MAGNETIC RESONANCE IMAGING IN OBSTETRICS AND GYNAECOLOGY

ESSAY

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER IN
OBSTETRICS AND GYNAECOLOGY

BY

SHADIA MOHAMMED MOHAMMED AHMED
M.B., B.Ch.

UNDER THE SUPERVISION OF

PROF. DR. AHMED GALAL EL-LATHY
Professor of Obstetrics and Gynaecology
Faculty of Medicine
Ain Shams University

DR. MOHAMMED ADEL EL NAZER
Lecturer in Obstetrics and Gynaecology
Faculty of Medicine
Ain Shams University

FACULTY OF MEDICINE
AIN SHAMS UNIVERSITY
CAIRO

1988

To My Husband

بسم الله الرحمن الرحيم

ACKNOWLEDGEMENT

I would like to express my sincere gratitude and heartfelt thanks to Prof. Dr. Ahmed Galal El–Lathy, Professor of Obstetrics and Gynaecology, Ain sham University, to whome I am greatly indebted for his valuable guidance, expert assistance and fruitful criticism.

I wish to thank Dr. Mohammed Adel El–Nazer, Lecturer in Obstetrics and Gynaecology, Ain Shams University, for his valuable advice and cooperation throughout this work.

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INTRODUCTION

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Magnetic Resonance Imaging (MRI) is a new technique for viewing the internal anatomy of the body. It is based on the phenomenon of nuclear magnetic resonance (NMR) which was discovered in *1946 by Bloch et al. and Purcell et al.* and for which they were jointly awarded the 1952 Nobel Prize for physics. They showed that when certain atomic nuclei are placed within a magnetic field and then stimulated by radio waves of a particular frequency they will re-emit some of the absorbed energy in the form of radiosignals. This is known as nuclear magnetic resonance. It has been used since that time by chemists and physicists for the study of matters at molecular level *(Block and Purcell, 1953)*.

The idea to extend NMR to studies on humans dates back to Jasper Jackson, who in 1967 produced what are believed to be the first NMR signals from a live animal. After that, and in 1971, *Daniel et al.,* discovered a difference in the NMR properties of malignant and normal tissue of the same organ type. However, it was only in the last decade that the NMR proton imaging developed. In 1973, *Lauterbur* published the first two-dimensional proton NMR image for a water sample.

The first clinical trial of the NMR technique was started at the University of Aberdeen *(Edelastein et al., 1980)*. Since these early reports the advances of MRI have been dramatic. Its value in the assessment of pathologic problems in nervous system and musculoskeletal system has been clearly demonstrated *(Worthington, 1983)*. It was not until 1984 that the foetus was imaged by MRI *(Johnson et al., 1984)*. Since that time the potential values of the technique in obstetric practices were demonstrated.

It is clear from the large volume of published work that this method represents significant advance in medical imaging.

MRI is non-ionizing, non invasive and has the capacity to produce direct multidirectional images in any plane, MRI does not require the use of iodine containing contrast media and, unlike X-ray and computerized tomography, is free from artifacts due to bone, metal (surgical clips), or air interface. As compared to diagnostic ultrasound, MRI is neither operator nor patient dependent *(Hricak et al., 1985)*. MRI has no proved harmful biological effects in the diagnostic range of radiofrequencies. Its high soft-tissue contrast resolution makes it the most exciting diagnostic approach since the introduction of X-rays in 1985 *(Margulis, 1986)*.

The pelvis is an area offering distinct advantages for MRI. The images are not degraded by respiratory motion, and the normal abundance of fat renders superb delineation of tissue planes. The ability of MRI to obtain direct transaxial, coronal and sagittal images enhances the evaluation of the bladder, uterus, and rectum despite their close opposition. It can be expected that MRI will play an important role in the clinical management of obstetrical and gynecological problems *(Hricak et al., 1983)*.

Magnetic Resonance without Nuclei

Meaney (1984) suggests that we eliminate the word "nuclear" from nuclear magnetic resonance (NMR) imaging and simply use magnetic resonance imaging (MRI). He wishes to avoid the fear of the public over things "nuclear." As will be seen, the nuclear magnetic resonance technique involves no nuclear radiation.

PHYSICAL PRINCIPLES

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Properties of Atomic Nuclei

In general, atomic nuclei contain both protons and neutrons. The exception is the hydrogen (^1H) nucleus which consists of a single proton. The constituent nucleons each possess an intrinsic angular momentum or "spin." However, pairs of protons or pairs of neutrons align in such a way that their spins cancel out. So the nucleus to have a net spin must contain an odd number of proton, neutron, or both. Because the nucleons each have an associated electric charge distribution, the net rotation or spin generates a magnetic field. Each nucleus may be considered therefore to act as a small bar magnet, or magnetic dipole (Fig. 1). In the absence of any externally applied field, the orientation of the dipoles is random (Fig. 2) *(Pykett et al., 1982)*.

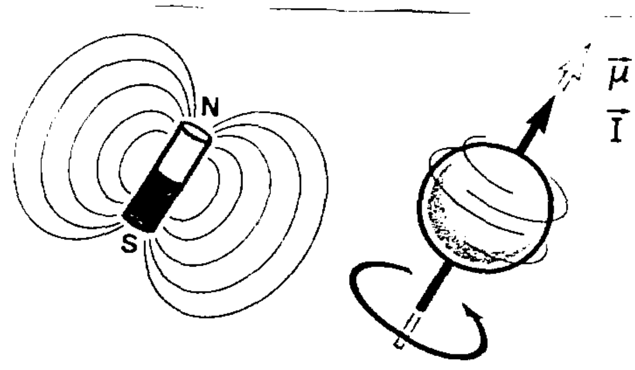

Fig. 1: Magnetic nuclei behave like microscopic bar magnets

(Reprinted from GEC, 1982)

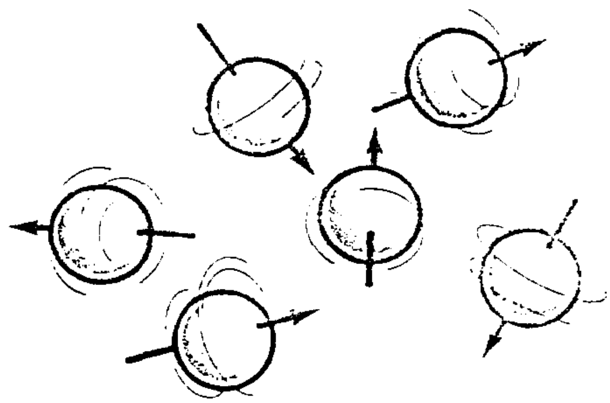

Fig. 2: In the absence of a magnetic field, spins are randomly oriented *(Reprinted from GEC, 1982)*

Nuclei in Magnetic Field

When the randomly oriented dipoles are placed in a static magnetic field, they tend to align parallel to that field producing a net magnetic moment or a net magnetization vector in the direction of the static field *(Thickman et al., 1984)*. Application of a radio frequency pulse (RF) via a coil surrounding the sample under study will displace the net magnetization vector from its direction parallel to the static field by an angle (Fig. 3). This angle depends on the strength and duration of the applied radio frequency pulse. A radio frequency pulse enough to produce an angle of 90° is called a 90° radio frequency pulse (RF 90) *(Pykett et al., 1982)* (Fig. 4).

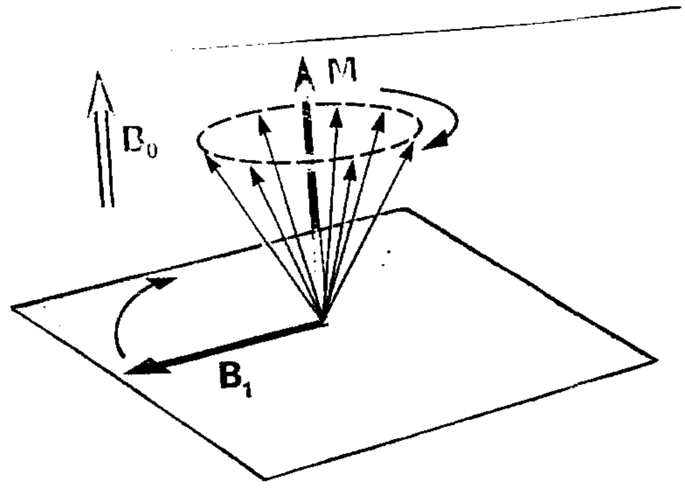

Fig. 3: Transverse magnetization is induced by a radio frequency field B_1 rotating synchronously with the precessing spins.
B_0 = static field
M = net magnetization vector

(Reprinted from GEC, 1982)

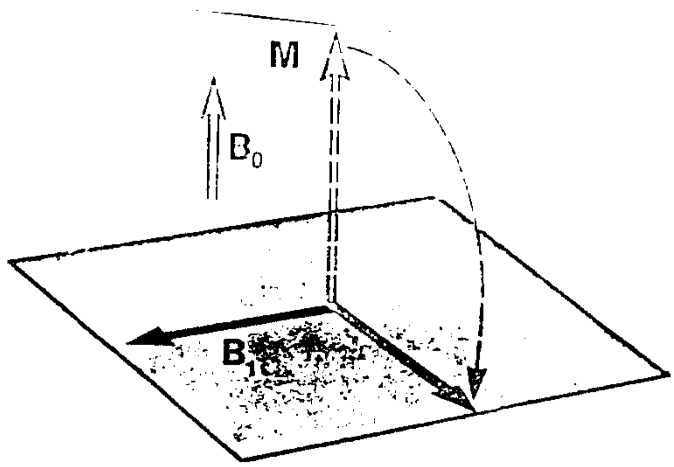

Fig. 4: If the duration of the B_1 field is sufficient to rotate the magnetization by an angle of 90°, the entire magnetization ends up in the transverse plane.

(Reprinted from GEC, 1982)

The Larmor Frequency

The nuclei of particular (NMR) sensitive element will respond only to stimulation by a radio frequency pulse of specific frequency termed the resonant or larmor frequency (F_0) according to the formula:

F_0 = B_0 ($\Upsilon/2\pi$) where

Υ = is a gyromagnetic ratio, a constant for each sensitive nuclear species.

π = 90°

B_0 = strength of static field.

(Pykett et al., 1982)

Production of NMR Signals

For the most part, MRI has limited to hydrogen nuclei or protons. Hydrogen proton is favourable from the NMR stand point because it gives a relatively high signal and is abundant in biologic tissues.

When a group of protons is exposed to a static magnetic field and then a radio frequency pulse (in the Larmor frequency) is applied, the net magnetization vector of this group of protons will be displaced by an angle. By choosing a suitable (RF) pulse, this angle will be a 90°. Now, the magnetization vector is displaced to rotate in a perpendicular plane to the plane of the applied static field (Fig. 4). The energy absorbed by the protons will be re-emitted following the stoppage of (RF) pulse application. These emitted energy generates an electric signal called the