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Feasibility of CT Image Analysis For Assessment of Thermal Ablation

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Extended Abstract

Background:
Minimal invasive procedures are an emerging trend in modern surgery. One of the more popular procedures is thermal ablation for tumour treatments. In many cases, a needle type applicator is inserted into the target tissue. Then, radio-frequency (RF), microwave (MW), or laser energy is administrated around the tip of the applicator. This results in a rapid temperature elevation and finally ablation of the cancerous tissue in the vicinity of the applicator. Accurate mapping of the induced damage is still one of the major technical challenges that need to be resolved for such treatments.

Objective:
The aim of this study was to explore the feasibility of assessing the thermal ablation size, around the applicator, by applying image processing tools to CT images acquired during the process.

Methods:
Three ex-vivo bovine livers were scanned by CT during a thermal ablation procedure. Ablation was induced using a 14G MW antenna with a power of 40 Watts for the duration of 6 minutes. The anticipated ablation zone radius was approximately 17 mm. During the heating, CT images were acquired every 5 seconds, perpendicular to the antenna, and were analysed using two methods: The first was Hounsfield units (HU)-based analysis, where a radial projection of the image was created around the MW tip. The mean HU value of each radius was calculated. The radius that yielded the same value as the reference value of the untreated-tissue was considered to enclose the ablation zone. With the second method, the textural entropy of the CT image was calculated, and the equivalent radius of the entropy region was found. Additional liver blocks were heated using the same conditions, but for different time durations. They were cut post-ablation for a gross histology analysis, and the ablated, “white” zone of the ablation was measured to form a “gold-standard” measurement of the ablated area as a function of time.

Results:

The HU-based ablation size estimation was calculated as a function of time, and was compared to the "gold-standard" curve. Both, the "gold-standard" curve and HU-based ablation size estimation results, depicted a monotonic increasing trend of ablation size.

At the end of the procedure the HU analysis radius was 16.9±4mm, while the measured radius was 17.9±1.2 mm. The preliminary results reported here demonstrate strong similarity between these two curves (average difference=0.67 mm, R^2=0.95).

The entropy-based method, also produced high correlation with the “gold-standard" curve (R^2=0.97), suggesting their validity as yet another ablation size estimation method.

The entropy curve has also depicted an increasing monotonic trend, but provided a consistent over-estimation of the ablation size for the estimated radius (average difference=5.12mm), and the ablation radius estimation at the end of the procedure was 24.2±8.3mm

Conclusions:

Based on the results presented here, it is suggested that a non-invasive estimation of the ablation zone can be obtained by implementing image analysis techniques to CT images, such as the HU-based analysis. The entropy-based analysis can provide an estimation of a "safety-margin”, where tissue beyond this region can be considered as untreated.

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