Simulation study on Magnetic Resonance Electrical characteristic Imaging of Human Peritoneal Cancer

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Abstract: Based on the new principle, new mechanism, new material and new imaging frontier technology, the research and realization of the new imaging frontier technology will provide the core technical support for the realization of early diagnosis, accurate diagnosis, minimally invasive treatment and accurate treatment of abdominal cancer. To carry out the study of magnetic resonance imaging (MRI) in order to realize the electrical conductivity and relative dielectric rate of the abdominal tissue in the human body. The simulation results on the human abdominal cavity model containing 10 kinds of tissues show that the location and size of the tumor can be detected by MREPT technique in the case of signal-to-noise ratio (SNR) SNR=30. In view of the great change of dielectric properties after carcinogenesis, the changes of dielectric properties are even up to a few. The MREPT technology expected to bring new engineering technology for human abdominal cancer.

1. Introduction

Cancer has always been a great threat to people's health and lives. For cancer, early detection and early intervention can significantly improve the quality of life and survival rate; if the cancer develops to the advanced stage, it is often powerless clinically. Thus, it can see that the early diagnosis of cancer is of great value. Therefore, medical imaging technology has developed rapidly. At present, the four common imaging techniques: X-ray imaging, ultrasound imaging, magnetic resonance imaging, nuclear medical imaging, each has its own characteristics, and has a wide range of clinical applications. In general, the occurrence of cancelation lesions in the human body can regard as a process from quantitative to qualitative change, or as a group. However, the existing imaging technology mainly aimed at the imaging of human morphology, and it is difficult to detect the functional changes in the early stage. Although nuclear medical images (such as Positron emission tomography) have certain functional imaging capabilities, such as reflecting glucose metabolism to a certain extent, However, because the technology must inject radionuclide drugs into the examined human body, it will inevitably cause certain radioactive damage to the human body, so the examination is generally aimed at patients. It is unthinkable to apply the test directly to asymptomatic people. Today, when faced with In an asymptomatic early cancer patient who already has a cancer lesion but whose morphological changes in tissues and organs have not yet been formed, doctors are often helpless and unable to achieve early detection. In recent years, magnetic resonance tomography based on magnetic resonance imaging (MRI) may be a useful tool to solve the above problems. Magnetic resonance imaging (Magnetic Resonance Imaging, MRI) is essential imaging diagnosis technology plays an important role in the clinical diagnosis of diseases.

The conductivity and dielectric rate of human tissue depend on cell composition, density and intracellular structure. A large number of studies have shown that there are significant differences in electrical properties between cancer and normal tissues. The distribution information of electrical characteristics in human tissue has potential application value for clinical disease diagnosis. In addition, electrical conductivity and dielectric rate are necessary for the reasonable design and development of electromagnetic field-related diseases, such as tumor hyper therapy and

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radiofrequency resection.

Magnetic resonance characteristic imaging (magnetic resonance electrical impedance tomography, MREPT) is a method to reconstruct the distribution of conductivity and relative dielectric rate in tissues according to the inhomogeneous RF magnetic field measurements caused by the interaction between human tissues and RF magnetic fields. This imaging method does not need to inject human current into the object to imaged, which simplifies the requirements of the hardware equipment of the imaging system. It also fundamentally solves the security caused by the injection current in MREIT. Haacke et al. first put the idea of MREPT forward. Until recently, thanks to the continuous improvement of the performance of MRI, equipment and the research and development of new RF pulse sequences, MREPT was used in human experiments in vivo.

2. Research status at home and abroad

Internationally, MREPT technology officially named in 2009, but in view of its huge potential clinical application value, a number of university research institutions and magnetic resonance manufacturers have carried out the related research of MREPT technology. Well-known research units related to MREPT technology mainly include the Magnetic Resonance Center of Minnie Soda University in the United States and Berna of New York University in cooperation with Siemens. Rd& Irene Schwartz Biomedical Imaging Center, Karlsrnhe Institute of Biomedical Engineering, Germany, GE all-ball research and service center. Philips European research and development center, etc. It is worth noting that Samsung, a non-traditional manufacturer of medical imaging equipment, has also funded MREPT research, which shows the potential commercial value of this purpose.At present, there are few units engaged in MREPT technology research in China. The team was early engaged in magnetic resonance radio frequency field and RF coil related research, since 2013 began to carry out MREPT technology research. The team leader went to New York University to carry out MREPT technical visit research for one year. In 2015, he systematically introduced MREPT technology to his domestic counterparts for the first time, and published MREPT technology related research papers. In addition, in 2016, he obtained the patent issued by the state of MREPT technology, and has the foundation of carrying out MREPT in depth. Based on the above research, the project group will integrate the excellent MR equipment manufacturers in the country, develop the MREPT radio frequency coil, compile the special scanning sequence, and the EPT reconstruction algorithm. Jointly develop a special MREPT device system, implement this new technology on MR devices with independent property rights, and carry out applied research in professional clinical institutions to select breast tumors (after breast cancer, The changes of dielectric properties are several times) and craniocerebral tumors. These two aspects serve as the foothold of clinical application research of MREPT. For patients with breast tumors, the results of MREPT imaging, pathological sections and physiochemical staining compared and analyzed. To study the correlation between conductivity and dielectric constant imaging data and the expression of breast tumor markers in patients with breast gland tumors, and to establish a clinical specification for the diagnosis and classification of breast tumors by conductivity and dielectric constant imaging. For patients with gloom, the results of MREPT imaging and pathological diagnosis compared and analyzed, and the conductivity of the patients studied.

The correlation between rate and dielectric constant and malignant degree of tumor (WHO grade) was established, and a tumor grading method based on conductivity and dielectric constant was established. After the completion of this item, it will become the first set of high-field MREPT clinical imaging system in China, which will effectively promote the development of high-end medical imaging equipment in China, for breast tumors. Early detection of gliomas, etc., provides advanced technology and equipment. At present, GE, Philips, Siemens, the three largest image giants in the world, is developing the system, but so far, no products have produced. China has its own The emergence of high field MREPT clinical imaging system will make the achievement in the forefront of the world and form a competitiveness in the field of high field magnetic resonance imaging.

The physical basis of the imaging mechanism of the current clinical MR system is the longitudinal relaxation time (T) and transverse relaxation time (T), of hydrogen contained in different tissues and organs of human body. The imaging information given by MRI reflects the effects of different physiology and pathological state of different tissues and organs on the T and T: of hydrogen contained in it. On the basis of MRI, there are many different functional magnetic resonance imaging techniques, such as diffusion imaging, Zhang Liang imaging, blood oxygen saturation imaging and so on, all of which have their own clinical value. However, none of them can directly solve the clinical problems of early diagnosis of cancer mentioned above. MREPT based on the existing Based on the MRI system, equipped with specific RF coil and other hardware, using a specific imaging algorithm, using topographic images to reflect the dielectric property parameters in human tissues, that is, the distribution of conductivity and dielectric constant. A large number of basic studies have confirmed that the EPs of human tissues and organs changes greatly after carcinogenesis and some even reach more than several times. This is because after carcinogenesis of tissues and organs, the permeability of cancer cells will change, and the microenvironment inside and outside cells (such as microcirculation, etc.) will also change, and these changes will directly lead to tissue. Therefore, (EPT) imaging of dielectric properties of tissues and organs expected to provide valuable information for early diagnosis of cancer. Scientists have long known the potential clinical value of EPT in human living tissues. In the past few decades, non-invasive EPT research on human living tissues has been in the ascendant. However, at present, only the measurement method of EPs value in vitro is more mature, and up to now, there is still no perfect non-invasive EPT method for human living tissues. In the current EPs imaging technology of human living tissue, electrical impedance tomography (EIT) technology has developed earlier. This technology can detect the human body. The impedance distribution map of human tissue is calculated by inversion of Table potential and other information (impedance is the reciprocal of conductivity of one of the tissue EPs parameters, reflecting part of the dielectric properties of tissue). Domestic scholars have also carried out a lot of fruitful research work in this area. However, based on the measurement of human body surface information, EIT technology relies on solving mathematical ill-conditioned inverse problems to reconstruct the spatial distribution information of EPs in human tissue. It is very difficult to realize high precision tomography. After EIT technology, MREIT technology appears, which based on MR current density imaging method, and passes to the human body. The internal injection current produces the phase change of MR image, and then obtains the advantage of tissue electrical impedance distribution n.MREIT technique, which does not need to solve the ill-conditioned inverse problem, and can provide high resolution tissue electrical impedance imaging. The disadvantage is that it is necessary to inject current into the human body, which limits the further development of its clinical application. In recent years, MREPT technology, which has emerged and developed rapidly, can realize high-resolution tissue EPs tomography and no ionizing radiation damage to human body, which expected to bring a new breakthrough to EPT technology.

3. Simulation design

The models simulated on 10 kinds of tissues, including skin, fat, muscle, ribs and vertebrae, liver, pancreas, kidney, large intestine, spleen and stomach. The low pass cage coil with 16 legs used to generate 64MHz RF excitation and receive RF magnetic field signal. Except for the liver and pancreas, all the other tissues in the abdominal cavity are normal tissues. In order to investigate the ability of MREPT to detect cancer tissues of different sizes, two cancer tumors with radius 3 and 1 cm were constructed in liver and pancreas, respectively.

The simulation research has based on XFDTD software to solve the positive problem with the spatial resolution of $2mm \times 2mm \times 2mm$ for the target conductivity and dielectric ratio in the model. Get amplitude B_1^+ and transceiver phase of $\phi^{\pm}$ Get the target based on calculation Distribution of B_1^+. Gao Si random noise with different signal-to-noise ratio (signal-to-noise rati-o,SNR) is applied to the target distribution to simulate the measured noise. It is required to perform Laplace operations on it; this will amplify the influence of noise on the reconstruction results. In order to overcome the above problems, Laplace operation realized based on kernel convolution for the reconstruction of electrical characteristics in the case of noise. The nuclear size is $5 \times 5 \times 5$, the kernel coefficient is determined by local polynomial regression. According to the relative error between the reconstructed electrical characteristics and the target electrical characteristics, the reconstruction results are quantitatively evaluated, and the definitions are as follows: $P = \frac{R_{tar} - R_{re}}{R_{tar}} \times 100\%$,Where R is the electrical conductivity of the tissue. The subscript tar represents the target electrical characteristics, and the re represents the reconstructed electrical characteristics.

4. Summary

In this paper, the latest imaging method MREPT in the field of electrical characteristic imaging applied to the abdominal cavity of human body and the feasibility of using this imaging method in the detection of human liver cancer and pancreatic cancer investigated by computer simulation. The simulation results show that under the condition of signal-to-noise ratio SNR=30. MREPT can accurately detect H C C tumors located in the inner radius of 3 cm and pancreatic cancer tumors with radius 1 cm. The accuracy of detection of small volume tumors at the boundary is relatively low, or even impossible to detect at all. Lift a new MREPT algorithm proposed effectively overcome the problem of large error of electrical characteristic reconstruction at the interface of different media, which is an important research direction of MREPT in the future.

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