Academic Journal of Medicine & Health Sciences
ISSN 2706-6819 Vol.1, Issue 1: 32-39, DOI: 10.25236/AJMHS.2020.010105

Discussion about advantages and defects between MRI and CT

ZHOU ZIQI (Oliver)

Harbin Engineering University A-level Courses Centre
Harbin, Heilongjiang 150000，China

ABSTRACT: *The report introduces two imaging modalities which are MRI and CT. Principles of imaging will be introduced respectively. MRI is based on nuclear magnetic resonance (NMR) while CT is based on pulse-echo reflection of X-ray. Additionally, the development history of MRI is included such as some experiments performed by scientists who contributed a lot in the investigation of MRI. Furthermore, comparisons are made between MRI and CT in cerebral infarction and femoral head necrosis. Advantages and disadvantages are stated after comparison. Additionally, MRI can be widely utilized in chemical manufacture industry and mining detection because magnetic field can be easily established and it can find out internal structure which is essential in supervision.*

KEYWORDS: *MRI, CT, Future expectations, Principles, Comparison, Advantages.*

Introduction

MRI (magnetic resonance imaging) and CT (computed tomography) are two imaging modalities which are widely utilized in hospitals and clinics currently. However, they always work in different occasions and sometimes they are combined in order to maximize their excellent performance. Therefore, comparisons are made between these two imaging modalities in distinct categories. Advantages and defects are stated and final conclusion is made to summarize their strengths and limitations. Finally, some improvements are made on current technologies and new proposals are suggested to compensate present drawbacks.

Background

In 1939, I.Rabi observed nuclear magnetic resonance (NMR) by experimenting with substances evaporated at high temperature. However the internal structure of substance is destroyed so it cannot be applied actually. At that era,

ISSN 2706-6819 Vol.1, Issue 1: 32-39, DOI: 10.25236/AJMHS.2020.010105

people mainly utilized NMR to find out the internal structure of chemical compounds. [4]

But till the end of 1945, (E.M) Purcell of Harvard University observed steady-state NMR (nuclear magnetic resonance) signals in paraffin samples. Almost at the same time, F. Block of Stanford University observed steady-state nuclear magnetism in water. Then these 2 scientists achieved Nobel prizes of physics in 1952. The success of the NMR experiment demonstrated the spontaneous spin of the nucleus and it also built a theoretical and experimental foundation for the generation of laser technology. It was the first real experiment to accomplish energy level inversion at that time. [4]

These scientists indeed contributed a lot for NMR and built solid foundation for MRI. Later on, other scientists such as P.Kusch (1955), A.Kastler (1966), J.H.Van Vleck (1977) all contributed for development of MRI. The year after scientist's name is the date they awarded the Nobel Prize.[4]

Principles:

The principle of NMR is the resonance phenomenon of nuclei. Nuclei are positively charged so they can spin spontaneously in their own electric fields. As the direction changes continuously, the angle between initial position and current position also changes. The change in angle produces angular momentum. When the number of protons is equal to the number of neutrons, the resultant momentum is equal to 0, if different, they produce a specific angular momentum and cause a magnetic field defined as magnetic moment. [1]

The ratio of angular momentum to magnetic moment is known as the gyromagnetic ratio which represents γ in later equation. If people establish a magnetic field named B0, the nucleus will not only spin spontaneously itself but also spin around B0. This motion type is called Larmor precession. The equation of Larmor precession is $\mu=\gamma P$. In this equation, P represents angular momentum, γ was just mentioned above and μ represents magnetic momentum. Each orientation of the nucleus represents an energy state in the magnetic field. The energy levels arranged in positive direction have higher energy and energy levels in negative direction have lower energy. In order to travel from one state to another, the nucleus must absorb energy which equals to the difference in energy levels. When the energy of radiation is exactly equal to the difference between two energy levels with different orientations, the spinning nucleus in the lower energy state will absorb energy and travel to a higher energy state. This phenomenon is called nuclear magnetic resonance (abbreviation NMR). [1]

MRI is the imaging modality which uses NMR. As the illustration is shown below, two external magnets create magnetic fields. The direction of each magnetic field is parallel to the magnet. When the nuclei are placed in an external magnetic field, they resemble magnetic diploes. After NMR phenomenon occurs, the magnetic resonance signal is produced from the difference in the number of magnetic dipoles with opposite directions. [1]

ISSN 2706-6819 Vol.1, Issue 1: 32-39, DOI: 10.25236/AJMHS.2020.010105

Additionally, a series of coils are included in the machine. As the graph is shown below, the gradient coils produce variation in the directions of magnetic fields in x, y, z three coordinates to find the specific location of magnetic resonance source. The founded magnetic resonance source is utilized to locate the position of each spinning nucleus. Finally, there is a radio frequency coil which is used to divert the direction of magnetic dipoles and generate longitudinal and transverse relaxations. The depths of tissues are represented by the difference in relaxation times and intensity of magnetic signal. The intensity of magnetic signal is proportional to the number of nuclei. Only a few numbers of nuclei can be diverted by external magnets and it depends on the strength of external magnets. [1]

Figure.1 The MRI machine

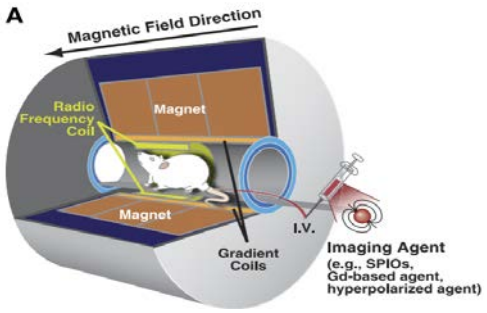

Figure.2 Internal structure of MRI machine

The CT imaging modality is based on the absorption of X-ray by human bodies. In a uniform object, the attenuation of X - ray is exponential. When X - ray penetrates human organs and tissues, the absorption coefficient of X - ray varies because the organs and tissues have different densities. If the computer divides the

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object passing along the X-ray path into many small units (voxels) and makes the thickness of each voxel equal to L. Then the total number of absorption coefficient will be calculated successfully.

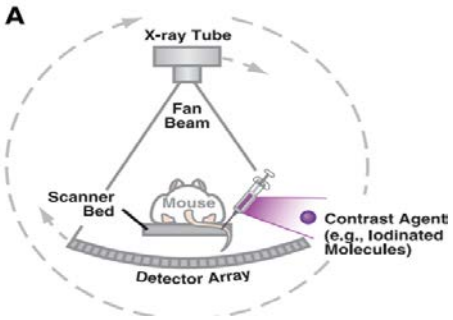
In order to establish CT images, the absorption coefficient of each voxel must be calculated first. If n absorption coefficients are required, n or more independent equations of the formula below need to be established. A large number of detectors are utilized to acquire enough number of measurements. Therefore, the CT imaging device should be used to scan multiple times from different directions to obtain sufficient data. Then computers can form equations. Therefore, CT value is defined as the ratio of the absorption coefficient of measured tissue to the absorption coefficient of water. Finally, CT value will be turned into gray scale and the image will be constructed. Some tissues can strongly absorb X-rays such as bones. Therefore, bones can appear white while others that absorb poorly (e.g. air) appear black.

High-contrasting image can show detailed morphological information clearly. [1]

$$H = \left(\frac{\mu_i}{\mu_{h_2o}} - 1 \right) \times 1000$$

The equation of absorption coefficient

Figure.3 The CT machine



ISSN 2706-6819 Vol.1, Issue 1: 32-39, DOI: 10.25236/AJMHS.2020.010105

Figure.4 The internal structure of CT machine

Comparison between MRI and CT:

All of the data is collected from Jinan People's Hospital affiliated to Shandong First Medical University. This report selects patients admitted to the department of Orthopedics of this hospital from March 2014 to February 2017. They have bone grafting due to femoral head necrosis. [3]

MRI can be used to produce images of femoral head necrosis. Doctors use machines called Philips Ingenia 3.0T MR to scan coronal, cross-sectional and sagittal areas of femoral head bones. Thickness of coronal bone is 0.4cm and spacing is 0.2cm. The transverse scanning layer is 0.5cm thick and the spacing is 0.25cm. The sagittal plane layer is 0.5cm thick and the spacing is 0.25cm. [3]

Doctors observe the boundary between healthy tissue and illness tissue. Software can be used to circle the boundary of necrotic tissue on the computer and the area of necrotic area is automatically calculated by the computer. The product of the thickness of MRI scanning layer is the necrotic volume of each layer. [3]

One of the CT machines is called GE Revolution 256-row CT scanner. This scanner is used for scanning with cross-sectional areas. The tube voltage is 120kV and the tube current is 100mA. Scanning layer has thickness 1 ~ 3mm. [3]

The CT imaging data is transferred into the computer for coronal and sagittal reconstruction. The boundary between normal and necrotic bones is observed, and the color is added by the software. Then 3D reconstruction is carried out after the automatic identification and the color marking. Finally, the morphology of necrotic areas in femoral head is observed. The CT method could display bones' high density hardening zones clearly and it is better for bones as well as hard tissues. The MRI method has lots of flaws because the collected MR signals are unstable. But it can show more details for soft tissues. [3]

In femoral head necrosis, MRI has advantages of higher resolution, numerical calculation and no radiation. As for CT, the software is used to identify different tissues automatically and colors are added. Clear images could be produced for bones. [3]

Figure.5 The entire picture shows images produced by MRI and CT. The first two images are CT images and the last two images are MRI images.

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The subjects selected in this investigation are patients with cerebral infarction in Sihui People's Hospital of Guangdong Province from September in 2019 to June in 2020. [2]

MRI can be utilized for scanning cerebral infarction. The patient is examined in a supine position using a 1.5-t MRI scanner, and the cranial axial scanning is performed. The doctors set up flip angle equals 150 degrees and matrix equals 448×336. Time interval is approximately 7ms and doctors should collect for 4 times. This method is named T2W2. As for T1W1, flip angle is equal to 90 degrees and matrix built is 256×256. Time interval is 7.8ms and doctors should collect for 2 times. [2]

The patient was in the supine position during the examination with MSCT (Multi-slice spiral CT machine). Tube voltage is 120KV and tube current is 150mA. Layer distance is 5mm. SPSS21.0 software is utilized to analyze the data collected. [2]

MRI has several advantages. Firstly, the lesion shape, size, area can be displayed initially.

Secondly, it can accurately detect tiny tissues due to higher resolution for brain. Finally, MRI can tell lesion tissue from normal tissue although they have similar density. Therefore, if the patient presents early cytotoxic edema, T1T2 methods in MRI scan can distinguish illness tissues because it receives MR signals. Similar densities cause no problem to MRI. CT cannot distinguish easily from each other because these tissues have similar densities. Similar densities cause similar absorption coefficient in tissues. Therefore, doctors can hardly diagnose accurately. [2]

CT has the advantages of clear image, convenient operation and low cost. It can accurately display the structure of brain tissue and locate the infarct site. Additionally, it donot bring secondary damage to brain tissue. [2]

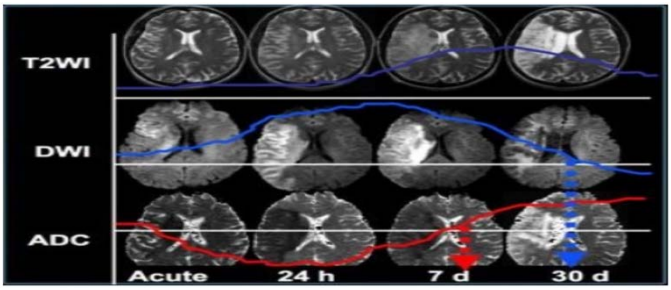

Figure.6 Image of a patient's brain

The image shows internal structure of a patient's brain. The x coordinate represents time after this illness appears and y coordinate represents the different methods utilized for detection. [2]

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Conclusion

Summarizing from context above, MRI has three advantages. Firstly, it has no X-ray radiation, sp that it is healthier for patients. Secondly, it has higher resolution for soft tissue scanning because there are plenty of hydrogen nuclei in soft tissues. All of these hydrogen nuclei will cause nuclear magnetic resonance. Thirdly, images could be used to diagnose lesion which has similar density with normal tissue because MRI utilizes magnetic resonance signals to construct the image. As for CT, the densities are similar to each other for tissues so that their absorption coefficient must also be similar. Therefore, it's difficult to distinguish distinct tissues when lesion is acute. [2][3]

CT has two advantages after summarizing. Firstly, it takes short time to examine. If the patient has really acute illness and requires necessary prescriptions immediately, CT must be their optimum choice. At the same time, the image will be clear. Secondly, it shows harden sections clearly such as bones. The density difference between soft tissues and bones is huge, so the absorption coefficient difference is also large. Therefore, the image could display it specifically. While for MRI, few amounts of hydrogen atom nuclei are included inside bones so that it produces poor images. [2][3]

Future expectations

In the future, a combination method for MRI and CT may be investigated. For this imaging modality, the advantages of MRI can perfectly compensate the defects of CT. Secondly, computers may have multi-functions. The scanning systems will be controlled by computers and graphs can be drawn automatically by computers. Additionally, images could be printed from computers itself which can reduce the time taken for diagnosis.

Finally, AI diagnosis may be achieved in the future. Robots can be utilized to diagnose the patients more specifically than human beings. Doctors may feel tired after working for a long time and cause more human errors on diagnosing. While robots will never feel tired and keep working. Additionally, high resolution camera of robots will detect each pixel and make errors as few as possible. Robots can be manufactured on a large scale so that it will resolve the problem if number of patients is large.

References

[1]Gambhir, M. L. (2012). A MOLECULAR IMAGING PRIMER: MODALITIES,IMAGING AGENTS, AND APPLICATIONS. California.

ISSN 2706-6819 Vol.1, Issue 1: 32-39, DOI: 10.25236/AJMHS.2020.010105

[2] Li Guoguang, Chen Shaoming, Li Xiong. Comparative analysis of CT and MRI application in early clinical grouping diagnosis of cerebral infarction. Sihui.
[3] Wu T, Zhao YQ, Zhou T, Jia SQ. (2020). CT and MRI findings and prognostic risk factors of early necrosis of femoral head. Jinan.
[4] Zhang Y. (2010). The history and application of nuclear magnetic resonance technology.