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Efficacy and safety of radiofrequency ablation of hepatocellular carcinoma in the hepatic dome with the CT-guided extrathoracic transhepatic approach

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Abstract

Purpose: The purpose of this study was to determine the efficacy and safety of radiofrequency (RF) ablation for the treatment of hepatocellular carcinoma (HCC) in the hepatic dome with CT-guided extrathoracic transhepatic approach.
Materials and methods: Fifteen patients with 15 HCCs (size range: 0.8–4 cm, mean size: 1.8 cm) in the hepatic dome were treated by RF ablation using cooled-tip electrodes and with CT-guided extrathoracic transhepatic approach. Therapeutic response of the tumor to RF ablation and procedure-related complications including hepatic injury, hemoperitoneum, and thermal injury of diaphragm were evaluated.
Results: The average number of needle punctures to ensure the correct needle position in the targeted tumor was 3.7 (range: 1–6 punctures). The average ablation time was 14.7 min (range: 8–25 min). Complete necrosis without marginal recurrence after at least 13-month follow-up was attained in 13 tumors (86.7%). There were no major complications related to the procedures. Six patients had shoulder pain that lasted three days to two weeks after the procedures and their symptoms were resolved with conservative treatment.
Conclusions: RF ablation using CT-guided extrathoracic transhepatic approach is an effective and safe technique for the treatment of HCC in the hepatic dome.

Keywords: Radiofrequency (RF) ablation; Liver neoplasm; Therapy; CT; Guidance

1. Introduction

Radio-frequency (RF) ablation has gained wide acceptance as a promising alternative technique to surgery for the treatment of hepatocellular carcinoma (HCC) [1]. Due to its minimally invasive nature with the resultant reduced morbidity and hospitalization, as compared with conventional surgery, RF ablation is sometimes favored over surgery for the treatment of focal hepatic tumors. However, there are some inherent shortcomings of RF ablation for the treatment of focal hepatic tumors. First, the fact that RF ablation relies on image guidance to accurately localize the targeted tumors limits its use in some cases such as when the visibility of the lesion is poor on the guiding images. Second, although the safety of RF ablation has been established through many published reports, the unwanted thermal injury of the surrounding structures adjacent to the tumors could be an unsolved problem in terms of the procedure's safety. From this point of view, for the hepatic tumor located adjacent to the gallbladder, bowel, stomach, central bile duct and diaphragm, RF ablation could be less preferable than using the other therapeutic methods such as percutaneous ethanol injection and transarterial chemoembolization [2,3].

Hepatic tumor that is located in the hepatic dome just beneath the diaphragm might be the one of the most difficult situations for performing imaging-guided tumor ablation when considering the two previously mentioned shortcomings of RF ablation. Ultrasonography has been the most commonly used guidance modality for the accurate placement of the RF ablation needle in the targeted tumors, yet the tumors located just beneath the diaphragm are very difficult to target with ultrasonographic guidance. There have been some reports demonstrating the treatment of HCCs located in the hepatic dome by percutaneous ethanol injection (PEI) or by microwave coagulation therapy under CT guidance [4–6]. However, all these cases were treated with the transthoracic transpulmonary approach for introduc-

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ing the needle, and this complicated the pneumothorax in many cases [1,5–7]. Further, several alternative techniques for the ablation of hepatic dome HCCs, including thermal ablation with intraperitoneal or intrapleural saline infusion, the transthoracic extrapulmonary approach by artificially inducing pneumothorax, MRI-guided ablation including navigation technology for obtaining the real-time MR imaging, and as a more invasive technique, the thermal ablation using laparoscopy and thoracoscopy has been reported on [8–14]. However, these techniques are either invasive or they have not yet been popularized.

The CT-guided extrathoracic transhepatic approach is a commonly used technique for the ablation of ultrasonically invisible hepatic tumors and it could be used for the tumor located in the hepatic dome. To our knowledge, there have been no studies that have focused solely on the safety and therapeutic efficacy of using RF ablation for the tumor located in the hepatic dome with the CT-guided extrathoracic transhepatic approach, although this is not a totally novel procedure. Therefore, the purpose of our study was to demonstrate the therapeutic efficacy and safety of performing RF ablation for HCCs located in the hepatic dome with the CT-guided extrathoracic transhepatic approach.

2. Materials and methods

This study was approved by our institutional review board. After the nature of the procedure and the possible complications had been fully explained, a written informed consent was obtained from each patient and from a family member at the time of enrollment in the study. In particular, the possibilities of unintended transdiaphgragmatic thermal injury and hepatic hemorrhage that might occur from the long distance of penetrated liver parenchyma and the possible requirement for multiple ablation needle insertions were carefully explained to each patient, as well as to the family members, before the start of the procedures. According to the consensus of the medical team, we selected RF ablation for the treatment modality as being the most appropriate therapeutic method when considering the patient's liver functional reserve and general condition, as well as taking into consideration the morphologic features of the HCC such as the presence of encapsulation.

2.1. Patients

From January 2000 to February 2005, we performed RF ablation for about 300 patients with HCCs. Among them, 19 patients who had HCC located in the hepatic dome were treated with RF ablation under CT guidance. The selection criteria for the HCC in the hepatic dome were the tumors abutting the diaphragm or the tumors just beneath the diaphragm, the upper margin of the tumor was located within 1 cm of the diaphragm and the most of the tumors were invisible on sonography. Four patients with not more than 6-month follow-up were excluded from our study. Therefore, the remaining 15 patients (11 men and 4 women, age range: 35–67 years, mean age: 56 years) with HCCs located in the hepatic dome formed the final study group. The size range of the HCCs located in the hepatic dome was from 0.8 to 4.0 cm in diameter with a mean tumor diameter of 1.8 cm. All the HCCs were of the nodular type with the capsule showing hyperattenuation on the dynamic arterial phase, and the HCCs were considered to be hypervascular. Among the 15 lesions, biopsy under CT guidance was performed on only three lesions. Because of the difficulty in obtaining biopsy specimens from the small hepatic dome tumors, the diagnosis of 12 HCCs was based on the histopathologic report of another concomitant tumor that showed the same imaging findings, the combined reading of the ultrasonography, CT and MRI that included the dynamic images and the superparamagenetic iron oxide (SPIO)-enhanced images, the characteristic angiographic findings and the elevated serum alpha-fetoprotein level (200–1000 ng/ml). The pretreatment workup for all the patients included ultrasonography, three-phase spiral computed tomography (CT) and MRI; the MRI included the gadolinium-enhanced dynamic imaging and the ferumoxide-enhanced imaging. Gadolinium-enhanced dynamic MRI was obtained using three-dimensional Fourier transform gradient echo imaging (volumetric interpolated breath-hold examination, VIBE: Siemens, Erlangen, Germany). The ferumoxide-enhanced imaging was comprised of a respiratory-triggered T2-weighted turbo spin-echo sequence and a breath-hold $T2^*$-weighted FISP sequence. All the patients had liver cirrhosis as was evidenced by a CPT score <9 (range: 6–8, mean: 7). Nine patients were classified as class A and the remaining six were class B. None of the patients had ascites surrounding the hepatic dome or in the subphrenic space. The cause of liver cirrhosis in all the patients was viral hepatitis B. The patients who fulfilled the following criteria were included in the study: the inability to undergo surgical resection because of an unfavorable location of tumor, impaired liver function and multiplicity of HCCs, the presence of a single tumor nodule not more than 5 cm in diameter or not more than three tumor nodules with diameters less than 3.0 cm, the absence of extrahepatic metastasis, the absence of portal vein thrombosis, no severe coagulation disorders, a prothrombin activity >40%, a platelet count >40,000 per mL and no hepatic encephalopathy.

2.2. RF ablation technique

RF ablation was performed on the patients after 12 h of fasting during with a hospital stay of from two to seven days. All the patients received 1 g of cefazolin (Cefamezin; Dong-Ah, Seoul, Korea) intravenously on the procedure day and also at 24 h after the procedure. For the CT-guided approach, a Somatom Plus-4 scanner (Siemens Medical Systems, Erlangen, Germany) was used, and the scanning parameters were 110 kVp, 80–200 mA, 5-mm collimation and a table speed of 7-mm/s. Before the examinations, the patients were instructed to hold their breath at same degree for each CT scan because maintaining the same hepatic level for each CT scan during the ablation procedure is essential for accurately targeting the tumors with the CT-guided approach.

Of the 15 tumors, ten of the tumors were depicted as a subtle low attenuation on the nonenhanced CT that was acquired before the procedure. Among the five tumors that were not depicted on the nonenhanced CT, the arterial phase image of the dynamic contrast-enhanced CT was acquired in two patients before the procedure because of the difficulty in determining the proba-