Austin Surgery Case Reports

Open Access

Austin Publishing Group

Mini Review

Ablation by Laser Irradiation, Microwave Emission or Both of Them in Cancer Therapy?

Kabiri S[1] and Rezaei F[2]*
[1]Department of Physics, Sharif University of Technology, Iran
[2]Department of Physics, K. N. Toosi University of Technology, Iran
***Corresponding author:** Fatemeh Rezaei, Department of Physics, K. N. Toosi University of Technology, 15875-4416, Shariati, Tehran, Iran

Received: July 21, 2022; **Accepted:** August 06, 2022; **Published:** August 13, 2022

Keywords

Cancerous tissue; Laser; Therapy; Microwave antenna; Nanoparticle

Introduction

Placement of a needle or catheter directly into a tumor and the use of heat, cold, or a chemical to destroy it are known as ablation. Prolonged exposure of tumor cells at temperatures ranging from 45 to 55 or short exposure at temperatures higher than 60 can cause irreversible cell damage, which is the aim of ablation. Laser and microwave antennas are two of the most successful tools for treating inoperable tumors. The effectiveness of these methods is determined by two factors; i) comprehensive removal of the tumor, and ii) not injuring the healthy tissue around the tumor. As the literature shows, in recent years, these two techniques have been employed in a neck and neck competition and the proponents of each method are trying to justify superiority of their methods. The aim of this special issue is to investigate the pros and cons of the two methods and see if there is any way to exploit the advantages of both methods simultaneously.

Microwave and Laser Ablation

MWA or Microwave Ablation uses a needle that carries an electric current. The end of the needle is placed into the tumor and starts heating the tissue through the dielectric loss. Most clinical microwave antennas work at the frequency of 915MHz or 2.45 GHz. Of course, it has been proved that 2.45 GHz antennas achieve more rapid and predictable ablations [1]. During the process of MWA, ultrasound or computed tomography are frequently used to ensure that the needle is correctly positioned. The most important advantages of MWA are its ability in producing acceptable necrosis in large areas. It should be mentioned that in research performed by Garrean et al [2] MWA could successfully remove 6.45 cm of the tumor. In addition, they showed that the high power of MWA can ablate stiff cancerous tissues too. These criteria have made it a promising technique for removing large and stiff inoperable tumors, such as the cases located in deep areas inside the liver. Moreover, Carrafiello et al [3] and Veltri et al [4] have demonstrated 100% success of the MWA in removing lung and liver cancerous tissues in clinical tests, in respect. Also, Guan et al [5] presented 96% success in removing kidney tumors of liver tissue using the MWA. It should be noted that despite the mentioned benefits, MWA has an important drawback too. For instance, due to its high power, it can cause unwanted injuries to the surrounding healthy tissues. So, it can't excellently influence on superficial and narrow cancerous tissues. From another perspective, Laser Ablation (LA) is a very effective method in tumor removal. For example, Johnson [6] expressed that Ho:YAG lasers are able to ablate tumors as small as 2mm, with minimal injury to the surrounding area. The same thing was reported by Jonler et al [7]. But, due to the limited penetration depth of light in tissue, laser irradiation can't be employed for ablating deep tumors and the average diameter of ablation crater in this technique is much less than MWA hole. Meanwhile, Huang et al [8] explained that one of the beneficial techniques for improving selectivity of LA is the addition of gold based nanoparticles in cancerous tissues. These nanoparticles are designed to absorb light in the Near-Infrared (NIR) region [9,10], where water and hemoglobin represent high transmissivity. Therefore, when nanoparticles are injected into the tumor, the tumor can be ablated with much lower laser power and minimal injury happens to the nearby healthy tissue. Besides, selectivity of LA is considerably improved after injection of gold nanoparticles [11,12].

Integration of the Two Methods

In our research [13], for solving the challenge of utilizing the sole laser or microwave irradiation alone, nanoparticle-mediated laser therapy was integrated with microwave ablation. It was shown by simulations that when these two methods are combined, the advantages of each one compensate for the disadvantages of the other. For instance, when this combinational treatment was applied on Hepatocellular Carcinoma (HCC), which is a kind of liver cancer with complicated structures, large tumor regions were removed by MWA and the remaining superficial narrow layers were removed by laser irradiation, of course with the aid of gold nanorods. It should be noted that new monitoring techniques such as Hyperthermal Treatment Planning (HTP) and ultrasound live tomography can assure the correct positioning of the laser's fiber and microwave needle. Laser ablation has the attractive possibility of being guided through a flexible and small fiber to the tissues in deep-lying organs, and Microwave needle can also be inserted into the tissues with minimal invasion. So, any type of cancerous tumor with arbitrary shape can be ablated by mixing the two methods of laser irradiation and microwave emission.

Conclusion

Microwave ablation and Laser ablation are considered as two of the most viable candidates for treatment of inoperable tumors. However, both of them have their own weaknesses and challenges. Photothermal therapy is a much localized treatment due to exploiting

Citation: Kabiri S and Rezaei F. Ablation by Laser Irradiation, Microwave Emission or Both of Them in Cancer Therapy?. Austin Surg Case Rep. 2022; 7(1): 1050.

highly focused laser beam and gold nanoparticles, while it is not a good choice for deep bulky tumors. On the other hand, microwave coagulation therapy is a very effective technique for coagulation of deep stiff tumors, whereas unwanted damages to the healthy tissues are inevitable when it is used in superficial tumors. Therefore, the two methods seem to be much more successful if they are combined. So far, simulations and numerical studies have proved that this combinational treatment can enhance coagulation therapy of complicated tumors dramatically, with nearly no damage to the surrounding area. *In vitro* and *In vivo* experiments are needed for further study of this novel combinational treatment.

References

1. Simo KA, Tsirline VB, Sindram D, McMillan MT, Thompson KJ, Swan RZ, et al. Microwave ablation using 915-MHz and 2.45-GHz systems: what are the differences?. HPB : the official journal of the International Hepato Pancreato Biliary Association. 2013; 15: 991-996.
2. Garrean S, Hering J, Saied A, Hoopes PJ, Helton WS, Ryan TP, et al. Ultrasound Monitoring of a Novel Microwave Ablation (MWA) Device in Porcine Liver: Lessons Learned and Phenomena Observed on Ablative Effects Near Major Intrahepatic Vessels. Journal of Gastrointestinal Surgery. 2008; 13: 334-340.
3. Carrafiello G, Mangini M, Fontana F, Ierardi AM, Marchi GD, Rotolo N, et al. Microwave ablation of lung tumours: single-centre preliminary experience. La radiologia medica. 2013; 119: 75-82.
4. Veltri A, Gazzera C, Rotondella C, Camerano F, Busso M, Gandini G. Image-guided microwave ablation of hepatic tumours: preliminary experience. La radiologia medica. 2011; 117: 378-392.
5. Guan W, Bai J, Liu J, Wang S, Zhuang Q, Ye Z, et al. Microwave ablation versus partial nephrectomy for small renal tumors: Intermediate-term results. Journal of Surgical Oncology. 2012; 106.
6. Johnson DE. Use of the holmium: YAG (Ho: YAG) laser for treatment of superficial bladder carcinoma. Lasers Surg Med. 1994: 14: 213-218.
7. Jønler M, Lund L, Bisballe S, Holmium: YAG laser vaporization of recurrent papillary tumours of the bladder under local anaesthesia. BJU international. 2004: 94: 322-325.
8. Huang X, El-Sayed IH, Qian W, El-Sayed MA. Cancer cell imaging and photothermal therapy in the near-infrared region by using gold nanorods. Journal of the American Chemical Society. 2006; 128: 2115-2120.
9. Salaheldin T A, Loutfy S A, Ramadan M A, Youssef T, Mousa S A, IRenhanced photothermal therapeutic effect of graphene magnetite nanocomposite on human liver cancer HepG2 cell model. Int J Nanomed. 2019: 14: 4397.
10. Sun T, Han J, Liu S, Wang X, Wang ZY, Xie Z. Tailor-Made Semiconducting Polymers for Second Near-Infrared Photothermal Therapy of Orthotopic Liver Cancer. ACS nano. 2019; 13: 7345-7354.
11. Mocan L, Matea C, Tabaran FA, Mosteanu O, Pop T, Puia C, et al. Selective ex vivo photothermal nano-therapy of solid liver tumors mediated by albumin conjugated gold nanoparticles. Biomaterials. 2017; 119: 33-42.
12. Mocan, L, Matea C, Tabaran F A, Mosteanu O, Pop T, Mocan T, Iancu C,Photothermal treatment of liver cancer with albumin-conjugated gold nanoparticles initiates Golgi Apparatus–ER dysfunction and caspase-3 apoptotic pathway activation by selective targeting of Gp60 receptor. Int J Nanomed. 2015: 10: 5435.
13. Kabiri S, Rezaei F, Liver cancer treatment with integration of laser emission and microwave irradiation with the aid of gold nanoparticles. Sci Rep. 2022; 12: 1-14.