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Effects Of Saline Infusion On The Lesion Size During The Radiofrequency Ablation Of Liver Cancer

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Abstract

INTRODUCTION

Radiofrequency ablation (RFA) of liver cancer is limited by its small heat deposition and the increase in impedance when tissue vaporisation occurs. One technique to overcome this limitation is to infuse saline into the cancer tissue prior to RFA [1]. Saline being a natural conductor of electricity; can raise the tumour tissue electrical conductivity. This permits a greater distribution of electrical currents and heat deposition, and subsequently, larger ablation volumes. Nevertheless, given that often it is difficult to predict the motion of the saline during infusion; there is a risk of saline diffusing into healthy regions of the tissue if excessive infusion is carried out. This will cause some part of the healthy tissue to be ablated, leading to undesirable damage. This in fact, has been confirmed in perhaps the only experimental trial to have been reported in the literature [2].

USE OF COMSOL MULTIPHYSICS

In this study, a computational model is developed and solved using COMSOL Multiphysics 4.3 to estimate the lesion size during saline-infused RFA. Transport of saline is set up by modifying the Poisson equation and the convection-diffusion equation [3] under the Mathematics module. Heating during RFA is set up based on the Joule heating module. To describe the lesion size, the two-state cell death model is used [4]; which is set up using the ODE module. The RFA treatment considered is temperature-controlled [5] and the Events module is used to facilitate with its implementation.

RESULTS

Figure 1 plots the lesion size obtained for infusion volume of 0 (no infusion), 5, 10, 15, 20 and 25ml. The percentage increase in the lesion size from the no infusion case is also shown. Saline infusion increases the lesion size following RFA. The largest lesion was obtained with 10ml of infusion. The percentage difference with lesion size obtained for the case with no saline-infusion is also shown. Increasing the volume did not necessarily lead to larger lesion size. The results indicate that there is an optimum infusion volume that will result in the largest lesion size. From Table 1, this optimum volume is 10ml.
Figures 2, 3 and 4 plot temperature probe against time obtained for the treatment with 5, 10 and 25ml saline infusion, respectively. With 5ml infusion, the probe temperature did not reach the threshold of 100oC after 600s. With 10ml infusion, the probe temperature increases beyond 100oC after 260s, after which the temperature-controlled mechanism is initiated. At 25ml infusion, the upper threshold was reached only after 60s. Multiple restarting of ablation occurs until the end of treatment; causing the ablation process to be ineffective.

CONCLUSION

Lesion size following an RFA treatment can be increased with prior saline infusion. However, increasing the infusion volume does not necessarily lead to larger lesions. An optimization procedure can be carried out in future studies to determine the optimal infusion volume.

Reference

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Figures used in the abstract

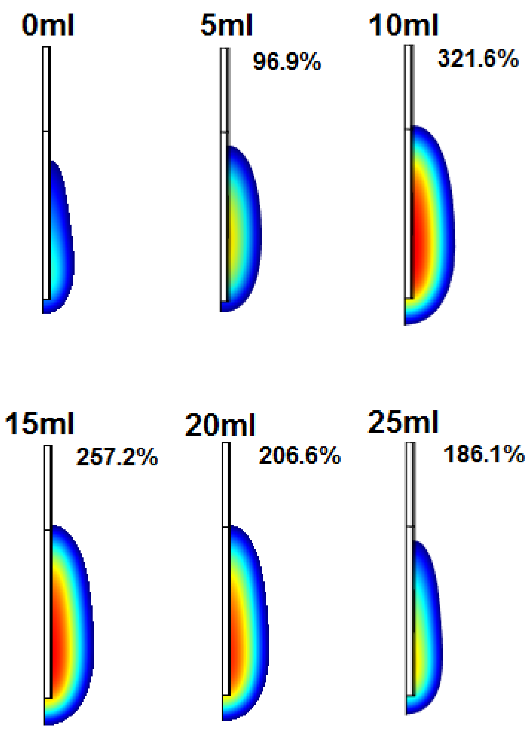

Figure 1: Lesion sizes following 600s of RFA treatment with prior saline infusion of 0, 5, 10 and 25ml.

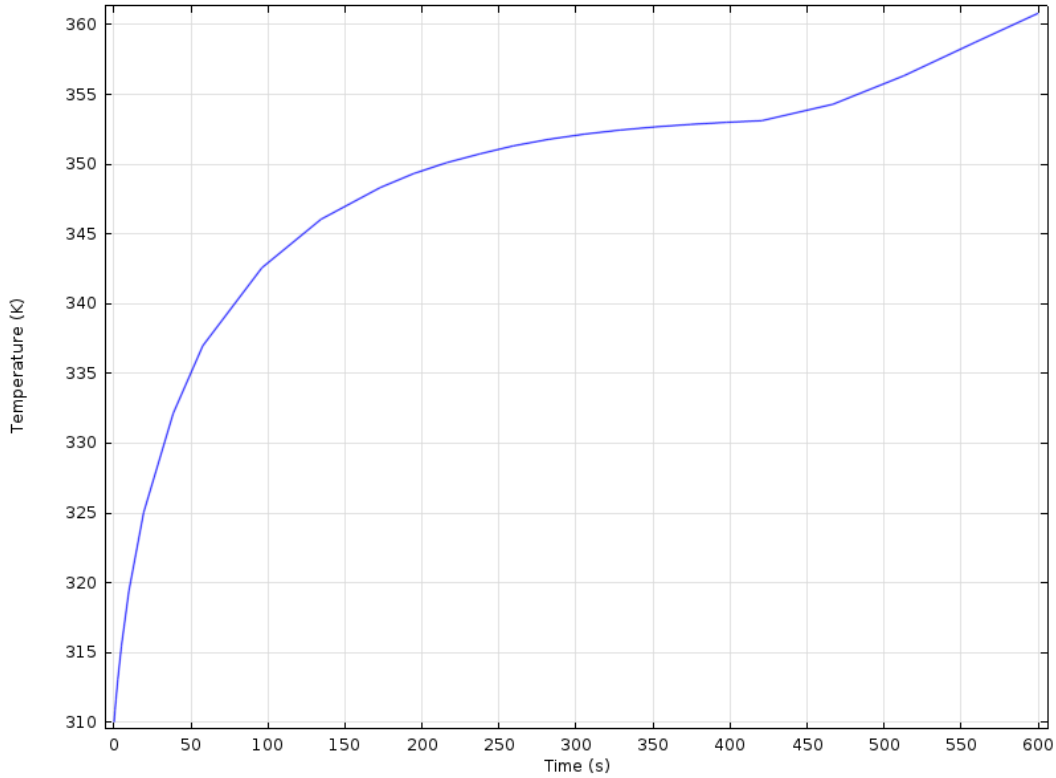

Figure 2: Plots of the probe temperature against time with 5ml saline infusion.

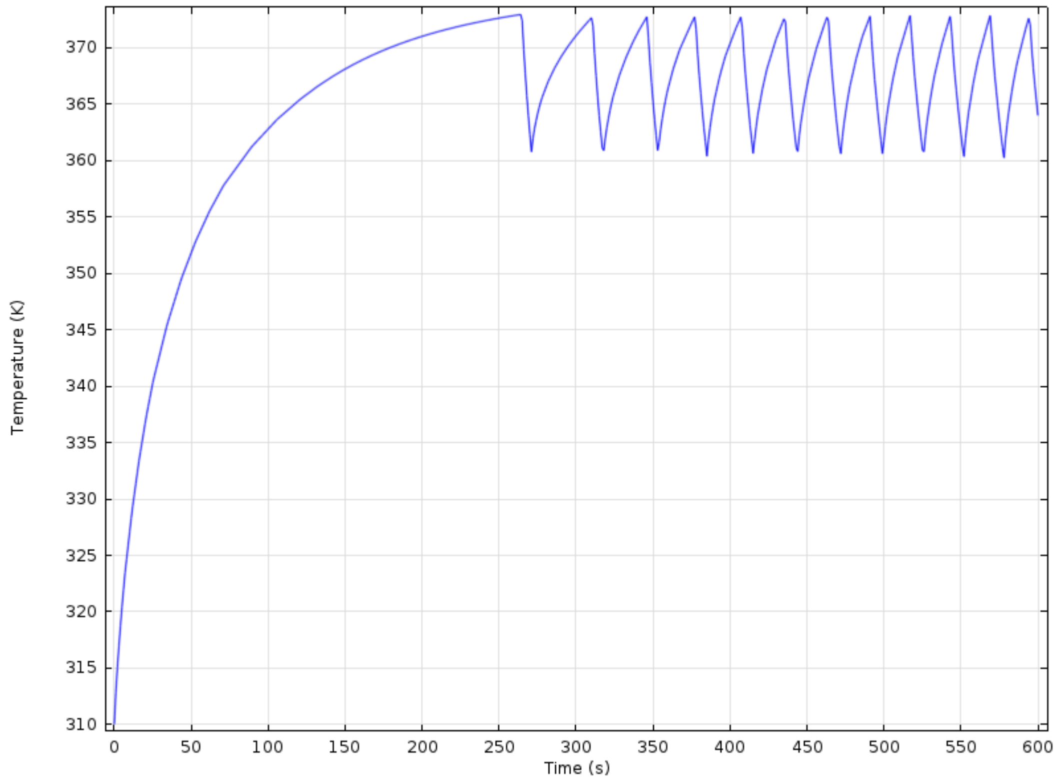

Figure 3: Plots of the probe temperature against time with 10ml saline infusion.

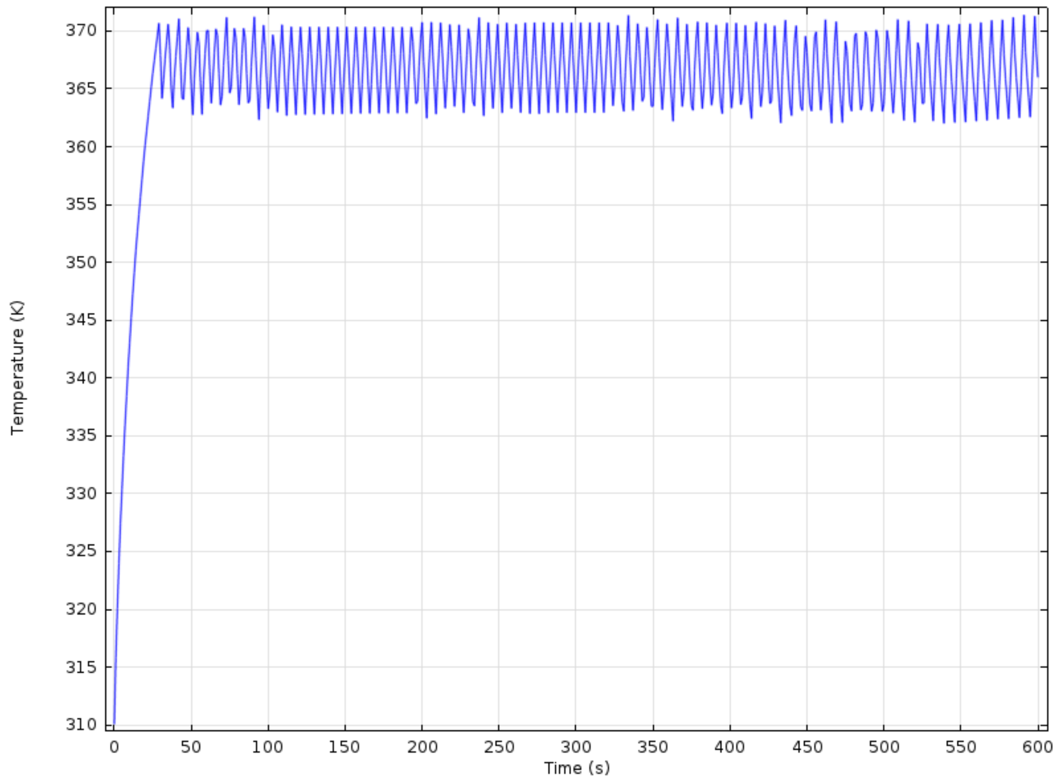

Figure 4: Plots of the probe temperature against time with 25ml saline infusion.