INTRODUCTION

HISTORICAL OUTLINE:

The first successful Nuclear Magnetic Resonance (NMR) experiments were described by Bloch and Purcen independently in 1946 and for their discovery they where jointly awarded the Nobel Prize for physician in 1952. Thus paving the way for the development of NMR spectroscopy as a powerful analytical tool in chemistry and biology **(Bradley et al., 1997).** Damadian in 1972 and Lauterbur in 1973, indicated the potential NMR to obtain images of the intact humen body **(Gonzales et al., 1985; Bradley et al., 1997; Sutton, 2003).**

Human in vivo, magnetic resonance (MR) images MRI were first published in 1977 by Mansfield and Maudsley, Damadian et al. and Hinshaw et al. The multiplanar facility of MRI was first demonstrated by Hawkes et al. in 1980 **(Bradley et al., 1997).**

Since then MRI techniques has so far been proceed for the assessment of uterine cavity and tubal patency.

Lee and associates in 1996 published their work of MR hysterosalpingography (HSG) on rabbit uterus using dilute gadopentate dimeglumine as a contrast agent and T1W gradient-echo MR images, for the assessment of the

uterine cavity and tubal patency with sensitivity and specificity of 95.5%, 86% (no statistical differences was found between MR HSG and conventional HSG **(Lee et al., 1996).**

The first research on human uterus specimens removed for benign cause using 3D MR HSG with dilute gadolinium by Maher RAO in 1999, demonstrated permeation of contrast into the myometrium, reaching the serosal surface of the myometrium **(Maher et al., 1999)**, both previous mentioned studies, were unable to detect the Fallopin tubes reliably with their techniques, whereas demonstration of the uterine cavity was quite feasible.

Another study used saline as a contrast agent was evaluated in a model of human female by utilizing dynamic scanning and a rapid acquisition with relaxation enhancement (RARE), along with the injection of sterile water. Tube with a minimum diameter of 1 mm were successfully imaged by Frye RF et al in 2009 **(Frye et al., 2009).**

Magnetic resonance hystorography and hysterosalpiygography using hyperpolarized ^{3}He. Demonstration of feasibility in another model. Another study, used hypeipolerized ^{3}He procine uterus was studied both within the body and outside the body submerged in a

water bath. 3D.FLASH sequence was used for imaging, correlation with iodinated contrast and X-ray flouroscopy was obtained. The uterine cavity could be well depicted. Tubal patency could be confirmed due to leakage of contrast material by Klaus et al in 2000 **(Klaus et al., 2000).**

The last study, was on infertile women underwent 3D dynamic and 3D MR angiography sequences before, during and after injection of a diluted gadolinium solution by Wiesnen et al. in 2010. Evaluation of pelvic anatomy, myometrium and ovaries was possible in all patients on the basis of T2W / FSE, three dimensional visualization of the dilated cavum uteri was possible. This technique proved bilateral Fallopian tubes patency which was confirmed in each patients by conventional HSG by Wiesnen et al in 2010 **(Wiesnen et al., 2010).**

AIMS OF THE STUDY

Comparative study to correlate findings of Magnetic Resonance Hysterosalpingography with conventional HSG in the detection of uterine abnormalities and fallopian tube patency.

To show whether really MR HSG has a role to play in infertility as a safe alternative to conventional HSG.

To emphasize the advantage of MRI / MR HSG in showing any adnexal pathology related to infertility.

THE FEMALE REPRODUCTIVE SYSTEM

The female reproductive organs are divided into:

1. **INTERNAL ORGANS GROUP WHICH ARE: TWO OVARIES, TWO FALLOPIAN TUBES, THE UTERUS AND VAGINA (fig. 1).**

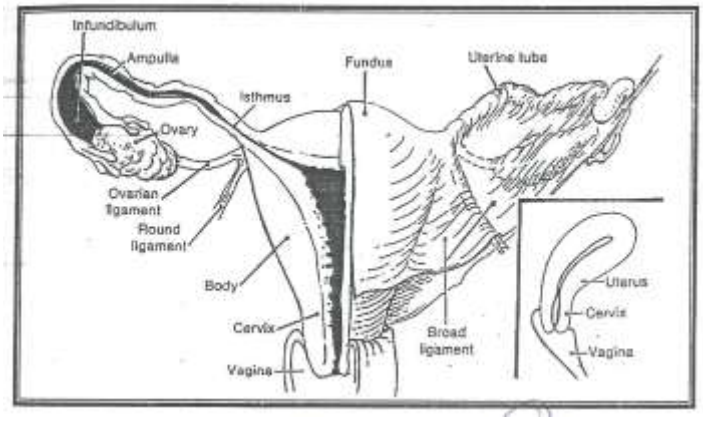

Fig. (1): Female internal reproductive organs **(Brounskil et al., 1993).**

2. **THE EXTERNAL ORGANS ARE COLLECTIVELY CALLED THE VALVUA.**

THE OVARY

The ovary is the female sex gland. Ovaries lie on each side of the uterus, in the true pelvis **(Brounskil et al., 1993).** Each is attached to the back of the broad ligament of uterus, by a fold of peritoneum called Mesoovarium.

It is an almond-shaped, having medial and lateral surfaces, tubal and uterine side, the position and mobility varies. It lies almost free in the peritoneal cavity, it's about 3cm length x 2cm width xicm thickness cm.

In nullliparous they are smooth, each composed of an outer cortex and inner zone, called the medulla, after puberty the cortex contains multiple follicles.

Blood supply: ovarian arteries from abdominal aorta.

Venous drainage: Right ovarian v. -IVC

Left ovarian v. -left renal v –IVC

(Brounskil et al., 1993).

UTERINE (FALLOPIAN) TUBES

The fallopian tubes lie in the upper margins of the broad ligament of the uterus, each about 10 cm in length, they are divided into four parts:

1. **THE UTERINE PORTION**: within the wall of the uterus,

2. **THE ISHMUS PORTION:** narrow, straight cord like, which lies between the ampulla and the uterus

3. **THE AMPULLARY PORTION:** the widest part (dilated), it runs a tortuous course, about 5-cm in length.

4. **THE INFUNDIBULUM:** it is funnel in shape, outer expanded portion which opens into the peritoneal cavity. The mouth of the opening is surrounded by a number of finger like processes (the fimbriae), it runs to curl around the anterior and the lateral surface of the ovary **(Mackenna and Callander, 1997).**

Fallopian tube is directly continuos with the lining of the body cavity on one end, and with the lining of the uterus and vagina on the other. This has great clinical significant, because infection of tube or uterus (gonorrhea) may pass into the abdominal cavity causing peritonitis, plus tubal damage and occlusion, later on it will cause infertility.

Blood supply: uterine and ovarian artery **(Mackenna and Callander, 1997).**

THE UTERUS

5. Is a hallow, pear shaped muscular organ, with mainly a small cavity inside, lying between the bladder and rectum (Fig. 2). It measures about 7.5-8 x 5 x 2-2.5 cm, opens into the vagina inferiorly, forms an angle of 100-110 with the vagina, but it is quite mobile organ **(Mackenna and Callander, 1997).**

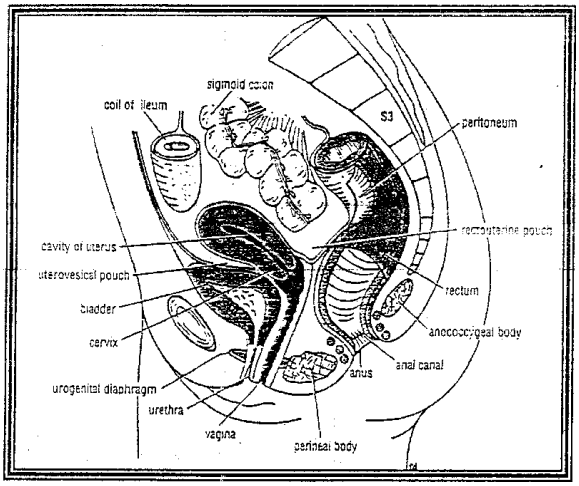

Fig. (2): Sagittal section of female pelvis **(Mackenna and Callander, 1997).**

The uterus above the entrance of the fallopian tubes (cornua) is known as the fundus, succeeded by the body, which is the largest part, it lies above a slightly constricted area called the isthmus, below it is the cervical portion of the uterus. It is about 2.5 cm in length, the opening of the cavity of the cervix into the uterus is called the internal os, while the opening of the cavity into the vagina is called the external os **(Mackenna and Callander, 1997).** (Fig. 3)

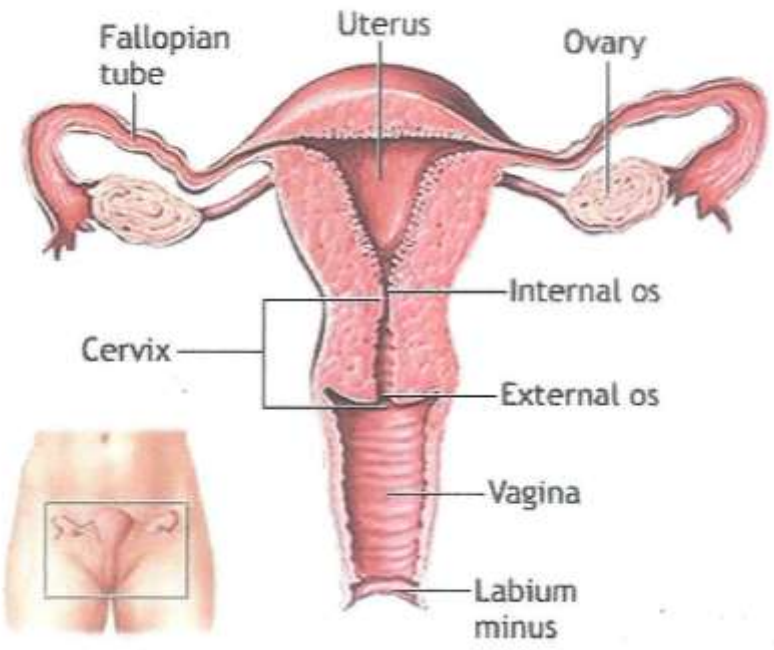

Fig. (3): Normal anatomy of female reproductive system **(Mackenna and Callander, 1997).**

The uterus is supported by several ligaments including the following:

1. The broad ligament: which pass from each side of the uterus to the lateral wall of the pelvis, the fallopian tube lies in it is free edge.

2. The round ligament: two bands of fibrous tissue which are attached to the uterus below the uterine tubes, then pass laterally through the inguinal canal to the vulva **(Mackenna and Callander, 1997).**

3. Anterior and posterior ligaments: these are attached to the bladder, and sacrum respectively **(Mackenna and Callander, 1997).**

BLOOD SUPPLY: uterine artery and branches from ovarian arteries form abdominal aorta.

THE VAGINA

It is a fibromuscular canal, about 7.5 cm in length, which extends from the vulva to the uterus. It runs upwards and backwards. The anterior and the posterior wall are normally in contact, at it is upper end, in to which projects the cervix, surrounded by a deep sulcus (the fornices).

Blood supply: internal iliac and uterine arteries **(Mackenna and Callander, 1997).**

The steps of MR examination can be described quite simply:

1. The patient is placed in a magnet.
2. A radio frequency wave is sent in.
3. The radio wave is turned off.
4. The patient emits a signal, which is received and used.
5. Reconstruction of the final MR image. The strength of this signal and it is decay with time is influenced by **(Snell, 2001)**:
    - Strength of the magnetic field.
    - Proton density.
    - Spin lattice relaxation time; time constant Tl.
    - Spin spin lattice; time constant T2.
    - Flow.

MULTIPLE PARAMETERS:

WHAT ARE Tl AND T2?

MRI has a great inherent soft tissue contrast in many areas. The tissue contrast depends on the choice of imaging sequence, Which highlight the influence of certain tissue characteristics, essentially the Tl and T2 relaxation time **(Dousset and Buthiau, 1995)**.

The relaxation of the protons back to equilibrium at lower energy state is termed the longitudinal relaxation. It's referred to by the time constant Tl. Immediately after the RF pulse is applied, the exited protons process together in synchronism or in-phase with each other at the resonant frequency. During relaxation however they quickly get off phase due to small variation in local magnetic fields. This loss of phase is termed transverse relaxation or time constant T2 **(Sadler, 2000)**.

MULTIPLE TECHNIQUES:

PULSE SEQUENCE:

MRI pulse sequence in clinical use can be grouped into the basic classes:

Spin echo and gradient echo sequences, these basic sequences covering a broad range of contrast values. This

means the sequence of the RF that we give **(Bellon and Diaz, 1994).**

SPIN ECHO (SE):

If we give a pulse consisting of a 90 pulse and 180 pulse, then this called "spin echo" sequence, with SE sequence we cannot produce only T2 but also Tl **(Maher et al., 1999)**.

INVERSION RECOVARY (IR):

A 180-degree inversion pulse is used. This inversion time is chosen to cancel signal from fat. It gives images with a combination of both Tl and T2 sequence **(Brounskil and Sprawls, 1993)**.

GRADIENT ECHO:

By varying the flip angle and value of TR (round 10 ms), the imaging time of order of 1 second are possible. This technique has numerous applications such as GRASS, FISP, and FLASH **(Brounskil and Sprawls, 1993)**.

TR AND TE:

It is important to understand that the gray scale on MR image is not readily predictable and can dramatically altered by machine-dependent parameter (such as pulse sequence, TR, TE). So the pulse that we use e.g. 90-degree

can be repeated after a certain time, which is called TR: time to repeat **(Dousset and Buthiau, 1995)**.

After sending the 90- degree pulse, we wait a time to receive the signal, called TE. This time to echo. These TR, TE can be chosen by the operator and they will influence the resulting signal and thus also the image. If we use a short TR and short TE, the resulting picture is Tl W image, while if we use a long TR and long TE, the resulting picture is T2 W image **(Dousset and Buthiau, 1995)**.

MRI LIMITATION:

Absolute contraindication:

1. Cardiac pacemaker.
2. Non- compatible surgical and vascular clips.
3. Small ferromagnetic foreign bodies (Cardiac valve, intra ocular foreign, cochlear implants).

Relative contraindications:

1. Claustrophobia.
2. The 1st trimester of pregnancy, as precaution although MRI
   has not proved to be teratogenic.

(Dousset and Buthiau, 1995).

TYPES OF MAGNET:

1. ***Resistive:*** In practice, limits the fields' strength to a maximum of 0.5 Tesla.

2. ***Superconducting:*** Used in the high field system up to 4 Tesla, but it necessitate the immersion of the coils in liquid helium to maintain their superconductive properties.

3. ***Permanent:*** These are rarely used to their great weight, which limits the field strength.

(Dousset and Buthiau, 1995).

FIELD OF STRENGHT: [15]

1. Low: ultra low field up to 0.35 Tesla.

2. Mid field from 0.35 to o.6 Tesla.

3. High field from 1 up to 4 Tesla.

(Bellon and Diaz, 1994).