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Q1 : How protons do helps in MR imaging?

Ans: The human body is mostly water. Water molecules (H_2O) contain hydrogen nuclei (protons), which become aligned in a magnetic field. An MRI scanner applies a very strong magnetic field (about 0.2 to 3 teslas, or roughly a thousand times the strength of a typical fridge magnet), which aligns the proton "spins."
The scanner also produces a radio frequency current that creates a varying magnetic field. The protons absorb the energy from the magnetic field and flip their spins. When the field is turned off, the protons gradually return to their normal spin, a process called precession. The return process produces a radio signal that can be measured by receivers in the scanner and made into an image, Filippi explained.

Protons in different body tissues return to their normal spins at different rates, so the scanner can distinguish among various types of tissue. The scanner settings can be adjusted to produce contrasts between different body tissues. Additional magnetic fields are used to produce 3-dimensional images that may be viewed from different angles. There are many forms of MRI, but diffusion MRI and functional MRI (fMRI) are two of the most common.

D MRI

This form of MRI measures how water molecules diffuse through body tissues. Certain disease processes — such as a stroke or tumor — can restrict this diffusion, so this method is often used to diagnose them, Filippi said. Diffusion MRI has only been around for about 15 to 20 years, he added.

F MRI

In addition to structural imaging, MRI can also be used to visualize functional activity in the brain. Functional MRI, or fMRI, measures changes in blood flow to different parts of the brain.

Q2: Differentiate between longitudinal and transverse magnetization.

Ans: Longitudinal magnetism and transverse magnetism are components of the net magnetism vector.

Longitudinal magnetism

Longitudinal magnetization is the component of the net magnetization vector parallel to the magnetic field (z-axis). This is due to a difference in the number of spins in parallel (low energy) and anti-parallel (high energy) state – i.e. before a radiofrequency pulse.

Transverse magnetization

Transverse magnetization is the component of the net magnetization vector perpendicular to the magnetic field (x-y plane). This is due to the spins of individual protons getting more or less into phase (coherence) – i.e. after a radiofrequency pulse.

Transverse vs longitudinal

During excitation, the longitudinal magnetization decreases. After a 90-degree flip angle, the populations of the two spins states are identical. Therefore the longitudinal magnetization is null. Transverse magnetization appears due to phase coherence, except for a 180-degree flip angle.

It is worth noting that it is only the net magnetization vector that lies in the transverse plane, not the magnetic moments or the nuclei themselves. The magnetic moments of the nuclei only move in alignment with or against magnetic field strength – i.e. low or high energy state.

Q3: Write a note on gradient fields.

Ans: The gradient of a function is a vector field. It is obtained by applying the vector operator V to the scalar function f(x, y). Such a vector field is called a gradient (or conservative) vector field.

Gradients or gradient coils are used to vary magnetic field strength over the extent of magnetic field. Gradient system consists of three sets of coils that produce field with changing strength in X, Y, Z directions. Three gradients are used for slice selection, phase encoding and frequency encoding when applied in three directions perpendicular to each other.

Q4: Describe four basic steps of MR imaging.

Ans: Four basic step are involved in getting an MR image-

1. **Patient is placed in the magnet**

   All randomly moving protons in patent's body align and precess along external magnetic field. Longitudinal magnetization is formed long Z-axis.

2. **RF pulse is sent**

   Precessing protons pick up energy from RF pulse to go to higher energy level and precess in phase. This results in reduction in longitudinal magnetization and formation of transverse megnetization in X-Y plane.

3. **MR signal**

   Transverse magnetization vector precess and generates current. When RF pulse is switched off, this current produces signal in the coil.

4. Image formation

Signal is transformed into image by complex mathematical process—Fourior Transformation by computers.

Q5: Write the typical values of long and short TR/TE in spin-echo sequence and Gradient-echo sequence.

Ans: ***Spin – Echo – Sequence***

Short TR 300 – 800

Long TR >2000

Short TE 10 – 25

Long TE >60

Gradient – Echo – Sequence

Short TR <50

Long TR >100

Short TE 1 – 5

Long TE >10

Q6: Define the following terms:

A) ***TR***

TR (Time to Repeat) is the time interval between start of one RF pulse and start of next RF pulse. Typically in spin-echo sequence time interval between beginnings of 90 degree pulses is TR.

B) ***TE***

TE (Time to Echo) is the time interval between start of RF pulse and reception of the echo (signal).

Short TR and short TE gives T1-weighted images.

Long TR and long TE gives T2-weighted images.

Long TR and short TE gives proton density images.

C) ***Transverse Relaxation:***

Protons which were precessing in phase because of RF pulse, start losing phase after RF pulse is switched off. This going out of phase of protons results into gradual decrease in the magnitude of TM and is termed as Transverse relaxation. The time taken by TM to reduce to its original value is transversal relaxation time or T2. Longitudinal and transversal relaxations are different and independent processes because underlying mechanisms are different.

D) ***Longitudinal Relaxation:***

Recovery of longitudinal magnetization.

The process of recovery of longitudinal magnitization is called longitudinal relaxation.

E) ***T1 Weight Image (on the basis of TR and TE)***

LM is one of the determinants of strength of MR signal. Stronger the LM more will be the magnitude of TM after 90 degree pulse that results into stronger signal. If T1 is short, there is early or maximum regain of LM after RF pulse is switched off. So, if next RF pulse is sent, TM will be stronger and resultant signal will also be stronger. So, T1, T2 RELAXATION AND OTHER PARAMETERS 19 material with short T1 have bright signal on T1 weighted images.

F) ***T2 Weight Image (on the basis of TR and TE)***

Tissues with long T2 are bright on T2-W images. Longer the T2 of any tissue, larger TM will remain for more time.

This will lead to stronger signal, because stronger TM gives stronger signal

G) ***<u>Proton Density Image (on the basis of TR and TE)</u>***

Contrast in the image is determined by density of protons in the tissue. T1 effect is reduced by keeping long TR and T2 effect is reduced by keeping TE short. Hence long TR and short TE gives PD-weighted image .