# A Review on Radiofrequency Ablation Techniques for Hepatocellular Carcinoma

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## Abstract

Liver cancer is the deadliest among the five types of cancer with the highest death rates in the world as per the World Health Organization. The current methods available for the treatment of liver cancer are the resection of hepatic tissue and the various techniques of tumor ablation. Amongst the various ablation techniques, widely used is the radiofrequency ablation. Even though resection presents the best results, only 10% to 15% of the affected patients may eligible for this procedure whereas radiofrequency ablation encompasses a larger scope of patients and provides a non-invasive method when compared to resection. Lot of research activities are carried out to bring about the new technological paradigms generating enough volumetric necrosis for complete regression of the tumor, leading to a high survival rate of patients. These technological paradigms encompass aspects of operability, innovation and of theoretical framework. In terms of operability, there is the use of better imaging sources to aid the healthcare professional in the positioning of electrodes; in terms of innovation, there are new technologies such as MEMS sensors and metallic magnetic nanoparticles to increase the efficiency of the process; in terms of theoretical framework, there is the development of more precise mathematical models that would expand the possibilities of application and increase its effectiveness. These new challenges are new possibilities that may reshape the concept and the use of radiofrequency ablation as it is currently known.

Keywords: Hepatocellular Carcinoma; Ablation; Radiofrequency; MEMS, Nanoparticles

## 1. Introduction

The liver is a common site for both primary malignancy and metastatic disease. The World Health Organization ranks liver cancer among the five cancers with the highest death rate in the world [1]. Resection of hepatic tissue and radiofrequency ablation are the most widely used practices of the treatment currently. Although the resection presents the best results, only 10% to 15% of those affected by this disease can perform this procedure [2]. For patients to undergo the resection the tumor size should be greater than 5cm. For patients with a tumor size of about 3cm to 5cm, who cannot undergo the resection procedure can be treated with embolization. Embolization is a procedure that injects substances to try to block or reduce the blood flow to cancer cells in the liver. Embolization does reduce some of the blood supply to the normal liver tissue, so it may not be a good option for some patients whose liver has been damaged by diseases such as hepatitis or cirrhosis. The goal of RFA is to completely destroy a tumor without damaging the surrounding liver tissue by inducing thermal injury to the tissue through electromagnetic energy deposition. The RFA presents advantageous aspects such as it does not require the hospitalization of the patient and anesthesia. However, it is necessary to improve fundamental points to increase the effectiveness of this procedure [3].

## 2. Discussion

In RFA procedure, the patient is a part of a closed-loop circuit that includes an RF generator, a needle electrode, and a large dispersive electrode (grounding pads).This creates an alternating electric field within the tissue that causes agitation of the ions present in the target tissue that surrounds the electrode, resulting in frictional heat around the electrode. The discrepancy between the small surface area of the needle electrode and the large area of the grounding pads causes the generated heat to be focused and concentrated around the needle electrode while the grounding pads disperse the energy over a larger area to avoid skin burns [4]. Permanent tissue destruction occurs at temperatures of >=45°C. With temperatures from 46°C to 60°C, irreversible cellular damage is produced only after relatively longer periods of exposure [5,6]. Success of ablation technique depends on various parameters like tissue temperature, applied power and tissue impedance from the radiofrequency equipment itself, proficiency of clinical experts and the use of imaging equipment for guiding the ablation electrode. For RF ablation, the important tissue properties are electrical conductivity and thermal conductivity. It should be noted that the tissue impedance more commonly quoted in the literature and displayed by RF ablation systems is inversely proportional to conductivity. High electrical conductivities (i.e., low impedances) allow more current flow. Thermal diffusion is also important to consider because it regulates how quickly heat can be transferred from the zone of direct heating into the surrounding tissue.

RFA has seen a good amount of success with the introduction of modified electrodes, MEMS based equipment and saline solutions in the ablation region, which allowed a significant increase in necrosis volume using a single electrode [7]. Online monitoring of the temperature and carrying out the entire procedure with the use of MEMS devices has advanced it to the next level making it more easier for the clinical experts [8]. The use of MEMS allows the insertion of microcomponents in the exact volume of the tumor thereby not affecting the non-cancerous cells. This new technological paradigm can also be used to insert microdevices for deploying the fluids in the tissue which can improve the rate of ablation. The efficiency of the procedure performed can be analyzed using the temperature analysis which basically talks about the heat distribution in the ablation region [9].

Nanobiotechnology has come up with the metallic magnetic nanoparticles to induce local hyperthermia in tumor tissues through radiofrequency interaction which has shown to be a potentially more effective therapeutic option since it transfers the temperature in the ablation area in a controlled and effective manner, thus causing almost nil harm for the healthy tissue [10]. Gold nanoparticles and Iron oxide nanoparticles are also being used to improve the necrosis area. RFA is undergoing a continual research to bring out the best possibilities for improving the survival rate of liver cancer patients and also to improve the quality of their life post the treatment procedures.

## 3. Conclusion

RFA involves a continual research with a paradigm of view such as low invasiveness, less hospitalization and anesthesia unnecessary and definitely good survival rates of patients with liver cancer. There is research with sufficient evidence for the new technological projections that will make it more effective in its ablation process, generating enough volumetric necrosis for complete regression of the tumor added to a high survival rate. Health professionals and clinical experts are being helped out for appropriate electrode positioning and combined use with other therapies, new technologies such as microsensors and microactuators, magnetic metallic nanoparticles and more mathematical models to improve the overall procedure of RFA and its effectiveness.

***Abbreviations and Acronyms***

RFA- Radiofrequency Ablation.

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