Treatment for Liver Cancer based on Microwave Coaxial Slot Antenna using Comsol

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Abstract
The purpose of this paper is to illustrate the Microwave Coagulation Therapy (MCT) that can be used mainly for the treatment of hepatocellular carcinoma. Surgical resection is not always feasible in patients with hepatocellular carcinoma. Microwave Coagulation Therapy (MCT) has been used as an alternative to resection, and its efficiency has been evaluated in tissue microwave irradiation from a dipole antenna causes water molecules in the dielectric substance to vibrate dramatically at a frequency of 2.45GHz. MCT has the advantage over other thermal ablation technique in that ablation is rapid and the area of ablation is immediately hypoechic on real time ultrasound monitoring and therefore completeness of ablation can be easily monitored.in this treatment Invasive technique is used in which thin microwave coaxial antenna is inserted into the tumour to produce the coaguted region including the cancer cells. Finite element method is an technique used for performing analysis of complex structures.

Keywords
MCT, FEM, Coaxial Antenna, Thermal Coagulation

I. Introduction
Cancer is a general term used to refer to a condition where the body's cells begin to grow and reproduce in an uncontrollable way. These cells can then invade and destroy healthy tissue, including organs. Cancer sometimes begins in one part of the body before spreading to other parts. These extra cells lump together to form a growth or tumour. Two types of tumours exist, benign and malignant. Begin tumour are not cancerous. The cells in benign tumours don't spread and it is rare for a benign tumour to be life threatening. Malignant tumours on the other hand, are cancerous. The cells in them are abnormal and divide randomly and chaotically. The cells behave aggressively and attack the tissue around them. They also can jump away from the malignant tumour and enter the bloodstream or lymphatic system to form new tumours in other parts of the body. This type of spread is known as metastasis. We are studying about liver cancer.

II. Liver Cancer
Liver cancer is one of the most common forms of cancer around the world, but is uncommon in the different areas, according to the Mayo Clinic. Primary liver cancer is the fifth most frequently diagnosed cancer globally and the second leading cause of cancer death. Liver cancers are malignant tumours that grow on the surface or inside the liver. They are formed from either the liver itself or from structures within the liver, including blood vessels or the bile duct.The liver is the largest organ in the body and is located in the right upper quadrant of the abdomen.

Fig. 1 shows the blood supply to the liver and hepatic tumor. The tumor receives 95% of its blood supply from the hepatic artery, while the normal liver tissue receives 75% of its blood from the portal vein and the rest from the hepatic artery

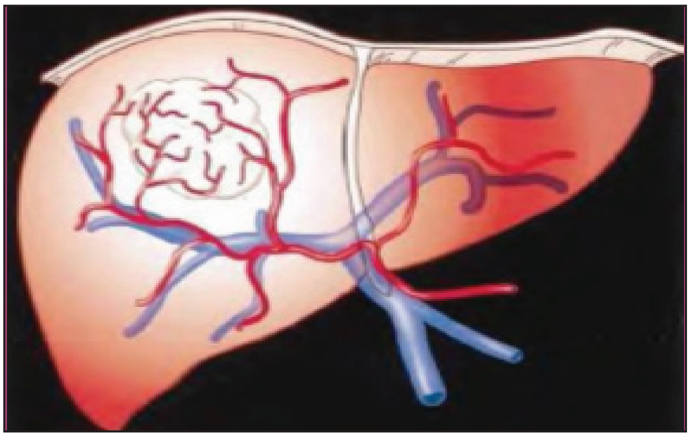

Fig. 1: Blood supply to the liver and hepatic tumor. The large, vessel is the portal vein, and the thin red vessel is the hepatic artery which feeds the tumor.

Antenna design
Finite element method is an a efficient technique used for performing the analysis of complex structure allowing the flexible in changing the shape of antenna. This method representing a given domain, however it may be by a geometrically simple shapes over which the approximation function can be systematically derived. 2D Finite Element Model (FEM) is developed to determine the absorbed power and the temperature distribution surrounding the thin microwave coaxial antenna using COMSOL Multiphysics. Developed antenna model for FM analysis consist of a thin coaxial cable with a 1mm wide ringshaped slot cut on the outer conductor 6 mm from the short circuited tip.The geometry of the antenna is modeled in 2D, and analyzed with variable dimension of slot having, 1mm, 1.2mm, 1.5mm and 1.7mm distances from the tip.

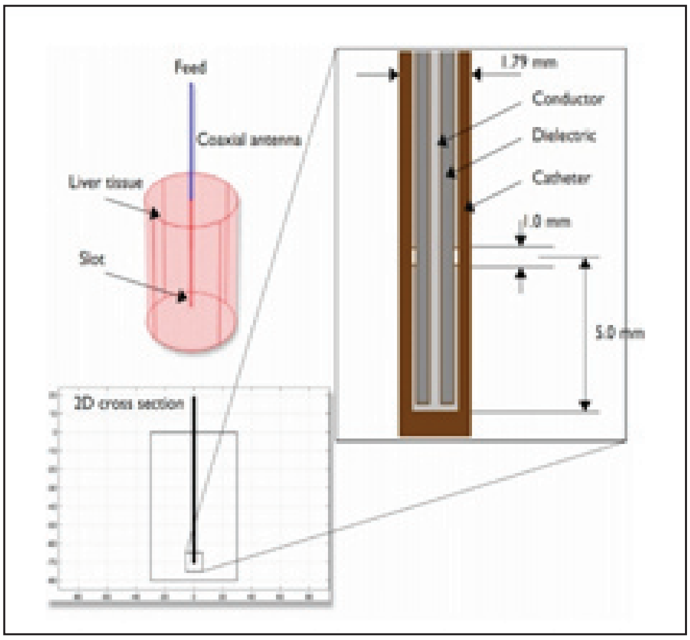

Fig. 2: Antenna Geometry for Microwave Coagulation Therapy

The antenna is operated at the 2.45GHz, a frequency widely used in microwave coagulation therapy. The geometry of the antenna is modulated in 2D, and analyzed with variable dimension of slot. A coaxial cable with a ring shaped slot on the outer conductor is short-circuited at the tip. A plastic catheter surrounds the antenna is as shown in above Fig. 1. The COMSOL multiphysics user interface contains a set of CAD tool for geometry modelling in 2D, 3D coaxial antenna designed in the CAD environment.

Finite element method was employed for the numerical modelling and analysis of the antenna. It involves dividing a complex geometry into small elements for a system of partial differential equation, evaluated at nodes or edges. The microwave source is set at the upper end of the coaxial cable. The material volume which is inserted in the antenna is shown at Table 1.

Table 1: Parameters for Model

Name	Value	Description
Rho_blood	1000kg/m³	Density of blood
Cp_blood	3639J/(kg.k)	Specific heat,blood
Omega_blood	0.0036000 1/s	Blood perfusion rate
T_blood	310.15 K	Blood temperature
Eps_diel	2.03	Relative permittivity,
		Dielectric
Eps_cat	2.6	Relative permittivity,
		Catheter
Frequency	2.45GHz	Microwave frequency
Pin	10[W]	Input microwave power

IV. Model Definition

Electromagnetic heating appears in a wide range of engineering problem and is ideally suited for modelling in COMSOL Multiphysics because of its multiphysics capabilities. This example comes the area of hyperthermic oncology and it models the electromagnetic field coupled to the bio-heat equation. In hyperthermic oncology, cancer is treated by applying localized heating to the tumour tissue, often in combination with chemotherapy or radiotherapy.

V. Simulation Results

Considering the parameters in Table 1 the geometry of the model was developed using COMSOL geometric construction tools, Fig. 2 and 3 show the temperature and surface distribution in the liver tissue with 2D modelling at the end of the heating process (the steady state), in a longitudinal plane.

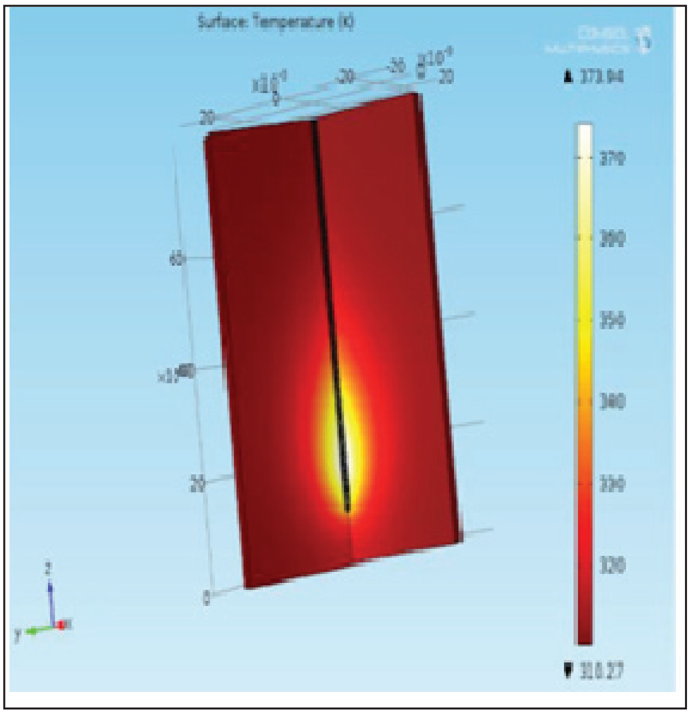

Fig. 2: Surface Temperature in the Liver Tissue

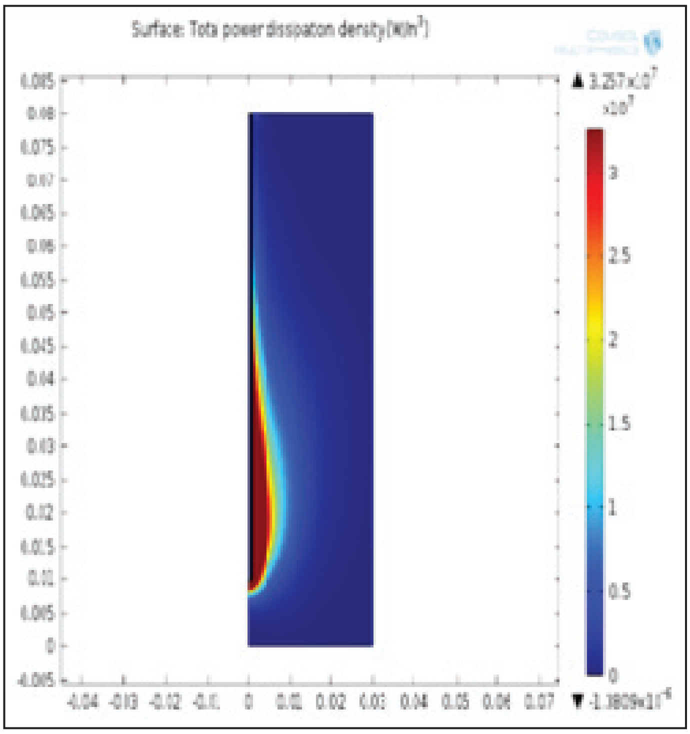

Fig. 3: Temperature Distribution in the Liver Tissue.

VI. Results and Discussion

The resulting steady-state temperature distribution in the tissue for an input microwave power of 10w.Thetemperature is highest near the antenna. It has been observed that with 10 w input tissue absorbed which are shown in Table 2. Heating power deposited in the liver tissue is computed for different designs with varying slot dimension as shown in Figs.

Table 2: Absorved power in Tissue

Organ Name	Total Power dissipation (W)
Liver	9.35301

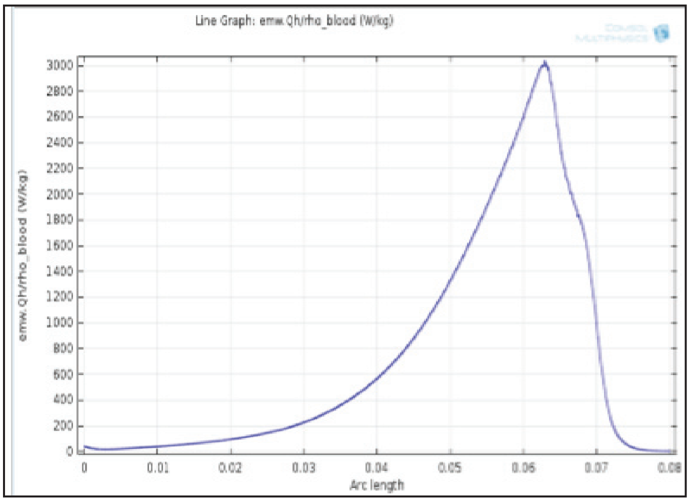

Fig. 4: Normalized SAR Value of Liver Tissue

VII. Conclusion

This work presentstheanalysisoftheaxisymmetricmodel using thin microwave coaxial antenna in COMSOLMultiphysics.The model is rigorously analysed on the basisof mesh statistics,SAR pattern and temperature distributionin tissue generated by the antenna. The models are givestemperature distribution, surface temperature on tissue andpower absorption in tissue with the variation of differentelectric, thermal and particular geometry with the coaxialresulting antenna. By steady-state temperature distributionin the tissue for an input microwave power of 10w.

VIII. Future Scope

The novel antennas are designed and optimized for the physical and dielectric properties of liver tissue under steady state conditions. While clinical treatment with MWA needs to control the tissue temperature and the lesion generation accurately, in order to minimize the side effects to surrounding tissue and surrounding organs. Further, the modelling does not represent the physical structure of blood vessel in the tissue. Recent reports represent that blood flow is rarely constant throughout the course of ablation procedure and thus role of varying blood flow must be considered. Therefore modelling of heat transport is needed in order to completely explain the process of MWA within the human tissue. For optimizing the antennas more efficiently, the work presented can be extended by performing the transient analysis. Moreover the formulation of 3D modelling for approaching realistic liver tissue can also be performed. Lastly there is need to validate these computational results with an in vivo animal model to show the efficacy of these models in predicting sizes of the ablation zone.

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