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ORIGINAL ARTICLE

The first clinical application of planning software for laparoscopic microwave thermosphere ablation of malignant liver tumours

Eren Berber

Departments of General and Endocrine Surgery, Cleveland Clinic, Cleveland, OH, USA

Abstract

Background: Liver tumour ablation is an operator-dependent procedure. The determination of the optimum needle trajectory and correct ablation parameters could be challenging. The aim of this study was to report the utility of a new, procedure planning software for microwave ablation (MWA) of liver tumours.

Methods: This was a feasibility study in a pilot group of five patients with nine metastatic liver tumours who underwent laparoscopic MWA. Pre-operatively, parameters predicting the desired ablation zones were calculated for each tumour. Intra-operatively, this planning strategy was followed for both antenna placement and energy application. Post-operative 2-week computed tomography (CT) scans were performed to evaluate complete tumour destruction.

Results: The patients had an average of two tumours (range 1–4), measuring 1.9 ± 0.4 cm (range 0.9–4.4 cm). The ablation time was 7.1 ± 1.3 min (range 2.5–10 min) at 100W. There were no complications or mortality. The patients were discharged home on post-operative day (POD) 1. At 2-week CT scans, there were no residual tumours, with a complete ablation demonstrated in all lesions.

Conclusions: This study describes and validates pre-treatment planning software for MWA of liver tumours. This software was found useful to determine precisely the ablation parameters and needle placement to create a predicted zone of ablation.

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Correspondence

Eren Berber, 9500 Euclid Ave /F20, Cleveland, OH 44195, USA. Tel.: +1 216 445 0555. Fax: +1 216 636 0662. E-mail: berbere@ccf.org

Introduction

Although liver resection offers patients with malignant liver tumours the best chance of a cure, the majority of the patients are not candidates because of inadequate liver remnant, underlying cirrhosis and accompanying medical co-morbidities. Thermal ablation modalities, including radiofrequency ablation (RFA) and microwave ablation (MWA) offer treatment options to a significant number of these patients in whom a hepatectomy is not feasible. These ablation modalities are needle-based therapies that rely on the skill and experience of the surgeon or radiologist performing the procedure. The success of the procedure depends on the selection of a correct ablation algorithm, and accurate needle placement, to ensure the creation of an ablation zone encompassing the tumour with a margin.

Pre-treatment planning, with the pre-operative determination of the surgical strategy, in regards to how the lesions in a given patient will be treated, may increase the efficiency and efficacy of the operation. Furthermore, this may also help in simplifying the procedure when an ablation modality with a complex algorithm is utilized.

Microwave thermosphere ablation is a newer technology, which offers significant advantages when compared with RFA, in terms of more efficient tissue heating, with potentially shorter ablation times and fewer treatment failures owing to a less prominent 'heat sink effect'.[1–8] Although there are reports on pre-planning for percutaneous RFA under computer tomography (CT) guidance in the radiology literature,[9,10] pre-planning for a surgical liver tumour ablation is a new concept, with no reports on MWA. The aim of this study was to describe the initial clinical use of a new, planning software for microwave thermosphere ablation of malignant liver tumours.

Patients and methods

This was an Institutional Review Board-approved prospective study. Pre-treatment planning software (Emprint Procedure

Planning Application, Covidien, Boulder, CO, USA) was used to determine the treatment strategy in patients undergoing laparoscopic MWA of malignant liver tumours. The patients' tri-phasic CT scans were loaded into the software, and the lesions were individually selected using target markers around the tumours in the axial, coronal and sagittal planes. A three-dimensional image of the lesion was created by the software (Fig. 1). Using a second set of target markers, the desired zone of ablation was overlapped around the tumour (Fig. 2). This projected ablation zone could be moved around the tumour, and its size in three dimensions could be adjusted using the computer mouse. Based on the predicted zone of ablation, the software calculated the ablation diameter, antenna insertion depth, and minimum and maximum margin covered around the tumour. By choosing the power setting, the software calculated the time required to create that ablation zone. Using the computer mouse, the needle angle, insertion length and its position within the tumour could be adjusted for the surgeon to choose the final ablation parameters.

This pre-planning software was used and validated in five patients who underwent laparoscopic MWA of nine malignant liver tumours between December 2014 and January 2015, by one surgeon (E.B.). The tumours were treated by following the parameters determined by this software pre-operatively. The microwave probe was inserted under laparoscopic ultrasound guidance into the tumours at the position determined by the pre-treatment software, and the ablation was carried out for the duration of time again calculated by this software pre-operatively. CT scans, obtained 2 weeks after ablation, were analysed for completeness of tumour destruction, guided by the planning software. Continuous data are expressed as the mean ± standard error of the mean.

Surgical procedure

The procedure was done under general endotracheal anaesthesia, with the patients supine. Two grammes of cefazolin was administered intravenously for antibiotic prophylaxis. Two 12-mm trocars were used in the right upper quadrant, 1 for the angled laparoscope and the other for the laparoscopic 10 MHz linear, side-viewing ultrasound transducer (Aloka, Wallingford, CT, USA). Initially diagnostic laparoscopy was performed, followed by surgeon-performed liver ultrasound. In those patients without a pre-operative tissue confirmation, a percutaneous biopsy of a representative lesion was performed using an automated biopsy gun. The size and the location of tumours were recorded. Then the microwave ablation antenna

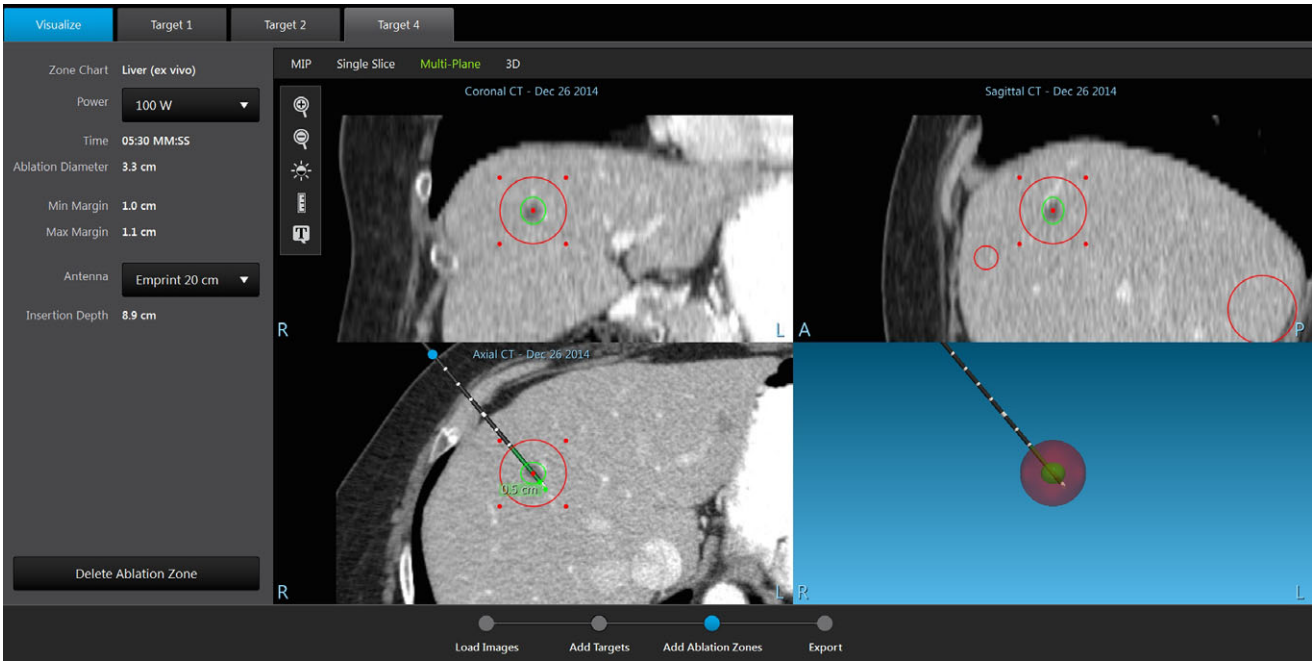

Figure 1 The computer captures are showing pre-treatment planning, which involves the selection of the liver tumour with the region of interest marker (green circle) in the axial, coronal and sagittal planes. Once this is done, the software creates a three-dimensional image of the lesion. Then another region of interest (red circle) is placed around the tumour, to represent the ablation zone planned. The software also demonstrates how the needle needs to be positioned within the tumour to create this ablation zone. This projected ablation zone can be moved around the tumour, and its size in three dimensions can be adjusted using the computer mouse. The insertion angle and depth of the needle can also be changed. In the final window, the software displays the predicted ablation zone overlapping around the tumour, which can be magnified to see the exact position of the antenna