

937 **Fig 2.** Clinical summary of a 34-year HBeAg-positive male patient
 938 infected with HBV-genotype C complicated with liver cirrhosis. The
 939 patient was treated with lamivudine monotherapy for 2.8 years,
 940 which resulted in HBeAg negativity and a decrease in HBV DNA to
 941 undetectable levels as measured by TMA-HPA for one year or more,
 942 despite the emergence of YMDD motif mutant (YIDD type). After
 943 the discontinuation of lamivudine, however, the patient developed
 944 severe biochemical relapse, during retreatment of lamivudine mono-
 945 therapy. The case was later controlled when combination therapy of
 946 lamivudine and IFN- α was used. HBV DNA was indicated by
 947 branched DNA signal amplification technology (Chiron Corp., Emery-
 948 ville, Calif., USA) to show the viral loads of higher ranges, and the
 949 results were expressed as 10^6 genomic equivalents per millilitre
 (MEq/ml). Thick line = HBV DNA level, thin line = ALT level.

ALT (IU/L)

Table 1. Clinical characteristics of enrolled patients

	Discontinuous group (n = 25)	Continuous group (n = 75)	p value
Age, years ^a	33 (19-75)	34 (20-75)	matched
Sex, male/female	19/6	57/18	matched
973 Period of observation ^b	2.1 (0.68-7.9)	1.8 (0.71-7.6)	matched
974 HBV DNA, LGE/ml ^a	7.6 (<3.7 to >8.7)	7.5 (<3.7 to >8.7)	NS
975 HBeAg, number of positive	20 (80.0%)	45 (60.0%)	NS
976 HBV genotype, number of C	22 (88.0%)	61 (81.3%)	NS
977 Liver cirrhosis ^c	2 (8.0%)	3 (4.0%)	NS
978 Family history of liver disease ^d	18 (72.0%)	59 (78.7%)	NS
979 T-Bil, mg/dl ^a	0.7 (0.3-20.7)	0.7 (0.3-10.5)	NS
980 ALT, IU/l ^a	97 (51-3,168)	150 (53-2,274)	NS
981 Albumin, g/dl ^a	3.9 (2.8-4.3)	3.8 (2.5-4.8)	NS
982 Cholinesterase, ΔpH ^a	1.0 (0.6-1.5)	1.1 (0.5-1.7)	NS
983 Duration of lamivudine therapy, years ^a	0.72 (0.10-5.6)	1.8 (0.71-7.6)	<0.0001
023	^a Data expressed as median (range).		
024	^b Period of follow-up after the start of lamivudine therapy.		
025	^c Scoring according to the system of Desmet et al. [22].		
026	^d Family history of positivity for hepatitis B surface antigen including third-degree relatives.		
027	LGE = Logarithm of genome equivalent per millilitre; T-Bil = total bilirubin; ALT = alanine transferase (normal		
028	range ≤ 50 IU/l); NS = not significant.		

Table 2. Characteristics of patients at discontinuation of lamivudine monotherapy

	Number	25
	Sex, male/female	19/6
	Age, years ^a	34 (19-75)
	Number of cirrhosis	2 (8.0%)
	HBV genotype, number with genotype C	22 (88.0%)
050	Family history of liver disease ^b	18 (72.0%)
051	HBeAg, number of positive	9 (36.0%)
052	HBV DNA, patients with <3.7 LEG/ml	18 (72.0%)
053	T-Bil, mg/dl ^a	0.7 (0.3-1.3)
054	ALT, IU/l ^a	23 (10-50)
055	BCP nt 1762/1764 (W/M/mi/N)	5/8/2/10
056	PC nt 1896 (W/M/mi/N)	10/3/2/10
057	Presence of YMDD motif mutant	3 (12.0%) ^c
058	Duration of lamivudine therapy, years ^a	0.72 (0.10-5.6)

073 ^a Data expressed as median (range), or number of patients.
 074 ^b Family history of positivity for hepatitis B surface antigen including third-degree relatives.
 075 ^c One patient was PCR-negative with serum sample at stop of treatment, but had been already detected before stop.
 076
 077 Abbreviations, as in table 1, BCP = Basic core promoter; PC = precore; nt = nucleotide. W = wild type (BCP, A1762G1764); PC; G1896); M = mutant type; mi = mixed type of wild and mutant virus; N = PCR-negative.
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 079
 080
 081

G¹⁸⁹⁶
G

A¹⁷⁶² G¹⁷⁶⁴
G

Table 3. Comparison of ALT and T-Bil levels after biochemical relapse and the emergence of YMDD motif mutant between patients who continued and those who discontinued lamivudine monotherapy

	Discontinuous group	Continuous group	p value	
105	Biochemical relapse cases (n = 34)			
106	17	17	NS	
107	Peak T-Bil, mg/dl ^a	0.9 (0.5-3.8)	1.1 (0.5-4.9)	NS
108	Peak ALT, IU/l ^a	384 (191-1,480)	538 (67-1,736)	NS
109	T-Bil ratio ^(b)	1.5 (0.3-3.5)	2.0 (0.2-12.3)	NS
	ALT ratio ^(b)	3.9 (1.0-18.7)	3.5 (0.1-10.8)	NS
125	YMDD motif mutant cases (n = 25)			
126	3	22	NS	
127	Peak T-Bil, mg/dl ^a	2.1 (0.7-3.8)	1.1 (0.5-4.9)	NS
128	Peak ALT, IU/l ^a	441 (50-638)	236 (26-1,736)	NS
129	T-Bil ratio ^(b)	1.0 (0.3-3.5)	1.8 (0.1-12.3)	NS
	ALT ratio ^(b)	5.9 (0.6-11.2)	1.7 (0.1-10.8)	NS
143	* Data expressed as median (range).			
144	For abbreviations, see table 1.			

Table 4. Predictors of early biochemical relapse after lamivudine monotherapy, determined by multivariate analysis

Factors	Category	Odds ratio (95% confidence interval)	p
158	Histology	1: no cirrhosis	1
160		2: cirrhosis	16.1 (2.30-113)
162	HBsAg	1: negative	1
163		2: positive	5.61 (1.77-17.8)
179	Basic core promoter (A1762G1764)	1: undetectable mutant	1
180		2: detectable mutant	3.93 (1.31-11.8)

Variables that achieved statistical significance ($p < 0.05$) on multivariate Cox proportional hazard model are shown.

(the ratios of peak level to pretreatment)

Proof

Favorable Efficacy of Long-Term Lamivudine Therapy in Patients With Chronic Hepatitis B: An 8-Year Follow-Up Study

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The long-term efficacy of lamivudine therapy in patients with hepatitis B virus (HBV) infection is still not clear. In this study, 20 non-cirrhotic Japanese patients infected with HBV received lamivudine therapy for more than 1 year and were followed for a median period of 8.5 years (range, 6.7–8.7 years). The rates of HBe antigen (HBeAg) negative, HBV-DNA undetectable, and alanine aminotransferase (ALT) normal level at the start of lamivudine were 55%, 25%, and 20% and 85%, 80%, and were 80%, respectively, at the last visit, including patients who received additional treatment. The values at the last visit tended to and were significantly higher than those at the start. The values improved at the last visit regardless of the emergence of YMDD motif mutant and continuation of lamivudine. YMDD mutant and biochemical relapse with mutant virus (breakthrough hepatitis) appeared in 65% and 45% during follow-up, respectively, but severe breakthrough hepatitis occurred in only 5%. Furthermore, 80% of patients who received additional treatment for breakthrough hepatitis, regardless of continuation of lamivudine, were ALT normal level at the last visit, in contrast to 25% untreated. HBsAg clearance occurred in two patients of the discontinuous lamivudine group with non-vertical transmission, who were relatively young. One was infected with HBV genotype C with breakthrough hepatitis and the other had no YMDD mutant and was infected with genotype D, a rare type in Japan. None developed cirrhosis or hepatocellular carcinoma (HCC) during follow-up. Our results suggest that long-term lamivudine therapy improves long-term prognosis, especially when additional treatment for breakthrough hepatitis is used. *J. Med. Virol.* 00:1–8, 2005. © 2005 Wiley-Liss, Inc.

KEY WORDS: YMDD motif mutant; HBV genotype; breakthrough hepatitis;

HBsAg clearance; hepatocellular carcinoma

INTRODUCTION

Lamivudine, an oral cytosine nucleoside analog clinically used for the treatment of chronic hepatitis B virus (HBV) infection, potently inhibits HBV replication by interfering with HBV reverse transcriptase activity [Doong et al., 1991; Dienstag et al., 1995; Nevens et al., 1997; Lai et al., 1998], and results in marked decrease of HBV-DNA and alanine aminotransferase (ALT) levels, seroconversion of HBe antigen (HBeAg) to anti-HBe (HBeAb), and histopathological improvement [Lai et al., 1998; Dienstag et al., 1999; Suzuki et al., 1999; Liaw et al., 2000; Schalm et al., 2000; Leung et al., 2001; Akuta et al., 2003a]. However, lamivudine-resistant HBV strains (YMDD motif mutant) have been reported in long-term lamivudine therapy, and the emergence of such mutant virus results in re-elevation of HBV-DNA (DNA breakthrough) and ALT (breakthrough hepatitis) [Tipples et al., 1996; Bartholomew et al., 1997; Lai et al., 1998; Dienstag et al., 1999; Liaw et al., 2000; Schalm et al., 2000; Leung et al., 2001; Yuen et al., 2001; Akuta et al., 2003a,b].

The optimal duration of lamivudine therapy for HBV-infected patients is still controversial for two main reasons; drug resistance and sustainability of the response to treatment. In particular, there is a need to evaluate short-term treatment with respect to post-treatment safety and the sustainability of the response

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to such treatment, and long-term treatment with regard to breakthrough hepatitis [Balzarini et al., 1996; Ling et al., 1996; Naoumov et al., 1996; Tipples et al., 1996; Bartholomew et al., 1997; Honkoop et al., 1997; Schalm, 1997; Allen et al., 1998]. Furthermore, the long-term prognosis of lamivudine-treated patients also remains unknown. Recently, Lok et al. [2003] reported the long-term safety and efficacy of continuous lamivudine treatment based on a median follow-up period of 4 years. However, the efficacy of long-term lamivudine treatment based on a longer follow-up period of more than 5 years is still not clear, especially when associated with or without continuation of lamivudine and with or without the emergence of YMDD mutant.

The present study included 20 consecutive non-cirrhotic Japanese patients with chronic hepatitis B, in whom more than 8 years had elapsed since the induction of lamivudine monotherapy. The aims of the present study were the following: (1) To evaluate the long-term efficacy and safety of more than 1-year lamivudine treatment in Japanese patients with genotype C-dominant hepatitis B; (2) to evaluate HBeAg status, HBV-DNA levels, and ALT levels according to continuation or discontinuation of lamivudine, and according to the emergence or not of YMDD motif mutant; and (3) to evaluate the efficacy of any additional treatment for breakthrough hepatitis.

MATERIALS AND METHODS

Patients

We studied 20 consecutive Japanese adult patients with chronic hepatitis B who agreed to enter a long-term lamivudine trial between September 1995 and July 1996 at the Department of Gastroenterology of Toranomon Hospital [Chayama et al., 1998]. The entry criteria included a positive test for HBV-DNA by dot hybridization and elevated ALT levels (greater than twice the upper limit of normal value [50 IU/L]) within 3 months before the start of therapy. A liver needle biopsy was performed in all patients just before the start of the trial, which confirmed the presence of chronic hepatitis. Individuals, who had hepatocellular carcinoma (HCC), apparent cirrhosis, or signs of hepatic decompensation, were excluded from the study. Also excluded were patients positive for serum markers of hepatitis C virus and human immunodeficiency virus. None of the participating patients received immunosuppressive or antiviral therapy at least 6 months before lamivudine therapy, and none had been previously treated with any nucleoside analogs. Each patient was treated with a single oral dose of 100 mg of lamivudine every day.

The patient characteristics at the start of lamivudine monotherapy are summarized in Table I. The follow-up period represented the time from the start of lamivudine monotherapy until the last visit. The median period of follow-up was 8.5 years (range, 6.7–8.7 years). During follow-up, 6 patients discontinued lamivudine treatment at their own request, and the other 14 patients continued until the last visit. The median period of

TABLE I. Patient Characteristics at the Start of Lamivudine Monotherapy

Number	20
Sex (male/female)	16/4
Age (year) ^a	44 (25–65)
HBeAg (no. of positive)	9 (45.0%)
HBV-DNA (gEq/ml) ^a	3.2×10^7 ($7.0 \times 10^5 - 3.2 \times 10^9$)
HBV genotype (no. of B/C/D/F)	3/15/1/1
Histology (no. of F1/2) ^b	12/8
Family history of liver disease ^c	13 (65.0%)
T-Bill (mg/dl) ^a	0.8 (0.2–1.7)
AST (IU/l) ^a	59 (24–247)
ALT (IU/l) ^a	100 (11–371)
Albumin (g/dl) ^a	4.1 (3.4–4.7)
Cholinesterase (Δ pH) ^a	1.0 (0.8–1.3)

T-Bill, total bilirubin; AST, aspartate transferase; ALT, alanine transferase.

^aData are expressed as median (range).

^bScoring according to the system of Desmet et al. [1994].

^cFamily history of positivity for hepatitis B surface antigen including third-degree relatives.

lamivudine treatment was 1.4 years (range, 1.0–5.6 years) for the discontinuation group, and 8.5 years (range, 6.7–8.7 years) for the continuous patients. As a whole, the median period of lamivudine treatment was 8.4 years (range, 1.0–8.7 years). In some patients, lamivudine therapy was supplemented with other additional treatments.

Methods

As indicators of lower activity of hepatitis, the rates of HBeAg negative, HBV-DNA undetectable (undetectable DNA levels by branched DNA signal amplification technology), and normal ALT level, were evaluated at two points; the start of lamivudine and last visit. The rates at the last visit were evaluated by including those patients who received additional treatment. Furthermore, the cumulative appearance rates of YMDD mutant by polymerase chain reaction (PCR)-based methods and breakthrough hepatitis (ALT becoming abnormal after a period of ALT normalization, accompanied by the emergence of YMDD mutant and re-elevation of HBV-DNA levels) were also evaluated. Clinical assessment and laboratory tests were performed at least once every month before, during, and after treatment. Adverse effects were monitored clinically by careful interviews and medical examination at least once every month. Patient compliance with treatment was evaluated with a questionnaire. All patients underwent abdominal ultrasonography every 6 months at least to exclude the development of cirrhosis and HCC.

Blood samples were obtained at least once every month before, during, and after treatment, and were analyzed for laboratory data including ALT levels, HBV-DNA levels, HBsAg, HBeAg/eAb, and YMDD motif mutant at various time periods. The serum samples were stored in aliquots at -80°C until use. HBsAg and HBeAg/eAb were determined by radioimmunoassay

(Abbott Diagnostics, Chicago, IL). HBV-DNA was measured by the branched DNA signal amplification technology (Chiron Corp., Emeryville, CA), and the results were expressed as genomic equivalents per milliliter (gEq/ml). The lower limit of the assay is 7.0×10^5 gEq/ml. HBV genotype and subgroups of genotype B were determined using the previously reported method [Okamoto et al., 1988; Usuda et al., 1999; Sugauchi et al., 2002]. Antibody against HCV was detected with chemiluminescent enzyme immunoassay (Lumipulse[®] II Ortho HCV, Ortho Diagnostic Japan, Tokyo). The YMDD motif mutant was detected using sensitive PCR-restriction fragment length polymorphism (PCR-RFLP) [Chayama et al., 1998].

Liver biopsy specimens were obtained percutaneously or at laparoscopy using a modified Vim Silverman needle of 2-mm internal diameter (Tohoku University style, Kakinuma Factory, Tokyo). Each specimen was scored according to the system of Desmet et al. [1994].

This study was conducted in accordance with the guidelines of the Declaration of Helsinki and its subsequent amendments, and informed consent was obtained from every patient. The study was approved by the Local Ethics Committee of Toranomon Hospital.

Statistical Analysis

Fisher's exact probability test was used to compare the rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level between the start point of lamivudine and the last visit. The cumulative appearance rates of YMDD mutant and breakthrough hepatitis during lamivudine treatment were calculated using the Kaplan-Meier technique, and were evaluated from the start point of lamivudine until the last visit or discontinuation. Statistical comparisons were performed using the SPSS software (SPSS, Inc., Chicago, IL). All *P*-values of less than 0.05 by the two-tailed test were considered significant.

RESULTS

Efficacy Measures, Lamivudine Resistance, and Safety For the Whole Group

The clinical course of 20 patients is shown in Figure 1. For the whole group, the rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level were 55% (11/20), 25% (5/20; HBV-DNA levels of five patients were detectable directly before treatment, but undetectable at the start by chance), and 20% (4/20) at the start of lamivudine treatment, respectively. Five patients received additional treatment for breakthrough hepatitis before or until the last visit. The rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level were 85% (17/20), 80% (16/20), and 80% (16/20) at the last visit, respectively. The rates of HBeAg negative (*P* = 0.082), HBV-DNA undetectable (*P* = 0.0012), and ALT normal level (*P* = 0.00036) at the last visit tended to be or were significantly higher than those at the start of lamivudine treatment.

YMDD mutant was not detected in any of the pre-treatment serum samples. For the whole group, YMDD motif mutant and breakthrough hepatitis appeared in 65% (13/20) and 45% (9/20) during lamivudine monotherapy, respectively. Additional treatment was provided to 55.6% (5/9) of patients who developed breakthrough hepatitis, while the other 15 patients received lamivudine monotherapy until the last visit or the time of discontinuation. The cumulative appearance rates of YMDD mutant and breakthrough hepatitis were 70.2% and 46.4% at the end of 5 years; 70.2% and 52.3% at the end of 8 years, respectively (Fig. 2). None developed severe adverse events during long-term lamivudine treatment, apart from the development of breakthrough hepatitis.

Clinical Course of 13 Patients With YMDD Motif Mutant

During lamivudine monotherapy, 69.2% (9/13) patients with emergence of YMDD mutant developed breakthrough hepatitis. In these patients, seven continued lamivudine therapy after the development to breakthrough hepatitis, and additional therapy was provided to three of the seven patients (two patients received interferon [IFN], and one received glycyrrhizin [Stronger[®] Neo-Minophagen C[®]]). The remaining two patients discontinued lamivudine therapy after the development of breakthrough hepatitis, and instead received IFN therapy. At the last visit, ALT normal level and DNA undetectable were detected in 55.5% (5/9) and 66.7% (6/9) of patients who developed breakthrough hepatitis, respectively. Especially, 80% (4/5) of patients who received suitable additional treatment for breakthrough hepatitis, irrespective of lamivudine therapy, were ALT normal level at the last visit in contrast to 25% (only 1/4 patients) of patients untreated for breakthrough hepatitis.

In patients with emergence of YMDD mutant, 30.8% (4/13) did not develop breakthrough hepatitis. At the last visit, 100% (all 4 patients) and 75.0% (3/4) of patients, who did not develop breakthrough hepatitis, were ALT normal level and DNA undetectable, respectively, irrespective of continuous lamivudine therapy.

Clinical Courses of Seven Patients Without YMDD Motif Mutant

All seven patients free of YMDD mutant were HBeAg negative, DNA undetectable, and ALT normal level at the last visit, irrespective of continuous lamivudine therapy. Three patients who transiently discontinued the treatment showed ALT relapse after the cessation of lamivudine therapy, but their ALT levels became stable spontaneously without any additional treatment.

Efficacy Measures According to Patients' Background

The rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level at the two points of the start of lamivudine and the last visit are shown in Figure 3,

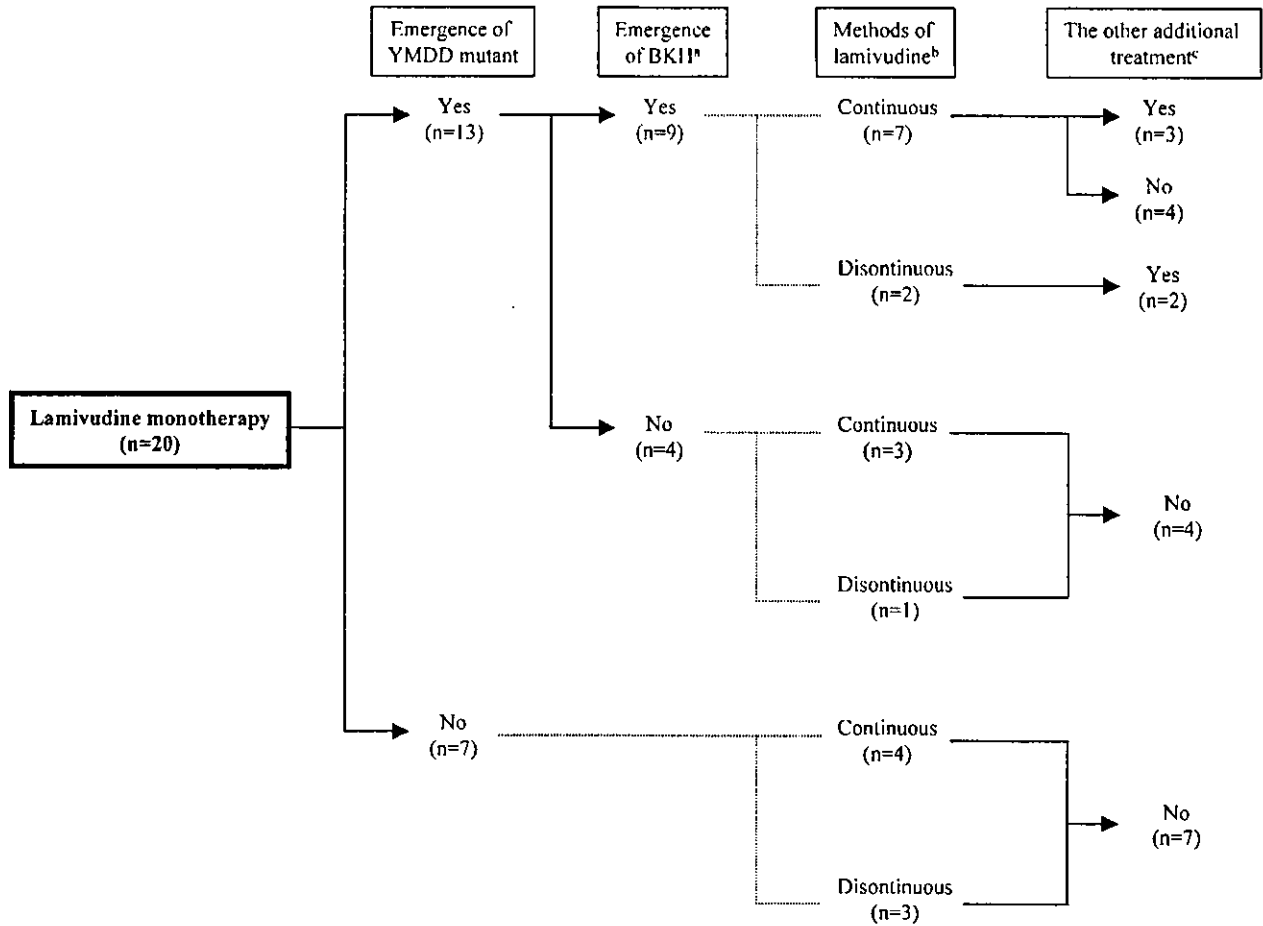


Fig. 1. Clinical course of 20 patients. YMDD motif mutant and breakthrough hepatitis (ALT becoming abnormal after a period of ALT normalization, accompanied by emergence of YMDD mutant and re-elevation of HBV-NA levels) appeared in 65% and 45% during lamivudine monotherapy, respectively. *BKH, breakthrough hepatitis.

^{b,c}The methods of lamivudine treatment and the other additional treatment for BKH were decided at patients' own requests. For the whole group, 30% discontinued lamivudine treatment during follow-up. Additional treatment was provided to 55.6% of patients who developed breakthrough hepatitis.

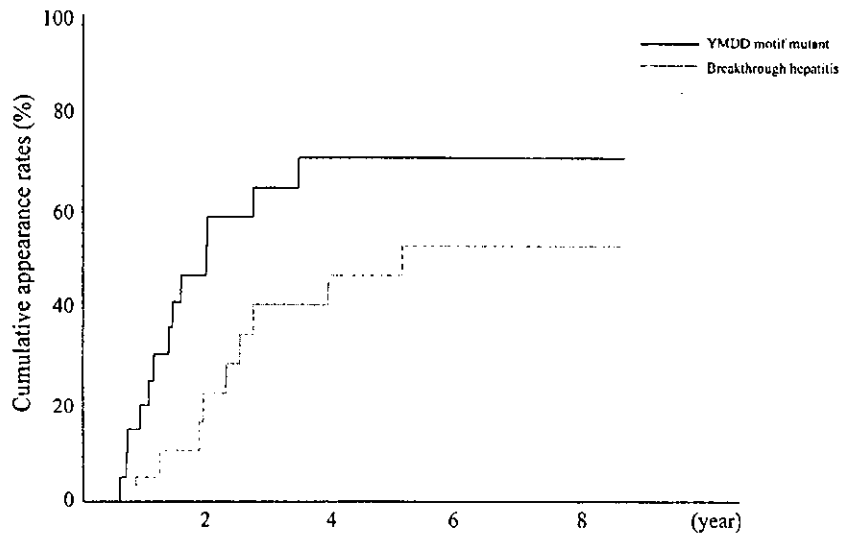


Fig. 2. Cumulative appearance rates of YMDD motif mutant and breakthrough hepatitis throughout follow-up.

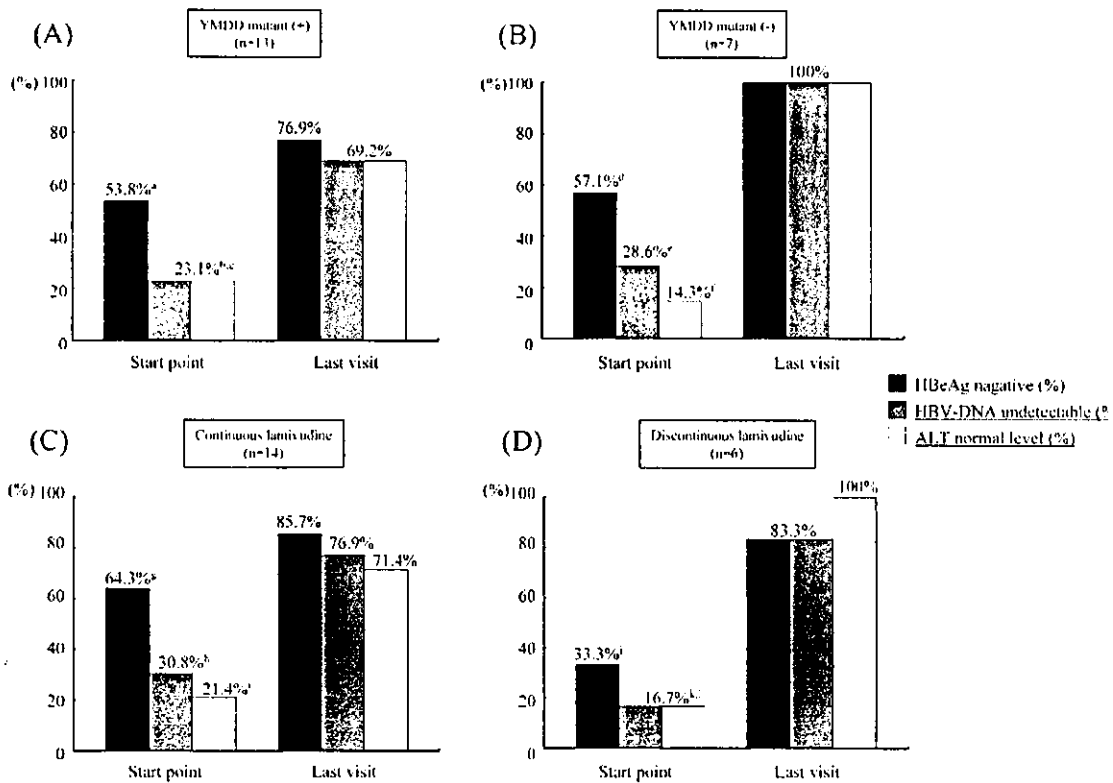


Fig. 3. The ^{Q2} rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level at the start of lamivudine treatment and last visit. The results at the last visit were evaluated by including five patients who received additional treatment. ^{a,d,g}Not significant, compared with HBeAg negative rates at each last visit. Fisher's exact

probability test. ^b*P* = 0.047, ^c*P* = 0.021, ^e*P* = 0.047, ^f*P* = 0.080, compared with HBV-DNA undetectable rates at each last visit by Fisher's exact probability test. ^g*P* = 0.047, ^h*P* = 0.0047, ⁱ*P* = 0.021, ^j*P* = 0.015, compared with ALT normal rates at each last visit by Fisher's exact probability test.

according to the emergence of YMDD mutant and lamivudine therapy. The rates of HBV-DNA undetectable and ALT normal level at the last visit tended to be or were significantly higher than those at the start, regardless of the emergence of YMDD mutant and continuous lamivudine therapy. The rate of HBeAg negative at the last visit was also higher than at the start, even when there was no significance based on the relatively small numbers of HBeAg-positive patients at the start of lamivudine therapy.

In five patients who received additional treatment for breakthrough hepatitis, the rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level were 20 (1/5), 0 (0/5), and 0% (0/5) at the start of lamivudine; and 60 (3/5), 60 (3/5), and 80% (4/5) at the last visit, respectively. The rates of ALT normal level at the last visit were significantly higher than at the start (*P* = 0.048). The rates of HBeAg negative and HBV-DNA undetectable at the last visit were also higher than at the start, though statistically insignificant due to the small number of patients.

HBsAg Clearance With Lamivudine Therapy

HBsAg clearance by radioimmunoassay was noted in 10% (2 males of 20 patients) of the whole group

during follow-up, and they showed undetectable HBV-DNA levels using a sensitive quantitative PCR assay (Amplicor HBV Monitor Test, Roche Molecular Systems, Inc., NJ). The lower limit of this assay is 2.6 log copies/ml. The characteristics of these two male patients who could achieve HBsAg clearance by radioimmunoassay are shown in Table II. Furthermore, HBsAg clearance occurred in 33.3% (2/6) cases of the discontinuation group and none of the continuous (0/14). The discontinuation group tended to achieve higher rates of HBsAg clearance than the continuous group (*P* = 0.079).

One patient with HBsAg clearance was infected with HBV genotype C (HBV/C), the major type in Japan, and was a relatively young adult under 40 years of age who developed HBV by non-vertical transmission (i.e., patients whose mothers did not suffer from chronic HBV infection). He developed breakthrough hepatitis, especially according to continuous YMDD type [Akuta et al., 2003c] of YMDD motif mutant, and developed HBsAg clearance at about 5 years after the cessation of long-term lamivudine treatment followed by IFN treatment for breakthrough hepatitis.

The other patient with HBsAg clearance was infected with HBV/D; a rare type in Japan, and the infection was considered not to be transmitted vertically. The YMDD motif mutant did not emerge during long-term

TABLE II. Characteristics of Two Patients Who Could Achieve HBsAg Clearance*

Patient	Age (year)	Sex	Genotype	Histology	Etiology of HBV infection ^a	Emergence of YMDD infection ^a	Emergence of BKH ^c	Treatment for BKH	Methods of lamivudine	Duration of lamivudine (year)
1	38	M	C	F2	Non-vertical	YVDD ^b	+	Interferon	Discontinuous	1.0
2	46	M	D	F1	Non-vertical	—	—	—	Discontinuous	1.1

*HBsAg clearance were determined by radioimmunoassay.

^aEtiology of HBV infection in both patients was not vertical transmission from mother to infant.

^bYMDD mutant type was continuous YVDD type, which tended to be detected in the relatively younger patients [Akuta et al., 2003^{Q3}].

^cBKH, breakthrough hepatitis.

lamivudine treatment, and HBsAg clearance at about 3 years after the cessation of lamivudine treatment was noted together with transient post-treatment ALT relapse.

In conclusion, HBsAg clearance occurred in two male patients with non-vertical transmission infection, who discontinued lamivudine therapy. One patient was a relatively young adult infected with HBV/C and developed breakthrough hepatitis and the other patient was infected with HBV/D but without YMDD mutant.

Development of Severe Breakthrough Hepatitis

Severe breakthrough hepatitis was defined as a rise in ALT level to ≥ 300 IU/L, accompanied by elevation of total bilirubin level to ≥ 3.0 mg/dl and coagulopathy with plasma prothrombin time of $< 75\%$ of control activity. Severe breakthrough hepatitis occurred in only 5% of all patients (1/20), and in 7.7% of patients with the emergence of YMDD mutant (1/13). The patient was a male infected with HBV/C and developed severe breakthrough hepatitis at about 3 years after the start of lamivudine treatment, according to the mixed type of YMDD mutant [Akuta et al., 2003c]. He was suitably provided with combination therapy of lamivudine + IFN, which resulted in the stabilization of hepatitis. At the last visit, he was HBeAg negative and ALT normal level.

Development of Cirrhosis and HCC

None of the patients developed cirrhosis or HCC during follow-up and at end-point.

DISCUSSION

To our knowledge, this report provides the results of the longest follow-up study (median follow-up period of 8.5 years) of patients with chronic hepatitis B on the longest lamivudine treatment (median treatment period of 8.4 years). In our study, the rates of HBeAg negative, HBV-DNA undetectable, and ALT normal level at the last visit for the whole group tended to be and were significantly higher than those at the start of lamivudine. In particular, we could achieve very high rates (80% and 80%) of HBV-DNA undetectable and ALT normal level at the last visit, respectively, by including patients who received additional treatment for breakthrough hepatitis. Furthermore, these patients showed similar improvement at the last visit, irrespective of

emergence of YMDD mutant and lamivudine therapy. In the present study of Japanese dominant HBV/C, the cumulative appearance rates of YMDD mutant and breakthrough hepatitis were also approximately similar to previous reports based on the shorter follow-up periods than this study [Lai et al., 1998; Liaw et al., 2000; Leung et al., 2001; Lok et al., 2003], and severe breakthrough hepatitis with icteric flare-up occurred in only 5% (only one infected with HBV/C). Furthermore, 80% of patients, who received suitable additional treatment for breakthrough hepatitis, were ALT normal level at the last visit. Hence, our results indicate that long-term lamivudine treatment also induces long-term favorable prognosis and is safe in patients with breakthrough hepatitis if suitable additional treatments are provided, to say nothing of the favorable prognosis in patients without YMDD mutant and breakthrough hepatitis. We agree with Lok et al. [2003] who provided data in support of the benefits of long-term lamivudine treatment [Akuta et al., 2004].

With regard to the treatment of breakthrough hepatitis, IFN and new nucleotide analogs (e.g., adefovir dipivoxil and entecavir) are reported to be effective in patients with YMDD mutant [Perrillo et al., 2000; Tassopoulos et al., 2001; Peters et al., 2002; Suzuki et al., 2002]. Especially, a recent report suggested that breakthrough hepatitis should be avoided, and that adefovir dipivoxil should be introduced when YMDD mutant is first detected or at the first sign of worsening hepatitis [Lok, 2004]. We agree with the recommendation of this report that other additional treatment for breakthrough hepatitis should be introduced earlier to achieve a more safe response to long-term lamivudine.

The benefits of continuous lamivudine after the emergence of YMDD mutant are still unclear. Previous studies showed that YMDD mutants are less replication-competent compared with the wild-type, and are associated with lower HBV-DNA levels compared with pretreatment HBV-DNA levels [Fu and Cheng, 1998; Lai et al., 1998; Melegari et al., 1998; Dienstag et al., 1999; Ling and Harrison, 1999; Ono-Nita et al., 1999; Leung, 2000]. We had reported that 3-year lamivudine therapy induced histopathological improvement regardless of the appearance of YMDD mutants, associated with breakthrough hepatitis, and suggested the benefit of long-term treatment [Suzuki et al., 2003]. In contrast, a recent study compared continuous lamivudine group with discontinuous group, and showed that there might be no benefit to continue treatment after emergence of

YMDD mutant based on comparison of the hepatitis flare rates, decompensation rates, HBeAg seroconversion rates, and HBV-DNA levels at a relatively short follow-up period [Liaw et al., 2004]. In the present study, we could not conclude whether it is beneficial to continue lamivudine therapy after emergence of YMDD mutant because we did not include a control group to compare between the continuous and discontinuous therapy, although patients with breakthrough hepatitis showed a favorable clinical course in response to additional treatment.

Recently, Liaw et al. [2003] reported that lamivudine treatment might suppress the disease progression and development of HCC in advanced chronic hepatitis B based on a median treatment duration of about 3 years. Ikeda et al. [2003] indicated that persistently low HBV-DNA might save patients from hepatocarcinogenesis in HBV-related cirrhosis, and our study also showed that the suppression of HBV-DNA levels with lamivudine also seems to suppress HCC. In our study of non-cirrhotic patients, the rate of HBV-DNA undetectable at the last visit was very high (80%) when we included five patients who received additional treatment for breakthrough hepatitis. This result supports the favorable prognosis of patients treated with long-term lamivudine who do not develop cirrhosis and HCC during follow-up. Furthermore, excluding cirrhotic patients as major risk factors for HCC might lead to a more favorable prognosis.

HBsAg clearance rates based on long-term lamivudine treatment remain inadequately defined at present. Previous reports from the United States indicated that the rate of HBsAg clearance was 23% in patients who discontinued lamivudine after HBeAg seroconversion and followed for up to 3 years [Dienstag et al., 2003]. Our results also indicated that HBsAg clearance occurred in only 10% of the whole group at a median follow-up of 8.5 years, but in contrast was noted in 33.3% of discontinuation patients and 0% in the continuous-treatment group. Thus, the discontinuation patients tended to achieve a higher rate of HBsAg clearance than continuous patients, and this result suggests that various factors, like virological rebound and/or immunological response after discontinuation of lamivudine, might affect HBsAg clearance. However, in this study of a small number of discontinuation patients, we could not conclude that HBsAg clearance could be achieved in the lamivudine discontinuation group, and further prospective studies should be performed. Interestingly, one patient, who could achieve HBsAg clearance regardless of breakthrough hepatitis, was a relatively young adult infected with HBV/C through non-vertical transmission; and the other patient infected with HBV/D, a rare type in Japan, was considered have acquired the disease through no-vertical transmission. These results suggest that these patients might have achieved HBsAg clearance with lamivudine based on the relatively short duration of HBV infection in comparison to vertical transmission and/or the different HBV genotype. To our knowledge, this is the first report that investigated the

characteristics of HBsAg clearance during long-term lamivudine treatment. Further studies of a large group of patients are required to clarify whether the HBV genotype, duration of HBV infection, and method of lamivudine therapy influence HBsAg clearance following long-term lamivudine treatment.

In conclusion, the present study of Japanese patients with genotype C-dominant hepatitis B indicates that long-term lamivudine treatment is safe and induces long-term favorable prognosis, especially when a suitable additional treatment is used for breakthrough hepatitis. Further prospective studies are necessary to determine whether long-term lamivudine treatment improves long-term prognosis, including clearance of HBsAg and suppression of hepatocarcinogenesis.

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ORIGINAL ARTICLE

Long-term follow-up of interferon monotherapy in 454 consecutive naive patients infected with hepatitis C virus: Multi-course interferon therapy may reduce the risk of hepatocellular carcinoma and increase survival

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Abstract

Objective. The long-term effects of multi-course interferon (IFN) monotherapy in patients infected with hepatitis C virus (HCV) are still unclear. **Material and methods.** To evaluate the effects of multi-course IFN on hepatocarcinogenesis and survival, a follow-up study was conducted comprising 454 consecutively recruited non-cirrhotic naive patients infected with HCV, who had received IFN monotherapy between 1987 and 1992. The median follow-up was 11.3 years. **Results.** A sustained response (SR) after the first IFN was achieved by 152 patients (33.5%) (Group A). Of 302 patients (66.5%) with non-SR after the first IFN, 130 patients (28.6%) did not receive additional IFN (Group B), and the remaining 172 patients (37.9%) received multi-course IFN monotherapy (Group C). With regard to hepatocarcinogenesis and survival rates for liver-related deaths, Groups A and C both showed significantly better long-term clinical outcome than Group B ($p < 0.001$; log-rank test). Three independent factors were identified by multivariate analyses (fibrosis stage 3, Group B, and age ≥ 50) for all patients and two factors (fibrosis stage 3 and age ≥ 50) for Group C associated with hepatocarcinogenesis. With regard to hepatocarcinogenesis rates according to the mean alanine aminotransferase (ALAT) levels during the IFN-free period in Group C, significantly higher rates were noted in patients with ALAT levels above $1.5 \times$ the upper normal limit (17.6%) than those below the limit (0%) ($p < 0.05$). **Conclusions.** Multi-course IFN monotherapy reduces the risk of hepatocarcinogenesis and increases survival, and low ALAT levels during the IFN-free period are associated with lower hepatocarcinogenesis rates in multi-course IFN.

Key Words: HCV, hepatocellular carcinoma, interferon monotherapy, liver-related death, multi-course, survival analysis

Introduction

Hepatitis C virus (HCV) usually causes chronic infection, which can result in chronic hepatitis, liver cirrhosis, and hepatocellular carcinoma (HCC) [1–5]. In patients with HCV chronic hepatitis, treatment with interferon (IFN) can induce viral clearance and marked biochemical and histological improvement [6,7]. Recently, several studies based on single-course IFN monotherapy also showed that in patients receiving IFN therapy there was a reduced risk of development of HCC and liver-

related death in comparison with untreated patients, especially in responders to the treatment [1,8–12]. However, it is still a matter of controversy whether or not the effect of IFN therapy is beneficial [13–21].

The response to IFN therapy varies among different HCV genotypes [22,23]. In Japan, about 70% of patients with chronic hepatitis C are infected with HCV genotype 1b, while about 25% are genotype 2a. Sustained response (SR) to IFN monotherapy is as low as 10 to 20% in genotype 1b infection [24–27]. We also encounter IFN-resistant patients infected with genotype 2a, even

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though SR is more than 60% in this group [28,29]. We previously reported that a second course of IFN monotherapy for IFN-resistant cases could increase the SR rates in patients who could not attain SR after the first course [30]. Thus, we reported an increase in the viral clearance rates as one of the short-term benefits of two or more courses (herein called multi-course) of IFN monotherapy. However, the long-term benefits of multi-course IFN monotherapy are still unclear, whether associated with SR or not.

The present study included 454 consecutive naive cases with chronic hepatitis C, in whom more than 10 years had elapsed since the induction of IFN monotherapy. The aims of the study were: 1) to evaluate the long-term efficacy of multi-course IFN therapy on hepatocarcinogenesis and survival, examined by analysis of the outcomes of single- and multi-courses of IFN; 2) to analyze the predictive factors associated with hepatocarcinogenesis, if any, in patients who received multi-course IFN therapy.

Material and methods

Patients

Among 573 consecutively recruited HCV-infected patients, in whom IFN monotherapy was induced between February 1987 and August 1992 at Toranomon Hospital, 454 were selected for the present study based on the following criteria: 1) patients naive to IFN monotherapy; 2) patients with chronic hepatitis, without cirrhosis or HCC, as confirmed by biopsy examination within 6 months of enrolment; 3) patients negative for hepatitis B surface antigen (radioimmunoassay, Dainabot, Tokyo, Japan), positive for anti-HCV (third-generation enzyme immunoassay, Chiron Corp., Emerville, Calif., USA), and positive for HCV RNA qualitative analysis with PCR (nested polymerase chain reaction or AmpliCor; Roche Diagnostic Systems, Calif., USA); 4) patients free of co-infection with human immunodeficiency virus; 5) patients not treated with antiviral or immunosuppressive agents within 6 months of enrolment; 6) lifetime cumulative alcohol intake <500 kg (mild to moderate alcohol intake); 7) patients free of other types of hepatitis, including hemochromatosis, Wilson disease, primary biliary cirrhosis, alcoholic liver disease, and autoimmune liver disease; 8) patients without or with well-controlled diabetes; and 9) patients who consented to participate in the study.

With regard to the clinical features of 454 patients at the start of the first course of IFN monotherapy, there were 322 men and 132 women, aged 15–70 years with a median age of 48 years. The numbers of patients with fibrosis stages 1, 2, and 3 were 260,

160, and 34 patients, respectively. HCV genotypes were 1b in 313 patients and non-1b in 125, and the genotype in the remaining 16 patients was not determined. The median alanine aminotransferase (ALAT) level was 142 IU/l (range, 24–636 IU/l), and the median platelet count was $17.4 \times 10^4/\mu\text{l}$ (range, 7.4×10^4 – $39.2 \times 10^4/\mu\text{l}$). The median viremia level was 2.7 Meq/ml (range, <0.5–67.1 Meq/ml). The median follow-up time was 11.3 years (range, 0.1–16.3 years).

Furthermore, at the first course of IFN monotherapy, 327 patients (72.0%) received IFN- α alone, 119 patients (26.2%) received IFN- β alone, while the remaining 8 patients (1.8%) received a combination of IFN- α and IFN- β . A median IFN dose per day of 6 million units (MU, range; 1–10 MU) was administered. As a whole, a median total dose of IFN of 526 MU (range; 10–3696 MU) was administered during a median period of 23.9 weeks (range; 0.6–205.4 weeks). Patients mainly received IFN monotherapy, including initial aggressive induction therapy (every day within 8 weeks, followed by three times per week).

The study protocol was approved by the Human Ethics Review Committee of Toranomon Hospital.

Methods

The primary measure of efficacy of treatment was SR, defined as negative HCV RNA by qualitative analysis with PCR and normalization of transaminase levels (aspartate aminotransferase (ASAT), 11–38 IU/l; ALAT, 6–50 IU/l) at 24 weeks after cessation of IFN therapy. Patients who achieved SR after the first course of IFN monotherapy were classified as Group A. Patients who did not attain SR after the first course of IFN monotherapy were classified into two groups; based on whether they received other courses of IFN monotherapy or not. Patients who did not receive further courses of IFN monotherapy, because of concerns about adverse effects, lack of time for treatment, physicians' recommendation based on the emergence of depression and cardiopulmonary disease during and after the first course of IFN, or the lower levels of ALAT, were classified as Group B. Patients who received two or more courses of IFN monotherapy were classified as Group C.

Laboratory investigations

Blood samples were frozen at -80°C within 4 h of collection and were not thawed until used for testing. HCV genotype was determined by PCR using a mixed primer set derived from nucleotide sequences of the NS5 region [31]. In all cases, HCV-RNA

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viremia levels were measured by branched DNA assay version 2.0 (Chiron Corp) at commencement of therapy using frozen samples, and the results were expressed as 10^6 genomic equivalents per milliliter (Meq/ml). The lower limit of the assay was 0.5 Meq/ml. Samples with undetectable levels using this quantitative assay (<0.5 Meq/ml) were also evaluated by HCV-RNA qualitative analysis with PCR (nested polymerase chain reaction or Amplicor, Roche Diagnostic Systems) during and after therapy especially, and the results were expressed as positive or negative. The lower limit of the assay was 100 copies/ml.

Liver histopathological examination

Liver biopsy specimens were obtained percutaneously or at peritoneoscopy 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. All specimens for examination contained 6 or more portal areas. Histopathological diagnosis was made by an experienced liver pathologist (H.K.) who was blinded to the clinical data. Chronic hepatitis was diagnosed based on histopathological assessment according to the scoring system devised by Desmet et al. [32].

Follow-up

Clinical and laboratory assessments were performed at least once every month before, during, and after treatment. Adverse effects were monitored clinically by means of careful interviews and medical examinations at least once every month. Patient compliance with treatment was evaluated with a questionnaire. Blood samples were also obtained at least once every month before, during, and after treatment, and were also analyzed for ALAT levels and HCV-RNA levels at various time-points.

Follow-up time represented the time from the start of the first course of IFN treatment until death, or until the last visit. During this time, we especially evaluated liver-related death, which included HCC, cholangiocellular carcinoma, liver failure, or esophageal variceal bleeding.

Diagnosis of hepatocellular carcinoma

Patients were examined for HCC by abdominal ultrasonography every 3 to 6 months. If HCC was suspected based on ultrasonographic results, additional procedures such as computed tomography, magnetic resonance imaging, abdominal angiogra-

phy, and ultrasonography-guided tumor biopsy, if necessary, were used to confirm the diagnosis.

Statistical analysis

The χ^2 test, Fisher's exact probability test, and the Mann-Whitney U-test were used to compare the background characteristics between groups. Multiple comparisons were examined using the Bonferroni test. The cumulative hepatocarcinogenesis and survival rates were calculated using the Kaplan-Meier technique, differences between survival curves were tested using the log-rank test. Statistical analyses of hepatocarcinogenesis and survival periods according to groups were calculated using the period from start of the first course of IFN monotherapy. The stepwise Cox regression analysis was used to determine independent predictive factors that were associated with hepatocarcinogenesis. We also calculated the odds ratios and 95% confidence intervals (95% CI). Potential predictive factors associated with hepatocarcinogenesis included the following 10 variables: age, gender, histological stage, HCV genotype, viremia level, serum ALAT, platelet count, total IFN dose, total IFN duration, and treatment group. Each variable was transformed into categorical data consisting of two simple ordinal numbers for univariate and multivariate analyses. Variables that reached statistical significance ($p < 0.05$) or marginal significance ($p < 0.10$) on univariate analysis were tested by the multivariate Cox proportional hazard model to identify significant independent factors. Statistical comparisons were performed using SPSS software (SPSS Inc., Chicago, Ill., USA). All p -values of less than 0.05 by the two-tailed test were considered significant.

Results*Efficacy of IFN monotherapy*

SR was achieved by 152 patients (33.5%) after the first course of IFN monotherapy (Group A). After the first course of IFN, 130 (28.6%) out of 302 (66.5%) non-SR patients did not receive a second course of IFN monotherapy (Group B), while the remaining 172 (37.9%) received two or more courses of IFN monotherapy (Group C). Of the 172 patients in Group C, 103 patients received two courses of IFN (30 of whom achieved SR), 51 patients received three courses (8 of whom achieved SR), 16 patients received four courses (4 of whom who achieved SR), and 2 patients received six courses (none achieved SR). Thus, 42 patients of Group C attained SR after multi-courses of IFN monotherapy.

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In Groups A and B, the median total duration of IFN was 24.4 weeks (range, 4.0–205.4 weeks) and 23.4 (range, 2.9–90.0). The median total dose of IFN was 531 MU (range, 43–3696 MU) and 495 (range, 41–877). In the first, second, third, fourth, fifth, and sixth courses of IFN monotherapy in Group C, the median total durations of IFN were 23.9 weeks (range, 0.6–149.4 weeks), 24.0 (range, 1.3–313.7), 26.3 (range, 3.1–255.0), 29.6 (range, 3.9–86.3), 34.2 (range, 23.6–44.7), and 47.7 weeks (range, 25.3–70.1), respectively. In the first, second, third, fourth, fifth, and sixth courses of IFN monotherapy in Group C, the median total doses of IFN were 519 MU (range, 10–2399 MU), 573 (range, 29–4005), 525 (range, 28–3477), 566 (range, 81–1286), 555 (range, 402–708), and 690 (range, 180–1200), respectively. The median cumulative total durations and cumulative total doses, which represented the cumulative total duration and total dose of every course of every patient of Group C, were 58.5 weeks (range, 8.4–474.4 weeks) and 1380 MU (range, 340–5240 MU), respectively. The median periods free of IFN in Group C were 3.6 years (range, 0.1–7.7 years). Finally, the median dose of IFN per week in Groups A, B, and C were 21.8 MU/week (range, 6.7–42.0), 22.0 (range, 4.5–42.0), and 22.1 (range, 3.7–44.6), respectively.

Clinical features of patients of Groups A, B, and C

The clinical features of patients in Groups A, B, and C at the start of the first IFN monotherapy are summarized in Table I. The ages of patients of Group B were significantly higher than those of Group A ($p=0.001$; Bonferroni test) and Group C ($p=0.013$; Bonferroni test). Viremia levels and frequencies of genotype 1b in Group A were significantly lower than those in Group B ($p < 0.0001$; Bonferroni test) and Group C ($p < 0.0001$; Bonferroni test). Fibrosis stage of Group A was significantly milder than those of Group B ($p =$

0.005; Bonferroni test) and Group C ($p=0.004$; Bonferroni test). There were no other significant differences in clinical features at the start of IFN therapy among the three groups.

Cumulative hepatocarcinogenesis rates in Groups A, B, and C

During the follow-up, 2 patients (1.3%), 23 (17.7%), and 19 (11.0%) developed HCC in Groups A, B, and C, respectively. In Groups A, B, and C, the cumulative hepatocarcinogenesis rates were 1.1, 15.0, 0.7% at the end of 5 years; and 2.2, 26.0, 9.0% at the end of 10 years, respectively. The rates were significantly different among the three groups ($p < 0.0001$; log-rank test) (Figure 1). In particular, the rates in Group B were significantly higher than those in Group C ($p < 0.0001$; log-rank test) and Group A ($p < 0.0001$; log-rank test), and the rates in Group C were significantly higher than those in Group A ($p=0.0030$; log-rank test).

Cumulative survival rates for overall death and liver-related death in Groups A, B, and C

During the follow-up period, 2 patients (1.3%), 13 patients (10.0%), and 8 patients (4.7%) died in Groups A, B, and C, respectively. In Groups A, B, and C, the cumulative survival rates for overall death were 100, 95.0, and 100% at the end of 5 years; and 98.0, 78.0, and 96.0% at the end of 10 years, respectively. The rates were significantly different among the three groups ($p < 0.0001$; log-rank test). Especially, the rate in Group B was significantly lower than those in Group C ($p=0.0003$; log-rank test) and Group A ($p < 0.0001$; log-rank test). However, the rate in Group C was not significantly lower than that in Group A (no significance; log-rank test).

During the follow-up period, 0 patients (0%), 10 patients (7.7%), and 6 patients (3.5%) died of liver-

Table I. Patient characteristics at the start of first course of interferon monotherapy.

	Group A (n=152)	Group B (n=130)	Group C (n=172)
Sex (male/female)	113/39	81/49	128/44
Age (year) ^a	47 (15–64) ^a	52 (23–70)	47 (22–67) ^c
Viremia level (Meq/ml) ^a	1.4 (<0.5–45.0)	5.3 (<0.5–67.0) ^d	4.8 (<0.5–57.0) ^e
HCV genotype (1b/non 1b*ND)	65/75/12	112/15/3 ^f	136/35/1 ^g
Fibrosis stage (F1/F2/F3)	103/45/4	62/60/8 ^h	95/55/22 ⁱ
ASAT (IU/l) ^a	81 (16–374)	74 (22–398)	75 (24–400)
ALAT (IU/l) ^a	151 (24–546)	120 (32–636)	140 (26–594)
Platelet count ($\times 10^4/\mu\text{l}$) ^a	18.7 (9.7–31.0)	17.1 (9.7–39.2)	16.5 (7.4–34.5)

^a(Median). ^b $p=0.001$, ^c $p=0.013$, compared with Group B by Bonferroni test. ^d $p < 0.0001$, ^e $p < 0.0001$.

^f $p < 0.0001$, ^g $p < 0.0001$, ^h $p=0.005$, ⁱ $p=0.004$, compared with Group A by Bonferroni test.

*Non 1b of Group A (2a/2b/3b; 58/15/2), non 1b of Group B (2a/2b; 8/7), non 1b of Group C (2a/2b; 24/11).

Abbreviations: HCV = hepatitis C virus; ASAT = aspartate aminotransferase; ALAT = alanine aminotransferase.

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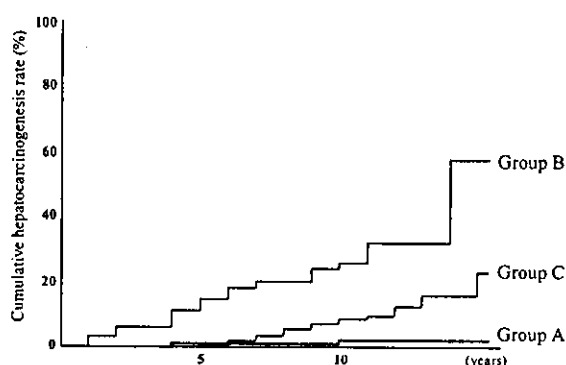


Figure 1. Cumulative hepatocarcinogenesis rates in the three study groups. The cumulative hepatocarcinogenesis rates were significantly different among the three groups ($p < 0.0001$; log-rank test). In particular, the rate in Group B was significantly higher than that in Group C ($p < 0.0001$; log-rank test) and that in Group A ($p < 0.0001$; log-rank test), and the rate in Group C was significantly higher than that in Group A ($p = 0.0030$; log-rank test). See text for the definition of the three groups.

180 related causes in Groups A, B, and C, respectively.
 181 All liver-related deaths were caused by liver cancer,
 182 and none died of hepatic failure without liver cancer.
 183 In Groups A, B, and C, the cumulative survival rates
 184 for liver-related deaths were 100, 96.6, and 100% at
 185 the end of 5 years; and 100, 83.7, and 97.8% at the
 186 end of 10 years, respectively (Figure 2). The rates
 187 were also significantly different among the three
 188 groups ($p < 0.0001$; log-rank test). In particular,
 189 the rate in Group B was significantly lower than that
 190 in Group C ($p = 0.0011$; log-rank test) and that in
 191 Group A ($p < 0.0001$; log-rank test), and the rate in
 192 Group C was significantly lower than that in Group
 193 A ($p = 0.0420$; log-rank test).

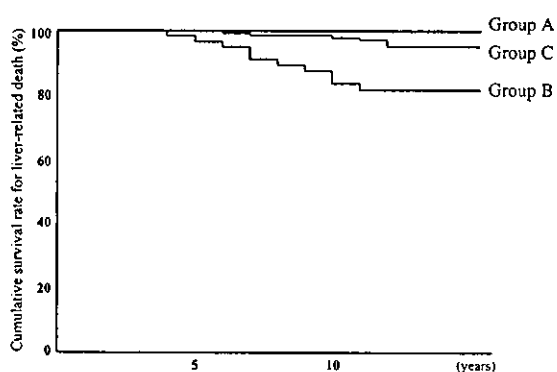


Figure 2. Cumulative survival rates for liver-related deaths. The cumulative survival rates for liver-related deaths were significantly different among the three groups ($p < 0.0001$; log-rank test). In particular, the rate in Group B was significantly lower than that in Group C ($p = 0.0011$; log-rank test) and that in Group A ($p < 0.0001$; log-rank test), and the rate in Group C was significantly lower than that in Group A ($p = 0.0420$; log-rank test).

Predictive factors associated with hepatocarcinogenesis by multivariate analysis

We then analyzed the data for the whole population sample to determine those factors that could predict hepatocarcinogenesis. Univariate analysis identified five parameters that tended to correlate, or significantly correlated with carcinogenesis. These included age ($p < 0.0001$), fibrosis stage ($p < 0.0001$), platelet count ($p < 0.0001$), total IFN dose ($p = 0.0691$), and Group ($p < 0.0001$). These factors were entered into a multivariate analysis, which then identified three parameters that independently influenced carcinogenesis; Group ($p = 0.008$), fibrosis stage ($p = 0.001$), and age ($p = 0.023$) (Table II).

Predictive factors associated with hepatocarcinogenesis in Group C by multivariate analysis

We also analyzed the data of 172 Group C patients to determine those factors that could predict hepatocarcinogenesis. Nine potential predictive factors associated with hepatocarcinogenesis were evaluated, excluding group of treatment. Three parameters were identified by univariate analysis that significantly correlated with hepatocarcinogenesis. These included age ($p = 0.0087$), fibrosis stage ($p < 0.0001$), and platelet count ($p = 0.0044$). All three factors were entered into a multivariate analysis, which in turn identified two parameters that independently influenced hepatocarcinogenesis, including fibrosis stage ($p < 0.0001$), and age ($p = 0.015$) (Table III).

Hepatocarcinogenesis rates according to fluctuation of ALAT levels at IFN-free period in Group C

In Group C, the hepatocarcinogenesis rates were also evaluated according to the mean ALAT levels at the IFN-free period. For this purpose, we selected 110 consecutive patients (64.0%) of Group C in whom ALAT levels were closely monitored. Thirty out of 110 patients (27.3%) achieved SR after multi-courses of IFN monotherapy (SR group), and the

Table II. Factors associated with hepatocarcinogenesis in 454 patients, identified by multivariate analysis.

Factors	[Category]	Odds ratio (95% CI)	<i>p</i> -value
Fibrosis stage	1: F1, F2	1	
	2: F3	5.86 (2.18–15.7)	0.001
Group	1: A, C	1	
	2: B	3.17 (1.39–7.23)	0.008
Age (year)	1: <50	1	
	2: ≥ 50	2.63 (1.10–6.28)	0.023

Cox proportional hazards model.

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Table III. Factors associated with hepatocarcinogenesis in 172 patients of Group C, identified by multivariate analysis.

Factors	[Category]	Odds ratio (95% CI)	<i>p</i> -value
Fibrosis stage	1: F1, F2	1	<0.0001
	2: F3	10.9 (3.65–32.7)	
Age (years)	1: <50	1	0.015
	2: ≥50	3.87 (1.26–11.9)	

Cox proportional hazards model.

194 remaining 80 patients (72.7%) could not attain an
195 SR (NSR group).

196 Overall, the hepatocarcinogenesis rate in patients
197 with ALAT levels below $1.5 \times$ the upper limit of
198 normal (<75 IU/l, normal for ALAT, 6–50 IU/l)
199 was 0% (0 of 36 patients). The rates in those with
200 ALAT from $1.5 \times$ to $2 \times$ (75–100 IU/l), from $2 \times$
201 to $4 \times$ (100–200 IU/l), and above $4 \times$ (>200 IU/l)
202 of the upper limit of normal were 23.8% (5 of 21
203 patients), 13.0% (6 of 46), and 28.6% (2 of 7),
204 respectively (Table IV). In the NSR group, the
205 hepatocarcinogenesis rate in patients with ALAT
206 levels below $1.5 \times$, from $1.5 \times$ to $2 \times$, from $2 \times$ to
207 $4 \times$, and above $4 \times$ were 0% (0 of 17 patients),
208 27.8% (5 of 18), 15.4% (6 of 39), and 33.3% (2 of
209 6), respectively. In the SR group, none of the
210 patients developed HCC.

211 In conclusion, overall, the hepatocarcinogenesis
212 rates in those patients with ALAT levels above $1.5 \times$
213 (17.6%) the upper limit of normal were significantly
214 higher than in those below $1.5 \times$ (0%) of the upper
215 limit of normal ($p=0.005$). In the NSR group, the
216 hepatocarcinogenesis rates in those patients with
217 ALAT levels above $1.5 \times$ (20.6%) tended to be
218 higher than in those with below $1.5 \times$ (0%) ($p=$
219 0.059).

Discussion

218 HCC is currently considered a very common malign-
219 nancy and its incidence is increasing, in both Japan
220 and the USA. Persistent HCV infection is a major
221 risk factor for the development of HCC. About 80%
222 of Japanese HCC patients are also diagnosed with
223 HCV-associated cirrhosis or chronic hepatitis C
224 [33]. Thus, HCV-related chronic liver disease is

one of the major disorders affecting the national
health of Japan, and prevention of HCC and
improvement of survival remain the important issues
in treatment for HCV-related chronic liver disease.

Several studies based on the single-course IFN
monotherapy showed that IFN therapy reduced the
risk of development of HCC and liver-related death
in comparison with untreated patients and especially
in responders to the treatment [1,8–12]. Further-
more, a recent report demonstrated that re-treat-
ment with IFN at certain intervals also reduced the
incidence of HCC in patients with chronic hepatitis
C, even if eradication of HCV was not achieved by
re-treatment [34]. Apart from defining the suppres-
sive action of the multi-course IFN treatment on
HCC, the same study, however, indicated that the
long-term benefits of such treatment were still
inadequately defined, probably because the survival
rate and the incidence of hepatocarcinogenesis based
on fluctuation of ALAT at the IFN-free period were
not analyzed. Hence, in our study, we evaluated 454
consecutive naive cases with chronic hepatitis C, in
whom more than 10 years had elapsed since the
induction of IFN monotherapy at our hospital (i.e. a
longer follow-up period than that in the previous
report [34]), to examine the influence of multi-
course IFN on hepatocarcinogenesis and survival.

Our group previously reported that the cumulative
hepatocellular carcinogenesis rates in HCV patients
of untreated and SR groups for IFN monotherapy
were 4.8 and 1.4% at the end of 5 years, and 12.4%
and 1.4% at the end of 10 years, respectively [10].
In this study, the hepatocarcinogenesis rates were
low in the SR group who received a single-course
IFN (Group A), which were 1.1 and 2.2% at the
end of 5 and 10 years, respectively. However, the
hepatocarcinogenesis rates in patients of Group B
who received a single-course IFN but did not
show SR (15.0 and 26.0% at the end of 5 and 10
years, respectively) were higher than those of
untreated patients described in our previous study
[10]. This discrepancy between our results and
the previous report may be due to differences in
patients' backgrounds, as patients of the present
study had higher ALAT levels and more progressive
stages of fibrosis, which are known risk factors for

Table IV. Hepatocarcinogenesis rates according to the fluctuation of ALAT levels at the IFN-free period in Group C.

	ALAT levels (IU/l) ^a			
	<75	75–100	100–200	>200
Hepatocarcinogenesis rate (%)	0%	23.8%	13.0%	28.6%
(Number)	(0/36)	(5/21)	(6/46)	(2/7)

^aNormal level of ALAT, 6–50 IU/l.

Abbreviations: ALAT = alanine aminotransferase; IFN = interferon.

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225 HCC [11,33,35,36], than those of the previous
226 study.

227 With regard to multi-course IFN, Hino et al. [34]
228 recently reported that re-treatment reduced the
229 incidence of HCC, although the follow-up duration
230 of their population sample was less than 10 years.
231 Our study, based on a longer follow-up period of 10
232 years or more, also indicated that hepatocarcinogen-
233 esis rate in the multi-course IFN (Group C) was
234 lower than that in the non-SR group after a single
235 course of IFN (Group B). Considered together, we
236 conclude that the hepatocarcinogenesis rates in
237 Groups A and C were significantly lower than those
238 in Group B, indicating that HCV-RNA eradication
239 at an early stage, or multi-course IFN irrespective of
240 SR are important for the suppression of hepatocar-
241 cinogenesis. To our knowledge, our study is the first
242 to report the hepatocarcinogenesis rates for a follow-
243 up period of 10 years or more in multi-course IFN.

244 In a previous study from our laboratory, we
245 reported that the cancer-suppressive activity of
246 single-course IFN monotherapy in patients with
247 HCV-RNA eradication was similar to that in patients
248 with ALAT normalization without HCV-RNA elimi-
249 nation [10]. Other studies also indicated a higher
250 incidence and more rapid development of HCC in
251 HCV patients with high ALAT levels [35,36].
252 Collectively, these results suggest that the carcino-
253 genic process in patients with chronic hepatitis C is
254 enhanced by high levels and fluctuations of ALAT,
255 and indicate a close relationship between suppres-
256 sion of inflammatory necrosis of hepatocytes and
257 lower incidence of HCC in patients with HCV-
258 associated chronic liver disease.

259 Our results of multi-course IFN therapy are the
260 first to show a 0% hepatocarcinogenesis rate in
261 patients with ALAT levels below 75 IU/l at the
262 IFN-free periods, emphasizing the importance of
263 keeping low ALAT levels at such periods with
264 respect to suppression of hepatocarcinogenesis.
265 Thus, patients who fail to achieve SR after single-
266 course IFN should receive multi-course IFN at
267 the time of ALAT relapse, at certain intervals.
268 Based on our results and those of Okanoue et al.
269 [37], who demonstrated an increased incidence of
270 HCC in 5 years or more after IFN therapy in
271 transient biochemical responders, it is important to
272 normalize ALAT levels by multi-course IFN at
273 certain intervals.

274 Previous studies have shown that gender, age,
275 fibrosis stage, and IFN regimen are important
276 pretreatment predictors of hepatocarcinogenesis
277 [10,11,34]. In the present study, higher age and a
278 more progressive fibrosis stage were associated with
279 higher hepatocarcinogenesis rates in the whole
280 population sample and in Group C. Furthermore,

our analysis of IFN treatment-related factors showed
that Group B (non-SR after single-course IFN) was
also a risk factor for hepatocarcinogenesis. This
result is almost similar to that of a previous study,
which identified the number of courses of IFN as a
risk factor for HCC [34].

Previous studies indicated that the liver-related
overall mortality rates of HCV patients were 57–
94%, emphasizing the need for improvement in
survival of patients with chronic hepatitis C with or
without cirrhosis [1,10,12,18–21,38]. Our results
also indicated that the proportion of liver-related
overall deaths was 69.6% (16 of 23 patients). Our
study is the first to report the survival rates for
overall death and liver-related death in multi-course
IFN therapy (Group C). The results indicated that
overall and liver-related deaths in Groups A and C
were significantly lower than those in Group B,
suggesting that HCV-RNA eradication at an early
stage or multi-course IFN irrespective of SR is also
important for reducing liver-related deaths, like the
suppression of hepatocarcinogenesis.

The aims of IFN therapy for chronic hepatitis C
include the reduction of the risk of development of
HCC and liver-related death by viral clearance, and
when viral clearance could not be achieved, then by
ALAT normalization without viral clearance. The
reported post-IFN monotherapy viral clearance rate
for genotype 1b (the most major type in Japan) is as
low as 10 to 20% [24,26,27]. The antiviral efficacy
of IFN has improved recently following combination
with ribavirin [39–41] and the use of pegylated IFN
[42–45], but these modifications also could not
achieve a sufficient SR (SR is still <50% in patients
with genotype 1 with higher pretreatment viral
loads). Furthermore, the combination therapy is
sometimes associated with serious adverse effects
such as hemolytic anemia [46]. Hence, the develop-
ment of more effective and safe IFN regimens is
needed.

In conclusion, our retrospective study indicates
that multi-course IFN monotherapy reduces the risk
of hepatocarcinogenesis and increases survival.
Large-scale prospective studies should be conducted
in the future to confirm this finding.

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