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**Review Article**

# Role of percutaneous thermal ablation in cancer treatment

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## ABSTRACT

The main aim of using thermal ablation strategies is to eliminate the targeted malignant cells within a specific volume. However, it should be noted that some researchers have reported the potential limitations of some of these techniques. On the other hand, more updated investigations indicated that these limitations could be overcome by the adjuvant use of other management modalities as chemotherapy. Many limitations have been reported with the modality, including the prolonged therapeutic time. Therefore, cryoablation and microwave ablation techniques were introduced in the literature as safe and efficacious modalities that overcame the limitations of the radiofrequency technique. Overall, percutaneous thermal ablation is associated with favorable outcomes and should be used in clinical settings due to the various advantages that have been reported for the modality, in addition to being less invasive.

**Keywords:** Thermal ablation, Management, Radiofrequency, Microwave ablation, Carcinoma

## INTRODUCTION

Percutaneous ablation therapy has been introduced as a non-invasive modality that uses needle-like parameters for the effective introduction of the therapeutic technique. It has been demonstrated that the modality involved thermal and non-thermal techniques. The thermal techniques include a microwave and radiofrequency ablation, as well as cryoablation. On the other hand, the non-thermal techniques include irreversible electroporation and chemical ablation. The main goal of using thermal ablation strategies is to eliminate the targeted malignant cells within a specific volume.[1]

Since the introduction of these modalities to the medical field, evidence shows that they have been widely accepted and used to manage different focal malignant lesions related to the lungs, liver, kidneys, and bones.[2-6] However, it should be noted that some researchers have reported the potential limitations of some of these techniques. On the other hand, more updated investigations indicated that

these limitations could be overcome by the adjuvant use of other management modalities as chemotherapy.[7-9] In the present literature review, we aim to discuss the role of percutaneous thermal ablation in managing cancer based on evidence from the current investigations in the literature.

## METHODS

This literature review is based on an extensive literature search in Medline, Cochrane, and EMBASE databases which was performed on 25th September 2021 using the medical subject headings (MeSH) or a combination of all possible related terms, according to the database. To avoid missing potential studies, a further manual search for papers was done through Google Scholar, while the reference lists of the initially included papers. Papers discussing the role of percutaneous thermal ablation in managing cancer were screened for useful information. No limitations were placed on date, language, age of participants, or publication type.

## DISCUSSION

### *Overview*

The main aim of applying the differently reported thermal ablation strategies is to lessen the size of and eliminate the tumor tissues. This can be done by influencing a state of irreversible cellular injury whether by decreasing or increasing the temperature level. Hyperthermic ablation and cryoablation are the two main strategies that have been reported for the process of thermal ablation. Using these strategies, they have been demonstrated that different energies as electromagnetic and ultrasound sources are used as the main source of energy. Other techniques were also reported in the literature as efficacious modalities that can induce cellular necrosis. Nevertheless, these were not adequately validated in the literature. Therefore, we will not discuss them in the current review. We will focus on the percutaneous thermal ablation approaches that have been adequately validated in the literature together with their clinical use for managing hepatocellular, renal cell, and lung cancer. Cytotoxic temperatures should be directed at the tumor tissue and the surrounding margins to make sure that the tumor was adequately eradicated with favorable prognostic outcomes. Several factors can influence the capability of cooling or heat the different sizes of the tumor tissues within the different environments.

### *Hepatocellular carcinoma*

The modality was also reported to treat hepatocellular carcinoma. In the 1990s, evidence shows that radiofrequency ablation was first introduced in the literature and clinically applied on a huge scale in the settings of treating hepatocellular carcinoma, particularly for deep-seated and recurrent liver cancers and small liver cancer.[10,11] In a previous investigation by Huang et al it has been demonstrated that the long-term efficacy for radiofrequency percutaneous ablation was not inferior to surgical resection of hepatocellular carcinoma $\leq$2 cm among 833 included patients.[12] In a previous investigation by Xu et al the authors described the use of the modality using microwave and radiofrequency ablation to manage hepatocellular carcinoma.[13] The study reported that they managed to get complete ablation in most of the cases (92.6%). Besides, it has been demonstrated that the mean survival time was 32 months with estimated cumulative survival rates of 50.0%, 58.5%, and 75.6% at 3, 2, and 1 year, respectively. In 2013, a previous comparative investigation was also published by Zhang et al that compared the effectiveness of radiofrequency against microwave percutaneous ablation to manage hepatocellular carcinoma.[14] The authors reported that the complete ablation rates were comparable between the two groups, being 86.7% and 83.4% for microwave and radiofrequency ablation, respectively. Furthermore, the differences between the included two groups were non-significant with regards to the mean disease-free survival and overall rates at 5, 3, and 1 year. However, it has been observed that the radiofrequency ablation group had a more significant disease-free survival rate than the microwave ablation group. Accordingly, the authors generally concluded that the efficacy of both modalities is significant with favorable outcomes and comparable parameters, and both can be effectively used in managing hepatocellular carcinoma. Favorable findings were also reported in the previous investigation by Yin et al that reported the effectiveness of using computed tomography-guided percutaneous microwave ablation to manage hepatocellular carcinoma.[15] The authors reported that the overall survival rates were 95.45%, and 89.09% for the included patients at 1 and 2 years, respectively. Furthermore, it has been reported that no fatal complications were estimated among the included cohort, and a worse overall survival was significantly associated with tumor-related symptoms and/or tumor invasion of blood vessels. The only significant risk factor that was reported for tumor recurrence was also reported to be correlated with the number of the underlying nodules. The efficacy of high-power microwave percutaneous ablation was also investigated by Zhang et al.[16] It has been reported that for 3-5 cm lesions, the estimated ablation rates were 82.61%, and 100% for the 1st and 2nd ablation, respectively. However, it has been reported that local recurrence was observed among 24.44% of patients, and the overall survival rates were 95.56% and 86.67% for 1 and 2 years, respectively. There were no major complications or mortality events noticed that might be related to the treatment procedure. Local recurrence was significantly associated with hepatitis B viral infection, the proximity of the risk area, the number of lesions, and the levels of pre-ablation alpha-fetoprotein. A recent meta-analysis that was conducted by Han et al analyzed the findings of 26 investigations, including 21 cohort studies and five randomized controlled trials, to compared the efficacy of radiofrequency and microwave percutaneous ablation and reported that no significant difference was

noticed between the two groups in terms of overall, and disease-free survival rates.[17] Furthermore, the authors demonstrated that median ablation time was significantly longer in the radiofrequency group than in the microwave one. Accordingly, it has been demonstrated that both modalities have similar therapeutic effects, however, microwave percutaneous ablation can be performed under local anesthesia due to the estimated short median ablation time among the included population.

Despite the reported efficacy of radiofrequency percutaneous ablation, evidence also shows that the modality has been reported with many limitations. Among the reported limitations, the most important one is the heat sink effect which can limit the ability of the modality to limit the efficacy of the modality in inactivating the tumor cells. Therefore, might not achieve adequate ablation.[18] This has been indicated in a previous in vitro investigation by Lehmann et al that showed that an obvious heat sink effect was obtained by a minimum vascular flow of 1 mL/min.[19] Lin et al also reported that the minimum vascular flow can be used as an independent tool that can predict the potential of recurrence following radiofrequency percutaneous ablation.[20] On the other hand, this disadvantage is not present when the microwave percutaneous ablation modalities are used because when using this modality, charged ions and polar molecules within the body of the affected patient are used to generate the targeted heat using external high-frequency microwave electric powers.[13,21-23] Many advantages have been reported for favoring the modality over radiofrequency percutaneous ablation. These include reduced ablation time, increased infra-tumor temperature, increased ablation range. Therefore, the modality is less likely to be affected by the vascular heat sink.[24,25]

### *Renal cell carcinoma*

Evidence also shows that the modality has been effectively used for the management of renal cell carcinoma. Different investigations have compared the efficacy of the modality to different management approaches. In a previous meta-analysis that was conducted by Dib et al the authors analyzed the results of 31 case series investigations that reported the efficacy of radiofrequency ablation and cryoablation for the treatment of renal cell carcinoma.[26] The authors reported that the pooled total clinical efficacy for radiofrequency percutaneous ablation for the management of renal cell carcinoma was 90% with no significant heterogeneity among the included investigations. Furthermore, the estimated clinical efficacy for cryoablation was 89% in this context. However, the heterogeneity among the included investigations was significant. Furthermore, it has been reported that no significant differences were noticed between patients that were indicated for the administration of both modalities, indicating the efficacy and safety of both modalities in the management of renal cell carcinoma. In another meta-analysis, Patel et al analyzed the results of 58 investigations and reported that thermal ablation and partial nephrectomy had similar rates of worse renal functions.[27] No significant differences were noticed between the two groups in terms of renal functions. Finally, it has been demonstrated that the rates of developing end-stage renal disease were low among the different approaches that were analyzed in this study. Katsanos et al also conducted a meta-analysis to compare the efficacy and safety of using either percutaneous thermal ablation and surgical nephrectomy for the management of small renal cell carcinoma.[28] A total of 6 studies, including five cohort investigations and 1 randomized clinical trial, were included in the final analysis. It has been reported that the ablation group was associated with a significantly lower rate of complications compared to the surgery group. Although a significant decline was noticed among patients within the surgery group more than the ablation one, the authors demonstrated that the 5-year disease-free survival and local recurrence rates were similar between the two groups. Therefore, it has been concluded that the efficacy of thermal ablation is similar to that of surgical nephrectomy with the advantage of being associated with lower rates of complications.

### *Lung tumors*

Evidence indicates that certain patients are usually indicated to receive percutaneous thermal ablation. For instance, among the different lung tumors, evidence shows that patients suffering from non-small cell lung cancer (NSCLC) and other metastatic lesions are indicated to receive the therapeutic modality. However, no clear guidelines were reported in the literature to indicate the frequency and application of using the modality in these patients. A previous study also showed that it could be used in recurrent cases as salvage therapy in cases that were previously treated with radiation. Severe lung emphysema is an absolute contraindication in these patients, while impaired pulmonary functions are relative contraindications. Many management modalities have been proposed for NSCLC, including surgery and percutaneous thermal ablation. In a previous review, Palussière et al estimated the efficacy of using radiofrequency thermal ablation in the management of different lung tumors and reported that the efficacy of achieving complete ablation ranges between 80 and 90% for tumors <3 cm.[29] On the other hand, it should be noted that a previous investigation by Simon et al concluded that the clinical efficacy of the radiofrequency percutaneous thermal ablation is not significant in the settings of managing T2 tumors (>3 cm).[30] This has been furtherly indicated in further investigations that demonstrated that local recurrence rates are relatively high in these situations, and analysis showed that tumor size is the only factor that can predict local recurrence and reduced efficacy of the modality. A tripled rate of failure has been furtherly estimated for tumors >2 cm.[31,32] It has been furtherly demonstrated that the modality is associated with many limitations that have been previously discussed. Therefore, cryotherapy and microwaves were effectively introduced

to overcome these limitations and were also reported with less frequent complications.[29,33]

## CONCLUSION

Our findings indicate the significant effectiveness of radiofrequency thermal ablation in the management of these tumors. However, many limitations have been reported with the modality, including the prolonged therapeutic time. Therefore, cryoablation and microwave ablation techniques were introduced in the literature as safe and efficacious modalities that overcame the limitations of the radiofrequency technique. Overall, percutaneous thermal ablation is associated with favorable outcomes and should be used in clinical settings as a result of the various advantages that have been reported for the modality, in addition to being less invasive.

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