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Original Research Article

Percutaneous Microwave Ablation for the Liver Tumor: Assessment of Therapeutic Efficacy Using Intraoperative Reconstructed CT

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Abstract: Microwave ablation (MWA) provides a promising treatment for liver tumor. This study aimed to evaluate the therapeutic efficacy of reconstructed CT–guided MWA in liver tumors. A retrospective study was conducted for 52 liver tumors (2.24 ± 0.84 cm, 0.8–4.0 cm) in 49 patients (29 men and 20 women; 59.7 ± 12.0 years) who were treated with reconstructed CT-guided MWA from February 2015 to September 2015. Baseline characteristics of patients and tumors were recorded, and technical details were depicted. Technical success and technique efficacy were evaluated. In results, MWA was performed in all patients successfully (n=49), and the complete ablation rate was 100% (52/52). Mean follow-up time was 10.1 ± 2.5 months (range, 6–15 months). Cumulative local tumor recurrence (LR) was 1.9% (1/52), 5.8% (3/52), and 7.7% (4/52) at 1, 3, and 6 months respectively. Cumulative distant recurrence (DR) was 3.8% (2/52), 7.7% (4/52), and 7.7% (4/52) at 1, 3, and 6 months respectively. Until May 2016, all patients were conscious and alive. In conclusion, reconstructed CT-guided MWA is feasible with high technique efficacy in the treatment of hepatic tumors.
Keywords: liver tumor; microwave ablation; reconstructed CT.

INTRODUCTION

Microwave ablation (MWA) has become a well-accepted tool in the management of liver tumors [1-3]. Ultrasound and CT are two main guiding modalities used in MWA procedures. Ultrasound aids in guiding the puncture with real time and benefits with no radiation to patients and doctors, but it cannot delineate the tumor localizing deep or under the diaphragm without a good vision. CT is a common instrument, which provides good quality images, with high accuracy indicating the target tumoral site and clearly mapping the ablated zone. Furthermore, reconstructed CT can create multiplanar reconstructions (e.g. coronal, sagittal, other oblique planes) besides trans-axial images for the ablation of nodules that were difficult to access, and a safe approach will be provided. The advantages [4, 5] have been reported in the ablations of hepatic dome tumor under the guidance of reconstructed CT to avoid injury to surrounding structures. While, more than the provision of a safe and optimized approach, reconstructed CT images can also be used to confirm the spatial relationship between the antenna and the targeted tumor from at least two planes, thus making accurate ablation.

In this study, we aimed to evaluate the overall technical success and efficacy of reconstructed CT-guided MWA of liver tumor not limited to specific locations.

MATERIAL AND METHODS

Patient population

A retrospective review was conducted on data acquired from our hospital after being approved by institutional review board. Although informed consent for this retrospective study was waived for all the enrolled patients, written informed consent was obtained from every patient for each procedure.

The inclusion criteria for hepatic MWA were: Child–Pugh A or B; absence of vascular invasion; and pre- and post-operative images were obtained. The exclusion criteria were the following: platelet count less than $50\times10^3/mm^3$ or prothrombin activity lower than 50%; loss of follow-up after MWA; extra-hepatic metastases or any other malignancy.

From February 2015 to September 2015, 49 patients (20 men, 29 women; mean age, 59.7 ± 12.0 years) with 52 hepatic tumors who underwent reconstructed CT-guided MWA therapy with a curative intention in our department were identified. The demographics of all cases are listed in Table 1. 18 tumors were centrally located and 34 tumors were adjacent (<=2 cm) to risk structures such as diaphragm (n=24), gall bladder (n=7), and gastrointestinal tract (n=3). Mean tumor size was 2.24 ± 0.84 cm, (range, 0.8–4.0 cm). Postoperative outcomes were analyzed including the residuals of tumor and recurrence primarily, complications secondly.

Table1: Baseline Characteristics of Patients

Characteristic	Value
Sex	
Male	29
Female	20
Age(y)	59.7 (range, 35–79)
Child-Pugh classification	
A	45
B	4
Diagnosis	
HCC	41
CLM	8
No. of tumor per patient	
1	46
2	3
Diameter of tumor(cm)	2.24 ± 0.84(range, 0.8–4.0)
Location	
parenchyma	18
adjacent to risk area	34
diaphragm	24
gall bladder	7
gastrointestinal tract	3
ECOG performance status	
0	41
1	4
2	4

HCC: Hepatocellular carcinoma, CLM: Colorectal liver metastasis, ECOG =Eastern Cooperative Oncology Group

Microwave ablation

All interventions were performed under reconstructed CT guidance (Emotion 16, SIEMENS, Germany). MWA was performed using a microwave ablation system (ECO-100A Yi Gao, Nanjing, China) with a frequency of 2450 ± 50 MHz and a continuous adjustable power output of 0-150 W, under general anesthesia. An internally cooled antenna (14G in diameter; active tip, 11mm) was used.

A homemade grid was affixed on the abdominal skin. Plain CT images were obtained under expiration, and reconstructed CT images were generated individually to demonstrate tumor shape, tumor location, and the optimized puncture trajectory. The tumor center was the targeted zone with a puncture point away inferior to the base of the lung. A satisfied puncture trajectory which was pursued should avoid injury to large vessels, gallbladder, and intestines. A vivid example was presented in Fig. 1.

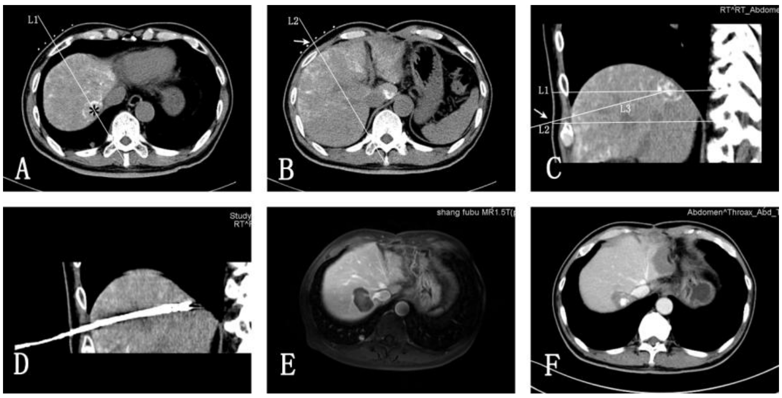

Fig-1: Reconstructed CT-guided MWA of a 1.73 cm diameter HCC nodule located at segment VIII adjacent to diaphragm. (A) The asterisk indicated the nodule and L1 indicated the simulative puncture route passing through the lung parenchyma. (B) The selected section contained no lung tissue when scanned with CT. L2 was parallel to L1, and the arrow showed the selected puncture point. (C) The illustration showed the spatial positional relationship of L1, L2, puncture point (arrow) and tumor on oblique reconstructed image. (D) The real antenna was accurately inserted into the nodule based on the trajectory (L3) determined on image C. (E) MRI, the second day after MWA, showed complete ablation. (F) 3 months after MWA treatment, enhanced CT showed uniform hypoattenuation in the ablated area, which indicated complete ablation

According to the puncture trajectory determined as referred above, the antenna was inserted into patient step by step at the end of expiration. CT scans were followed immediately after each partial insertion and reconstruction CT images were generated to show the spatial direction relationship between the antenna and the target tumor in axial and oblique planes, which was used to guide the direction and depth of next partial insertion of the antenna. The final position of the antenna was confirmed by an additional CT scan and its reconstructed images.

Depending on the tumor size, a mode with a certain power output for a suitable duration was set for ablation according to the standard recommendations provided by the manufacturer of the equipment. After completion of the ablation session, a CT scan was performed to assess eventual complications, such as of pneumothorax, bleeding et al. All procedures were performed by the same experienced interventional radiologists.

The number of punctures was calculated according to the number of times the antenna was withdrawn, and if only the direction of antenna has been changed without any withdrawl the puncture number was considered the same. In other words, if puncture angle was adjusted without any minor withdrawl of antenna, the number of puncture is still considered to be one.

Follow-up

MR or contrast enhanced CT was performed on the second day after MWA and follow-up MR or CT were obtained at 1month, 3month, 6 month of the first half year respectively. Complete ablation (CA) was defined as the ablation zone completely covering the tumor area without any irregular enhancement around the treatment margin; Incomplete ablation (ICA) was defined as any irregular contrast enhancement that was found inside or next to the ablation zone; Local tumor recurrence (LR) was defined as a new lesion that appeared in or adjacent to the successfully treated lesion or an enlargement of the treated lesion; Distant recurrence (DR) was defined as the presence of new intra-hepatic or extra-hepatic tumor nodules [6]. According to the Society of Interventional Radiology (SIR) grading system, complications from major to minor were recorded [7, 8].

Technical Success was a term simply used to address whether the tumor was treated according to protocol and was covered completely by the ablation zone [8]. Technique efficacy was demonstrated with 6 months' follow-up for each treated tumor.

Statistical analysis

Continuous data are expressed as means ± standard deviation. Statistical analyses were performed using SPSS 19.0 (SPSS, Chicago, IL, USA).

RESULTS

Technical success

MWA was performed in all patients (n=49) successfully. No residual tumor was detected in MR or CT the second day after MWA. The procedure lasted for 35 minutes in average, ranging from 26-56 minutes. The mean scan times were 4.33, ranging from 3-13. The number of punctures done were 3 for 2 procedures (2/52, 3.8%), 2 for 14 procedures (14/52, 26.9%), one for 36 procedures (36/52, 69.2%). The mean number of punctures were 1.35.

Technique efficacy

Cumulative LR was 1.9% (1/52), 5.8% (3/52), and 7.7% (4/52) at 1, 3, and 6 months respectively. Cumulative DR was 3.8% (2/52), 7.7% (4/52), and 7.7% (4/52) at 1, 3, and 6 months respectively (Fig. 2). Until May 2016, all patients were alive.

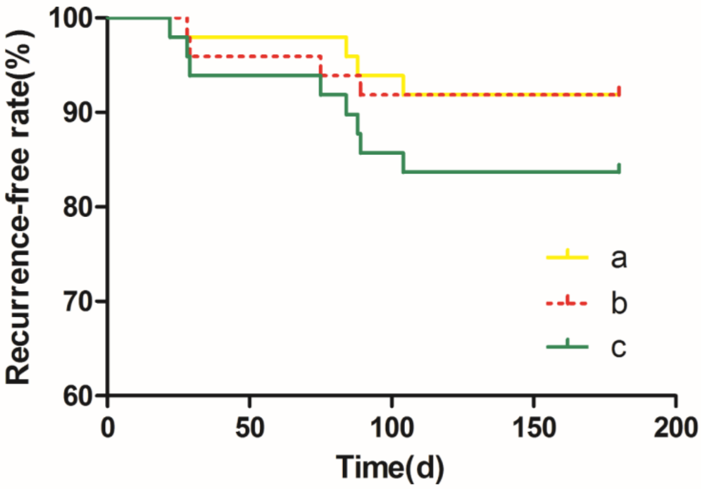

Fig-2: The cumulative recurrence-free survival curve of 52 tumors treated with intraoperative reconstructed CT-guided MWA. a : local recurrence-free; b: distant recurrence-free; c : total recurrence-free(neither local nor distant recurrence occurred)

Complications

A number of adverse events were noted and graded by SIR grading system. Post-MWA minor complications (fever, nausea, vomiting, and abdominal pain) occurred in 37 patients (75.5%), while major complication related subcutaneous seeding occurred once which was properly controlled using I^{125} insertion.

DISCUSSION

We reported the experience of reconstructed CT-guided MWA of hepatic tumors. All MWA procedures were achieved in 52 lesions with complete ablation. At six month follow-up, all patients (n=49) survived, LR and DR was detected in 4 patients respectively. One major complication occurred in 1 patient presenting with subcutaneous seeding.

CT and ultrasound are two of most guiding modalities used in liver thermal ablation. While, for nodules abutting the diaphragm, it is difficult to be demonstrated on ultrasound because of scattering of echoes due to the gas present, and it is inevitable to puncture through lung parenchyma and the diaphragm under the guidance of axial CT images, which may cause pneumothorax. Though some researchers artificially induced hydrothorax before ablation [9-12], patients with adhesions of the pleura or poor lung function may not be indicated for artificial pleural effusion. Multiplanar reconstruction (MPR) can generate images in any plane, and could be used to optimize puncture trajectory, avoiding the damage to important structures. Previous studies [4, 5] showed that CT-guided thermal ablation by oblique insertion using MPR images was a feasible and safe therapeutic option for the treatment of tumor located under the diaphragm. In this study, MWA of 24 lesions locating under the diaphragm were achieved by caudal-cranial oblique insertion using MPR images without injury of lung parenchyma.

In another aspect, MPR images could be used to evaluate the positional relationship between the lesion and the antenna in multiple planes. Conventional axial CT images guided ablation can only provide the visual positional relationship in one plane, while the operator had to evaluate the caudal-cranial positional relationship by counting the number of slices, which was significantly affected by partial volume effect of CT scanning. In this study, after each insertion of the antenna, axial CT images were acquired and MPR images were generated to guide the next insertion of the antenna, thus leading to accurate puncture in at least two dimensions (Fig. 3). The average number of punctures was 1.35 in this study, which was comparable to Gao's study.[4] In the current study, the technique efficacy was compared favorably with other studies [13, 14]. Cumulative DR and LR were both 7.7% (4/52) at 6 months follow-up in our study. Additionally, MRP images could also be used to evaluate the shortest distance between the antenna and the risk structures, such as gall bladder and gastrointestinal tract, to avoid the thermal injury caused by excessive ablation [15].

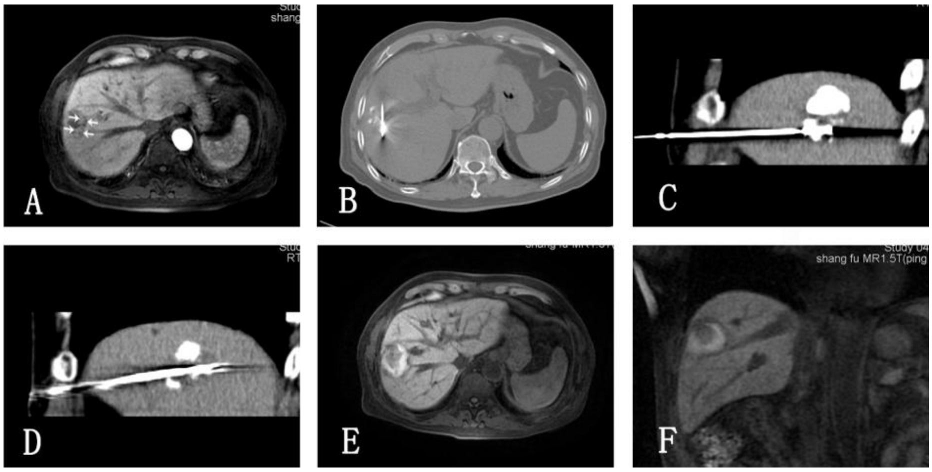

Fig-3: Reconstructed CT-guided MWA of HCC nodule. (A) MR image illustrates a 2.52 cm diameter HCC nodule (arrows). (B) The antenna was judged at center of the nodule on axial CT images only, but (C) reconstructed sagittal image demonstrated that the antenna was actually at the bottom of the nodule. (D) After adjusting the antenna, a satisfactory insertion was achieved on both transverse and sagittal images. Considering the adjustment done here, number of puncture was calculated as two for this procedure. (E) and (F) The second day post-ablation T1-weighted images demonstrated that the nodule was completely eliminated without surrounding tissue damage

Because the MPR images were usually generated automatically once the reconstruction plane was fixed, the employment of MPR images did not extend operation time. Thorough analysis of tumor features and preparation for possible approaches are strongly highlighted before the procedure. Antennas should be advanced further in a step-by-step manner, and after each insertion there is enough distance left for adjustments.

The present study has several limitations including single-center, retrospective as well as unpaired design, and the relatively small number of patients with a short follow up. Due to the small number in this study, the evaluation of factors like patients' age, HBV-DNA, AFP level, tumor size, and location were not performed.

CONCLUSION

In summary, reconstructed CT-guided MW ablation is feasible with high technique efficacy in the treatment of hepatic tumors.

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