

MRI Guided Dielectric Barrier Discharge Plasma in Vivo: A Preliminary Study for Rectal Wall of Rabbit

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Introduction:

Colorectal cancer is the second most prevalent cancer in the world after breast cancer [1]. Magnetic resonance (MR) imaging, as a noninvasive tool, has been widely used in the assessment of depth of cancer invasion, and can be used to identify the staging of colorectal cancer [2]. Recently, Atmospheric cold plasma has demonstrated promising performance in tumor treatment in many studies, mainly due to its low-temperature property and existence of various agents such as active free radicals, ions, and ultraviolet (UV) [3]. In this preliminary study, by using flexible tubing which worked as a plasma generator and also a MR imaging antenna, we introduced a two-in-one technology for colorectal cancer treatment and assessment.

Methods & Materials:

A healthy normal white rabbit was used to test the feasibility and safety of the flexible plasma tubing, and the experimental protocol was proved by the animal care committee at Peking University. A schematic diagram of the flexible tubing worked as plasma generator and MR imaging antenna is shown in Fig. 1. The tubing was made of Teflon with an outside diameter of 3mm. Three openings (diameter: 0.5mm) on the sidewall (1mm thick) were made by drilling. The MR imaging antenna was comprised by a matching circuit and silver guide-wire (0.3mm in diameter). The guide-wire was inserted into the flexible tubing for imaging, and a low frequency (a few tens of Kilohertz) AC (15-25KV) power supply was applied to an annular electrode on the tubing. Helium was introduced in to the tubing for plasma generation with a flow rate of 50sccm. Once ignited, the helium plasma plume could last for 11 cm and expelled from the opening on sidewall. The flexible tubing was placed into rabbit's rectum through anal opening. Proton density weighted Imaging (PDWI) sequences was employed to ensure that the flexible plasma tubing was at the right place, then rabbit was treated by the ignited plasma for 3 times, each time for 5mins. The current and voltage of the plasma were monitored by an oscilloscope. After plasma treatment, the rectal tissue was histopathologically characterized with hematoxylin-eosin staining.

Results:

Fig. 2 shows the picture of the plasma sustained in vivo. Fig. 3(a) is the coronal PDWI of rectum, indicating that the plasma tubing is located at expected position and three openings can be clearly imaged (red arrows). Fig. 3(b) is the axial PDWI of rectal, which shows the rectal wall and plasma tubing. The histopathological result shows that after plasma treatment there is no damage for rectal cells (Fig.4), which indicates that the cold plasma is safe for normal cells with above operating parameter.

Conclusion and Discussion:

MRI is an advanced medical imaging technique that can provide satisfied soft tissue contrast without radiation. Experimental results show that the proposed plasma tubing can be not only ignited in vivo, but also be tracked effectively by MR images. Actually, although cold plasma has been demonstrated a strong cancer killing effect in vitro, little safety related study is reported in vivo. Here, the flexible tubing, which serves as both the media of plasma generator and imaging markers, is successfully introduced in vivo. After 15 mins plasma treatment, histopathological result shows no damage for rectal cells. This two-in-one technology presents an innovative method for potential colorectal cancer treatment and assessment. More works will be carried out for in vivo model of rabbits colorectal cancer.

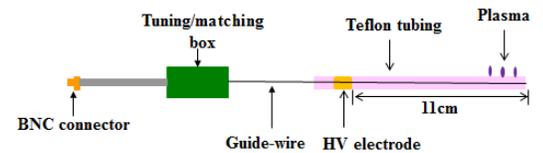


Fig.1. Schematic diagram of the flexible tubing worked as plasma generator and MR imaging antenna

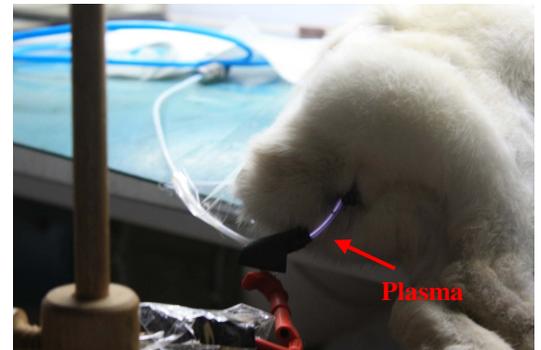


Fig.2. Plasma generated in vivo

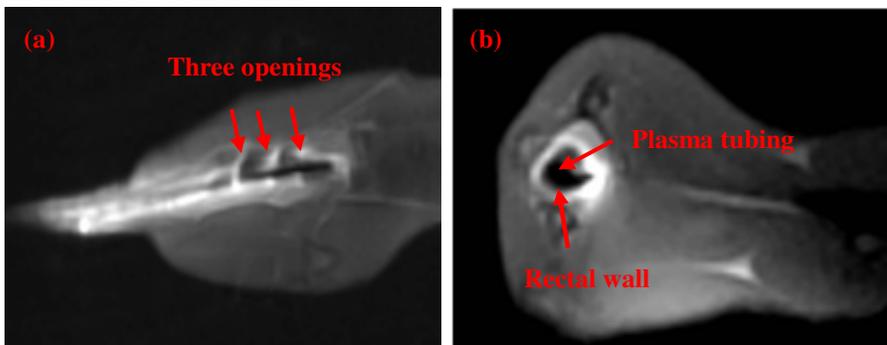


Fig.3. (a) coronal PDWI of rabbit's rectum; (b) axial PDWI of rabbit's rectum.

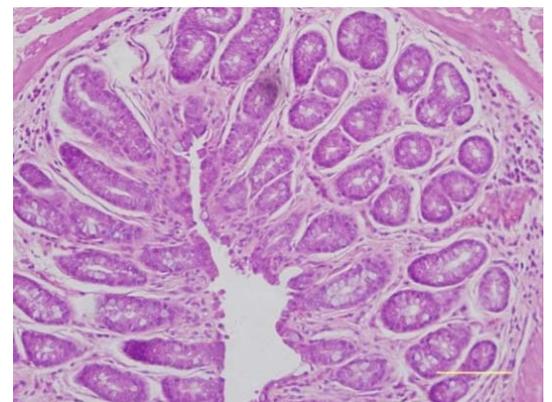


Fig.4. Histopathological result of rabbit tissue (rectum) after 15min plasma treatment

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