MAGENTIC RESONANCE IMAGING IN UTERINE LESIONS

Thesis

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Radiodiagnosis

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الله

بسم الله الرحمن الرحيم

قالوا سبحانك لا علم لنا إلا ما
علمتنا إنك أنت العليم الحكيم .

صدق الله العظيم
البقرة - ٣٢ -

بسم الله الرحمن الرحيم

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TO...

MY FAMILY

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Introduction & Aim of The Work

INTRODUCTION
AND
AIM OF THE WORK

Magnetic resonance imaging has become an important diagnostic tool in studying the female pelvis. The clinical application of magnetic resonance imaging has opened a new diagnostic field that holds great promise for gynecology. It appears well suited for studying the female pelvis because it is non invasive, non ionizing, has superb soft tissue contrast resolution and has the capacity to produce multidirectional images. In addition it does not require the use of iodine containing contrast media.

MRI of the female pelvis offers a unique display of pelvic anatomy, it provides an excellent method for evaluating the uterine zonal anatomy and it can reflect the variability in the appearance of the uterus in response to different hormonal stimuli.

MRI also allows the display of the pathological conditions of the uterus and cervix including benign and malignant uterine and cervical neoplasms.

The aim of this study is to show the ability of magnetic resonance imaging to demonstrate the different pathologic conditions of the uterus, their relations to the surrounding pelvic structures and the manifestations of these uterine lesions on MRI.

Physical Principles of MRI

Physical-Principles of Magnetic Resonance Imaging

Properties of atomic nuclei:

The core of atoms that accommodates most of the elemental mass is called the nucleus, it consists of neutrons and protons. Certain nuclear species possess angular momentum, or spin, a property first suggested by ***Wolfgangpauli in 1924***. To put it more simply some nuclei can be thought of as behaving like small spinning spheres.

Since nuclei bear electric charges, their spinning produces a magnetic moment μ expressing the strength and direction of the magnetic field surrounding the nucleus. The fields produced by these magnetic dipoles are analogous to those of a microscopic bar magnet (Fig. 1-1) ***(Stark and Bradly, 1988).***

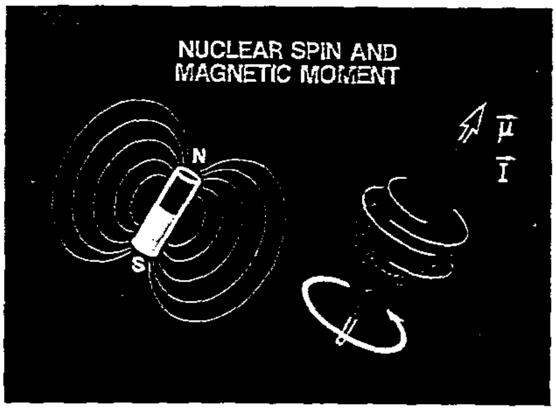

Fig. (1-1) Magnetic nuclei behave like microscopic bar magnets. N, North pole; S, South pole (After Stark and Bradley, 1988).

The technique of NMR (Nuclear magnetic resonance) cannot be applied to all nuclei. Only nuclei which are (a) rotating and therefore possessing the property known as spin, and (b) possess an odd number of protons and neutrons, can be made to resonate. Examples of some of the nuclei that can be measured using NMR and of particular interest in medicine are (^{1}H, ^{31}P, ^{23}Na, ^{13}C, ^{19}F). ***(Kean and Smith, 1986).***

Hydrogen is the most frequently used nucleus for MR signal because of its abundance in biological tissues and its high MR sensitivity ***(Shafik, 1991).***

In the absence of an externally applied magnetic field, nuclei within a sample are randomly oriented so that the magnetic moments from the individual nuclei effectively cancel each other out and there is no net magnetic moment (fig. 1-2).

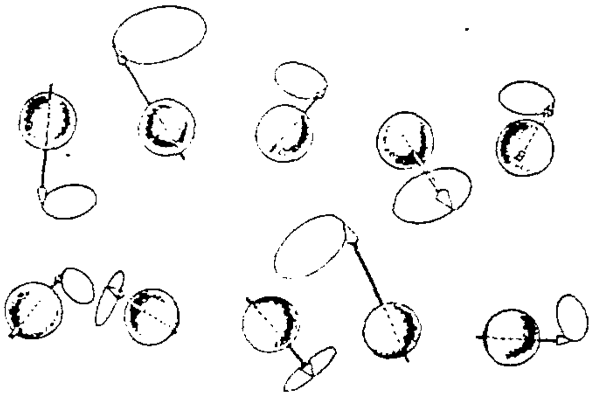

Fig. (1-2) shows the randomly oriented nuceli in abscence of an external magnetic field. (After Harms et al., 1986).

However, when the sample is placed in a magnetic field (Bo) the nuclei within the sample tend to align themselves with the direction of the external magnetic field, producing a net magnetic moment in the direction of the magnetic field (Mo). In fact the nuclei within the sample tend to align themselves parallel and anti parallel to the direction of the magnetic field. Slightly over half having their own magnetic moment in the same direction as the magnetic field. (Fig.1-3). The net magnetisation of the sample is therefore very small and is proportional to the magnetic field strength.

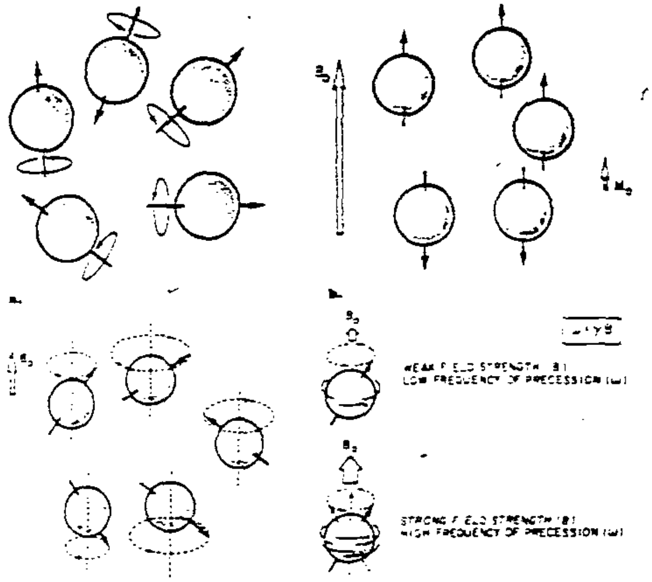

Fig. (1-3) (a) In the absence of an external magnetic field the spinning protons randomly oriented therefore the net magnetization is zero, (b) Shows the degree ofalignmentof protons with an applied magnetic field with net magnetization M (After Osborn and Hendrick, 1988).

The magnetic field in which the sample is placed is often referred to as the external magnetic field. The units of magnetic field are tesla and Gauss: 1T (Tesla = 10,000 G (Gauss) ***(Kean and Smith, 1986).***

Precession (Fig. 1-3)

If we consider an individual nucleus which is aligned in the same direction as the external magnetic field which is in the vertical or Z direction and if an oscillating magnetic field is applied in the horizontal plane (an RF pulse) at the correct frequency, the nucleus will resonate. The resonance of the nucleus takes the form of precession about the equilibrium position, the frequency of the oscillating magnetic field in the horizontal plane which produces this precession, or resonance, is called the larmor frequency. ***(Kean and smith, 1986).*** It is derived from the following equation, $W= Bo^{y}$ where Bo= the strength of the external magnetic field. y = constant for each particular nucleus ***(Shafik, 1991).***

Radio frequency field:

Magnetic resonance absorption can only be detected if transverse magnetization (magnetization perpendicular to Bo) is created, since it is the transverse component Mxy that is time dependant and thus, according to Faraday's law of induction, can induce a voltage in a receiver coil. By contrast, the longitudinal magnetization in thermal equilibrium is static and does not meet the requirements for magnetic induction. Transverse magnetization is created when a small radio frequency (RF) field rotating synchronously with the precessing spins, is applied. When this radio frequency field acts in a direction perpendicular to the main field, the effect is to rotate the magnetization away from its rest state. Just as the individual magnetic moments sense the force of the external field, constraining them to precess, the macroscopic magnetization now experiences a torque of the radio frequency field, forcing the magnetization to rotate about it, if the duration of the field is such that the net magnetization is rotated by an angle of 90 degrees, it will become transverse, or perpendicular to the static field (fig 1-4) ***(Stark and Bradley, 1988).***

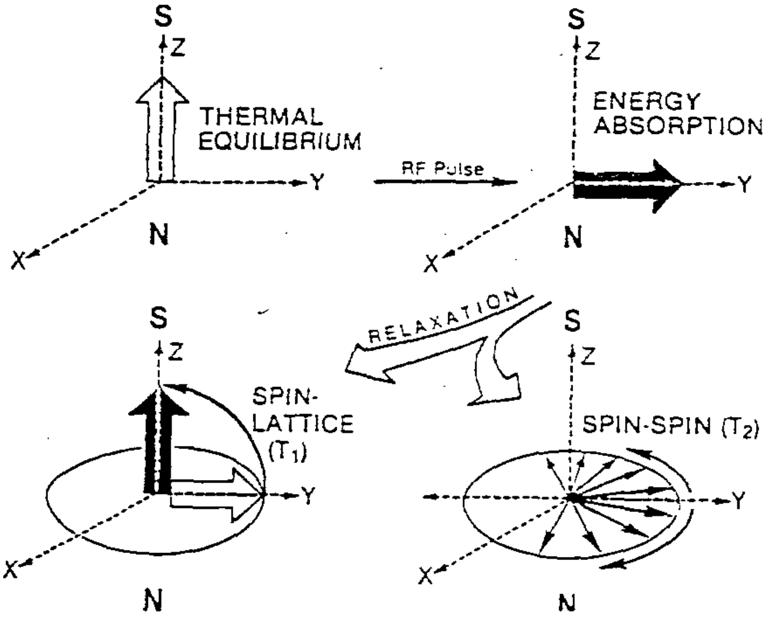

Fig. (1-4) shows how the net magnetization is tipped into the transverse plane following RF pulse and T1, T2 relaxation following the removal of the RF pulse (After Harms et al., 1986).

Free induction decay

An NMR signal which is detected immediately after an RF pulse is called free induction decay (FID). The term implies that precession occurs in the absence of a driving RF field, and is therefore free. (Fig 1-5) ***(Kean and Smith, 1986).*** The transverse magnetization Mxy does not persist. It decays to zero exponentially with a time constant T2*, as does the amplitude of the detected voltage V. ***(Stark and Bradley, 1988).***

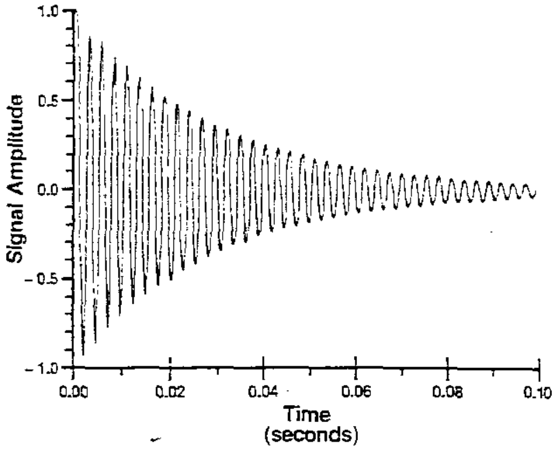

Fig. 1-5: Computed free induction decay signal for a single frequency. Note that the amplitude of the signal decays exponentially with a time constant T2, (After Stark and Bradley, 1988).

Relaxation times

The transverse magnetization does not persist. In fact, it will eventually decay to zero following a 90 degree RF pulse, while at the same time the longitudinal magnetization grows back to its equilibrium value. The processes determining the return to equilibrium of both longitudinal and transverse magnetization are summarized under the