Hepatocellular Carcinoma With Cirrhosis: Are Patients With Neoplastic Main Portal Vein Invasion Eligible for Percutaneous Radiofrequency Ablation of Both the Nodule and the Portal Venous Tumor Thrombus?

Antonio Giorgio[1]
Antonella Di Sarno
Giorgio de Stefano
Nunzia Farella
Umberto Scognamiglio
Manuela de Stefano
Valentina Giorgio

OBJECTIVE. The purpose of this study was to examine the results of percutaneous radiofrequency ablation of both medium-sized hepatocellular carcinoma (HCC) and the accompanying main portal venous tumor thrombus in patients with cirrhosis.

SUBJECTS AND METHODS. From January 2005 to January 2008, among 1,837 consecutively registered patients with HCC seen at our institution, 412 had HCC and portal venous invasion; 27 of the 412 had a single HCC nodule accompanied by main portal venous tumor thrombus. Thirteen patients (10 men, three women; mean age, 70 years; range, 66–74 years) with 13 HCC nodules 3.7–5 cm in diameter extending into the main portal trunk underwent percutaneous radiofrequency ablation. Fourteen matched patients (10 men, four women; mean age, 69 years; range, 67–73 years) with 14 HCC nodules 3.6–4.8 cm in diameter extending into the main portal trunk refused radiofrequency ablation and composed the control group. Diagnosis of main portal venous tumor thrombus was made with fine-needle biopsy in all cases. Radiofrequency ablation was performed first on the main portal venous tumor thrombus and then on the HCC nodule. Efficacy of radiofrequency was defined as complete necrosis of HCC and complete recanalization of the main portal trunk and its branches. HCC necrosis was evaluated with enhanced CT. Recanalization of portal vessels was analyzed with color Doppler and contrast-enhanced ultrasound. Radiofrequency ablation was performed under ultrasound guidance with a perfused needle electrode.

RESULTS. Complete necrosis of the HCC associated with complete recanalization of the main portal vein and its branches was achieved in 10 patients (efficacy, 77%). In the other three patients, necrosis of the HCC ranged from 70% to 90%, and recanalization of the main portal trunk was not complete. No major complications occurred. In three cases, mild to moderate ascites and increased aspartate aminotransferase and alanine aminotransferase levels were found. The follow-up periods ranged from 3 to 36 months among the treated patients and 2 to 10 months among the untreated patients. The cumulative survival rate was 77% 6, 12, and 36 months after procedure in the treated group and 43% and 0% 6 and 12 months after diagnosis in the untreated group ($p < 0.0001$). All 10 successfully treated patients were alive and the portal system was patent at the end of the follow-up period. All three untreated patients died of progressive disease within 5 months of diagnosis.

CONCLUSION. Radiofrequency ablation can destroy both single intraparenchymal medium-sized HCCs and the accompanying main portal venous tumor thrombus with high efficacy and safety and a low rate of complications.

Keywords: cirrhosis, hepatocellular carcinoma, portal vein, portal venous tumor thrombus

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[1]All authors: Infectious Disease and Interventional Ultrasound Unit, D. Cotugno Hospital, Via Quagliariello 54, 80131 Naples, Italy. Address correspondence to A. Giorgio (assanui1@virgilio.it).

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Hepatocellular carcinoma (HCC), one of the most common malignant tumors worldwide, originates mainly in cirrhotic livers [1, 2]. The incidence is approximately 3–4% per year [3] and varies with geographic region, the incidence being lower in some areas [4, 5]. Screening programs facilitate diagnosis of the disease at an early stage, when the patient is eligible for curative treatment [3]. Nevertheless, neoplastic portal venous invasion is found in 12.5–70% of patients with HCC [6–10].

The presence of an HCC nodule accompanied by portal venous tumor thrombus is a crucial finding. The prognosis among these patients is generally poor if they are not treated. A median survival time of 2.7–4.0 months has been reported [11, 12]. Transarterial chemoembolization, combined therapy with 5-fluorouracil (5-FU) and interferon, and hepatectomy with or without removal of

the tumor thrombus have been used, but no standard treatment exists [3]. To the best of our knowledge, HCC extending into the portal vein is not an indication for percutaneous radiofrequency ablation [13, 14]. In a study by Seror et al. [15] that involved patients with large infiltrative HCC and segmental portal venous involvement managed with multipolar radiofrequency ablation, patients with invasion of the main branches of the portal vein and the main portal trunk were clearly excluded [15].

On the basis of our experience with one-shot percutaneous ethanol injection in the management of large HCC extending into the right or left branch of the portal vein [16] and on the basis of data reported by Livraghi et al. [14], Neeman et al. [17], and Poggi et al. [18], we speculated about use of radiofrequency ablation of both HCC and the neoplastic tissue extending into the portal vein as an alternative to the aforementioned options. The aim of this prospective pilot study was to assess the feasibility, safety, and survival rate of the use of percutaneous radiofrequency ablation in the management of both HCC and the accompanying portal venous tumor thrombus.

Subjects and Methods

Patients

From January 2005 to January 2008, 1,837 patients with HCC and cirrhosis were consecutively seen as inpatients or outpatients in our interventional ultrasound unit. Most of them had been referred to our unit for percutaneous ultrasound-guided ablation of a single HCC or multiple HCCs. Among the 1,837 patients, 412 (22.4%) had portal venous invasion: 237 had a single large (> 5 cm in diameter) infiltrating HCC with portal segmental involvement extending or not extending into the main branches of the portal vein and main portal trunk; 148 patients had more than two nodules, at least one nodule being larger than 3 cm in diameter with segmental portal venous invasion with or without invasion of the main branches and main portal trunk; and 27 patients had a single HCC nodule up to 5 cm in diameter accompanied by neoplastic invasion of the left or right branch of the portal vein and main portal trunk. The 27 patients had compensated liver disease (Child-Pugh class B7 or lower) and were enrolled in the study. Patients with a single HCC larger than 5 cm and those with more than two nodules, ascites, or low hepatic functional reserve were excluded. Lack of data and information on the feasibility, effectiveness, and complications of the radiofrequency ablation procedure forced us to use strict inclusion criteria for this pilot study.

TABLE 1: Baseline Characteristics

Characteristic	Treated	Untreated
No. of patients	13	14
Age (y)		
Mean ± SD	70 ± 3	69 ± 2
Range	66–74	67–73
Sex		
Men	9 (69.2)	10 (71.4)
Women	4 (30.8)	4 (28.6)
Child-Pugh class		
A5	4	2
A6	8	10
B7	1	2
Hepatis B virus infection	3	2
Hepatis C virus infection	10	12
No. of hepatocellular carcinoma nodules	13	14
Tumor diameter (cm)		
Mean ± SD	4.3 ± 0.4	4.1 ± 0.4
Range	3.7–5.0	3.6–4.8
Baseline clinical variables		
Albumin (g/dL)	3.80 ± 0.25	3.70 ± 0.32
Bilirubin (mg/dL)	0.92 ± 0.29	0.98 ± 0.37
International normalized ratio	1.09 ± 0.10	1.09 ± 0.14
Platelets (×1,000/mm^3)	124.08 ± 11.42	117.50 ± 11.29
α-Fetoprotein (ng/mL)	108.77 ± 111.71	93.78 ± 75.64
Ascites (%)	0	0

Note—Values are number of patients or mean ± SD. Values in parentheses are percentages. Differences between the two groups were not significant.

Cirrhosis was related to chronic hepatitis C virus infection in 22 cases and to chronic hepatitis B virus infection in five cases. HCC extending into the main portal trunk was the initial diagnosis for all 27 patients, and none of the patients had been treated with medical, surgical, or locoregional therapy. All patients were asked to undergo radiofrequency ablation of the HCC nodule and main portal venous tumor thrombus as an alternative to transarterial chemoembolization or chemotherapy or to hepatectomy plus transarterial chemoembolization [3].

All patients were thoroughly and properly informed of the success rate and limitations of the technique and other treatments. This prospective pilot study was approved by our institutional ethics committee, and all patients gave informed written consent. Thirteen patients agreed to undergo radiofrequency ablation, and 14 refused any kind of treatment. In our geographic area, refusing any kind of treatment is not surprising owing to traditions deeply rooted in the local sociocultural environment. The 14 patients constituted the control group. The treated patients and controls were matched for sex, age, size of nodules, location of nodules, and invasion of the portal vein. Table 1 shows the baseline characteristics of the two groups of patients.

No patient had ascites or other signs of portal hypertension at the time of diagnosis before radiofrequency ablation. Imaging findings of HCC accompanied by portal venous invasion were made at sonography as the first imaging examination. Most of the patients were unaware of the underlying chronic liver disease. None of the nodules had a superficial location.

The right branch of the portal vein was partially involved in nine patients in the treated group and 10 patients in the untreated group, and the left branch in four patients in the treated group and four patients in the untreated group. The main portal trunk was involved in all cases. The length of the main portal venous tumor thrombus ranged from 1.7 to 3.5 cm from the bifurcation in the treated group and from 1.9 to 3.3 cm in the untreated group. Thrombosis was complete in all

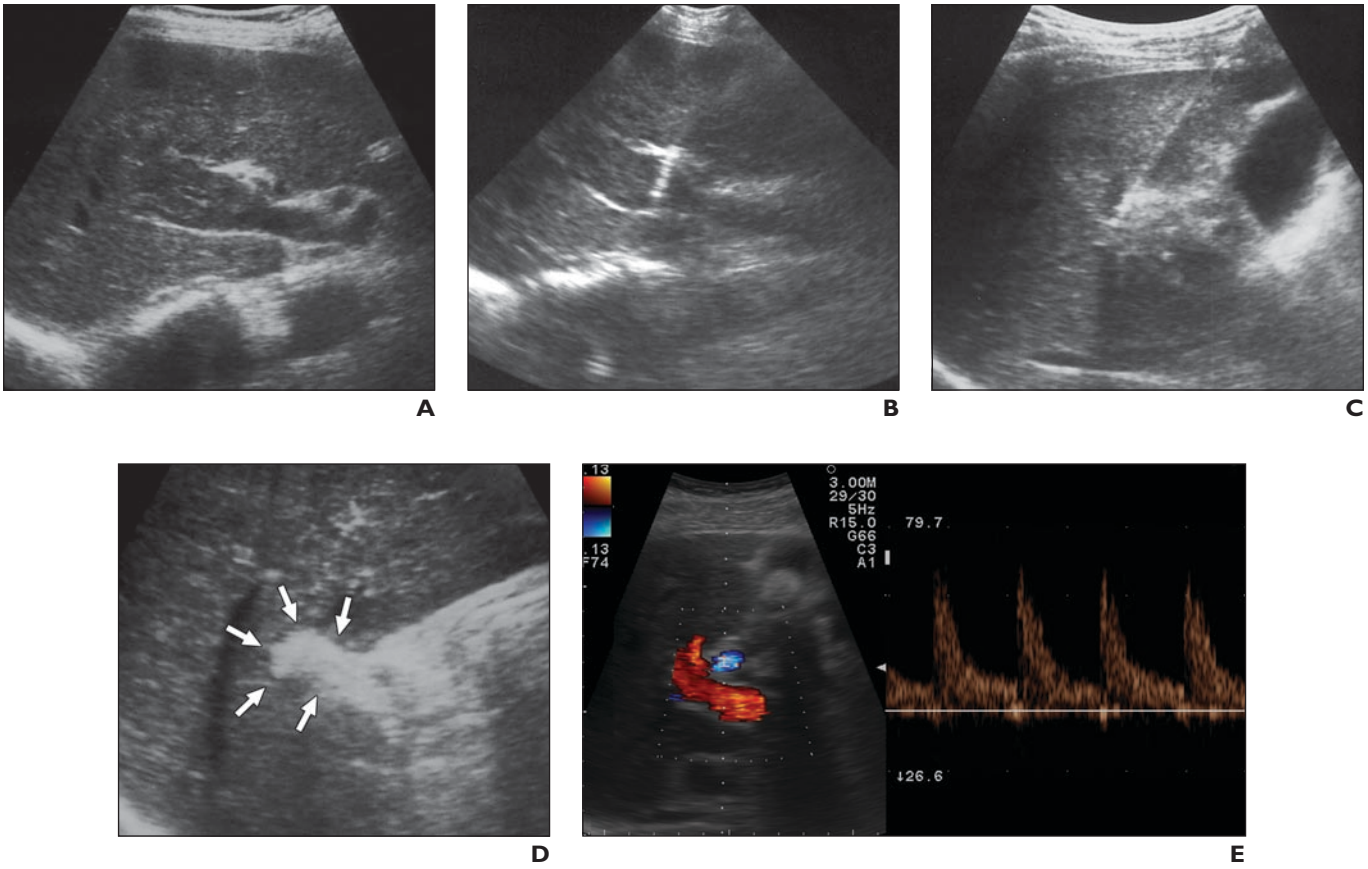

Fig. 1—70-year-old man with hepatocellular carcinoma and cirrhosis.
A, Ultrasound image shows large tumor thrombus in main portal vein.
B, Ultrasound image shows electrode needle inserted axially in distal part of tumor thrombus in main portal trunk. Transducer is in right seventh intercostal space for scanning of entire right lobe of liver. Image shows needle in right to left orientation, but needle is inserted through right intercostal space and patient is lying on left side.
C, Ultrasound image shows electrode needle inserted in proximal part of tumor thrombus of main portal trunk. Radiofrequency generator is on function (tissue around needle tip appears hyperechoic).
D, Ultrasound image shows that after two needle insertions in main portal venous tumor thrombus, main portal trunk (*arrows*) appears completely hyperechoic. Radiofrequency ablation of tumor thrombus of main portal trunk is considered sufficient.
E, Color Doppler examination 1 week later shows patency of main portal vein with hepatopetal flow, and spectral analysis shows normal flow in hepatic artery.

cases in the two groups ($p = 0.66$). The diameter of the main portal venous tumor thrombus ranged from 1.7 to 2.2 cm in the treated group and from 1.7 to 2.0 cm in the untreated group ($p = 0.65$).

Methods

The diagnosis of HCC nodule was based on α-fetoprotein level and findings at ultrasound examination, contrast-enhanced ultrasound (CEUS) examination, CT, or MRI. In particular, characterization of HCC nodules was based on the presence of enhancement during the arterial phase and washout during the portal venous or late phase at CEUS, contrast-enhanced CT, or contrast-enhanced MRI [19–24]. In all cases (both patients and controls), the diagnosis of main portal venous tumor thrombus was achieved with fine-needle biopsy (21-gauge needle, Ecojet, HS) under ultrasound guidance. Percutaneous radiofrequency ablation was performed with general anesthesia and a 1.7- or 2.0-mm perfused needle electrode (HiTT, Integra) as reported elsewhere [25]. The procedure was performed as follows.

Patients with HCC nodules in the right hepatic lobe lay on their left side. The needle electrode was inserted into the nodule and in the right branch of the portal vein percutaneously by the intercostal route. Patients with HCC nodules in the left hepatic lobe and tumor thrombus in the left branch of the portal vein lay in the supine position. In all cases radiofrequency ablation of tumor thrombus in the main portal trunk was performed by the intercostal route with the patient lying on the left side.

Radiofrequency ablation was performed under ultrasound guidance first on the tumor thrombus in the main portal trunk (Fig. 1A), then on the thrombus in the right or left portal branch, and finally on the intraparenchymal HCC nodule. The electrode needle was inserted percutaneously axial to the main portal trunk to pass through the whole main portal venous tumor thrombus, and the needle tip was advanced up to the posterior wall of the main portal trunk (Fig. 1B). The caliber of the perfused needle electrode was tailored to the diameter of the tumor thrombus in the main portal trunk. If the tumor thrombus exceeded 2 cm in diameter, a 2-mm-caliber electrode needle was used. A 1.7-mm-caliber perfused needle electrode was used when the diameter of the tumor thrombus in the main portal trunk was less than 2 cm. A 2-cm active needle tip was used when the diameter of the main portal venous tumor thrombus was greater than 2 cm. A 1-cm active needle tip was used when the diameter of the main portal venous tumor thrombus was less than 2 cm.

For radiofrequency ablation of intraparenchymal HCC nodules, a 2-mm-caliber perfused needle electrode with a 3-cm active needle tip was used in all instances. Care was taken to avoid the hepatic artery and common bile duct during percutaneous insertion of the needle electrode in the main portal trunk. Color Doppler ultrasound was used to aid in identification of the hepatic artery. When the length

of neoplastic thrombus in the main portal trunk exceeded 2 cm (seven patients), two needle electrode insertions in the tumor thrombus were performed without withdrawal of the needle from the liver. The first insertion was in the distal part of the main portal trunk (Fig. 1B) and the second in the proximal portion (Fig. 1C). Under sonographic guidance, the electrode needle was inserted percutaneously into the main portal venous tumor thrombus, the current generator was activated, and the energy was applied. In cases of a second insertion in the tumor thrombus without withdrawal of the electrode needle from the liver, the generator was maintained on function until the second application of energy was delivered.

The elapsed time for every application after insertion of the needle electrode ranged from 10 to 15 minutes. When the main portal trunk appeared completely hyperechoic (Fig. 1D), the radiofrequency application was considered sufficient, and the electrode needle was withdrawn from the main portal venous tumor thrombus after it was verified that the radiofrequency generator was still on function. The time for the entire procedure (main portal trunk, right or left branch of the portal vein, and the HCC nodule) was up to 45 minutes.

The procedure was defined as complete when complete recanalization of the main portal trunk and right or left branch of the portal vein and complete necrosis of the HCC nodules were achieved. Recanalization of the main portal trunk and portal branches was evaluated with color Doppler and CEUS examinations. Necrosis of HCC nodules was evaluated with CEUS and contrast-enhanced CT.

All radiofrequency ablations were performed by the same physician, who had 30 years of experience in interventional ultrasound. In each procedure another operator (one of two physicians with 20 and 15 years of experience in interventional ultrasound) provided support. Psychologic assistance was provided to all patients in the study.

Follow-Up

Two or more radiofrequency ablation sessions were scheduled if the main portal venous tumor thrombus was longer than 2 cm. In that case, at least two sessions were considered necessary for ablation of the entire main portal venous tumor thrombus, thrombus of the right or left portal venous branch, and intraparenchymal HCC nodule, even when the main portal trunk appeared patent in the second session. A 2-week interval between radiofrequency sessions was because we judged 2 weeks the appropriate period if decompensation of cirrhosis were to develop after the procedure.

The day after radiofrequency ablation, all treated patients underwent clinical, laboratory, abdominal ultrasound, color Doppler, and CEUS examinations. Abdominal ultrasound and color Doppler examinations were performed every week for the first 4 weeks. Abdominal ultrasound, color Doppler examination, contrast-enhanced CT, and CEUS were performed 1 month later to assess the patency of the main portal trunk and its branches and necrosis of the HCC nodule. Clinical and laboratory tests, including α-fetoprotein, abdominal ultrasound, and color Doppler examination were scheduled to be performed every 2 months. Contrast-enhanced CT and CEUS were scheduled to be performed every 6 months after the procedure. Patients in the untreated group underwent monthly clinical, laboratory (including α-fetoprotein), ultrasound, and color Doppler examinations.

Statistical Analysis

Student's *t* test for quantitative data and a chi-square test for qualitative data were used to compare baseline characteristics of patients in the two groups, and results were expressed as *p*. Survival probability was calculated with the Kaplan-Meier method, and the difference was determined with a log-rank test. For overall survival, the time from the date of radiofrequency ablation (treated group) or date of diagnosis (untreated group) to the last follow-up examination or death was used. Results were presented as hazard ratios with corresponding 95% CI and *p*. Data processing and analysis were performed with SAS software (version 8.2, SAS Institute).

Results

The mean number of radiofrequency ablation sessions per patient was 1.8 (range, 1–3). The number of needle insertions ranged from two to four per session, and one or two applications were performed for every insertion. Two applications were performed when the length of the main portal trunk tumor thrombus was more than 2 cm. The waiting time between consecutive radiofrequency sessions was 2 weeks. Complete necrosis of HCC nodules and complete recanalization of the right and left branches of the portal vein associated with recanalization of the main portal trunk were observed in 10 of 13 treated patients (success rate, 77%). Complete recanalization of the main portal trunk at color Doppler examination was observed the day after the procedure in two patients, after 1 week in four patients, and after 1 month in the other four.

Complete necrosis of HCC nodules was achieved in six of 10 patients with a single radiofrequency session, in three of 10 patients with two radiofrequency sessions, and in one of 10 patients with three radiofrequency sessions. In all 10 successfully treated patients, recanalization of the main portal trunk (Fig. 1E) and its branches was always accompanied by complete necrosis of the tumor (Fig. 2).

In the three unsuccessfully treated patients (23%), contrast-enhanced CT showed incomplete necrosis of HCC nodules ranging from 70% to 90% and incomplete recanalization of the main portal trunk (Fig. 3). With pixel-by-pixel evaluation of the density of the lesion, we differentiated necrotic areas from neoplastic tissue. Successive ROIs were traced on every 3-mm-thick contiguous slice to delineate the border of the whole lesion and necrotic areas so that it was possible to perform quantitative evaluation of necrosis and perfused tissue volumes and the ratio between them. In particular, two patients were treated with three radiofrequency sessions and had 90% necrosis of the HCC nodule on CT, but the neoplastic thrombus in the main portal trunk persisted unmodified at conventional ultrasound and color Doppler examinations. The other patient was treated with two radiofrequency sessions and had 70% necrosis of the HCC nodule and persistence of a 1-cm thrombus in the main portal trunk (2 cm length before radiofrequency ablation) at the level of the bifurcation of the main portal trunk.

After the radiofrequency procedures, no major complications were detected. Only three patients had mild ascites and increased aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels. Spironolactone was administered, ascites disappeared within 1 week, and AST and ALT levels returned to pretreatment levels within 2 weeks. All patients were discharged from the hospital the day after the procedure.

The follow-up period ranged from 3 to 36 months for the treated group and 2 to 10 months for the untreated group. The 10 successfully treated patients were alive, and the portal system (main portal trunk and its branches) was patent in all of them at the end of the study. Figure 4 shows the cumulative survival curves of the treated group compared with the untreated group. The 6-, 12-, 24-, and 36-month cumulative survival rates of treated patients all were 77%. The 6- and 12-month cumulative survival rates of untreated patients were 43% and 0%. The difference was statistically significant ($p < 0.0001$; harzard ratio, 2.58; 95% CI, 1.37–4.87). The mean survival time of treated patients was 28.3 ± 3.8 (standard error) months, and the mean survival time of untreated patients was 6.8 ± 0.5 months ($p < 0.001$).

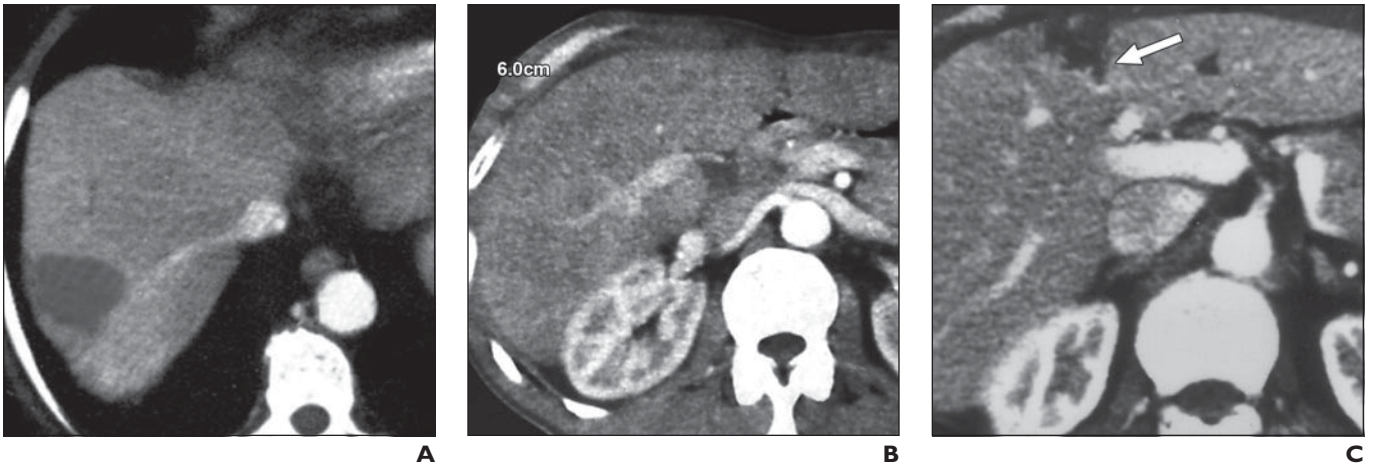

Fig. 2—69-year-old woman with hepatocellular carcinoma and successful treatment.
A, Contrast-enhanced arterial phase CT scan shows complete necrosis of hepatocellular carcinoma nodule in segment VIII of liver.
B and **C,** CT scans 3 years after radiofrequency ablation show that right branch of portal vein (**B**) and main portal trunk (**C**) are patent. Arrow indicates incidental hemangioma.

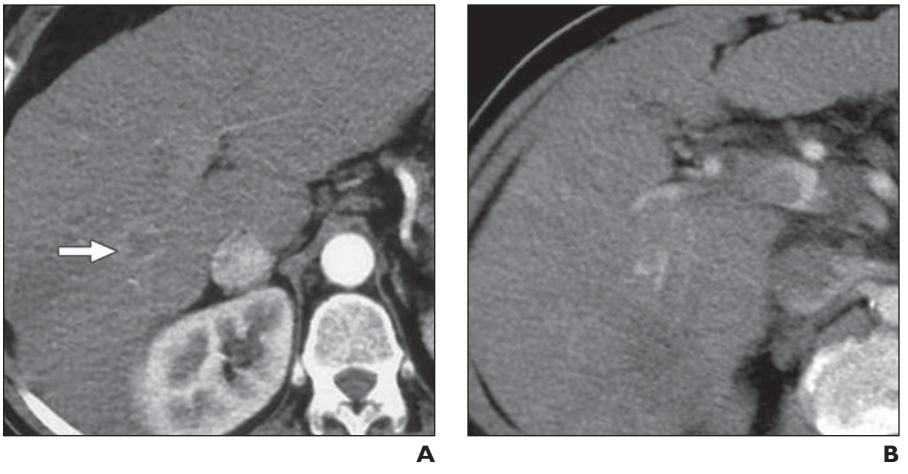

Fig. 3—67-year-old woman with unsuccessfully managed hepatocellular carcinoma.
A, CT scan shows hepatocellular carcinoma nodule (*arrow*) with incomplete necrosis.
B, CT scan shows persistent thrombus in main portal trunk.

During the follow-up period, only one patient in the treated group had a distant hepatic recurrence 7 months after the procedure. The patient underwent another session of radiofrequency ablation, and complete necrosis of the new nodule was observed 1 month later at contrast-enhanced CT and CEUS. In the treated group, all three unsuccessfully treated patients died within 5 months after the procedure. Infiltrative right lobe neoplastic disease developed in two of them, and the third had multiple nodules of HCC. In the untreated group, nine patients died of variceal bleeding and diffuse HCC, and five patients died of diffuse HCC and hepatorenal syndrome.

Discussion

Many therapeutic procedures, such as liver transplantation, liver resection, percutaneous ethanol injection, and radiofrequency ablation, have been used in the management of HCC. Use of these techniques improves survival, but the prognosis is very poor in cases of HCC with neoplastic involvement of major branches of the portal vein or main portal trunk, and survival time dramatically decreases, the reported median survival ranging from 2.4 to 4.8 months [3]. Many therapeutic options have been reported to improve survival, including combination therapy with 5-fluorouracil and interferon and transarterial chemoembolization plus liver resection with or without removal of the portal venous tumor thrombus [26–32]. Nevertheless, no standard treatment technique has existed, to our knowledge [3].

Percutaneous ablation techniques such as percutaneous ethanol injection and radiofrequency ablation have gained great popularity in the management of single HCC nodules up to 5 cm in diameter and of three nodules up to 3 cm each and can achieve complete response in selected patients [23, 32]. These techniques, however, are usually not indicated in the management of intermediate and advanced HCC [13, 14]. Seror and coworkers [15], in a study of multipolar radiofrequency ablation of large (> 5 cm) HCCs, including those with infiltrating and segmental portal venous involvement, excluded patients with main branch or main portal trunk involvement.

In 1990 Livraghi et al. [33] reported the first four cases, to our knowledge, of percutaneous ethanol injection of HCC and portal venous involvement. We [16] reported the results of one-shot percutaneous ethanol injection in the management of large HCC accompanied by invasion of the right or left branch of the portal vein in 23 patients with cirrhosis [16]. To our knowledge, no findings have been published on the use of radiofrequency ablation of main portal venous tumor thrombus. Therefore, on the basis of our experience with percutaneous ethanol injection and surgical removal of portal venous tumor thrombus [26–29], we speculated it should be possible to use heat to destroy the tumor thrombus in the main portal trunk and over the intraparenchymal nodule.

Our 3-year experience seems to show that the percutaneous approach to radiofrequency ablation is feasible. Ten of 13 treated patients had complete recanalization of the main portal trunk and right or left branch of the portal vein and complete necrosis of the HCC nodule. Moreover, both the cumulative 1- and 3-year survival rates were 77%, and the

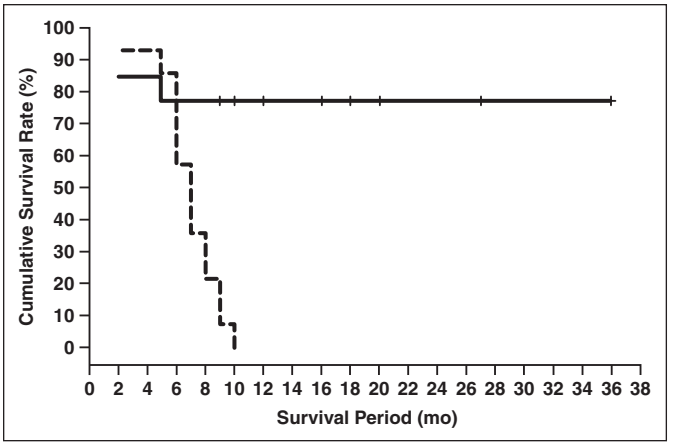

Fig. 4—Graph shows cumulative survival curves of treated patients (*solid line*) compared with untreated patients (*dashed line*).

mean survival time was 28.3 ± 3.8 months among treated patients.

Seror and coworkers [15] reported 68% and 56% survival rates 1 and 2 years after multipolar radiofrequency ablation of large (> 5 cm) infiltrative HCCs with segmental portal venous involvement without major complications. Livraghi et al. [34] using radiofrequency ablation achieved 90% necrosis of medium-sized HCCs (3–5 cm) and 45% necrosis of large HCCs (5–9 cm) with a 3-year survival rate of 85% among patients with Child-Pugh class A disease. Nevertheless, our data cannot be compared with those from our previous series or with data from other investigators' experiences. This preliminary experience was a pilot study of a procedure performed on only 13 patients with good hepatic reserve.

Chen and colleagues [27] surgically treated 438 patients with HCC and portal venous invasion: 286 patients had portal venous tumor thrombus not extending into the portal trunk and were treated with hepatic resection; 152 patients had portal venous tumor thrombus extended into the main portal trunk and were treated with hepatic resection and thrombectomy. The 6-month recurrence rates were 11.3% in the first group and 76.9% in the second group. The investigators concluded that hepatic resection with thrombectomy has better outcome in the care of HCC patients with portal venous tumor thrombus confined to the first or second branch of the portal vein compared with thrombus extending into the main portal trunk.

Konishi et al. [28] reported on the overall survival of 18 HCC patients treated with direct removal of the portal venous tumor thrombus in the main portal trunk. The 1- and 2-year survival rates were 48% and 38%. The six patients who underwent complete removal had 1- and 2-year survival rates of 75% and 75%. In three of five patients who died within 90 postoperative days, incomplete removal of the portal venous tumor thrombus led to early recurrence and death. In the series described by Takizawa et al. [6], patients with HCC and portal venous tumor thrombus underwent surgical treatment followed by continuous hepatic arterial infusion therapy and had a 3-year survival rate of 53%. Lau et al. [35] reported that 49 patients with initially unresectable HCC underwent nonsurgical treatment, such as systemic chemotherapy or intraarterial implantation of yttrium-90 microspheres followed by salvage surgery. The 5-year survival rate among those 49 patients was 57%. That series included seven patients with HCC involving the main portal vein, and the 5-year survival rate among the seven patients was 56%.

Our results seem similar to those obtained with the surgical approach, even though it is always difficult to compare such different series and even though we did not compare radiofrequency ablation and surgery but only radiofrequency and no treatment. We believe, however, that our results must be considered in the light of use of a less invasive and less expensive technique.

A probable explanation for our results is that heat spreads into the main portal trunk because of a tunnel effect so that the solid neoplastic thrombus crumbles under the flux pressure in the portal vein and therefore is removed. The duration of this pulverizing process probably varies with tumor type and would explain why a thrombus managed with radiofrequency ablation can take 24 hours to a month to disappear, disappear immediately after treatment, not disappear completely, or not disappear at all. Furthermore, if radiofrequency ablation does not produce complete necrosis of the intraparenchymal tumor, it probably would not produce complete effects on the thrombus and vice versa. Among the treated patients in our study, recanalization of the main portal trunk persisted for the same follow-up period as local control of the HCC nodules. Unsuccessfully treated patients have a poor prognosis. In this study, all three unsuccessfully treated patients died of extension of the neoplastic disease within 5 months of treatment. The same poor prognosis was observed among untreated patients.

The overall rate of complications in our series was very low in comparison with the extent of ablation procedures. Only three patients had mild ascites and an increase in serum levels of AST and ALT, which returned to pretreatment levels in a few days. In addition, neither major complications nor effects on the biliary tract were observed. In our previously reported single-center experience [36, 37] and that of Delis et al. [38] and in the multicenter experience of Livraghi et al. [39], the rates of major complications were 0.3–0.9%.

This study had limitations, the main one being that the sample was not random. The second limitation was the small number of treated patients. A third limitation may be that biopsies of intraparenchymal HCC nodules were not performed in this series. Those findings might have been important not for characterization of the HCC itself, which can be easily diagnosed with current dynamic imaging techniques, but because the histologic type of HCC probably would have helped us to predict the efficacy of radiofrequency ablation. We can retrospectively speculate that the success of our treatment probably was related to greater or lesser differentiation of tumor cells. Such a hypothesis should prompt performance of biopsy of the intraparenchymal HCC nodules in future studies to confirm this hypothesis and the results of this study.

Our 3-year experience shows that in patients with cirrhosis with compensated disease, percutaneous radiofrequency ablation can destroy medium-sized intraparenchymal HCCs accompanied by portal venous invasion with high efficacy and a low rate of complications. These preliminary results can be considered encouraging owing to the 3-year cumulative survival rate, and the procedure may be a prudentially palliative therapeutic option for advanced disease. These results need further confirmation by us or others with a larger series of patients and a longer observation time to determine whether they can be maintained more than 5 years.

It also must be clearly determined whether this treatment must be performed only by selected and extremely expert practitioners of interventional ultrasound.

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