels within a month after splenectomy and were almost stabilized at six months.

Postoperative complications following splenectomy developed in three patients; hemoperitoneum ($n = 1$), portal vein thrombosis ($n = 1$) and secondary thrombocytopenia ($n = 1$). Some patients received prophylactic anticoagulation to protect against portal vein thrombosis after splenectomy. One patient with hemoperitoneum died due to multiple organ failure, while the other patients recovered with medical treatment.

Complications of splenectomy plus IFN combination therapy

Figure 1 shows patients that underwent combination therapy (group D). During the observation period, one patient (Case 3) of group D died of liver failure caused by progression of HCC. The causes of death in three other patients were not deemed to be complications related to the combination therapy. None of the patients of group D developed serious complications (e.g. portal vein thrombosis, post-operative hemorrhage, pneumonia, sepsis) from the splenectomy. Postoperatively, none of the patients showed worsening of liver biochemical test results or developed decompensated liver disease with ascites, encephalopathy, jaundice or variceal bleeding. There were also no deaths in the immediate postoperative period. Three patients (18.8%) of group D discontinued IFN therapy for the following reasons; severe thrombocytopenia (Case 1), NSAID-induced liver injury (Case 2) and peripheral neuropathy (Case 13). In contrast, eight patients (25.8%) of group C discontinued IFN therapy. Three (37.5%) of them discontinued IFN therapy due to severe thrombocytopenia. When frequency of discontinued IFN therapy was compared with group C and D, there was no significant difference ($P = 0.73$). However, there were cases, eight in group C but 0 in group D, who required a reduction in IFN dosages during treatment as compared with the beginning of treatment ($P = 0.03$). The splenectomy could have increased the ability for patients to undergo IFN.

Effect of IFN therapy after splenectomy

Eleven of 16 (68.8%) patients of group D had HCV genotype 1b and five (31.3%) had HCV genotype 2a (Fig. 1). The viral response was determined at least 6 months after IFN therapy; SVR was noted in four (36.4%) patients, BR in one (9.1%) and NR in six (54.5%). Three patients continue to receive IFN therapy at present. In this study, patients with SVR were all male and had genotype 2a. One of the patients with SVR received pegylated-IFNα–2b (Case 5, Fig. 1), while other patients received IFNα2b. Meanwhile, 18 of 32 (56.3%) patients of group C had HCV genotype 1b, 12 (37.5%) had HCV genotype 2a and two (6.3%) had HCV genotype 2b. Group C had more patients with low HCV-RNA (< 100 000 IU/mL) than group D (12 [37.5%] of group C and three [18.8%] of group D, $P = 0.09$). In group C, SVR was noted in 7(21.9%) patients, BR in six (18.8%) and NR in 17 (53.1%). Two patients continue to receive IFN therapy at present.

SVR were not significantly different between group C and D ($P = 0.43$). This result might be a reason that group D had more patients with HCV genotype 1 and higher HCV-RNA than group C.

Rate of hepatocarcinogenesis

During the follow-up period of up to 17 years (median observation period of 5.9 years), HCC developed in 65 patients (36.1%): 40 (33.1%) in group A, five (45.5%) in group B, 16 (50.0%) in group C and four (25.0%) in group D. HCC appearance rates at the end of the third year were 19.9, 20.0, 25.0 and 6.3% in group A, B, C and D, 28.5, 57.3, 34.5 and 14.1% at the end of the fifth year, and 48.2, 78.7, 43.8 and 39.8% at the end of tenth year, respectively (Fig. 2). There was no significant difference in the rate of HCC appearance among the four groups (log-rank test, $P = 0.42$). In particular, the HCC appearance rate in group D was not significantly different compared with group A (log-rank test, $P = 0.50$).

In addition, the rate of carcinogenesis correlated inversely with the duration of IFN administration (Fig. 1). For group D, 9 of 14 patients were treated with IFN for ≥ 12 months. The carcinogenic rate at the end of the 5th year in the remaining patients of the same group who were treated with IFN for < 12 months (20.0%) was higher than in those treated for ≥ 12 months (9.1%). Multivariate analysis showed that the hazard ratio of carcinogenesis for patients treated with IFN for

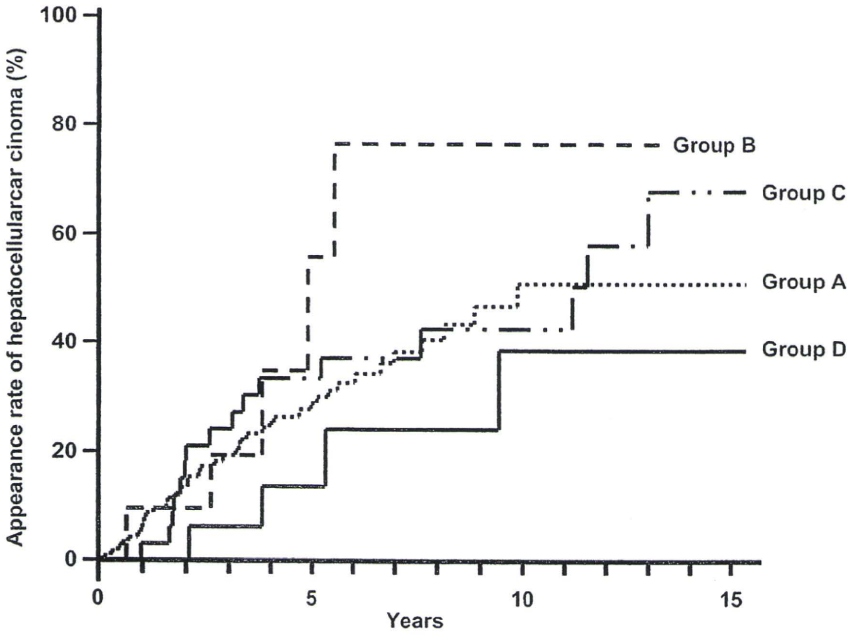

Figure 2 Crude hepatocellular carcinogenesis (HCC) curves in patients of groups A, B, C and D. There was no significant difference in the HCC appearance rate among the four groups (log-rank test, $P = 0.42$).

≥ 12 months was 0.022 after adjustments for significant covariates, but was not significantly different ($P = 0.43$).

We also assessed the effects of splenectomy and long-term IFN therapy on hepatocarcinogenesis by comparing patients of group D (splenectomy + IFN administration for ≥ 12 months) with those of group A. The combination therapy reduced the hazard ratio to 0.03 (multivariate analysis with adjustments for significant covariates), though it was significant ($P = 0.83$). We also assessed compared patients of groups C and B (splenectomy alone). Administration of IFN for ≥ 12 months reduced the hazard ratio to 0.03 (multivariate analysis after adjustments for significant covariates), but was not significant ($P = 0.83$). These results suggest that the combination of splenectomy plus long-term IFN decreased the likelihood of hepatocarcinogenesis.

Effect of splenectomy and IFN combination therapy on survival

During the observation period, one of the 16 patients of group D (Case 3) died (Fig. 1). The survival rates for groups A, B, C and D were 84.2, 90.9, 87.5 and 100% at the end of the third year, 72.0, 90.9, 87.5 and 100% at the fifth year, 41.4, 36.4, 83.3 and 83.3% at the tenth year, respectively (Fig. 3). The survival rate for patients of group D was the highest compared with the other groups (log-rank test, $P = 0.002$). We also compared the effect of combination therapy on the survival rate of patients of group A and group D. The survival rate of group D was significantly higher than of group A (log-rank test, $P = 0.004$). We also compared the effect of combination therapy on the survival rate of patients of group C and group D. The survival rate of group D was not significantly different compared with group C (log-rank test, $P = 0.29$). The combination therapy significantly improved the hazard ratio of survival to 9.69 ($P = 0.028$, multivariate analysis with adjustments for significant covariates, Table 2). These results suggest that the splenectomy simply increased the ability for patients to undergo IFN and may not directly improve patient survival.

DISCUSSION

CHRONIC HEPATITIS C virus (HCV) will continue to cause significant morbidity and mortality through to at least 2015.[10] HCV infection remains a common cause of chronic liver disease and is an increasing indication for liver transplantation. Thrombocytopenia (platelet counts $< 150 \times 10^3/\mu L$) is a common complication in patients with chronic liver disease (CLD), and is reported in as many as 76% of cirrhotic patients.[11]The ability to increase platelet levels could significantly reduce the need for platelet transfusions and facilitate the use of IFN-based antiviral therapy and other medically indicated treatments in patients with liver disease. Current treatment options for severe

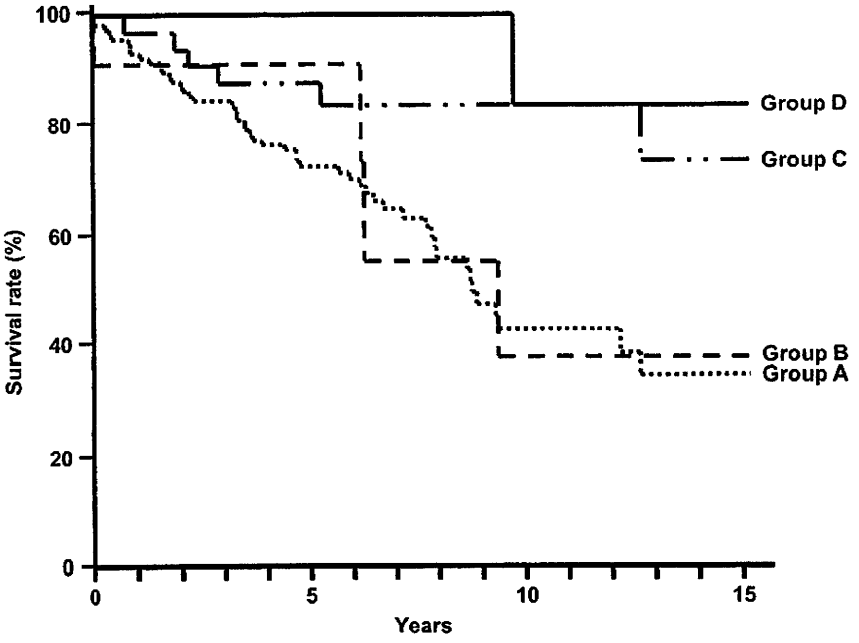

Figure 3 Survival rates for patients of groups A, B, C and D. The survival rate was significantly different for group A, B, C and D (log-rank test, $P = 0.002$). The survival rate of patients of group D was significantly higher than that of group A (log-rank test, $P = 0.004$).

thrombocytopenia include platelet transfusion, splenic artery embolization and splenectomy. We studied the usefulness of the combination therapy of splenectomy and long-term IFN in patients with advanced HCV-related cirrhosis and thrombocytopenia.

With regard to the usefulness of splenectomy, some studies reported that splenectomy improved PLT counts in cirrhotic patients with thrombocytopenia.[2,3] Furthermore, Shimada *et al.*[12] reported that splenectomy resulted in significant falls in ammonia levels and rises in serum albumin. Thus, there is evidence that splenectomy is beneficial and results in recovery of liver function by improving of blood supply to the liver.[6,13] In the present study, at 6 months after splenectomy, leukocyte count increased 1.6 times, PLT count increased 2.3 times, and total bilirubin decreased nearly 0.6 times, relative to prior the procedure. Furthermore, liver function test results also improved in most patients with splenectomy.

Table 2 Significance of combined therapy of survival rate in patients of advanced hepatitis C virus-related cirrhosis with low platelet count (time-dependent proportional hazard model)

Factors	Category	Hazard ratio (95% CI)	*P*
Combined therapy (splenectomy + IFN)	1: no 2: yes	1 9.69 (1.28–76.9)	0.028

IFN, interferon therapy.

With regard to the value of IFN therapy after splenectomy, Hayashi *et al.*[6] reported that splenectomy in patients with HCV cirrhosis can be done safely to allow application of antiviral treatment and potentially avoid transplantation.[6] In this study, only three of 16 (18.8%) patients discontinued IFN therapy after splenectomy. Among the three patients, IFN therapy was discontinued because of thrombocytopenia in only one (6.3%) patient. On the other hand, 13 (81.3%) of the 16 patients on combination therapy were able to complete the full course of IFN therapy, continue IFN therapy or stopped therapy due to NR. Thus, it may be said that IFN therapy is safe in most patients with advanced HCV-related cirrhosis and thrombocytopenia. Furthermore, the present results indicate that splenectomy is an effective method in patients with chronic HCV infection and hypersplenism to increase peripheral leukocyte and platelet counts so that subsequent IFN therapy can be better tolerated. In this study, regarding the reduction of IFN dosages during treatment when comparing group C and D, group D did not have any cases who a reduction in IFN dosages was necessitated by thrombocytopenia ($P = 0.03$). Hayashi *et al.*[6] reported that five of their seven patients underwent splenectomy and then completed a full course of pegylated IFN and ribavirin

treatment or stopped therapy due to NR, and that none of their patients required dose reductions or treatment discontinuation due to thrombocytopenia. In the present study, the viral response to IFN therapy was SVR in four (36.4%) patients, BR in one (9.1%) and NR in six (54.5%). SVR was not significantly different between group C and D ($P = 0.43$). This result might be a reason that group D had more patients with HCV genotype 1 and higher HCV-RNA than group C. All patients with SVR of group D had genotype 2, suggesting that SVR seems to be achievable by combination therapy in patients with HCV-related cirrhosis with genotype 2 and thrombocytopenia.

We also analyzed the effect of the combination therapy on hepatocarcinogenesis in patients with advanced HCV-related cirrhosis and low PLT count. Chen *et al.*[14] reported that the 5-year tumor-free survival rate was significantly higher after hepatectomy and splenectomy than after hepatectomy alone (37 vs. 27.3%, respectively, $P = 0.003$). In contrast, Yao *et al.*[15] reported that splenectomy in early stage of tumor inoculation stimulated tumor growth and metastasis in their rat model of HCC.[15] In this study, the HCC appearance rate in patients who underwent splenectomy alone (group B) was not significantly different from that of the control (log-rank test, $P = 0.52$). In addition, the HCC appearance rate in patients who received the combination therapy was also not significantly different from the control (log-rank test, $P = 0.50$). We previously reported that long-term IFN therapy for 12 months or longer reduced the rate of hepatocarcinogenesis in patients with liver cirrhosis caused by HCV.[5] Multivariate analysis of long-term follow-up showed that the combination therapy, including IFN administration for ≥ 12 months, decreased the hazard ratio of hepatocarcinogenesis to 0.03, though this was not significant ($P = 0.83$). The reason for the lack of significance might be the small population sample of this study. Yoshida *et al.*[16] reported that IFN therapy significantly reduced the risk for HCC, especially among virologic and biochemical responders. That the combination therapy decreased the hazard ratio of hepatocarcinogenesis to 0.03 suggests the ability of long-term IFN to inhibit HCC, especially among non-responders.

We also examined the effects of the combination therapy on survival. In this study, multivariate analysis using time-dependent variables showed significant improvement of survival in patients who received the combination therapy (group D) compared with the control group (group A) (hazard ratio 3.40, $P = 0.017$; 95% CI 1.24–9.35). This may be considered the crucial finding of this study. In splenectomy, Morimasa *et al.*[17] reported no difference in survival rate between splenectomy and endoscopic injection sclerotherapy (EIS) for esophageal varices. Similarly, the survival rate in the splenectomy group in this study (group B) was not significantly different from the control ($P = 0.88$). Furthermore, the survival rate of group D was not significantly different compared with group C (log-rank test, $P = 0.29$). These results suggest that the splenectomy increased the ability for patients to undergo IFN and that the combination therapy of splenectomy and long-term IFN significantly improved survival rate in patients with advanced HCV-related cirrhosis and thrombocytopenia. The likely mechanism of action of the combination therapy is first improvement of leucopenia and thrombocytopenia following splenectomy, which allowed administration of IFN, and then IFN produced remission of liver fibrosis, control of necroinflammatory process, and induced suppression of the HCC growth process, consequently leading to improvement of survival rate. Moreno and Muriel[18] reported that IFN resulted in remission of liver fibrosis, and that control of the necroinflammatory process can therefore induce suppression of the HCC growth process. Our results also suggested that patients with NR may need to continue the combination therapy with long-term IFN therapy.

"Pegylated IFN plus ribavirin" and "eltrombopag" are promising drugs and can be potentially used in combination therapy. Recent multicenter trials have demonstrated the superiority of pegylated IFN plus ribavirin compared to pegylated IFN alone or non-pegylated combination therapy.[19,20] In addition, several promising novel agents that stimulate TPO and increase PLT count, such as the oral platelet growth factor eltrombopag, are currently in development for the prevention and/or treatment of thrombocytopenia.[21] Eltrombopag may be a substitute for splenectomy or PSE. Thus, combination therapy of pegylated IFN plus ribavirin after splenectomy or eltrombopag may improve survival rate and reduce the rate of hepatocarcinogenesis.

Our study had certain limitations. In particular, in this study, four (25%) of the patients who underwent combination therapy had a history of splenectomy. A randomized control study with a larger number of cases should be conducted to confirm the effectiveness of this therapy.

In conclusion, the combination therapy of splenectomy and long-term IFN decreased the rate of hepatocarcinogenesis and significantly improved the survival rate in patients with advanced HCV-related cirrhosis and low PLT count.