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Percutaneous ultrasonography-guided radiofrequency ablation of hepatocellular carcinomas: usefulness of image fusion with three-dimensional ultrasonography

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AIM: To evaluate the usefulness of fusion imaging with real-time ultrasonography (US) and three-dimensional (3D) US for the guidance of radiofrequency ablation (RFA) of hepatocellular carcinomas (HCCs) 2–5 cm in diameter.

MATERIALS AND METHODS: This study was conducted as a retrospective cohort study. It was approved by the institutional review board and informed consent was waived. During percutaneous RFA of HCCs, targeting was performed under conventional fusion imaging guidance, whereas monitoring and controlling were conducted under fusion with 3D US guidance. Technical success, technique effectiveness, incidence of major complications, and local tumour progression rate were evaluated. According to tumour size (small: <3 cm versus medium: 3–5 cm), the roundness indexes of the ablation zones and local tumour progression rates were compared.

RESULTS: There were 29 small-sized HCCs (2.5 ± 0.3 cm) and 17 medium-sized HCCs (3.4 ± 0.5 cm). All RFA procedures were performed in a single RFA session. Both the technical success and technique effectiveness rates were 100%. One patient with medium-sized HCC developed a hepatic abscess ($n = 1$) as a major complication. The local tumour progression rate was 8.7% (4/46) with a mean follow-up period of 18.2 months. The roundness indexes of the ablation zone were not significantly different between small- and medium-sized HCCs, and the local tumour progression rates were also not significantly different between the two groups [3.4% (1/29) versus 17.6% (3/17); $p = 0.135$].

CONCLUSION: Image fusion with real-time US and 3D US is useful for the guidance of percutaneous RFA for HCCs 2–5 cm in diameter.

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Introduction

Radiofrequency ablation (RFA) has been widely utilized as a curative treatment option for the management of hepatocellular carcinomas (HCCs) <3 cm in diameter.[1,2] Although RFA has shown promising results for very early stage HCCs <2 cm in diameter,[1,3] it is still challenging for HCCs >2 cm due to a high rate of local tumour progression.[4] According to a recent study,[5] the local tumour progression rate after RFA for medium-sized HCCs (3–5 cm) was up to 70%. Hence RFA is not recommended for tumours >5 cm in both the Barcelona Clinic Liver Cancer (BCLC) and the European Association for the Study of the Liver (EASL) guidelines.[1,6] As local tumour control by RFA is affected by tumour size, some investigators have reported the effectiveness of combined treatment of RFA and transcatheter arterial chemoembolization (TACE) for medium-sized HCCs (3–5 cm).[5,7,8]

The major contributing factor for local tumour progression after RFA is an insufficient ablative margin. To cover the entire tumour with a sufficient ablative margin of at least 0.5 cm, sequential overlapping ablations are usually performed. However, repositioning of the electrode during RFA under two-dimensional (2D) ultrasonography (US) guidance is technically difficult due to the echogenic zone generated during the RFA procedure. Sometimes irregular shapes are encountered in the ablation zone on the immediate post-RFA CT images, which imply that overlapping ablations under US guidance are technically challenging.[9] Meanwhile, several studies reported that three-dimensional (3D) US guidance was useful for local ablation therapy of liver tumours.[10,11]

With the technical development of US, fusion imaging of real-time US and CT/MRI images has been utilized in the RFA of small, inconspicuous HCCs.[12,13] Recently, percutaneous RFA was performed for HCCs 2–5 cm in diameter under the guidance of fusion imaging with 3D US. Although, local tumour control by RFA treatment alone may be not be enough for these tumours, the therapeutic outcomes after fusion imaging with 3D US-guided RFA would be acceptable even in medium-sized HCCs. Therefore, the purpose of the present study was to evaluate whether fusion imaging with real-time US and 3D US is useful for the guidance of RFA of HCCs that are 2–5 cm in diameter.

Materials and methods

Study population

This single-arm study was conducted as a retrospective analysis of a prospective database from October 2011 to June 2012, and was approved by the institutional review board. Informed consent from patients was waived. Percutaneous US-guided RFA was performed under the guidance of fusion imaging (Volume Navigation, Logiq E9, GE Healthcare, Milwaukee, WI, USA) during the study periods. The results of fusion imaging-guided RFA were recorded in an electronic database (Microsoft Office Access; Microsoft, Redmond, Washington) immediately after the RFA procedures were conducted. The inclusion criteria were as follows: (1) treatment-naïve HCC ranging from 2–5 cm in diameter; (2) patients who underwent percutaneous fusion imaging with 3D US-guided RFA; and (3) patients were followed for more than 1 month after the RFA procedure. The exclusion criteria were as follows: (1) patients with multinodular HCCs and (2) locally recurrent HCCs after previous chemoembolization or RFA. Finally, 46 consecutive patients (32 men, 14 women; mean age 62.2 years; age range 33–87 years) with 46 HCCs including 29 small-sized HCCs and 17 medium-sized HCCs were included in this study. The diagnosis of HCC was based on either histological confirmation by percutaneous biopsy ($n = 6$, 13%) or typical imaging features on CT or MRI images ($n = 40$, 87%).[14] HCC size was defined as the longest diameter of the tumour on US images at the time of the RFA procedure.

Fusion imaging-guided RFA

Before conducting the RFA procedure, written informed consent was obtained from all patients. Fusion imaging-guided RFA was performed by an interventional radiologist (M.W.L.) with 9 years of experience conducting RFA, including more than 300 cases of fusion imaging-guided RFA at the beginning of the present study on an inpatient basis. For local anaesthesia, 2% lidocaine hydrochloride (Huons Lidocaine HCI INJ; Hwaseong-City, South Korea) was injected at the puncture site. For pain control, both pethidine hydrochloride (Samsung Pharmaceutical, Seoul, Korea) mixed with 5% dextrose in water and fentanyl citrate (Gu Ju INJ; GUJU Pharma, Seoul, Korea) mixed with normal saline were injected intravenously. We used fifteen-gauge internally cooled, length-adjustable electrodes (Proteus RF Electrode; STARmed, Gyeonggi-do, Korea) with a 200 W RF generator (VIVA RF System; STARmed) or modified clustered electrodes (Octopus electrode; STARmed) with a multichannel RF generator (Well Point RF system; STARmed) capable of producing a maximum power of 200 W at a frequency of 480 kHz, consisting of three generators.[15,16] The type and number of electrodes were chosen based on the size, location, and geometry of the tumour. The modified clustered electrodes (Octopus electrode) were composed of three 17-gauge cooled tip electrodes with either 2.5 cm or 3 cm long active tips, and three electrodes could be inserted in the tumour separately or simultaneously.[16] In order to avoid complications or the heat-sink effect, multiple electrodes (Octopus electrode) were preferred over a single electrode (Proteus electrode) if the index tumour was located close to critical structures such as the diaphragm, gall bladder, or blood vessels >3 mm in diameter. When using multiple electrodes, three electrodes were placed separately in the index tumour 1–2 cm apart from each other to maximize ablation volume; RF energy was administered using the switching monopolar mode.[16] This mode was time efficient as RF energy was deployed to one of three electrodes alternatively without a resting phase by the following method: the current automatically switches to the other electrode if an impedance value that