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REVIEW

Practice guidelines for ultrasound-guided percutaneous microwave ablation for hepatic malignancy

Ping Liang, Jie Yu, Ming-De Lu, Bao-Wei Dong, Xiao-Ling Yu, Xiao-Dong Zhou, Bing Hu, Ming-Xing Xie, Wen Cheng, Wen He, Jian-Wen Jia, Guo-Rong Lu

Ping Liang, Jie Yu, Bao-Wei Dong, Xiao-Ling Yu, Department of Interventional Ultrasound, Chinese PLA General Hospital, Beijing 100853, China
Ming-De Lu, Department of Hepatobiliary Surgery and Medical Ultrasonics, The First Affiliated Hospital of Sun Yat-Sen University, Guangzhou 510080, Guangdong Province, China
Xiao-Dong Zhou, Department of Ultrasound, Xijing Hospital of Fourth Military Medical University, Xi'an 710032, Shaanxi Province, China
Bing Hu, Department of Ultrasound in Medicine, 6th People's Hospital of Shanghai Jiaotong University, Shanghai 200233, China
Ming-Xing Xie, Department of Ultrasound, Medical Imaging Union Hospital of Tongji Medical College of HUST, Wuhan 430022, Hubei Province, China
Wen Cheng, Department of Ultrasound, The Third Affiliated Hospital of Harbin Medical University, Harbin 150081, Heilongjiang Province, China
Wen He, Department of Ultrasound, Beijing Tiantan Hospital of Capital Medical University, Beijing 100050, china
Jian-Wen Jia, Department of Ultrasound, Peking University Third Hospital, Beijing 100191, China
Guo-Rong Lu, Department of Ultrasound, The Second Affiliated Hospital of Fujian Med University, Quanzhou 362000, Fujian Province, China
Author contributions: Liang P had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis; Liang P and Lu MD designed the research; Liang P, Yu J, Lu MD, Dong BW, Yu XL, Zhou XD, Hu B, Xie MX, Cheng W, He W, Jia JW and Lu GR performed the research and data acquisition; Liang P, Yu J, Lu MD and Yu XL contributed data analysis and interpretation; Liang P, Yu J and Lu MD wrote the paper.
Correspondence to: Ping Liang, MD, Department of Interventional Ultrasound, Chinese PLA General Hospital, 28 Fuxing Road, Beijing 100853, China. liangping301@hotmail.com
Telephone: +86-10-66939530 Fax: +86-10-88210006
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Abstract

Primary liver cancer and liver metastases are among the most frequent malignancies worldwide, with an increasing number of new cases and deaths every year. Traditional surgery is only suitable for a limited proportion of patients and imaging-guided percutaneous thermal ablation has achieved optimistic results for management of hepatic malignancy. This synopsis outlines the first clinical practice guidelines for ultrasound-guided percutaneous microwave ablation therapy for hepatic malignancy, which was created by a joint task force of the Society of Chinese Interventional Ultrasound. The guidelines aim at standardizing the microwave ablation procedure and therapeutic efficacy assessment, as well as proposing the criteria for the treatment candidates.

Key words: Practice guidelines; Microwave radiation; Catheter ablation; Liver cancer; Ultrasound

Core tip: Thermal ablation has undergone rapid development as a minimally invasive procedure, with optimistic results and rapid rehabilitation. This synopsis outlines the first clinical practice guidelines for ultrasound-guided percutaneous microwave ablation therapy for hepatic malignancy, which was created by a joint task force of the Society of Chinese Interventional Ultrasound. The guidelines aim at standardizing the microwave ablation procedure and therapeutic efficacy assessment, as well as proposing the criteria for treatment candidates.

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INTRODUCTION

Primary liver cancer is the sixth most commonly diagnosed cancer worldwide and hepatocellular carcinoma (HCC) accounts for 70%-90% of the total incidence. There were 748300 new liver cancer cases and 695900 cancer deaths worldwide in 2008 and half of the cases and deaths were estimated to occur in China as a result of the high prevalence of chronic viral hepatitis[1,2]. Metastases are another common hepatic malignancy. Colorectal liver metastasis is one of most common hepatic metastases. It has been reported that 14.5%-23.0% of colorectal cancer patients have synchronous liver metastases at the time of exploration for their primary tumor and 76.8% eventually develop liver metastases[3]. A number of different locoregional therapies for hepatic malignancy have been performed, including surgical resection, percutaneous ethanol injection, microwave ablation (MWA), radiofrequency ablation (RFA), high-intensity-focus ultrasound and transcatheter arterial chemoembolization (TACE). Traditionally, surgical resection is the reference standard for treatment of patients with hepatic malignancy, however, only a small proportion of them have the chance to be candidates because of disease progression, anatomical location, and poor liver function. As an alternative therapy, imaging-guided percutaneous ablation has been widely applied for management of hepatic malignancy, owing to its advantages of minimal invasion, favorable efficacy, and reproducibility[4-7]. Among thermoablative techniques, RFA is the most extensively used worldwide. MWA of liver cancer was first adopted in Japan by Saitsu *et al*[8] and has been widely applied in China over the past two decades[5,6,9-15]. Several studies[16-19] showed that the local tumor control, complications and long-term survival were equivalent for RFA and MWA in treatment of hepatic malignancy. A recent multicenter study from China documented that 1007 patients with primary liver cancer treated by MWA achieved 1-, 3-, and 5-year survival rates of 91.2%, 72.5%, and 59.8%, respectively[20]. For liver metastases, MWA offers a mean 1-, 3- and 5-year survival rate of 73%, 30% and 16%, which represents an advantage over palliative chemotherapy even in patients with extrahepatic disease[17].

PURPOSE

The purpose of these guidelines is to establish basic clinical practice guidance to assist physicians with: (1) evaluating patients with hepatic malignancy, including primary liver cancer and liver metastases, who may be candidates undergoing percutaneous MWA under ultrasound (US) guidance; (2) providing relevant and updated technical information for performing this treatment; and (3) understanding the consequences of this treatment.

A working group including 44 experts from the Society of Chinese Interventional Ultrasound (SCIU) met in June 2011 to consider the evidence for developing the draft guidelines. Additional meetings were conducted *via* teleconference. The guidelines were circulated in draft form to the full expert panel for review and approval. In addition, practitioner feedback was obtained from physicians in the province of interventional treatment, and their comments were incorporated into the guidelines. These recommendations represent the panel's attempt to extract practical guidelines from a combination of published evidence and expert opinion where the literature falls short.

LITERATURE SEARCHES

The expert panel completed the review and analysis of data published since 1990. Computerized literature searches of MEDLINE, EMBASE and the Cochrane Collaboration Library were performed. The searches of the English-language literature from 1990 to June 2011 combined the terms "hepatic neoplasms" and "liver neoplasms", with the MeSH terms "microwaves" and "catheter ablation". The searches were limited to human-only studies and to specific study designs or publication types: randomized clinical trials, meta-analyses, systematic reviews, and major clinical trials in MWA of liver tumors.

DESCRIPTION OF MWA

Mechanism

MWA refers to all electromagnetic methods of inducing tumor destruction by using devices with frequencies ≥ 900 MHz[21]. The rotation of dipole molecules accounts for most of the heat generated during MWA[22,23]. Water molecules are dipoles with unequal electric charge distribution, and they attempt to reorient continuously at the same rate in the microwave oscillating electric field. Therefore, electromagnetic microwaves heat matter by agitating water molecules in the surrounding tissue, producing friction and heat, thus inducing cellular death *via* coagulation necrosis. Another mechanism responsible for heat generation is ionic polarization, which occurs when ions move in response to the applied electric field of microwaves. Displacement of ions causes collision with other ions, which converts kinetic energy into heat. However, it is a far less important mechanism than dipole rotation in living tissue. Currently, two kinds of frequencies: 915 and 2450 MHz are used for MWA. A frequency of 2450 MHz is more commonly adopted, which is also the frequency used in conventional microwave ovens given optimal heating profiles[23]. Microwaves of 915 MHz can penetrate more deeply than 2450 MHz microwaves[24], therefore, the low frequency MWA may theoretically yield larger ablation zones.

Technical advantages

MWA shows the following theoretical technique advantages over RFA. (1) active tissue heating of RFA is limited to a few millimeters surrounding the active electrode, with the remainder of ablation zone relying on the conduction of electricity into the tissue[22]. Microwaves use electromagnetic energy with the much broader field of power density (up to 2 cm surrounding the antenna) to rotate rapidly adjacent polar water molecules to achieve primarily active heating, which can yield a much broader zone of active heating[21]; (2) RFA is limited by the increase in impedance with tissue boiling and charring[22], because water vapor and char act as electrical insulators. MWA does not seem to be subject to this limitation. Therefore, temperature > 100 ℃ is readily achieved[25]; (3) Owing to the active heating ability, MWA can achieve higher intratumoral temperatures, larger ablation volumes, and shorter ablation times[25-28]. Because the cooling effect of blood flow is most pronounced within the zone of conductive rather than active heating, MWA is less affected by blood-vessel-mediated cooling (the heat-sink effect). These benefits have the potential to allow for a more uniform tumor kill in the ablation zone, both within the targeted zone and perivascular tissue[28,29]; (4) MWA allows for simultaneously multiple probe deployment to reduce the duration of therapy and increase the diameter of ablation zone[21,22,25]; and (5) MWA does not require the placement of grounding pads and the electrical energy is deployed in the target tissue only, which avoids applied energy loss and skin burns. Moreover, MWA is not contraindicated by the metallic materials like surgical clips or pacemaker.

However, as one of most recent advances in the field of thermoablative technology, MWA has a few limitations: (1) The higher thermal efficiency of MWA may become a double-edged sword to injury easily the adjacent critical tissues because of the tissue surrounding the antenna being rapidly ablated; and (2) Simultaneous deployment of multiple probes of microwave antennae can significantly increase the diameter of the ablation zone, whereas recession of the coagulation zone for the inter-antenna distance may not entirely cover the large tumor and result in incomplete ablation[30].

Apart from theoretical comparison of technical characteristics, in limited comparative clinical trials between MWA and RFA, two ablation techniques achieved similar tumor necrosis effects and survival[18,19,31,32]. However, Japanese researchers thought RFA had a tumor control advantage in small liver lesions[33,34]. However, randomized controlled trials with large samples and long-term follow-up are lacking and are strongly recommended to provide evidence-based medicine.

Equipment

All MWA systems are composed of three basic elements: microwave generator, low-loss flexible coaxial cable, and microwave antenna. Microwaves are generated by a magnetron in the generator. Antennae are connected *via* a low-loss coaxial cable to the generator and transmit microwaves from the magnetron into the tissue. Antennae can be classified as three types (dipole, slot, or monopole), based on their physical features and radiation properties[35]. Antenna shape includes straight, loop and triaxial. Design of the antenna is crucial to the therapeutic efficacy. Currently, the design has focused largely on needle-like, thin, coaxial-based interstitial antennae[35-37], for the purpose of achieving larger ablation zones and being appropriate for percutaneous use. To prevent over-heating of the shaft, avoid skin injury, and permit further deposition of energy into tissue with low impedance during ablation, cooled-shaft antennae have been developed in recent years. The cooled-shaft antennae have facilitated remarkable progress in obtaining larger ablation zones[25,38]. The diameter of the antenna is from 1.6 to 2.8 mm (10-16 G), while the antenna with a diameter of 14-16 G is clinically commonly used.

Some types of commercially available radiofrequency devices contain a thermocouple in the nickel-titanium lateral tine of expandable electrode tip to allow temperature recording during the ablation procedure. The aim of temperature monitoring is to ensure that the maximum energy is applied by using the standard algorithm with the system[39]. The microwave machine can also be equipped with a thermal monitoring system that continuously measures temperature in real time during ablation. The thermal monitoring needles are usually classified into thermocouple and thermistor types, with a diameter of 0.7-0.9 mm (20-22 G). The thermal monitoring needle is inserted into the target area through a nonconducting needle trocar for real-time temperature monitoring during ablation under US guidance. The purposes of temperature monitoring include the following. (1) Therapeutic: the temperature monitoring needle is inserted about 5-10 mm away from the tumor margin. Total tumor necrosis is considered to be achieved when the temperature remains at 54 ℃ for at least 3 min or reaches 60 ℃ instantly; and (2) Protective: for high-risk localized tumors (< 5 mm from the vital tissues, such as bile duct, gastrointestinal tract, gallbladder, and blood vessels), the real-time temperature of the tumor margin is monitored to ensure that temperature does not reach damaging levels. The temperature cutting off of ablation therapy is set at 54 ℃ in the patients without a history of prior laparotomy, or 50 ℃ in patients with a history of laparotomy. The emission of microwaves is reactivated after the temperature decreases to 45 ℃, and then in cycles until the entire tumor is completely encompassed by hyperechoic water vapor.

DIAGNOSIS AND INDICATIONS

Diagnosis

Pathological diagnosis is necessary for both HCC and metastatic cancer patients. The specific pathological result ensures that the tumor ablated is actually malignant, and tumor differentiation will also provide forceful surveillance guidance for the patients. Furthermore, the metastatic site can be confirmed to guide future chemotherapy and radiotherapy schedules. If the patients need to undergo biopsy to achieve pathological diagnosis, it is preferred to perform intraoperative tumor biopsy before ablation under US guidance. According to several

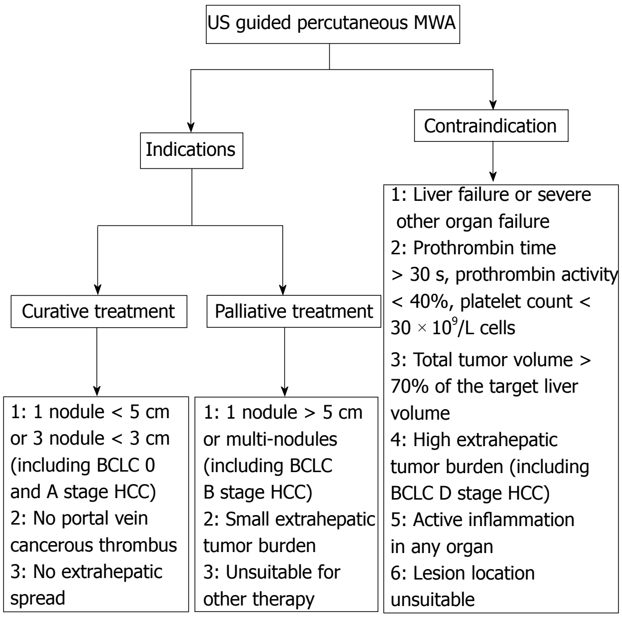

Figure 1 Indications and contraindications of ultrasound-guided percutaneous microwave ablation. MWA: Microwave ablation; BCLC: Barcelona Clinic Liver Cancer; HCC: Hepatocellular carcinoma; US: Ultrasound.

reports with large-volume liver cancer patients treated by MWA, the neoplastic seeding as a complication of liver puncture is low risk with a rate of 0.4%-0.6%[10,40,41] and is considered generally acceptable. Ablation immediately after biopsy might decrease seeding rate after biopsy and the thermal effect can stop bleeding after biopsy.

If the patient has obtained a histopathological diagnosis during previous treatment, or the tumor location or the patient's condition is not appropriate for the biopsy procedure, a combination of contrast-enhanced US, contrast-enhanced computed tomography (CT) and/or magnetic resonance imaging (MRI) associated with a rising serum tumor marker level is recommended. Contrast-enhanced imaging should include early arterial phase enhancement and be performed to define better the extent and number of primary lesions, vascular anatomy, vessel involvement, tumor involvement, and extrahepatic disease[42-44].

Indications

Given the complexity of the hepatic malignancy, multidisciplinary assessment of tumor stage, liver function, and physical status is required for proper therapeutic planning. In general, the indications for MWA are broad (Figure 1). One important application is to treat patients who are not considered surgical candidates. Included in this category are patients with inadequate liver remnant to tolerate resection, tumor multinodularity, unresectable lesions at difficult anatomical locations, or patients who decline resection. Previous MWA was limited to treat small liver tumors, but with the improvement of antennae and treatment strategies, lesions 5-8 cm can also be effectively ablated[10,45,46].

For patients with very early stage and early stage HCC [based on the Barcelona Clinic Liver Cancer (BCLC) Staging System[47]] and limited metastases, MWA should be considered as curative therapy. The inclusion criteria are: (1) a single nodule with a diameter < 5 cm or a maximum of three nodules with a diameter < 3 cm; (2) absence of portal vein cancerous thrombus; or (3) no extrahepatic spread to surrounding lymph nodes, lungs, abdominal organs, or bone.

Palliative treatment criteria for MWA include patients (1) with lesions > 5 cm in diameter or multiple lesions (including BCLC B stage HCC); (2) suffering from a small extrahepatic tumor burden (including part of BCLC C stage HCC); or (3) unsuitable for other modalities and capable of tolerating the MWA procedure.

Contraindications

Contraindications include patients who have: (1) clinical evidence of liver failure, such as massive ascites or hepatic encephalopathy, or with a trance-like state; (2) severe blood coagulation dysfunction (prothrombin time > 30 s, prothrombin activity < 40%, and platelet count < 30 × 10^9/L cells); (3) high intrahepatic tumor burden (tumor volume > 70% of the target liver volume or multiple tumor nodules) or high extrahepatic tumor burden (including BCLC D stage HCC); (4) acute or active inflammatory and infectious lesions in any organ; (5) acute or severe chronic renal failure, pulmonary insufficiency or heart dysfunction; and (6) tumor proximity to diaphragm, gastrointestinal tract, gallbladder, pancreas, hepatic hilum and major bile duct or vessels. Successful treatment of the high-risk localized tumor may require adjunctive techniques (*e.g.*, artificial fluid infusion or percutaneous ethanol injection) to prevent off-target heating of adjacent structures during the ablation procedure.

PATIENT PREPARATION AND DATA REQUIRED

Patients considered for MWA should be accurately evaluated through clinical history, physical examination, laboratory values and performance status. Pre-therapy evaluation of serum liver enzymes, cholinesterase, blood cell count, coagulation, creatinine, and tumor markers such as α-fetoprotein/carcinoembryonic antigen should be monitored and known before the procedure. The impaired liver function and coagulation status need to be corrected to withstand the ablation procedures. A full pre-ablation imaging work-up (a combination of contrast-enhanced imaging including US, CT or MRI) should be performed to stage, locate the lesions and exclude portal venous thrombosis and metastases accurately (Table 1).

Patients should receive both written and verbal information about the procedure prior to therapy. Informed written consent must be obtained from the patient. Patients should be informed that this therapy is not likely to cure their disease and is a palliative treatment directed at their liver lesions. Patients must be informed of the potential side effects of therapy as well.

Table 1 Indications and check list for microwave ablation of hepatic malignancy

Curative therapy	Palliative therapy	Check list
Single nodule with a diameter < 5 cm	Lesion > 5 cm in diameter	Histocytologic diagnosis
Maximum of 3 nodules with a diameter < 3 cm	Multiple lesions	US features of nodule (blood, location and size)
Absence of portal vein cancerous thrombus	Suffering from a small extrahepatic tumor burden	CEUS, CT or MRI of liver (lesion number, size, blood and location, portal venous thrombosis)
No extrahepatic spread	Unsuitable for other modalities	Laboratory tests (routine, coagulation function, serum biochemical item and tumor markers)

US: Ultrasound; CEUS: Contrast-enhanced ultrasonography; CT: Computed tomography; MRI: Magnetic resonance imaging.

TECHNIQUES

Patients are laid in the supine or oblique position in the interventional US suite. Color Doppler and gray-scale US are performed to choose the safest intercostal or subcostal needle access. Local anesthesia and/or intravenous conscious analgesia-sedation is usually sufficient for the percutaneous approach. Local anesthesia is induced first with 1% lidocaine from the insertion point at the skin to the peritoneum along the US-guided puncture line before inserting the antennae. Then, the skin is pricked with a small lancet, and the antenna is introduced into the chosen area of the tumor. In the multiple-needles procedure two or three prefixed puncture lines are made. Two or three active needle antennae directly connected to the MW generator are inserted into the tumor in parallel 1-2.5 cm apart. After placing all the antennae (breathing cooperation is required from the patient to complete the insertion), venous conscious analgesia-sedation is induced with propofol and ketamine associated with standard hemodynamic monitoring. At each insertion, the tip of the needle is placed in the deepest part of the tumor. 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. In general, the microwave energy application is set at 50-80 W for 5-10 min in a session.

Size of the ablation zone can be roughly judged by an expanding hyperechoic area arising during the procedure. For accurate assessment of the treatment efficacy, the thermal monitoring system attached to the MW generator can be used during MWA. One to three thermocouples are placed at different sites 5-10 mm outside the tumor. The thermocouple can be introduced into the parenchyma through an 18 G, 70-mm long, nonconducting needle trocar. If the measured temperature does not reach 60 ℃ by the end of treatment and does not remain at 54 ℃ for at least 3 min, the treatment is prolonged until the desired temperature is reached. Overheating can also be avoided by thermal monitoring, thus decreasing the incidence of complications. In recent years, contrast-enhanced US has been used for immediate assessment of technical success which is performed 10-15 min after MWA[48]. If the foci of nodular enhancement in the treated tumor is observed, a new MWA session with an identical device is performed as part of another course of treatment. When withdrawing the antenna, the needle track is coagulated with the circulated distilled water in the shaft channel, which is stopped to prevent bleeding and tumor-cell seeding.

This ablation therapy often includes a 5-10-mm ablative margin of apparently healthy tissue adjacent to the lesion to eliminate microscopic foci of disease, and the uncertainty that often exists regarding the precise location of actual tumor margin. For patients with severe liver cirrhosis or the lesion adjacent to critical organs, an ablation margin of < 5 mm or conformal ablation based on tumor shape and contours is recommended to ensure safe and radical treatment; otherwise, a 5-10-mm surgical margin is preferred. Reducing the tumor bulk or conformal ablation is the strategy for patients undergoing palliative ablation treatment.

CARE AFTER MWA

After the MWA procedure, the punctured site is covered with a sterile dressing under pressure. The patient then undergoes recovery for 4-6 h of bed rest. The patients are observed for 2-3 additional days and discharged from the hospital when they feel no severe pain or when their body temperature does not exceed 38 ℃.

COMBINED TREATMENT WITH OTHER MODALITIES

The therapeutic efficacy of MWA can be augmented by other therapies. Similar to other thermal ablation techniques, the coagulation area of MWA is also influenced by perfusion-mediated cooling. Interruption of hepatic blood flow can significantly increase the coagulation diameters[49]. TACE is an effective method for reducing the blood flow of liver tumor because of its artery-blocking effect. When combined with MWA, it may yield increased ablation volume. MWA can destroy the remaining viable part of the tumor after TACE, whereas TACE may possibly control microscopic intrahepatic metastasis that cannot be treated by MWA[50]. As the two modalities are complementary, the combination of them is preferred, especially for treating large and multiple tumors. The combination of TACE decreases the number of microwave antenna insertions and microwave irradiation time. The decision as to whether combined therapy with TACE, intermittent treatment, or sequential therapy is adopted should be based on the patient's general condition, liver function, local tumor size and number, tumor infiltration, tumor vascularization, and reaction of tumor to local treatment. Therefore, the principle of individual treatment must be advocated.

For patients with high-risk localized tumors, combination of multiple techniques to ensure favorable effects and few complications is also recommended. Hepatic tumor in high-risk sites refers to tumor adjacent to important organs and tissues including the diaphragm, gastrointestinal tract, hilum and major bile duct or vessels. The thermal energy may spread into surrounding structures, therefore, the major concern for MWA of such tumors lies in the increased opportunity of thermal injury in the important structures. However, combined with artificial ascites, artificial pleural effusion, intraductal saline perfusion, intermittent emission of microwave antennae, and temperature monitoring assisted with small-dose percutaneous ethanol injection[51-55], MWA becomes feasible for the treatment of dangerous site tumors without sacrificing the therapeutic efficacy.

Although US guidance has the benefits of real-time visualization of applicator placement, portability of the technology, nearly universal availability and low cost, it has several limitations including occasional poor lesion visualization as a result of a lack of innate tissue conspicuity or overlying bone- or gas-containing structures. MWA assisted by a real-time virtual navigation system is a feasible and efficient treatment of patients with lesions undetectable by conventional US[56]. Recently, 3D US-guided MWA avoids the limitation of inaccurate needle placement and the skill requirement resulting from conventional US guidance. These new techniques provide an appealing alternative option, enabling the physician to perform consistent, accurate therapy with improved treatment effectiveness[57,58].

FOLLOW-UP AND THERAPEUTIC EFFICACY ASSESSMENT

The Working Group on Image-Guided Tumor Ablation proposed that postprocedural follow-up of patients to assess any treatment-emergent side effects and tumor response is conducted in the first week or, at the latest, no more than 4 wk after the last course of a defined ablation protocol[59]. Subsequent routine follow-ups are then recommended every 3-4 mo. Evaluation of therapeutic effects, including technique effectiveness, local tumor progression, and complications, is recommended. The Working Group also recognized the need for close surveillance and early reintervention to achieve optimal primary tumor ablation success.

Frequent imaging studies may be required for individual patients to assess the therapeutic efficacy and to detect the intrahepatic recurrent lesion. To ensure continuity of the follow-up, most of the studies are recommended to be performed serially at the institution where the ablation is performed. The imaging studies should consist of a high-quality, contrast-enhanced CT/MRI or US, adhering to standard scanning protocols to facilitate comparisons. Intravenous contrast is critical because pathological studies have shown that the best correlation of necrotic tissue is defined by the zone of non enhancement on cross-sectional studies[60-62]. If any areas of the ablated mass are devoid of enhancement on follow-up enhanced imaging performed 1 mo after MWA, technique effectiveness, namely complete response, is achieved[59]. Then routine contrast-enhanced US, CT or MRI and serum tumor markers are repeated to detect the local treatment response and intrahepatic and extrahepatic metastases at 3-mo intervals after MWA. If irregular peripheral enhancement in scattered, nodular, or eccentric pattern occurs in the original sites that were previously considered to be completely ablated during follow-up, which represents local tumor progression, further ablation should be considered as soon as possible if the patient still meets the criteria for MWA. US scanning is the routine baseline examination method for the ablation zone. During follow-up, the treated lesions slowly diminish in size, becoming undetectable by US, or appearing only as small hyperechoic areas or isoechoic areas with a hypoechoic rim, or simply as heterogeneous areas. On contrast-enhanced imaging, the ablation zone presents as a non-enhancement area. Additionally, positron emission tomography may be helpful in identifying distant extrahepatic metastatic disease, and it can be considered as a part of the postoperative evaluation if necessary.

Major complications of MWA are events that lead to substantial morbidity and disability, increase the level of care, or result in hospital admission or substantially lengthen hospital stay. Major complications includes bile duct stenosis, uncontrollable bleeding, liver abscess, colon perforation, skin burn and tumor seeding (Table 2)[4,5,13,19,34,36,42,63,64]. These can be controlled by surgical operation, interventional approach, or medical therapy. Side effects are undesired consequences of the procedure that, although occurring frequently, rarely if ever result in substantial morbidity. Side effects include pain, post ablation syndrome, and asymptomatic pleural effusions, which are usually self-limited and do not require any further treatments. Low-grade fever and general malaise are common manifestations of post ablation syndrome. Careful patient selection, the most appropriate imaging modality, and the best puncture routine may also help prevent complications.

DISCLAIMER

The SCIU has written and approved the guidelines to promote the cost effective use of high-quality MWA therapeutic procedures. Percutaneous MWA techniques are recommended for use by clinical or imaging doctors with at least 3 years experience with interventional procedures. These generic recommendations cannot be rigidly applied to all patients in all practice settings. The guidelines and technology assessments are not intended to supplant physician judgment with respect to particular patients or special clinical situations, and not be deemed

Table 2 Procedure-related complications for microwave ablation of hepatic malignancies

Study	Intraperitoneal bleeding	Bile duct injury	Colon perfo-ration	Liver abscess	Skin burn	Tumor seeding	Symptomatic pleural effusion	Perioperative mortality
Sakaguchi *et al*[4]	0.51%	0.26%	0.00%	0.26%	0.77%	0.00%	1.28%	0.00%
Martin *et al*[5]	0.00%	0.00%	0.00%	2.00%	0.00%	0.00%	0.00%	0.00%
Zhang *et al*[13]	0.00%	1.25%	0.00%	0.00%	0.00%	0.00%	0.63%	0.00%
Shibata *et al*[19]	0.00%	2.78%	0.00%	2.78%	2.78%	0.00%	0.00%	0.00%
Kuang *et al*[38]	0.00%	0.00%	1.11%	1.11%	0.00%	0.00%	2.22%	0.00%
Liang *et al*[40]	0.09%	0.18%	0.18%	0.44%	0.26%	0.44%	1.06%	0.18%
Yin *et al*[46]	0.92%	0.92%	0.00%	0.00%	0.92%	0.00%	3.67%	0.00%
Dong *et al*[63]	0.00%	0.00%	0.00%	0.00%	0.85%	0.00%	0.00%	0.00%
Iannitti *et al*[64]	0.00%	0.00%	0.00%	0.00%	3.45%	0.00%	0.00%	0.00%

inclusive of all proper procedures or exclusive of other procedures reasonably directed towards obtaining the same results. Accordingly, SCIU considers adherence to this guideline assessment to be voluntary, with the ultimate determination regarding its application to be made by the physician in light of each patient's individual circumstances. At present, the guidelines have been put into practice in China by seven branches of the Chinese Medical Association, through holding standardized courses (3 finished), training and checking interventional physicians (> 300 physicians having obtained MWA licenses), and founding ablation demonstration bases (5 founded). MWA is undergoing rapid development and receiving keen interest in Europe and America, so access and training systems for MWA guidelines are expected to be recommend according to the situation in each country. The guidelines will be updated when data or publications might change a prior recommendation or when the panel feels clarifications are required for the oncology community.

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