MRI OF SUPERIOR MEDIASTINUM

ESSAY

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To...

My Parents

بسم الله الرحمن الرحيم

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CONTENTS

INTRODUCTION
AND
AIM OF WORK

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The superior mediastinum is a very important region as it consists of various structures together with the multiplicity of lesions affecting it.

Over the past few years, CT imaging of superior mediastinum has become wide spread and has replaced conventional tomographic examinations for the evaluation of various lesions.

Recent reports have shown that MRI also has substantial capacity for the evaluation of superior mediastinal lesions, and has the advantage of requiring no intravascular contrast media for distinct delineation of masses from mediastinal vessels, in addition to multiplanar and multisequence imaging thus permitting optimum delineation of masses.

The aim of this work is to highlight the role of Magnetic Resonance Imaging in different superior mediastinal lesions.

MRI PHYSICS

PHYSICS

Harms et al., in 1984, stated that certain nuclei (^{1}H, ^{31}B, ^{14}Fe, ^{23}Na, ^{13}C, ^{14}N among others) have an inherent spin. The spinning of the charged nucleus results in a magnetic moment that behaves like a tiny bar magnet. Hydrogen is the most frequently used nucleus for MR signal because of its abundance in biological tissues and its high MR sensitivity.

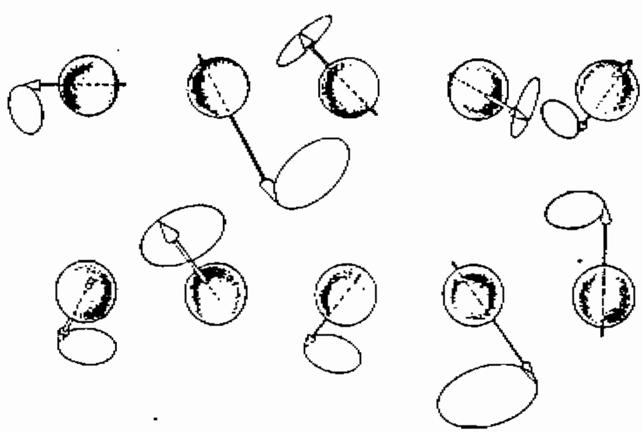

Fig. (1-1): Shows the randomly oriented nuclei in absence of an external magnetic field (Harms et al., 1986).

In absence of an external magnetic field, the nuclei are oriented randomly, with a net magnetization equal to zero (fig. 1-1). When the nuclei are subjected to an external magnetic field, the nuclei tend to orient themselves in the direction of the external magnetic field ***(Harms et al., 1984)*** (Fig. 1-2). When any externally applied magnetic field, there is always a very small net excess of dipoles aligned in the lower energy parallel direction compared with antiparallel orientation. This excess population is represented by a vector called the net magnetization "M". The main reason for using powerful magnets in MRI is to maximise "M" which results in a greater signal strength ***(Edelman et al., 1990)***.

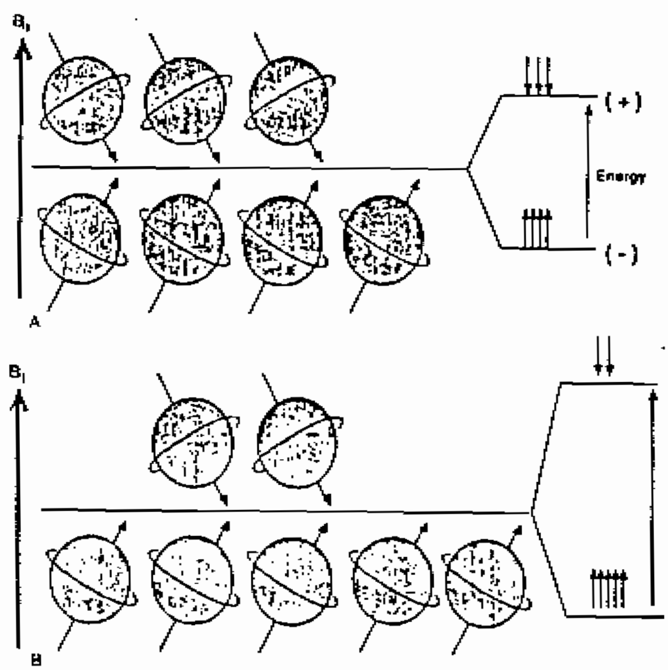

Fig. (1-2): The degree of alignment of protons with an applied magnetic field (Edelman et al., 1990).

Precession:

Each nucleus spins at a different frequency called larmor frequency (W), which is represented in the equation $W=B_o\gamma$, where B_o= the strength of the external magnetic field, γ = constant for each particular nucleus.

Excitation:

It takes place when a radio frequency pulse RF with a specific larmor frequency is applied in a plane perpendicular to the plane of external field (the vertical plane Z), causing the nuclei to precess or resonate (spin). In resonance the nuclei tend to resonate in phase with the net magnetization in a plane perpendicular to the vertical plane (horizontal or x-y plane) (Fig. 1-3).

Relaxation:

When the RF pulse is switched off. The nuclei start to relax with their larmor frequency. The loss of magnetization occurs first in the transverse plane by dephasing of the nuclei (spin - spin relaxation) then in the vertical plane (spin - lattice relaxation) till at the end the net magnetization returns to vertical plane (plane of external field) (Fig 1-3).

a. spin-spin relaxation T2

It is the loss of nuclear phase conferance (dephasing). As a result the nuclear magnetization in the horizontal plane (X-Y) drops to zero. The dephasing is due to very small variations in the external field or field inhomogenicity T2* and it is caused by interactions between the spinning nuclei (fig. 1-3).

b. Spin-lattice relaxation Tl

It is the return of the net magnetization to equilibrium with the applied magnetic field in the Z direction, Tl depends upon the power of the external magnet. Tl increases with the increase in the strength of the external magnet. Tl takes place due to loss of energy of the spinning to others in the environment (fig. 1-3).

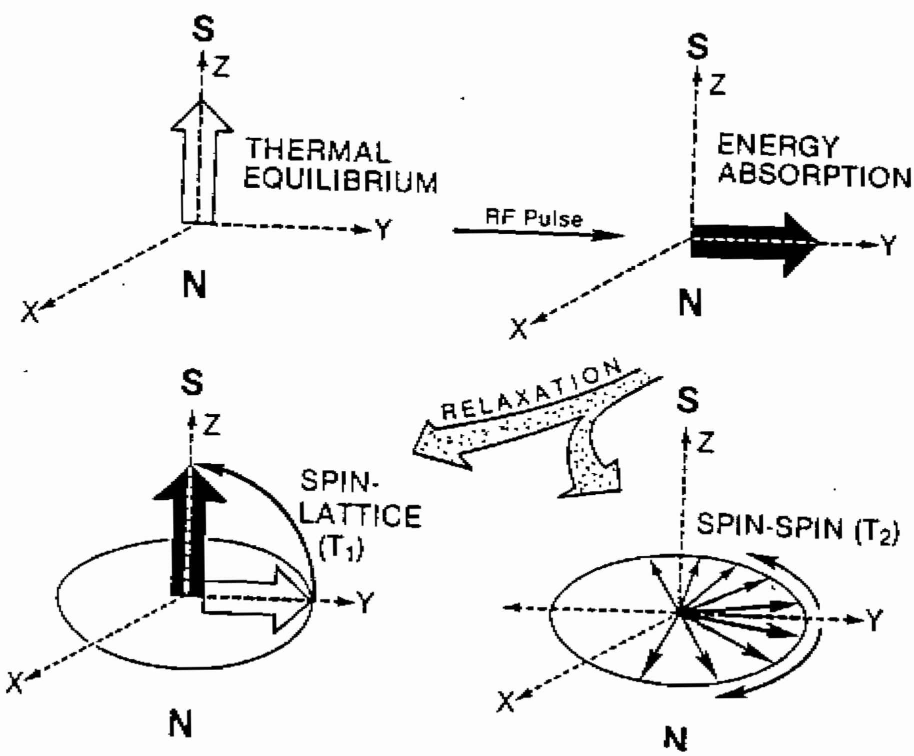

Fig. (1-3): Shows how the net magnetization is tipped into the transverse plane following RF pulse and Tl, T2 relaxation following the removal of the RF pulse. (Harms et al., 1986).

Tl and T2 characterize distinct types of nuclear interactions in a molecular environment, that is why MRI potentially passes greater pathophysiologic specificity than other imaging modalities.

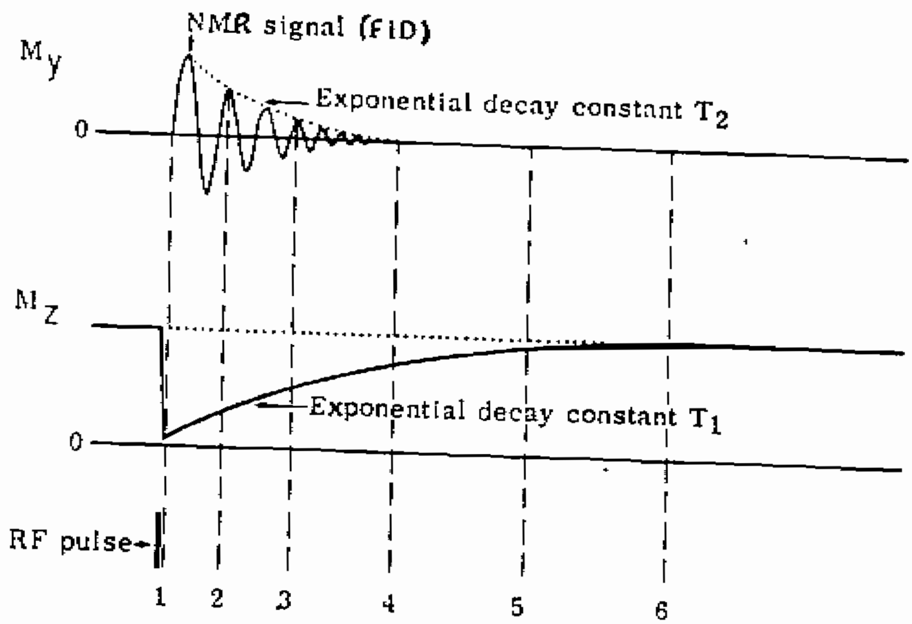

Fig. (l-4): Shows Tl, T2 curves following removal of RF pulse, as both Tl, T2 are variations of magnetic momentum in time (Kean and Smith, 1986).

The net magnetization is tipped 90° in the transverse plane and Tl=0, while T2 is maximum. Then each returns to equilibrium through an exponantial curve as a function of time, with Tl being usually longer than T2 ***(Harms et al., 1986).***

Biological Tl and T2:

The simplest concept is to relate Tl and T2 values to free and bound water in tissues. Water when bound to large molecules is slowed, with consequent shortening on Tl while free water has long Tl. For example, in tumors free water increases their Tl. On the other hand, T2 of free water is longer than that of bound water as large molecules dephase quickly ***(Kean and Smith, 1986).***

Signal production:

Following switching RF pulse off, relaxation takes place and a signal is received via coils (fig. l-5).

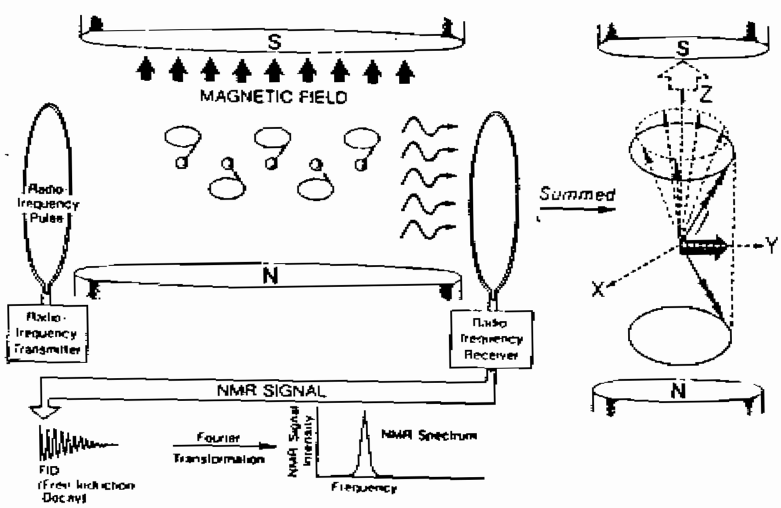

Fig. (l-5): Shows the RF transmitter, RF receiver, where the signal passes through a fourier transformer and signal production (Harms et al., 1984).

Pulse sequences:

I. Spin Echo (SE):

A 90º RF pulse tips the net magnetization in the X-Y plane, now all nuclei are in phase, then the nuclei start to dephase. After certain time delay (t), a 180º RF pulse is applied. Following the second RF pulse the nuclei start to rephase again with refocusing of the net magnetization to produce an echo-signal after a time interval called echo time (TE) (fig. 1-6).

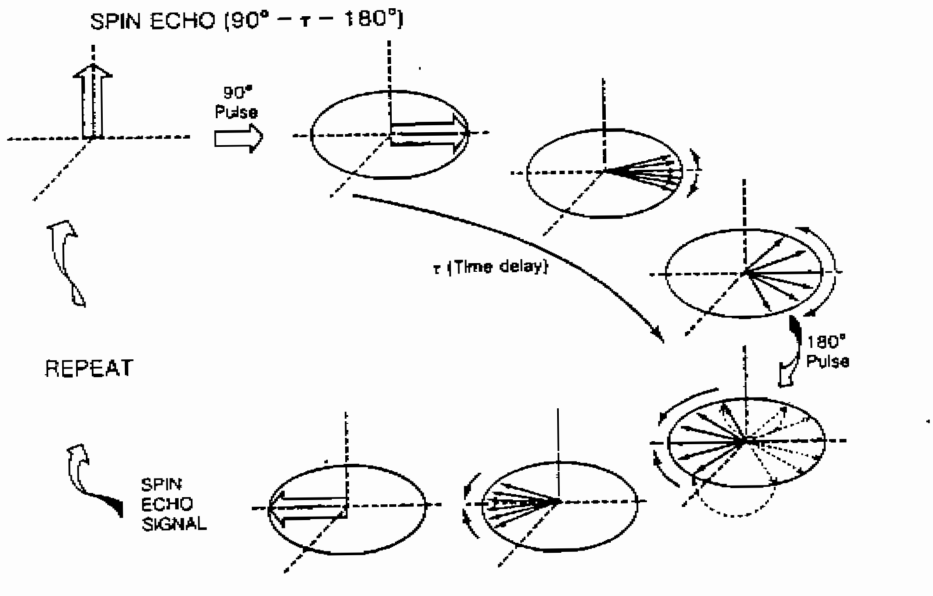

Fig. (I-6): Showing the SE pulse sequence (Harms et al., 1984).

The delay interval between 90º RF pulse and 180º pulse = TE/2 as the nuclei take the same time to dephase and rephase. Time delay between successive 90º RF pulse = (TR) repetition time, and the time