The effects of contrast media Gd- on the magnetization of tissues for (MRI)

Prepared By: Akar Jabbar & Omer Mala

Supervised by :Msc.Riyadh Saeed

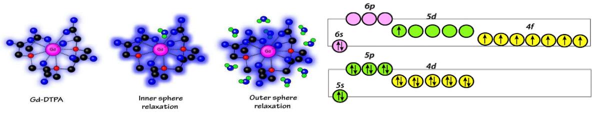
Introduction

Magnetic Resonance Imaging (MRI) is a powerful imaging technique that uses a strong magnetic field and radio waves to create detailed images of the body. Contrast agents, such as Gadolinium-based contrast agents (GBCAs), are commonly used in MRI to enhance the visibility of certain tissues or blood vessels.

The effects of contrast media, specifically GBCAs, on the magnetization of tissues is a topic of great interest in MRI. GBCAs contain gadolinium, a paramagnetic metal ion that can alter the magnetic properties of nearby water molecules. In the presence of a magnetic field, the spins of water molecules align and create a net magnetization.

Methodology

Magnetic Resonance Imaging (MRI) is a powerful imaging technique that uses a strong magnetic field and radio waves to create detailed images of the body. Contrast agents, such as Gadolinium-based contrast agents (GBCAs), are commonly used in MRI to enhance the visibility of certain tissues or blood vessels. The effects of contrast media, specifically GBCAs, on the magnetization of tissues is a topic of great interest in MRI. GBCAs contain gadolinium, a paramagnetic metal ion that can alter the magnetic properties of nearby water molecules. In the presence of a magnetic field, the spins of water molecules align and create a net magnetization. This water molecule approaches very close (mean distance ~0.25 nm) to the metallic center, fitting into a crevice of the ligand. These direct and intimate magnetic interactions between water and the Gd^{+3} ion give rise to a process known as inner sphere relaxation. Outer sphere relaxation is another mechanism by which gadolinium-based contrast agents can enhance the relaxation of nearby water molecules in magnetic resonance imaging (MRI).In outer sphere relaxation, the gadolinium ion is surrounded by water molecules that form a second coordination sphere around the gadolinium ion

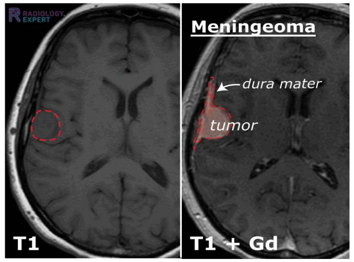


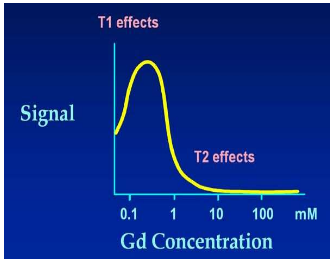
Discussion

The spins are like spinning tops and so will also react with a processional motion This precession has a characteristic frequency, called the Larmor frequency . It is proportional to the strength of the magnetic field. There is a gradual alignment of the spins parallel to the field while, like a spin- ning top, the spins transfer energy to the surroundings.

$Wo = \gamma Bo$

Where wo = Precession frequency in Hz, Bo = Strength of external magnetic field in Tesla γ = Gyromagnetic ratio, which is specific to particular nucleus Precession frequency of the hydrogen proton at 1, 1.5 and 3 Tesla is roughly 42, 64 and 128 MHz respectively. When contrast agent injected into the bloodstream, GBCAs bind to plasma proteins and are then distributed to tissues throughout the body. In tissues where the GBCA accumulates, such as tumors or areas of inflammation, the paramagnetic properties of the GBCA shorten the T1 relaxation time of the surrounding water molecules. This causes those tissues to appear brighter on T1-weighted MRI images, increasing the contrast between the target tissues and their surroundings. The use of GBCAs in MRI has revolutionized the diagnosis and monitoring of many medical conditions, including cancer, multiple sclerosis, and cardiovascular disease. The improved contrast provided by GBCAs allows clinicians to more accurately detect and localize lesions, making it easier to plan appropriate treatments.





Conclusion

In conclusion, while the use of GBCAs in MRI has provided significant benefits in terms of improved image quality and diagnostic accuracy, it is important to consider the potential risks associated with their use. Clinicians should weigh the benefits and risks of GBCAs for each individual patient, and use caution when administering them, particularly in patients with impaired kidney function. Ongoing research is needed to fully understand the long-term effects of GBCAs and to identify strategies to minimize their risks. The standard formula for calculating the dose of a gadolinium-based contrast agent is as follows:

Dose (in millimoles) = Patient weight (in kilograms) x Dose per unit weight (in millimoles per kilogram)

For example, if a patient weighs 70 kilograms and the dose per unit weight is 0.1 mmol/kg, the dose of the gadolinium-based contrast agent would be: Dose = 70 kg x 0.1 mmol/kg = 7 mmol.

References

- Lösch, F. Eckstein, M. Haubner, K.-H.J.M.r.i. Englmeier, A non-invasive technique for 3-dimensional assessment of articular cartilage thickness based on MRI part 1: development of a computational method, 15 (1997) 795-804.
- E.L.J.P.R. Hahn, Nuclear induction due to free Larmor precession, 77 (1950) 297.
- R.H. Hashemi, W.G. Bradley, C.J. Lisanti, MRI: the basics: The Basics, Lippincott Williams & Wilkins2012.
- A. Datta, K.N.J.A.o.c.r. Raymond, Gd− hydroxypyridinone (HOPO)-based high-relaxivity magnetic resonance imaging (MRI) contrast agents, 42 (2009) 938-947.