Apparent diffusion coefficient in evaluating early treatment response after CT-guided microwave ablation for non-operable pulmonary malignancy: promising results

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Aims and objectives

Image-guided ablation techniques are common treatment options for non-operable primary and metastatic lung tumors, most commonly radiofrequency (RFA) and microwave ablations (MWA). The local tumor progression rate following local ablation can be more than 30 %, so that early detection of these patients makes them benefit from a repeated ablation [1-3].

The post-ablation imaging follow-up usually consists of an early chest CT performed within the first week after treatment, followed by further CT examinations at regular intervals with additional PET/PETCTs if required [4,5].

MR diffusion-weighted imaging (DWI) is an imaging modality; which is based on the measurement of motion of water molecules, has also been reported as a non-invasive evaluation modality [6-8].

In this method, the apparent diffusion coefficient (ADC) represents the water content and distribution, the cellular density and integrity of the cell membranes, suggesting the potential usefulness of an ADC map for estimating tumour viability (6).

Few studies have reported the use of DWI to evaluate the treatment outcome of RFA [7, 8]. A previous study reported that the ADC value of an ablated rabbit tumour model (VX2 tumour) was significantly higher than that of untreated tumours, and that FDG uptake on micro- PET for small animals with ablated tumours was significantly lower than for untreated tumours. These results indicate that DWI at 2 days and FDG-PET at 3 days after RFA are both feasible modalities for monitoring the early effects of local ablation procedure [8].

The aim of this study is to determine retrospectively the early treatment response of microwave ablation (MWA) in patients with non-operable pulmonary tumors using apparent diffusion coefficient (ADC) value.
Methods and materials

47 patients with 68 lung lesions from December 2007 till December 2017 were included (22 males & 25 females) and treated with MWA according to the guidelines. All lesions were evaluated by MRI with diffusion weighted imaging (DWI) and ADC value measurement before and 24 hours after MWA. DWI was obtained using axial single-shot echoplanar imaging with Quiet breathing for short-time inversion recovery (SPAIR)-DWI (6 mm thick, gapless, TR/TE 5 5700/82 ms, b values 0,400 and 800, matrix size 128 x 128) using 3 tesla MRI machine. Quantitative ADC maps were calculated using commercially available software and an imaging workstation. Diagnosis of lung tumors relied on chest CT and/or MRI with contrast. Follow-up post ablation by chest CT and/or MRI after 24 hours, three, six months, one year and every 6 months onwards to determine responsive cases and local progression cases with residual tumor activity. Immediate post ablation changes in ADC values were compared to the net response based on CT and/or MRI follow-up.
Results

44 lesions (64.7%) showed complete response to treatment and 24 lesions (35.3%) with local progression (residual activity). ADC values were significantly higher in lesions that responded to MWA than in non-responding lesions.

The mean ADC value before treatment was $0.8 \pm 0.2 \times 10^3 \, \text{mm}^2/\text{s}$ (mean ± SD), while after treatment it was $1.7 \pm 0.3 \times 10^3 \, \text{mm}^2/\text{s}$ with a statistically significant difference ($P = 0.001$) for the responsive group.

The mean ADC of the local progression group before treatment was $0.7 \pm 0.2 \times 10^3 \, \text{mm}^2/\text{s}$, and increased after treatment in responding lesions to reach $1.4 \pm 0.3 \times 10^3 \, \text{mm}^2/\text{s}$ with a statistically significant difference ($P = 0.001$).

The mean ADC value before treatment didn’t show significant difference between responding ($0.8 \pm 0.2 \times 10^3 \, \text{mm}^2/\text{s}$) and local progression group ($0.7 \pm 0.2 \times 10^3 \, \text{mm}^2/\text{s}; \ P = 0.857$).

There is statistical significance of the mean ADC value measured 24 hours after ablation between the responding ($1.7 \pm 0.3 \times 10^3 \, \text{mm}^2/\text{s}$) and non-responding groups ($1.4 \pm 0.3 \times 10^3 \, \text{mm}^2/\text{s}$) with significant relatively higher values at the former ($P = 0.001$); a cut-off ADC value (1.42) has been suggested as a reference point to predict the response (66.67 % Sensitivity, 84.21% Specificity, 66.7% PPV & 84.2% NPV).
Fig. 1: CT chest of 59 patient with bronchial carcinoma showing lesion in superior segment right lower lung lobe.

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Fig. 2: Axial T2 weighted image shows a hyperintense mass (arrow) relative to muscle.

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**Fig. 3:** Diffusion-weighted image taken before MWA shows a slightly hyperintense mass (arrow).

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**Fig. 4:** ADC map of the lesion with The apparent diffusion coefficient (ADC) value before MWA was 0.97 x10^{-3} mm²/s

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Fig. 5: T2 weighted MR image 24 hours after MWA shows an inner hypointensity area with outer hyperintensity area (arrow).

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Fig. 6: DWI after MWA shows decreased signal intensity (arrow), compared with images obtained before the procedure.

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Fig. 7: ADC map with ADC value after MWA was $1.8 \times 10^3 \text{ mm}^2/\text{s}$

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**Fig. 8:** CT follow-up after 12 month showing no lesion (complete ablation)

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Conclusion

ADC value calculated from DWI performed 24 hours post-treatment is a good quantitative measurement that may allow early prediction of the treatment response after MWA for management of patients with non-operable lung tumors before morphological changes in CT/conventional MRI are detectable.
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