Comparative Study of Shear Wave Velocities Using Acoustic Radiation Force Impulse Technology in Hepatocellular Carcinoma: The Extent of Radiofrequency Ablation

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**Background/Aims:** The purpose of this study was to assess the value of acoustic radiation force impulse (ARFI) for predicting the extent of radiofrequency ablation (RFA) in hepatocellular carcinoma (HCC) by correlating the elasticity of HCC and peritumoral parenchyma (as measured by ARFI) with the extent of ablation determined by computed tomography (CT).

**Methods:** From September 2009 to June 2011, 158 patients underwent RFA ablation for HCC (single, ≤3 cm). We evaluated the data of a total of 38 prospectively enrolled patients who underwent both ARFI imaging and contrast-enhanced CT after one session of 12 minutes of RFA without a change in needle position. The ARFI imaging indices, including the mean shear wave velocity (SWV) of HCC, mean SWV of the peritumoral parenchyma and tumor size, were evaluated to determine the statistical correlation with RFA extent after one session of 12 minutes of RFA.

**Results:** A stiffer liver parenchyma in patients with cirrhosis results in a smaller ablation zone.

**Conclusions:** SWV of ARFI in liver parenchyma was well correlated with RFA extent. After evaluating the correlation between ARFI and RFA extent, we suggest that the SWV in liver parenchyma might be a non-invasive supplementary tool for predicting the extent of RFA.

(Gut Liver 2012;6:362-367)

**Key Words:** Elasticity imaging techniques; Hepatocellular carcinoma; Radiofrequency ablation

**INTRODUCTION**

Radiofrequency ablation (RFA) induces localized coagulation necrosis by creating resistive ionic heating (50°C to 100°C) through one or more electrodes, which are directly inserted into the tumor, delivering high-frequency alternating currents. A potential eradicator of RFA should include the entire tumor plus a 5-10 mm peritumoral safety margin in an ideal sphere of necrosis, whereas an area of coagulation smaller than expected may lead to local recurrence. In clinical practice, many factors (i.e., probe gauge, tip length, temperature achieved, heating duration, heat-sink effect of nearby blood vessels, incomplete fusion of RFA lesions between prongs of expandable electrodes or surgical clips near the tumor) may alter this ideal geometrical shape producing an irregularly sized, distorted or incomplete area of necrosis. Until now, there are no studies that have evaluated the influence of objective stiffness value in tumor or parenchyma on the ablation extent.

Acoustic radiation force impulse (ARFI) has the advantage of enabling a “real-time” evaluation of liver fibrosis and is free of adverse effects; it is comfortable for the patient and examiner and needs no external compression, and this makes evaluation of deep tissue feasible. ARFI imaging is able to noninvasively evaluate the stiffness of hepatic tissues, characterize focal hepatic lesions, and guide the placement of interventional devices.

This study aimed to assess the stiffness liver by using an ARFI imaging technique and to identify the correlation between not only the severity of hepatic parenchymal fibrosis and RFA extent of hepatocellular carcinoma (HCC) but also the HCC stiffness and RFA extent respectively in patients with HCC and underlying liver cirrhosis.
MATERIALS AND METHODS

1. Patients

The subjects were drawn from a consecutive series of 158 patients with HCC and who treated by RFA between September 2009 and June 2011.

Of the 158 prospective patients, 38 were enrolled in the study, based on the inclusion and exclusion criteria. Inclusion criteria were adult patients with a single primary HCC smaller than 3 cm (0.8 to 3 cm) in diameter, visible HCC on ultrasonography, no eligibility for surgical resection or refusal of surgery, and an acceptable and safe path through intercostal approach between the lesion and the skin as observed on ultrasonography. All patients had underlying liver cirrhosis. Exclusion criteria were HCC located in left lobe, recurred HCC after RFA or transarterial chemoembolization, multiple HCCs, incomplete ablation of HCC after shear wave velocities (SWV) is uncheckable or unreliable by high variability (>1 m/sec) and presence of extrahepatic metastasis or vascular invasion.

B-mode ultrasound (US) pre-RFA image and Real-time elastography on an Acuson S2000™ system (Siemens, Mountain View, CA, USA) were performed on the 38 patients for evaluation of the HCC and peritumoral parenchyma before performing RFA. Then RFA was performed to treat HCC.

Of the 38 patients (16 women, 22 men; mean age, 62.3 years; range, 40 to 78 years), 10 have HCC in segment 5, 11 in segment 6, 4 in segment 7, and 13 in segment 8.

On CT images before performing RFA, the longitudinal diameter of HCC ranged from 0.8 to 2.5 cm with a mean value of 1.68±0.57 cm. On elastographic images, the region of interest (ROI) box depth ranged from 30 to 80 mm with a mean depth of 45.97±0.2 mm.

The diagnosis of HCC was made based on the guidelines proposed by the Korea Liver Cancer Study Group and the National Cancer Center. According to these criteria, a patient is considered positive for HCC if the patient has one or more risk factors (HBV infection, hepatitis C virus infection or cirrhosis) and one of the following: a serum α-fetoprotein (AFP) level of >400 ng/mL and a positive finding with at least one of three typical imaging studies (spiral computed tomography [CT], contrast enhanced dynamic magnetic resonance imaging [MRI] or hepatic angiography), or a serum AFP level of <400 ng/mL and positive findings with at least two of the three imaging studies. A positive finding for typical HCC with dynamic CT or MRI is indicative of arterial enhancement, followed by venous washout in the delayed portal/venous phase.

2. Pre-RFA image acquisition

In the case of all the patients, Acuson S2000™ US system (Siemens) with a curved array 4-1 MHz was used. Before performing RFA, longest diameter of HCC on CT scan was measured, and SWV of both HCC and peritumoral parenchyma was analyzed by ARFI imaging by one operator. Tumor location was described according to the Couinaud segmental anatomic clas-

Fig. 1. Hepatocellular carcinoma (HCC) and underlying LC in S5 in the liver of a 56-year-old man. HCC and underlying liver cirrhosis in S5 of liver in a 56-year-old man. (A, B) On a B-mode image obtained using a 4-MHz curved array, the HCC appears as a well-defined, hypoechogenic mass approximately 19.5 mm in size, located in the S5 segment of the liver. The HCC appears as dark coloration on real-time acoustic radiation force impulse imaging. (C, D) Measurement of shear wave velocity of the HCC and hepatic parenchyma at similar region of interest depths (5.4 and 5.5 cm below the skin) reveals that stiffer tumors display greater velocity (2.19 m/sec) than cirrhotic parenchyma (1.71 m/sec). (E) Post-radiofrequency ablation computed tomography scan in the arterial phase displays an oval, well-ablated and necrotic alteration in the HCC, which was (3.7×2.6×0.1)/4 cm³ in size.