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Role of Gray Scale and Color Doppler Ultrasound in Differentiating Benign From Malignant Ovarian Masses

Corresponding Author: XXXXX

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I. Introduction

Ovarian mass is one of the common most problems in clinical practice in gynaecology, and it also poses a great challenge in diagnosing the ovarian mass clinically hence requires a diagnostic radiological workup.

In the management of the ovarian mass at first,definitive diagnosis must be made as treatment would differ for benign and malignant masses. Majority of ovarian masses are benign which composes nearly 80% and we should be able to extract the remaining 20% of malignant ovarian masses which needs a more aggressive treatment.

Ultrasonography(US) is considered as the primary imaging modality for ovarian mass as well as diagnosing the nature of the ovarian mass as benign or malignant and this is always correlated by gross and microscopic specimens from histopathology which will give the definitive diagnosis.

However if morphology itself is considered there is maximum chances of over diagnosing because of morphological overlapping between benign and malignant tumours. Hence to overcome this problem we include Doppler with pulsed Doppler spectral analysis which improves the characterisation of benign and malignant masses by means of quantitative blood flow to the ovarian mass.

CT has a role during staging of carcinoma and MRI gives a clear detailing of non-diagnostic cases on ultrasound. But the above mentioned modalities are expensive and cannot be advised to all patients.

Cystic ovarian masses are commonly encountered ovarian tumours in women and they present with vague symptoms. Cystic ovarian lesions are either physiological, or pathological. They can occur as functional cysts, benign or malignant tumours. It is very essential to differentiate as it requires executing a definitive treatment.

As the symptoms are being vague in making the definitive diagnosis the combination of clinical examination, Ultra-sonography and tumour markers are taken into account in diagnosing ovarian masses.

Functional ovarian cysts, which are unilocular usually resolve spontaneously. Oral contraceptives, over a period of 3 to 6 months, also resolves the functional ovarian cysts, this also helps to distinguish a physiological ovarian cyst from a pathological one, hence follow up scans are required to finalize whether the cyst is physiological or pathological.

A simple, unilocular cystic ovarian lesion, can be monitored with serial ultra-sonography and CA 125 in post-menopausal women, for its resolution over a period of time and unnecessary excision avoided ,CA 125 levels to arrive at proper diagnosis.

II. Aims And Objectives

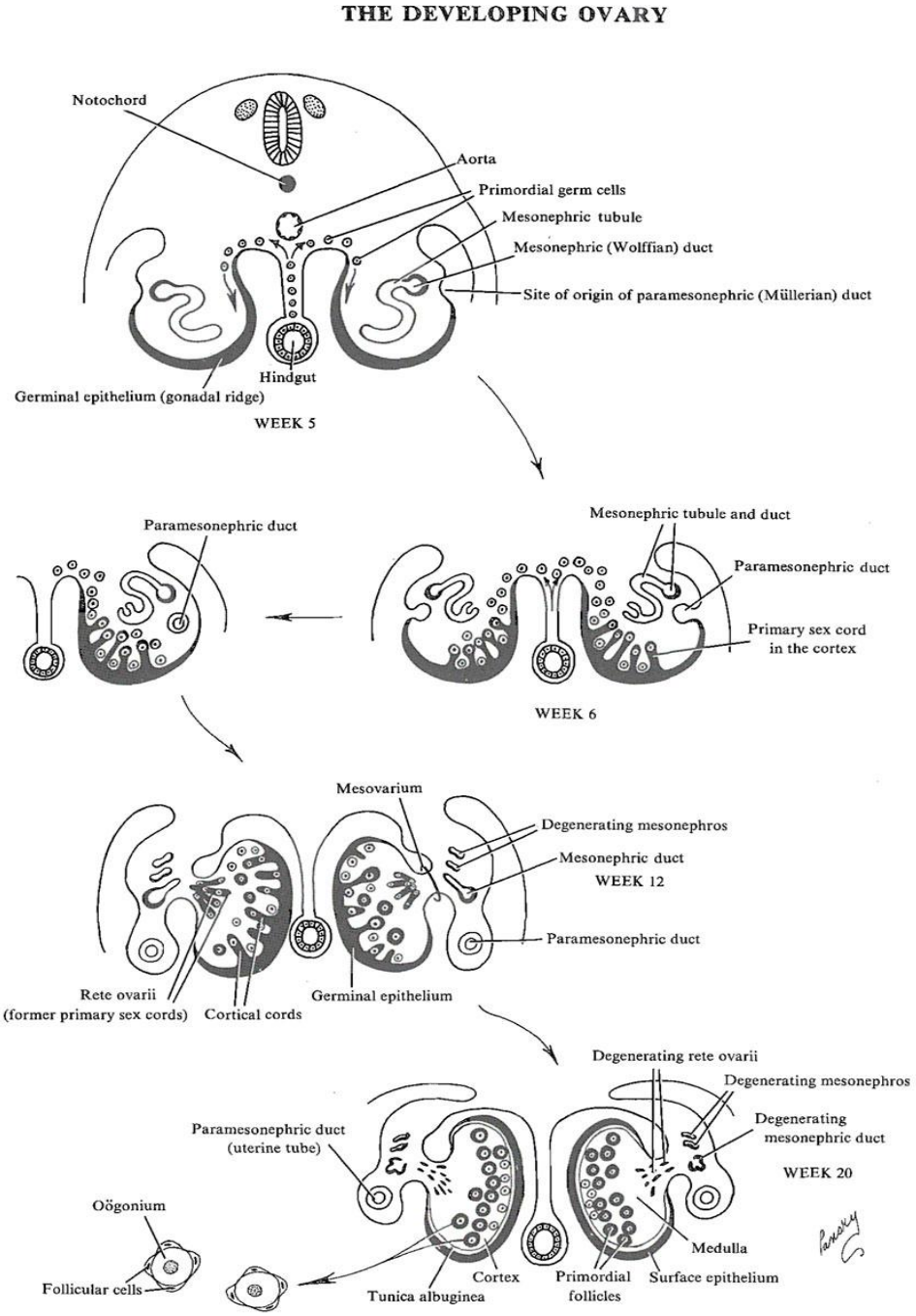
1. Assessment of efficiency of trans-abdominal and trans-vaginal ultrasonography in evaluation of ovary and detection of ovarian mass.
2. To assess usefulness of gray scale ultrasound, color doppler,spectral doppler in evaluation various benign and malignant ovarian masses.
3. To assess ultrasonographic findings of benign and malignant ovarian mass by using resistive index and pulsatility index.
4. To find out appropriate resistive index and pulsatility index value for discrimination between benign and malignant ovarian masses .
5. To study age distribution and menopausal status related to ovarian masses.
6. To assess efficacy of ultrasonography with histo-pathology.

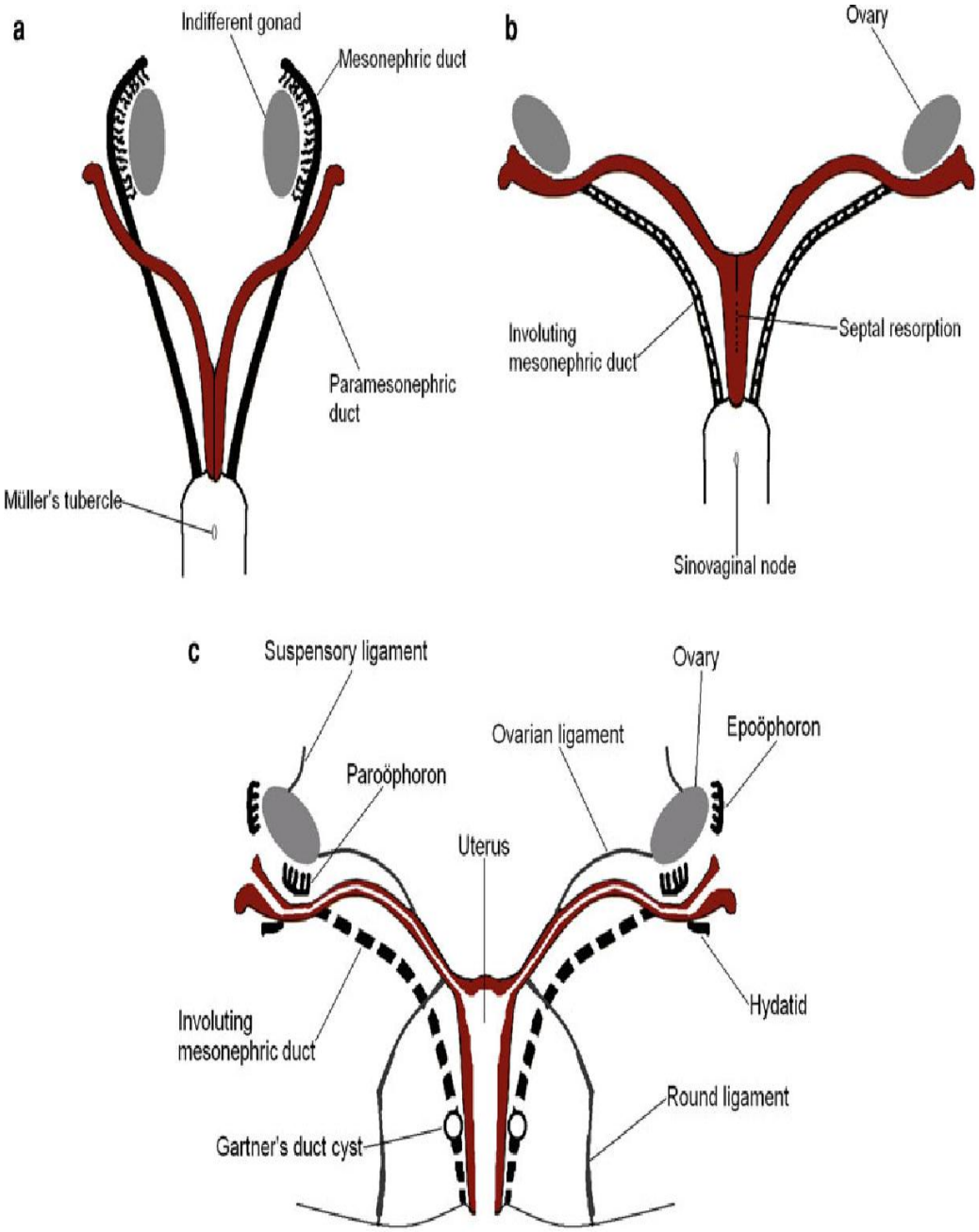
EMBRYOLOGY [1,2]

The gonads develop from primordial germ cells which are formed near the wall of yolk sac close to the allantois and then migrates along the dorsal mesentery of hindgut to invade the genital ridge.

Then the germ cells are surrounded by primitive sex cord which is similar in both female and male foetus.

Two ducts are formed from urogenital ridge mesonephric duct which is important in male and para-mesonephric duct which is important in females in forming the internal genital organs.
Para-mesonephric duct forms fallopian tubes and uterus and mesonephric duct degenerates. The remnants of mesonephric ducts known as epoophoron are located in the mesentry of ovary (mesovarium)Round ligament which represents gubernaculum in males.





DEVELOPMENT OF OVARY

ANATOMY [2,4,5,6,7]

The female reproductive tract consists of external genitalia and internal genitalia. The internal organs are situated within lesser pelvis and constitutes ovaries, fallopian tubes,uterus, cervix and vagina. The external organs are in front of pubic arch constitute mons pubis, labia majora, labia minora, clitoris, bulb of vestibule and vestibule.

The ovaries are paired sex glands or gonads in female they are greyish pink in color and started becoming scarred as the female starts to ovulate because the formation of corpora lutea . They are attached to the posterior leave of brad ligament near the upper limit of uterine peritoneal fold behind mesovarium and below the lateral part of uterine tube.

Each ovary is approx. 3 cm long 1.5 cm wide and 1 cm thick and measures volume of 6 cc generally and ultrasound volume measurements shows up to 11 cc in reproductive age, 6 cc in post menopausal women and 3 cc before menarche.

The position of ovary changes permanently after pregnancy. The long axis lies vertically in nulliparous women and they assume horizontal and oblique orientation after pregnancy.It has lateral and medial surfaces,superior (tubal) and inferior (uterine) anterior (mesovarian) and posterior(free) borders.

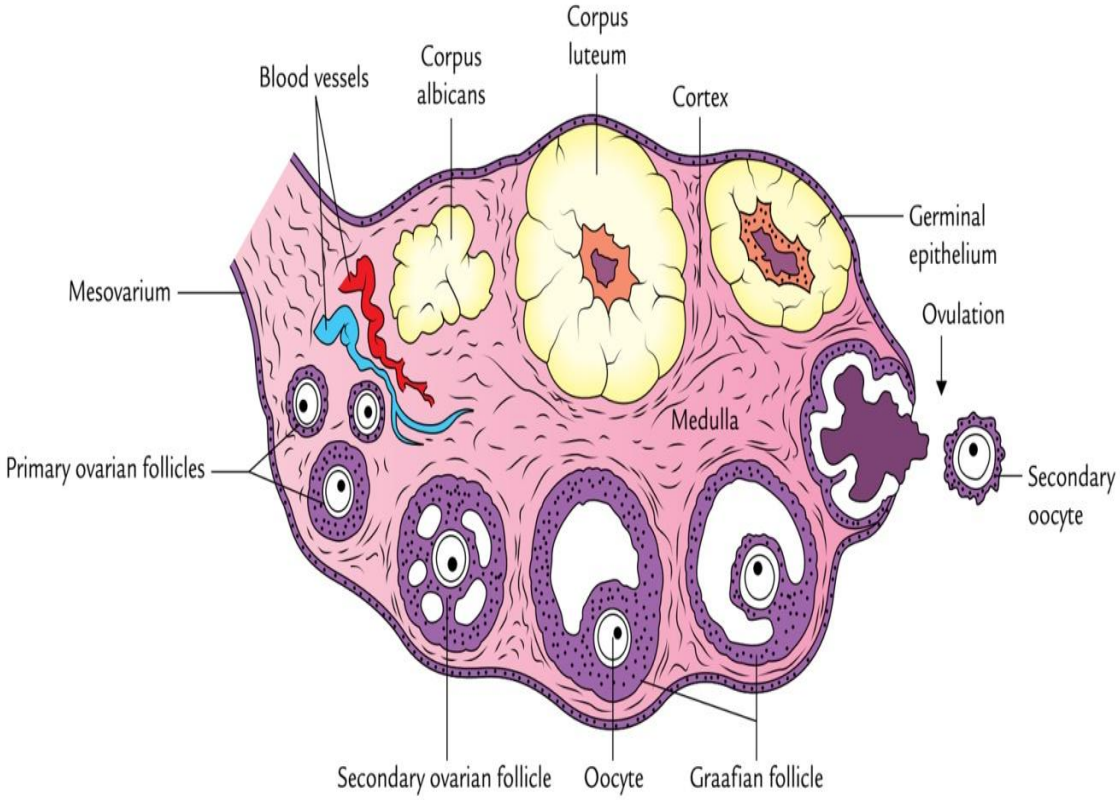
Ovaries lie in the ovarian fossa in the lateral pelvic wall and is related anteriorly to obliterated umblical artery and posteriorly to ureter and internal iliac artery and vein. On the upper surface offimbrial part of fallopian tube, suspensory ligament is attached which contains ovarian vessels and nerves.

The inferior end of fimbrial part of fallopian tube is attached to lateral angle of uterusby round ligament of uterus which lies postero inferior to fallopian tube. The lateral surface is in contact with peritoneum behind which obturator vessels and nerves.The medial end is largely covered by fallopian tube.

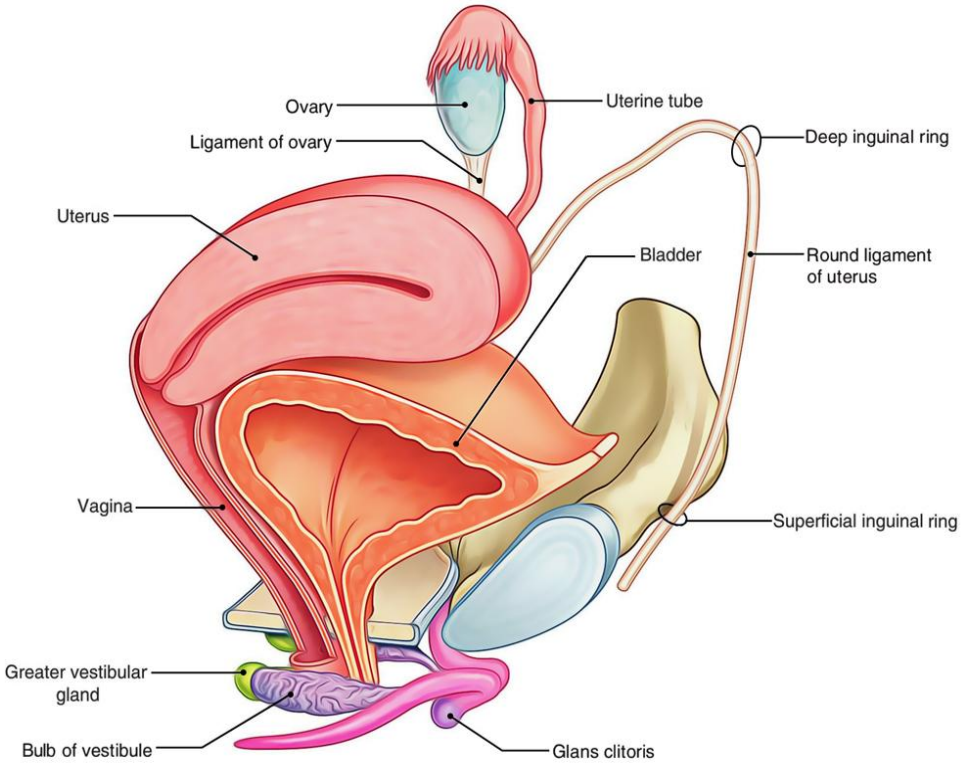
In embryonic life ovaries are situated in lumbar region near kidneys but they gradually descend into the lesser pelvis. Accessory ovary may occur in the mesovarium or in the adjacent part of the broad ligament.

❖ **MICRO STRUCTURE OF OVARY**

The ovary is covered by a single layer of cuboidal cells known as germinal epithelium. The substance of the gland consists of outer cortex which shows the structural changes during ovular cycle. The medulla consists of connective tissue, some unstripped muscles, blood vessels and nerves. Medulla also has hilus cells which are homologous to the interstitial cells of the testes. After puberty cortex forms the predominant portion enclosing medulla except hilum.



NORMAL ANATOMY OF OVARY



RELATIONS OF OVARY

❖ **CORTEX:**

The cortex is the thick peripheral part and includes ovarian follicles in distinct phases of adulthood.It's covered by the germinal epithelium that is created from a single layer of cuboidal cells in younger age. In the afterwards life, the epithelial cells become flattened. The germinal epithelium becomes constant with the peritoneum at the mesovarian border. Instantly underneath the germinal epithelium, the connective tissue of the cortex is condensed to create a whitish tough fibrous tissue layer named tunica albuginea.

❖ **MEDULLA**

The medulla is located deep to the cortex. It is composed of loose connective tissue and shows vasculature within it especially veins.

❖ **ARTERIAL SUPPLY**

The ovary is primarily supplied by an ovarian artery which originates from the aorta in the level of L1 vertebra. It reaches the ovary after passing successively via the suspensory ligament of ovary, mesosalpinx, and mesovarium. It ends by anastomosing with the uterine artery. The ovary is also supplied by an ovarian branch of the uterine artery via the mesovarium.

➢ **VENOUS DRIANAGE:** The veins of the ovary come forth from the hilum and create the pampiniform plexus around the ovarian artery, from which a single ovarian vein is composed near the superior aperture of the pelvis/pelvic inlet. The right ovarian vein empties into the inferior vena cava while the left ovarian vein empties into the left renal vein

➢ **LYMPHATIC DRIANAGE**

The lymphatics from the ovary follow the ovarian vein and drain into the pre-aortic and para-aortic lymph nodes (from the bifurcation of aorta to the level of renal vessels).

➢ **NERVE SUPPY:**

The ovary is innervated by the postganglionic sympathetic (T10, T11) and parasympathetic (S2, S3, S4) fibres, originated from abdominal autonomic plexuses. The function of autonomic nerves to the ovary is not clear. In spite of the fact that normally it's believed that sympathetic fibres are vasomotor and parasympathetic fibres are vasodilators.The visceral afferent fibres from the ovary run along the sympathetic nerve pathways to the spinal sections T10, T11 hencethe ovarian pain is sent in the umbilical region which is dermatome being supplied by

T10 spinal section. The intractable ovarian pain can be relieved by transecting the suspensory ligament, which include the afferent (general visceral afferent) fibres.

The blood vessels, lymphatics, and nerves pass over the pelvic inlet, cross the external iliac vessels, and after that goes into the suspensory ligament of the ovary (lateral end of broad ligament) and eventually goes into the hilum of ovary via the mesovarium.

SONOGRAPHIC ANATOMY OF OVARY[7]

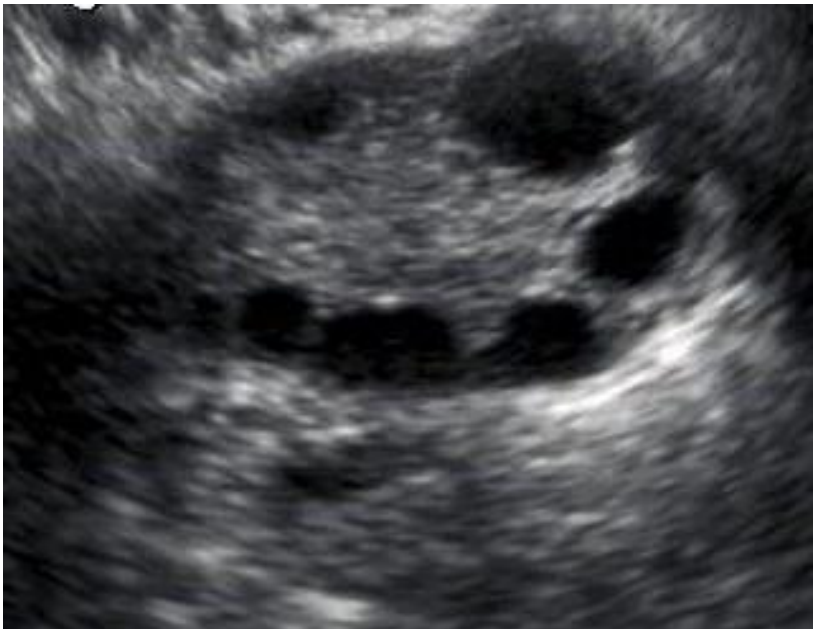
❖ **POSITION**

The normal ovaries are present laterally or postero-laterally to the anteflexed midline uterus and its position is influenced by uterine location. In retroverted uterus the ovaries are located laterally and superiorly. In enlarged uterus the ovaries are pushed more superiorly and laterally, in hysterectomy patients the ovaries are pushed inferiorly and medially. Due to the extreme superior location of ovary sometimes both the ovaries are not visualized in trans-vaginal ultrasound as limited view is available.

❖ **ECHOTEXTURE**

The normal ovary has homogenous echotexture with a central echogenic medulla and well defined anechoic cystic follicles located more peripherally in the cortex.The appearance of ovaries changes with age and phase of menstrual cycle. During early proliferative phase more number of follicles develop and increase in size until about 9 th day after which one follicle is developed more for ovulation increases in size upto 20 -25 mm. following ovulation corpus luteum develops which appears more hypoechoic to iso echoic in appearance.

The ovarian volume is the best to measure the ovarian size which is based on the formula for a prolate ellipse (0.523*length*width*height) .In the first few years of life the volume of ovary remains nearly same measuring 1 cc , from 5 years of age it gradually starts growing reaching upto 4.2+/-2.3cc at the time of menarche.Echogenic ovarian foci upto 1-3 mm may be present in normal ovary which need not be followed up on USG but focal calcification of ovary must be followed up as it may represent previous infection or stromal reaction towards early neoplasm changes.



NORMAL APPEARANCE OF OVARY ON ULTRASOUND

CLINICAL PRESENTATION AND PREDISPOSING FACTORS

❖ **PREDISPOSING FACTORS[13]**

1. **REPRODUCTIVE:** Parity is the important risk factor. Nulliparous women have higher risk than comparison to parous women.

Oral contraceptives provide a protective effect towards ovarian cancer. This supports the theory that ovulation is an important deciding agent of ovarian cancer and OCP use decreases the number of ovulation hence decreasing the risk.

Ovarian cancer may develop due to defect in reparative process that happens during the process of ovulation when surface is ruptured and repaired thus it may be related to the ovulatory process.

2. **GENETIC FACTORS:**Family history plays an important role in ovarian cancer.The life time risk of developing ovarian cancer in general population is 1.6% but if first degree relative is involved the risk increases to 4-5 % and it rises to 7% when two relatives are involved.

3. **HEREDITORY OVARIAN CANCER**

The family in which multiple persons have ovarian cancers alone or associated with another cancers also is known as hereditary ovarian cancer.Two syndromes are identified to be involved in hereditary ovarian cancer

Lynch syndrome

These families are at higher risk of developing colorectal, small bowel, stomach, endometrial , ovarian and breast cancers.

Breast ovary cancer syndrome

Associated with early onset of breast and ovarian cancers. Found to be related to BRCA 1 gene mutation.

❖ **CLINICAL FEATURES[13]**

There are no specific clinical features describing ovarian cancer. All the symptoms are constitutional and needs a high clinical suspicion for doubting ovarian neoplasm from the clinical features itself. However specific clinical features implies advanced disease.

The symptoms are as follows:

a. Distension of abdomen
b. Pain in abdomen and pelvis
c. Abnormal uterine bleeding due to increased estrogen production due to stromal hyperplasia and leutinization
d. Amenorrhea
e. Pressure symptoms : urinary frequency , urgency and dysperunia.
f. Gastro intestinal symptoms : dyspepsia ,nausea, vomiting, bloating, anorexia, diarrhea , epigastric distress.
g. Symptoms due to acute conditions like torsion, rupture, intra abdominal haemorrhage.

❖ **PHYSICAL FINDINGS**

a. Distension of abdomen is the common finding due to large palpable tumor, ascites, partial bowel obstruction, ileus or large omental cake of tumour.
b. Presence of ascites
c. Cachexia and anemia
d. The best method of clinical evaluation is bimanual palpation
e. Culdesac nodularity is noted in advanced carcinoma
f. Post menopausal bleeding
g. Distant metastasis due to supraclavicular axillary and inguinal lymph nodes.

III. Imaging And Evaluation Of Leisons

❖ **IMAGING EVALUATION OF OVARIAN LESIONS**

Adnexal masses present a special diagnostic challenge because benign adnexal masses greatly outnumber malignant ones. Determination of a degree of suspicion for malignancy is critical and is based largely on imaging appearance which is possible today due to advancement of machinery and increased awareness regarding trending changes of ovarian masses towards malignant end. Endo-vaginal ultrasonography (US) is the most practical modality for assessment of ovarian tumors because it is readily available and has a high negative predictive value. Morphologic analysis of adnexal masses is accurate for identifying masses as either low risk or high risk. The most important morphologic features are non-fatty solid (vascularized) tissue, thick septations, and papillary projections. Color Doppler US helps identify solid, vascularized components in a

mass. Spectral Doppler waveform characteristics (eg resistive index, pulsatility index) correlate well with malignancy.

Computed tomography can help assess the extent of disease in patients before and after primary cyto-reductive surgery. Magnetic resonance (MR) imaging is better reserved for problem solving when US findings are non-diagnostic or equivocal because, although it is more accurate for diagnosis, it is also more expensive. The signal intensity characteristics of ovarian masses make possible a systematic approach to diagnosis. Mature cystic teratomas, cysts, endometriomas, leiomyomas, fibromas, and other lesions can be accurately diagnosed on the basis of T1- weighted, T2-weighted, and fat-saturated T1-weighted MR imaging findings.

❖ COLOR DOPPLER EVALUATION[16,18,20,22,23,25-32]

Color Doppler US can assist in differentiating solid from cystic tumor and tissue from non-vascularized from vascularized structures. It is also used in conjunction with pulsed Doppler US to identify vessels for waveform analysis. Most studies have relied on waveform analysis to distinguish benign from malignant ovarian masses. Benign lesions tend to initiate new tumor blood vessel formation peripherally from pre-existing host vessels, whereas malignant tumors tend to initiate new tumor blood vessel formation centrally Waveform analysis is based on the fact that malignant tumor vessels are morphologically abnormal: They lack smooth muscle in their walls and demonstrate an irregular course and arterio-venous shunt formation. In addition, malignant tumor vessels generally have low impedance, which causes high diastolic flow and low systolic-diastolic variation. Some differentiation between benign and malignant masses is achieved by quantifying these differences.

Two indexes have been used in analyzing Doppler waveforms: the pulsatility index and the resistive index. Both increase with increasing distal vascular resistance, and the two indexes have a high correlation. A comparison of different studies shows that no standard has been established concerning which Doppler index to use or what cutoff value is most appropriate. However, resistive indexes less than 0.6and pulsatility indexes less than 1.0 are generally considered to be suspicious for malignancy.

In a study of 82 patients, Timor-Tritsch et al (94) demonstrated that use of a morphologic scoring system in conjunction with color Doppler US affords better differentiation of benign and malignant ovarian masses than would use of either procedure alone. Their morphologic scoring system yielded a sensitivity of 94%, a specificity and 87%, and a disappointing positive predictive value of 60%. When the pulsatility index or resistance index was included, more acceptable levels of sensitivity (94%), specificity (99%), and positive predictive value (94%) were obtained. Brown et al used a scoring system based solely on findings of solid (hyperechoic) components, pattern of flow (central or peripheral), ascites, and septations and demonstrated high levels of accuracy.

Problems associated with Doppler include operator dependence and lack of standard criteria. Moreover if septations, solid mass and papilla are absent it is difficult to detect signal for waveform analysis. In addition some Doppler indices can be misleading in premenopausal women and usually have a lower specificity because of physiological alteration of ovary during menstrual cycle because of lowered blood vessel resistance thereby mimicking malignancy. Hence it is recommended that Doppler is done between days 3 to 10 day of menstrual cycle to avoid confusion with normal leuteal flow, finally acute inflammatory adnexal disease and endometriosis are common condition associated with an increased number of capillaries and dilation of blood vessels which show a low pulsatality index.

Use of combination of morphological analysis with US and pulsed Doppler waveform analysis with color Doppler US may help overcome these problems.Thus, Color Doppler with spectral analysis using indices such as PI and RI is of immense value in yielding better characterization of ovarian neoplasm. It is factually correct that low impedance to blood flow with high velocity is suggestive of malignancy, whereas moderate-to-high impedance to blood flow is correlated to benign tumors, hence multiparameter analysis utilizing B-mode gray scale USG along with Color and Spectral Doppler offers good sensitivity, specificity, and positive predictive value. It should always be the diagnostic modality of choice for the patients with adnexal masses to establish the diagnosis of ovarian malignancy.[55]

❖ COMPUTED TOMOGRAPHY(CT) EVALUATION[33]

Among the ovarian masses CT is mainly used to see the extent of mass in surrounding soft tissue or as a substitute for second look laparotomy. CT of abdomen and pelvis is useful to see the possible sites of spread including peritoneal metastasis, lymphadenopathy as well as primary site in ovarian secondaries.

On oral administration of contrast CT delineates bowel from peritoneal secondaries which provides a major advantage over US and MRI.

In some studies CT demonstrated a reasonable accuracy in determining which patients may have tumor implants that can be optimally surgically de-bulked(All tumor nodules greater than 2 cm can be removed). Patients with un-resectable disease would undergo percutaneous or laproscopic biopsy after which they will

undergo chemotherapy and optimal surgical debulking after completion of chemotherapy. Clinical studies have shown that optimal debulking after chemotherapy have shown improval in survival rates.

❖ **MAGNETIC RESONANCE(MR) EVALUATION**[17,34-39]

It combines the best features of CT and USG. The accuracy of MR imaging in diagnosis of mature cystic teratoma, endometriomas and leiomyomas is well established and from its best contrast resolution and its usefulness in tissue characterisation and specific tissue localisation.

For adequate pelvic MR imaging the images must be at least in two planes. Acquisition of both T1 and T2 weighted images helps in distinguishing normal pelvic structure fat containing masses (mature teratoma) hemorrhagic masses(endometrioma hemorrhagic cyst hemorrhagic foci and neoplastic masses,where fat saturated T1 imaging will differentiate between masses and fat. In small fields of view and high resolution images tiny papilla and thin septa can be noted clearly. Administration of anti-peristaltic drugs before MRI will reduce the bowel movements which helps better visualization of adnexal structures and peritoneum. Cystic and solid components demonstrate low intensity on T1 weighted MRI and relatively high intensity on T2 weighted MRI. Generally benign masses have cystic component and malignant masses have both cystic and solid components.

There are differences between both cystic and solid components signal intensity, cystic lesion which have fluid component have prolonged relaxation times on T1 and T2 weighted images and high signal intensity on T2 weighted images and solid masses although contain some fluid relatively donot show high intensity in T2 compared to cystic benign lesions.

Fibrosis and smooth muscle shows low to moderate intensity on T1 weighted images and low intensity on T2 weighted images because of T2 shortening caused by actin myosin and collagen noted within them. Fibrotic lesions are fibroma, fibro-thecoma,cyst adenofibroma,Brenner'stumour and the wall of chronic pelvic abscess.Gadolinium contrast differentiates between papilla clots as papilla gets enhanced on giving gadolinium contrast while clot and debris remain unenhanced.

❖ **POSITRON EMISSION TOMOGRAPHY(PET) SCAN**[107-110]

This is controversial of using PET SCAN as routine investigation in ovarian tumors as the benign and borderline tumors are over diagnosed and its not suitable for seeing structure extent of disease and relationship with surrounding organs as it is functional scan. The PET SCAN is more useful in recurrence when CT MRI shows negative results.

IOTA SCORING[15,18,19]

❖ **IOTA stands for International Ovarian Tumour Analysis group**

To date, the IOTA study is the largest study in the literature on ultrasound diagnosis of ovarian pathology. It started years ago in 1999 and included nine European centres. The 5-year survival rate associated with ovarian cancer is less than 30%. The limiting factor for early diagnosis of ovarian tumour is lack of standardised terms and procedures in gynaecological sonography. A standardized technique for preoperative classification of adnexal masses was defined by IOTA group. Major highlight of the study were 10 simple ultrasound rules that had high sensitivity and specificity and were applicable to a large number of tumours. On application of one or more M-rules in the absence of a B-rule, or one or more B-rules in the absence of a M-rule, the mass is classified as malignant or benign respectively. If both M-rules and B-rules apply, or if no rule applies, the mass could not be classified, and was labelled as inconclusive. Although large no. of studies are available proving the efficacy of these rules, however a prospective study directly applying these diagnostic rules to the patient was lacking. This study was performed to truly establish the diagnostic utility of these rules in our country and to estimate and compare the sensitivity and specificity of given rules with histological diagnosis and establish their use as a tool in early diagnosis of ovarian malignancy.

The 10 simple rules are as follows

Rules for predicting a malignant tumour (M-rules)	**Rules for predicting a benign tumour (B-rules)**
M1 Irregular solid tumour	B1 Unilocular cyst
M2 Presence of ascites	B2 Presence of solid components where the largest solid component is <7 mm in largest diameter;
M3 At least four papillary structures	B3 Presence of acoustic shadows
M4 Irregular multilocular solid tumour with largest diameter ≥100 mm	B4 Smooth multilocular tumour with largest diameter <100 mm

Rules for predicting a malignant tumour (M-rules)	**Rules for predicting a benign tumour (B-rules)**
M5 Very strong blood flow (color score 4)	B5 No blood flow (color score 1)

➢ **Benign descriptors**
- Unilocular tumor with ground-glass echogenicity in premenopausal woman
- Unilocular tumor with mixed echogenicity and acoustic shadows in premenopausal woman
- Unilocular anechoic tumor with regular walls and largest diameter of lesion < 100 mm
- Unilocular tumor with regular walls

➢ **Benign features**
- Unilocular tumor
- Largest diameter of largest solid component < 7 mm
- Acousticshadows
- Smooth multilocular tumor with largest diameter < 100 mm
- No intratumoral blood flow on color or power Doppler

➢ **Malignant descriptors**
- Tumor with ascites
- Woman aged > 50 years
- CA-125 > 100 IU/mL
- at least moderate color Doppler blood flow in postmenopausal woman

➢ **Malignant features**
- Irregular solid tumor
- Ascites
- At least four papillary projections
- Irregular multilocular solid tumor with largest diameter ≥ 100 mm
- Very strong intratumoral blood flow on color or power Doppler

CLASSIFICATION & PATHOLOGY

CLASSIFICATION

1. <u>NON NEOPLASTIC</u>

A. Functional cyst
B. Complex cyst
C. Hemorrhagic cyst
D. Endometrioma
E. Polycystic ovarian disease
F. Ovarian hyper stimulation syndrome

2. <u>NEOPLASTIC LESIONS OF OVARY</u>

A. EPITHELIAL TUMORS

a. Serous tumors
b. Mucinous tumors
c. Endometriod carcinoma
d. Clear cell carcinoma
e. Brenner tumor

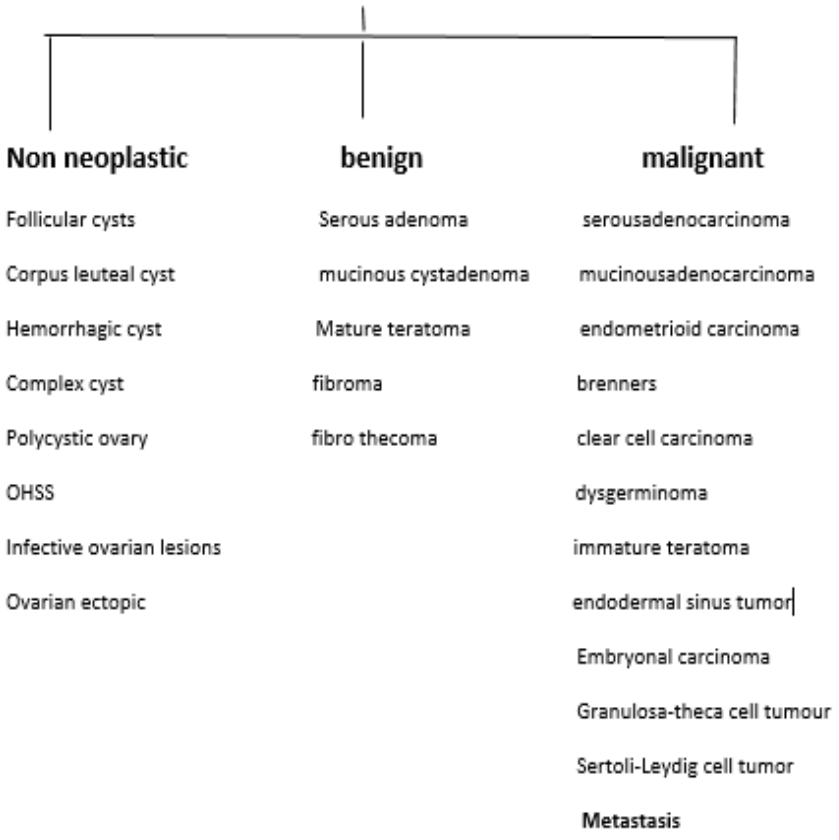
B. GERM CELL TUMORS

a. Mature teratoma
b. Immature teratoma
c. Dysgerminoma
d. Endodermal sinus tumor

C. SEX CORD STROMAL TUMOR
- Granulosa cell tumor
- Fibrothecoma
- Sertoli leyding cell tumor
- Sclerosing stromal tumor

D. INFECTIVE LESIONS OF OVARY
E. OVARIAN ECTOPIC
F. COLLISION TUMOR
G. METASTASIS

CLASSIFICATION OF OVARIAN MASSES



❖ **NON NEOPLASTIC LESIONS**

➢ **FUNCTIONAL CYSTS**[45]

They include follicular corpus leuteal and theca leutein cysts.The management of adnexal masses in women of reproductive age remains a common clinical gynecologic problem. Most ovarian cysts are functional cysts i.e, follicular cysts that result from a failure of the follicle to rupture or regress or corpus luteum cysts that derive from hemorrhage in a corpus luteum. Simple cysts are generally thin-walled (<3 mm), unilocular cysts less than 3 cm in diameter. Corpus luteum cysts may enlarge secondary to internal haemorrhage and cystic transformation. Cysts larger than about 1 cm often represent corpus luteum cysts. Small simple cysts are common in postmenopausal patients. A simple unilocular cyst without solid components is highly unlikely to be malignant in a menstruating female and in an-ovulatory cycles.

At USG, a functional ovarian cyst is typically anechoic with thin, smooth walls and posterior acoustic enhancement. Similar USG characteristics may be seen in benign ovarian neoplasms such as serous cystadenomas.

More complex appearances can be produced by hemorrhage in a corpus luteum cyst. Hemorrhagic cysts have a variety of appearances depending on the stage of evolution of the clot, but lace like reticular echoes or an intracystic solid clot are most typical.

The most helpful feature in distinguishing functional cysts from ovarian neoplasms is the presence of papillary projections and nodular septa in the latter. The reported blood flow detection rate in functional cysts has ranged from 19% to 61%. However blood flow assessment in initial Doppler USG assessment is not helpful in distinguishing follicular cysts from benign ovarian cysts.

❖ **HEMORRHAGIC CYSTS**[44,46,48]

Internal haemorrhage is more common in corpus luteal cysts. Women with hemorrhagic cysts often present with acute onset of pelvic pain. Hemorrhagic cysts are seen in different sonographic appearance in different stages in acute hemorrhagic stage, clot formation, clot retraction and clot resolution. Acute blood is anechoic and clot is echogenic for 24 hours and then RBC lysis begins which decreases the echogenicity so that by the end of 96 hrs it becomes totally anechoic.

The average diameter is 3.0-3.5 cm in size with wall thickness (2-3 mm) and regular posterior enhancement noted.Within the cyst fine septations noted which gives rise to appearance of fish net or fine reticular appearance.

Retracting blood clot appears triangular or curvilinear homogenous structure with reticular pattern due to fibrin strands. Sometimes this retracting blood clot appears like mural nodule which can be differentiated by Doppler as there is vascular supply noted in nodule and absent in blood clot. The blood can be separated into two layers fluid level or fluid debris level.

❖ **ENDOMETRIOMA**[49-52]

Endometriosis is presence of endometrial glands and stroma outside the uterus and it is commonly seen in women of child bearing age.

One of the theory of endometriosis is retrograde menstruation and lymphatic spread. Ovary is the most common ectopic site accounting for approx. 80% cases.They are mostly smallbut can increase up to size of 10-15 cm . They mostly contain obliterated endometrial lining with thin walls which later becomes fibrotic and thickened and have irregular border. Clinical presentation of endometrioma is pelvic pain and infertility, however many patients are asymptomatic.

At USG they are seen as cystic or solid lesion sometimes with thick septations (sometimes may not show septations) with diffuse low level echoes. fluid – fluid levels can be seen. On Color doppler the flow was characteristically limited, with few spots of vascular color seen in each mass.

❖ **POLYCYSTIC OVARIES**[53-58]

It was first described by stein and levenathal. As comprising of amennorhea, hirsutism, insulin resistance, obesity and sclerotic ovaries. It is one the most common endocrinopathies affecting 5-10% of women in reproductive age.

Biochemical tests reveal high levels of LH and increased LH/FSH values (increased LH and decreased FSH) and increased androgen values. Mean ovarian volume is increased approaches 14 cm as compared to normal volume of ovary which is around 9-10 cm.The follicles generally measures 5-8 mm.

In USG the diagnosis is made by the following new guidelines(2018 international consensus guideline)In patients more than 8 yrs post menarche and using high frequency endovaginal probe:

1)Follicle per ovary more than or equal to 20
2) Ovarian volume more than 10 cc ensuring no corpora lutea cysts or dominant follicles are present.
Other features which are not included in the criteria are

a. Hyperechoic central stroma
b. Peripheral location of follicles (string of pearl sign)
c. Follicles of similar size measuring 2-9 mm.

The presence of a single multifollicularovary is enough to provide the sonographic criterion for PCOS.Three-dimensional (3D) ultrasound is a relatively new imaging modality[56] that has the potential to improve the sensitivity and specificity of ultrasound in the diagnosis of PCOS[57]3D ultrasound not only permits improved spatial awareness and volumetric and quantitative vascularassessment but also provides a more objective tool to examinestromal echogenicity through the assessment of the mean greyness(MG) of the ovary [58]The mean echogenicity of the grey voxels represents the mean tissue densityor echogenicity in the region of interest and provides a newmeasure that can be objectively quantified.

In conventional 2D ultrasonography, blood flow in the tissueof interest can be assessed subjectively by the application ofcolour or power Doppler to a single plane to examine the flowpattern or objectively by measuring flow velocity and the resistance to flow through the application of pulsed-wave Dopplerand subsequent analysis of the waveforms derived from asingle vessel. Both of these techniques have significant limitations because they only examine parts of an organ blood flow.

In contrast, the VOCAL-imaging program in 3D ultrasonography facilitates the assessment of total blood flow through thequantification of the power Doppler signal within the definedvolume of interest, allowing the objective assessment of totalvascular flow within an organ or a specified volume of tissue[119]

❖ **OVARIAN HYPERSTIMULATION SYNDROME(0HSS)[59-62]:**

This is the infrequent complication for ovarian induction. Clinically there are three stages of OHSS are described ; mild moderate and severe. The mild form is associated with lower abdominal discomfort , but no significant weight gain. The ovarian size is increased but less than 5 cm in average diameter.

With severe OHSS there is severe abdominal pain,abdominal distension and weight gain. The both ovaries are markedly enlarged with maximum diameter measuring 10 cm and contains numerous large thin walled cysts which replaces most of the ovaries. There is associated ascites and pleural effusion is present.

OHSS can occur even without any medication or induction. Olotunbosum et al report spontaneous OHSS in four consecutive pregnancy in a patient with PCOS. Rosen and Lew reported a severe OHSS in a patient with PCOS and hypothyroidism patients which are considered as the risk factors for OHSS.

❖ **OVARIAN ECTOPIC[64,65]**

Ovarian ectopic pregnancies are one of the rarest presentations, with an incidence rate of approximately 1% to 6% of all diagnosed ectopics.Despite the enhanced capabilities of modern sonographic equipment, preoperative diagnosis of ovarian pregnancy remains a challenge and is most often made at time of surgery. Increased awareness of these rare, but potentially life threatening, presentations by sonographers and health care providers can lead to earlier and possibly less invasive treatment options for the patient. There is overall increase incidence of ectopic gestation due to increasing prevalence of sexually transmitted disease and Pelvic inflammatory disease PID, induced abortions, assistant reproductive techniques and increased availability of diagnostic facilities, hence diagnosis is important as early as possible. On ultrasound it may appear as a wide echogenic ring with an internal echo lucent area on the ovarian surface; the presence of ovarian cortex, including corpus luteum or follicles around the mass; and the echogenicity of the ring usually greater than that of the ovary itself.

❖ **GRANULOMATOUS ETIOLOGY IN OVARY-TUBERCULOSIS[66-69]**

Tuberculosis (TB) is still a major worldwide concern. There is no pathognomonic clinical feature or imaging findings for definite diagnosis of extra pulmonary TB. Therefore, TB involvement of Gastrointestinal or Genitourinary tract can be easily confused with peritoneal carcinomatosis and advanced ovarian carcinoma. Patients have diverse symptoms including pelvic pain, infertility, fever, abnormal uterine bleeding, ascites and pelvic mass. CA-125 level, a tumor marker for ovarian cancer may also increase in TB. Although the presence of a pelvic mass associated with ascites, high CA-125 levels and peritoneal seeding strongly suggests pelvic malignancies, we should always consider the possibility of miliary tuberculosis, tuberculosis peritonitis or ovarian TB with peritoneal seeding, to prevent unnecessary surgery and starting appropriate and timely therapy. Tuberculosis (TB) should be always being considered in the differential diagnosis of advanced ovarian cancer, especially in the regions that are endemic for the disease. On ultrasonography multilocular complex retro-uterine/adnexalmass, debris, septations, and irregular thick walls, commonly bilateral and shows echogenic debris within the pelvis.

❖ **NEOPLASTIC LESIONS OF OVARY[70-76`]**

The tumors arise from 3 components of ovary

1. Ceolomic surface epithelium
2. Germ cell line
3. Stroma of the ovary

Rarely lymphoma can primarily arise from ovary.
Metastasis can occur from primary like gastric, breast and colon carcinoma.

1. EPITHELIAL TUMOR

Epithelial tumors constitute around 60% of ovarian neoplasms and 85% of malignant ovarian neoplasms. Epithelial tumors are rare in pre- pubescent patients their prevalence increase as age increases and peaks in seventh and eight decade of women lifetime.They can be classified as benign (60%) malignant (35%) and borderline (5%) depending on their histologic characteristics and clinical behaviour.

➢ **Serous and mucinous tumors:**

Epithelial tumors are primarily cystic in nature may be either unilocular or multilocular in nature and if malignant in nature they contain varying solid component. The two most common varients of epithelial ovarian neoplasms are serous and mucinous types.

In terms of their pathology, disease course and prognosis are different from each other but clinical differentiation of these tumors is difficult because they present as cystic mass and on USG they may not be that well differentiated from each other in appearances.However some features helps in differentiating the serous

from mucinous tumors. A tumor which manifests as unilocular or multilocular with thin septa and regular wall with homogenous hypo echoic to anechoic locules and has no endophytic or exophytic vegetations is considered as benign serous neoplasm.

Benign mucinous cystadenoma typically presents as large cystic adnexal mass multilocular and numerous thin septations. Loculations may contain low level internal echoes due to increased mucin content. Different locules show different levels of echogenicity.

60% of serous neoplasms are benign,15% has low malignant potential and 25% are malignant. In contrast 80% of mucinous neoplasms are benign, 10-15% are having low malignant potential and 5% are malignant.

The features more suggesting towards benign nature of neoplasm is the size < 4 cm and wall and septal thickness < 3mm, lack of internal structure and absence of ascites or any other invasive features.

Large benign neoplasms are occasionally seen and they tend to grow in a slow and silent progression. Mucinous tumors tends to grow upto large in size as compared to serous cystadenoma.Papillary projections are characteristic of epithelial neoplasms histologically they represent the proliferating neoplastic epithelium growing over stromal component core. Identification of such papillary projections on US is necessary because they tend to provide adequate evidence of epithelial neoplasm diagnosis on imaging. They even represent the aggression of tumor. These papillary projections are generally absent in benign tumors even if they are present they appear very small in size, they tend to profuse in malignant epithelial neoplasms but tends to be dominated by solid component.

❖ **SEROUS CYSTADENO CARCINOMA VS MUCINOUS CYSTADENO CARCINOMA**

Mucinous tumors are typically multilocular, with numerous smooth, thin-walled cysts. Mucoid material is found within the cysts, some -times accompanied by hemorrhagic or cellular debris. A proportionately greater solid, non-fatty, non-fibrous tissue is often considered the most powerful predictor of malignancy appearance is similar to an ovarian mucinous cystadenoma, but with mural thickening, solid components, or aggressive features

Serous cystadeno carcinoma is more heterogeneous in appearance than a serous cystadenoma and shows papillary projections, thick septations, and/or solid components, presence of ascites which may be concerning for peritoneal metastaticspread/ discrete peritoneal deposits may be seen.

Bilaterality and peritoneal metastasis are frequently found in serous as compared to mucinous neoplasms. The rupture of mucinous cystadenoma can lead to pseudo myxoma peritonii.

➢ **Endometroid tumor**

Endometroid neoplasms account for 10-15% of ovarian carcinoma , almost all of them are malignant and most of them are synchronous with endometrial hyperplasia and endometrial carcinoma. Imaging is nonspecific and shows large complex cystic mass with solid component and endometrial thickening may be noted.

➢ **Clear cell carcinoma**

They constitute approximately 5% of carcinomas which are always invariably malignant. It may develop in patients with endometrioma with solid component hence it is always worthy to remove. Imaging shows a unilocular cyst with solid protrusion. The cyst margin is smooth and the solid protrusion are rounded and few in number.These findings suggest but are not specific as it appears like serous cystadenoma so clear cell carcinoma should be kept as differential diagnosis in potentially at risk patients.

➢ **Brenner tumor**[77-78]

They constitute 2-3% of ovarian neoplasms and are rarely malignant. They are composed of transitional epithelium and dense stroma. They are usually small in size <2 cm in size but patients may sometimes appear with abdominal mass and pain. They appear as multilocular cystic mass but sometimes appear as solid mass due to small size. Extensive amorphous calcification is present in solid component.

2. GERM CELL TUMORS[79]

These are the second most common group of tumors which constitute 10-15% of ovarian neoplasms. They have mature teratoma, immature teratoma, endodermal sinus tumor and dysgerminoma,out of which only mature teratoma is considered as benign and it is the most common lesion. Elevated levels of alpha feto protein and HCG (Human chorionic gonadotropin) helps in establishing the diagnosis.

➢ **Mature teratoma**[80-84]

Mature teratoma is the most common ovarian benign lesion in women aged less than 45 years. Although all three germ cell layers are present ectodermal germ cell lines predominates so that the lesions are often called as dermoid cyst. They are often asymptomatic and are incidentally diagnosed on routine pelvic ultrasound. At

gross examination mature teratomas are unlilocular and in 88 % of patients it is filled with sebaceous material and it is lined by squamous epithelium.Mature teratomas have a characteristic appearance on ultrasound. Ultrasound findings include the presence of a Rokitansky nodule, fat fluid levels, dermoid mesh, and the "tip of the iceberg sign". The Rokitansky nodule, or dermoid plug, is a cystic lesion with a densely echogenic tubercle projecting into the cyst lumen. Dermoid mesh is a specific sign that refers to the matrix of echogenic bands made by hair fibers floating within the cyst. The "tip of the iceberg sign" applies to the acoustic shadowing that sebum can have on hair containing lesions. Ultrasound can also be useful in differentiating benign ovarian masses from malignant lesions. Characteristics suggestive of malignancy include ovarian volume of above 20 cm or greater, increased vascular support to a lesion on color Doppler, septations, papillary projections, and heterogeneous tissue echogenicity.Even then there are numerous pitfalls in diagnosis of mature teratoma because echogenic bowel blood clot and hemorrhagic cyst also shows manysimilar appearance on ultrasound.The complications of mature cystic teratoma includes rupture, torsion malignant degeneration. The rupture can lead to leakage of sebaceous material into peritoneal cavity leading to granulomatous peritonitis. Less more common of teratomas are monodermal types which includes struma ovarii (in which mature thyroid epithelium predominates) and carcinoids of ovary.

Cystectomy should be the first line treatment in lesions that are preoperatively consistent with teratoma. 1-2% of these tumors shows malignant transformation into squamous cell carcinoma in peri menopausal women which is diagnosed in late stages because appearance of benign cysts and SCC appears alike on ultrasound due to their internal echogenic components. Intra tumoral blood flow is more in malignant(88%) than benign (20.15%)The mean RI and PI values are less in malignant tumors (RI=0.31 and PI=0.40) as compared to benign (RI=0.62 and PI =1.06)Kurjak et al also reported the mean values of RI in benign cysts of 8 patients as 0.64 which is above the cutoff values of 0.4 for differentiating benign from malignant neoplasms.

- **Immature teratomas**[80-84]

Immature ovarian teratomas are uncommon ovarian germ cell tumors. They differ from mature ovarian teratomas (dermoid cysts) both histologically by the presence of immature tissue, and clinically by their more malignant behaviour and affects younger age group(usually during first two decades of life.) They grow rapidly and frequently demonstrate rupture of capsule. The tumor capsule is not always welldefined.The proportion of immature neuroepithelium present correlates with the tumor grade and hence prognosis.

Ultrasound appearance can be as a complex adnexal mass although is non-specific. They tend to be large 14-25 cm and average size being 7cm . They have prominent solid component and complex cystic appearance which contains serous or mucinous or sebaceous materials Calcifications may be present. Hemorrhage is often present.

The yolk sac present within the cyst is responsible for secretion of alpha feto protein and it is the major predictor of grade stage and rate of recurrence.

Immature teratomas are often associated with presence of mature teratoma in the opposite ovary in 26% of patients.

- **Dysgerminoma**[8-86]

Ovarian dysgerminomas are a type of germ cell tumor of the ovary. They are the most common malignant germ cell tumors of the ovary and are thought to account for ~1% of all ovarian neoplasms. This is the counterpart of seminoma in testes in males.Dysgerminoma in pure form is not associated with any form of endocrinal secretion but thesynctitiotrophoblast gaint cell secrete HCG which area present in 5% of dysgerminomas causing increase in level of human choriogonadotropin levels in serum

May be seen as a septated ovarian mass with varying echotexture. Color Doppler interrogation may show prominent flow signal within the fibrovascular septa.

- **Endodermal sinus tumor**[87,88]

Endodermal sinus tumor also known as yolk sac tumor is a rare malignant ovarian germcell tumor that usually occurs within second decade of life. The tumor appear as large complex pelvis mass that extends into abdomen and contains both solid and cystic components. The cystic component is composed of epithelial line cysts produced by the tumor or co existing teratomas. The tumor grows rapidly and have poor prognosis. The serum shows high level of alpha feto protein levels.

3. **SEX CORD STROMAL TUMORS**[89]

Gonadal cells that arise from ceolomic epithelium (sex cord) and mesenchymal cells of embryonal gonads include granulosa cells,theca cells , fibroblasts, leydig cells , and sertoli cells. Ovarian tumors which are

composed of these types of cells are known as sex cord stromal cell tumors. These group of tumors are comprised of 8% of total tumors and affects all age groups.

The most common types of sex cord stromal tumors are Granulosa cell tumor (malignant) , fibrothecoma(benign) and sertoli leydig cell tumor . Sex cord stromal tumors are of interest because of its endocrinal affects which are rare in other ovarian neoplasms. The vast number are either benign(fibro thecoma, sclerosing stromal cell tumor) and if malignant they are confined to ovary (granulosa cell tumor, sertoli leydig cell tumor).

- **Granulosa cell tumor**[{90,100}]

Granulosa cell tumors constitute less than 5 % of all ovarian tumors. Unlike epithelial ovarian tumors, they occur in a younger age group, are usually detected in an early stage and often have features of hyperestrogenism. The presenting symptoms are usually nonspecific with abdominal pain or distension. They follow an indolent course and are characterized by a long natural history.

Granulosa cell tumors (GCT) are derived from the granulosa cells. They constitute less than 5 % of the ovarian tumors and more than 70 % of the sex cord-stromal tumors. There are two distinct histological types—adult GCT (AGCT) and juvenile GCT (JGCT) which display different clinical and histopathological features. AGCTs are more common and are usually seen in perimenopausal and postmenopausal women, with a peak incidence at 50–55 years. JGCTs are rare tumors, representing 5 % of all GCTs and occurring in premenarchal girls and young women.

In androgen secreting GCT, testosterone or its precursors can be used as tumor markers.

a. Inhibin
b. Mullerian InhibitingSubstance(MIS)/ Anti Mullerian Hormone (AMH)
c. Follicle Regulatory Protein (FRP)

Imaging findings of adult ovarian granulosa cell tumor vary widely and range from solid masses to tumors with varying degrees of fibrotic hemorrhagic to multi locular cystic to completely cystic lesions. Intra tumoral bleeding, fibrous degeneration, infarcts which lead to heterogeneous arrangement of tumor cells ultimately leading to heterogenous appearance of tumor . In contrast to epithelial neoplasms, granulosa cell tumors doesnot have intra cystic papillary projections have fewer propensities for peritoneal seeding and are confined to ovary at the time of diagnosis. Oestrogenic affects include uterine enlargement endometrial proliferation and haemorrhage.

- **Fibrothecoma**[{40,92}]

Fibromas , thecomas ,fibrothecomas are ovarian tumor of gonadal stromal origin or may be varients of a single entity. They are spectrum of benign tumors. They contain fibrous tissue and theca cells with abundant of lipid in cytoplasm. These theca cells are responsible for estrogenic effects of these tumors. In contrast pure fibromas contains spindle cells and not theca cells which does not have any estrogenic effects. They are of significance because they appear as solid tissue mimicking malignancy and fibromas are associated with meigs syndrome which has ascites and pleural effusion which again mimics as malignancy. They can occur in both pre menopausal and post menopausal women.

In USG they appear as solid hypoechoic masses with sound attenuation which at times may be striking. However US findings are variable and sometimes hyperechoic masses may be seen. Dense calcifications are often seen. Scattered edema and cystic degeneration may also be seen.

- **Sclerosing stromal tumor**[{93-95}]

Sclerosing stromal tumor is a distinct type of ovarian stromal tumor. It is a rare benign stromal tumor which shows a distinctiveclinical and histological characteristics. It is prevalent in young age groups(second and third decades) which is earlier as compared with other stromal tumors and show heterogenous cellular pattern which distinguishes it from fibroma thecoma and other varients of stromal tumors. Patients present with menstrual irregularities and pelvic pain and rarely ascites.

On US they appear as solid and cystic tumors with centrally located multiple cystic lesions . Multiple intra tumoral vessels are noted with periphery in location and central intercystic space on Doppler ultrasound.

- **Sertoli leydig cell tumor**[{96}]

Sertoli leydig cell tumor are sex cord stromal tumors which account for less than 0.5% of all ovarian tumors. They are typically unilateral and shows exclusively found in young women between 20and 30 years. Because sertoli leydig tumors are androgen producing tumors which causes secondary amennorhea, hirsutism, and virilisation and endocrine disorders, however 50% of people donot show any endocrinal features.Sertoli

leydig cells appear solid in sonography and shows rich vascularity and shows less resistive index and may have peripheral necrosis.

- **Collision tumors**[97]

Collision tumor represents the coexistence of two adjacent but histologically distinct tumors with no histological admixture at the interface. Ovarian collision tumors are rare. They are most commonly composed of teratoma and cystadenoma or cystadeno carcinoma. However other histologic combinations have been reported (teratoma granulosa cell tumor cystadeno carcinoma and sarcoma). The mechanism ofdevelopment for collision tumor is uncertain.

- **Metastatic ovarian tumor**[98,99,100,102]

The colon and stomach are the most common primary sites which metastatize to ovaries followed by breast carcinoma. Previously it is thought to be by trans-coelomic spread but now it is believed to be retrograde lymphatic spread. This represents 10% of all ovarian tumors that are developed in reproductive age group. They contain a mucin producing cell known as signet ring cell which is originated from gastro intestinal tract. Differentiation of primary and metastatic tumor is having great importance in view of treatment, treatment response, and prognosis. They are many metastatic tumors of ovary which can mimic primary ovarian neoplasm.

Breast cancers metastatize to ovary by hematogenous route,gastrointestinal tumors metastatize via peritoneum and pelvic tumors metastatize from contiguous tumor involvement.

These tumors are typically seen sonographically as bilateral, solid ovarian masses, with clear well-defined margins. An irregular hyper-echoic solid pattern and moth-eaten like cyst formation is also considered a characteristic feature.At sonographic assessment predominantly or purely solid tumor more likely to represent metastatic tumors and cystic lesions mostly represent primary, there is no difference between vascular features of the lesion hence the Doppler is of least importance in distinguishing between primary and secondary ovarian malignancy.

The degree of suspicion is majorly based on imaging which is aided by other factors like CA-125 in serum must also be considered in preoperative determination of ovarian neoplasm as primary or secondary.

- **KRUKENBERG TUMOR**[103]

Krukenberg tumor, also known as carcinoma mucocellulare, refers to the "signet ring" subtype of metastatic tumor to the ovary. The colon and stomach are the most common primary tumors to result in ovarian metastases, followed by the breast, lung, and contralateral ovary**.** Most imaging features are non-specific, consisting of predominantly solid components or a mixture of cystic and solid areas. It is often difficult to differentiate from other ovarian neoplasms.

These tumors are typically seen sonographically as bilateral, solid ovarian masses, with clear well-defined margins. An irregular hyper-echoic solid pattern and moth-eaten like cyst formation is also considered a characteristic feature. Assessment of ovarian tumor vascularity with transabdominal color Doppler imaging revealed an abnormal vascular pattern with high-velocity, low-impedance signals within the heterogeneous solid masses

FIGO CLASSIFICATION OF OVARIAN TUMORS

FIGO Stage	**Stage description***		
I	T1 N0 M0	I	The cancer is only in the ovary (or ovaries) or fallopian tube(s) (T1). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IA	T1a N0 M0	IA	The cancer is in one ovary, and the tumor is confined to the inside of the ovary; or the cancer is in one fallopian tube, and is only inside the fallopian tube. There is no cancer on the outer surfaces of the ovary or fallopian tube. No cancer cells are found in the fluid (ascites) or washings from the abdomen and pelvis (T1a). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IB	T1b N0 M0	IB	The cancer is in both ovaries or fallopian tubes but not on their outer surfaces. No cancer cells are found in the fluid (ascites) or washings from the abdomen and pelvis (T1b). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IC	T1c N0 M0	IC	The cancer is in one or both ovaries or fallopian tubes and any of the following are present: • The tissue (capsule) surrounding the tumor broke during surgery, which could allow cancer cells to leak into the abdomen and pelvis (called **surgical spill**). This is stage **IC1**.

			• Cancer is on the outer surface of at least one of the ovaries or fallopian tubes **or** the capsule (tissue surrounding the tumor) has ruptured (burst) before surgery (which could allow cancer cells to spill into the abdomen and pelvis). This is stage **IC2**. • Cancer cells are found in the fluid (ascites) or washings from the abdomen and pelvis. This is stage **IC3**. It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
II	T2 N0 M0	II	The cancer is in one or both ovaries or fallopian tubes and has spread to other organs (such as the uterus, bladder, the sigmoid colon, or the rectum) within the pelvis **or** there is primary peritoneal cancer (T2). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIA	T2a N0 M0	IIA	The cancer has spread to or has invaded (grown into) the uterus or the fallopian tubes, or the ovaries. (T2a). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIB	T2b N0 M0	IIB	The cancer is on the outer surface of or has grown into other nearby pelvic organs such as the bladder, the sigmoid colon, or the rectum (T2b). It has not spread to nearby lymph nodes (N0) or to distant sites (M0).
IIIA1	T1 or T2 N1 M0	IIIA1	The cancer is in one or both ovaries or fallopian tubes, **or**there is primary peritoneal cancer (T1) and it may have spread or grown into nearby organs in the pelvis (T2). It has spread to the retroperitoneal (pelvic and/or para-aortic) lymph nodes only. It has not spread to distant sites (M0).
IIIA2	T3a N0 or N1 M0	IIIA2	The cancer is in one or both ovaries or fallopian tubes, **or**there is primary peritoneal cancer and it has spread or grown into organs outside the pelvis. During surgery, no cancer is visible in the abdomen (outside of the pelvis) to the naked eye, but tiny deposits of cancer are found in the lining of the abdomen when it is examined in the lab (T3a). The cancer might or might not have spread to retroperitoneal lymph nodes (N0 or N1), but it has not spread to distant sites (M0).
IIIB	T3b N0 or N1 M0	IIIB	There is cancer in one or both ovaries or fallopian tubes, **or**there is primary peritoneal cancer and it has spread or grown into organs outside the pelvis. The deposits of cancer are large enough for the surgeon to see, but are no bigger than 2 cm (about 3/4 inch) across. (T3b). It may or may not have spread to the retroperitoneal lymph nodes (N0 or N1), but it has not spread to the inside of the liver or spleen or to distant sites (M0).
IIIC	T3c N0 or N1 M0	IIIC	The cancer is in one or both ovaries or fallopian tubes, **or**there is primary peritoneal cancer and it has spread or grown into organs outside the pelvis. The deposits of cancer are larger than 2 cm (about 3/4 inch) across and may be on the outside (the capsule) of the liver or spleen (T3c). It may or may not have spread to the retroperitoneal lymph nodes (N0 or N1), but it has not spread to the inside of the liver or spleen or to distant sites (M0).
IVA	Any T Any N M1a	IVA	Cancer cells are found in the fluid around the lungs (called a malignant pleural effusion) with no other areas of cancer spread such as the liver, spleen, intestine, or lymph nodes outside the abdomen (M1a).
IVB	Any T Any N M1b	IVB	The cancer has spread to the inside of the spleen or liver, to lymph nodes other than the retroperitoneal lymph nodes, and/or to other organs or tissues outside the peritoneal cavity such as the lungs and bones (M1b).

❖ **KEY FEATURES IN DIFFERENTIAL DIAGNOSIS OF OVARIAN NEOPLASMS;**

The imaging appearance of ovarian neoplasms ranges from cystic to solid masses although ovarian tumors have similar clinical and predominant or specific key features are present for each type of ovarian neoplasm

1. Serous cystadenoma is thin walled unilocular or multilocular cystic tumor filled with serous fluid. This tumor is very common and mimic a physiological cyst or occasionally atypical mature cystic teratoma that lacks a eccentric mural nodule.
2. Mucinous cystadenoma is less common and it is mostly multilocular and large.
3. Ovarian tumors associated with endometrial hyperplasia or carcinomas include endometroid carcinoma, granulosa cell tumor , and occasionally thecoma or fibrothecoma.
4. Although rare endometroid carcinoma is the most common tumor arising from endometrioma followed by clear cell carcinoma.
5. The presence of fatty opacity is highly determinant of mature cystic teratoma which are predominantly cystic with dense calcifications and immature cystic teratoma are with predominantly solid with small foci of lipid material and foci of sparse calcification.
6. Malignant germcell tumors are large solid masses that occur in predominantly young women. Dysgerminoma may demonstrate the vascularized fibrous septa. Serum tumor markers are available to further support the diagnosis.
7. Ovarian tumors with highly vascular solid components include sclerosing stromal tumors ,sertoli leydig cell tumor ,struma ovarii and cystadenofibroma.
8. When bilateral complex ovarian cysts are noted differential diagnosis are serous epithelial carcinomas and metastasis.

9. Tumors showing calcification include serous cystadenoma, brenners tumor ,mature and immature teratomas.
10. Tumor not having specific characterstics can be grouped as collision tumors.

IV. Materials And Methods

The present prospective study was contacted during the period from 2018-2019 in department of Radio-diagnosis, new civil hospital, Surat. The study was conducted mainly with the help of Department of Obstetrics and Gynaecology.

SELECTION OF CASES

The study includes the patients clinically suspected to have ovarian neoplasm and referred to the department of radio-diagnosis from the department of obstetrics and gynaecology where detailed history is taken, examination findings are tabulated and evaluation is done with US and Doppler imaging.

EQUIPMENTS USED

All patients are examined on Phillips affinity G with multi frequency convex array transducer (frequency range 2 to 5MHz) and multi frequency linear array transducer (frequency 5 to 12 MHz) and multi frequency endo transducer (frequency 4 to 9MHz).

PATIENTS PREPARATION AND SCANNING TECHNIQUE

The examination was performed after patients were referred. Before the scan patients were asked to drink adequate water, so as the bladder is distended and patient was examined in supine position. The whole of the abdomen is examined in longitudinal and transverse plane giving special reference to pelvis. The ovaries were identified and if any ovarian mass is present , was examined for its location size , echo-texture , mural nodules septations, calcification, it's effect on surrounding organs , extension into abdomen, ascites, lymph node involvement , metastasis to liver, peritoneum , serosal surface , omentum etc.

Trans-vaginal USG is also done in married patients after voiding of bladder, for better characterization of tumor.

Morphological indexing of ovarian masses is done by using IOTA scoring based on features like septa, wall of the cyst, presence of solid mass, ascites, vascularity etc. and divided them into benign and malignant based on the characteristics shown by the tumor. The ones which show any characteristics from B0-B5 is considered as benign and the ones which show the structural characteristics from M0-M5 will be considered as malignant and the ones which show both characteristics from B0-B5 and M0-M5 are regarded as indeterminate.

Subsequently power and Doppler flow imaging and spectral analysis were performed. Doppler parameters were optimised to calculate the impendence indices and detection of flow and they were noted as being present or absent and further classified as vascularity noted in central or peripheral region or septal region and vessels being arranged regularly or randomly.

On spectral Doppler the lowest RI and PI values and highest PSV are considered as the features of a malignant mass when RI <0.6 and PI <1.0 and PSV is max >15 cm/sec. measurements are noted from three consecutive waveforms and smallest sample volume is noted.

The sonographic findings are compared with intraoperative and histo-pathological findings in follow up scans.

PROFORMA

Name: Date:

Age:

Outdoor/Indoor No:

Chief complaints:

Menstrual history:

Obstetric history:

Past history:

Family history:

GENERAL EXAMINATION:
- Vital signs - Temperature
- Pulse
- Blood pressure
- Pallor, Edema, Cyanosis, Clubbing, Jaundice, Obesity, Lymphadenopathy

SYSTEMIC EXAMINATION:
- Respiratory system
- Gastro intestinal
- Cardiovascular system
- Central nervous system

GYNECOLOGICAL EXAMINATION:
- Per abdomen examination
- Site and size of mass
- Surface
- Tenderness
- Consistency
- Location
- Mobility
- Associated other palpable masses
- Per vaginal examination
- Per speculum examination
- Per rectal examination

INVESTIGATIONS:
- Laboratory investigations: CBC ESR Blood grouping
CA-125.
- Radio imaging
- X-ray abdomen standing
- X-ray KUB
- X-ray chest
- Ultrasound {pelvic mass detailed evaluation by gray scale, Doppler and spectral waveform sonography}

GRAY SCALE FINDINGS:
- Number (single/multiple)
- Location
- Size
- Margin (well defined /ill defined)
- Nature of lesions (cystic, solid or mixed)
- Internal characterstics

a. Echo-texture (hypo-echoic,hyper-echoic,an-echoic)
b. Uni-loculated or multi-loculated
c. Wall thickness
d. Septations
e. Posterior enhancement of wall
f. Papillary projections

COLOR DOPPLER FINDINGS:
- Blood flow present or absent
- Amount of blood flow
- Location of blood flow
- RI, PI, PSV values

PROVISIONAL DIAGNOSIS:
HISTO-PATHOLOGICAL FINDINGS:

V. Observation And Analysis

The study is aimed at the evaluation of efficacy of US in detecting the ovarian masses. It was done in the department of Radio diagnosis in new civil hospital Surat over a period of 12 months from 2018-2019

Table 1 AGE DISTRIBUTION OF LESIONS

SR.NO	AGE GROUP IN YEARS	N0. OF LESIONS
1	0-10	1
2	11-20	10
3	21-30	32
4	31-40	14
5	41-50	10
6	51-60	14
7	61-70	3
8	71-80	1

➢ Maximum patients were from the age group 20-30. Youngest patient is of age 9 years and oldest patient is of 75 years. Mean age of the patients is (34.25 years).

2. Age distribution of benign and malignant lesions.

➢ A further classification ofthe age distribution based on major pathologies was done. There was total of 17 malignant lesions and 68 benign lesions noted.

➢ Benign lesions of ovary noted to be more common in the age group below 40 years making 54 out of 68 cases. The cases were clustered between 21-30years age group with 31 cases out of 68 benign cases.

➢ Malignant lesions are noted to be more common in older age groups.14 out of 17 cases were seen above the age of 40 years. The cases were clustered within the age group 51-60 years with 8cases out off 17 cases making 47.06% of the cases.

Table 2 AGE DISTRIBUTION OF BENIGN AND MALIGNANT LESIONS

SR NO.	AGE GROUP IN YEARS	NO. OF BENIGN LESIONS	NO.OF MALIGNANT LESIONS
1	0-10	0	1
2	11-20	10	0
3	21-30	31	1
4	31-40	13	1
5	41-50	6	4
6	51-60	8	6
7	61-70	0	3
8	71-80	0	1

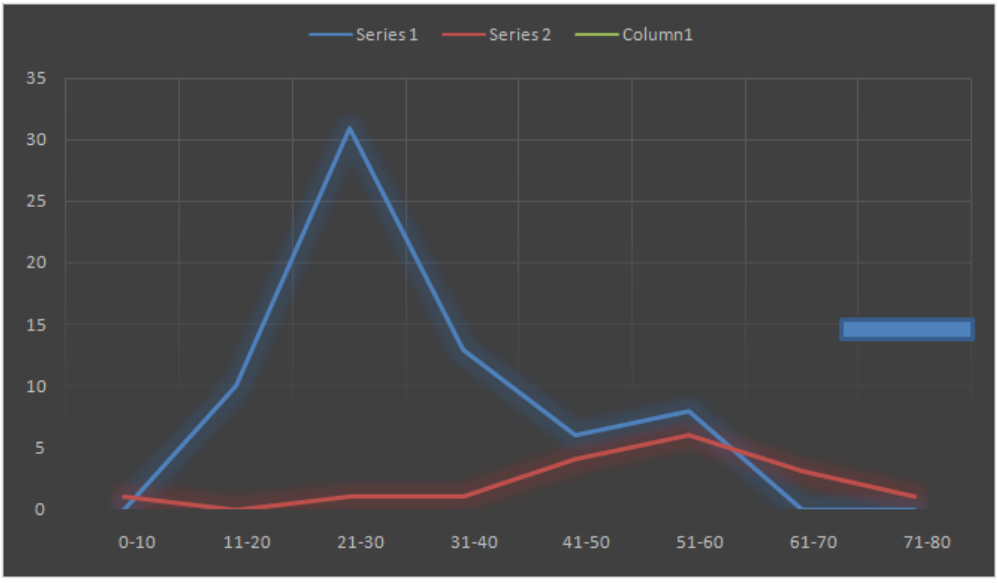
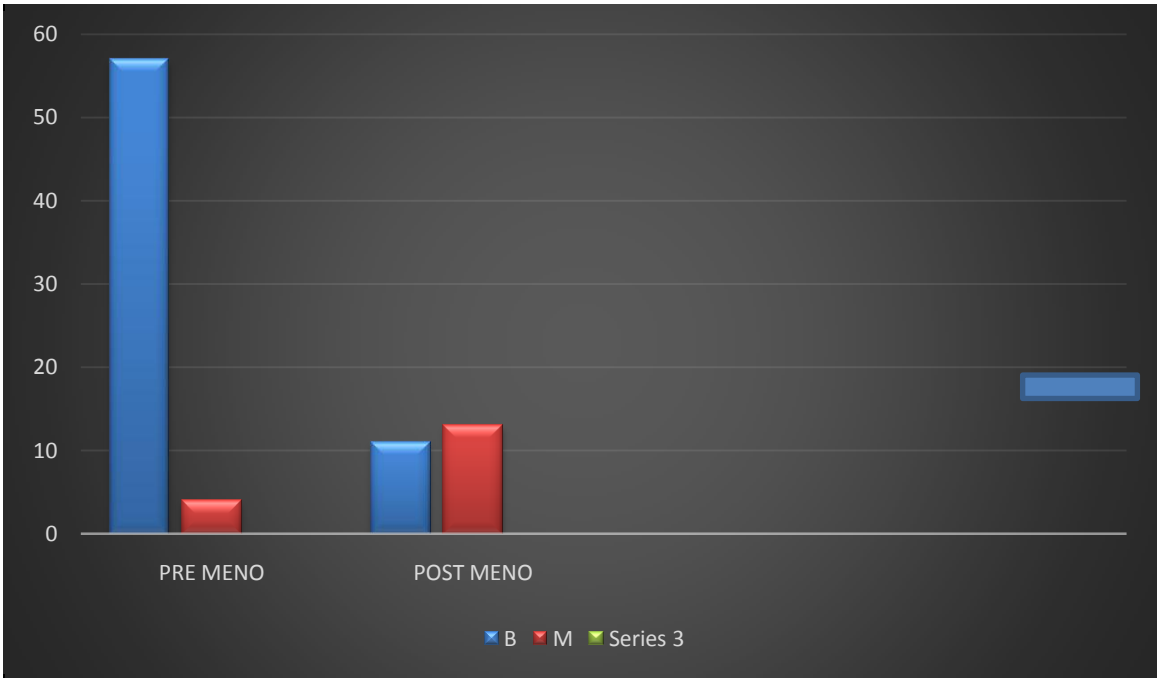


Table 3DISTRIBUTION OF MASSES ACCORDING TO MENOPAUSAL STATUS

SR NO.	MENOPAUSAL STAUS	BENIGN NO.	MALIGNANT NO.	TOTAL NO
1.	PRE-MENOPAUSAL	57	4	61
2.	POST-MENOPAUSAL	11	13	24
	TOTAL	68	17	85



➢ Out of 68 benign cases 57 are in premenopausal age group making 83.82% and 11 were in post menopausal age group making 16.18%.

➢ Out of 17 malignant cases 04 are noted in premenopausal age group making 23.53% and 13 are noted in post menopausal age group making 76.47%.

Table 4: SYMPTOMATIC DISTRIBUTION

	ABD PAIN	DISTENSION	ABD LUMP	INFERTILITY	ANOREXIA WEIGHT LOSS FEVER	MENSTRUAL IRREGULARITY	OTHER
BENIGN	40	12	8	9	4	18	6
MALIGNANT	12	10	8	-	7	-	4

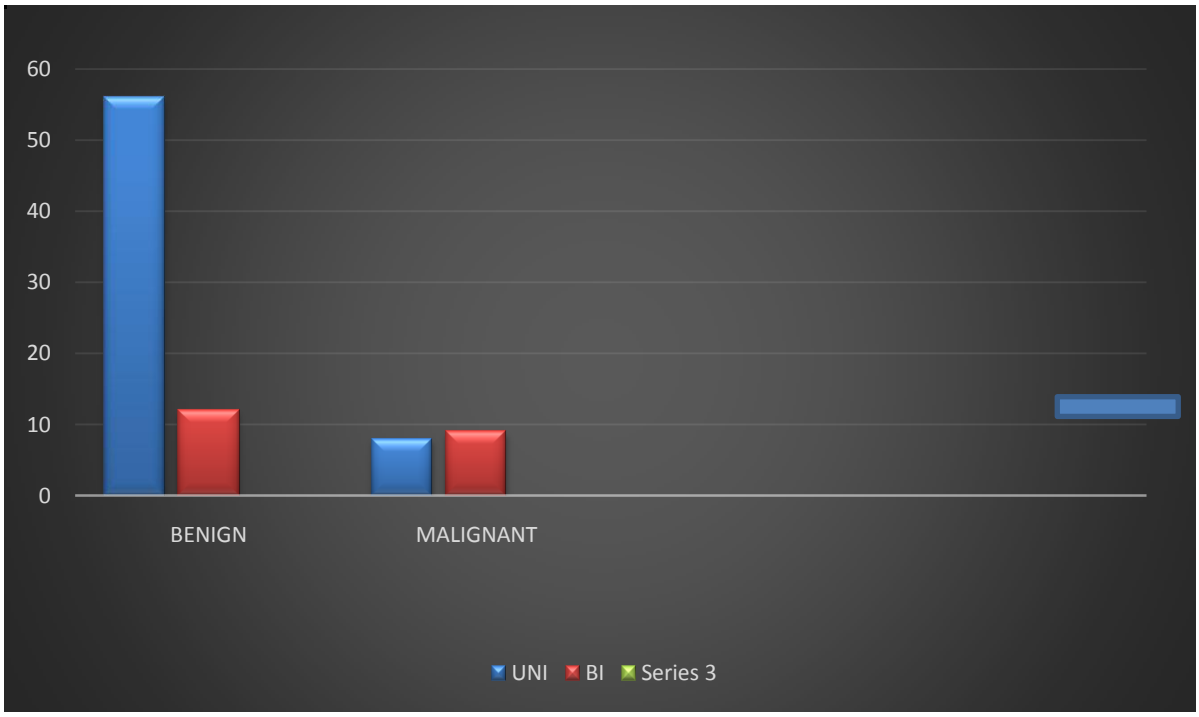
➢ Abdominal pain was the chief complaintof most of the patients with 52 among 85 patients so seen in 61.18%.

➢ Anorexia and weight loss is also a common complaint more commonly seen in malignant patients.

➢ Abdominal distension and abdominal lump are other complaints which are commonly seen in patients with ovarian neoplasms.

Table 5: DISTRIBUTION ACCORDING TO LATERALITY

SR NO.	OVARIAN MASSES	UNILATERAL	BILATERAL	TOTAL NO
1	BENIGN	56	12	68
2	MALIGNANT	8	9	17



- Total bilateral lesions constitute 24.71%
- Total unilateral lesions constitute 75.29%
- 9 cases out of 17 malignant lesions are bilateral in distribution depicting the fact that bilaterality is most frequently seen with malignant lesions.

Table 6: IOTA RULES

M RULES	B RULES
M1 irregular solid tumor	B1 unilocular cyst
M2 presence of ascites	B2 Presence of solid components where the largest solid component is <7mm in largest diameter
M3 at least 4 papillary structures	B3 presence of acoustic shadow
M4 irregular multilocular solid tumor with largest diameter >100mm	B4 Smooth multilocular tumour with largest diameter <100mm
M5 very strong blood flow (color score 4)	B5 no blood flow (color score 1)

Table 7: IOTA FINDINGS

Sr no	B1	B2	B3	B4	B5	M1	M2	M3	M4	M5	FREQ	BENIGN	MALIGNANT	T%
1	1	0	0	0	1	0	0	0	0	0	20	20	0	0
2	0	0	0	1	0	0	0	0	0	0	12	12	0	0
3	1	0	0	0	0	0	0	0	0	0	10	10	0	0
4	0	1	0	1	0	0	0	0	0	0	11	10	1	90
5	0	0	0	0	0	1	0	0	0	0	4	1	3	75
6	0	0	0	0	0	0	0	0	1	0	4	1	3	75
7	0	0	0	0	0	0	0	1	0	1	4	0	4	100
8	0	1	0	1	0	0	0	1	0	0	4	3	1	25
9	0	1	0	0	0	0	0	0	0	0	2	2	0	0
10	1	1	0	0	1	0	0	0	0	0	1	1	0	0
11	0	0	0	0	0	0	0	1	1	1	2	0	2	100
12	0	0	0	0	0	1	0	0	0	1	1	0	1	100
13	0	0	0	0	0	0	0	0	1	1	1	0	1	100
14	0	0	0	0	0	0	1	1	1	1	1	0	1	100
15	0	0	0	0	1	1	0	0	0	0	2	2	0	0
16	1	0	1	0	0	0	0	0	0	0	5	5	0	0

	PATHOLOGICAL FINDINGS	
IOTA SCORE	MALIGNANT	BENIGN
TEST POSITIVE	15	5
TEST NEGITIVE	2	63

Table 8: COMPARISON OF IOTA AND HPE

- SENSITIVITY OF IOTA SCORING IN DETERMING MALIGNANT LESIONS IS 88.35%
- SPECIFICITY OF IOTA SCORING IN DETERMING MALIGNANT LESION IS 92.64%
- POSITIVE PREDICTIVE VALUE OF IOTA SCORING IS 75%
- NEGATIVE PREDICTIVE VALUE OF IOTA SCORING IS 96.9%

Table 9: SITE OF VASCULARITY

	PRESENCE OF NV	CENTRAL	SEPTAL	PERIPHERAL	BOTH
BENIGN	10	0	1	9	0
MALIGNANT	15	1	1	1	12
TOTAL	25	2	2	9	12

The tumors evaluated with color Doppler study which shows the presence of neovascularization are 88.2% in malignant tumors and 14.7% in benign tumors. In cystic lesions site of vascularity is equal in wall and septa but in solid lesions central and peripheral vascularisation was found in 70.58% of malignant tumors.

Table 10: CYSTIC VS SOLID LESIONS

	BENIGN	MALIGNANT
SOLID LESIONS	3	4
CYSTIC LESIONS	61	2
MIXED	4	11

Benign lesions are mostly cystic in nature and malignant lesions are mostly mixed in nature. The probability of a mass being malignant is more if the mass is more solid.
In our study 61 out of 68 benign lesions are cystic in nature and 11 out of 17 malignant masses are mixed in nature.

Table 11: SPECTRAL DOPPLER VALUES

	RI <0.6	PI<0.8	RI<0.4	PI<1
BENIGN N=10	3	1	1	2
MALIGNANT N=15	15	12	4	15

- Out of 10 benign masses showing vascularity 3 of them have significant RI value <0.6 and 1 of them have RI value of <0.4 , one of them have PI value less than 0.8 and two of them have and PI values<1.0.
- Malignant neoplasms offer low resistance of blood flow due to presence of aberrant tumor vessels. This study used a pre-established cut off of RI and PI as <0.6 and <1 respectively in which 100% of malignant tumors showed RI<0.6 and whereas only 30% of benign tumors which show vascularity showed a RI<0.6 and 100% of malignant tumors show PI values <1.0 and 20% of benign masses show PI value <1.0 .
- In a study done by Kurjak et al Jean buy et al and alcazar scoring system 100 % of malignant tumors showed RI<0.6 and of benign tumors showed >0.6 RI values.

Table 12: SENSITIVITY AND SPECIFICITY OF RI AND PI VALUES

	SENSITIVITY	SPECIFICITY
RI<0.6	100	70%
RI<0.4	26.6	90%
PI<0.8	80	90%
PI<1.0	100	80%

- This study proved that sensitivity of spectral flow analysis is better if cut of values are RI <0.6 and PI <1.0 as compared to RI<0.4 and PI<0.8
- This study also showed the special role of Doppler in labelling the solid tumor of ovary as benign if it did not show any significant vascularity. The definitive diagnosis of malignancy is only done if color Doppler showed intratumoral vascularity (mainly central)
- And spectral Doppler showed low resistance velocity waveform in intra tumoral vessels.

Table 13: TWO BY TWO TABLE FOR COMPARISION OF POSITIVE USG FINDINGS AND DOPPLER INTO MALIGNANT AND BENIGN LESIONS

	PATHOLOGICALDIAGNOSIS	
GRAY SCALE USG	MALIGNANT	BENIGN
TEST POSITIVE	15	5
TEST NEGITIVE	2	63

Table 14: TWO BY TWO FOR COMPARISION OF POSTIVE GRAY SCALE USG FINDINGS AND DOPPLER FLOW (IOTA SCORE)

	PATHOLOGICAL DIAGNOSIS	
USG+DOPPLER	MALIGNANT	BENIGN
TEST POSITIVE	15	1
TEST NEGITIVE	2	67

TABLE 15:TWO BY TWO TABLE FOR THE COMPARISON OF GRAY SCALE ALONE AND IN COMBINATION WITH COLOR DOPPLER AND SPECTRAL FLOW ANALYSIS

	SENSITIVITY	SPECIFICITY	PPV	NPV
IOTA ALONE	88.24%	92.64%	75%	96.9%
IOTA WITH DOPPLER AND SPECTRAL FLOW ANALYSIS	88.24%	98.5%	93.75%	97.20%

The present study established the increase in the specificity ,PPV ,NPV in establishing the pre operative diagnosis of ovarian masses (especially in tumor of benign and malignant when structural and morphological assessment is done by IOTA and Doppler study with spectral flow analysis) when compared to gray scale ultrasonography alone and much higher values are attained when IOTA is combined with spectral flow analysis.

Table 16: :FINAL HISTOPATHOLOGICAL DIAGNOSIS OF BENIGN LESIONS

HISTOPATHOLOGICAL DIAGNOSIS	NO. OF LESIONS
FOLLICULAR CYST	20(29.41%)
CORPUS LEUTEAL CYST	6(8.83%)
HEMORRHAGIC CYST	15(22.05%)
SEROUS CYSTADENOMA	9(13.23%)
MUCINOUS CYSTADENOMA	6(8.83%)
MATURE TERATOMA	11(16.18%)
FIBROMA	1(1.47%)

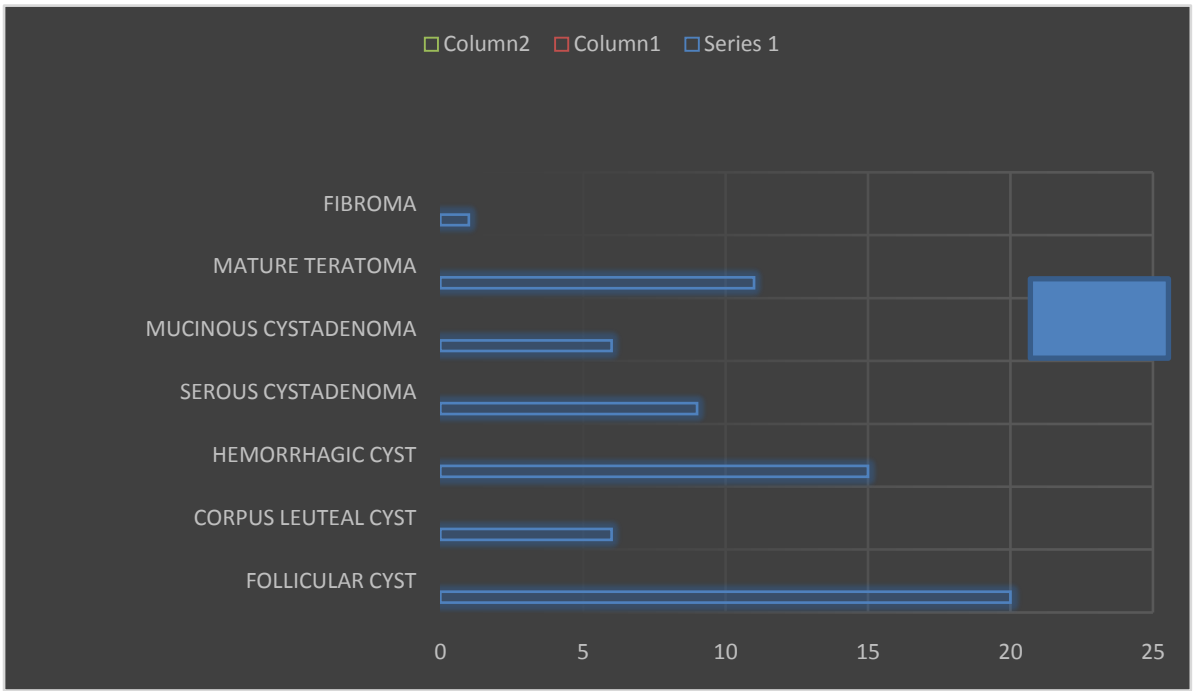
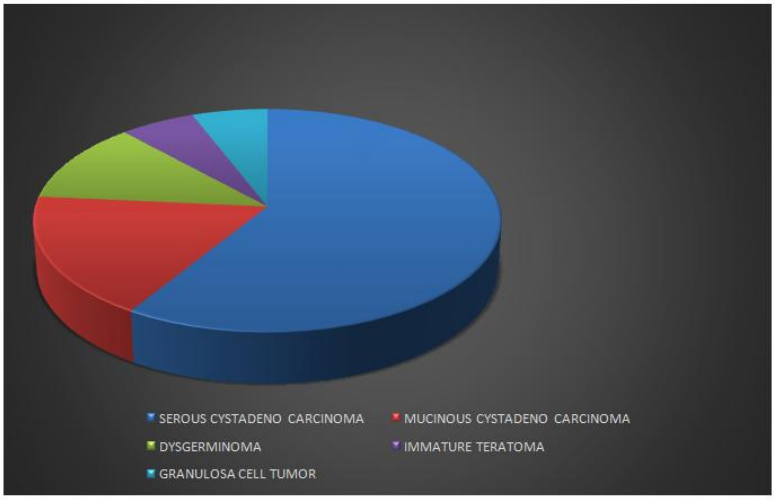


Table 17: HISTOPATHOLOGICAL DIAGNOSIS OF MALIGNANT

HISTOPATHOLOGICAL DIAGNOSIS	NO.OF LESIONS
SEROUS CYSTADENO CARCINOMA	10 (58.82%)
MUCINOUS CYSTADENO CARCINOMA	3 (17.64%)
DYSGERMINOMA	2 (11.77%)
IMMATURE TERATOMA	1 (5.88%)
GRANULOSA CELL TUMOR	1 (5.88%)



The most common carcinoma in this study is serous cystadeno carcinoma making (58.82%) 10 cases out of 17 cases.

VI. Discussion

COMPARISION FOR AGE DISTRIBUTION OF OVARIAN MASSES

- In the present study 85 cases ranging from 9 years to 75 years were studied with mean age 34.25 years.
- The finding was comparable with A.Margherita sassone et al (1991) in which 143 patients with ovarian masses were studied with age ranging from 20-85 years with mean age of 41 years.
- L.Scheidner et al (1993) assessed 55 patients ranging from 10-79 years with mean age 53 years.
- Dinesh sood et al (1994) studied 50 patients ranging from 13-72 years with mean age 37 years.
- Doughlas L Brown et al (1998) studied 211 ovarian masses in patients ranging from 16-78 years with mean age 39 years.

COMPARISION OF OVARIAN MASSES WITH MENOPAUSAL STATUS:

- In the present study out of 85 patients 61 patients are premenopausal and 24 patients are postmenopausal group. Out of 17 malignant cases 13 cases are in postmenopausal group.
- This study is comparable to Deborah Levine et al(1994) in which 36 patients were studied of these 26 were premenopausal and 10 were postmenopausal.
- Sugandha garg Amarjit kaur et al (2017) studied 55 patients in which 50 patients are suitable for study out of which 35 patients are premenopausal and 15 patients are in postmenopausal group.

Table 18:COMPARISION OF IOTA SCORING SYSTEM FOR SONOGRAPHIC EVALUATION OF OVARIAN MASS

IOTA SCORING	Our study	Sugandha garg et al
SENSITIVITY	88.24%	91.66%
SPECIFICITY	92.64%	84.84%
PPV	75%	68.75%
NPV	96.9%	88.88%

- In sugandha garg et al study out of 55 patients 29 were benign 16 were malignant and 5 were not determined correctly using IOTA score where sensitivity is 91.66% specificity is 84.84% and PPV is 68.75% and NPV is 88.88%
- In our study out of 17 malignant masses confirmed by histopathological diagnosis 14 were classified as malignant and rest 3 couldnot be determined and out of 68 benign cases 63 were determined as benign and 5 were not determined making sensitivity 82.35% specificity 92.64% PPV 73.68% and NPV 95.45%.

Table 19: COMPARISON OF PRESENCE OF NEOVASCULARITY

Lesion	K.B Taori et al study	Madan et al study	Our study
Benign	**42.24%**	**68.08%**	**14.7%**
Malignant	**92.59%**	**92.50%**	**88.2%**

- K.B Taori et al evaluated the study group comprised of 60 patients with neoplastic ovarian masses. Color Doppler showed the presence of tumor neovascularisation in 92.59% of malignant tumors in contrast to 42.24% in benign lesions. Vascularisation in benign lesions tend to be peripherally located and malignant lesions noted more in central portion
- In study of Madan et al study 92.50% malignant masses were vascularised as compared to 68.08% benign adnexal masses shown peripheral vasculature.
- In our study 88.2% malignant masses (15 out of 17 cases) shown vascularisation in central portion and 14.7% of benign masses showed vascularisation (10 out of 68 cases)
- Thus by comparison it can be stated that malignant lesions tends to be vascularised as compared to benign lesions and the benign lesions shows peripheral vascularisation whereas malignant lesions shows central neovascularisation.

Table 20: COMPARISION FOR THRESHOLD VALUES OF RI AND PI

	Brown et al study				Our study			
	RI <0.4	**RI <0.6**	**PI <0.8**	**PI <1.0**	**RI <0.4**	**RI <0.6**	**PI <0.8**	**PI <1.0**
SENSITIVITY	**30**	**100**	**67**	**100**	**26.6**	**100**	**80**	**100**
SPECIFICITY	**96**	**65**	**96**	**46**	**90**	**70**	**90**	**80**

- Brown et al used PI cutoff value of 1.0 with any value less than that considered indicative of malignancy and determined sensitivity and specificity is 100% and 46% respectively. With use of 0.4 the sensitivity and specificity were 30% and 96% respectively.

- For the proposed RI value of 0.6 sensitivity and specificity were 100% and 65 % respectively. The RI cut off value with the highest accuracy in their population were 0.4 and 0.45 each had a slightly different sensitivity and specificity.
- With the using of cutoff criteria PI<1.0 we got sensitivity 100% and specificity 80% and using PI <0.8 we got sensitivity 80% and specificity 90%.
- With the cut off of RI<0.6 we got sensitivity 100% and specificity 70%
- With the cutoff value of RI<0.4 we got sensitivity 26.6% and specificity 90%.
- Thus by comparision the cut off values of RI AND PI with good sensitivity in <0.6 and <1.0 respectively

Table 21: COMPARISON FOR RELATIVE VALUES OF GRAY SCALE USG ALONE AND IN COMBINATION WITH DOPPLER AND SPECTRAL DOPPLER ANALYSIS IN DIFFERENTIATION BETWEEN BENIGN AND MALIGNANT NEOPLASMS

	SENSITIVITY		SPECIFICITY	
	OUR STUDY	**Taori et al**	**OUR STUDY**	**Taori et al**
Gray scale USG With Doppler(IOTA)	**88.24%**	**51.85%**	**92.64%**	**81.48%**
Gray scale with combined color and SPECTRAL Doppler USG	**88.24%**	**81.48%**	**98.5%**	**93.93%**

- Fliescher et al in their study demonstrated that the combined gray scale and color Doppler sonography has sensitivity of 85% and specificity of 93% in the detection of malignant tumors. Doppler sonography was highly accurate in excluding malignancy in their study no malignant lesion failed to demonstrate low impedence flow.
- Thus by comparison it can be stated that color doppler and spectral Doppler tremendously increased the reliability in diagnosis of malignant lesions of ovary. Gray scale ultrasound in combination with color Doppler sonography and spectral Doppler analysis is the first and foremost diagnostic modality in patients with ovarian tumor, so to establish the definitive diagnosis of malignancy in early course of disease.

VII. Summary And Conclusion

- Our study consisted of 85 patients youngest being 9 year old and theoldest being 75 years old. The peak incidence of age was
- 21-30 years of age group with 32 patients falling in that age group the average age being 34.25 years.
- Benign lesions of ovary noted more commonly in age group below 40 years making 54 cases out of total 68 cases making79.41% . Malignant lesions were most commonly noted in age group more than 40 years. The cases are clustered in 51-60 years with 6 cases out of 17 making 35.29%.
- Abdominal pain is the most common complaint the patient presented with in this series with 52 among 85 patients making it 61.18%. Abdominal distension and abdominal lump are also other common complaints. Anorexia and weight loss are more noted in malignant lesions.
- In this study 61 pre-menopausal patients and 24 are post -menopausal patients. In premenopausal age group 57 patients are diagnosed with benign ovarian lesions out of 68 benign ovarian cases making 83.82% while in post- menopausal patients 13 out of 17 malignant ovarian masses noted making 74.47%.
- In this study 68 out of 85 masses were considered to be benign making 80%. The most common benign mass is follicular cyst 20 cases in 68 cases making 29.41%. The second most common lesion is benign hemorrhagic cyst 15 cases out of 68 making it 22.05%. Other benign lesions include 6 corpus leuteal cysts, 9 serous cystadenoma ,6 mucinous cystadenoma, 11 mature teratoma, 1 fibroma.
- In this study most common malignant lesion is serous cystadeno carcinoma 10 lesions out of 17 making 58.82% and other malignant lesions include 3 mucinous cystadeno carcinoma, 2 dysgerminoma, 1 immature teratoma, 1 granulosa cell tumor.
- In our study using IOTA scoring in sonographic evaluation out of 17 malignant masses confirmed by histopathological diagnosis 15 were classified as malignant and rest 2 couldnot be determined and out of 68 benign cases 63 were determined as benign and 5 were not determined making sensitivity 88.24% specificity 92.64% PPV 75% and NPV 96.90%.
- In our study 88.24% malignant masses (15 out of 17 cases) shown vascularisation in central portion and 14.7% of benign masses showed vascularisation (10 out of 68 cases). The site of tumor vascularity did not affect the diagnosis in cystic lesions as the vasculature is equally distributed in periphery and septa. But in solid lesions the central and peripheral vascularity is seen in 82.35% of cases.
- In our study on Doppler spectral analysis with using of cutoff criteria PI<1.0 we got sensitivity 100% and specificity 90% and using PI <0.8 we got sensitivity 80% and specificity 90%.

- With the cut off of RI<0.6 we got sensitivity 100% and specificity 80%.
- With the cutoff value of RI<0.4 we got sensitivity 26.6% and specificity 90%

VIII. Conclusion

The present study of 85 ovarian masses conducted in government medical college,Surat in the year of (2018-2019) summarizes the following, Ultrasonography is the first modality to be chosen in suspected cases of ovarian masses. Gray scale ultrasound is helps in morphological assessment of the masses and adding doppler to the investigation helps in distinguishing the nature of the ovarian mass. The present study established the increase in the specificity ,PPV ,NPV in establishing the pre operative diagnosis of ovarian masses (especially in tumor of benign and malignant when structural and morphological assessment is done by IOTA and Doppler study with spectral flow analysis) when compared to gray scale ultrasonography alone and much higher values are attained when IOTA is combined with spectral flow analysis.

Hence combination of gray scale ultrasound and doppler is more sensitive and specific as compared to gray scale ultrasound alone.

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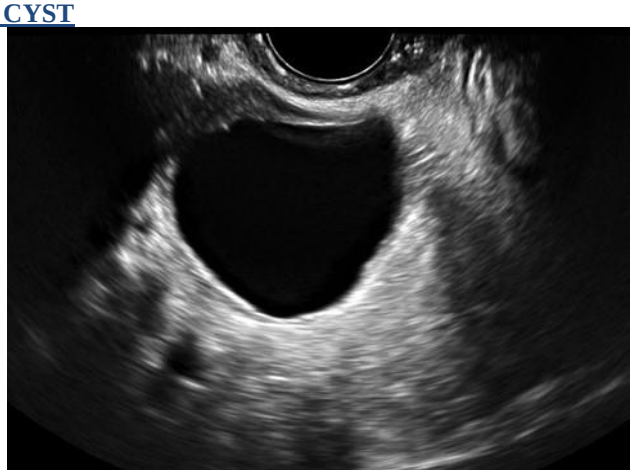
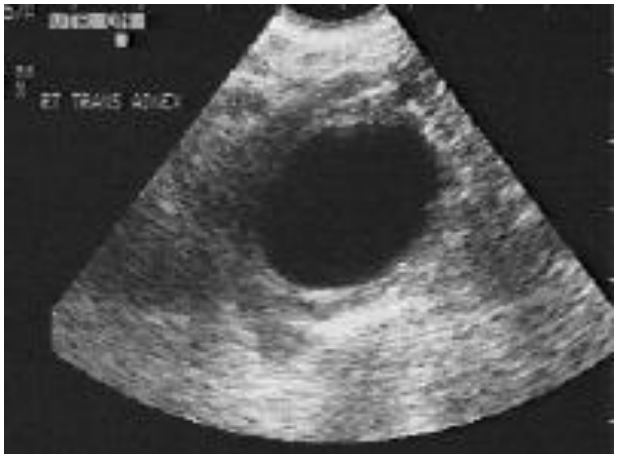
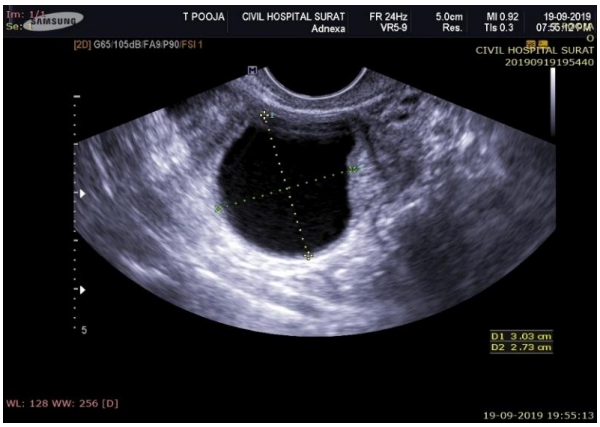
CASES IAMGES

CASES

SIMPLE FOLLICULAR CYST

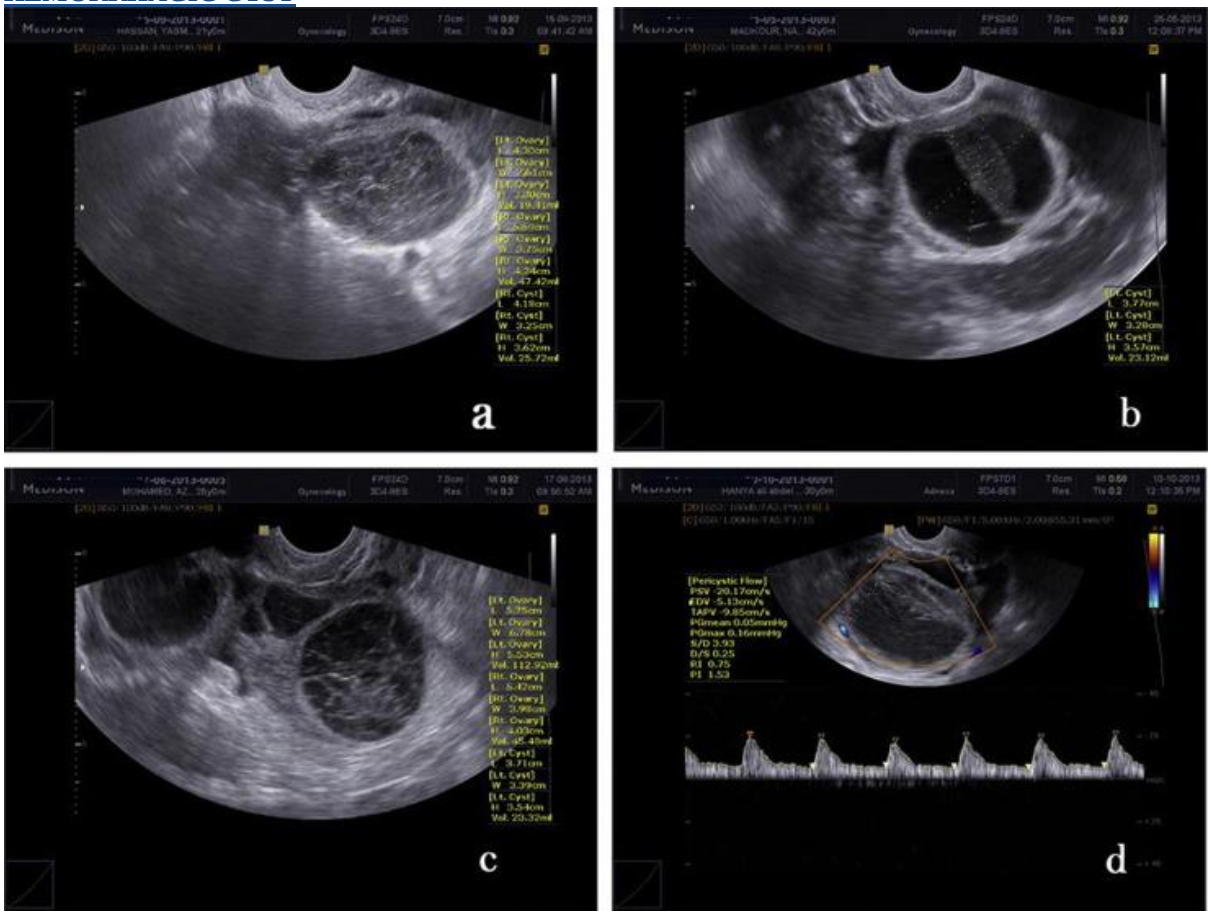


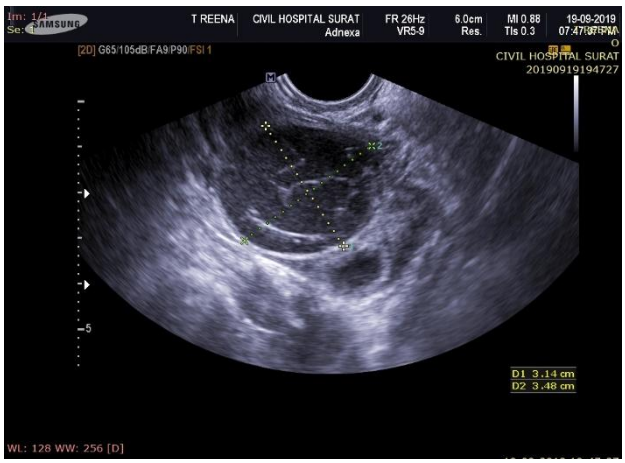




Anechoic cystic lesion with no evidence of echoes and septations and no evidence of internal vascularity

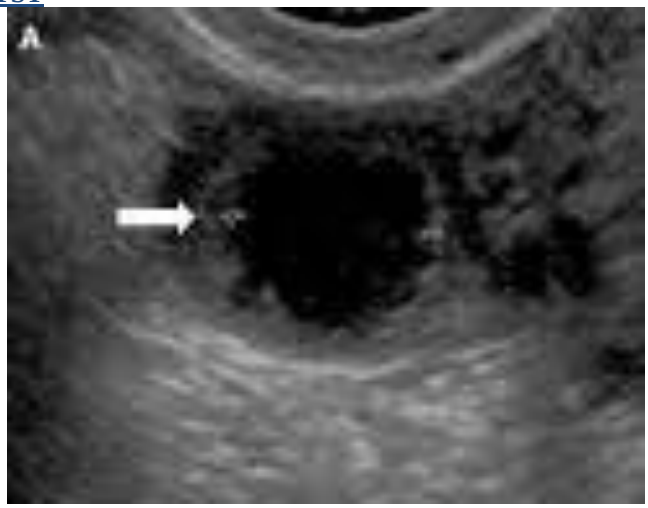
HEMORRHAGIC CYST

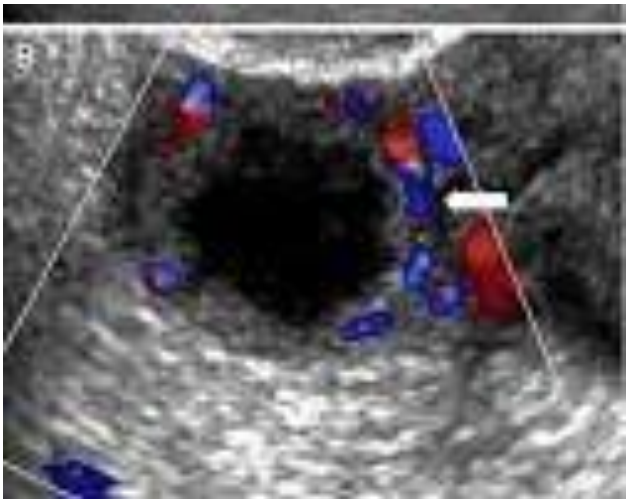




Usually hemorrhagic cyst appears as anechoic cystic lesion with evidence of echoes and septations but they vary in appearances.

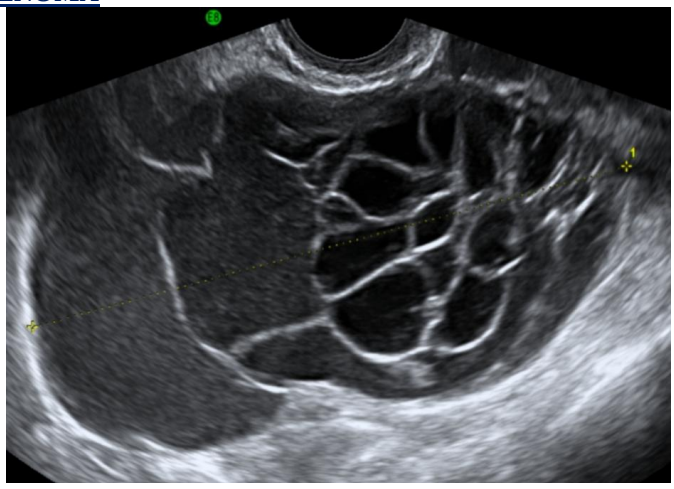
CORPUS LEUTEAL CYST



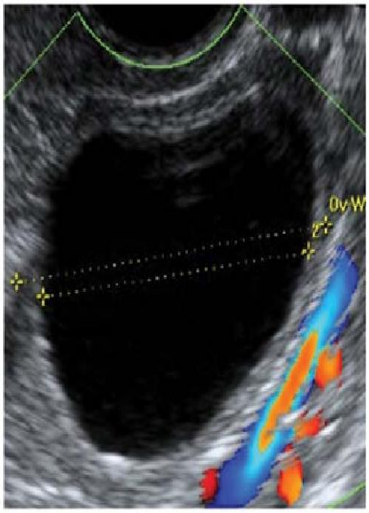


Ring of fire appearance on Doppler ultrasound

MUCINOUS CYSTADENOMA



Cystic lesions with internal echoes and thick septations with no evidence of internal vascularity



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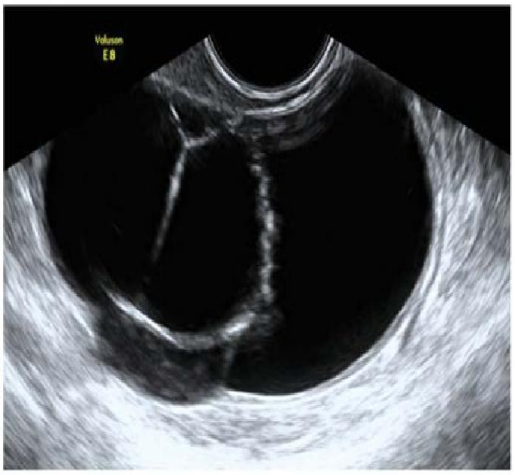
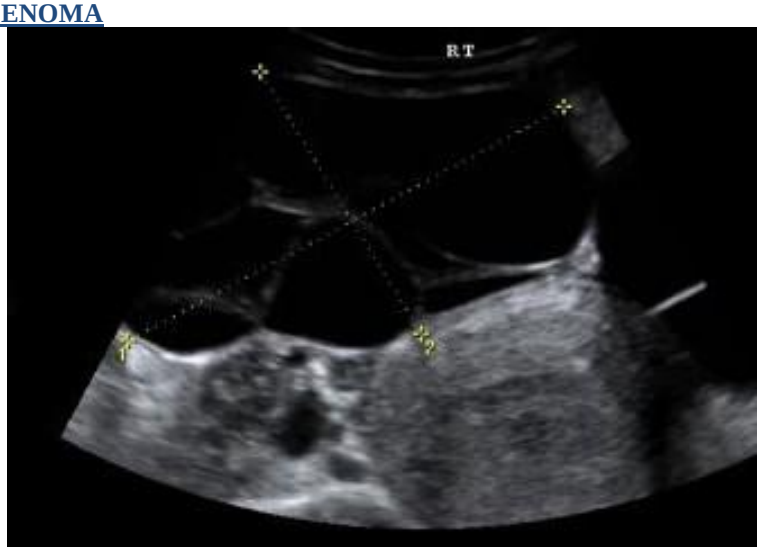
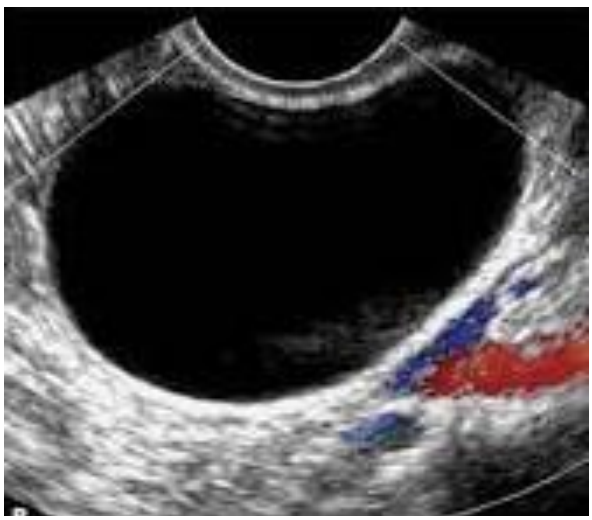


Cystic lesions with evidence of septations and showing peripheral vascularity in right image and no vascularity showing its benign nature in left imagewith high RI and PI value

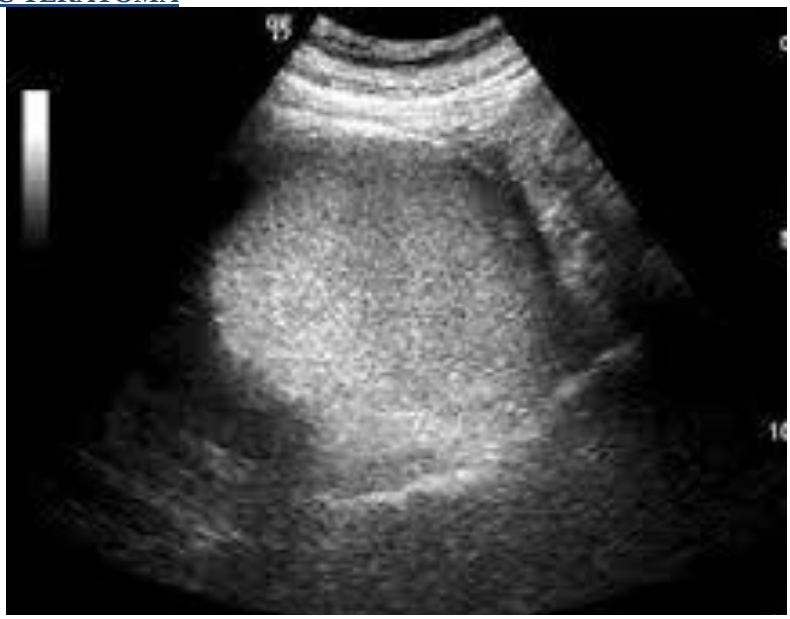
SEROUS CYSTADENOMA



Multiloculated anechoic cystic lesion with evidence of thin septations in it and showing peripheral vascularity on color doppler showing its benign nature.

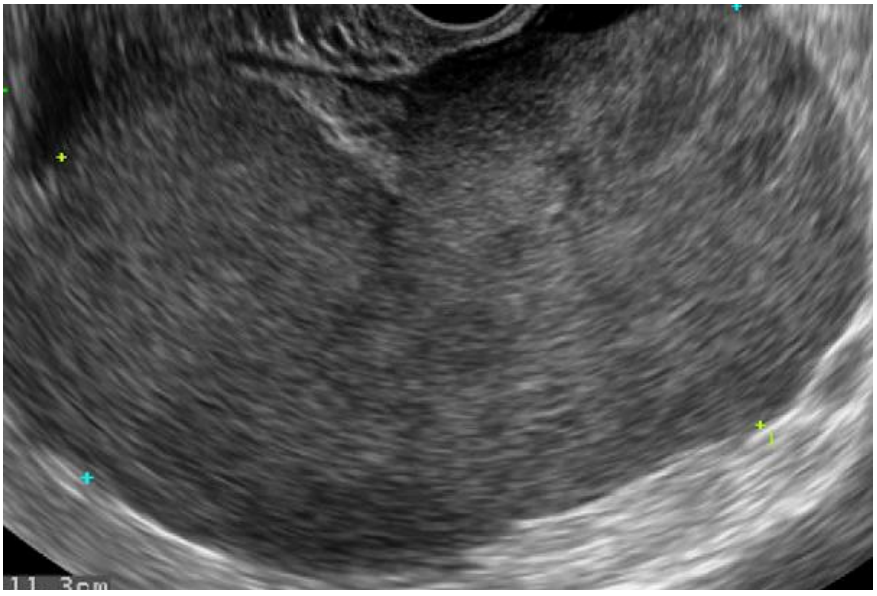


MATURE CYSTIC TERATOMA



Echogenic dermoid plug almost completely filling anechoic cyst noted involving right ovary

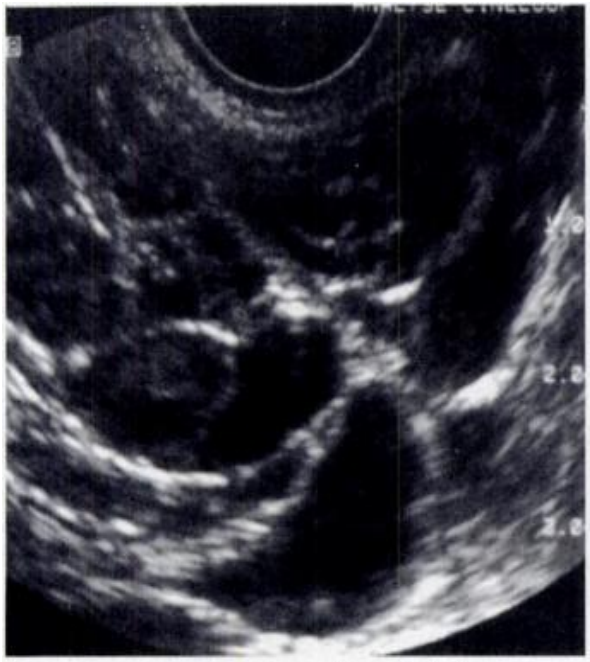
OVARIAN FIBROMA

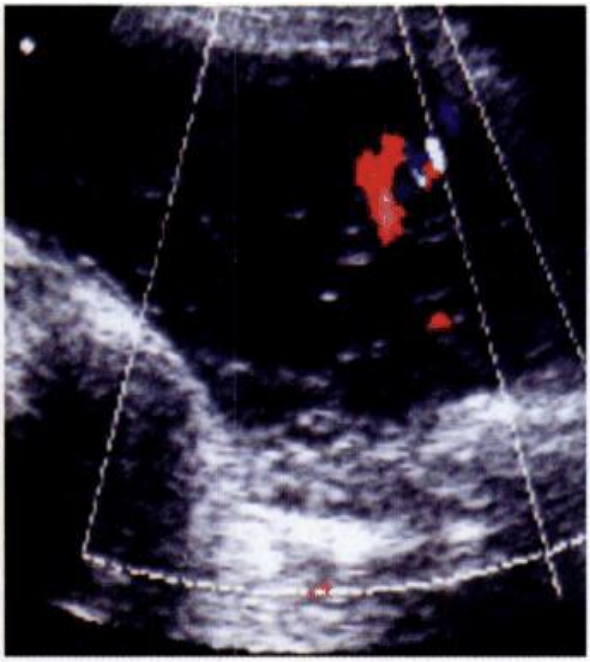


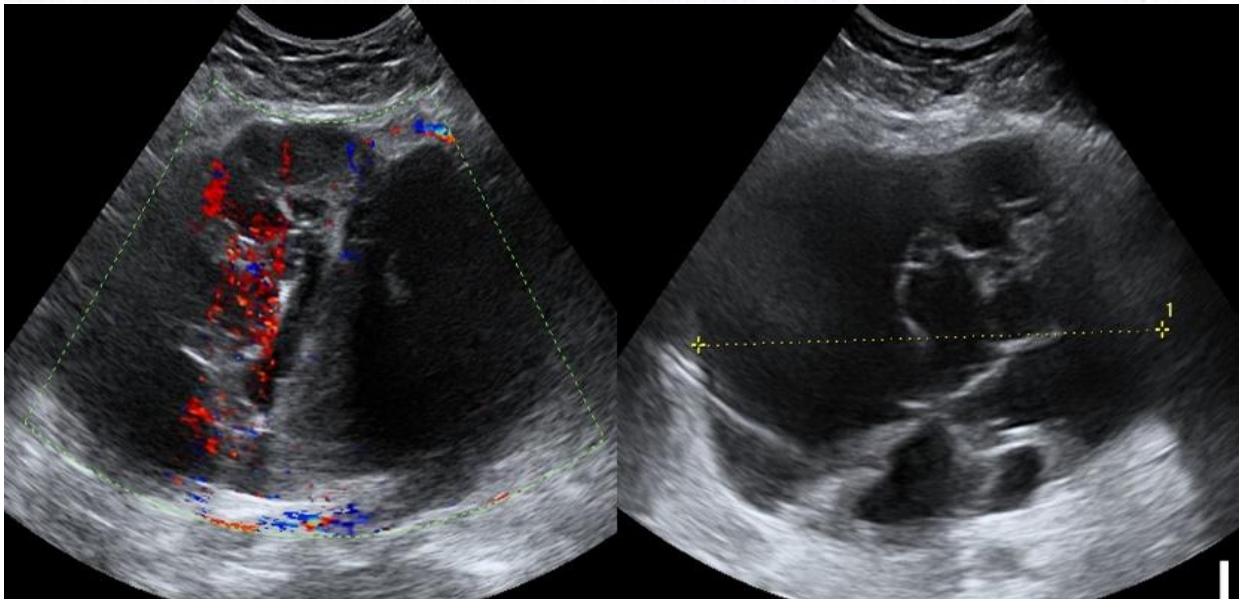
Heterogenous lesion (Solid mass with cystic degenerative areas within it) with ascites and color Doppler show no vascularity hence depicting its benign nature.

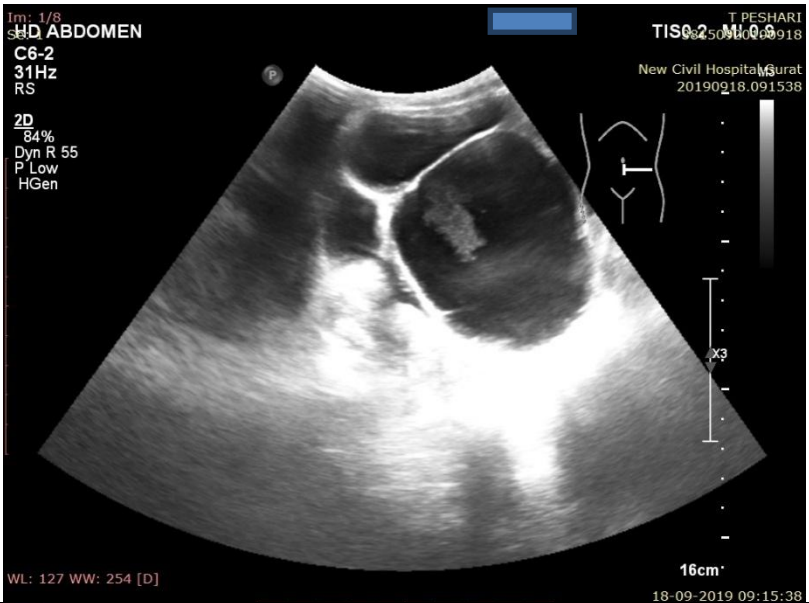
MUCINOUS CYSTADENOCARCINOMA

Cystic lesions with multiple internal septations which show vascularityand color doppler shows significant RI PI values





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C6-2
31Hz
RS
2D
84%
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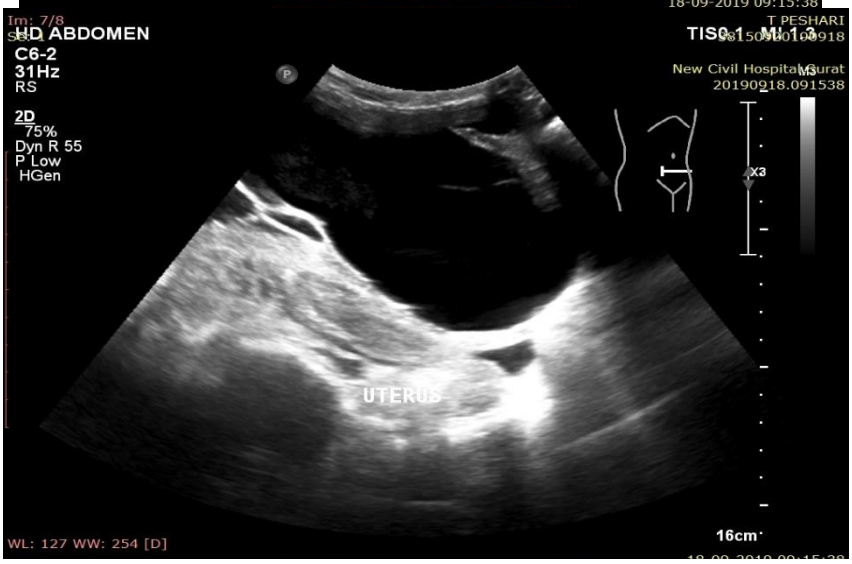
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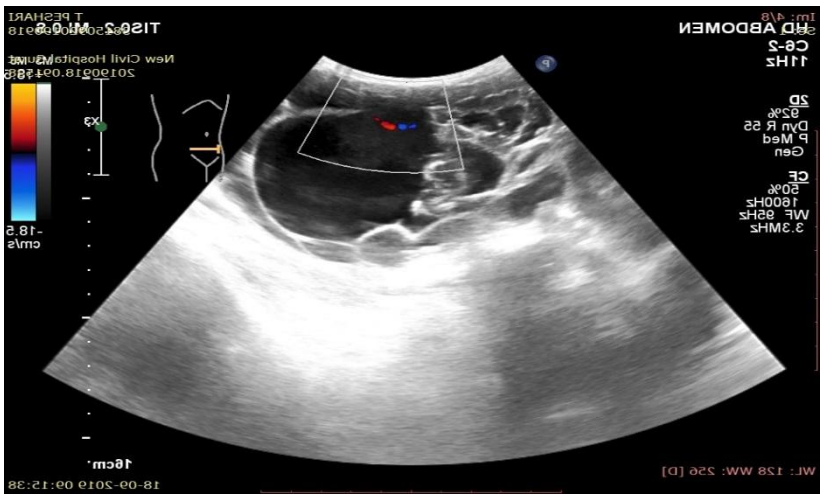
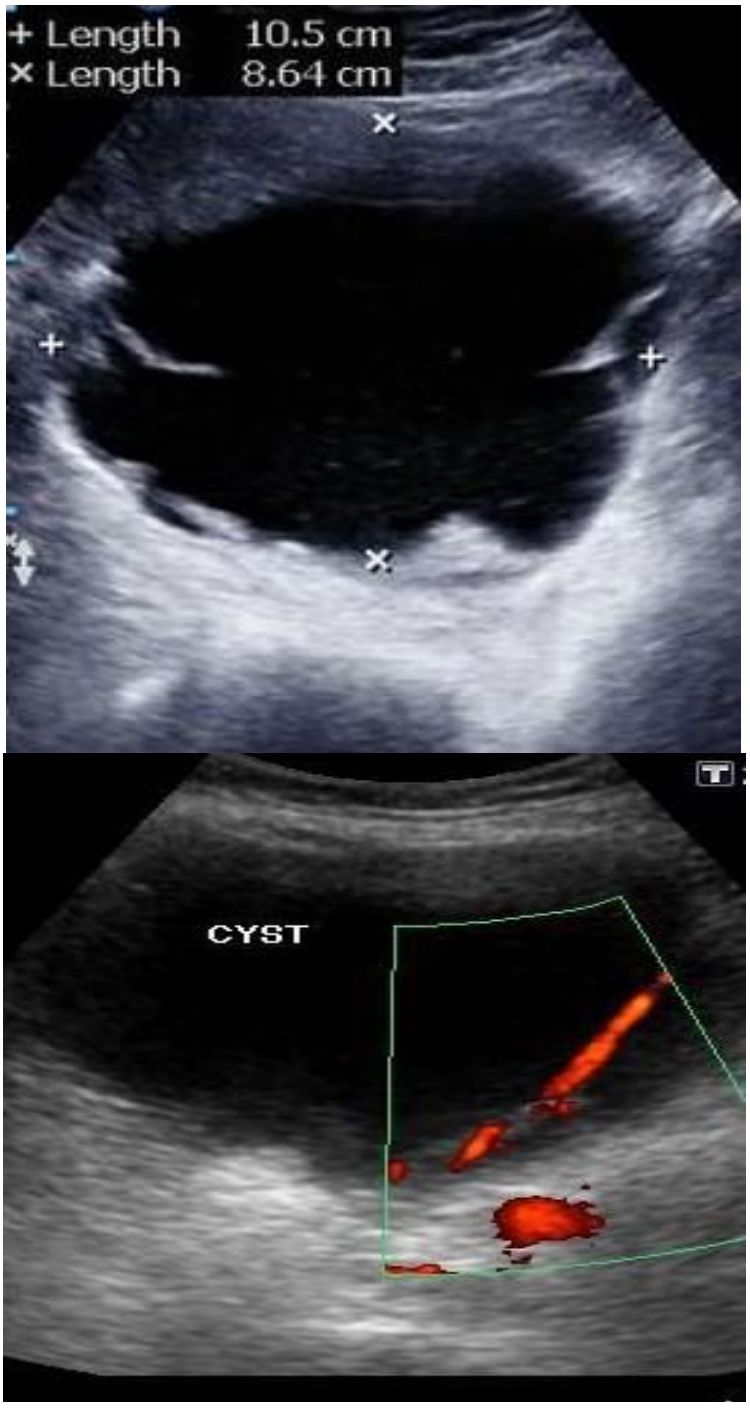


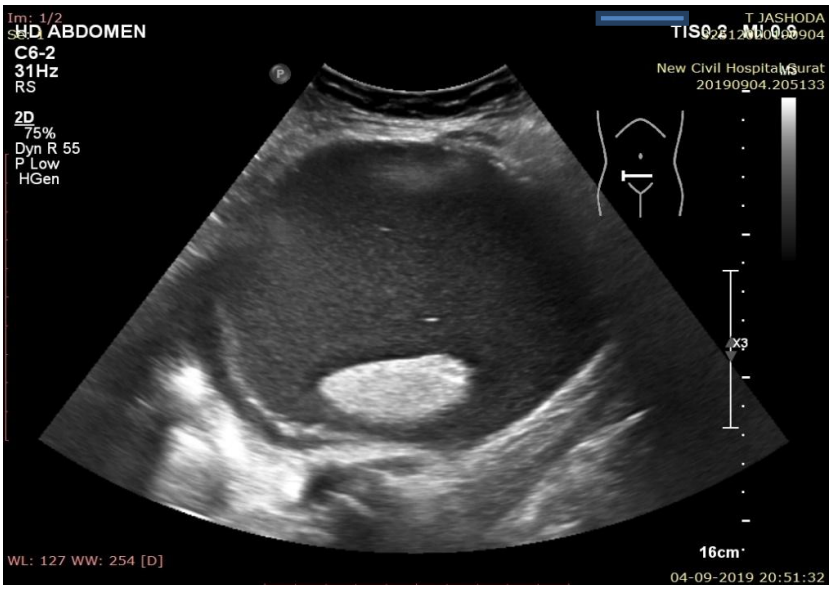
SEROUS CYSTADENOCARCINOMA

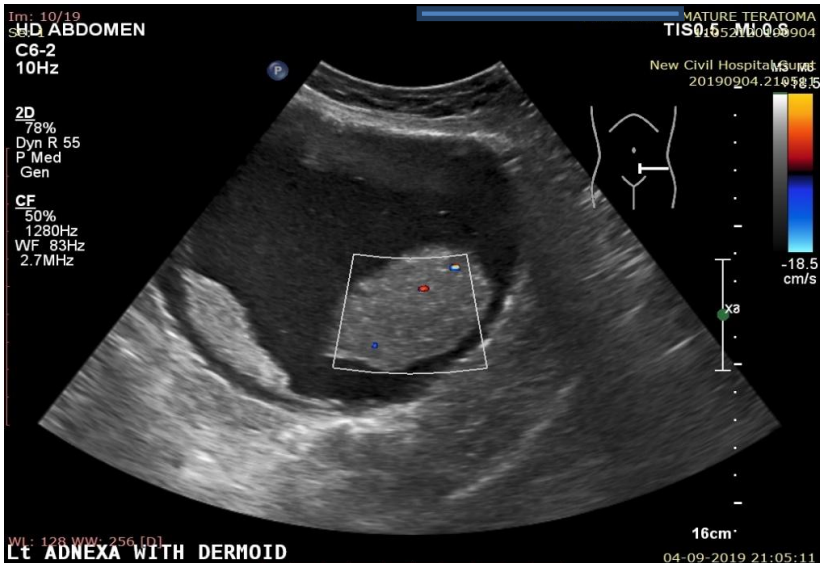
Cystic lesions with internal echoes and papillary projections and projections showing vascularity



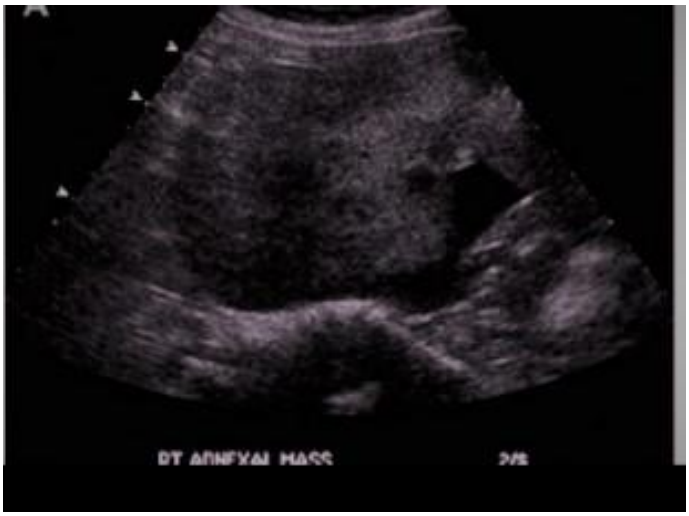
IMMATURE TERATOMA

Mixed echogenic lesion (irregularly solid and cystic) with internal echoes with no evidence of vascularity in solid part in color Doppler diagnosed as immature teratoma on histopathology

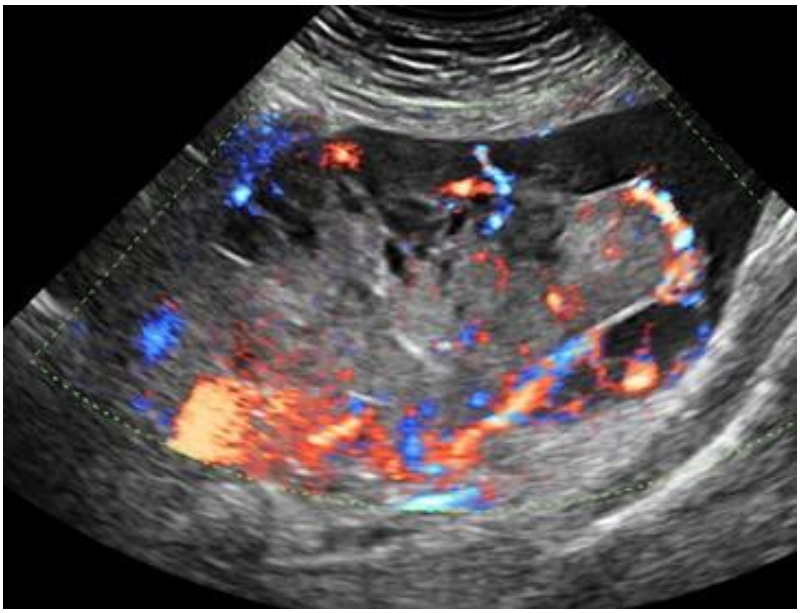




DYSGERMINOMA

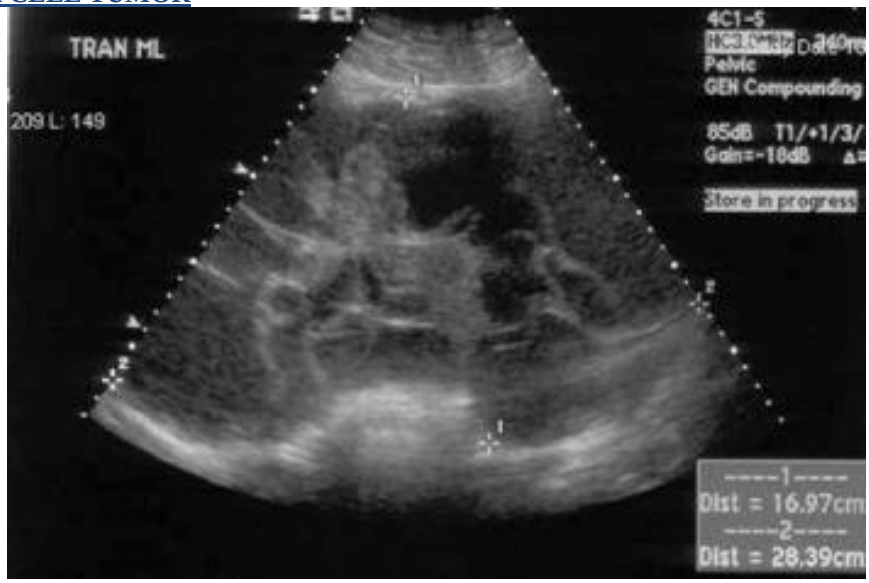


Septated ovarian mass with varying echotexture. Color Doppler interrogation show prominent flow signal within the fibrovascular septa.



Vascularity shown along fibro vascular septa

GRANULOSA CELL TUMOR



Heterogenous mixed(multi locular cystic with solid component) echogenic lesion which showsvascularity on color Doppler and significant RI and PI values.