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Percutaneous ultrasound-guided radiofrequency ablation with artificial pleural effusion for hepatocellular carcinoma in the hepatic dome

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Background. Nodules of hepatocellular carcinoma (HCC) located in the hepatic dome cannot be depicted on ultrasography because of pulmonary air. Therefore, percutaneous treatment is not possible in such cases. The purpose of this study was to clarify the feasibility and safety of percutaneous sonographically guided radiofrequency (RF) ablation with the concurrent use of artificial pleural effusion for HCC located in the right subphrenic region. ***Methods.*** Between May 2001 and June 2002, 24 patients with 28 HCC nodules located directly below the diaphragm were enrolled in this study. The patient population included 17 men and 7 women (age range, 51–87 years; mean age, 66.5 years). The maximum diameter of the HCC nodules ranged from 1.0 cm to 4 cm (mean ± SD, 2.1 ± 0.8 cm). ***Results.*** We infused 200–1100 ml of 5% glucose solution intrathoracically to separate the lung and liver; thus, obtaining an image of the whole tumor was impossible on gray-scale sonography. Complete tumor necrosis was achieved in a single session of RF ablation in 27 (96.4%) of the 28 lesions, while two sessions of RF ablation were required for the remaining lesion (3.6%). During treatment, no dyspnea or other complications concerned with the respiratory system were observed. Clinical courses have been satisfactory without recurrences at 1–13 months after treatment (mean, 7.9 months). ***Conclusions.*** Percutaneous RF ablation with artificial pleural effusion in patients with HCC in the hepatic dome may be a safe and feasible therapy.

Key words: hepatocellular carcinoma, radiofrequency ablation, artificial pleural effusion, hepatic dome

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Introduction

Radiofrequency (RF) ablation is a less invasive treatment procedure than thoracoscopic transdiaphragmatic ablation and has recently become a common therapy in the percutaneous approach in patients with hepatocellular carcinoma (HCC).[1–3] However, the nodules of HCC located in the hepatic dome cannot be depicted on ultrasonography (US), because of pulmonary air.[4,5] In such cases, percutaneous treatment is not possible; therefore, the surgical approach is the only option for curative therapy. However, it was hypothesized that making an artificial pleural effusion, which would act as an acoustic window, could resolve this limitation. We examined the feasibility and safety of this new technique, percutaneous sonographically guided RF ablation, with the concurrent use of artificial pleural effusion, for HCC located in the right subphrenic region.

Subjects and methods

Between May 2001 and June 2002, 24 patients with 28 HCC nodules were enrolled in this study. Informed consent to the procedure, outlined below, was obtained from all patients. The patient population included 17 men and 7 women (age range, 51–87 years; mean age, 66.5 years). All patients had Child-Pugh class A liver cirrhosis. The maximum diameter of the HCC nodules ranged from 1.0 cm to 4 cm (mean ± SD, 2.1 ± 0.8 cm). Twenty-four HCC nodules were located in Couinaud's segment 8, 2 nodules were located in segment 7, and 2 nodules were located in segment 4. Clinical information of the 24 patients is shown in Table 1. Patients with HCC were considered for percutaneous RF ablation with artificial pleural effusion if the nodules were located directly below the diaphragm and were adjacent to the air-filled lung, and obtaining an image of the whole tumor, especially of its upper part, was impos-

Table 1. Baseline characteristics of patients

Patient characteristics	Value
Age (years; mean ± SD)	66.5 ± 8.2 (range, 51–87)
Sex (M : F)	17 : 7
Number of tumors (uninodular : binodular)	20 : 4
Size of tumor (cm; mean ± SD)	2.1 ± 0.8 (range, 1.0–4.0)
Child-Pugh classification A : B : C	24 : 0 : 0
Background liver disease (HBV : HCV : HBV + HCV: no infection)	2 : 21 : 1 : 0
Serum albumin levels (<3.0 : 3.0–3.5 : >3.5)	0 : 13 : 11
Serum bilirubin levels (<1.0 : 1.0–2.0 : >2.0)	15 : 9 : 0

HBV, hepatitis B virus; HCV, hepatitis C virus

sible on gray-scale ultrasonography (US). Patients with a past history of a chronic pulmonary disease, a chronic heart disease, a bleeding tendency, on a renal disease were excluded.

All patients were sedated consciously, using an intravenous injection of 25 mg hydroxyzine and 15 mg pentazocine just before this treatment. The patients' vital signs were monitored every 5 min during treatment. To infuse 5% glucose solution into the right pleural cavity without injuring the lung, a small skin incision was made on the chest wall under local anesthesia, and then a Veress needle (Olympus Optical, Tokyo, Japan), which is used for the intraperitoneal infusion of CO_2 gas for laparoscopic surgery, was intrathoracically inserted through the chest wall. Once the needle enters the pleural cavity and no tissue resistance is encountered, the blunt-tipped inner stylet extends to push the lung away to prevent injury. Glucose solution (5%) was infused intrathoracically to separate the lung and liver; hence, it was possible to obtain an image of the hepatic dome (Fig. 1, Fig. 2b). We used a cool-tip needle RF system (Radionics, Burlington, MA, USA), as follows. An RF ablation electrode needle was inserted percutaneously under sonographic guidance, and was positioned precisely within the HCC nodule. Twelve patients, with 12 nodules that had recurred locally after percutaneous therapy, were additionally examined by contrast harmonic US because viable lesions of HCC were not well visualized by conventional gray-scale US. We changed the sonographic mode to coded phase-inversion harmonic US, using a GE LOGIQ 700 EXPERT Series unit (General Electric Medical Systems, Milwaukee, WI, USA) and we detected hypervascular lesions after the administration of the sonographic contrast agent, Levovist (Schering, Berlin, Germany). We inserted the RF needle into the enhanced lesions, guided by coded phase-inversion harmonic US (Fig. 3). Treatment efficacy was assessed on the basis of post-treatment three-phase dynamic computed tomography (CT) scan findings about 1 week after the treatment.

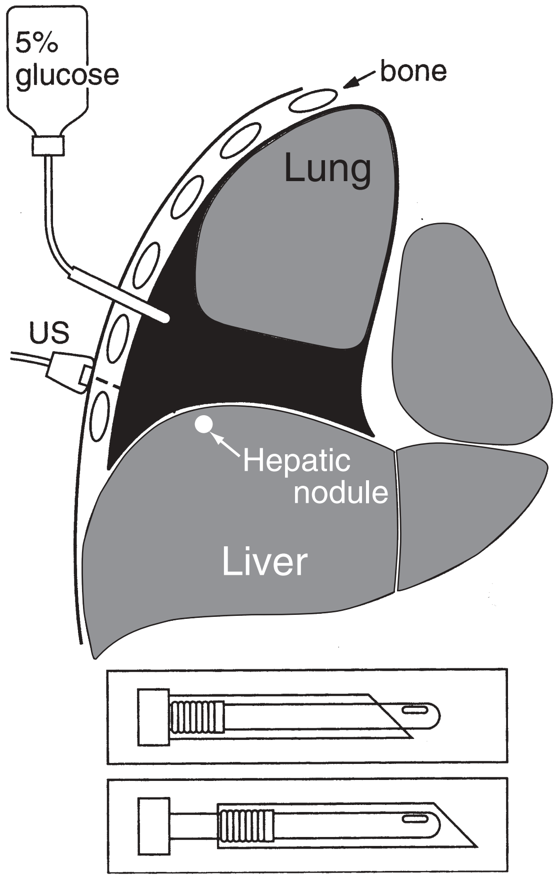
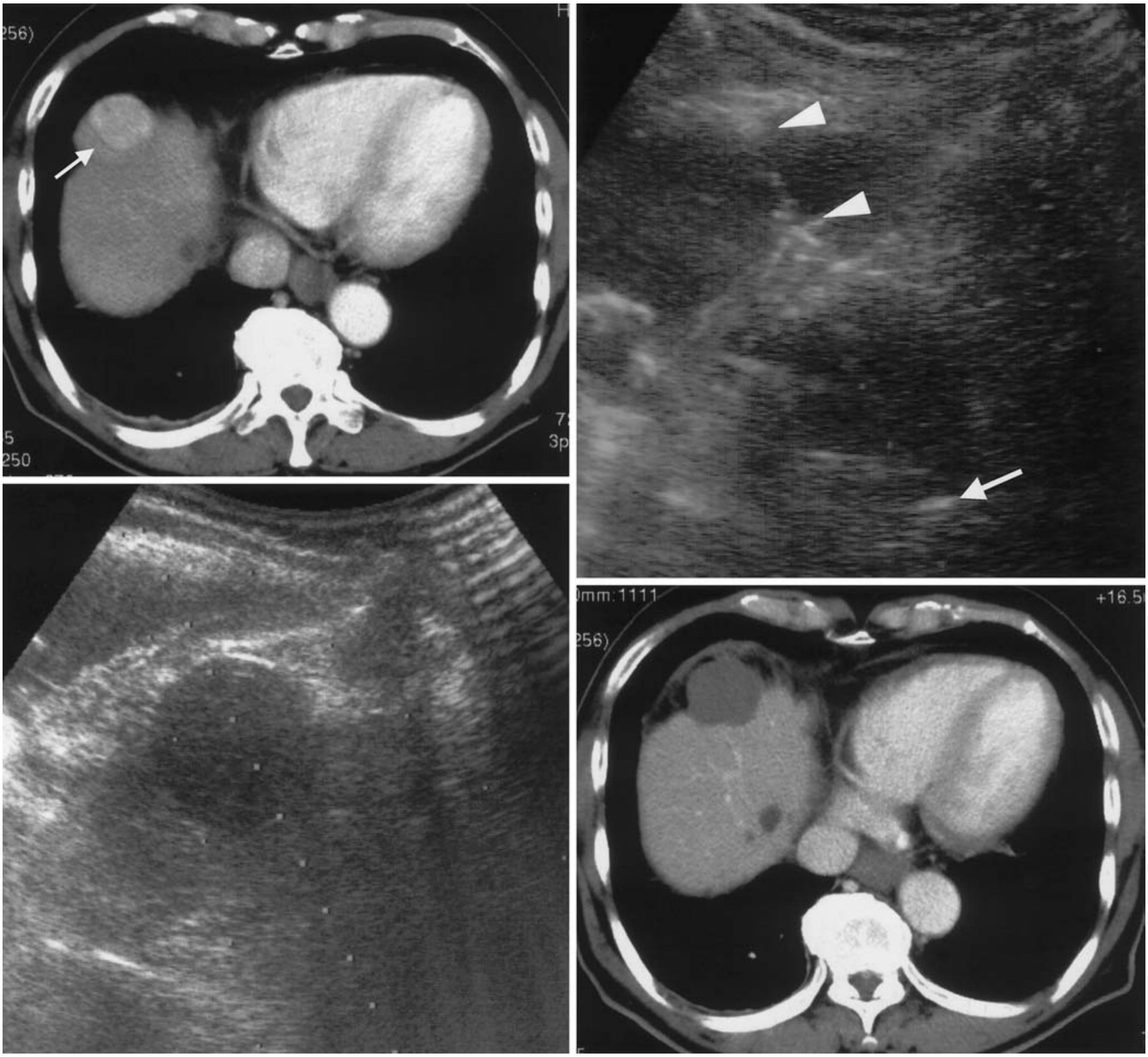


Fig. 1. Schematic drawing of artificial pleural effusion procedure. Small hepatic nodule (*arrow*) is located in the right subphrenic region. As soon as the Veress needle reaches the pleural cavity, the blunt-tipped inner stylet projects outward to push the lung away, preventing injury. Ultrasonography (*US*) could show the whole tumor after the intrathoracic injection of 5% glucose solution

Results

The range of the infused volume of 5% glucose solution was 200–1100 ml (mean, 645 ml). In 23 patients with 27



a b c d

Fig. 2a–d. Findings in a 72-year-old man with hepatocellular carcinoma in the hepatic dome. **a** Early-phase dynamic computed tomography (CT) scan shows 3.0-cm diameter hepatocellular carcinoma (*arrow*) in enhanced area located in the right subphrenic region. **b** B-Mode ultrasonography shows the whole tumor located in the hepatic dome after the intrathoracic injection of a total of 1000 ml of 5% glucose solution. **c** B-Mode ultrasonography shows the radiofrequency electrode needle (*arrowheads*) penetrating the nodule of hepatocellular carcinoma; the top of the needle is indicated by the *arrow*. **d** Early-phase dynamic CT scan obtained 1 month after percutaneous radiofrequency ablation therapy shows that the tumor and surrounding area are not enhanced, thus indicating complete necrosis of the lesion

HCC nodules that were hypoattenuated, and were not enhanced after contrast-agent administration, the findings were considered to represent necrotic and ablated tissue (Fig. 2c), whereas, in 1 patient with an enhanced tumor region, this was considered to represent residual foci of the tumor. A second treatment session of RF ablation was performed within 1 week of diagnosis in this patient, and necrosis was induced. During and after treatment, no dyspnea or other complications concerned with the respiratory system were observed. The pleural effusion disappeared within several days after treatment, and neither intrathoracic hemorrhage nor peritoneal dissemination of the tumor was seen. However, in 1 patient, little extrathoracic fluid collection was

Fig. 3a–d. A 1.0-cm recurrent hepatocellular carcinoma after local therapy in the right hepatic dome of a 65-year-old man. **a** Early-phase dynamic CT scan shows a recurring tumor (*arrow*) in the right hepatic dome. The surrounding area, which was previously treated by radiofrequency ablation, is not enhanced. **b** After the intrathoracic injection of 5% glucose solution, contrast harmonic US shows the enhancement of viable foci of hepatocellular carcinoma (*arrow*). **c** Contrast harmonic US shows a radiofrequency electrode needle inserted into the viable foci of hepatocellular carcinoma (*arrows*). **d** Early-phase dynamic CT scan obtained 6 months after radiofrequency ablation therapy shows that the tumor and the surrounding area are not enhanced, indicating complete necrosis of the lesion

pointed out by chest X ray on day 3 after treatment, but there were no symptoms. The clinical courses have been satisfactory, without recurrences, in a period of 1–13 months after treatment (mean, 7.9 months).

Discussion

RF ablation has become a common therapy in the percutaneous approach in patients with primary and metastatic hepatic malignancies.[1–3] However, nodules located just beneath the diaphragm (i.e., in the hepatic dome) often cannot be detected with US because of the acoustic window formed by the air in the right lung. Ohmoto et al.[4] described an alternative method of ablation therapy for a nodule in the hepatic dome, which included the injection of saline solution into the peritoneal cavity to separate the lung and liver. However, percutaneous RF ablation with the peritoneal instillation of solution may have a high risk of bleeding after the removal of the RF needle, whereas the intrathoracic instillation of solution does not increase the risk of bleeding from the liver. An injected peritoneal solution may not spread to a great enough degree to separate the lung and liver in patients with previous hepatectomy, as a result of adhesion, whereas percutaneous RF ablation with an artificial pleural effusion can be performed even for the patient with recurrences of HCC after hepatectomy.

Thoracoscopic transdiaphragmatic ablation therapy has been reported for patients with HCC located just under the top of the diaphragm.[5] The procedure is performed under general anesthesia, and a few wounds are made by ports inserted on the chest wall. However, percutaneous RF ablation with artificial pleural effusion is a less invasive therapy, because this procedure is performed under local anesthesia, and only a small incision is made, for the insertion of a Veress needle.

Contrast harmonic US studies are reported to be excellent for depicting tumor vascularity in HCC, sensitively and accurately.[6–9] Therefore, it has been hypothesized that contrast harmonic sonography could be helpful in improving the detectability of residual (i.e., viable) tumor before RF ablation.[7,8] In our series of HCC patients, this hypothesis was proved, as RF ablation could be effectively performed under contrast harmonic imaging guidance.

Based on our experience, we believe that percutaneous RF ablation with artificial pleural effusion in patients with HCC in the hepatic dome seems to be a safe and feasible therapy. Furthermore, with the concurrent use of contrast harmonic imaging guidance, RF ablation could be effectively performed in patients with recurrence of HCC.

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