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MDCT Evaluation of Ovarian Masses to Predict Specific Features for Diagnosing Malignant Lesions

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Abstract

Ovarian cancer is a diverse group of tumours arising from various cell types in the ovary, which is closely linked to the fallopian tube. It is often called the "silent killer" due to its asymptomatic growth, delayed diagnosis, and inadequate screening. Multidetector computed tomography (MDCT) is the preferred imaging technique for staging, assessing tumour respectability, and planning treatment. An observational study was conducted at K.S. Hegde Charitable Hospital, Karnataka between October 1, 2022, and April 30, 2024. A total of 94 patients with ovarian masses were enrolled in the study after meeting the predefined inclusion and exclusion criteria. This study aims to predict specific features for diagnosing malignant ovarian lesions. Patients underwent CECT abdomen and pelvis scans, followed by CA 125 histopathology evaluations. Results showed that 54.3% were diagnosed with malignant lesions on MDCT, while histopathology confirmed malignancy in 51.1%. MDCT demonstrated high sensitivity (95.8%), specificity (89.1%), PPV (90.2%), NPV (95.3%), and accuracy (92.6%) in predicting malignancy. Key predictors included bilateral ovarian lesions, mixed (solid cystic) lesions, soft tissue or mixed density lesions, heterogeneous enhancement, cyst wall thickness ->3 mm, presence of solid components/ mural nodule, necrosis in solid lesion, pelvic sidewall invasion, pelvic organ involvement, lymph node involvement and ascites. High CA-125 levels were significantly associated with malignant lesions, emphasizing its diagnostic value alongside MDCT features. This study demonstrated high sensitivity, specificity, and accuracy of MDCT in diagnosing malignancy of ovarian tumours. It effectively detected pelvic side wall invasion and ascites, as significant predictors of malignancy making it a valuable tool for detection of ovarian malignancy.

Keywords: Ovarian cancer; Multidetector Computed Tomography (MDCT); CA 125; histopathology

Abbreviations: ACR: American college of Radiology; AFP: Alpha-fetoprotein; CA-125: Cancer Antigen-125; CA 15-3: Cancer Antigen 15-3; CA-19-9: Carbohydrate Antigen 19-9; CT: Computed Tomography; DALYs: Disability-adjusted Life Years; EOC: Epithelial Ovarian Cancer; ESGE: European Society for Gynecological Endoscopy; ESGO: European Society of Gynecological Oncology; FDG: Fluorodeoxyglucose; FDG-PET-CT: Fluorodeoxyglucose Positron Emission Tomography-Computed Tomography; FDA: Food and Drug Administration; GCTs: Granulosa Cell Tumours; HDI: Human Development Index; HE4: Human Epididymis Protein 4; hCG: Human Chorionic Gonadotropin; IOTA: International Ovarian Tumour Analysis; ISUOG: International Society of Ultrasound in Obstetrics and Gynecology; MDCT: Multidetector Computed Tomography; MUC16: Mucin 16; O-RADS: Ovarian-Adnexal Reporting and Data System; OC 125: Ovarian Cancer 125; PET: Positron Emission Tomography; WFDC2: WAP Four-Disulfide Core Domain Protein 2;

Introduction

Preamble

The ovarian tissue hosts a diverse array of neoplasms since it is closely connected to the distal fallopian tube and has a wide range of cell types [1]. The seventh most common disease in women is ovarian cancer. Due to the elevated risk factors, the incidence of this malignancy is rising globally [2]. Among women with diagnosed gynecological cancers, ovarian cancer is the most

common cause of death. In general, ovarian cancer ranks as the fifth most common cause of mortality for women [3]. This illness has poor prognosis since the majority of patients are detected at an advanced stage. Rapid and precise imaging detection of ovarian tumors seems to have a major therapeutic influence on how these patients are managed, allowing for the reduction of needless procedures for benign lesions and the triage of malignant ovarian tumours [4]. Details about the tumor nature may be ascertained via a comprehensive history, clinical evaluation, and mass characteristics. A few intrusive and biochemical tests may potentially provide further information [5]. The current screening tests have limited predictive capability. Comprehensive gynecological assessment, transvaginal ultrasonography, and laboratory markers such as the cancer antigen-125 (CA-125) test are the main tools for early identification, albeit none of these have shown a discernible reduction in the disease's morbidity or death [6]. The imaging is often performed in conjunction with the measurement of CA-125 levels. Only half of early-stage epithelial ovarian tumors had increased CA-125 levels, compared to the majority of epithelial ovarian malignancies overall [7]. Postmenopausal women had better specificity and positive predictive value than premenopausal women. Other physiological or benign pathological disorders such endometriosis, pregnancy, ovarian cysts, and inflammatory peritoneal illnesses are also associated with elevated CA-125 levels. Therefore, research is now being done on other biomarkers to increase the specificity of ovarian cancer biomarkers [8].

The majority of females diagnosed with ovarian cancer have non-specific symptoms, such as weight fluctuations, frequent urination, and stomach pain or discomfort. As a result, ovarian cancer is often identified by CT scans performed to assess the abdomen after concerning ultrasound results or to determine the reason of non-specific symptoms [9]. In addition to these, CT has become a most sought modality for radiological investigations due to accessibility, affordability, fast and short scan time and patients choice, owing to the relatively more comfort. The most recent advancement in helical CT technology is multidetector computed tomography (MDCT), which was first commercially available in 1998. Significant anatomic volumes might be covered with isotropic sub millimeter spatial resolution thanks to a 16-row CT scanner. Large volumetric data sets may be created using MDCT scanners, enabling the production of very high-quality two- and three-dimensional reconstructed pictures. Currently, multidetector CT is thought to be the best imaging technique for ovarian cancer patients in terms of staging, assessing the *resectability* of the tumor accessibility and acceptability of patients and optimizing therapy planning. Additionally, multidetector CT scanners increased the sensitivity of CT in identifying metastases to the peritoneum [10]. Given the paucity of literature on the subject in Indian settings, the aim of this study is to diagnose ovarian malignancies on MDCT and predict specific features for diagnosing malignant lesions to aid in early treatment planning prior to the availability of a histopathological diagnosis.

Aim

To predict specific features of malignant ovarian lesions on MDCT.

Literature Survey

Epidemiology

The sixth most frequent malignancy in women is ovarian cancer. Globally, there is an increasing trend in the incidence of cancer due to increased risk factors. In 2018, ovarian cancer accounted for 4.4% of all cancer-related deaths in women. The death rate trend seems to be reversing, despite the fact that high Human Development Index (HDI) nations have greater cancer incidence. While malignant ovarian neoplasms present a significant public health risk, most ovarian tumors are benign or borderline. The fifth most prevalent cause of cancer-related mortality among females is ovarian carcinoma, which is also the second most common gynecologic cancer [11]. There were 294,422 new cases of ovarian cancer recorded in 2019. The regions with the highest reported age-standardized incidence rate (ASIR) were continental Europe, high-income nations around the world, and America. Central Europe has the highest age-standardized incidence of GBD areas. There were 198,412 recorded deaths from ovarian cancer in 2019. Nations with high SDI and World Bank high-income status have the highest ASR death rates. The adjusted years of life with disabilities (DALYs) resulting from ovarian cancer were 5,359,737 in 2019. Of these, 154,077 were connected to years of life with disabilities (YLDs) and 5,205,660 were linked to lost years of life (YLLs) [12].

Risk Factors

Ovarian cancer is linked to a number of risk factors. It mostly affects women who have gone through menopause, and becoming older is linked to a higher incidence, an advanced stage of the illness, and a lower reported survival rate. Some case-control studies suggest that parity may have a protective effect, as a higher age of first delivery is associated with a lower risk of ovarian cancer. A positive family history of breast or ovarian cancer is the highest risk factor for ovarian cancer; a personal history of breast cancer also increases risk [13]. Several research have shown that smoking raises the chance of several health problems, notably mucinous epithelial tumours.

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Pathology

There is currently no acknowledged pathophysiology for ovarian cancer. The diverse nature of ovarian cancer, which includes several histologic kinds with distinct behaviors and features, is one of the main obstacles to understanding the pathophysiology of the disease [14]. The majority of ovarian cancers (approximately 90%) are epithelial tumors, with high-grade serous adenocarcinoma being the most prevalent type, making it the leading cause of ovarian malignancies [15]. Several hypotheses have been put forward to explain the origin and progression of ovarian cancer, as follows:

Incessant Ovulation Theory: At first, it was believed that the ovarian cell surface epithelium was the source of all ovarian malignancies. These surface epithelial cells are physically damaged during ovulation, yet they recover right away. Ovulation happens regularly in a woman's life cycle, which repeatedly damages the epithelium and eventually damages the DNA of the cells. Damaged DNA makes epithelial cells very malleable, which promotes invagination into the cortical stroma. Eventually, this invagination becomes caught, creating cortical inclusion cysts, which are spheres of epithelial cells in the stroma. Ovarian hormones that are present within the ovary cause the epithelial cells to proliferate, which eventually results in the development of cancerous cells [16,17].

Theory of Fallopian Tubes: Most scientists used to think that the ovary was the source of ovarian cancer. As such, very few made an effort to search elsewhere for precursor lesions of ovarian cancer. Epithelial dysplasia was reported to be present at a high prevalence in the Fallopian tubes (50%) of women having preventive salpingo-oophorectomy who had BRCA1/2 gene mutations. This epithelial dysplasia was named tubal intraepithelial carcinoma (TIC) because it resembled high-grade serous ovarian cancer. Regardless of BRCA status, other investigations have discovered comparable histological features between high-grade serous peritoneal cancer and ovarian cancer. Research looking at the contralateral ovary of ovarian cancer patients either found normal histology or morphologic alterations that did not mirror features of a high-grade serous tumor [18,19]. These investigations lead to the conclusion that the fallopian tube is most likely the site of the precursor lesions for ovarian cancer, which later spread to the nearby ovary.

The Two-Pathways Theory: Kurman and Shih first put up this notion in 2004, attempting to include the histology, clinical, and genetic data related to ovarian cancer. They distinguished between two forms of ovarian cancer: type I and type II. Low-grade serous, mucinous, endometrioid, clear cell, and transitional histology types make up type I ovarian cancer. On the other hand, high-grade serous, undifferentiated, and carcinosarcoma histology types make up type II ovarian cancer.

Types

The four histological subtypes of endometrioid, clear cell, mucinous tumor, and serous epithelial ovarian cancer that are most prevalent. Due to their distinct biology and reactions to therapy, they have additional subgroups. There are two forms of ovarian cancer: Type I and Type II tumors. Type II tumors are more deadly and are believed to be generated by prolonged ovarian cycles that result in inflammation and endometriosis. Low-grade serous, endometrioid, clear-cell, and mucinous carcinomas are all classified as type I tumors; Sero mucinous and Brenner tumors are uncommon subtypes. Atypical proliferative (borderline) tumors are the primary source of type I cancers. High-grade serous carcinoma, carcinosarcoma, and undifferentiated carcinoma are examples of type II tumors that are mostly derived from intraepithelial serous tubal carcinoma. With the exception of clear cell tumors, which are regarded as high grade, type I tumors are often low grade and manifest at an early stage. Typically, they have little proliferative activity. They have an excellent prognosis and are identified early. On the other hand, Type II tumors are often of an advanced stage and are considered high-grade tumors. Compared to type I, they exhibit a higher degree of chromosomal instability, strong proliferative activity, quick and aggressive development, and p53 alterations in the majority of cases [20].

Clinical Features

Ovarian cancer symptoms are non-specific, which makes it easy to ignore them in the early stages of the illness as they may be mistaken for symptoms of other potential conditions. Frequently, the late stage (stage III or stage IV) is when the symptoms first manifest. Abdominal fullness, bloating, nausea, abdominal distention, early satiety, exhaustion, altered bowel motions, urine symptoms, back pain, dyspareunia, and weight loss are among the presenting symptoms. The symptoms appear months before ovarian cancer is officially diagnosed [21].

In clinical situations of high suspicion, a comprehensive physical examination should be performed, including rectovaginal examination on an empty bladder to search for pelvic and abdominal tumors. A palpable pelvic mass, ascites, or reduced breath sounds because to pleural effusions may also be detected in advanced instances. It is unusual to observe a sister Mary Joseph nodule because of metastases to the umbilicus. A clinical hint to the existence of occult cancer is the sign of Lesar-Trélat, which is defined as a dramatic rise in the discovery of seborrheic keratosis [22].

Diagnosis

For a screening method to be considered successful, it must possess a sensitivity of at least 75% and a specificity of at least 99.6% in order to achieve a positive predictive value (PPV) of 10%. The majority of activists and gynecologic oncologists believe that no more than 10 laparotomies per instance of ovarian cancer found would be appropriate, despite the fact that the 10% PPV limit is arbitrary. Serum markers, TVS, and a two-stage screening technique that triggers TVS in response to growing serum markers are among the methods that have been examined for identifying epithelial ovarian cancer [23].

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Table 1: MDCT findings of corresponding ovarian cancers [61].

Multidetector computed tomography findings	Histopathology/surgery findings
Thick walled, large solid cum cystic mass, ascites, lymph nodes	Papillary carcinoma n = 18
Thick walled, large masses with central necrosis	Malignant mullerian n = 12
Large multiseptated, solid cum cystic, ascites except one which was a large cyst with thin internal septations	Adenocarcinoma n = 32
Large Solid masses, lymph nodes, omental thickening except one which was less than 4 cm and had well defined thin walls	Endometroid carcinoma n = 14

Table 2: Age distribution of patients presented with ovarian lesions.

Age range	Number	Percentage
<20	3	3.2
20-30	5	5.3
31-40	14	14.9
41-50	24	25.5
51-60	23	24.5
61-70	15	16
71-80	10	10.6
Total	94	100

Table 3: Distribution of patients according to site of ovarian lesions.

Distribution of ovarian lesions according to site:		
Site [Side] of ovarian lesions	Frequency	Percent
Right	36	38.3
Left	27	28.7
Bilateral	31	33
Distribution of bilateral ovarian lesions		
Yes	31	33
No	63	67
Total	94	100

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Table 4: Distribution of patients according to internal characteristics of ovarian lesions.

Distribution of internal characteristics of ovarian lesions:		
According to cystic and solid components	**Frequency**	**Percent**
Cystic	56	59.6
Solid	19	20.2
Mixed	19	20.2
Densities of components of ovarian lesions		
Fluid	48	51.1
Fat and fluid	3	3.2
Hemorrhagic	7	7.4
Soft tissue	19	20.2
Mixed	17	18.1
Distribution of enhancement patterns of ovarian lesions		
Rim	10	10.6
Heterogenous	40	42.6
No	44	46.8
Total	**94**	**100**

Table 5: Distribution of patients according to size of ovarian lesions.

Ovarian lesions according to size:		
Size	**Frequency**	**Percent**
<4 cm	14	14.9
>4 cm	80	85.1
Total	**94**	**100**

Table 6: Distribution of patients according to cyst wall thickness.

Distribution of ovarian lesions according to cyst wall thickness (Applicable for cystic ovarian lesions):		
Cyst wall thickness	**Frequency**	**Percent**
<3 mm	47	62.7
>3 mm	28	37.3
Total	**75**	**100**

Table 7: Distribution of patients according to internal septations of lesions

Distribution of presence of septations in ovarian lesions		
	Frequency	**Percent**
Present	48	51.1
Absent	46	48.9
Total	**94**	**100**
Nature of septations in those ovarian lesions with septations		
	Frequency	**Percent**
Regular	45	93.8
Irregular	3	6.3
Total	**48**	**100**
Thickness of septations in those ovarian lesions with septations		

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Thin	31	64.6
Thick	17	35.4
Total	**48**	**100**

Table 8: Distribution of patients according to internal components of ovarian lesions.

Distribution of internal components of ovarian lesions:		
Presence of solid components/ mural nodule	**Frequency**	**Percent**
Present	34	36.2
Absent	60	63.8
Presence of classifications		
Present	19	20.2
Absent	75	79.8
Presence of necrosis within the ovarian lesion		
Present	19	20.2
Absent	75	79.8
Total	**94**	**100**

Table 9: Distribution of patients according to local extension and metastases.

Distribution of extent of ovarian lesion and its deposits		
Presence of pelvic side wall invasion	**Frequency**	**Percent**
Present	38	40.4
Absent	56	59.6
Presence of pelvic organ involvement		
Present	37	39.4
Absent	57	60.6
Presence of omental deposits		
Present	33	35.1
Absent	61	64.9
Presence of peritoneal thickening		
Present	34	36.2
Absent	60	63.8
Presence of lymph nodal involvement		
Present	43	45.7
Absent	51	54.3
Total	**94**	**100**

Table 10: Distribution of patients according to associated findings and distant metastases.

Distribution of associated findings in ovarian lesions:		
Presence of ascites	**Frequency**	**Percent**
Present	45	47.9
Absent	49	52.1

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Presence of pleural effusion		
Present	15	16
Absent	79	84
Presence of liver lesions		
Present	3	3.2
Absent	91	96.8
Total	**94**	**100**

Table 11: Distribution of patient age, lesion dimensions, and enhancement characteristics of solid components of all ovarian lesions.

	Mean	Median	Minimum	Maximum	IQR (Q1, Q3)
Age (years)	50.87	51.5	13	80	41.75,61
Diameter of lesion	11.03	9.4	1.1	33	6.575,14.425
Dimension of solid component (cm)	2.83	2.3	0.3	12.2	1,3.8
Plain	40.03	40	27	58	32,46
Arterial	57.51	57	40	85	50,64
Venous	76.51	74	54	144	66,80
Delayed	69.77	70	50	97	60,79

Table 12: Distribution of patient age, lesion dimensions, and enhancement characteristics of solid components of malignant lesions

Patients with Malignant tumors	Mean	Median	Minimum	Maximum	IQR (Q1,Q3)
AGE (years)	53.33	55	17	77	44,61.75
Diameter of lesion	10.89	9.45	1.7	32	6.35,13.825
Dimension of solid component (cm)	3.16	2.5	0.3	12.2	1,4.5
Plain	39.15	37	27	58	31.75,45.25
Arterial	56.96	57	40	71	50,64
Venous	77.92	75.5	54	144	67.75,81
Delayed	70.81	71	55	97	63,80

Table 13: Distribution of patient age, lesion dimensions, and enhancement characteristics of solid components of benign ovarian lesions.

Patients with Benign tumors	Mean	Median	Minimum	Maximum	IQR (Q1, Q3)
Age (years)	48.3	47	13	80	37.5,59.5
Diameter of lesion	11.17	9.25	1.1	33	7.175,14.875
Dimension of solid component (cm)	1.86	1.5	0.3	4	0.6,3.4
Plain	42.56	43	30	56	31,53.5
Arterial	59.11	56	47	85	51,66
Venous	72.44	71	58	92	63,82
Delayed	66.78	64	50	89	60,75

Table 14: Association between the enhancement patterns of ovarian lesions in plain, arterial, venous, delayed phases and the nature of the lesion.

Ranks					
	Based on histopathological diagnosis	**N**	**Mean Rank**	**Sum of Ranks**	**P value**

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PLAIN	Malignant	26	17.23	448	0.469
	Benign	9	20.22	182	
	Total	35			
ARTERIAL	Malignant	26	18.02	468.5	0.985
	Benign	9	17.94	161.5	
	Total	35			
VENOUS	Malignant	26	19.1	496.5	0.288
	Benign	9	14.83	133.5	
	Total	35			
DELAYED	Malignant	26	19.06	495.5	0.305
	Benign	9	14.94	134.5	
	Total	35			

Table 15: Association between laterality and ovarian lesions.

			Based on HPE diagnosis		**P value**
			Malignant	**Benign**	
Bilateral	**Yes**	Frequency	24	7	<0.001 Significant
		Percentage	50.00%	15.20%	
	No	Frequency	24	39	
		Percentage	50.00%	84.80%	
Total Percentage		Frequency	48	46	
		100.00%	100.00%		

Table 16: Distribution of patients according to histological diagnosis of malignant ovarian lesions based on histopathological diagnosis.

MALIGNANT	Number	Percentage
Granulosa cell tumor	1	1.1
Serous cystadenocarcinoma (High grade serous carcinoma)	29	30.9
Mucinous cystadenocarcinoma	3	3.2
Borderline ovarian tumor	4	4.3
Clear cell adenocarcinoma	2	2.1
Endometrioid carcinoma	2	2.1
Metastatic adenocarcinoma ovarian in origin	4	4.3
Malignant melanoma metastasis	1	1.1
Undifferentiated carcinoma favouring Non-Hodgkins Lymphoma	1	1.1
Total	**48**	**51**

Table 17: Distribution of patients according to histological diagnosis of benign ovarian lesions based on histopathological diagnosis.

	Frequency	Percent
BENIGN		
Non neoplastic adnexal cyst (simple serous cyst)	3	3.2
Hemorrhagic cyst	2	2.1

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Endometrioma (endometriosis)	6	6.4
Serous cystadenoma	10	10.6
Low grade serous carcinoma	1	1.1
Mucinous cystadenoma	9	9.6
Benign mixed ovarian tumor (Sero mucinous cystadenoma)	2	2.1
Serous cyst adenofibroma	4	4.25
Teratoma	3	3.2
Brenner tumor	2	2.1
Thecoma	1	1.1
Ruptured products of conception	1	1.1
Ovarian torsion	3	3.2
Total	**46**	**49**

Table 18: Distribution of patients according to MDCT and HPE diagnoses of ovarian lesions.

Distribution of ovarian lesions based on radiological diagnosis	Frequency	Percent
Malignant	51	54.3
Benign	43	45.7
Distribution of ovarian lesions based on histopathological diagnosis		
Malignant	48	51.1
Benign	46	48.9
Total	**94**	**100**

Table 19: Distribution of patients according to sensitivity, specificity and accuracy of MDCT in predicting malignant ovarian lesions.

Sensitivity	95.8
Specificity	89.1
PPV	90.2
NPV	95.3
Accuracy	92.6

Table 20: Forward stepwise logistic regression for MDCT features of malignant ovarian lesions.

S. No	Variables	Univariate (OR)	95% CI	Multivariate (OR)	95% CI
1	Size: maximum diameter of lesion > 4	0.478	0.147-1.553		
2	Bilateral ovarian lesions	5.571	2.084-14.898		
3	Mixed - solid cystic lesions	18.04	5.939-54.799		
4	Density - Soft tissue or Mixed density	31.533	8.424-118.039		
5	Heterogeneous Enhancement of lesion	5.286	1.204-23.210		
6	Cyst wall thickness - > 3 mm	13.567	4.333-42.480		
7	**SEPTUM:**				
	Presence of septum	0.651	0.288-1.469		

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	Irregular nature of septum	-	-		
	Thick septum	7.944	2.033-31.041		
8	Presence of solid components/ mural nodule	4.469	1.776-11.243		
9	Presence of calcifications	1.857	0.659-5.235		
10	Necrosis in solid ovarian lesion	27	3.421-213.11		
11	Pelvic sidewall invasion	151.364	18.67-1227.21	63.517	4.066-992.139
12	Pelvic organ involvement	135	16.756-1087.695		
13	omental deposits	-	-		
14	Presence of peritoneal thickening	-	-		
15	lymph node involvement	12.788	4.737-34.528		
16	Ascites	15.977	5.779-44.176	25.441	2.586-250.313
17	Pleural effusion	-	-		
18	Liver lesions	-	-		

Table 21: Sensitivity, Specificity, PPV, NPV and Accuracy of each MDCT feature for malignant ovarian lesions and CA125.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Side - Bilateral	50	84.8	77.4	61.9	67
Component - Solid+Mixed	68.8	89.1*	86.8	73.2	78.7
Maximum Diameter of Lesion- >4 cm	89.6*	19.6	53.8	64.3	55.3
Presence of Heterogeneous enhancement	75	91.3*	90*	77.8	83
Cyst wall thickness- >3mm	68.8	86	78.6	78.7	62.8
Presence of Septum	45.8	43.5	45.8	43.5	44.7
Septum- Irregular	13.6	100*	100*	57.8	30.9
Septum-Thick	59.1	84.6	76.5	71	37.2
Presence of Solid component	52.1	80.4	73.5	61.7	66
Presence of Calcifications	25	84.8	63.2	52	54.3
Presence of Necrosis	37.5	97.8*	94.7*	60	67
Presence of Pelvic side wall invasion	77.1	97.8*	87.4	80.4	87.2
Presence of Pelvic organ involvement	75	97.8*	97.3*	78.9	86.2
Presence of Omental deposits	68.8	100*	100*	75.4	84
Presence of Peritoneal thickening	70.8	100*	100*	76.7	85.1
Presence of lymph node involvement	72.9	82.6	81.4	74.5	77.7
Presence of Ascites	77.1	82.6	82.2	77.6	79.8
Presence of Pleural effusion	31.3	100*	100*	58.2	64.9
Presence of Liver lesions	6.3	100*	100*	50.5	52.1
High CA-125	95.8*	73.9	79.3	94.4	85.1

Table 22: Distribution of patients according to CA-125 levels.

Distribution of CA-125 in patients with ovarian lesions		
	Frequency	**Percent**

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Normal	36	38.3
High	58	61.7
Total	**94**	**100**

Table 23: Association between CA 125 and imaging findings.

Ranks					
	Based On Radiological Diagnosis (Malignant/ Benign)	**N**	**Mean Rank**	**Sum of Ranks**	**P value**
CA – 125	Malignant	51	64.97	3313.5	<0.001
	Benign	43	26.78	1151.5	
	Total	94			

Table 24: Contingency table for association between CA-125 with ovarian tumors based on histopathological diagnosis.

			Malignant	**Benign**	
CA – 125	**Normal**	**Frequency**	2	34	<0.001
		Percentage	5.60%	94.40%	
	High	**Frequency**	46	12	
		Percentage	79.30%	20.70%	
Total Percentage		**Frequency**	48	46	
		51.10%	48.90%		

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Table 25: Association between histopathological diagnosis with tumours marker (CA 125) assay in diagnosis of malignant ovarian tumors.

	Based on pathological diagnosis	N	Mean Rank	Sum of Ranks	P value
CA – 125	Malignant	48	66.89	3210.5	<0.001
	Benign	46	27.27	1254.5	
	Total	94			

Tumor Markers

Oncomarkers, another name for biomarkers, are quantifiable attributes of many cell types that are vital to cancer research and therapy. Genes, proteins, and other molecular characteristics that may act as objective medical indicators are included in these molecular signatures. Biomarkers are primarily used to: (1) estimate the probability of disease development or degenerative processes; and (2) measure the efficacy of treatment therapies. In the course of cancer screening, diagnosis, and treatment monitoring, chemicals generated by neoplasm cells or cells nearby are known as cancer biomarkers. These molecules may be measured in bodily fluids and blood. Biomarkers include things like antigens, cytoplasmic proteins, enzymes, hormones, receptors, oncogenes, and their derivatives [24]. Many blood tumor indicators have been tested over the last 20 years to see whether they might identify early-stage epithelial ovarian cancer. Given the diversity of ovarian malignancies across patients, it is improbable that a single marker will be sensitive enough to serve as the best first screening. The majority of early research found that using several markers increased sensitivity at the cost of a significant drop in specificity [25].

CA-125: CA125, a glycoprotein produced by the MUC16 gene, can be detected using OC 125 monoclonal antibodies. It is commonly found in malignant ovarian tissues, with a normal limit of 35.0 U/mL for both premenopausal and postmenopausal women [26]. The FDA supports CA125 as a biomarker for tracking ovarian cancer and therapy response, but its reliability is limited due to potential secretion by non-tumor cells in inflammatory conditions [27]. CA125 is a significant prognostic indicator for treatment outcomes in advanced ovarian cancer, with lower levels and faster normalization associated with better prognosis and response to treatment. Elevated CA125 levels can also predict chemoresistance, allowing for timely treatment modifications to improve patient outcomes [28,29]. Relying solely on CA125 levels for diagnosing epithelial ovarian cancer (EOC) is limited due to potential false positives in healthy individuals and those with benign diseases. Additionally, 20% of EOC patients may not have elevated CA125 levels, and circulating immune complexes can interfere with detection, highlighting the need for a more comprehensive approach to minimize unnecessary costs and improve diagnostic accuracy [30].

CA 15-3: In 1988 research, 41% of cancer patients had increased CA 15-3 levels (>30 U/mL), which were associated with disease progression during chemotherapy, treatment response, and residual tumor in instances of ovarian cancer in particular and at late stages of the illness [31]. There were notable differences between the cancer group and the benign and healthy control groups, suggesting that cancer patients had greater levels of tumor markers. When compared to single markers, combinations of tumor markers demonstrated higher sensitivity; in particular, the combination of CA72-4, CA15-3, and CA125 showed promise as an ovarian cancer diagnostic tool [32].

CA-19-9: A sensitive marker for hepatobiliary, gastric, and pancreatic cancers is CA19-9. Studies have recently looked at its possible use in OC screening. CA19-9 was one of the six biomarkers that Fahmy et al. examined. They presented encouraging findings with high sensitivity and specificity, demonstrating the test's capacity to rule the illness in or out. Out of the three markers, CA-125 had the best diagnostic performance in distinguishing between mucinous ovarian tumors that were benign, borderline, and malignant [33].

Other markers

HE4: The WFDC2 gene produces the glycoprotein HE4, which functions as a serine proteinase inhibitor. By employing enzyme immunoassay, it may be found in the blood and urine of patients

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and acts as a possible biomarker for ovarian cancer (OC). In certain OC subtypes, HE4 is overexpressed; in endometroid tumors, it is 100%, but in serous OC, it is 93%. This feature makes it useful for differentiating between different kinds of tumors, which facilitates differential diagnosis. Although the FDA advised against using HE4 for early-stage asymptomatic OC screening, it did approve its use in 2008 for patient monitoring after an OC diagnosis.

hCG: Since OC is one of the tumor forms that expresses human chorionic gonadotropin (hCG), it may be used as a prognostic and therapeutic target. Patients with ovarian cancer have had their levels of human chorionic gonadotropin (hCG) and its component β-hCG examined for expression and potential diagnostic uses. Vartiainen et al. discovered that 29% of individuals with ovarian cancer had high levels of hCGβ, with this frequency rising with later stages and certain cancer types. 79% of patients had increased CA125 values, which were linked to the stage of malignancy. Although there were considerable correlations between hCGβ and CA125 and prognosis, only hCGβ, stage, and grade remained significant in a multivariate model. A threshold of 2 pmol/L for hCGβ allowed for the distinction of individuals with varying prognosis, especially in cases of severe illness [34].

Inhibin: Ovarian follicles are the primary producers of inhibitors, which are growth factors that regulate fertility and include α and β subunits. Because various subtypes of ovarian cancer create varied quantities of inhibin species, measuring total inhibin is essential to the investigation of this disease. Postmenopausal women with granulosa cell tumors and mucinous epithelial malignancies had elevated levels of total inhibin. When combined with CA125, inhibin enhances the identification of ovarian cancer, especially for certain subtypes. Inhibin, however, is not a very useful marker for premenopausal women [35]. Patients with ovarian granulosa cell tumors (GCTs) have higher blood levels of inhibin, making it a useful tumor marker. Inhibin RIA and inhibin ELISA are two examples of assays that have been created and have the potential to be widely used. Although total inhibin levels in healthy postmenopausal women are generally low, they may identify instances of ovarian cancer. When inhibin and CA125 are combined, detection of ovarian tumors is enhanced, leading to excellent sensitivity and specificity [36].

AFP: A fetal serum protein called alpha-fetoprotein (AFP) may be used as a marker to identify malignant growths. However, as high AFP levels are unusual in epithelial ovarian cancer (EOC), higher AFP in EOC might result in a misdiagnosis, especially in young women. This highlights the necessity for thorough assessment and presents difficulties for an appropriate diagnosis. According to a research, aggressive conduct and a poor prognosis are linked to AFP-producing EOC. All instances had verified AFP expression, indicating differentiation into components of the yolk sac. Older women's serum AFP levels are seldom checked, which might result in missed diagnosis [37].

Imaging Investigation

In individuals with a strong clinical suspicion of ovarian cancer, radiological imaging modalities like transvaginal ultrasound (TVUS), abdominal and pelvic ultrasonography are highly recommended due to their exceptional sensitivity in detecting abnormalities. It provides a reasonable understanding of the ovarian mass's dimensions, location, and complexity. Additional imaging using a pelvic MRI, a chest and abdomen CT scan, a pelvic MRI, or a PET scan may be performed to determine the extent of the tumor.

Ultrasonography: Ultrasound (US) is the first-line imaging modality for suspected adnexal tumors due to its widespread availability, low cost, and high spatial resolution, particularly with transvaginal imaging. The Ovarian-Adnexal Reporting and Data System (O-RADS) US risk classification is a useful tool for categorizing adnexal masses into risk groups, with features such as large size, multilocular masses, and solid components indicating a higher risk, and guiding referral to a gynecologist-oncologist or surveillance [38]. MRI is useful for further characterization of adnexal masses that remain indeterminate on ultrasound, helping to distinguish between benign and malignant lesions when the origin or complexity of the mass cannot be clearly classified [39].

MRI: According to Jeong, MRI's superior contrast resolution and non-ionizing radiation enable detailed characterization of soft-tissue types, but a meta-analysis has shown that Diffusion-weighted imaging (DWI) sequences are not a reliable diagnostic tool for differentiating between benign and malignant ovarian neoplasms [40]. DWI is sensitive in detecting peritoneal metastases, particularly when combined with gadolinium-enhanced imaging, and can be more sensitive than CT in this regard, although CT remains the preferred method for ovarian cancer staging [41,42].

PET: According to the ESGO/ISUOG/IOTA/ESGE Consensus Statement, 18 FDG-PET imaging is not recommended for initial detection of ovarian cancer due to its limited ability to distinguish between benign and borderline tumors, and poor performance for certain subtypes, despite a specificity of 78% [43]. The FDG absorption in late follicular to early luteal cysts in premenopausal females are another established risk factor [44]. Malignant ovarian lesions have higher FDG uptake, but no established cut-off value exists, and assessment should consider menstrual state,

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ultrasonography, and tumor markers [45]. PET-CT performs better than CT in identifying peritoneal metastases, malignant lymph nodes, and recurring illness despite these limitations [46,47].

d. Multidetector CT: The development of helical CT scanners, particularly multidetector-row computed tomography (MDCT) scanners, marked a significant advancement in CT technology, enabling faster scanning times, increased z-axis coverage, and improved image quality, with major milestones including the introduction of 4-slice MDCT in 1998 and 8- and 16-slice MDCT in 2000-2002 [48-50]. Automatic exposure control techniques were introduced in 1994 and advanced in 2001-2002 to address radiation exposure concerns in CT scanning, leading to changes in hardware and expanded [51-53].

CT and MDCT features of ovarian masses

In their research, El-Badrawy et al. found that in addition to ancillary findings of implants, ascites, adenopathy, and pleural nodules, the solid or mixed solid and cystic components of all lesions were indicative of malignancy on CT. In the two instances of primary ovarian cancer that were pathologically determined to be of the epithelial type (serous cystadenocarcinomas), multilocularity was more noticeable. The pancreatic, stomach, breast, colon, and GIST cancers all had metastases to the ovaries. They were mostly solid or had patches of degeneration caused by cysts [54-57]. Nougaret al. discovered that the following factors were significantly associated with LGSC at histopathology for both readers: the presence of bilateral ovarian masses; irregular ovarian mass margins; solid or predominantly solid ovarian mass texture; ovarian mass calcifications; higher total tumor volumes (TTVs); solid tumor volumes (STVs); larger solid proportion of ovarian masses; presence of peritoneal disease (PD); nodular PD pattern; and PD calcifications. Greater STV, PD, and bilateral ovarian masses were all shown to be substantially correlated with LGSC at histology, even after multivariate analysis [58]. Furthermore, they discovered that invasive peritoneal lesions (LGSC) at histopathology were substantially correlated with the presence of the nodular PD pattern and PD calcifications.

Ovarian masses come in a variety of forms, and their CT appearances vary greatly. Therefore, accurate histologic characterization is not always attainable. However, many cancers have dominant radiologic characteristics, and understanding these important discoveries may aid in the development of a particular diagnosis [59]. After contrast is administered, advanced ovarian cancer on CT usually appears as thick-walled cysts with septations and papillary projections that are easier to observe. The likelihood of correctly identifying malignancy is increased by ancillary symptoms such as ascites, peritoneal implants, adenopathy, and invasion of the pelvic organ or sidewall. The presence of bilateral and cystic-solid masses, a large soft-tissue component with necrosis, a tumor with thick and irregular septa, and large papillary components are among the findings that are related to the MDCT diagnosis of ovarian malignant tumours. These findings can be explained by the pathophysiological differences that underlie borderline and malignant tumours. Thin sections across a large amount of tissue may be produced with multidetector CT, which has the benefit of perhaps increasing the sensitivity of CT in identifying peritoneal carcinomatosis. Thin section collection could make it possible to find implants smaller than a centimeter. Additionally, multiplanar pictures with less artifacts may be produced using thin-section CT [60].

When the tumor's wall measured three millimetres or more, it was considered thick. The existence and quantity of septa, their thickness (whether less than, equal to, or higher than 3 mm), the presence of irregularity, and papillary projections were noted for cystic and solid-cystic lesions while a cancer diagnosis was sought. The following CT main findings were diagnostic of a malignant adnexal mass: size more than 4 cm, bilateral adnexal mass presence, a partially cystic and solid mass with solid components increasing with injection of contrast material, and necrosis in a solid tumor. When characterizing an adnexal mass in cystic and solid-cystic lesions, imaging features and augmentation of the wall or septa were crucial. the existence of an uneven, thick wall or septum that is thicker than 3 mm, as well as papillary projections that became more prominent after I.V. administration of contrast material, was suggestive of cancer. Malignancy was confirmed by ancillary observations such as lymphadenopathy, ascites, peritoneal metastases, and invasion of the pelvic organ or sidewall. When one main criterion or one primary and one ancillary finding were present, a lesion was classified as malignant. Because wall or septal thickening has also been reported in benign lesions such endometriomas and abscesses, it was seen in this context as less suggestive of cancer.

Previous studies on the sensitivity, specificity and accuracy of MDCT features for predicting malignant ovarian

In order to categorize ovarian masses, Khattak et al. calculated the 64-slice MDCT's sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy. The results of the MDCT

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for reader A showed that the sensitivity was 92% (0.83, 0.97) and the specificity was 86.7% (0.68, 0.96), while the NPV and PPV were 86.7% (0.63, 0.92) and 94.5% (0.86, 0.98), respectively. Reader A reported an accuracy of 90.5%. The values for reader B were 94.6% (0.86, 0.98) 90% (0.72, 0.97) 96% (0.88, 0.99) and 87.1% (0.69, 0.95) for sensitivity, specificity, PPV, and NPV, respectively. Reader B calculated an accuracy of 93.3%. The two radiologists' agreement was determined to be excellent, with a strong kappa value of 0.887. They came to the conclusion that MDCT is a dependable imaging technique with little interobserver variability for reliably diagnosing ovarian masses based on the findings of their investigation. Using histology and surgical findings as the gold standard, Mubarak et al. assessed the diagnostic accuracy of multidetector 64-slice computed tomography (MDCT) in the detection and distinction of benign and malignant ovarian tumours. In the process of differentiating benign from malignant ovarian tumours, MDCT was shown to have 97% sensitivity, 91% specificity, and 96% accuracy; PPV and NPV, on the other hand, were 97% and 91%, respectively. A non-invasive, safe, and reliable method for distinguishing between benign and malignant ovarian tumours is MDCT imaging [61].

Using histology as the gold standard, Mukhtar et al. assessed the diagnostic accuracy of multidetector computed tomography (MDCT) in the assessment of ovarian cancer. The MDCT's sensitivity, specificity, NPV, PPV, and overall diagnostic accuracy scores were 95.6%, 97.3%, 93.5%, 97.3%, and 96.8%, respectively, using histology as the gold standard. When it comes to identifying benign from malignant lesions and staging malignant patients, MDCT demonstrated great accuracy. This could be highly beneficial for the therapy of ovarian illness [62].

Using post-operative histology results as the gold standard assess the use of multi-detector computed tomography (MDCT) in the identification and distinction of adnexal masses. Adnexal masses were identified as benign in 55 (49%) instances and malignant in 57 (51%) cases based on final histology. Three patients that looked malignant on MDCT were later shown to be benign upon histopathological examination. Similarly, four patients that initially seemed benign on MDCT later turned out to be malignant upon histopathological examination. For the purpose of identifying a malignant adnexal mass, the MDCT's sensitivity, specificity, positive predictive value, and negative predictive value were, in order, 93.0%, 94.5%, 94.6%, and 92.8%. Solid or cystic masses, necrosis in solid lesions, cystic lesions with thick, uneven walls or septa, and/or papillary projections were all shown on MDCT to be more predictive of malignancy. A great and precise non-invasive technique for differentiating between benign and malignant adnexal masses is magnetic resonance imaging (MDCT) [63]. Tsili et al assessed the precision of multidetector computed tomography (MDCT) in the identification and distinction of adnexal masses using a 16-row CT scanner. Upon histopathologic analysis, 143 adnexal mass lesions were found; 96 (67%) of them were benign, and 47 (33%) were malignant. Of the 143 adnexal masses, multidetector CT identified 129 (90%) with an overall accuracy of 89.15% for the diagnosis of cancer. Necrosis in a solid mass, peritoneal metastases, and the appearance of papillary projections in a cystic lesion were the MDCT results that were more predictive of malignancy. Accurate identification and characterization of adnexal masses were shown using multidetector computed tomography on a 16-row CT scanner. According to Moideen et al., when CA 125 was used in combination with CT results, it was able to diagnose the stagings of ovarian tumors with 92.9% sensitivity, 75% specificity, 92.9% PPV, 75% NPV, and 88.9% accuracy [64].

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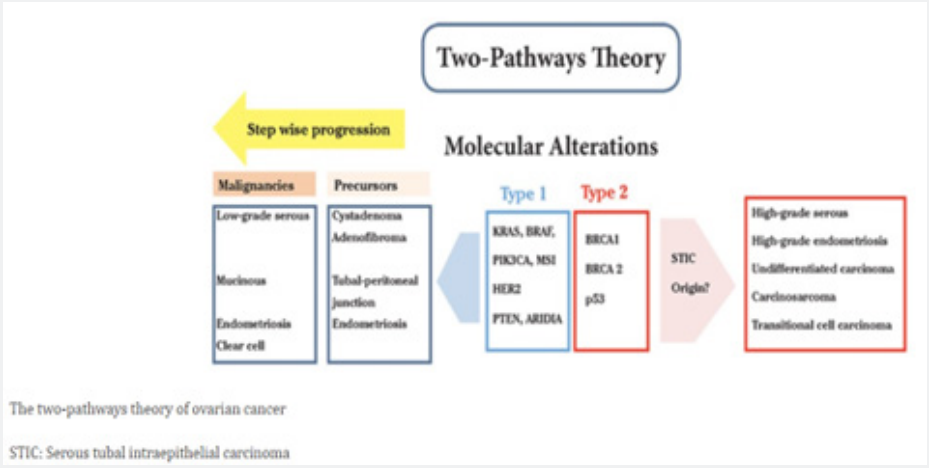

Figure 1: Two pathways theory of ovarian cancer[18].

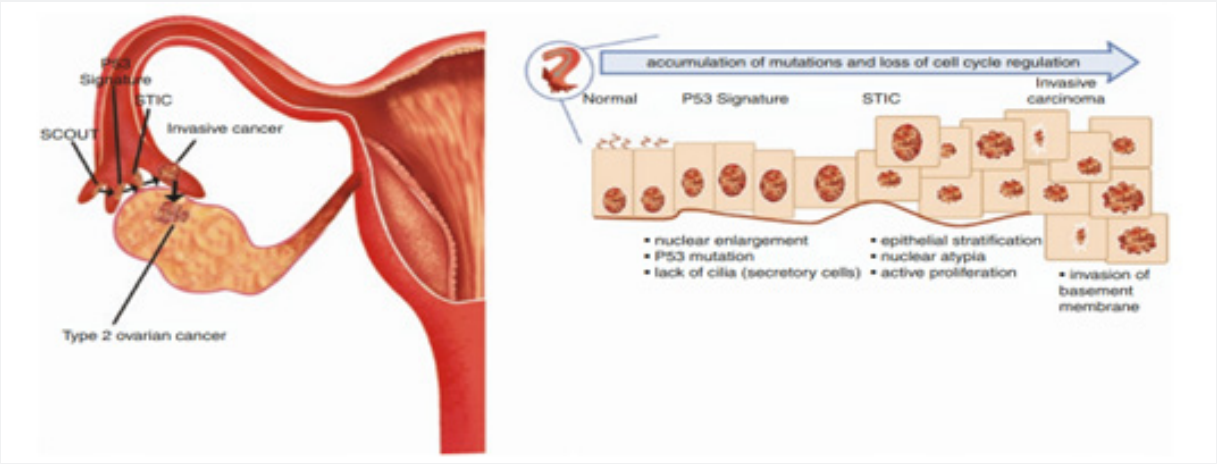

Figure 2: Type II high-grade serous carcinoma with tubal origin[19].

Materials And Methods

Study type: Cross sectional study

Study design: Cross sectional descriptive study.

Study setting: Justice K.S. Hegde Charitable Hospital attached to K S Hegde Medical Academy, a unit of NITTE (deemed to be University), Mangaluru – 575018.

Study duration: Study was conducted from 01/10/2022 to 30/04/2024.

Study population: All patients with ovarian masses underwent MDCT at Justice K.S. Hedge Charitable Hospital, Mangalore.

Sample size: This was a time-bound study, and patients with ovarian masses who underwent MDCT from 01/10/2022 to 30/04/2024 were considered.

Inclusion criteria: All patients with ovarian masses who undergo MDCT.

Exclusion criteria:

a. Patients with no histopathological diagnosis

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b. Patients with other malignancies with metastatic ovarian deposits.

c. Patients on treatment for ovarian malignancies.

Methods of data collection: Patients referred to the Department of Radiodiagnosis at Justice K.S. Hegde Charitable Hospital for MDCT evaluation of ovarian masses were selected for the study. MDCT scans were performed using a GE Revolution EVO 125 slice CT scanner with pre and post intravenous iodinated contrast administration, along with oral negative contrast. Pre-contrast 5 mm axial sections were obtained through the pelvis to assess calcification of the tumor. Post-contrast images were obtained with 5 mm axial sections during the arterial and venous phases, and delayed phase in selected cases, to assess bladder and ureteric infiltration by the tumor. Subsequently, 1.2 mm multiplanar reconstruction was obtained for a detailed evaluation of the tumor and peritoneal spread. The imaging features of ovarian masses were described on MDCT, and specific features of malignant lesions were identified. An association between imaging findings, tumor marker (CA 125) assay, and histopathology was evaluated to predict specific features for diagnosing malignant ovarian lesions.

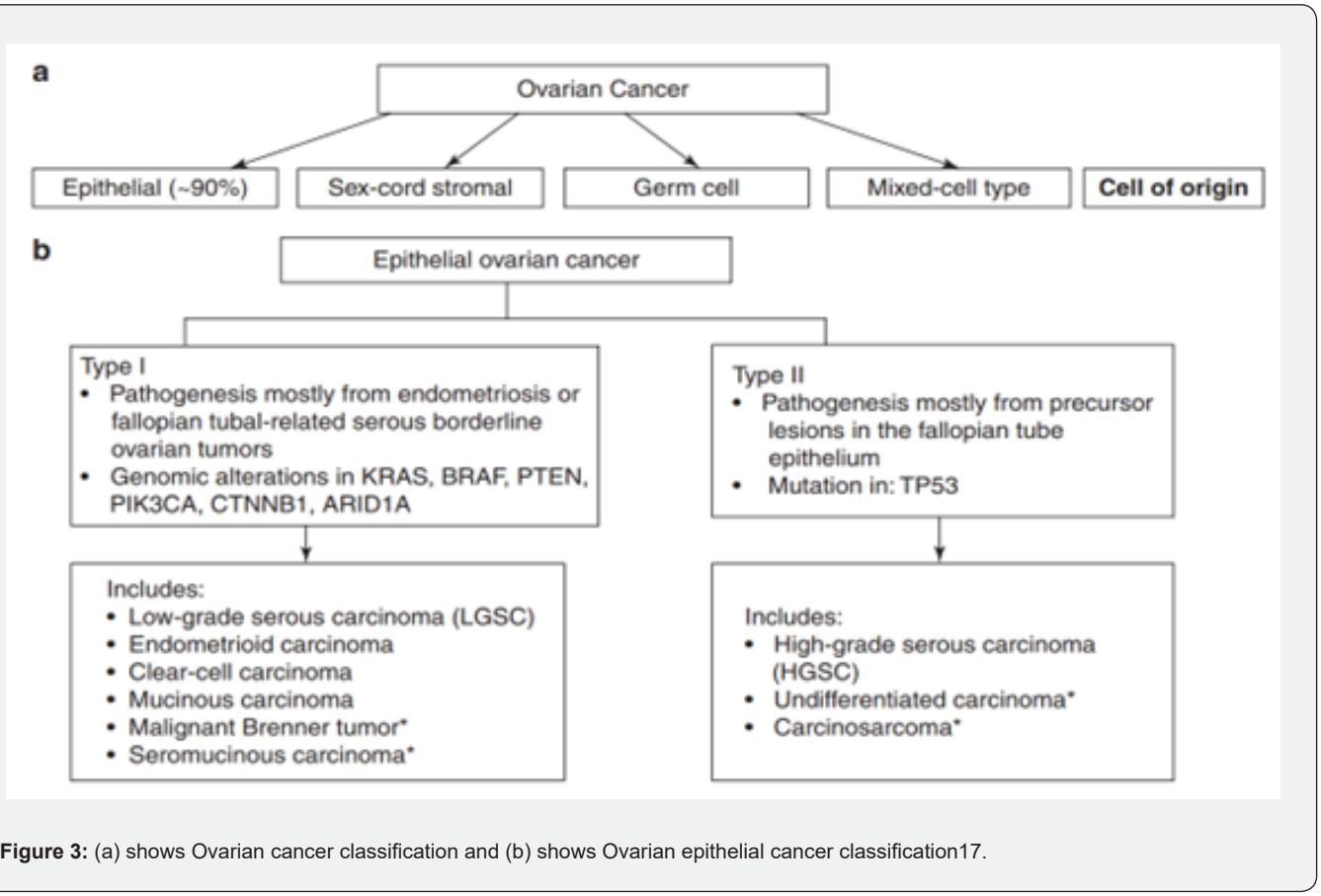

Figure 3: (a) shows Ovarian cancer classification and (b) shows Ovarian epithelial cancer classification17.

Statistical analysis: Data was entered using MS Excel and IBM SPSS Statistics for Windows, Version 26.0. was applied for analyzing the data. Qualitative data was expressed in frequency and percent. Mean (SD) and Median (IQR) was calculated for quantitative data. Since the continuous variables were not normally distributed, we used Mann-Whitney test and Kruskal Wallis test to check the significance in difference between categorical variables and the continuous variables. Chi-square test was applied between categorical variables for testing association. Variables which were found significant in the univariate analysis were loaded and forward stepwise logistic regression was applied. p value of below 0.05 is taken as statistically significant. Sensitivity, specificity, PPV, NPV and accuracy of MDCT and its features for predicting malignant ovarian lesions was estimated.

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Results:

The study is conducted with main aim of predicting specific features of malignant ovarian lesions on MDCT. This study included 94 patients who had visited the department of radiology and imaging of K.S. Hedge medical academy with history of either clinically suspected or USG diagnosed ovarian lesions and undergone CECT abdomen and pelvis for further evaluation. Post-CECT examination, all the patients underwent CA 125 histopathology evaluation.

SPSS was used for statistical analysis and the results were presented in following sub sections:

1. The demographic features of patients with ovarian lesions.

2. MDCT features of ovarian lesions.

3. Histopathological diagnosis of ovarian lesions.

4. Correlation between MDCT and histopathological diagnosis.

5. The sensitivity, specificity and accuracy of MDCT features of ovarian lesions for predicting malignant nature of lesions.

6. Association between CA 125 and imaging findings.

Association between CA 125 and histopathological diagnosis. Out of 94 patients, 33% had bilateral lesions. Among those with unilateral presentation, 38% had right sided ovarian lesions. Most of the patients showed cystic ovarian lesions (59.6%) followed by solid and mixed which accounts for 20.2% each. The patients who had solid ovarian lesions showed soft tissue densities (20%). The ovarian lesions which were predominantly cystic and those had mixed densities showed fluid density (51.1%), 3.2% fat and fluid, 7.4% hemorrhagic, and 18.1% mixed densities [soft tissue and fluid] within. Out of 94 patients, 47 % had non enhancing ovarian lesions. Out of 50 Patients who had enhancing lesions, 80% showed heterogenous enhancement pattern followed by rim enhancement in 20%. Septations was present in 51.1% of the patients. Most patients (93.8%) had ovarian lesions with regular septations, and among those, the majority (64.6%) had thin septations, while a smaller proportion (35.4%) had thick septations. Solid components were present among 36.2% of the patients, while calcifications and necrosis were present among 20.2%, each, of the patients. 40.4% of patients had pelvic side wall invasion, while 39.4% had involvement of nearby pelvic organs. Additionally, 35.1% of patients had omental deposits, 36.2% had peritoneal thickening, and 45.7% had lymph node involvement.

Presentation of ascites, pleural effusion and liver lesions were 47.9%, 16% and 3.2%, respectively.

The mean age of the patients presented with ovarian lesions in the study was 50.87 years. The mean diameter of the lesion observed was 11.03. The mean dimension of the solid component was 2.83 cm. The mean plain, arterial, venous and delayed HU value was 40.03, 57.51, 76.51 and 69.77 respectively. The mean age of the patients presented with malignant ovarian lesions in the study was 53.33 years. The mean diameter of the malignant ovarian lesion observed was 10.89 with range between 1.7cm to 77cm. The mean dimension of the solid component was 3.16 cm with range between 0.3cm to 12.2cm. The mean plain, arterial, venous and delayed HU value was 39.15, 56.96, 77.92 and 70.81, respectively. The mean age of the patients in the study was 48.30 years. The mean maximum diameter of the lesion was 11.17 cm. The mean maximum dimension of the solid component was 1.86 cm. The mean plain, arterial, venous and delayed HU value was 42.56, 59.11, 72.44 and 66.78, respectively. Comparing the above two tables (table 13 and table 14), the mean Hounsfield Unit (HU) values in malignant ovarian lesions were slightly elevated in the venous and delayed phases compared to benign ovarian lesions, showing a difference of 5.48 for the venous phase and 4.03 for delayed images. The mean Hounsfield unit (HU) values in benign lesions were slightly elevated in arterial phases than malignant lesions with a difference of 2.15 HU. Majority of the benign ovarian lesions were observed in the age group of 48 years and the malignant lesions were in 53 years. Maximum observed diameter of the malignant ovarian lesions was 11cm and the benign lesions were of 11 cm. Most frequently observed size of the solid component among the benign lesions was 2cm and that of malignant lesions was 3cm. The malignant lesions showed equal unilateral and bilateral distribution. Majority of the benign lesions had unilateral presentation and this association was proven statistically significant. Among benign ovarian lesions, the most commonly observed types include serous cystadenoma, accounting for 10.6% of cases, followed by mucinous cystadenoma at 9.6%. Endometriosis is the next most common benign lesion, comprising 6.4% of cases.

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Thecoma were among the least common benign lesions [1.1%]. Serous cystadenocarcinoma (High grade serous carcinoma) is the most common malignant ovarian lesion [30.9%]. Borderline ovarian tumours and metastatic adenocarcinomas originating were 4.3% of cases. Mucinous cystadenocarcinoma is of 3.2% of cases. Endometrioid carcinoma and clear cell adenocarcinoma each are of 2.1%. Based on MDCT features 54.3% of the patients were diagnosed to have malignant ovarian lesions. Based on the histopathological diagnosis, 51.1% of them had malignant ovarian lesions. The sensitivity, specificity, PPV, NPV and accuracy for predicting malignant ovarian lesions on MDCT were 95.8%, 89.1%, 90.2% and 92.6% respectively. Bilateral ovarian lesions, mixed and solid cystic lesions, soft tissue or Mixed density, heterogenous enhancement, cyst wall thickness - > 3 mm, presence of solid components/ mural nodule, necrosis in solid lesion, Pelvic sidewall invasion, Pelvic organ involvement, lymph node involvement and ascites were found to be potential predictors of malignancy in univariate analysis. Forward stepwise logistic regression was applied for multivariate analysis. Variables which were found significant in the univariate analysis were loaded and forward stepwise logistic regression was applied. (R^2= 0.556). Pelvic sidewall invasion and ascites were found to be significant predictors of malignancy based on the multivariate analysis. Among the MDCT features, diameter of lesion >4 cm was the most sensitive marker (89.6%) for diagnosing malignant ovarian tumor. Liver lesions, pleural effusion, peritoneal thickening, omental deposits and irregular septum were the most specific (100%) MDCT findings for diagnosing malignant ovarian tumor. Liver lesions, pleural effusion, peritoneal thickening, omental deposits and irregular septum also had the maximum PPV (100%) for diagnosing malignant ovarian tumor. Pelvic side wall invasion had the maximum NPV (80.4%) in diagnosing malignant ovarian tumor. Accuracy was maximum for the pelvic organ involvement (86.2%) to diagnose malignant ovarian tumor.

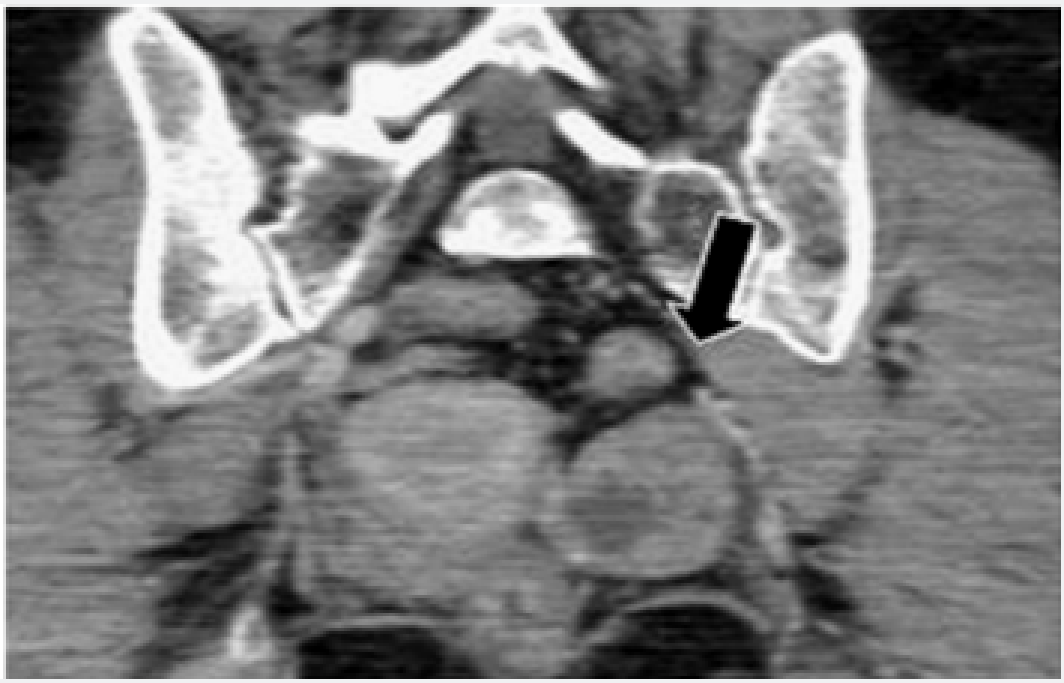

Figure 4: CECT Coronal MPR images shows a solid left ovarian mass enhancing unevenly and displaying a region of necrosis (arrow) [10].

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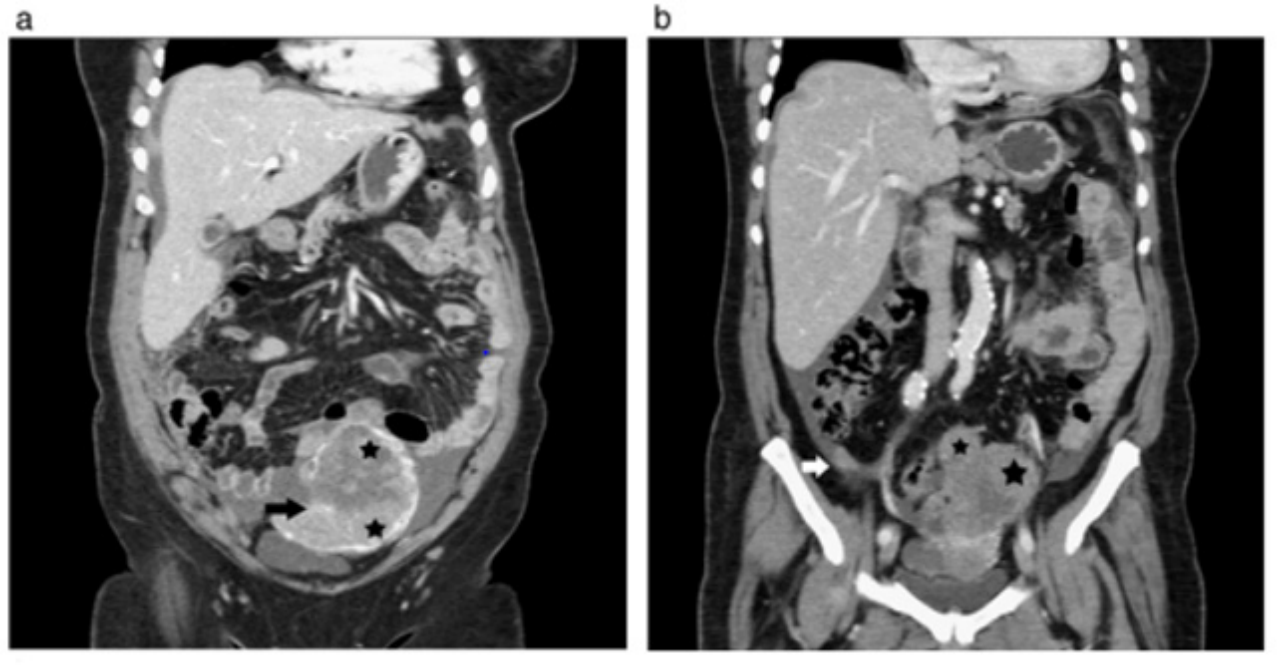

Figure 5 (a, b): CECT coronal images of ovarian serous cystadenocarcinoma in two different patients. Two serous ovarian cystadenocarcinomas are shown in the figure. (a, b) Coronal reformations show a partially solid and cystic mass with solid portions increasing (asterix), which is thought to have a left adnexal origin. As shown by pathology (a), there is effacement of the fat plane between the bulk and the uterine corpus (arrow), a result suggesting invasion. Due to peritoneal carcinomatosis, there are also ascites and peritoneal masses (small arrow) (b).

Bilateral ovarian mass identified in MDCT was found to have a sensitivity, specificity, PPV, NPV and accuracy of 50%, 84.8%, 77.4%, 61.9% and 67% for diagnosing malignant ovarian tumors.

Presence of solid and mixed components was found to have a sensitivity, specificity, PPV, NPV and accuracy of 68.8%, 89.1%, 86.8%, 73.2% and 78.7% for diagnosing malignant ovarian tumors. The sensitivity, specificity, PPV, NPV and accuracy of ovarian tumors with **size of more than 4 cm** for detecting malignant tumor was 89.6%, 19.6%, 53.8%, 64.3% and 55.3%, respectively.

Presence of heterogenous enhancement was found to have a sensitivity, specificity, PPV, NPV and accuracy of 75%, 91.3%, 90%, 77.8% and 83% for diagnosing malignant ovarian tumors.

Cyst wall thickness of more than 3 mm had a sensitivity, specificity, PPV, NPV and accuracy of 68.8%, 86%, 78.6%, 78.7% and 62.8% for diagnosing malignant ovarian tumors.

Presence of septum in MDCT was found to diagnose the malignant ovarian tumors with have a sensitivity, specificity, PPV, NPV and accuracy of 45.8%, 43.5%, 45.8%, 43.5% and 44.7%. When the **septum was irregular** it had a sensitivity, specificity, PPV, NPV and accuracy of 13.6%, 100%, 100%, 57.8% and 30.9% for diagnosing malignant ovarian tumors.

Thick septum was found to have a sensitivity, specificity, PPV, NPV and accuracy of 59.1%, 84.6%, 76.5%, 71% and 37.2% for diagnosing malignant ovarian tumors. When **solid components were present**, it was found to have a sensitivity, specificity, PPV, NPV and accuracy of 52.1%, 80.4%, 73.5%, 61.7% and 66% for diagnosing malignant ovarian tumors.

Presence of calcification was found to diagnose the malignant ovarian tumors with have a sensitivity, specificity, PPV, NPV and accuracy of 25%, 84.8%, 63.2%, 52% and 54.3%.

Necrosis was found to have a sensitivity, specificity, PPV, NPV and accuracy of 37.5%, 97.8%, 94.7%, 60% and 67% for diagnosing malignant ovarian tumors.

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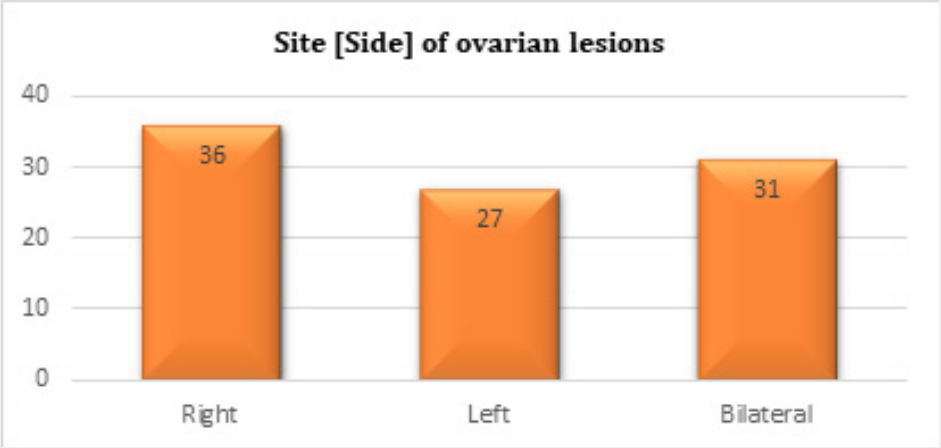

Figure 6: Distribution of patients according to site of ovarian lesions.

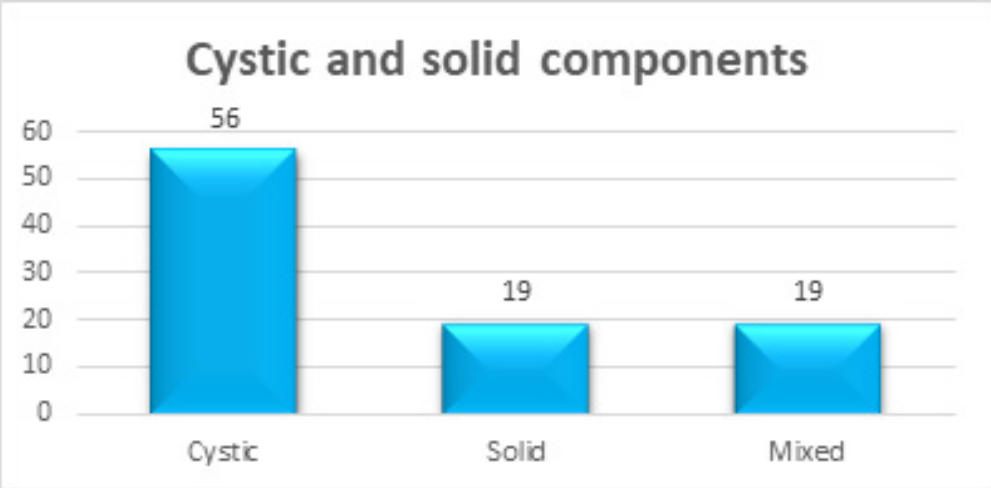

Figure 7: Distribution of patients according to internal characteristics of ovarian lesions.

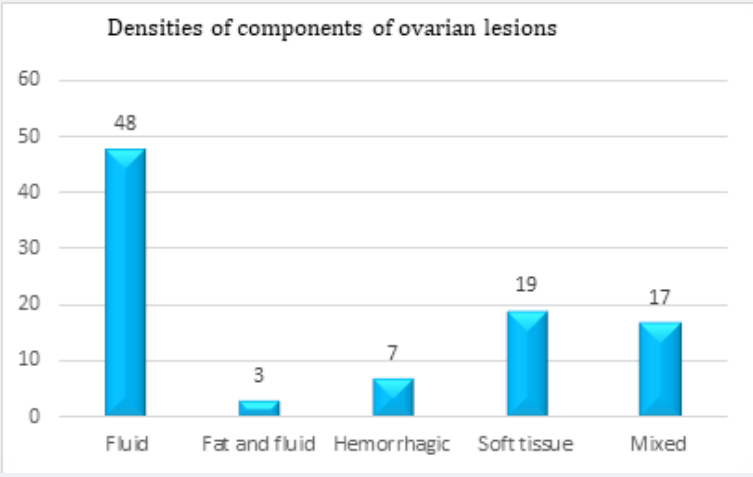

Figure 8: Distribution of patients according to densities of components of ovarian lesions.

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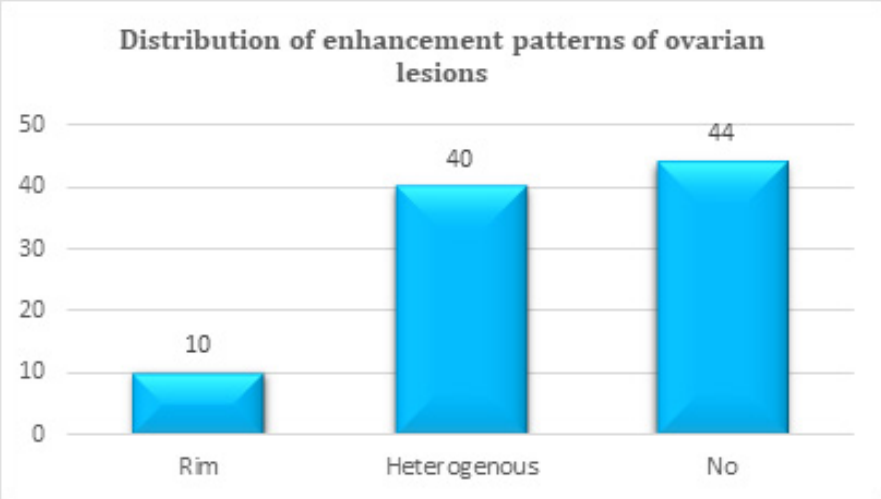

Figure 9: Distribution of patients according to enhancement patterns of ovarian lesions.

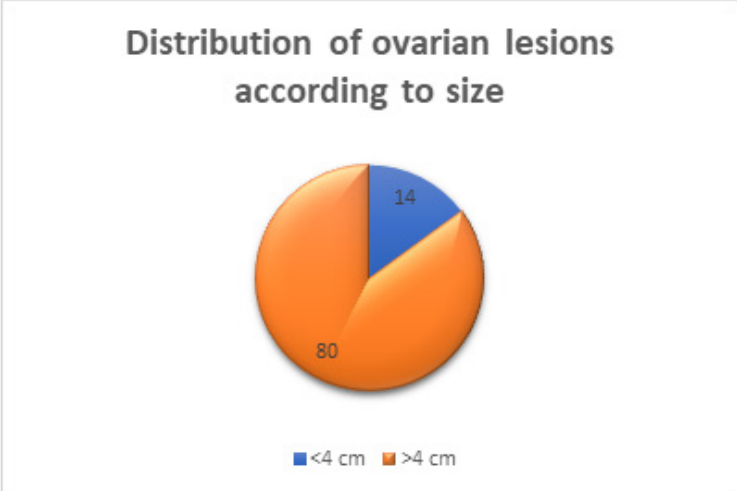

Figure 10: Size distribution of patients with ovarian lesions.

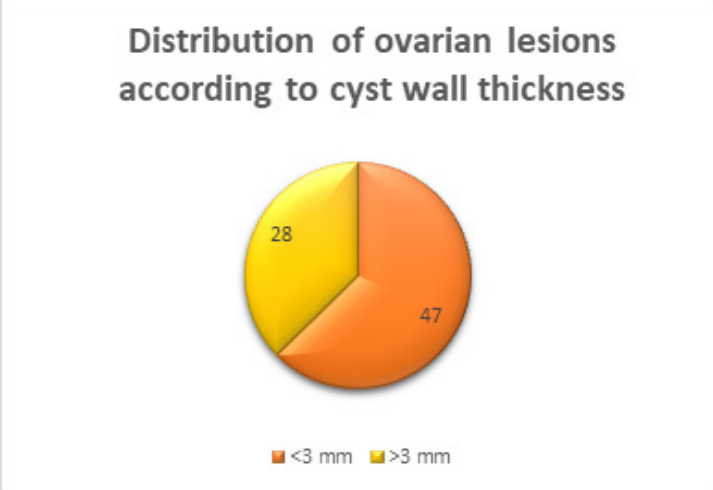

Figure 11: Distribution of ovarian lesions according to cyst wall thickness.

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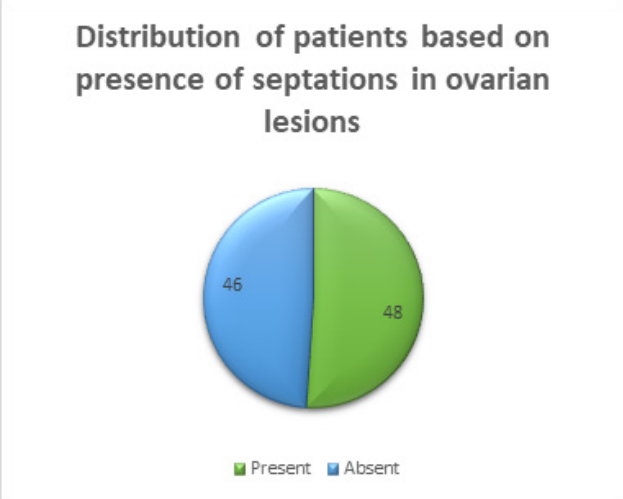

Figure 12: Distribution of patients based on presence of septations in ovarian lesions.

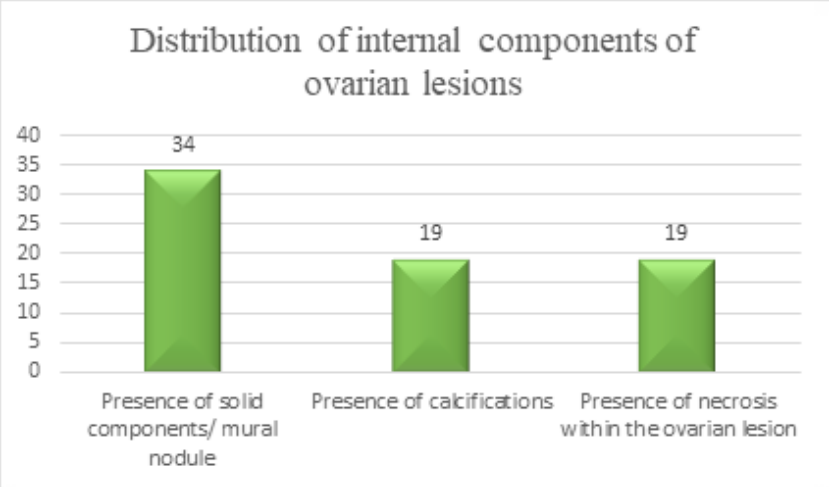

Figure 13: Distribution of internal components in patients with ovarian lesions.

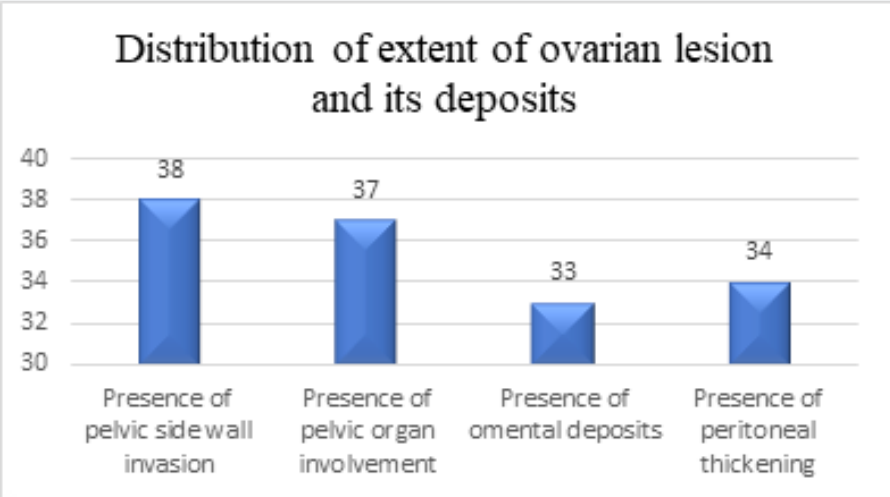

Figure 14: Distribution of extent of ovarian lesion and its deposits.

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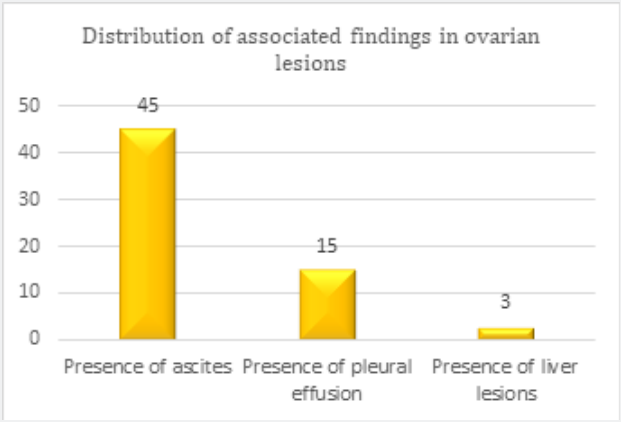

Figure 15: Distribution of associated findings in ovarian lesions.

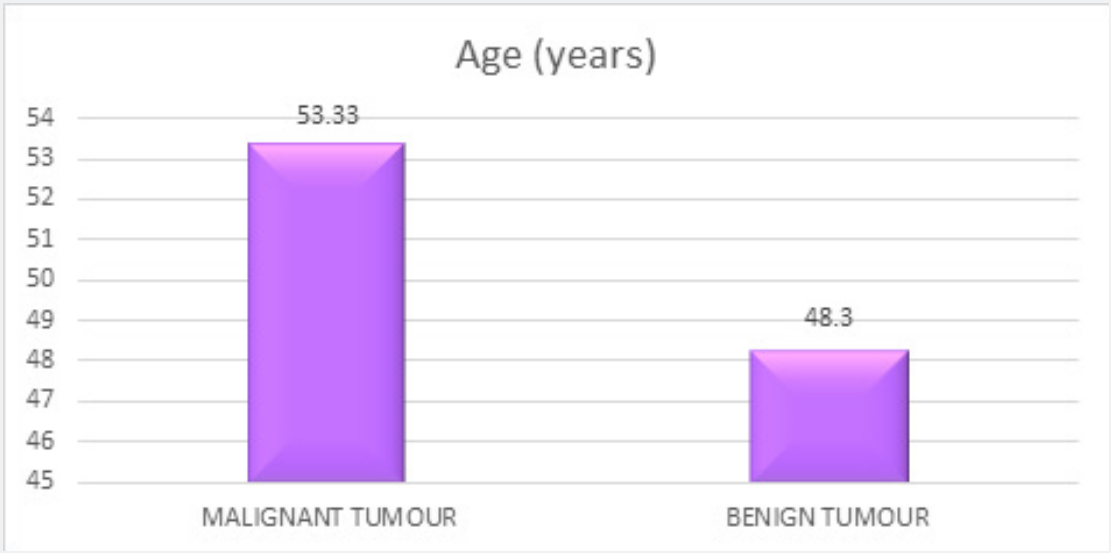

Figure 16: Association between age and malignant and benign ovarian lesions.

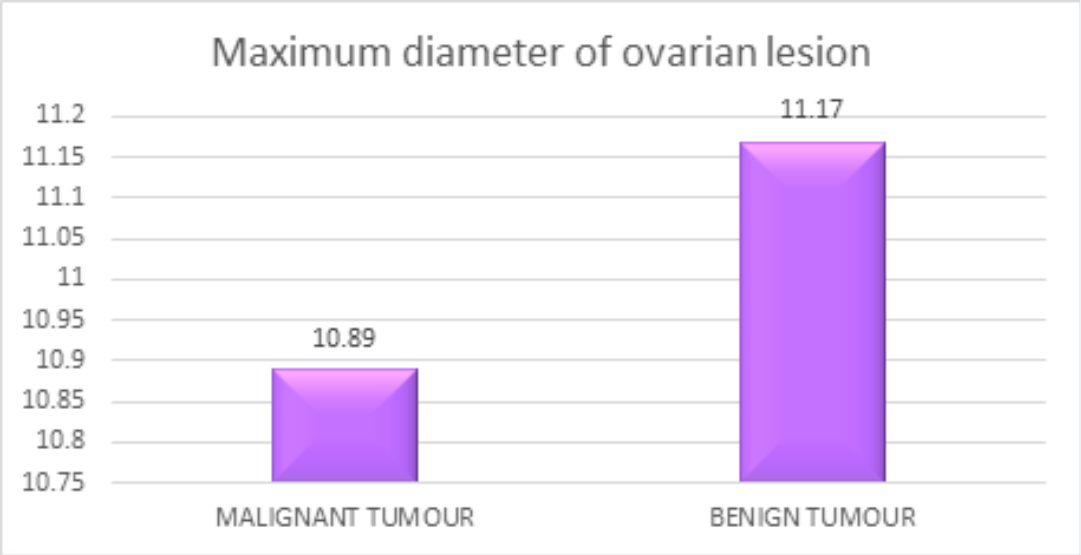

Figure 17: Distribution of diameter of ovarian lesions between malignant and benign lesions.

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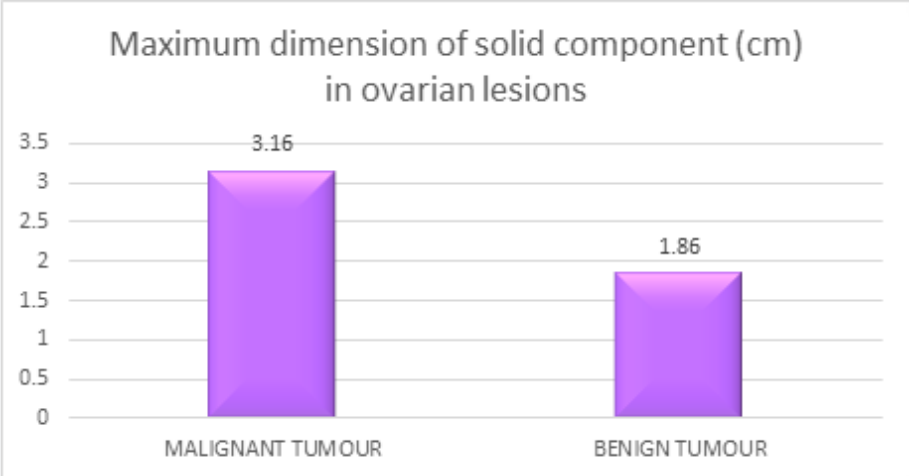

Figure 18: Association between of diameter of solid component in ovarian lesions [malignant and benign lesions].

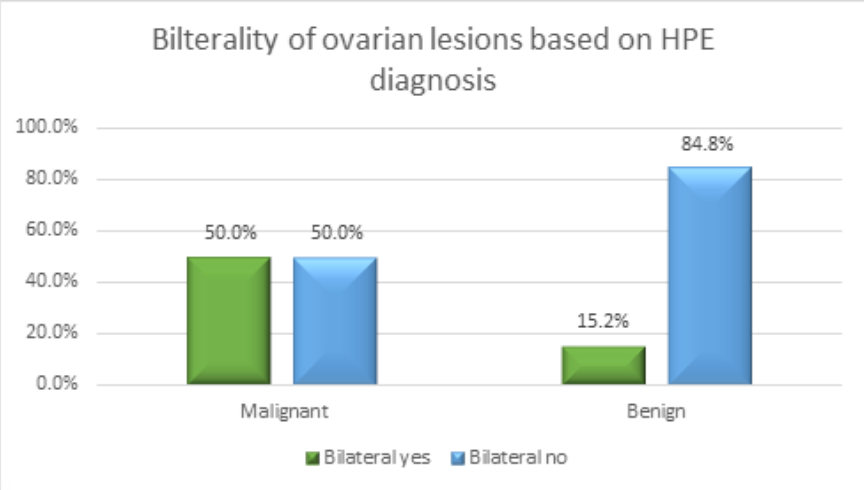

Figure 19: Association between laterality and ovarian lesions based on histopathological diagnosis.

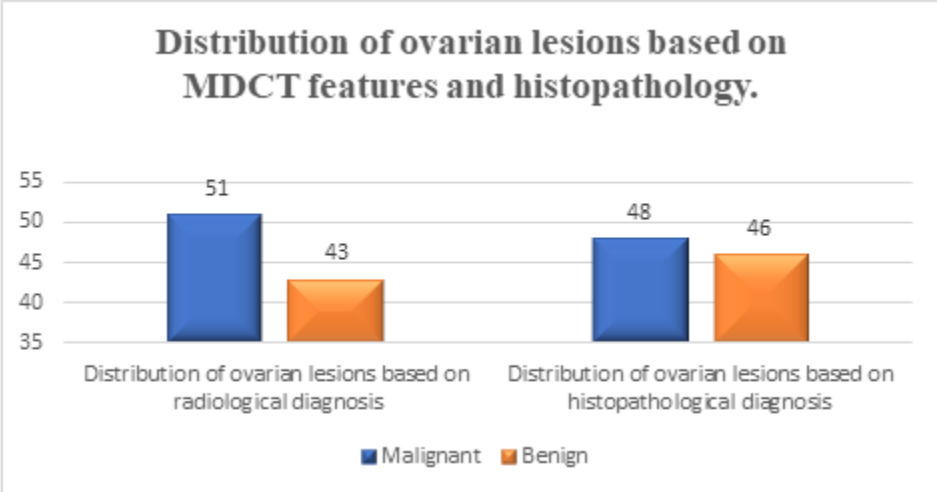

Figure 20: Distribution of ovarian lesions based on MDCT features and histopathology.

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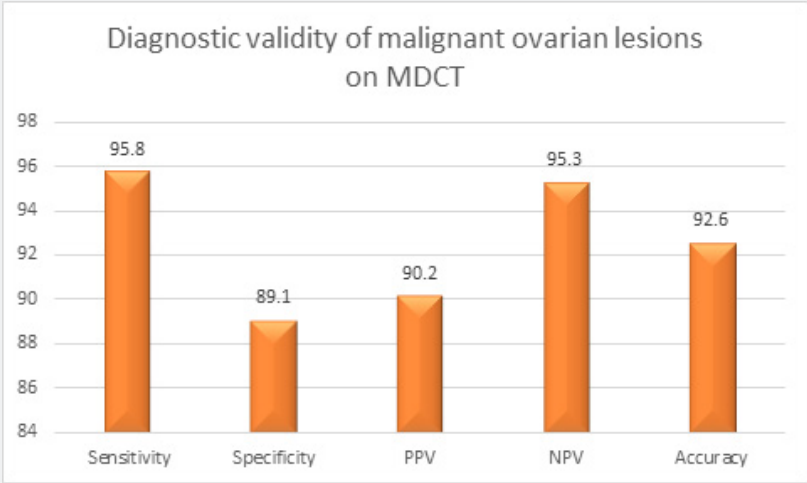

Figure 21: Diagnostic validity of malignant ovarian lesions on MDCT.

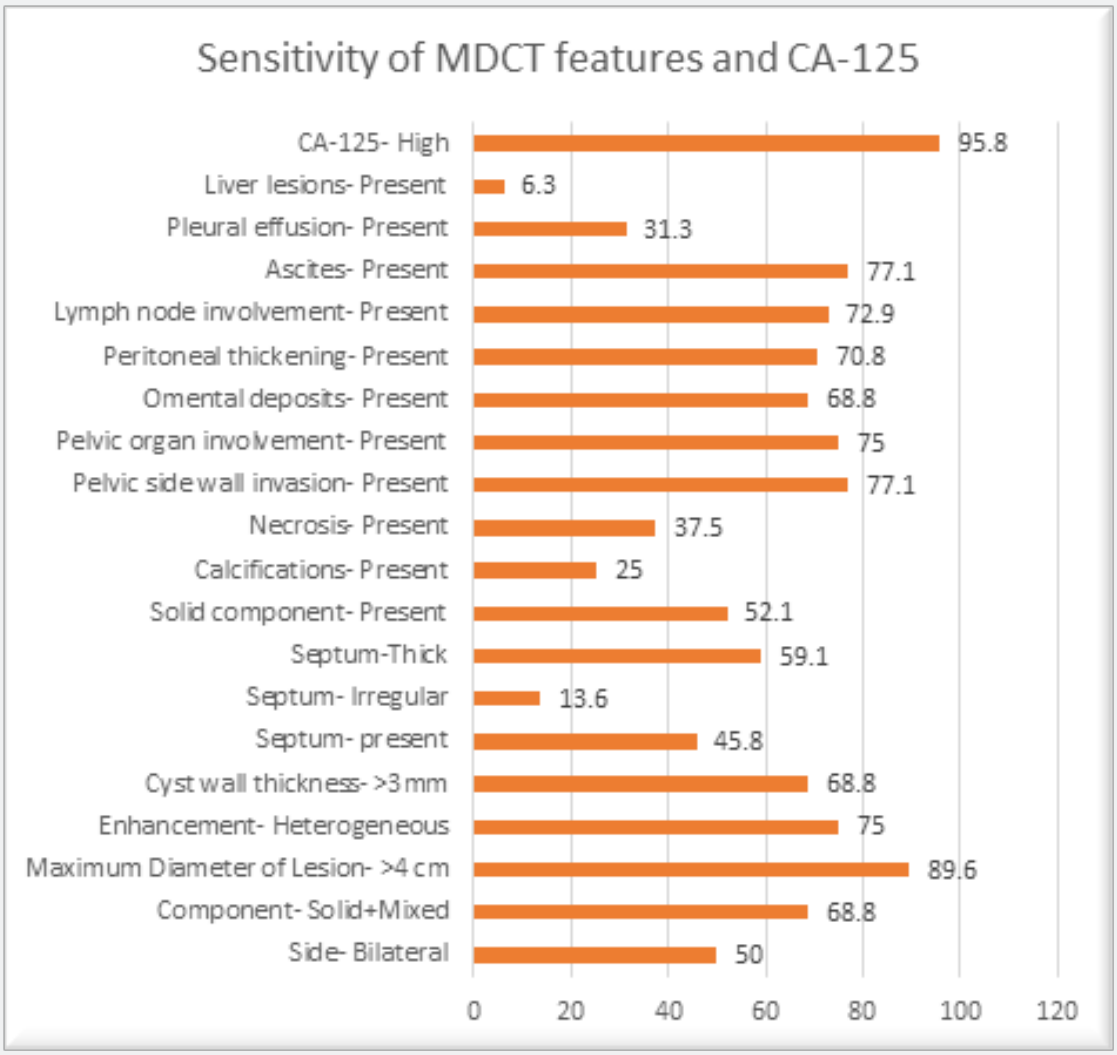

Figure 22: Sensitivity of MDCT features of malignant ovarian lesions and CA-125.

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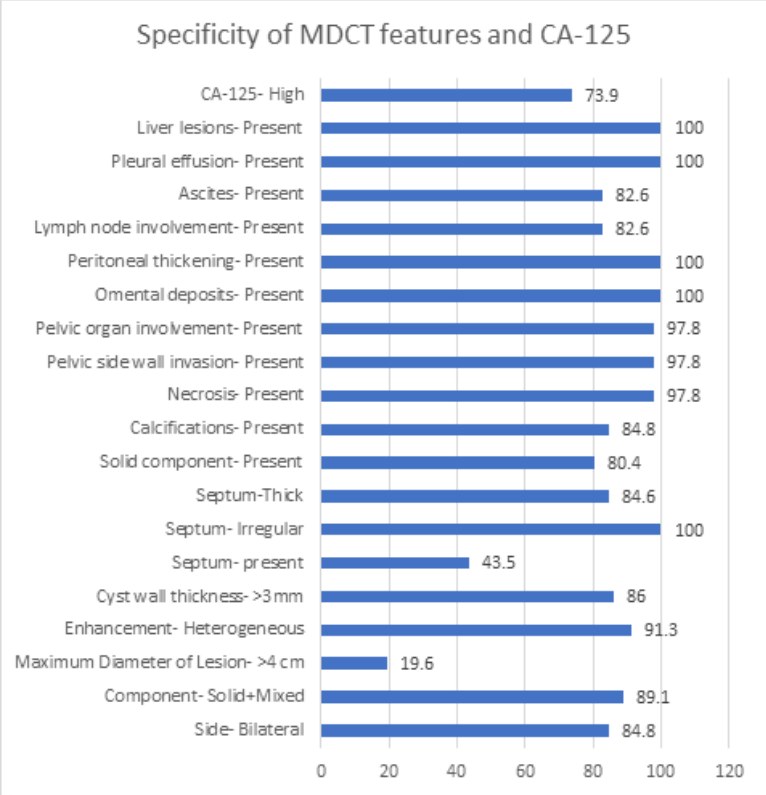

Figure 23: Specificity of MDCT features of malignant ovarian lesions and CA-125.

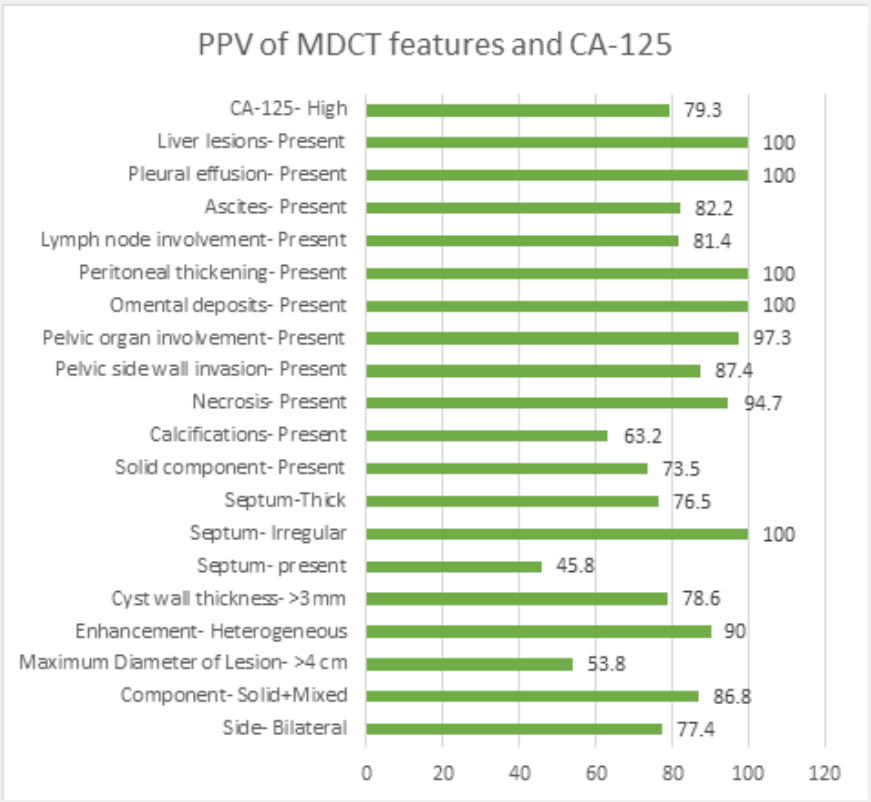

Figure 24: PPV of MDCT features of malignant ovarian lesions and CA-125.

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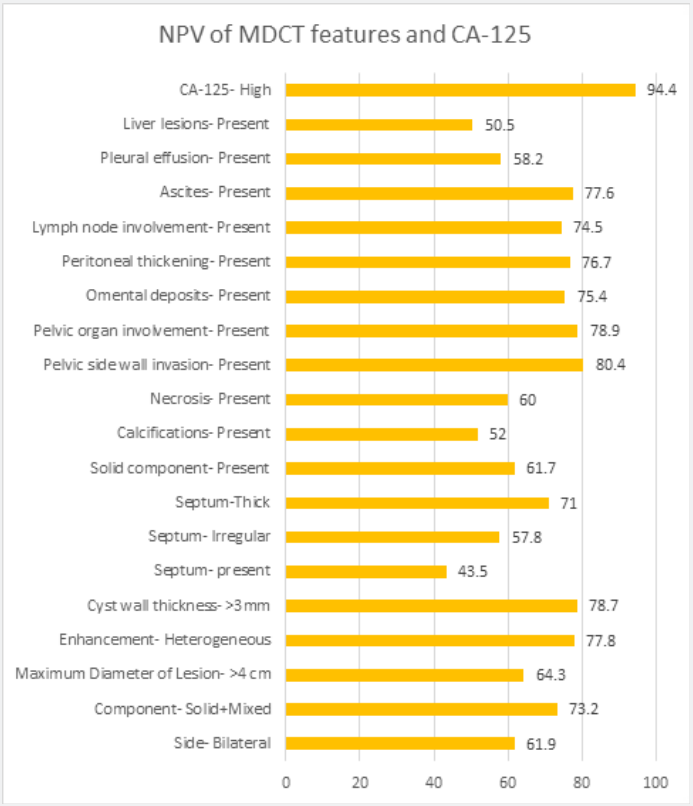

Figure 25: NPV of MDCT features of malignant ovarian lesions and CA-125

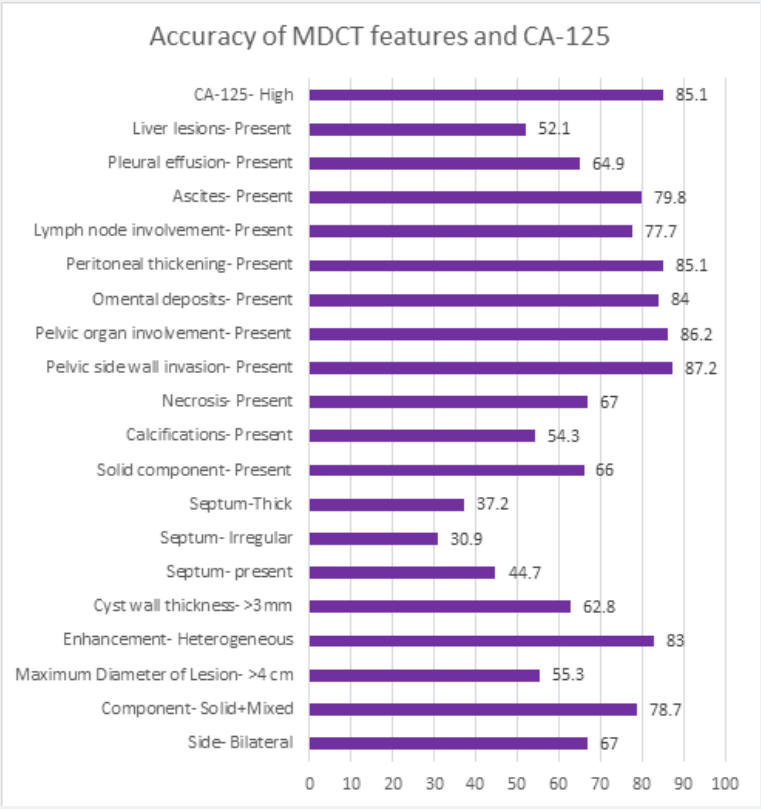

Figure 26: Accuracy of MDCT features of malignant ovarian lesions and CA-125

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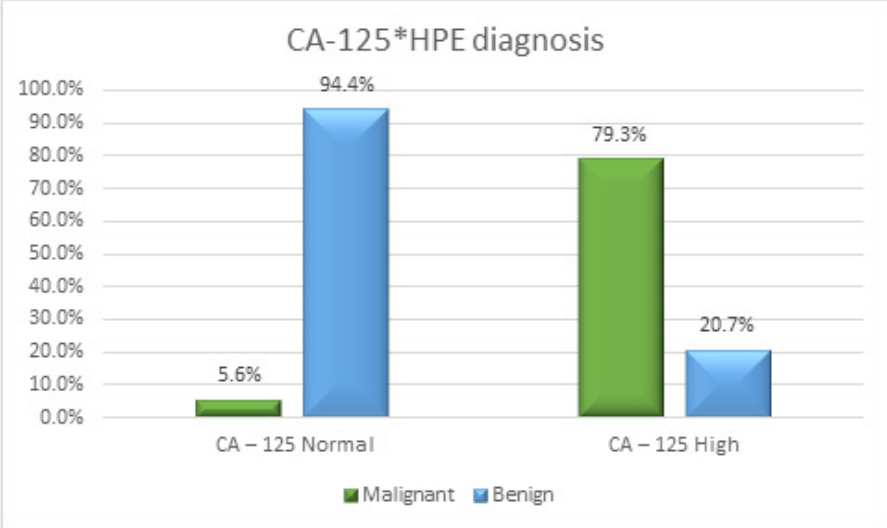

Figure 27: Association between CA-125 with ovarian tumours based on histopathological diagnosis.

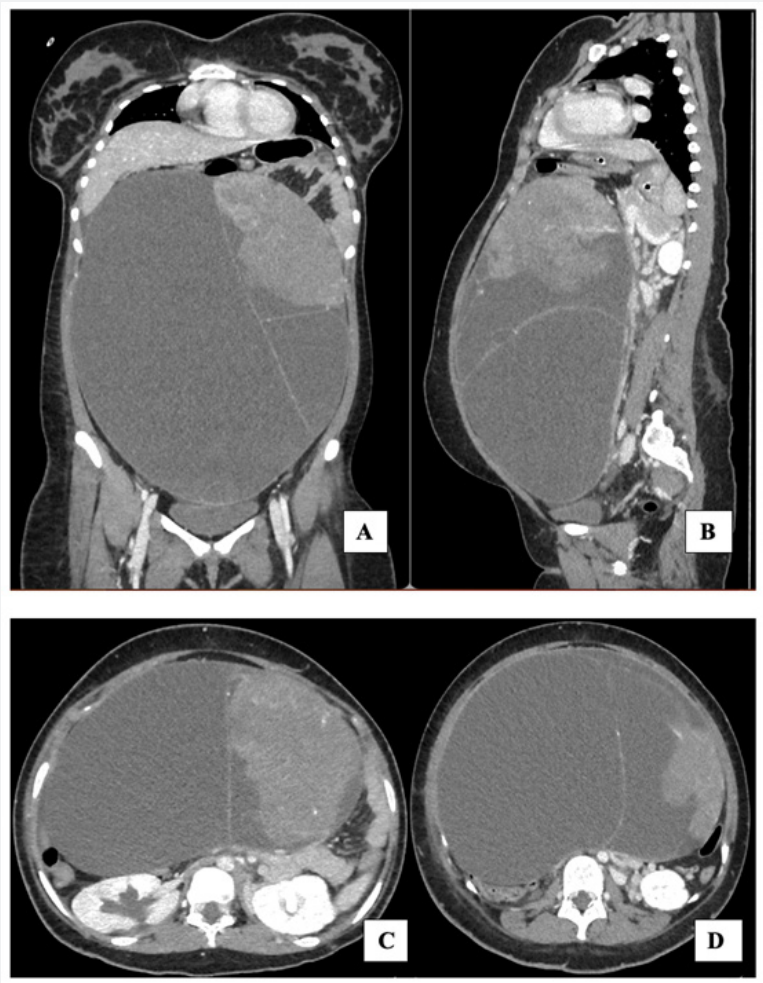

Figure 28: Figure A (Coronal view), Figure B (Sagittal view), Figure C and D (axial views) show CECT venous phase images of left ovarian thick-walled mixed solid cystic lesion measuring 32 cm in maximum dimension with heterogenous enhancement. The lesion shows presence of few thin regular septum, solid component and calcifications. HPE analysis revealed Borderline ovarian tumor.

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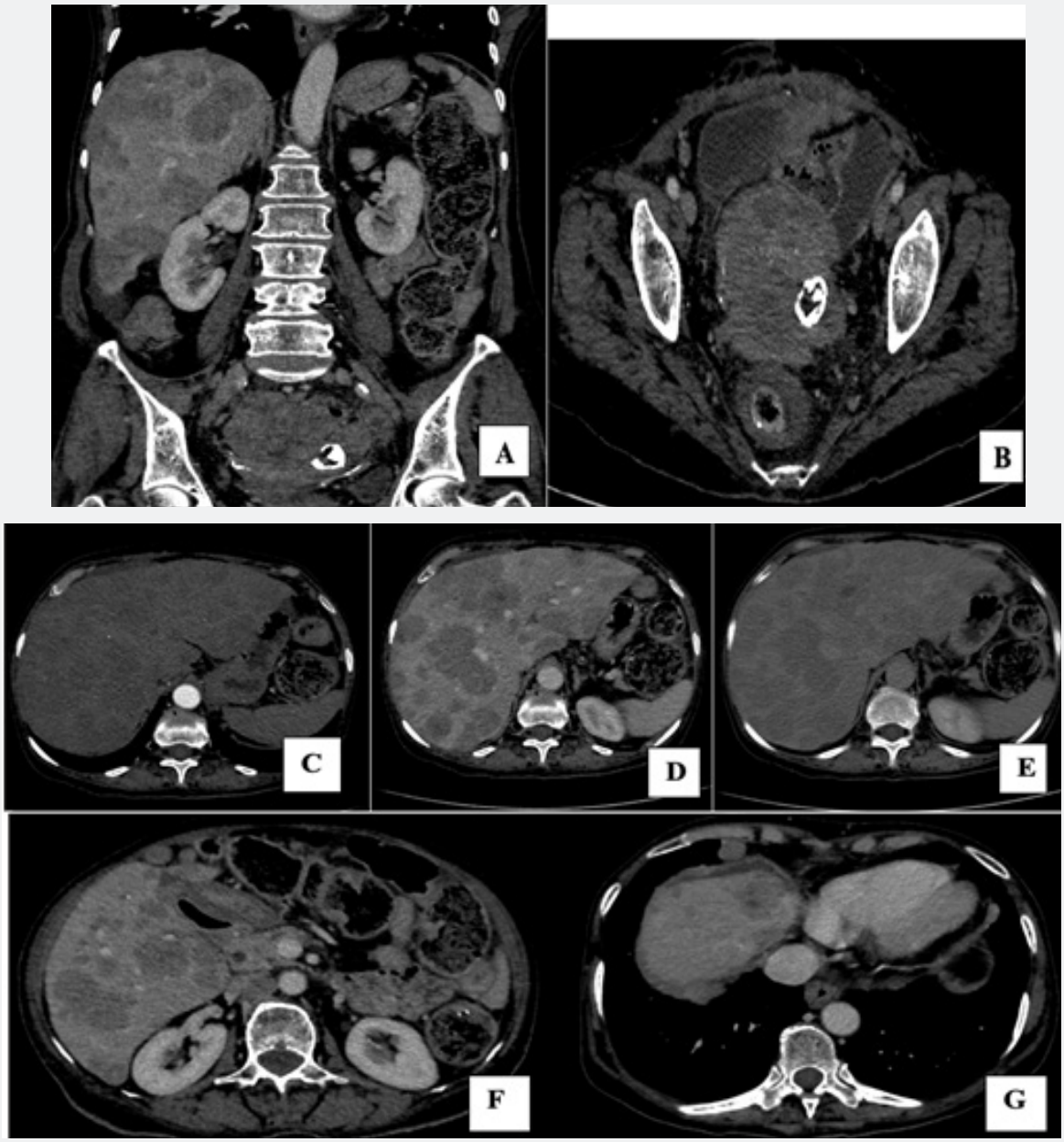

Figure 29: Figure A (coronal view venous phase) and Figure B (axial view venous phase) show a heterogeneous solid lesion in the pelvic cavity, with areas of non-enhancement and well-defined rim calcific focus. Figure C (axial view arterial phase), Figure D (axial view venous phase) and Figure E (axial view delayed phase show hepatomegaly and multiple bilobar variable sized heterogeneously enhancing lesions (metastases). Figure F (axial view) and Figure G (axial view) venous phase show multiple para-aortic lymph nodes, peritoneal, subdiaphragmatic deposits and parenchymal deposits in right lower lobe of lung. HPE analysis revealed Serous Cystadenocarcinoma.

Pelvic side wall invasion was able to diagnose the malignant ovarian tumors with have a sensitivity, specificity, PPV, NPV and accuracy of 77.1%, 97.8%, 87.4%, 80.4% and 87.2%

Involvement of pelvic organs had a sensitivity, specificity, PPV, NPV and accuracy of 75%, 97.8%, 97.3%, 78.9% and 86.2% for diagnosing malignant ovarian tumors. When **omental**

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deposits were found, it had a sensitivity, specificity, PPV, NPV and accuracy of 68.8%, 100%, 100%, 75.4% and 84% for diagnosing malignant ovarian tumors.

Presence of peritoneal thickening had a sensitivity, specificity, PPV, NPV and accuracy of 70.8%, 100%, 100%, 76.7% and 85.1% for diagnosing malignant ovarian tumors.

Lymph node involvement had a sensitivity, specificity, PPV, NPV and accuracy of 72.9%, 82.6%, 81.4%, 74.5% and 77.7% for diagnosing malignant ovarian tumors.

Ascites found in the MDCT had a sensitivity, specificity, PPV, NPV and accuracy of 77.1%, 82.6%, 82.2%, 77.6% and 79.8% for detecting malignant ovarian tumors.

Pleural effusion had a sensitivity, specificity, PPV, NPV and accuracy of 31.3%, 100%, 100%, 58.25 and 64.9% for diagnosing malignant ovarian tumors. When **liver lesions** were found, it had a sensitivity, specificity, PPV, NPV and accuracy of 6.3%, 100%, 100%, 50.5% and 52.1% for diagnosing malignant ovarian tumors.

In diagnosing the malignant ovarian tumors high CA-125 levels had a sensitivity, specificity, PPV, NPV and accuracy of 95.8%, 73.9%, 79.3%, 94.4% and 85.1% in our study. There was a significant association between higher CA-125 and the malignant ovarian tumors as there is a significant difference in CA-125 levels between patients diagnosed with malignant and benign ovarian lesions based on radiological diagnosis. Malignant cases have a significantly higher mean rank of CA-125 compared to benign cases. The table 25 shows that significantly higher proportion of patients with malignant ovarian lesions have high CA-125 levels compared to those with benign lesions. Conversely, a higher proportion of patients with benign lesions have normal CA-125 levels compared to those with malignant lesions. This association was statistically significant. There is a statistically significant association between CA-125 levels and the pathological diagnosis of malignant ovarian lesions, with malignant cases typically having higher CA-125 levels compared to benign cases. Diagnostic validity of various MDCT features and CA-125 in predicting the malignancy of ovarian lesions are enumerated below. CA-125 had the highest sensitivity (95.8%), followed by diameter of lesion >4 cm (89.6%). Liver lesions, pleural effusion, peritoneal thickening, omental deposits and irregular septum had 100% specificity and PPV. CA-125 had the highest NPV (94.4%), followed by pelvic side wall invasion (80.4%). Pelvic side wall invasion had the maximum accuracy (87.2%), followed by pelvic organ involvement (86.2%).

Discussion

The preoperative exploration of an adnexal mass is of utmost significance for treatment planning. Imaging plays a crucial role in the diagnosis of ovarian neoplasms. In the assessment of a suspected adnexal mass, ultrasound examination is the first-line imaging test. However, MRI and CT are useful for further characterization and staging of malignant lesions. Although imaging findings of ovarian neoplasms often overlap, several subtypes have distinct imaging, pathologic, and histologic characteristics that differentiate them from one another. Even though, USG is considered as the first line imaging modality for diagnosing ovarian neoplasms, the indeterminate lesions and lesions with no classical features require further imaging evaluation for characterization. MRI is considered a more promising modality for diagnosing ovarian lesions, offering high positive predictive value (PPV) and negative predictive value (NPV). Recently, the ACR-ORADS MRI committee published a lexicon and risk stratification system for adnexal lesions, aiming to enhance communication between referring physicians and radiologists. The main idea of this system is to avoid unnecessary surgical treatment in women with benign and borderline lesions, while identifying those with potential malignancies for early and effective oncological treatment [65]. Although MR imaging has potential advantages over other imaging modalities for diagnosing ovarian lesions, its use as a routine imaging modality is limited by factors such as accessibility, cost, acceptability (particularly for claustrophobic patients), and contraindications (like metal implants, pacemakers, or prosthetics).

Due to these limitations, various government programs in India, such as, Ayushman Bharat Pradhan Mantri Jan Arogya Yojana (PM-JAY), Rashtriya Arogya Nidhi (RAN), Dr. YSR Aarogyasri Health Scheme, Yeshasvini Scheme, and Central Government Health Scheme (CGHS), among others, have opted to cover CT scan as a more accessible and widely available diagnostic option. MDCT is the preferred choice for investigations due to its rapid scanning time, typically taking only a few minutes, which is often shorter than the preparation time itself. Furthermore, MDCT is more affordable and accessible than other imaging modalities like MRI. It is particularly beneficial for patients in severe pain or those who have difficulty remaining still, as it requires minimal time and effort from the patient, making it a more comfortable and practical option. Therefore, the primary objective of my study was to identify and develop specific MDCT characteristics of malignant ovarian lesions, enabling accurate diagnosis without the need for additional imaging tests. This would significantly benefit patients by streamlining the diagnostic process, reducing delays, and potentially improving treatment outcomes for malignant ovarian lesions. In light of the above, the present study was undertaken among 94 women who presented with ovarian masses at a tertiary care facility in South India, in which the MDCT features, their predictive capability and association with the malignant diagnosis were assessed. Studies in the past have explored the utility of multiple modalities of CT including MDCT and their features in evaluating ovarian malignancies. In a study similar to ours, Tsili et al from Greece evaluated the utility of MDCT among 143 adnexal masses in102 women for malignancies of ovaries. Mubarak et al from Pakistan also determined the diagnostic capability of the MDCT in ovarian malignancies among 100 masses. Khalda et al in their research from Sikkim, India also determined the diagnostic validity of MDCT in identifying and differentiating 112 adnexal masses. Similar studies on the diagnostic validity of MDCT in

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ovarian lesions were undertaken in Pakistan. Study from Oman assessed the validity of CA-125 markers in diagnosing the ovarian carcinoma [66].

Demography: Age

Overall mean age of the patients in the current study was 50.87 years. Mukhtar et al included patients with a mean age of 42.67 years. Most of the patients in Khalda et al study was in the age group of 31-40 years (25%) and 41-50 years (29.5%). The mean age of the patients with malignant ovarian masses in the current study was 53.33 years. Tsili et al and Mubarak et al reported 97.3% and 91.6% sensitivity and specificity included relatively older patients in their study (mean=60 years). The relatively older age of the patients in the malignant group than benign can be attributed to the association of higher age with cancer incidence, in general. In our study, the mean age of the benign ovarian lesion patients was 48.30 years, which was similar to the age group included in Tsili et al. study (mean=48 years). Much younger patients were found in the benign group in Mubarak et al study who reported a mean age of 23.5 years.

Our research reveals that malignant ovarian cancer is increasingly affecting younger individuals, primarily driven by factors such as obesity, smoking, delayed childbearing, having no children and a personal or family history of breast, ovarian, or colorectal cancer [67].

Additionally, inherited cancer syndromes and lower socioeconomic status and education levels [68], are also linked to a higher risk. These factors collectively contribute to the growing trend of ovarian cancer among younger people, highlighting the crucial need for awareness and early detection to improve outcomes.

MDCT features of ovarian lesions

Among the ovarian lesions reported in our study, cystic (59.6%) followed by solid and mixed (20.2%) were the components present. This pattern was reflected in the Khalda et al study as well (cystic-51% and 18%-Solid). While most of our patients had a cyst wall thickness of <3 mm (62.7%), Khalda et al also reported similar thin-walled status in adnexal masses among 52% of the lesions. In our study, septations were present in 51.1% of the patients, of which the majority regular septations in the ovarian lesions (93.8%). Khalda et al found septations were absent in most of the patients (54%). Ascites was found among 47.9% of the patients with ovarian lesions in our study. A relatively lower proportion of patients had ascites in Khalda et al study (34%).

According to the MDCT findings, the mean maximum diameter of the benign and malignant lesions among our patients was 11.17 cm and 10.89 cm, respectively. Although the size was mentioned separately for benign and ovarian lesions in Tsili et al study, the overall mean size of the lesions was lower than our study (mean=9.3 cm). While 33% of the patients in our study had bilateral lesions only 18% of the Khalda et al study was found to be bilateral.

Bilateral and larger-sized ovarian lesions are more indicative of malignant ovarian cancers due to several factors related to tumor biology, growth patterns, and metastatic behavior. Malignant cells can spread through hematogenous, lymphatic, and trans coelomic routes, leading to bilateral involvement. Aggressive tumors, such as high-grade serous carcinomas, can quickly affect both ovaries. Larger lesion size indicates malignancy due to the rapid and uncontrolled growth of cancer cells, driven by high proliferative capacity and angiogenesis. Their invasive nature and resistance to cell death also contribute to unchecked growth and larger tumor sizes. In my study, I found an increase in bilateral and large lesions, which is consistent with the fact that malignant tumors often grow silently, leading to late detection and advanced disease stages.

Diagnosis of ovarian lesions

In our study, 51.1% of the ovarian lesions were malignant in the final diagnosis by means of histopathological examination, which is similar to the malignancy rate reported in Khalda et al (50.9%) study. In contrast, only 33% of the patients in Tsili et al study had malignant ovarian lesions. Mukhtar et al reported a much higher malignancy rate in their patients (71.5%). In the present study, as per the radiological investigation, 54.3% of the ovarian lesions were found to be malignant, which is close to the proportion of malignancy reported in Khalda et al study (50%). A much higher proportion of malignant diagnoses was made in Mubarak et al and Mukhtar et al studies (76% and 70%). Among the patients of benign lesions in our study, serous cystadenoma (10.6%) followed by mucinous cystadenoma (9.6%) were the most common. Khalda et al echoed this pattern with 25.9% having been found to have serous cystadenoma among the lesions. Although Tsili et al also reported serous cystadenoma as one of the most common. uterine lesions which comprised of leiomyoma and adenomyosis formed the most common benign diagnosis in their patients (29/96). Mubarak et al found endometrioma as the most common benign ovarian mass (12). In the present study, serous cystadenocarcinoma (30.9%) was the most common malignant ovarian lesion noted, which is in line with the findings of Khalda et al (26.8%) and Tsili et al (17/47). Mubarak et al also reported adenocarcinomas (32) as the most common malignant lesion.

Correlation between MDCT and histopathological diagnosis

In the present study, bilateral ovarian lesions, mixed and solid cystic lesions, soft tissue or mixed density, heterogenous enhancement, cyst wall thickness -> 3 mm, presence of solid components/ mural nodule, necrosis in solid lesion, pelvic sidewall invasion, pelvic organ involvement, lymph node involvement and ascites were found to have an association with the malignancy in univariate analysis. Most of these MDCT features (bilaterality, solid cystic lesions, necrosis of solid lesion, septal irregularity,

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pelvic wall invasion, lymph nodes and ascites) were also found to be significantly associated with malignancy in Tsili et al study as well. Size of tumor more than 4 cm in MDCT was not found to be significant predictor of malignancy, which was also reverberated in Tsili et al. CECT-based evaluation of the ovarian mass also reported a similar positive association of all these factors with malignant ovarian tumours. These findings indicate the high utility of CT as a whole in detecting malignant ovarian tumours in a much less invasive procedure. Although USG is the first modality of investigation as per the current guidelines, CT abdomen is also recommended in the investigations of ovarian mass and malignancy [69]. However, multivariate analysis revealed that pelvic sidewall invasion and ascites were statistically significant predictors of malignancy in the index study. In contrast, necrosis of solid lesions, papillary projections and peritoneal metastases were determined to have a significant association with ovarian malignancy by Tsili et al. These variations might be due to the tumor features according to the population and local settings or the tumor histology, which can be brought out if adequately powered studies for individual malignant tumours are undertaken to detect the association of MCDT features with those tumours.

Diagnostic validity (sensitivity, specificity and accuracy) of MDCT and its features for ovarian malignancy

The accuracy of MDCT in detecting ovarian malignancy in the current study was 92.6%. Tsili et al reported that MDCT had a slightly lower accuracy (89.15%) for the pelvic masses in their study among similar malignancies. Higher accuracy of 96% and 96.83% were documented in the Mubarak et al and Mukhtar et al studies from Pakistan. The sensitivity and specificity of MDCT towards malignant ovarian lesions were 90% and 88.76% as per the Tsili et al study. While we found a similar specificity (89.1%), sensitivity was slightly higher (95.8%) than the Tsili et al study. However, Mukhtar et al reported both sensitivity (95.55%) and specificity (97.34%) higher than our study. Mubarak et al reported 97.3% and 91.6% sensitivity and specificity for MDCT towards malignant ovarian mass. A sensitivity of 93% and specificity of 94.5% were detected in the Khalda et al study for MDCT in diagnosing malignant lesions. In the present settings, MDCT had a positive and negative predictive capability of 90.2% and 92.6% when detecting ovarian malignancies. Tsili et al documented lower PPV (78.26%), but higher NPV (95.18%) among their patients[10]. Mubarak et al reported 97.3% and 91.6% PPV and NPV among their patients for the diagnosis of a malignant ovarian mass. In line with Mubarak et al, Mukhtar et al also showed higher PPV (93.47%) and NPV (97.34%) than our study. Khalda et al in their study from Sikkim detected 94.6% and 92.8% PPV and NPV for predicting the malignant lesions.

The diagnostic validity of MDCT found in our study was either comparable to or better than the measures reported for other modalities of CT such as CECT. As reported by Bhund et al CECT of the abdomen and pelvis had an accuracy of 94.2% for detecting ovarian malignancy [70]. In the present study, bilateral ovarian mass identified in MDCT was found to have a sensitivity, specificity, PPV, NPV and accuracy of 50%, 84.8%, 77.4%, 61.9% and 67% for diagnosing malignant ovarian tumors. Moideen et al from Karnataka reported that CT findings of bilaterality had a relatively higher sensitivity, specificity, PPV, and accuracy of 85.1%, 85.1%, 85.1% and 85% for malignant ovarian tumor. If a post-menopausal patient has ascites with an adnexal tumor, it suggests the potential existence of cancer. The existence of these observations posed challenges in ruling out malignancy, resulting in inaccurate positive results. Among our patients, ascites found in the MDCT had a sensitivity, specificity, PPV, NPV and accuracy of 77.1%, 82.6%, 82.2%, 77.6% and 79.8% for detecting malignant ovarian tumors. Sensitivity (87.5%) and NPV (90.4%) were found higher in the Moideen et al study for malignant ascites detected in CT for diagnosing the ovarian carcinoma, however, lower accuracy (61%) than our study reported. Pelvic sidewall invasion had the maximum accuracy (87.2%), followed by pelvic organ involvement (86.2%). One case in almost all the benign ovarian tumors in the present study had high CA-125 ranging from 50.8 (Thecoma in right ovary and left ovary) to 605 (Bilateral Endometriotic cysts). While we noticed a sensitivity, specificity, PPV, NPV and accuracy of 72.9%, 82.6%, 81.4%, 74.5% and 77.7% in Lymph node involvement for diagnosing malignant ovarian tumors, Moideen et al reported a higher sensitivity and NPV of 81.8% and 93.5%, but lower accuracy of 70% than our study.

CA-125 and its diagnostic validity

The levels of serum CA125 are increased in fifty percent of early-stage tumors, which are mostly type 1 ovarian cancers, and in ninety-two percent of advanced-stage tumors, which are primarily type 2 ovarian cancers. The significant association which was identified between higher CA-125 and the malignant ovarian tumors in our study, was also reiterated in the Al-Musalhi et al study. Among our patients, high CA-125 levels had a sensitivity, specificity, PPV, NPV and accuracy of 95.8%, 73.9%, 79.3%, 94.4% and 85.1% for diagnosing malignant ovarian tumors. In contrast, Al-Musalhi et al reported relatively lower diagnostic validity measures for CA-125 in detecting malignant tumors of the ovary (sensitivity-69%, specificity-68%, PPV-31, NPV-92%).

Limitations

The present study has several limitations that must be acknowledged. Firstly, the study's single-center design limits the generalizability of the findings to other settings. Additionally, multidetector CT has some inherent limitations, including difficulty in detecting microscopic disease or small-sized tumors (<0.5 cm) and determining the laterality (unilateral or bilateral) of large adnexal masses.

Conclusion

Overall, MDCT diagnosed malignant ovarian lesions in 54.3% of patients, which was confirmed by histopathological diagnosis in 51.1% of cases. MDCT demonstrated a high diagnostic accuracy

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of 91.6% in detecting ovarian malignancy. The most sensitive marker for diagnosing malignant ovarian tumors was a lesion diameter >4 cm on MDCT (89.6%). MDCT was most accurate in detecting pelvic organ involvement (86.2%) in malignant ovarian tumors. Additionally, pelvic sidewall invasion and ascites were significant predictors of ovarian malignancy. Therefore, MDCT can serve as a valuable tool for minimally invasive detection of ovarian malignancy in current clinical settings.

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