

## IMPROVING LOCOREGIONAL HYPERTHERMIA USING THE AMC-8 WAVEGUIDE SYSTEM WITH 3-D POWER CONTROL AND 3-D HYPERTHERMIA TREATMENT PLANNING

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### Introduction

The thermal dose achieved in clinical hyperthermia is often suboptimal due to the incidence of treatment limiting hot spots in normal tissue, which are difficult to avoid due to the limited power control of most locoregional hyperthermia devices. The recently built AMC-8 hyperthermia system is operational for clinical application and provides 3D power control using two rings of four waveguides operating at 70 MHz. However, 3D power control is complex and sophisticated hyperthermia treatment planning tools are necessary for optimal treatment control.

### Purpose

To obtain insight in the potential gain of the AMC-8 system in terms of achieved tumour temperatures in comparison to the present AMC-4 system, hyperthermia treatment planning combined with temperature-based phase/amplitude optimization was applied on a cervix carcinoma patient for both hyperthermia systems.

### Methods

A 60 cm long CT-scan was made of the patient in treatment position. The tumour was outlined manually, the rest of the dataset was segmented semi-automatically into muscle, fat, bone and inner air (lungs, bowels). The segmented anatomy was downscaled to a resolution of  $1 \times 1 \times 1 \text{ cm}^3$  and slightly elongated for the AMC-8 planning. This anatomy was inserted into the AMC-4 or AMC-8 system such that the tumour was located centrally in the aperture midplane for the AMC-4 system (fig 1), and centrally in the midplane between the two antenna rings for the AMC-8 system (fig 2).

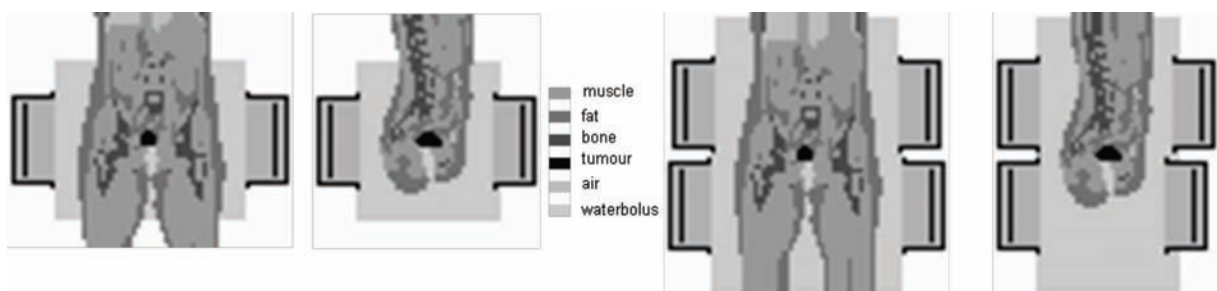


Fig. 1

Fig. 2

E-field distributions were calculated using the Finite Difference Time Domain method, and steady state temperature distributions were calculated by solving the Pennes bio heat transfer equation. For the optimization it was aimed to maximize the tumour temperature ( $\geq 43^\circ\text{C}$ ), respecting constraints to normal tissue of  $42^\circ\text{C}$ .

## Results

The tumour temperatures for the AMC-4 and AMC-8 system are shown in Table 1, expressed as  $T_{90}$ ,  $T_{50}$ ,  $T_{10}$ . The gain in tumour temperatures was  $\sim 0.7^\circ\text{C}$  for this case, which is a substantial increase. The limitations in normal tissue ( $42^\circ\text{C}$ ) were encountered at different locations for the two systems, due to the difference in antenna setup.

Table 1	AMC-4	AMC-8	Gain
$T_{90}$	$39.1^\circ\text{C}$	$39.8^\circ\text{C}$	$0.7^\circ\text{C}$ (31%)
$T_{50}$	$39.7^\circ\text{C}$	$40.5^\circ\text{C}$	$0.8^\circ\text{C}$ (29%)
$T_{10}$	$40.5^\circ\text{C}$	$41.1^\circ\text{C}$	$0.6^\circ\text{C}$ (17%)

## Conclusion

The favourable power distribution and 3D power control of the AMC-8 system are expected to accomplish an  $\sim 0.5\text{-}1^\circ\text{C}$  gain in tumour temperature in comparison to the AMC-4 system. Patients are now treated alternately with the AMC-4 and the AMC-8 system to assess this clinical gain in tumour temperature and differences in treatment limiting hot spots.