

Software assisted treatment planning of image guided RF ablations

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Abstract :

Percutaneous image guided radiofrequency (RF) ablation has gained increasing importance in the clinical routine as a minimally invasive method for the treatment of focal malignancies, especially in the liver. In case of larger tumors, repositioning or multiple placement of RF applicators is required to achieve complete ablations.

Image guided procedures can be assisted by appropriate software packages to improve the treatment efficacy [1]. In this report, we describe a software-assisted approach for an easy-to-use treatment planning system, adapted to the requirements and time constraints of daily clinical routine.

Keywords: RF Ablation, Image guidance, interventional oncology, Therapy planning

1 Problem

In recent years, percutaneous image-guided ablative therapies using thermal energy have been developed as minimally invasive strategies for the treatment of focal malignancies. Among them, radiofrequency (RF) ablation has taken a significant part in the clinical routine because of its efficacy combined with easy application and a low complication rate. In particular, RF-ablation has become one of the most important alternatives to surgical resection for the therapy of liver metastases as well as a complementary method to the treatment of liver malignancies.

The success of RF ablation therapy strongly depends on an adequate planning of the intervention, particularly for large tumors which require repositioning of the electrode or usage of multiple RF applicators. The planning includes the choice of suitable RF applicators as well as the determination of the access path and the estimation of the achievable affected area.

In this paper, we describe a software-assisted approach for an easy-to-use treatment planning system that is adapted to the requirements of daily clinical routine, e.g. time constraints.

2 Methods

The treatment depends on the size, shape and position of the target tumor. For a quick verification of these measures we use a morphology based region growing tumor segmentation as described by Bornemann et. al. in [2]. With a median time effort of 30 seconds per lesion and success rates from 88% (liver metastases) to 91,4% (lung metastases) in CT scans it seems highly suitable for our purposes. The segmentation task can be performed by the user with a single mouse interaction; the resulting area is represented in the original image as a colored overlay. A corresponding security margin can be defined by the physician; the resulting area will be calculated and visualized automatically afterwards (Figure 1).

Based on the detected tumor size and shape a suitable RF applicator can be chosen from a list of available types. The virtual model of the chosen applicator type can be placed and moved within the planning image by mouse interactions. After the positioning has been finished, the corresponding expected coagulation area can be visualized using its surrounding contour. Instead of using a time-consuming numerical simulation procedure (e.g. [3]), we use simple geometric shapes such as ellipsoids for a rapid estimation of the affected area, based on specifications given by the RF applicator vendors. The shape parameters can be adapted by the physician according to personal experience. After a position has been determined, additional coagulations can be set by repeating the previous step until the tumor area is completely enclosed (Figure 2). Each applicator position can be recalled and visualized for orientation purposes during the interventional probe placement task.

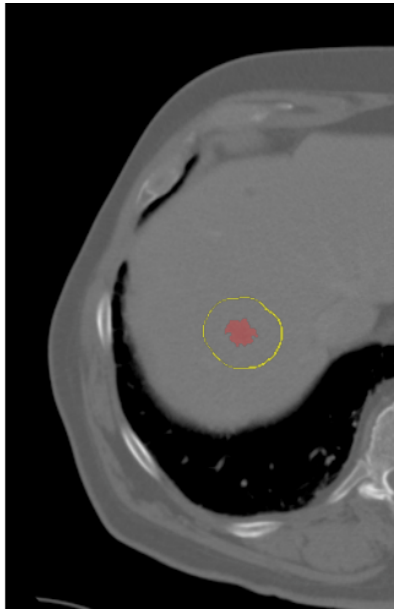


Figure 1: Segmented tumor with corresponding security margin

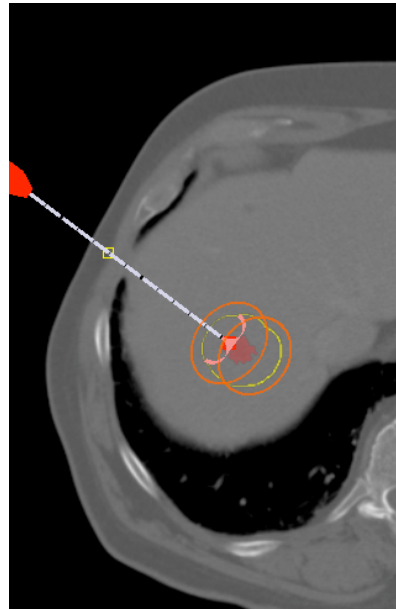


Figure 2: Treatment planning with a virtual RF applicator and corresponding estimated affected areas.

3 Results

The segmentation of the target tumor provides information about the size, shape and position of the tumor area, which is useful for the physician, concerning the choice of the RF applicator type and the trajectory planning. A simple geometric estimation of the achievable ablation area gives an initial feedback to the treatment strategy. The software assistant is adapted to clinical requirements such as easy applicability and minimum time effort. The software has been installed at several radiological departments for evaluation purposes.

The usage of virtual RF applicators and the visualization of corresponding coagulation geometries has been discussed with radiologists from collaborating hospitals within a software evaluation workshop in November 2007. In summary, the interactive applicator placement was rated as intuitive, while the variety and visualization of applicator models were rated as suitable and useful. The usage of simple geometric shapes for the visualization of the affected area seems to be useful for an initial estimation, although the manufacturer's specification of the reachable size were questioned and should be replaced by measurements of corresponding clinical studies, if available.

4 Discussion

Although the visualization of simple geometric shapes is not highly precise compared to the real coagulation shape, it provides a quick initial guess of the achievable affected area, which can be useful in most cases. Future work will concentrate on the evaluation of coagulation shapes that are more precise and on the influence of cooling effects caused by vascular structures.

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6 References

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