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REVIEW ARTICLE

Transvaginal Sonography in Infertility

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ABSTRACT

Transvaginal sonography offers a very accurate, easy and reproducible method to evaluate the female pelvis and the female factors of infertility. The addition of color gives us more information about organ perfusion and addition of 3D has opened a new dimension to diagnosis of pelvic pathologies. Transvaginal sonography has an important role in the management of infertility. Serial pelvic ultrasound examinations are useful in monitoring patients undergoing ovulation induction using ovulation-inducing drugs. In addition, the correct prediction of timing of ovulation is critical for infertility therapies such as intrauterine insemination, artificial or therapeutic insemination using donor sperm and the timing of intercourse during ovulation induction therapies.

More than any other new method, ultrasound has made significant improvements in modern management of infertility.

Keywords: Infertility, Transvaginal ultrasound, Sonosalpingography, Color Doppler, Interventional ultrasound.

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INTRODUCTION

The application of transvaginal ultrasound in the evaluation and assessment of the infertile couple is expanding each day. The transvaginal ultrasound picture depicts accurately the pelvic anatomy of the scanned area safely, quickly and reproducibly (Fig. 1).

The quality of depiction of the pelvic anatomy is dependent on the ultrasound equipment being used and the experience and proficiency of the person performing the scan.

It should be mandatory for the person performing the scan to know about the female endocrinology and be well versed with the causes and management of infertility, specially with the ovulation induction protocols.

Till date there are no known adverse biological effects of transvaginal ultrasound on the patient, on the oocytes or on the ultrasound operator 'American Institute of Ultrasound in Medicine' (AIUM).[1]

Transvaginal ultrasound today is the modality of choice in evaluating male and female infertility as a first step investigation and should be used by the clinician in the consulting chamber along with pelvic examination. It is like marrying palpation with imaging (Figs 2A and B) showing finger tip probe.

ULTRASOUND ASSESSMENT OF THE MALE PARTNER

Male factor infertility today comprises of almost 40% of the causes in an infertile male. The modern lifestyle and additives in food have become a major environmental cause of oligoasthenospermia. The function of male genital system encompasses the central nervous system (hypothalamus and pituitary), the adrenal glands, the testes, the epididymis, the seminal vesicles and the prostate gland (Fig. 3A). Any malfunctions of any of these may affect the male reproductive capacity.

In suspected male factor infertility ultrasound imaging of the ejaculatory system and of the testis is necessary to rule out structural anomalies. Scrotal and transrectal ultrasonography (TRUS) are used in evaluation of the reproductive tract disorders. Color flow imaging is used for assessment of varicocele. 3D is used for testicular volume and seminal vesicle and prostate evaluation. Computed tomography and endorectal magnetic resonance imaging can also be used.

Scrotal sonography is performed with patient in supine position using a 7.5 to 10 MHz linear probe. This can evaluate the testis for size, shape, hydrocele, benign tumors, atrophy, malignancy, orchitis, torsion, hemorrhage, focal lesions, etc. Ultrasound imaging is very sensitive in testicular evaluation[2-5] and varicocele (Figs 3B and C).

Transrectal Ultrasonography

Transrectal ultrasonography (TRUS) is an excellent approach for visualizing the seminal vesicles, prostate and ejaculatory ducts (Fig. 4). With TRUS we can assess obstructions, absence or hypoplasia of seminal vesicle and ejaculatory ducts. The TRUS is an excellent screening test for ejaculatory duct pathologies and is indicated in all men with severe oligospermia and a low volume ejaculate.[5]

Assessment of the Female Reproductive Tract

The female is responsible for 40% of causes of infertility and contributes in another 20% of mixed causes in the couple. Out of this the ovulatory dysfunction (30%) and tubal factor infertility (25%) are major factors.[6]

We advocate a transvaginal scan as the very first visit of the couple by the infertility specialist himself/herself just after a per speculum examination (p/s exam). This will

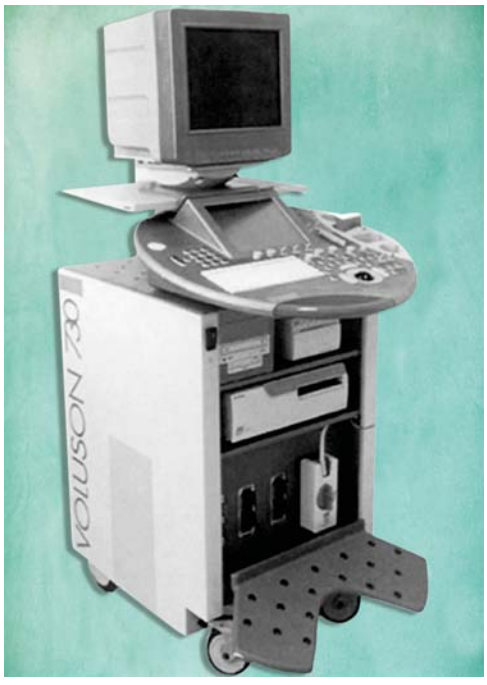
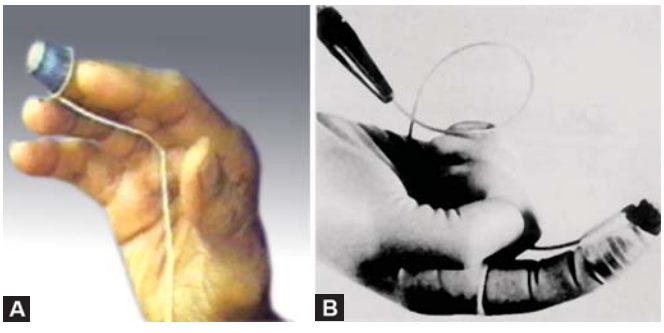


Fig. 1: USG machine and probes



Figs 2A and B: Finger tip probe

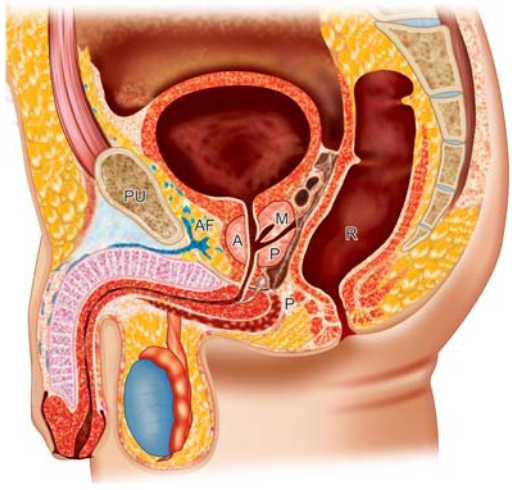


Fig. 3A: Male reproductive system (PU: pubic bone; AMP: anterior, middle and posterior lobes of prostate; R: rectum)

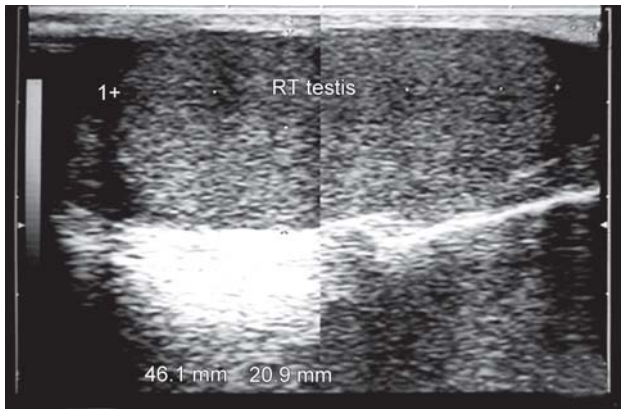


Fig. 3B: Testis

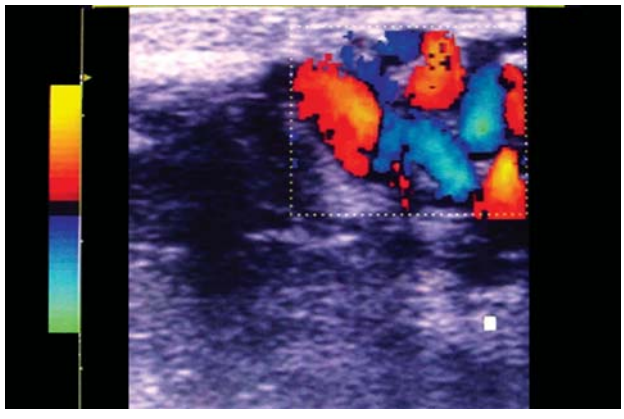


Fig. 3C: Varicocele

enable the clinician to come to a diagnosis on the very first visit regarding problems in vagina, cervix, uterus, endometrium, endometrial cavity, tubes, adnexa, ovaries and general pelvis as a whole. Such an examination helps to decide the further treatment line and actively manage infertility by a single day evaluation test and active management protocol (Rajan, Malhotra) (2000).[7,8]

Vaginal and Cervical Factor Infertility Evaluation

Vagina and the cervix is the first obstacle that the spermatozoa have to negotiate on their way to reach the oocyte. Vaginal septae, stenosis, vaginismus and coital difficulties are best assessed by a per speculum examination, however TVS helps to locate vaginal cysts and vaginal infiltrations.

Transvaginal ultrasound can very accurately assess both anatomical and functional problems of the cervix (Figs 5A and B).

Assessment of cervicitis, nabothian cysts at internal OS, poor cervical mucus, cervical agenesis and cervical stenosis should be done (Figs 6 and 7). Cervical conization and cervical infections should always be kept in mind and assessed for clinically before a transvaginal scan (TVS).

Uterine Factor Assessment and Evaluation

Uterus is the place for embryo implantation and pregnancy continuation. The normal adult uterus is a muscular organ

6 to 10 cm in length and 3 to 5 cm in width and has a unique capacity to grow and expand to hold a full term fetus during pregnancy.

Problems of uterus may lie in the musculature (fibroids, adenomyosis, etc.), in the uterine cavity (congenital uterine malformations, adhesions, uterine cavity polyps, etc.) or problems in the endometrial lining, i.e. inappropriate endometrial growth and secretary transformations in response to progesterone from corpus luteum.

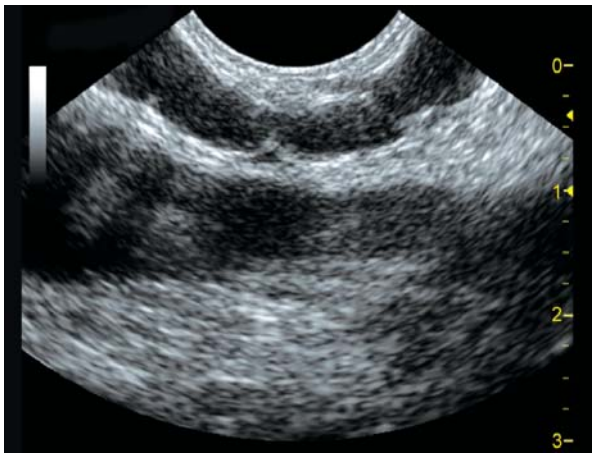
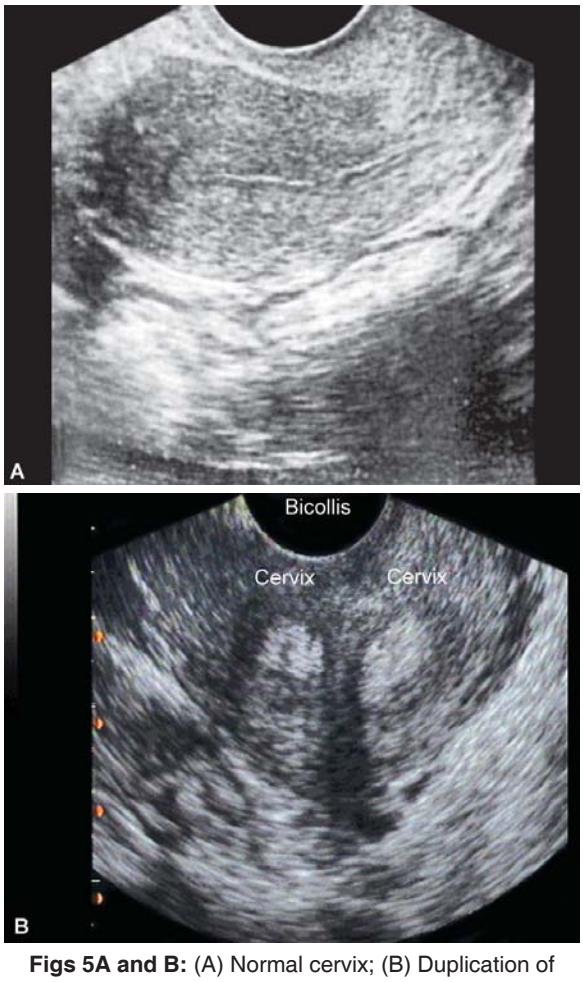
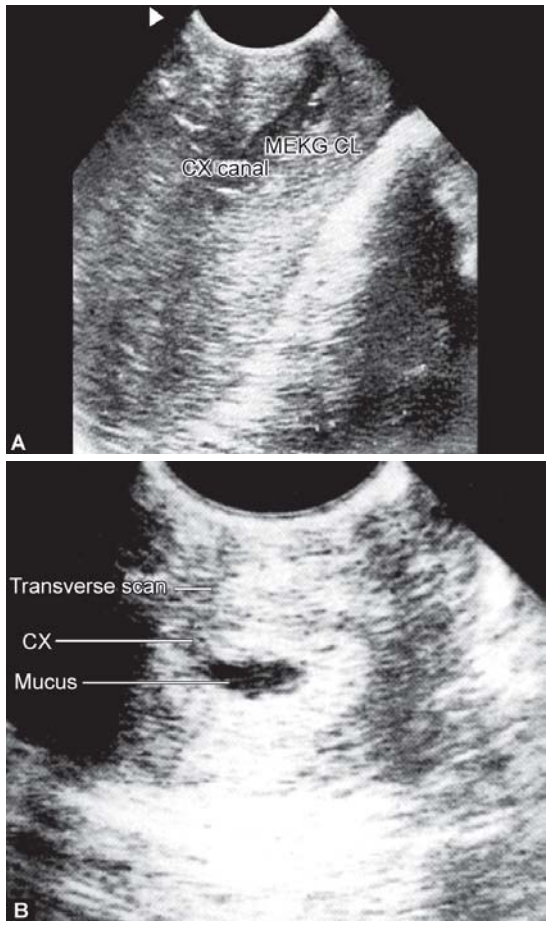


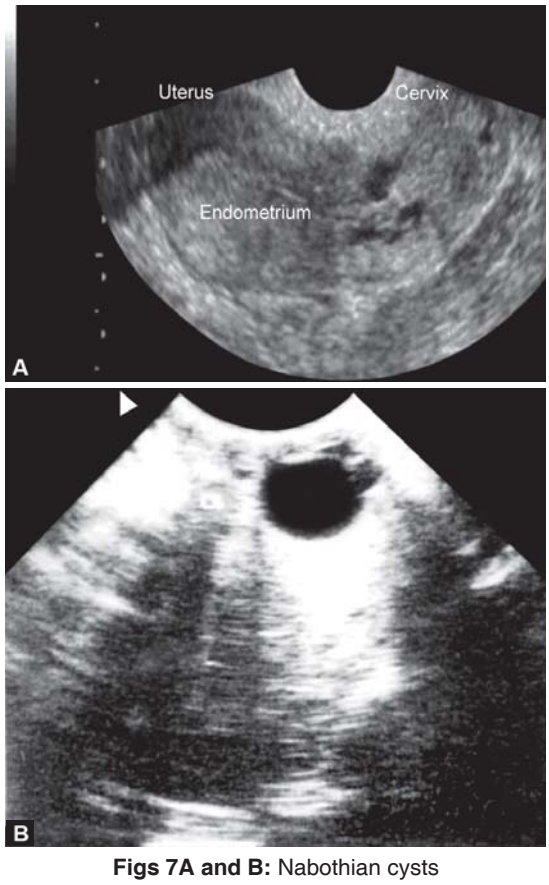
Fig. 4: TRUS: Seminal vesicle bow tie picture



Figs 5A and B: (A) Normal cervix; (B) Duplication of cervix in bicornuate bicollis



Figs 6A and B: Cervical mucus



Figs 7A and B: Nabothian cysts

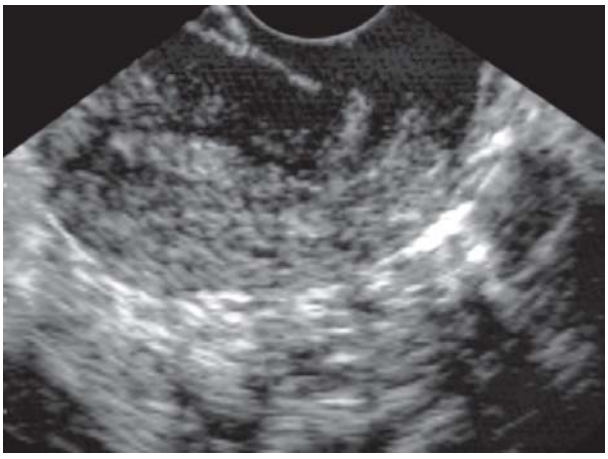


Fig. 8: Normal uterus

Transvaginal sonography (TVS) can accurately asses the uterine factors and with addition of fluid (saline) by sonohysterography the cavity can be accurately studied. With addition of color flow imaging, color Doppler studies of uterine artery, power angio; the spiral artery and endometrial vascularization can be evaluated to score the uterus for favorability of implantation (uterine scoring system for reproduction) (Applebaum, Dalal, Malhotra).

The Uterus

Transvaginal ultrasound examination of the body of uterus is done to observe detailed view of the myometrium and any anomalies. Leiomyomas are one of the most common benign neoplasms in women and have been reported to occur in up to 40% of women over the age of 35. A leiomyoma may be suggested by generalized enlargement of the uterus, irregularities in the surface contour, distortion of the endometrial echo, or as areas of hyper- or hypoechogenicity compared with the surrounding normal myometrium. Uterine leiomyomas do not have a true capsule and there may not be an acoustic interface and therefore no echo resulting from a structural boundary. A submucosal myoma within the uterine cavity may be imaged as an area of increased echogenicity and may be mistaken initially for blood, mucus or a polyp in the uterine cavity (Fig. 8).

Endometriosis

Endometriosis is a condition where there is ectopic menstruating endometrium leading to adhesions and/or cysts called the chocolate cysts. Minor degrees of endometriosis cannot be diagnosed by sonography. The endometrioma is generally shaggy and irregular sometimes with septations. These cysts are homogeneous with a low level echo patterns with good through transmission. They have fine stippling pattern filling the whole of the cyst.

Fibroids

Fibroids can cause infertility by blocking the cervical canal or by blocking the fallopian tubes mechanically. Fibroids pressing over the endometrial cavity diminishes the available endometrium for implantation and also interferes with the transport of sperms and oocytes. Intramural myomas also increase the uterine irritability and are implicated in causing implantation failures or early pregnancy losses (Fig. 9).

Transvaginal ultrasound is the most useful tool for screening for fibroids. The uterus is enlarged with contour deformity (Fig. 10) and focal masses with different echogenicities (Hypoechoic usually, hyperechoic when calcified and may be isoechoic also).

Congenital Anomalies

Congenital anomalies of the uterus occur in about 0.1 to 0.4% of general population of women and are due to the embryological problems in Müllerian system. Congenital anomalies of the uterus cause infertility and also is a significant cause of recurrent pregnancy loss.[9,10] About 80% of women with congenitally abnormal uterus may have no problems in conceiving but anomalies are responsible for almost 20% of recurrent pregnancy loss and hence should be carefully looked for and treated whenever encountered during infertility evaluation (Figs 11A and B: Bicornuate uterus) (TAS and TVS).

Uterine congenital anomalies can be diagnosed by HSG, TVS, contrast sonohysterography, hysteroscopy and laparoscopy and by a MRI 3D HSG and TVS without saline contrast are the most common methods. The anomalies which can be diagnosed are bicornuate uterus, unicornuate uterus, intrauterine septa (complete, incomplete or arcuate) (Fig. 12).[11]

Sonohysterography

Instillation of sterile saline into the uterine cavity under ultrasound guidance (TVS) will let us study the uterine cavity without any radiation exposure and without exposure to contrast media (Fig. 13). The saline distended cavity is anechoic surrounded by symmetric endometrial lining. Sonohysterography will enable the diagnosis of Asherman's syndrome or intrauterine adhesions, polyps, submucous fibroids and uterine septa (Figs 14 and 15).[12] HyCoSy or contrast hysterosalpingosonography involves the use of a sonography contrast media (Echovist) (Figs 16A and B).

Endometriosis of the Uterus (Adenomyosis)

Endometriosis is a disease in which typically the endometriotic implants are scattered in various extra uterine

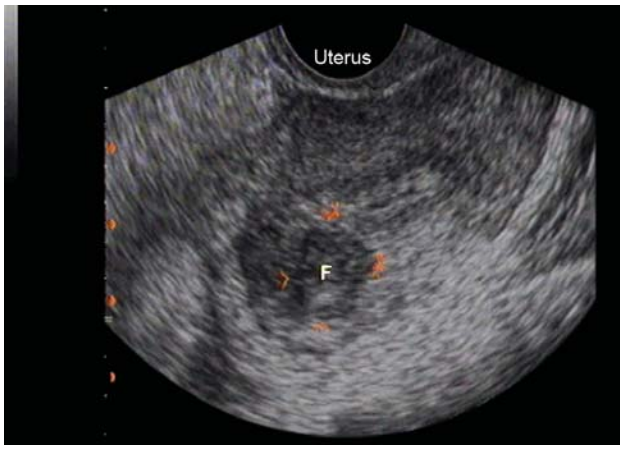


Fig. 9: Fibroid uterus

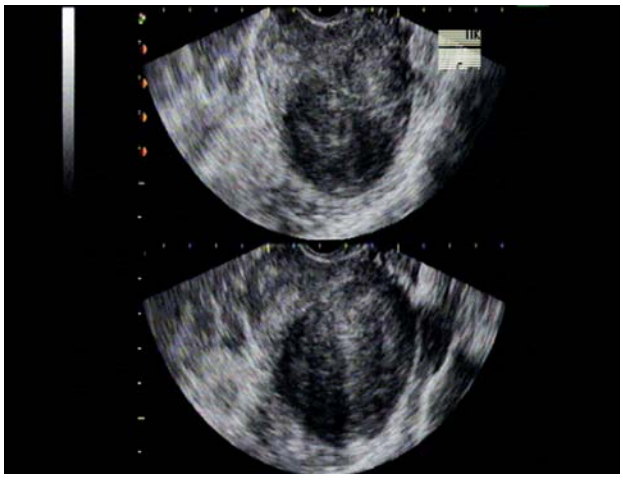
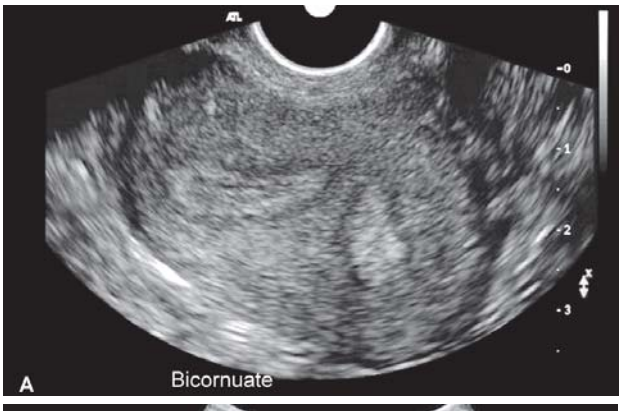
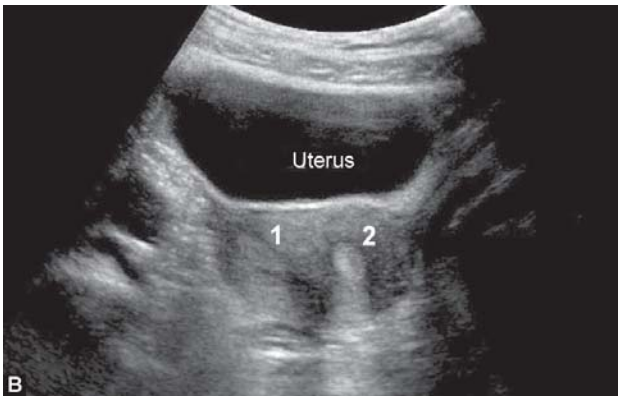


Fig. 10: Fibroid causing contour problem





Figs 11A and B: Bicornuate uterus: (A) TVS (*Courtesy:* Dr Mohit Shah); (B) TAS (*Courtesy:* Dr Ravi Kadasane)

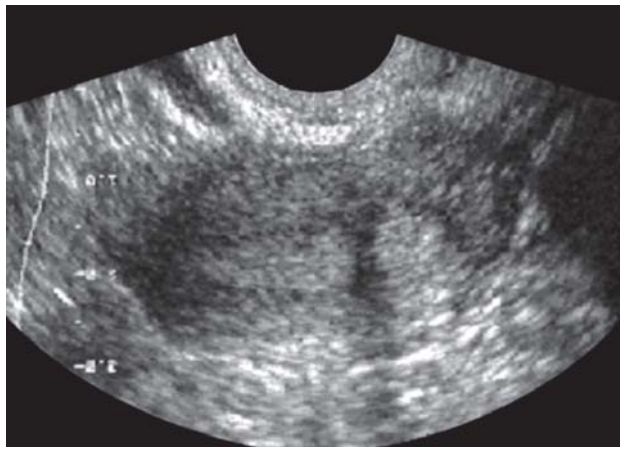


Fig. 12: Septate uterus

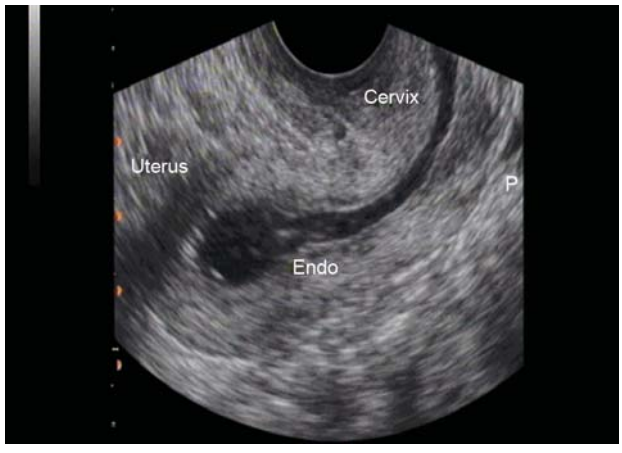


Fig. 13: Saline contrast sonography

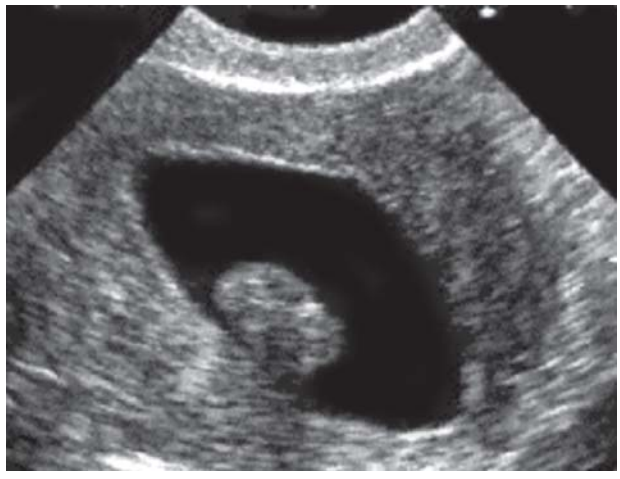


Fig. 14: Polyp fibroid

locations. However, sometimes the ectopic endometrium goes into the myometrium and causes adenomyosis. These endometrial tissue starts to proliferate inside the myometrium and tends to bleed on progesterone withdrawal during the menstrual cycle this giving the uterus a typically speckled appearance resembling 'Salt' and 'Pepper' (hyperechoic areas and hypoechoic areas). Depending on the extent of lesion and the severity of disease the uterus

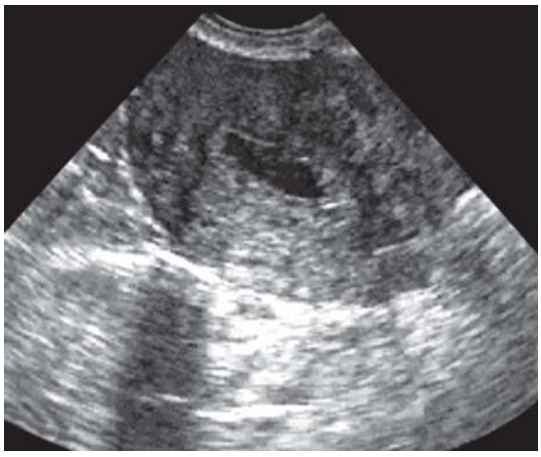


Fig. 15: Asherman's syndrome

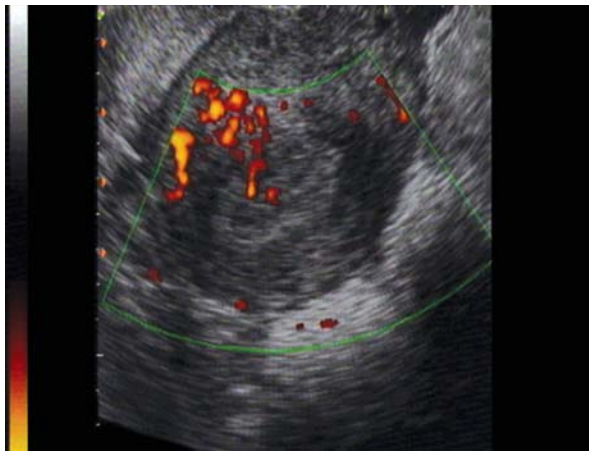


Fig. 17: Adenomyosis

will appear enlarged and sometimes all of the adenomyosis areas may together look like a fibroid (Adenomyoma) (Fig. 17).

Color Doppler imaging helps as the blood flow in these lesions resemble spiral arterial endometrial blood flow pattern while that of the fibroid is single vessel on the periphery. Also the identification of capsule around the mass is seen in leiomyomas while adenomyomas have no capsules.

Evaluation of Endometrial Growth

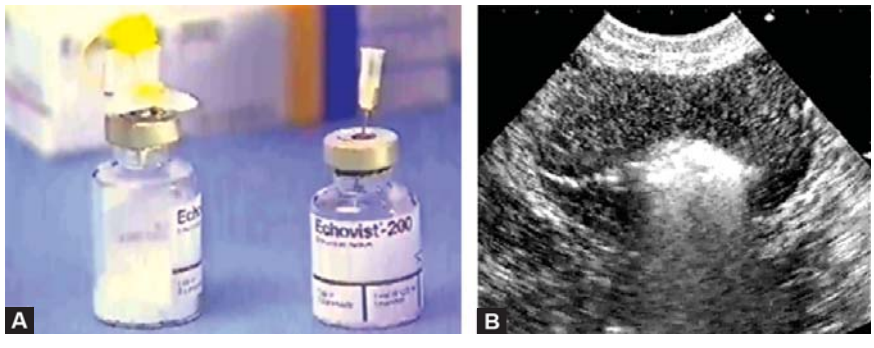
Endometrium is the inner lining of the uterus and has receptors for ovarian hormones and in response to the estradiol from the ovaries (or exogenous), the endometrial lining grows in a typical pattern which is recognizable by TVS. Endometrial growth correlates well with ovarian hormone levels. For ultrasound evaluation of the endometrium, we need to look at endometrial thickness, endometrial pattern and color flow in spiral arteries and endometrial receptivity scoring.

Endometrial thickness is the maximum distance between the echogenic interfaces of the myometrium and the endometrium, measured in a plane through the central longitudinal axis of the uterus. Very easy to obtain the plane and very easy and reproducible to measure (Figs 18A and B).

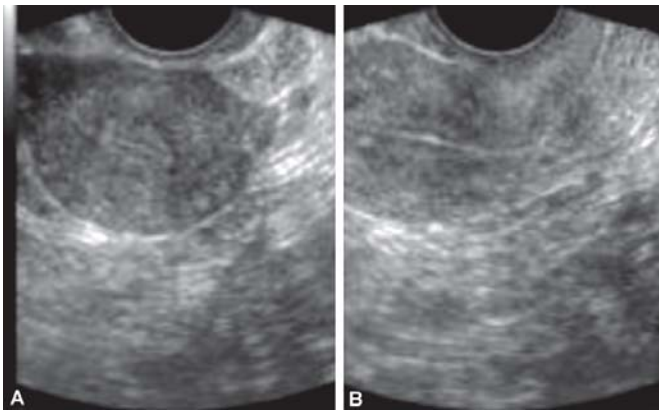
The basal study of endometrial thickness should be started from day 2 or 3 of menstrual cycle to look for proper Shedding. The endometrium on this day should appear as a thin bright echogenic line or the cavity shows some blood with debris (Fig. 19). A thick endometrium on basal scan (Day 2) indicates improper endometrium shedding.

The endometrium grows at the rate or 0.5 mm/day in the proliferative phase and 0.1 mm/day in the luteal phase. A thickness of more than 7 mm in the preovulatory period is associated with higher pregnancy rates.[13]

Endometrial pattern is the relative echogenicity of the endometrium and the myometrium as seen on a longitudinal TV scan. In a typical 3 layer pattern of proliferative phase (Fig. 20), the central line represents the uterine cavity and the outer lines represent the basal layer. Outside this is a hypoechoic interface in between endometrium and myometrium (some-times described as 5 line endometrium) (Fig. 21). The hypoechoic area in between the two bright lines represents functional layer of the endometrium.[14] Endometrium growth and pattern can be graded and classified.



Figs 16A and B: (A) Echovist and after instillation; (B) Ultrasonography



Figs 18A and B: Endometrial measure

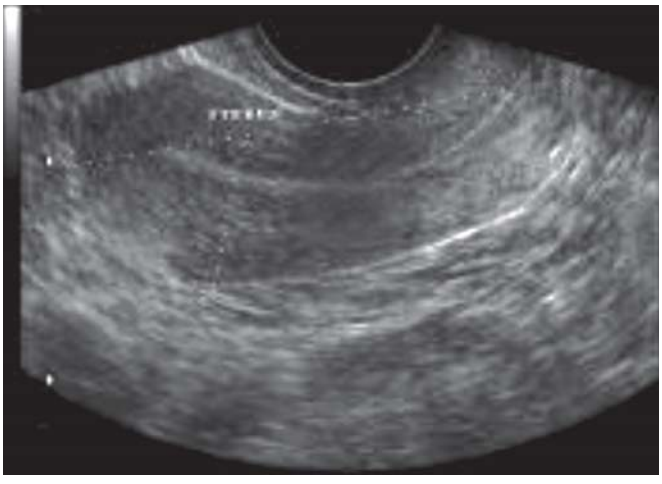


Fig. 19: Day 2/3 endometrium

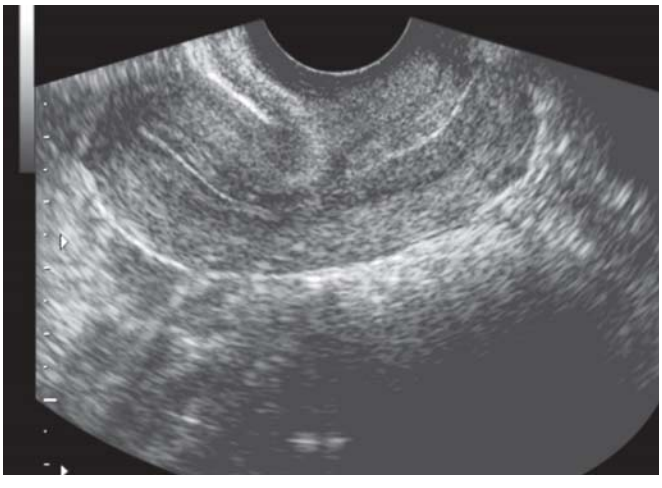


Fig. 20: Day 9 endometrium

1. Four patterns have been described from a fully echogenic endometrium (Grade A) to a distinct black region surrounding the midline.[15]

Smith's Grading

Grade A: Bright endometrium represents postovulation or the luteal phase.

Grade B: Endometrial reflectivity is similar to the myometrium. This characterizes late follicular phase.

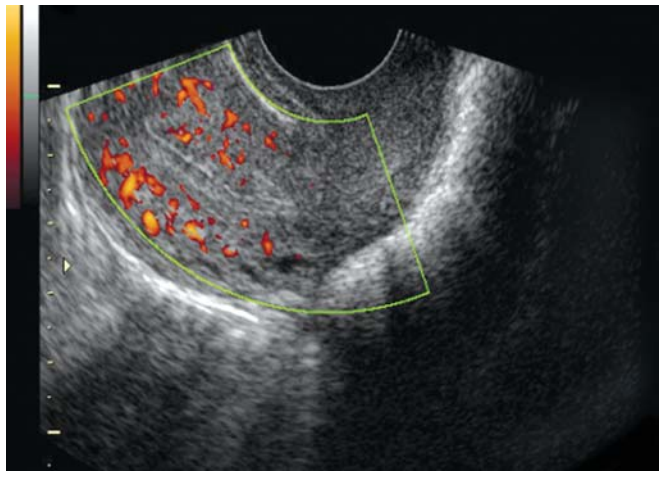


Fig. 21: Periovulatory endometrium

Grade C: A solid area of reduced reflectivity appears as a darker area next to the lighter myometrium. This is pattern of mid follicular phase.

Grade D: Echoes are absent in the endometrium, but a bright central echo is seen, described as the triple line.

Late follicular phase endometrial patten Grade B on the day of hCG is more associated with pregnancy (Smith et al).[15]

Postovulatory the endometrial echogenicity changes with loss of layers but spiral flow increases (Fig. 22).

Endometrial Thickness and Menstrual Cycle

Phase	*Appearance*
Menses (day 1-5)	Hypoechoic area is blood. Myometrial contractions are frequent. Thickness <4 mm
Early follicular phase (day 6-10)	Distinct 'triple-line' pattern Hypoechogenic endometrium Thickness 7-9 mm
Late follicular phase (days 11 ovulation)	Endometrial appearance similar to myometrium Thickness 9 to 12 mm at ovulation
Luteal phase	Bright, fluffy appearance absence of triple line Thickness 10 to 14 mm

Nowadays the endometrium pattern is simply described as multilayered or nonmultilayered. Serafini[16] has shown that a multilayered pattern to be more predictive of implantation than any other parameter measured.

Color flow Doppler of endometrium and uterine arteries[17] have been extensively studied by Steer et al and they have found that no pregnancy occurred if the PI of uterine was >3 and there was no spiral artery blood flow in the endometrial zones.

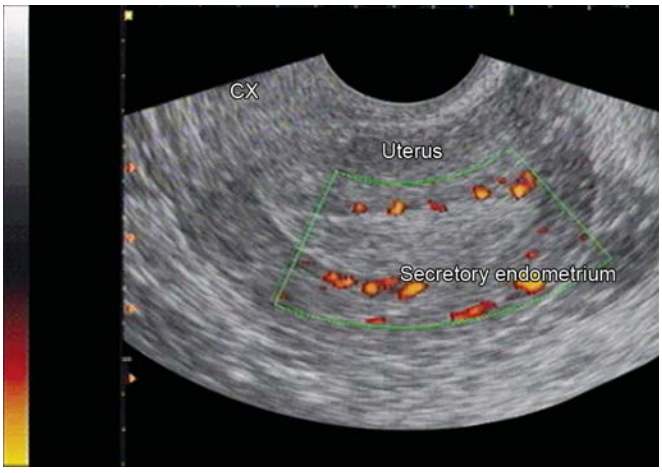


Fig. 22: Postovulatory endometrium

Color Doppler

Addition of color Doppler studies in evaluations of endometrial blood flow patterns and uterine artery flow pattern enabled us to evaluate the physiology of the endometrium. Various scoring systems have been proposed for prediction of implantation by color Doppler. The most popular is Applebaum's USSR.[18]

Estrogen produces a vasodilatory effect on the uterine arteries. It has been seen that RI, PI of uterine artery drops with increasing estradiol levels.

Tubal Evaluation

Normal tubes are isoechoic and are not usually visualized by TVS unless there is fluid contrast. The use of fluid contrast for evaluation of tubes has been described in literature as Sion test from Mumbai or as Sion procedure of sonosalpingography.

Sonosalpingography

Sonosalpingography also known as Sion test, used transvaginal sonography to confirm the tubal patency by visualizing the spill of fluid from the fimbrial end of fallopian tubes. Fallopian tubes are isoechoic and cannot be normally seen on ultrasound unless pathological or fluid surrounds the tubes. We propose to perform this test not as a substitute for hysterosalpingography or laparoscopy but as an noninvasive, cheap outdoor screening procedure in patients of infertility.

No. 8 Fr Foleys catheter is put inside the uterus the bulb is inflated with 2 ml of distilled water. Prior to procedure the patient is asked to evacuate the bladder and base line vaginal scan is performed. 20 to 60 ml of solution containing ciplox, hyalase and dexamethasone is taken in 50 ml catheter tip syringe and pushed via Foley's catheter and spill is studied from the fimbrial end.

The Foley's bulb is then deflated and some saline is pushed slowly to evaluate the uterine cavity as sonohysterography.

We have done the Sion procedure in the patients of suspected pelvic factors. In this we have flooded the pelvis using the same fluid about 200 to 300 ml, pushed via Foley's catheter and visualized the fallopian tubes.

Sonosalpingography is a good noninvasive screening test for evaluating tubal patency. Sono-salpingography however does not replace the good old hysterosalpingography in certain specific indications.

Laparoscopy has its additional advantage of having a therapeutic value also.

Sion procedure has an additional advantage of visualizing pelvic adhesions and tubo-ovarian mobility.

Transvaginal HyCoSy is a diagnostic technique for the investigations and differential diagnosis of uterine cavity and tubal patency.

OVARIAN EVALUATION BY ULTRASOUND

Ovarian status and follicle monitoring are one of the first steps in the evaluation of an infertile woman. It should be kept in mind that a detailed history including menstrual history is very essential for correlating findings of TVS.

Ovarian Study

By ultrasound the ovary is fairly easily recognized usually lying in the ovarian fossa and recognized in front of the iliac vessels when the transvaginal probe is panned to the vaginal fornices. Sometimes a bimanual examination improves the image by bringing the ovary nearer to the probe (Fig. 23).

The ovary is imaged for its morphology (normal, polycystic or multicystic) for its abnormalities (cysts,

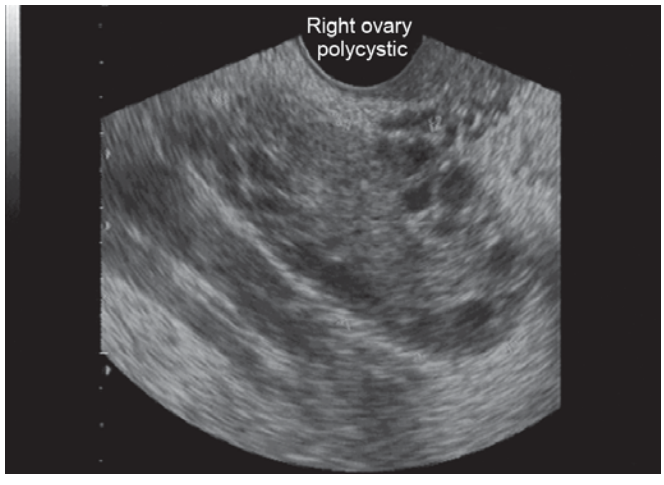


Fig. 23: Normal ovary infront of iliac vessels

dermoids, endometriomas, tumors, etc.) for its follicular growth in ovulation monitoring and for evidence of ovulation and corpus luteum formation and function.

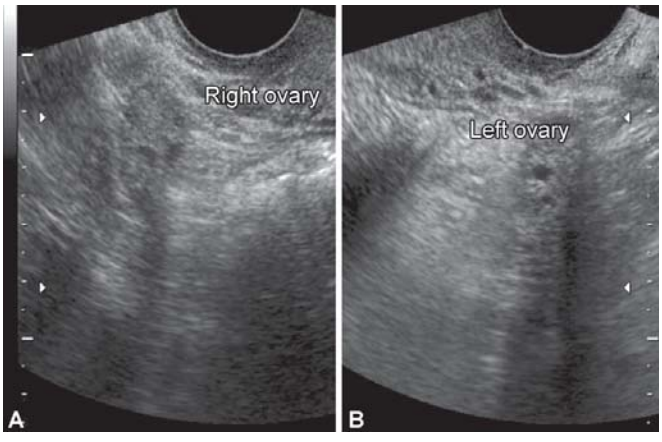
Follicular Development

Under the influence of follicle stimulation hormone (FSH) released by the anterior pituitary gland in response to pulsatile GnRH during the early part of the menstrual cycle, a few follicles will undergo progressive development. As follicular stimulation progresses, one or occasionally two follicles will continue to develop into the dominant follicle(s). Hackelöer et al[19] noted a linear increase in the size of the dominant follicle through a normal menstrual cycle. Developing follicles destined to ovulate increase in size 2 to 3 mm/day and reach a maximum diameter of 16 to 33 mm before ovulation (Figs 24 and 25).

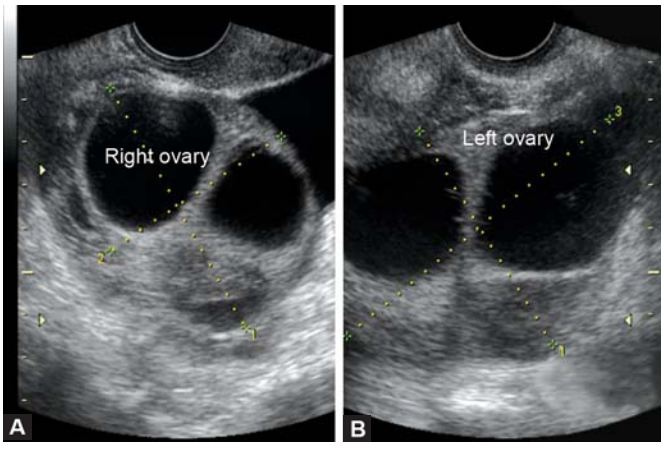
Prediction of Ovulation

The potential signs of impending ovulation are:

- Presence of a dominant follicle (usually more than 16-18 mm) (Figs 26 and 27).
- Anechoic area, double contour, around the follicle (possible ovulation within 24 hours)
- Separation and folding of the follicle lining (ovulation within 6-10 hours).
- Thickened proliferative endometrium (described later).



Figs 24A and B: Preantral follicles



Figs 25A and B: Dominant follicle

Confirming Ovulation

Sonography does appear to be very reliable in confirming ovulation once ovulation has occurred. Disappearance of the follicle is noted in 91% of cases after ovulation and a decrease in follicle size occurs in another 9%. Other signs suggesting that ovulation has occurred are the appearance of *cul-de-sac* fluid, particularly when it was not present in a previous scan, or the development of intrafollicular echoes suggesting the formation of a hemorrhagic corpus luteum.

Ovary in Anovulatory Cycles

In an anovulatory cycle, ultrasound imaging of the ovaries will reveal either a lack of any follicular development, particularly in the hypogonadotropic hypogonadal patient with type I or a few nonovulatory (less than 11 mm) follicles. A dominant follicle larger than 16 mm in diameter will not develop. A cyst may also be associated with anovulation.

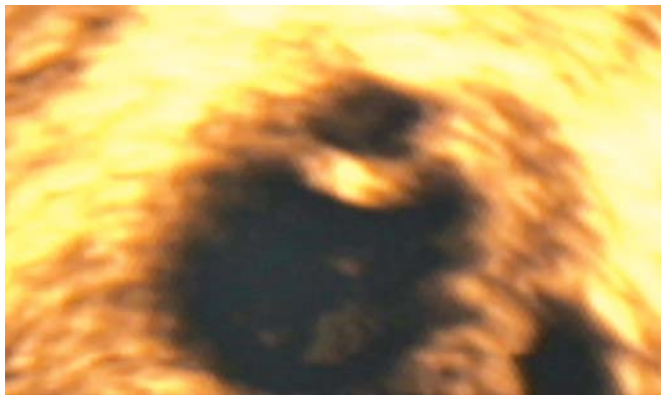


Fig. 26: Dominant follicle showing cumulus

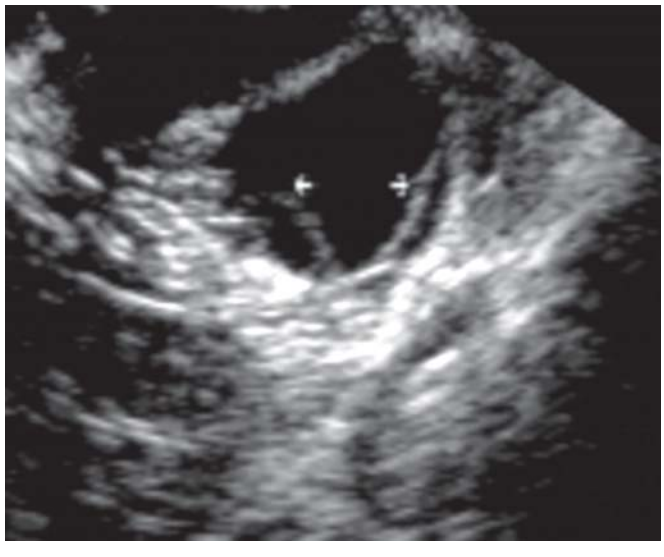


Fig. 27: Double contour

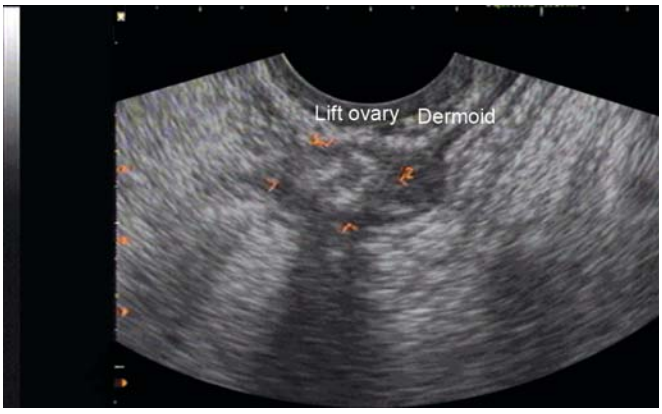


Fig. 28: Ovary lacking any follicles

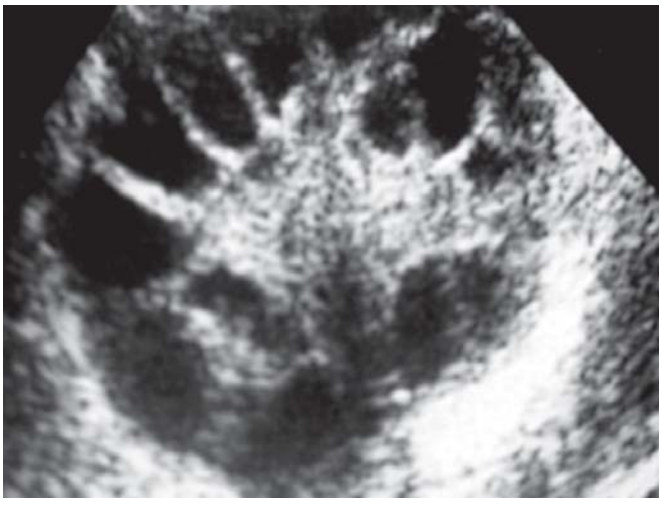


Fig. 29: Multiple small cysts

Anovulation with polycystic ovarian disease (PCOD) will often have enlarged ovaries greater than 8 cm^3 in volume with multiple small subcapsular follicles less than 10 mm in diameter. However, normal sized ovaries do not rule out PCOD. Anovulation can be diagnosed when serial scans do not show development of a follicle. A mature corpus luteum is noted sonographically in about 50% of patients after ovulation. If pregnancy does not occur the corpus luteum generally degenerates and disappears just before menstruation. Corpus luteum cysts may be 4 to 6 cm in diameter and occasionally even large but are more commonly 2.5 to 3 cm in diameter. They may persist for 4 to 12 weeks and may be responsible for suppressing normal follicular development until they resolve.

A normal ultrasound examination with normal size ovaries does not rule out PCOD if the clinical or biochemical abnormalities characteristic of the syndrome are present. Ultrasound may also suggest the diagnosis of PCOD in a patient with normal sized ovaries and the clinical and or endocrine criteria of PCOD by confirming anovulation:

- Enlarged ovary (more than 8 cm)
- Anovulation (lack of follicular development) (Fig. 28)
- Multiple small cysts (0.2-0.6) (Fig. 29)
- Resting or follicular endometrium (Fig. 19).

Endometrium

The endometrial cavity should be visualizable as a separate entity within the uterus in virtually all menstruating patients.

Sakamoto[6] described the characteristic sonographic image noted through the menstrual cycle in 1985. The proliferative endometrium is characterized by (a) the presence of a well-defined three line sign, (b) a hypoechogenic functional layer, and (c) a minimal or absent posterior acoustic enhancement. There is also a surrounding hypoechoic halo. During the luteal phase, the endometrium is hyperechoic, with posterior enhancement and absence of the three line sign and halo.

Early Proliferative Phase

The anechoic central echo noted during early menses is replaced by a hyperechoic central line and the endometrium begins to thicken, forming the three line sign. In the follicular phase, the halo which is about 2 mm thick and surrounds the endometrium, is present. There is no posterior enhancement. A follicular phase endometrium greater than 6 mm thick has been associated with a serum estradiol level over 200 pg/ml and a developing follicular greater in diameter.

Late Proliferative Phase

There is continued thickening of the endometrial echo complex in the late proliferative phase. The halo is still present. The endometrial complex is still imaged as three parallel lines, but the outer lines may begin to thicken. There is no posterior enhancement.

Luteal Phase

In the luteal phase the endometrium is thickened and is imaged as a homogeneous hyperechoic density with posterior enhancement and loss of the surrounding halo. The three line sign is gone. The rate of increase of thickness slows and the endometrial echo complex soon achieves its greater anterior posterior dimension. Posterior enhancement is assessed in the anterior posterior pelvic (AP-Pelvic) image plane, since some posterior enhancement may be noted in a trans pelvic (T-Pelvic) plane even during mid to late follicular phases.

Minimally stimulated or single line endometrium: Patients with low estrogen or excess androgen have generally have a single line endometrium similar to a late menstrual endometrium. Care must be taken when interpreting or

reporting such measurements as to whether full thickness of both layers of endometrium or only one layer is being used. Since, it is generally simpler just to measure the full endometrial thickness this is usually the measurement reported. The average thickness of the proliferative endometrium to be 8.4 ± 2.2 mm whole the secretory endometrium is 9.6 ± 3.4 mm.

Endometrial Motion

The endometrium can be seen to move during real time ultrasonographic imaging. This movement can be quite impressive when first seen.

ROLE OF TRANSVAGINAL COLOR DOPPLER IN INFERTILITY

The advent of transvaginal color Doppler sonology has added a new dimension to the diagnosis and treatment of infertile female. Color Doppler innovation is a unique noninvasive technology to investigate the circulation with organs like uterus and ovaries. Dynamic changes occur almost everyday of the menstrual cycle in a reproductively active female. These events are picked up very well by transvaginal color Doppler and definite conclusions can be drawn regarding the diagnosis, prognosis and treatment of infertile patients. As the vaginal probe lies close to the organs of interest various vessels supplying these structures can be studied in detail like the uterine artery, ovarian artery and their branches.

Study of Menstrual Cycle by Color Doppler

It provides vital information about follicular dynamics like blood flow to the growing follicle, the vascular supply of the endometrium and corpus luteum vascularization which are very important for a successful outcome in terms of pregnancy.

Changes in the Ovary

Dominant follicle within the ovary can be recognized by transvaginal color Doppler by day 8th or 10th of the cycle by a ring of angiogenesis around it, when compared to the subordinate follicles which do not demonstrate this these vessels become more abundant and prominent as the follicle grows to about 20 to 24 mm in size.

The Phases are as Follows

Early follicular (Day 5-7) late follicular (Day 11-13), early luteal (Day 15-17) and late luteal (Day 26-28). In general the index values are high in the early part of menstrual cycle and fall as ovulation approaches. According to Kurjak et al the RI in the early proliferative phase is 0.54 ± 0.04 and declines the day before ovulation when it is about 0.44 ± 0.04.[9] This is the best time for administration of surrogate hCG.

Doppler Assessment of Uterine and Ovarian Flow in Infertility and IVF

Goswamy et al found absent diastolic flow in infertility patients and with severe problems and even reversal of diastolic flow.

ROLE OF TRANSVAGINAL COLOR DOPPLER IN OTHER CONDITIONS ASSOCIATED WITH INFERTILITY

Luteinized Unruptured Follicle

This condition is recognized by serial ultrasonography to monitor the growth of follicle, with failure to see expected changes at the time of ovulation.

The typical blood flow pattern seen in the corpus luteum is absent.

Luteal Phase Defect

This is due to decreased vascularization of corpus luteum. The three to seven fold increase in blood supply is necessary to deliver, the steroid precursors to ovary and removal of progesterone as shown in experimental animals.

An increasing corpus luteum resistance index indicates less chances of embryo survival specially within first 8 weeks of pregnancy.

Fibroid

To define the borders of fibroid color Doppler is of real help as the vascular supply at the periphery of the leiomyoma can be delineated very well. Good vascularity denotes a favorable response to GnRH if used before laparoscopic surgery (Fig. 30).

Endometriosis

On gray scale scan endometrioma is seen as a homogeneously echogenic intraovarian mass. Color Doppler may demonstrate the flow around and not within the endometriotic cyst (Figs 31A and B).

Tubal Causes

During active phase of PID low impedance blood flow signals are usually detected and after effective antibiotic therapy flow tends to return to normal. In the absence of this change surgery is indicated.

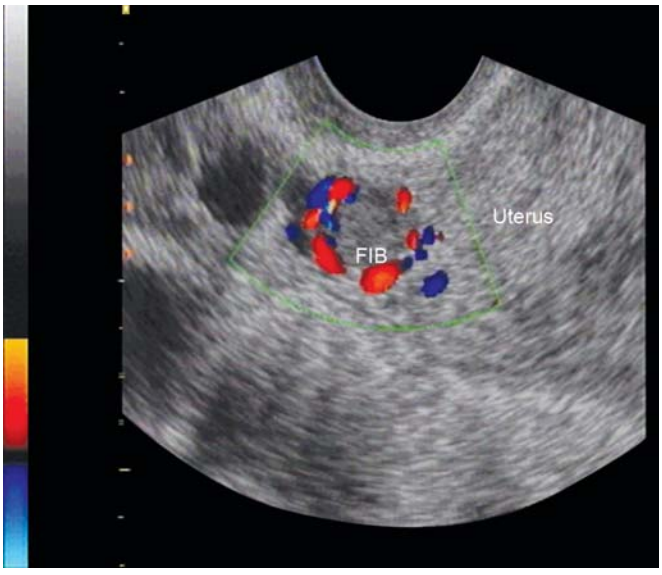
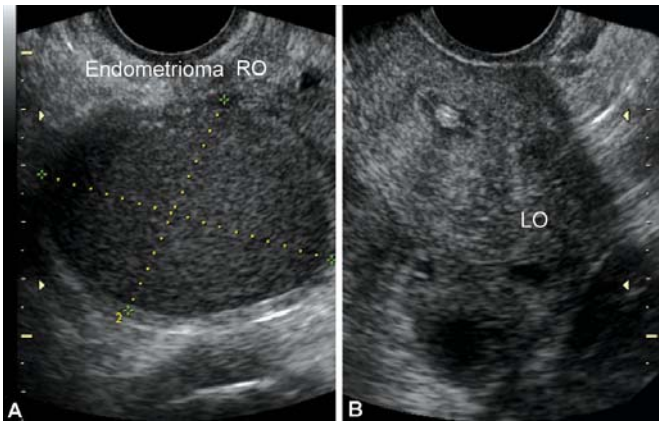


Fig. 30: Vascularity in a fibroid



Figs 31A and B: Blood flow to endometrioma

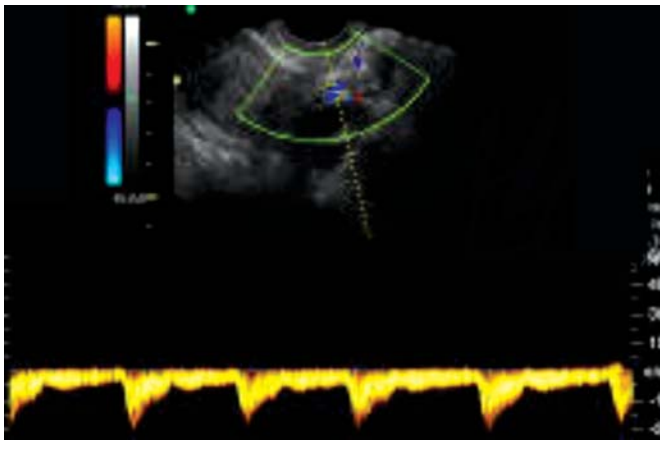


Fig. 32: Blood flow in PCO

Polycystic Ovarian Disease

Contrary to the normal ovarian blood flow, which is seen around the growing follicle, polycystic ovarian disease (PCOD) subjects show abundantly vascularized stroma. Waveforms obtained from the ovarian tissue showed a mean resistance index of 0.54 without cyclical change between repeated examinations (Fig. 32).

Uterine Factor

The possibility of decreased uterine blood flow may be associated with infertility as already discussed in proceeding paragraphs. Goswamy et al depicted in their study that uterine artery indices which were high in failed IVF cases improved after the patients were put on oral estrogen therapy and pregnancy rate improved when compared to those who did not get this treatment.

Color Doppler and its Contribution toward *in vitro* Fertilization

During stimulation protocols color Doppler ultrasound has its greatest contribution in monitoring follicular development and guiding oocyte harvesting procedures. The use of color Doppler ultrasound can occasionally be of help as it avoids accidental puncture of iliac vessels and also vessels on the surface of ovary.

Avoidance of Ovarian Hyperstimulation Syndrome

In a stimulated cycle resistance of the intraovarian vessels measured by transvaginal color Doppler correlates well with number of follicles, that is those with more than 15 mm size. This study in the early follicular phase can prevent ovarian hyperstimulation syndrome (OHSS).

Optimal Conditions for Embryo Transfer

Highest probability of pregnancy was predicted for patients who had medium values for prolactinindex (PI). Those with high PI had failure rate up to 35%. In other words the lower the PI value more the chance of pregnancy.

ULTRASOUND GUIDED ASSISTED REPRODUCTION TECHNIQUES

Historical Review

The ultrasound guided oocyte aspiration was initially peformed transabdominally through the full bladder, or directly, through the anterior abdominal wall. Subsequently, transvesical and periurethral approaches were developed. However, the first description of oocyte collection with transvaginal transducer was described by Wikland in 1985.

CONCLUSION

Ultrasound today has revolutionized the practice of infertility. To practice infertility and ART without a transvaginal scan is unthinkable in this modern era of

technology. The addition of color has given us a good insight to the physiology of female insight pelvis. Color Doppler today helps in prediction of success and complications. The addition of interventional procedures have simplified ART to an out patient procedure and prevented major operations in cases of ectopic pregnancy and ovarian cysts. 3D has nongiven us a new dimension of volume estimation and sculpture like images.

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