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Percutaneous microwave ablation for hepatocellular carcinoma adjacent to large vessels: A long-term follow-up

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ABSTRACT

Purpose: To retrospectively evaluate the effectiveness and safety of ultrasound (US)-guided percutaneous microwave ablation (MWA) in the treatment of hepatocellular carcinoma (HCC) adjacent to large vessels.
Materials and methods: From February 2006 to February 2013, 452 patients with 605 HCC nodules were treated with US-guided percutaneous MWA. Into large vessels group (Group L), 139 patients with 163 lesions (diameter, 1.0–7.0 cm; mean, 2.5 ± 1.1 cm) located less than 5 mm away from large vessels were enrolled. And 313 patients with 442 lesions (diameter, 1.0–8.0 cm; mean, 2.5 ± 1.2 cm) located more than 5 mm away from hepatic surface, large vessels, gallbladder and gastrointestinal tract were included in control group (Group C). During the ablation, the temperature of marginal ablation tissues was monitored and controlled.
Results: The median follow-up time was 24.5 months (range 2.1–87.7 months) in Group L, and 25.7 months (range 1.6–93.9 months) in Group C. Technical effectiveness was achieved in 157 of 163 (96.3%) tumors in Group L and 429 of 442 (97.1%) tumors in Group C, respectively ($p > 0.05$). The 1-, 3- and 5-year local tumor progression rates and the 1-, 3- and 5-year accumulative survival rates in the two groups have no significantly statistical differences. In addition, no immediate or periprocedural major complications, no delayed complication of vessels or bile ducts injury were found in both of the two groups.
Conclusions: With strict temperature monitoring, US-guided percutaneous MWA is an efficient and safe technology in treating hepatocellular carcinoma adjacent to large vessels.

1. Introduction

Hepatocellular carcinoma (HCC) is the fifth frequently diagnosed cancer worldwide and is the second main cause in the cancer-related deaths [1]. It was reported that 695,900 cancer deaths occurred all over the world in 2008, and half of these deaths were estimated to occur in China [1,2]. Improvement in abdominal imaging has made early diagnosis of HCC more easily [3]. Traditionally, hepatic resection is the first-line treatment option for patients who are with solitary tumors and well-preserved liver function [3–5]. However, resection also has limitations if it is used to treat HCC patients with unfavorable tumor locations. As report goes, resections for malignant zones close to main hepatic veins or the vena cava are sometimes practicable[6,7], but they are always associated with increased risks [8].

The emergence of local thermal ablation provides a feasible choice for these patients [9–13]. Minimally invasive percutaneous local ablation techniques, such as radiofrequency ablation (RFA), cryoablation and microwave ablation (MWA), have already been suggested as alternatives for the treatment of HCC [3]. And these techniques referred before, in treating small HCC, were turned out to be promising in clinical results [9–11]. However, an important inherent effect of heat-sink on thermal ablation may influence the treatment result for the tumors adjacent to large vessels (≥3 mm) [14].

At present, some researchers have already put RFA into practice of treating liver tumors adjacent to large vessels. And the result is satisfying [15–17]. However, as another kind of thermal ablation techniques, MWA has its special features. It destroys the tumors via high temperature produced by rotating adjacent polar water molecules in the targeted pathologic tissues through electromagnetic energy, which would lead to protein denaturation, cell membrane disruption, and finally coagulation necrosis with

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Table 1
The location distribution of tumors in Group L.

The vessels adjacent to tumors	No. of tumors
Inferior vena cava	19
Right hepatic vein	12
Middle hepatic vein	9
Left hepatic vein	2
Main portal vein	12
Right portal vein	41
Anterior branch of right portal vein	13
Posterior branch of right portal vein	22
Left portal vein	3
Left portal venous bifurcation	8
External branch of left portal vein	18
Internal branch of left portal vein	2
Inferior vena cava and Main portal vein	2

cellular death. Under the condition of giving 4–6 min treatment for patients with temperature being greater than 50 °C or reaching 60 °C immediately, the changes described before would appear [18,19]. MWA has several theoretical advantages over RFA. First, it would produce consistently higher intratumoral temperatures, larger ablation zones, less ablation time and less dependence on the electrical conductivities of tissue. Second, energy delivery is less limited by the exponentially rising electrical impedance of tumor tissue [19–22]. These advantages may make MWA treatment less affected by heat-sink [21]. Although MWA has been widely used in liver cancer therapy [10], there are no authoritative clinical achievements but only some foundational reports on the effects of treating the tumors adjacent to large vessels [23].

This study aims to assess the effectiveness, safety and clinical outcomes of US-guided MWA in treating patients with HCC adjacent to large vessels.

2. Materials and methods

2.1. Patients

This retrospective study was approved by the institutional review board of Chinese PLA General Hospital. Written informed consent for this procedure was obtained from all the enrolled patients. From February 2006 to February 2013, 452 consecutive patients (605 lesions) with HCC were enrolled and underwent percutaneous MWA treatment at this department. Among the 452 patients, 139 patients with 163 HCC lesions, located less than 5 mm from large vessels (large vessels were defined as the first or second branch of the portal vein, the base of hepatic veins, or the inferior vena cava of which diameters being equal or bigger than 3 mm) shown by contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI), were enrolled into large vessels group (Group L). And 313 patients with 442 lesions located in safe site (more than 5 mm from hepatic surface, large vessels, gallbladder and gastrointestinal tract) were included in control group (Group C). All the enrolled HCC patients are treated by MWA, and they were closely followed up until May 2013.

There were 109 males and 30 females in Group L with a median follow-up time 24.5 months (range 2.1–87.7 months), and 247 males and 66 females in Group C with a median follow-up time 25.7 months (range 1.6–93.9 months). No statistical differences of median follow-up time exist between the both groups ($p = 0.998$). The average ages were 59.5 ± 10.6 (range 33–86) years in Group L, and 58.4 ± 10.5(range 28–92) years in Group C, respectively ($p > 0.05$). The numbers of the lesions adjacent to different large vessels in Group L are list in Table 1.

2.2. Preprocedure evaluation

All patients enrolled in this study had to meet the following criteria: the percutaneous approach was accessible to the tumors; the size of single nodular HCC lesions was less than or equal to 8 cm; each multiple nodular hepatic lesions, three or fewer, was with a maximum dimension of 4 cm or less; there was no portal vein embolus nor extrahepatic metastases; the prothrombin time was less than 25 s; the prothrombin time activity percentage was higher than 40%; the platelet count was higher than 40 cells × 10^9/L. In the pre-operation, the number of tumors and the absence of portal vein thrombosis were evaluated by contrast-enhanced US (CEUS), CT or MRI. The maximum diameter of nodules was measured by arterial phase of CEUS. The absence of extrahepatic metastases was determined by means of a thorough clinical assessment, chest radiography, abdominal US, and abdominal CT or MRI or position-emission tomography (PET). HCC diagnosis was largely made through an intraoperative tumor biopsy before ablation with US guidance.

2.3. MWA system

The microwave ablation system (KY-2000; Kangyou Medical Instruments, Nanjing, China) consists of two MW generators, two flexible coaxial cables and two cooled shaft antennae. The machine is capable of producing 2450 MHz and 1–100 W [24]. The cooled shaft antenna (diameter: 1.9 mm, 15 gauge; length: 18 cm; pinpoint size: 5 mm or 11 cm) which is coated with polytetrafluoroethylene to prevent conglutination can be easily observed by ultrasound (US). Inside antenna shaft are dual channels, through which distilled water is circulated by a peristaltic pump continuously cooling the shaft and preventing overheating.

2.4. MWA procedure

First, after giving the patients local anesthesia with 1% lidocaine, US-guided biopsy was performed by an automatic biopsy gun with an 18-gauge cutting needle and 2 or 3 separate punctures were performed then. Second, under US guidance, the antennae were percutaneously inserted into the tumors. At each insertion, the tip of the needle was placed in the deepest part of the tumor. For tumors less than 2.0 cm, one antenna was inserted; for tumors measuring 2.0 cm or greater, two antennae were inserted with an interantenna distance of no more than 2.5 cm. Third, after all insertions, intravenous anesthesia, via the peripheral vein, was administered by a combination of propofol (Diprivan; Zeneca Pharmaceuticals, Wilmington, Del) and ketamine (Shuanghe Pharmaceuticals, Beijing, China) during standard hemodynamic monitoring. Fourth, MWA emission started, and the region of ablation was monitored by US. During the MWA process, the output of power is 40–60 W for 5–10 min in a session. Multiple thermal lesions are created along the major axis of the needle antenna by simply withdrawing the needle from the preceding thermal lesion, and reactivating the MW generator. If necessary, due to tumor size, multiple overlapping ablations are usually needed to envelope the entire tumor with a safety margin. If the heat-generated hyperechoic water vapor did not completely encompass the entire tumor, a prolonged microwave emission would be applied until the desired temperature was reached. Finally, when the antenna was withdrawn, the applicator track was heated with sufficient microwave energy by quitting the cooling-shaft water dump.

2.5. Thermal monitoring during the procedure

To continuously measure temperature in real time during the ablation, the microwave machine is also equipped with a thermal