

**Sudan University of science and  
technology  
College of graduate studies**

**Characterization of female Infertility  
using ultrasound**

توصيف عقم النساء بالموجات فوق الصوتية

A thesis submitted for partial fulfillment of M.Sc. degree in medical ultrasound

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# Abstract

Infertility is inability to conceive after one year of unprotected intercourse .it is one of the major problems that can facing any women in any period of her life .knowing the causes or characteristic of infertility will help in improve the result .the general objective of this study was to evaluate the characteristics of the infertility in the infertile women by studying the difference between the uterus size and the blood flow in the fertile and infertile women .the study was carried out in the department of ultrasound in college of medical radiology science using general electric logic 5m ultrasound machine .the data were collected by measuring the p1, r1,and ps1 values as well as the physical dimension of the uterus .the data were collected from 100 women ,50 of them were infertile and the other 50 were fertile women taken as control group.

The result showed that the mean values of p1, R1 ,and psv and  $0,79 \pm 0,4$  .  $2,564 \pm 1,5$  and  $57.75 \pm 24,8$  and the uterus size is  $44,08 \pm 4,6$  for infertile group and it was  $0,82 \pm 0,3$  .  $2,612 \pm 1,6$  and  $50,83 \pm 24,2$  for fertile group with uterus size  $46,72 \pm 3,2$ .

These values showed that there is difference between the control group and the study group .the variation between the fertile and infertile group was significant at  $p=0,05$  using t lest. The t values for p1 of fertile and infertile group 0,08 and 0,43 and t value for r0 0,73 and 0,17 .psv 0,7 and 1,41 .uterus width 0,29 , and 1,28 ,and uterus length 0,001 ,and 7,12.

General the result showed that the infertile group were different as well as they were different from control group.



# الخلاصة

العقم هو عدم الحمل لمدة عام بالرغم من الاتصال الجنسي ويعتبر العقم من المشاكل الرئيسية التي تواجه معظم النساء في فترات مختلفة من العمر معرفة الأسباب أو الخصائص للعقم تساعد في تقليل نسبة العقم والهدف العام من هذه الدراسة تقويم تدفق الدم ومؤشرات الشريان الرحمي ونسب مقاومة وسرعة التردد R1 ومعرفة مقاومة الدم وتردده P1 شريانا الدم في شريان الرحم وحجم الرحم في حالات العقم وتم جمع البيانات من psv الاعلى لنبض القلب 100 حاله حيث كانت 50 من الحالات مجموعة الدراسة و 50 حاله مرجعيه وقد اجريت هذه الدراسة في قسم الموجات فوق الصوتيه في كلية علوم الأشعة h الطبية جامعة السودان للعلوم والتكنولوجيا باستخدام جهاز جنرال إلكتريك P1,R1,PsV . للموجات فوق صوتيه ثم جمع البيانات عن طريق قياس logic

وفي P1 وأظهرت هذه الدراسة ان هناك اختلاف في مؤشرات تدفق الدم الرحمي psv سرعة القصوى لسريان الدم عند انقباض عضلة القلب و R1 معامل وطول الرحم كانت P1,R1,PSV 00,79 لمجموعات العقم ,حيث أن متوسط القيم وحجم الرحم في مجموعة العقم +24.8 - 57.75 and 0.4 + - 2.564, 1.5 + 44.08 - 4.6 وفي المجموعة المرجعيه +00.82 - 06.3 , +20612, 24.2-+106,50.83

وأظهرت هذه القيم ان هناك فرق بين المجموعه المرجعيه ومجموعة الدراسة وكان هذا الفرق معنوي عن طريق استخدام اختبار t للمجموعة بأكملها في المجموعتين P1 0.08, 00.43 لقيم t value مقابل المرجعيه على ع = 0.05 وكانت PSV وفيما يتعلق ب 0.73 and للمجموعتين R1 0.17 لقيم T value كما كانت 1.28 and 7.12 وطول الرحم . 001.7 AND القيم هي

وأظهرت النتائج عموما ان هناك فرق بين مجموعه العقم والمجموعة المرجعيه من حيث تدفق الدم الرحمي ومعامل السرعة القصوى لسريان الدم عند انقباض . وحجم الرحم , PsV عضلة القلب

# **Chapter one**

## **Introduction**

Infertility is the inability to conceive after one year of unprotected intercourse. This definition is based on the cumulative probability of pregnancy.

Classification:-

Primary infertility :- never conceived before.

Secondary infertility :- at least one previous conception.

The etiology of infertility is established and there is no possibility for conception.

Fecundability and age:-

An inverse relationship exists between female age and fertility.

conceiving in 12 months (%)	Age group
85	20-24
80	25-29
60	30-34
50	35-39

Causes of infertility in males:-

1-hormonal causes the disorder related to the function of the pituitary gland in the bottom of the brain or other glands that affect testicular function, such as the thyroid and adrenal and pancreatic.

Internal reasons in the testis

such as absence of the mother cells producing sperm, or cirrhosis of the testis, which may occur as a complication of the testis, which may be of mumps, especially in adulthood and beyond, and exposure to testicular radiation or harmful drugs and the effect of the presence of their functions, in addition to neglect the treatment of undescended testicle in early.

-obstructive reasons

as a result of blockage of the epididymis or spermatic cord due to congenital factors, or inflammatory genitourinary disease or as a result of some surgical intervention that affects the passage of sperm from the testicle.

Common causes of infertility of females include:-

Ovulation problems (polycystic syndrome pcos) .

Tubal blockage may be due to malformation infection for example endometritis.

Pelvic inflammatory disease.

Age related factor.

Uterine problems .

Advanced maternal age .

Unexplained infertility:-

In these cases abnormalities are likely to be present but not detected by current methods possible problems could be that the egg is not released at the optimum time for fertilization that it may not enter the fallopian tube sperm may not be able to reach the egg fertilization may fail to occur.

The use of ultrasound for fertility problems:-

When investigating a couple with fertility problems it is important to establish if the woman is ovulating, that the uterus and fallopian tubes are normal and that the woman's partner is producing normal sperm . ultrasound in particular trans-vaginal ultrasound ,has proved an invaluable aid to check the female pelvic anatomy for pathology which impairs fertility.



A base line transvaginal scan of the female pelvis should be undertaken to establish normality .

Identify the uterus to exclude hypoplasia or significant enlargement it measures approximately 6-8 cm in length 4cm transversely and 6-5 anteroposteriorly. the measurements are 1-2cm more in parous women .myometrium should be checked for fibroids .sub mucosal fibroids are frequently associated with fertility problems .check the outline of the cavity to exclude any abnormality ,such as bicornuate uterus .if the scan is undertaken between days 10 and 12 of the menstrual cycle, a triple layer of endometrium should be seen measuring at least 7cm. it is necessary to have a minimal endometrial thickness 7mm to ensure successful implantation .

Check each adnexum in turn to identify any tubal problems. normally the fallopian tubes can not be visualised unless they contain fluid hydrosalpinx or pus pyosalpinx .both these conditions may affect a woman's fertility .to check the fallopian tubes we use contrast medium and colour doppler but hysterosalpingography or laparoscopy and dye as a first line of investigation .

Check each ovary in women of child bearing age the ovarian volume is 4,1-5,7 cm .when scanning a normal ovary it is usual to see four or five follicles depending on where the woman is in her menstrual cycle .at ovulation the dominant follicles can have a mean diameter of 21 mm range 17-27mm. if no follicles are visualised this should be noted .after ovulation ,collapse of the dominant follicle is noted and cystic structure will be seen in the ovary this corpus luteum.

In women with fertility problems there are a variety of treatment in an assisted conception programme ultrasound is used to monitor options depending on the underlying causes of the fertility problem .monitor the response of both ovaries, and endometrium in response to hormonal treatment.

State of the problem:-

Infertility as a complaint brought to medical attention is on the increase there are several reasons for females reasons ultrasound has proved an invaluable aid to check female pelvic anatomy for pathology which impair fertility and inform the reasons of infertility Objective of this study :-

The general objective of this study is evaluate infertility in women of child bearing age using ultrasound in particular trans vaginal ultrasound.

Significant of the study:-

This study will provide rich information about the causes of infertility in child bearing women .the study differentiate between the different causes of infertility and common infertility reasons.

Overview of the study :-

This study falls in to five chapter with chapter one is an introduction which include the problem of the study ,objective ,significant of the study and overview . chapter two is literature review .chapter three is methodology that include material and chapter four include the result presentation ,and finally chapter five include discussion ,conclusion.



# chapter Two

## 2-1 Anatomy

### **Anatomy of the female reproductive system**

There are multiple anatomical structural which comprise internal and external genitalia

#### The internal genitalia

The female internal genitalia are consisting of:

- Tow ovaries
- Tow fallopian tube
- Uterus
- Cervix
- vagina

The vagina is the female organ for sexual intercourse, egress of menstrual flow, and passage of the fetus during labor and delivery. Extend from the uterus to the vestibule of the external genitalia.

#### The external genitalia

The female external genitalia are collectively known as the vulva or pudendum.

The vulva consists of the mons pubis, labia majora, labia minora, vestibule of the vagina, clitoris, the greater vestibular glands or Bartholin's glands, the fourchette, and perineum.

- The mons pubis: is composed of fibro-fatty tissue which covers the bodies of the pubis bones. It is covered with

pubic hair, and divides to become continuous with labium major of each side.

- labia majora : The most prominent features of the vulva, its are the larger, hair-covered two folds of skin which merge posteriorly into the perineum where they are joined together by the fourchette, they contain sebaceous glands and lie on either side of the introitus.
- Labia minora : its are two thin folds of skin which lie between the labia majora , their inner surfaces are the lateral boundaries of the vestibule. Anteriorly they divide into two thin folds, the upper of which unite over the clitoris to form the prepuce , and the lower of which unite to form the frenulum. They contain no hair but have a rich supply of venous sinuses, sebaceous glands, and nerves. They are very sensitive and contain some erectile tissue.
- The vestibule: is the triangular area bounded anterolaterally by the labia minora and posteriorly by the fourchette. At the apex of the triangle is the clitoris. It contains the urethral meatus located approximately 2 to 3 cm posterior to the clitoris, immediately in front of the vaginal opening. Into the vestibule open the ducts of Bartholin's glands. Vestibular bulbs are two oblong masses of erectile tissue which lie on either side of the vaginal entrance from the vestibule. Each bulb is covered by the bulbocavernosus muscle. These muscles aid in constricting the venous supply to the erectile vestibular bulbs and also act as the sphincter vaginae.
- Bartholin's glands: are two small rounded structures situated just posterior to the vestibular bulbs. During sexual excitation, they secrete a glairy fluid which serves as lubricant. Their ducts open in the groove between the labia minora and the hymen. Each duct is about 0.5cm

long, and unless it is inflamed the orifice cannot usually be seen. They are often the site of gonococcal infections and painful abscesses.

- The clitoris: lies just in front of the urethra and consists of: Glands, body, and two crura. Only the gland of the clitoris is visible externally. The gland is covered with modified skin containing many nerve endings. The body extends superiorly for a distance of several centimeters and divides into two crura, which are attached to the undersurface of either pubic ramus. The body and the crura are composed of erectile tissue. Each crus is covered by the corresponding ischiocavernosus muscle and by their contraction produce erection of the clitoris.
- Hymen: As the labia minora are spread, the vaginal introitus, guarded by the hymenal ring. The hymen may take many forms, however, such as perforated centrally cribriform plate with many small openings or a completely imperforate diaphragm, and varying in size from a pin-hole to one that admits two fingers. The hymen is partially ruptured at the first coitus and further disrupted during childbirth.

Blood supply:

The female external genitalia are supplied on each side by the internal pudendal artery which is a branch of the internal iliac artery and by the deep and superficial external pudendal arteries.

Nerve supply:

Most of the vulva is innervated by the branches of the pudendal nerve. Anterior to the urethra, the vulva is innervated by the ilioinguinal and genitofemoral nerves.

## **physiology of female reproductive system:**

### **External Genitalia**

- The mons pubic protects the pubic bone from trauma.
- The clitoris provides for sexual arousal and orgasm.
- The labia majora and minora protect the external genitalia, urethra, and distal vagina.

- Secretions from Bartholin's glands lubricate the external vulva during coitus and improve sperm survival.
- Secretions from Skene's glands lubricate the external genitalia during coitus.
- The urethral meatus is the external opening of the female urethra.
- The perineal muscle expands during childbirth to enlarge the vagina, allowing for passage of the fetal head.

## **Internal genitalia**

- The vagina aids in conception by conveying sperm to the cervix and helps in childbirth by serving as a passageway for the fetus.
- The uterus receives the fertilized egg, provides for implantation, nourishes and protects the growing fetus, and contracts to expel the fetus during childbirth.
- The ovaries produce and release mature ova and regulate the menstrual cycle through the production of estrogen and progesterone.
- The fallopian tubes move the sperm toward the ova and the ova toward the uterus, thereby aiding in fertilization.
- The pelvis supports and protects the reproductive and other pelvic organs. During the late months of pregnancy, the false pelvis supports the uterus and helps direct the fetus into the true pelvis for birth.

## **Hormonal factor**

- Hypothalamus GRH
- Pituitary FSH, LH



- Ovulation.
- Ovum pick up by healthy fimbria.
- Intercourse within proper period
- Cervix acts as a reservoir and sperm swim up.
- Fertilized egg travels towards uterus through a healthy tube.
- Endometrial implantation occurs within 1 week
- Corpus luteum secretes progesterone

### **Pathophysiology:-**

#### Etiology of infertility

- Female factor
- Male factor,
- Mixed male / female factors
- undetermined etiology, unexplained infertility

Male factor:

- Inability to have complete intercourse
- intercourse not occur at proper time

- abnormal semen

## Female factors

- Cervical factor.
- Uterine factors
- Tubal factor.
- Ovarian factors

## Ovulation problem:-

- Hypothalamic problems:-
  - Stress
  - Psychological disturbances
  - Weight changes
  - tumors and structural lesion of hypothalamus
- Pituitary:-
  - prolactenoma
  - Pituitary necrosis
- Ovary:-
  - polycystic ovary syndrome
  - Premature ovarian failure
- Systemic diseases:-
  - Hypo or hyperthyroidism
  - Renal failure
  - Hepatic dysfunction

## Tubal dysfunction:-

more common in those with secondary subfertility and in population with higher prevalence of STDs (Chlamydia, gonococci) may arise following a pelvic infection, endometriosis, or pelvic surgery.

## Male factor

- disorders of spermatogenesis
  - Scrotal temperature rise as a result of: -
    - undescended testes
    - varicocele
  - chromosomal abnormality
  - drugs:- psychotropic drugs, anti-epileptic, antihypertensive, antibiotics, chemotherapeutics.
- disorders of sperm transport
  - congenital malformation of the epididymis or vas deferens
  - obstruction due to inflammation, infection, or by vasectomy
- ejaculatory dysfunction
  - drugs
  - idiopathic
  - metabolic
  - systemic disease: diabetes, multiple sclerosis.

## Diagnosis:-

### **History**

- gynecological history
- systemic disease
- family history
- social history: alcohol, smoking
- drug history

### Examination of both partners

- examine the testis
- full general and pelvic examination of female.

### Investigation:-

- Assessment of the hypothalamo-pituitary-ovarian axis.
- Assessment of tubal patency. Hysterosalpingography (HSG)
- Semen analysis.
- Postcoital test.

### Treatment:-

According to cause

- ovulation problems (Induction of Ovulation)
- tubal disease (Tubal Surgery!?)

Empirical management!!

- male subfertility (no specific treatment)
- Unexplained infertility
- Resistant cases

assisted conception:

IUI, IVF, ICSI are widely used throughout the world.

### **Complications:-**

- hyperstimulation syndrome
- ectopic pregnancy
- multiple pregnancy

## **Interventional Radiology Treatments for Infertility**

Some common causes of infertility in both women and men can now be treated without surgery by interventional radiologists. Often these treatments do not require hospitalization or general anesthesia. Patients usually may return to normal activity shortly after the procedure.

### **Female Infertility: Blockage of the Fallopian Tube**

The most common cause of female infertility is a blockage of the fallopian tube through which eggs pass from the ovary to the uterus. Occasionally, these tubes become plugged or narrowed, preventing successful pregnancy.

Interventional radiologists can diagnose and treat a blockage in the fallopian tubes with a nonsurgical procedure known as selective salpingography. In the procedure, which does not require an incision, a catheter is placed into the uterus. A contrast agent, or dye, is injected through the catheter, and an X-ray image of the uterine cavity is obtained. When a blockage of the fallopian tube is identified, another catheter is threaded into the fallopian tube to open the blockage.

### **Secondary infertility in women: radiologic evaluation**

Imaging has become an essential tool in the workup of female infertility. Various imaging modalities are commonly employed to evaluate the female reproductive tract. Hysterosalpingography is typically performed as a baseline imaging study in the workup of female infertility. Ultrasound and pelvic magnetic resonance imaging studies are likewise routinely utilized to aid in the diagnosis of female infertility. The appropriate selection of imaging modalities is essential in establishing the etiology of female infertility in a timely, efficient, and cost-effective manner.

The role of hysterosalpingography (HSG) has evolved from being the only source of information about the uterus to a more minor role, after ultrasound, that essentially deals with the morphology of the fallopian tubes. But if its diagnostic yield in the uterus is challenged by ultrasound and hysterosonography, it retains a major impact in the work-up of female infertility. Hysterosalpingography brings decisive diagnostic information concerning the state of the tubes and peritoneum. The interventional procedures of selective salpingography and tubal recanalization have a definite therapeutic effect and allow numerous pregnancies that would otherwise have required in vitro fertilization or tubal microsurgery.

Infertility in females is multifactorial in origin. Though hysterolaparoscopy is the gold-standard investigation, USG is usually the first-line investigation. MRI has expanded the usefulness of imaging in female infertility. This pictorial essay reviews the role of imaging in the evaluation of female infertility.

## Ultrasonography (USG) (mainly transvaginal/endovaginal)

It is the first-line investigation and can be coupled with color Doppler and 3D/4D scans. It is readily available, inexpensive, noninvasive, radiation-free, relatively less time consuming, and

easily repeatable. Limitations include subjective errors, limited field of view, interference by obesity or by gaseous bowel loops, suboptimal visualization of fallopian tubes and broad ligament, failure to delineate small ovaries, and inability to obtain images in the surgical plane.

USG helps in determining the morphology of the uterus and ovaries, uterine and ovarian perfusion, and endometrial thickness, volume, and vascularity. It detects pathological lesions, including tubal lesions and abnormalities of follicular maturation and ovulation. Tubal patency can be confirmed through sonosalpingography. USG can guide oocyte retrieval and embryo transfer in in vitro fertilization procedures and drainage of pelvic collections or cystic lesions.

### Magnetic resonance imaging (MRI)

It is best for delineating the morphology and orientation of pelvic structures. Though it is noninvasive and radiation-free, it has limited availability and high cost, and hence cannot be repeated easily.[2,3] Longer examination time, failure to delineate sub-centimeter uterine lesions, and inability to characterize endometriomas at some stages are other limitations. MRI is contraindicated in patients with cardiac pacemakers and cochlear implants.

MRI also detects pathological lesions, including tubal lesions and pituitary adenoma. It helps in predicting the prognosis in conservatively treated cases of leiomyoma, adenomyosis, and endometriosis.

### X-ray hysterosalpingography (HSG)

It is a less-preferred procedure used to visualize the uterine cavity and confirm tubal patency. It involves ionizing radiation and carries the risk of infection and injury.



## Sonohysterosalpingography (Sono-HSG)

It involves airless, sterile, saline infusion through a soft plastic catheter in the cervix with simultaneous endovaginal USG. It allows excellent visualisation of the endometrial cavity and its lining. The procedure can also confirm tubal patency by demonstrating spillage of saline from a distended tube into the pelvic cavity.

## **Causes of Female Infertility with most appropriate intervention radiological tool:-**

### Polycystic ovarian syndrome (PCOD)

This is characterized by a combination of multiple clinical manifestations (i.e., hirsutism, menstrual disturbances, anovulatory cycles, and infertility) and hormonal imbalance (an abnormal luteinizing hormone / follicular stimulating hormone (LH/FSH) ratio and excessive androgen secretion).

USG characteristically reveals rounded ovaries with normal (30% case) or increased volume, multiple peripheral, sub-centimeter follicles (at least 15) with no dominant follicle ('string-of-pearls' appearance), thickened walls, and an echogenic and vascular stroma. Bulky and thick-walled ovaries with multiple, peripheral, sub-centimeter T2-hyperintense cysts and hypointense stroma are characteristic findings on MRI.

### Ultrasound Features of PCOS:-

- Increased stromal echo
- 10 or more follicles in one plain
- Follicles 2-10mm in diameter

- Increased ovarian volume

Polycystic ovary. Three-dimensional gray-scale (A) and color (B) images show a polycystic ovary. Spectral Doppler (C) and power Doppler (D) images show reduction in diastolic flow, reverse diastolic component, and increased stromal vascularity in polycystic ovary

## Pituitary adenoma

MRI is the modality of choice for detecting pituitary adenoma. Microadenoma (<1 cm) is usually hypointense to the normal pituitary on T1W images. Convex pituitary contour and deviations of the pituitary stalk are indirect signs. Dynamic postcontrast MRI reveals strong enhancement of the normal pituitary and its stalk in the early phase in contrast to the faint enhancement of a microadenoma.

Macroadenomas (>1 cm) may compress/invade surrounding structures, including the optic chiasm, cavernous sinus, and bony sella.

### Tubal diseases

These mainly include destruction or obstruction and peritubal adhesions.

HSG is useful for assessing tubal patency. Recently, MRI-based HSG has also been introduced. MRI is superior to USG for studying the tubes. Dilated tubes appear as fluid-filled, tortuous, sausage-shaped masses adjacent to the uterus with incomplete septae appearing as hyperechoic mural nodules (beads on string sign) and short linear projections (cogwheel appearance). The presence of partially effaced longitudinal folds inside the masses is specific for fallopian tubes on MRI. The presence of a normal-appearing ipsilateral ovary is a clue to the presence of a tubal mass.

Hematometra with hematosalpinx. Transvaginal USG (A), sagittal T2W (B) and axial fat-suppressed T1W (C) MRI images show hematometra (arrow) with hematosalpinx (arrowhead) on the right side. Note incomplete septae in tube (white arrow in A)

## Pelvic inflammatory disease (PID)

PID is a common cause of infertility and can manifest as pelvic collections, tubo-ovarian collections, uterine or broad ligament infection.

Pelvic inflammatory disease. Axial T2W (A) and oblique coronal fat-suppressed T2W (B) MRI images show pelvic inflammatory disease with resorbed tubes, an infected broad ligament, and thickwalled ovaries (white arrows)

USG and MRI are equally sensitive in detecting tubo-ovarian collections. The presence of peripheral vascularity of high-resistance type on color Doppler USG is suggestive of an infective mass. The presence of a high-signal-intensity inner rim on T1W images and enhancement on postcontrast images are helpful signs. MRI is superior to USG for revealing an infected uterus and broad ligament which appear hyperintense on T2W images.

Other signs of PID include probe tenderness, thickening of the tubes (mural thickness more than 5 mm) and tubo-ovarian masses (tube and ovary identifiable but inseparable).

Pelvic inflammatory disease. Transvaginal 2D gray-scale (A) and 3D color (B) USG images show subendometrial calcification (white arrows)

Pelvic inflammatory disease. Axial T2W MRI (A) and transabdominal USG (B) images show pelvic inflammatory disease with a digested/damaged left tube and mild collection in POD (white arrows)

Pelvic inflammatory disease. Axial T2W (A) and oblique coronal fat-suppressed T2W (B) MRI images show pelvic inflammatory disease with resorbed tubes, an infected broad ligament, and thickwalled ovaries (white arrows)

## Endometriosis

This condition mostly involves the ovaries but can secondarily involve other pelvic structures. USG is the preferred technique and shows a typical endometrioma located in the ovary as a well-defined cystic lesion with homogeneous low-level internal echoes (chocolate cyst) (more than 95%). It may also appear as an anechoic cyst, cystic mass with fluid-debris level or as a solid-appearing mass with or without thick septae. The presence of hyperechoic wall foci is characteristic on USG. MRI is more sensitive in detecting an endometrioma which appears hyperintense on T1W images and hypo- to hyperintense on T2W images. Fat-suppressed T1W images are very useful for detecting peritoneal implants.

The tubes may be involved in the form of a hematosalpinx or with peritubal adhesions, while uterine involvement appears as adenomyosis. Adhesions are seen on MRI as hypointense strands within the adjacent fat, obscuring adjacent interfaces. A posteriorly displaced uterus, kissing ovaries (both ovaries lying in the pouch of Douglas (POD) inseparable from each other), elevated posterior vaginal fornix, angulated small bowel loops, hydro-/hematosalpinx, and multilocular fluid collections are indirect indicators of pelvic adhesions.

Endometrioma. Transvaginal gray-scale (A), 3D color USG (B) USG, axial T2W (C) and T1W (D) MRI images show an endometrioma (arrows) on the right side and a polycystic ovary (arrowhead) on the left side in two different patients. Note the thick septae in the endometrioma (arrow in A)

## Leiomyoma

It infrequently causes infertility by interfering with transportation of sperms or implantation due to distortions of the uterine contour and cavity. Endovaginal USG is as sensitive as MRI in the detection of leiomyoma. MRI however is superior in the preoperative evaluation of the site, number, and size of leiomyomas.

A typical leiomyoma on USG appears as a well-defined, hypoechoic to heteroechoic solid lesion with variable posterior acoustic shadowing located in a submucosal, intramural, or subserosal location. Color Doppler reveals peripheral vascularity of mild to moderate resistance, differentiating it from an adenomyoma which reveals moderate central and peripheral vascularity of relatively low resistance. Leiomyoma appears hypointense to myometrium on both T1W and T2W images.

MRI can monitor post-treatment changes and recurrences in patients treated with uterus-conserving methods of treatment.

Subserosal fibroid. Sagittal fat-suppressed T2W MRI image shows a pedunculated subserosal fibroid along the anterior wall (white arrow shows the stalk)

## Adenomyosis

It uncommonly causes infertility possibly by reducing uterine/endometrial receptivity. Both endovaginal USG and MRI are equally sensitive for making a diagnosis.



USG findings include a diffusely enlarged or globular uterus, asymmetric walls ( $>2.5$  cm), ill-defined areas or diffusely altered uterine echogenicity, myometrial or subendometrial cysts, indistinct endometrial-myometrial interface, subendometrial echogenic nodules or strands with surrounding hypoechoic myometrium, and undulating outer margin of endometrium. MRI findings include hypointense masses with poorly defined margins on both T1W and T2W images; focal or diffuse, symmetric or asymmetric, widening of the junctional zone ( $>12$  mm) of the uterus; presence of hyperintense foci representing ectopic endometrium on T2W images. MRI can be used for monitoring patients undergoing conservative gonadotropin-releasing hormone (GnRH) analogue therapy.

Adenomyoma. Transvaginal 2D gray-scale (A), power Doppler (B) and triplex Doppler (C) USG images show a uterine adenomyoma

### Uterine anomalies (Müllerian duct anomalies)

These are considered as causes of infertility when all other causes have been excluded. Multiplanar MRI is diagnostic. These are classified according to the American Fertility Society criteria as follows:

- Class I or uterine hypoplasia or agenesis
- Class II or unicornuate uterus: A banana-shaped uterus with a single fallopian tube. A rudimentary horn (communicating or noncommunicating) may be present
- Class III or uterus didelphys: Two complete uteruses, each with its own cervix. A sagittal vaginal septum is seen in the majority of cases.
- Class IV or bicornuate uterus: Two uterine cavities with one cervix. MRI shows widely separated uterine horns with an intercornual distance of  $>4$  cm and concavity of the fundal contour or an external fundal cleft of  $>1$  cm in depth.
- Class V or septate uterus: A fibrous septum is seen that appears hypointense on T2W images while the muscular septum appears intermediate in intensity. MRI criteria includes a convex or flat external fundal contour or external fundal cleft of  $<1$  cm in depth.
- Class VI or arcuate uterus: It is a normal variant and is characterized by an external convex contour of the fundus with fundal endometrial indentation.
- Class VII or diethylbestrol-induced: Exposure to this synthetic estrogen antenatally can result in a T-shaped, hypoplastic, and constricted uterus.

Uterus subseptus. Transvaginal 2D gray-scale (A) and 3D color coronal (B) USG images show a uterus subseptus (white arrow shows the incomplete septum)

Uterus subseptus. Axial T2W (A) and fat-suppressed T1W (B) MRI images show a uterus subseptus (white arrows show incomplete septum)

## **Chapter three**

### **Methodology**

#### **What is ultrasound?**

Ultrasound is the name given to high-frequency sound wave over 2000 cycles per second .these waves ,inaudible to humans ,can be transmitted in beams and are used to scan the tissues of the body.

#### **Ultrasound generators:-**

The ultrasound waves are generated by apiezoelectric transducer which is capable of changing electrical signalis into mechanical waves.the same transducer can also receive the reflected ultrasound and change it back into electrical signals .transducer are both transmitters and receivers of ultrasound.

#### **Ultrasound transducer:-**

Transducer electrical device used for sonographic imaging that detects differences in pressure or electrical charge.

#### **Probe:-**

Scanning instrment that contain transducers used for sonographic imaging .

#### **Ultrasound printers**

Ultrasound printer used was digital graphic printer, 15,7 A and 50/ 60 Hz .Made by Sony Corporation-Japan, with serial number of 3-GB 619I-1

## **Ultrasound Gel**

Ultrasound gel is a type of conductive medium that is used in ultrasound diagnostic techniques and treatment therapies. It is placed on the patient's skin at the beginning of the ultrasound examination or therapy. Ultrasound gel is typically clear and thick, but not uncomfortably sticky. When it is applied to the skin, it doesn't dribble or drip off. It adheres to the skin lightly until it is wiped off at the end of the procedure. The most common complaint about ultrasound gel is that it is cold. For this reason, many medical professionals use special warmers to make their gel a more comfortable temperature before applying it to a patient's skin.

## **Transvaginal probe multi-frequency probe (10-8-6) MHz**

Transvaginal ultrasound is performed very much like a gynecologic exam and involves the insertion of the transducer into the vagina after the patient empties her bladder. The tip of the transducer is smaller than the standard speculum used when performing a Pap test. A protective cover is placed over the

transducer, lubricated with a small amount of gel, and then inserted into the vagina. Only two to three inches of the transducer end are inserted into the vagina. The images are obtained from different orientations to get the best views of the uterus and ovaries. Transvaginal ultrasound is usually performed with the patient lying on her back, possibly with her feet in stirrups similar to a gynecologic exam.

### **Ultrasound examination of female pelvis;-**

For pelvic sonogram performed transabdominally a, the patient's urinary bladder should be adequately distended. For a transvaginal sonogram, the urinary bladder is usually empty.

### **Uterus;-**

The vagina and uterus provide anatomic landmarks that can be utilized as reference points for the remaining normal and abnormal pelvic structures.

### **Ovaries (ovaries and fallopian tubes) -**

When evaluating the ovaries, attempt should be made to identify the ovaries first, the ovaries are situated anterior to the internal iliac vessels, which serve as landmarks for their identification. The following ovarian findings should be documented; size and position relative to the uterus. The ovarian size can be determined by

measuring the length in long axis with anteroposterior dimension measured perpendicular to the length .the ovarian width is measured in transaxial or coronal view. a volume can be calculated .

### **-Cul -De-Sac :-**

The cul-de-sac and bowel posterior to the uterus may not be clearly defined .this area should be evaluated for the presence of free fluid or a mass. if a mass is detected ,its size ,position ,shape ,echo pattern ,and relationship to the ovaries and uterus should be documented.

## **Chapter four Results**

The results of this study portrayed in two format; tables and figures. The tables present the mean and standard deviation of the study variables which include the blood flow indices of the uterus and its physical dimension for infertile and fertile (normal) women as well as the significant difference table between the two groups using t-test. The graphs displayed the significant relationship between the blood flow indices and the uterus dimension for the both groups.

Table 4-1 the mean and standard deviation of the age, blood flow indices and uterus dimensions for fertile and infertile women

Variables	Mean $\pm$ SD	Mean $\pm$ SD
-----------	---------------	---------------



	infertile	fertile
Age	30.2±7.1	28.8±7.3
PI	0.79±0.4	0.82±0.3
RI	2.564±1.5	2.612±1.6
PSV	57.75±24.8	50.83±24.2
Uteruswidth	5.44±0.2	5.39±0.2
Uteruslength	8.08±0.5	8.66±0.3
Uterussize	44.08±4.6	46.72±3.2

Table 4-2 independent t-test between the fertile and infertile women for blood flow indices and uterus dimensions

Variables	p	t
PI	0.08	0.43
RI	0.73	0.17
PSV	0.70	1.41
Uteruswidth	0.29	1.28
Uteruslength	0.001	7.12
Uterussize	0.026	3.33

Figure 4-1 scatter plot show an inverse linear relationship between the uterus length and PI of infertile women

Figure 4-2 scatter plot show direct linear relationship between the uterus length and PSV of infertile women

Figure 4-3 scatter plot show direct linear relationship between the uterus length and PI of fertile women

Figure 4-4 scatter plot show direct linear relationship between the uterus size and PI of fertile women

Figure 4-5 scatter plot show inverse linear relationship between the uterus length and RI of fertile women

Figure 4-6 scatter plot show inverse linear relationship between the uterus length and PSV of fertile women

Figure 4-7 scatter plot show inverse linear relationship between the uterus size and PSV of fertile women

## **Chapter five**

### **Discussion, conclusion and recommendation**

The main objective of this study was to evaluate the characteristics of the infertility in the infertile women by studying the difference between the uterus size and blood flow in the fertile and infertile women.

#### **5-1 Discussion**

As shown in Table 4-1 which gives the mean and standard deviation of blood flow indices and uterus dimension, there is some variation between the fertile and infertile women; these variation were significant at  $p = 0.05$  using t-test for uterus length and size and inconclusive for the rest of the variables between the two groups (Table 4-2). This result dictate that the length of the uterus which affected the size can be used to differentiate between the fertile and infertile women where it will be longer and larger in size in the fertile women than the infertile because it host a fetus which affects it is dimension regardless it is elasticity to go back to normal after delivery.

Although these differences might not be crucial in some situation; the relationship between the uterus dimension and blood flow indices can give a clear indication of the fertility. This study showed that there is a significant linear relationship between the PI and uterus length as well as PSV for infertile women. Where in case of PI and uterus length there is an inverse linear relationship in which the PI decreases by 0.59 units per each 1 cm of the uterus length starting from 5.6 as shown in Figure 4-1. PSV value show a significant direct linear association with the uterus length where the PSV increases by 22.1 units per each 1 cm of the uterus length starting -120 (Figure 4-2). These results also show that the blood flow indices (PI and PSV) can be estimated for the infertile women by using the uterus width and length as follows:  $PI = (-0.59 \times \text{uterus length}) + 5.58$  and  $PSV = (22.12 \times \text{uterus length}) - 120.92$ . RI does not show any significant linear relationship with the uterus dimension for this group.

For fertile women linear regression analysis showed that there is a significant linear association between the length and size of the uterus with the blood flow indices with no role to the uterus width. For PI there is a direct linear relationship with uterus

length and size (multiple regressions) as shown individually in Figure 4-3 and 4-4 where the PI increases by 0.89 units per each 1 cm of the uterus length and by 0.08 units per each 1 cm<sup>2</sup> of uterus size. This result showed that PI has a different relationship with the uterus length concerning fertility situation where it increases with the length for the fertile women and decreases with the length for the infertile one. The PI can be estimate for the fertile women using the following equation  $PI = (0.89 \times \text{uterus length}) - 6.91$  or  $PI = (0.08 \times \text{uterus size}) - 2.89$ .

The PSV in the fertile grouped showed a significant inverse linear relationship with the length and the size of the uterus (multiple regression). Where the PSV decreased by 64.4 units per each cm of the uterus length (Figure 4.6) and decreased by 4.7 units per each cm<sup>2</sup> of uterus size. This relationship were opposite of the same relation in case of infertile women. Similarly the PSV can be estimated using the uterus length and size for the fertile women using the following equations:  $PSV = (-64.41 \times \text{uterus length}) + 608.71$  or  $PSV = (-4.74 \times \text{uterus size}) + 272.39$ .

The RI index also has an inverse linear relationship with the uterus length for the fertile group where the RI decreased by 2.5 units per each 1 cm of the uterus length and the RI can be estimated using the uterus length using the following equation  $RI = (-2.53 \times \text{uterus length}) + 24.56$ . the RI index does not have significant linear relationship with uterus dimension in the infertile group as mentioned earlier; this is can be used as characteristic for both group.

## 5-2 Conclusion

The main purpose of this study was to characterize the fertility in women using ultrasound through the uterine blood flow indices and uterus dimension. The sample of this study consisted of 100 women; 50 of them were infertile and the other 50 were fertile women taken as control group.

The result of this study showed that there is a significant difference between the fertile and infertile women in case of the uterus length and size, the uterus width and blood flow indices showed inconclusive result.

The relationship of blood flow indices to uterine dimension showed a significant linear association between the uterus length

and PI and PSV for the infertile women. While it shows similar relationship with the uterus length and area, and PI and PSV (multiple regression). These relationships were reverse in case of the fertile and infertile.

For the infertile group there is an inverse linear relationship between the PI and uterus length and direct linear relationship between the PSV and uterus length. In case of fertile group there is a direct linear relationship between the PI and the uterus length (and uterus size) and inverse linear relationship between the PSV and uterus length (and uterus size).

### 5-3 Recommendations

- Using of large sample including other groups like abortion groups
- Application of uterus length and area in characterizing the fertile from infertile one
- Using of uterine dimension to estimate the blood flow indices in respect to fertility group
- Using the relationship between uterus dimension and blood flow indices to describe the fertility status.





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