Original Article

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Modified Computed Tomography Scoring System for Ovarian Tumors

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Abstract:

Objective: Ovarian cancer is the sixth most common cancer in Thailand. Given the absence of a computed tomography (CT) score for differentiating between benign and malignant ovarian tumors, this study aimed to develop a CT scoring system for differentiating between benign and malignant ovarian tumors using pathologic findings as the reference standard.

Material and Methods: This retrospective study included all female patients having undergone abdominal/pelvic CT scans for evaluation of ovarian masses at our institute, from January 2011 to December 2021. Two radiologists independently reviewed CT features and obtained a CT score for each tumor. Comparison of the differentiation performance of the CT score, with reference to the pathologic findings, was performed using Fisher's exact or chi-squared test. The diagnostic performance of the CT score was evaluated.

Results: A total of 144 patients with 191 ovarian masses were enrolled. Tumor component characteristics, septate thickness, ascites, and metastasis significantly differed between benign and malignant tumors (p-value<0.05). Multivariate logistic regression analysis showed that the presence of solid components and metastasis were significant independent differentiating factors (p-value<0.001). The CT score significantly differed between benign and malignant tumors (p-value<0.001), with 93.5% sensitivity and 81.6% specificity.

Conclusion: The CT scoring system can differentiate between benign and malignant ovarian tumors with high sensitivity and specificity. Furthermore, the presence of a solid component and metastasis are CT features that can be used to differentiate between benign and malignant tumors.

Keywords: benign, computed tomography, malignant, ovarian tumor, scoring system

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Introduction

Ovarian cancer is the sixth most common cancer in Thailand, with a mean annual incidence of 6.0 per 100,000 women in 2011[1]. Most women with ovarian cancer are not diagnosed until it is at an advanced stage given its non-specific clinical presentations; such as abdominal pain or distension[2,3]. Imaging modalities; such as ultrasonography, computed tomography (CT), and magnetic resonance imaging (MRI), have become essential for determining the likelihood of ovarian tumors being benign or malignant; since benign tumors can be followed up while malignant tumors require referrals to a gynecologic oncologist at a tertiary center for complete surgical staging[4].

Most ovarian masses are initially evaluated using ultrasound. However, the diagnostic accuracy of ultrasound examinations is operator-dependent. Furthermore, some conditions that limit the accuracy of transvaginal examinations, e.g., large masses or virginity, may be indications for performing CT or MRI scans[4]. CT is preferred for initial staging of pretreatment ovarian cancer[5]. Furthermore, CT scans can reveal the tumor response to therapy and facilitate the detection of persistent or recurrent disease[6]. Moreover, CT is more cost-effective and more widely available than MRI. However, CT scans involve exposure to ionizing radiation, which can cause radiation-induced diseases[7]. Contrastingly, MRI shows superior soft-tissue characterization, because the solid component is clearly depicted on T2-weighted images[8]. Additionally, MRI examinations can be performed without using any ionizing radiation; however, in low-to-middle income countries, they are often less accessible than CT scans[9,10].

In September 2020, the American College of Radiology (ACR) developed the Ovarian-Adnexal Reporting and Data System Magnetic Resonance Imaging (O-RADS MRI) for risk stratification of ovarian tumors. It was based on MRI features grouped into five categories according to the positive likelihood ratio for malignant neoplasm[11]. A subsequent study validated the accuracy of the O-RADS MRI for risk stratification of ovarian masses, indicating an accuracy of 97.0%, specificity of 91.0%, and sensitivity of 93.0% in stratifying the risk for malignancy of ovarian tumors[12].

However, there remains no CT scoring system for risk stratification of ovarian tumors. Therefore, this study aimed to develop a CT scoring system based on the existing O-RADS MRI for differentiating between benign and malignant ovarian tumors, with pathologic findings as the reference standard.

Material and Methods

Patients

This retrospective study was conducted using data obtained from all female patients, who underwent abdominal/pelvic CT scans for evaluation of ovarian masses at our institute; from January 2011 to December 2021. The inclusion criteria were as follows:

1. Age ≥15 years
2. Available of abdominal/pelvic CT scans
3. Available of pathologic findings

Among the 207 patients with available data, 154 patients met the inclusion criteria. Furthermore, five patients were excluded that had undergone hysterectomy due to inability to compare enhancement of the ovarian mass and myometrium as well as five patients with ovarian cysts <3 cm in size. Finally, 144 patients were enrolled in this study (Figure 1). The hospital information system records of the included patients were retrospectively reviewed. The demographic data; including age, menopausal status, family history of cancer, clinical presentations, and laboratory investigation data, were recorded. This study was approved by the Human Research Ethics Committee (Approval number REC. 64-119-7-4), which waived the requirement for informed consent.

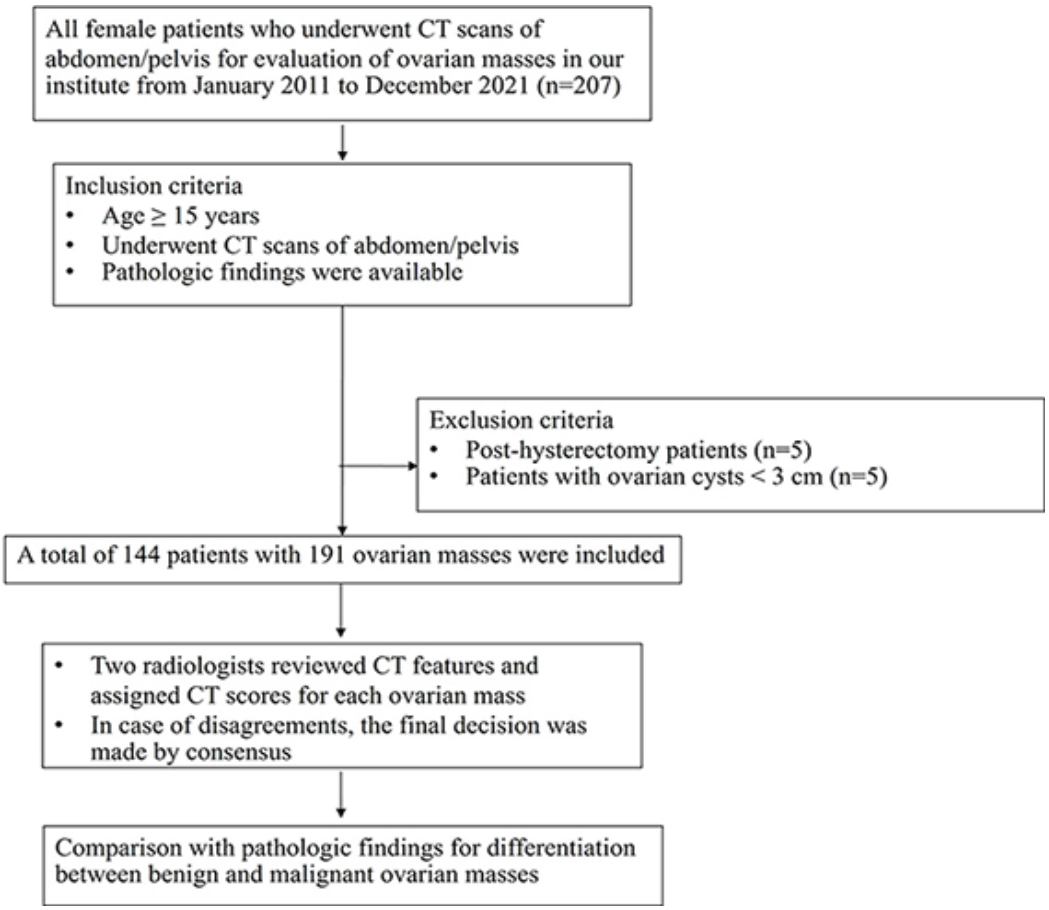


Figure 1 Study flowchart

Imaging protocol

Three CT machines were used for abdominal/pelvic CT scans; including two 160-slice CT scanners (Aquilion Prime; Toshiba Medical Systems, Tochigi, Japan) and a 512-slice CT scanner (Revolution CT; GE Healthcare, Waukesha, WI, USA). Positive oral contrast material was used. The protocol for abdominal/pelvic examinations consisted of at least a non-contrast pelvic CT scan, followed by portal venous phase CT scanning from the base of the lungs to the pubic symphysis, at 70 s after intravenous administration of 1.7–2.0 mL/Kg of non-ionic iodinated contrast media, e.g., Iohexol (350 mg iodine/mL; Omnipaque), Iopromide (370 mg iodine/mL; Ultravist), and Iodixanol (320 mg iodine/mL; Visipaque), followed by injection of 30–50 mL of saline solution using the bolus-tracking method with an automatic injector at a rate of 1.5–2.5 mL/s through a puncture in the peripheral vein (dorsum of the hand or median cubital vein). The scan parameters were as follows: 120 kVp; auto mAs; collimation 0.5 mm; thickness 3 mm; and interval 3 mm. Axial images underwent post-processing multiplanar reconstruction to the coronal and sagittal planes and were transferred to a picture archiving and communication system.

Imaging analysis

Two radiologists having 7 and 14 years of experience independently reviewed the CT features; including: laterality, maximal diameter, component characteristics, locularity, wall

thickness, septate thickness, fluid content, enhancement, calcification, ascites, and metastasis. For patients with multiple tumors, each tumor was evaluated separately. The maximal diameter in centimeters (cm) was measured in the axial plane. Based on the components, each tumor was categorized as a cystic mass, solid mass, mixed cystic/solid mass, mixed cystic/fatty mass, or mixed cystic/solid/fatty mass. The degree of enhancement was compared with that of the myometrium and classified as less than and equal to, or greater than that of the myometrium. Ascites and metastasis were categorized as absent or present. The definitions of these CT features are provided in Table 1.

Subsequently, the radiologists assigned a CT score to each ovarian tumor. The definition and an example of each CT score are presented in Figure 2 and Table 2. A CT score of 1 indicated ovarian cysts <3 cm in size.

Table 1 Lexicon of CT features

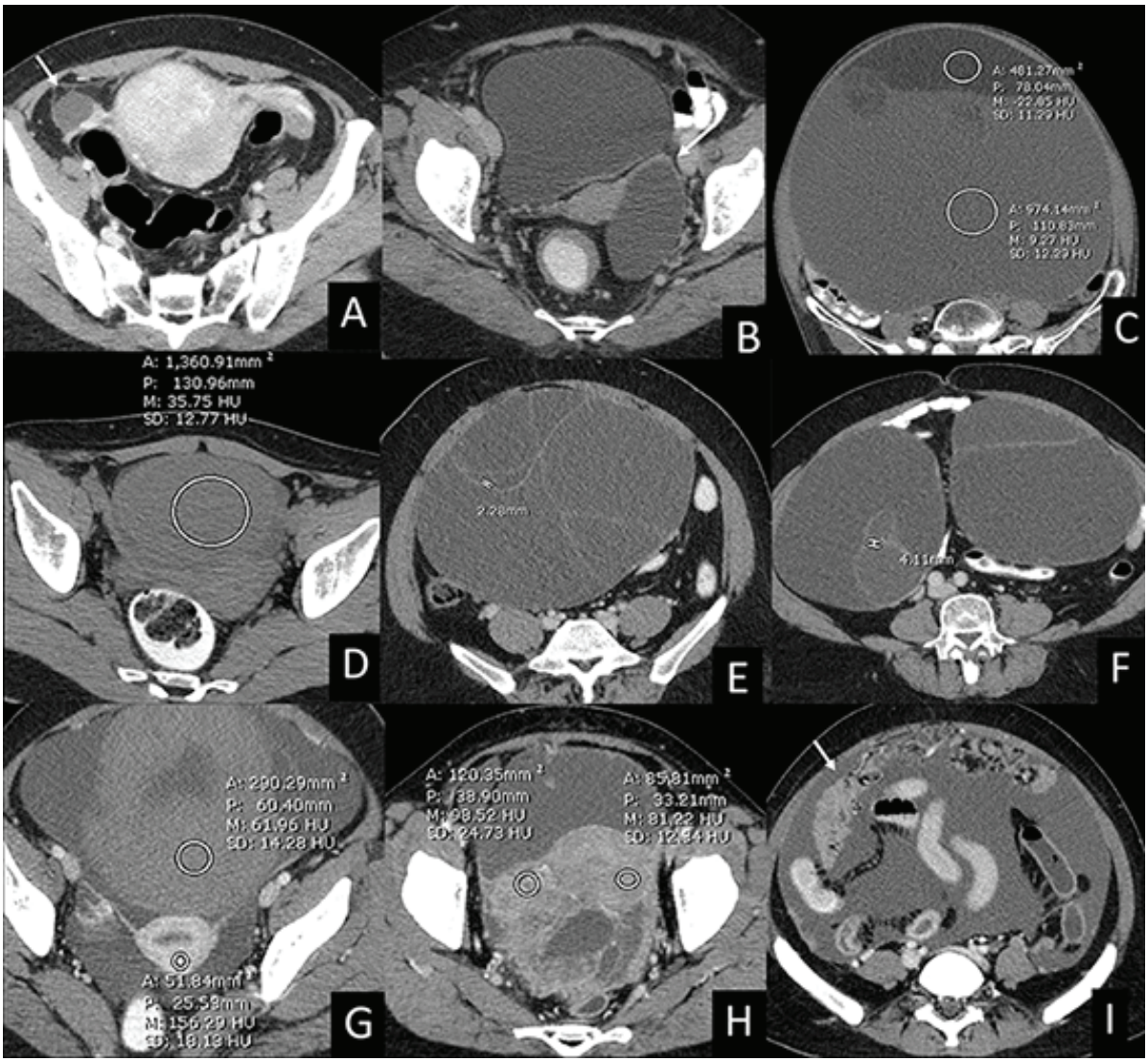
Term	Definition
Cystic mass	Cyst without a solid portion
Solid mass	Enhancing solid mass
Mixed cystic and solid mass	Cyst with enhancing solid portion
Mixed cystic and fatty mass	Cyst with lipid content
Mixed cystic, solid, and fatty mass	Cyst with enhancing solid portion and lipid content
Unilocularity	Single locule
Multilocularity	>1 locule
Thin wall	Wall thickness <3 mm
Thick wall	Wall thickness ≥3 mm
Thin septation	Septate thickness <3 mm
Thick septation	Septate thickness ≥3 mm
Simple content	Fluid content <30 HU in a non-contrast study[13]
Proteinaceous or hemorrhagic content	Fluid content ≥30 HU in a non-contrast study[13]
Necrosis	Non-enhancing solid portion
Enhancement	Increased ≥20 HU from non-contrast to contrast studies
Ascites	Fluid outside the pouch of Douglas or cul-de-sac or fluid extending beyond the space between the uterus and bladder[14]
Metastasis	Peritoneal, nodal, or distant metastasis[15]

CT=computed tomography

Table 2 CT scoring system

CT score	PPV	CT findings
1	-	Ovarian cysts <3 cm
2	-	A uniloculated simple cystic mass or a mixed cystic and fatty mass
3	86.9%	A uniloculated proteinaceous or hemorrhagic cystic mass or a multiloculated cystic mass with a thin wall and thin septation
4	95.3%	A multiloculated cystic mass with a thick wall or thick septation or a solid mass with enhancement lesser than that of the myometrium
5	99.1%	A solid mass with enhancement equal to or greater than that of the myometrium or metastasis with or without ascites

PPV=positive predictive value (for malignancy), CT=computed tomography



CT=computed tomography

Figure 2 CT scoring system

CT score 1: (A) cyst <3 cm (arrow). CT score 2: (B) uniloculated simple cystic mass and (C) mixed cystic and fatty mass. CT score 3: (D) uniloculated proteinaceous or hemorrhagic cystic mass and (E) multiloculated cystic mass with a thin wall and thin septation. CT score 4: (F) multiloculated cystic mass with a thick wall or thick septation and (G) solid mass with enhancement lesser than that of the myometrium. CT score 5: (H) solid mass with enhancement equal to, or greater than that of the myometrium and (I) metastasis (arrow)

By definition, tumors with a CT score of 1 were excluded from this study. A CT score of 2 indicated a uniloculated simple cystic mass or a mixed cystic and fatty mass. A CT score of 3 indicated a uniloculated proteinaceous or hemorrhagic cystic mass or a multiloculated cystic mass with a thin wall and thin septation. A CT score of 4 indicated a multiloculated cystic mass with a thick wall, or thick septation or a solid mass with enhancement lesser than that of the myometrium. A CT score of 5 indicated a solid mass with enhancement equal to or greater than that of the myometrium or metastasis, with or without ascites. The cutoff point for differentiation between benign and malignant ovarian tumors was a CT score of 4, with CT scores <4 and ≥4 indicating benign and malignant tumors, respectively[11].

In case of disagreements, the final decision was made by consensus. All radiologists were blinded to the patients' clinical information and pathologic results.

Reference standard

Pathological findings were used to categorize the benign and malignant ovarian tumors. We categorized borderline tumors as malignant tumors; as patients with borderline tumors had to be referred to a gynecologist for complete surgical staging, similar to the protocol for malignant tumors. However, most borderline tumors had a good prognosis; additionally, patients who wished to preserve their fertility could undergo fertility-sparing surgery, e.g., unilateral salpingo-oophorectomy[16].

In this study, benign tumors included: serous cystadenomas, mucinous cystadenomas, benign germ cell tumors, fibromas, struma ovarii, endometriotic cysts and other benign lesions. The malignant tumors included: serous borderline tumors, serous cystadenocarcinomas, mucinous borderline tumors, mucinous cystadenocarcinomas, ovarian collision tumor (mucinous adenocarcinoma and dermoid cyst), endometrioid carcinomas, clear cell carcinomas, malignant germ cell tumors, granulosa cell tumors and metastases.

Statistical analysis

Statistical analyses were performed by R software Version 4.2.0 (R foundation, Vienna, Austria). Categorical variables are presented as number and percentage. The patients' age, menopausal status, family history of cancer, clinical presentations, and laboratory investigations for both benign and malignant ovarian tumors were compared with the corresponding pathologic findings. The median values for patient age and laboratory data are presented with interquartile range (IQR) values. The menopausal status was evaluated using the chi-squared test, while family history of cancer and clinical presentations were analyzed using Fisher's exact test.

Each CT feature was compared with pathologic findings for benign and malignant ovarian tumors. The maximal diameter was presented with IQR values. The chi-squared test was performed for comparisons of uni- or bilaterality, component characteristics, uni- or multilocularity, wall thickness, septate thickness, fluid content, calcification, ascites and metastasis. Fisher's exact test was performed for comparisons of enhancement. Statistical significance was set at a p-value<0.05. Subsequently, multivariate logistic regression was performed. Comparisons of each CT score with pathologic findings for benign and malignant ovarian tumors were performed using Fisher's exact test; statistical significance was set at a p-value<0.05. Finally, the diagnostic performance of the CT score was calculated.

Kappa statistical analysis was used to determine interobserver agreement in CT features and CT score, with Kappa values of 0.20–0.40, 0.41–0.60, 0.61–0.80; and 0.81–0.99 indicating fair, moderate, substantial and almost perfect agreement, respectively.

Results

Patient characteristics

A total of 144 patients with 191 pelvic masses were enrolled in this study. The demographic characteristics of the patients are presented in Table 3. There was no

significant difference in age, menopausal status, family history of cancer, and clinical presentations between the benign and the malignant tumors. (p-value=0.128, 0.095, 0.176, and 0.423, respectively). Contrastingly, all laboratory test results, including CA-125 level, HE-4 level, and Risk of Ovarian Malignancy Algorithm (ROMA) score, significantly differed between benign and malignant ovarian tumors (p-value<0.001).

Ovarian mass characterization

All CT features were compared with pathologic findings as the reference standard to differentiate between benign and malignant ovarian tumors (Table 4). In the univariate analysis, component characteristics significantly differed between benign and malignant tumors (p-value<0.001). Specifically, cystic and solid masses were more frequently found in benign (n=26; 68.4%) and malignant tumors (n=28; 18.3%), respectively. Moreover, mixed cystic and fatty masses were found more frequently in benign tumors (n=5; 13.1%), while mixed cystic and solid masses were found more frequently in malignant tumors (n=100, 65.4%). Septate thickness significantly differed between benign and malignant tumors (p-value=0.009); specifically, thin and thick septation was found more frequently in benign (n=27, 71.1%) and malignant tumors (n=83, 54.2%), respectively.

Similarly, the incidence of ascites and metastasis significantly differed between benign and malignant tumors (p-value<0.001). Specifically, the incidence of ascites and metastasis were significantly greater in malignant tumors (n=96, 62.7% and n=104, 68.0%; respectively) than in benign tumors. In multivariate logistic regression analysis (Table 4), the presence of a solid component and metastasis were significant, independent factors for differentiating between benign and malignant ovarian tumors (crude odds ratio (OR)=62.4, p-value<0.001 and crude OR=78.53, p-value<0.001; respectively).

Table 3 Demographic data

Characteristics	Benign (n=38)	Malignant (n=153)	p-value
Age (years)*	47.5 (35.8, 61)	54 (43, 59)	0.128
Menopausal status†			0.095
Premenopausal	23 (60.5)	67 (47.1)	
Postmenopausal	15 (39.5)	86 (56.2)	
Family history of cancer			0.176
No	36 (94.7)	130 (85)	
Yes	2 (5.3)	23 (13.1)	
Clinical presentation			0.423
Abdominal pain	14 (36.8)	68 (44.4)	
Palpable mass	23 (60.5)	83 (54.2)	
Abnormal menstruation	1 (2.6)	1 (0.7)	
No symptom	0 (0.0)	1 (0.7)	
CA-125 (U/mL)*	28 (21.0, 73.0)	373.5 (77, 2,029)	<0.001‡
HE-4 (pmol/L)*	71 (47.0, 95.5)	187 (67, 697)	<0.001‡
ROMA score*ǂ	20 (6.0, 27.5)	67 (26, 96)	<0.001‡

CA-125=cancer antigen 125, HE-4=human epididymis protein 4, ROMA=Risk of Ovarian Malignancy Algorithm
Data are expressed as number (percentage), unless otherwise specified
*Data are expressed as median (interquartile range)
†Calculated using the chi-squared test, all other p-values were calculated using Fisher's exact test ‡p-value<0.05 was considered to indicate a statistically significant differenceǂROMA value specific to Roche Diagnostics: premenopausal ≥11.4% or postmenopausal ≥29.9%, high risk of epithelial ovarian cancer (tests accredited according to ISO 15189 standards)

Table 4 Univariate and multivariate logistic regression of CT features between benign and malignant ovarian tumors

CT features	Benign (n=38)	Malignant (n=153)	p-value	Multivariate analysis		
				Crude OR (95% CI)	Adjust OR (95% CI)	p-value
Uni-or bilaterality			0.824			
Unilaterality	16 (42.1)	70 (45.8)				
Bilaterality	22 (57.9)	83 (54.2)				
Maximal diameter (cm)*	11 (6.2, 15.8)	10 (6, 14)	0.614			
Component†			<0.001‡			<0.001‡
Cystic mass	26 (68.4)	13 (9)				
Solid mass	1 (2.6)	28 (18.3)		36.4 (4.56, 290.81)	11.06 (1.21, 100.76)	
Mixed cystic and solid mass	4 (10.5)	100 (65.4)		26 (8.91, 75.86)	11.66 (3.71, 36.66)	
Mixed cystic and fatty mass	5 (13.1)	2 (1.3)				
Mixed cystic, solid, and fatty mass	2 (5.3)	3 (2)				
Uni- or multilocularity			0.429			
Unilocularity	13 (34.2)	40 (26.1)				
Multilocularity	25 (65.8)	113 (73.9)				
Wall thickness			0.422			
Thin wall	25 (65.8)	70 (45.8)				
Thick wall	13 (34.2)	83 (54.2)				
Septate thickness			0.009‡	2.99 (1.38, 6.51)	0.49 (0.11, 2.19)	0.349
Thin septation	27 (71.1)	70 (45.8)				
Thick septation	11 (28.9)	83 (54.2)				
Fluid content			1			
Simple content	19 (50)	75 (49)				
Proteinaceous or hemorrhagic content	19 (50)	78 (51)				
Enhancement†			0.076			
Enhancement less than that of the myometrium	38 (100)	139 (90.8)				
Enhancement equal to or greater than that of the myometrium	0 (0) (0.0)	14 (9.2)				
Calcification			0.815			
Absent	28 (73.7)	118 (77.1)				
Present	10 (26.3)	35 (22.9)				
Ascites			<0.001‡	22.2 (6.49, 75.93)	0.27 (0.02, 3.49)	0.312
Absent	35 (92.1)	57 (37.3)				
Present	3 (7.9)	96 (62.7)				
Metastasis			<0.001‡	78.53 (10.47, 589.08)	35.06 (4.41, 278.4)	<0.001‡
Absent	37 (97.4)	49 (32)				
Present	1 (2.6)	104 (68)				

CT=computed tomography
Data are expressed as number (percentage); unless otherwise specified *Data are expressed as median (interquartile range)
†Calculated using Fisher's exact test, all other p-values were calculated using the chi-squared test, ‡p-value<0.05 was considered to indicate a statistically significant difference

Table 5 Comparison of the CT scoring system between benign and malignant ovarian tumors with distribution of pathologic findings

CT score	Pathological findings		P-value
	Benign (n=38)	Malignant (n=153)	
	(0.0)		<0.001‡
1	0 (0)	0 (0)	
2	15 (39.5) Other benign lesions (n=3) Endometriotic cyst (n=3) Mucinous cystadenoma (n=2) Benign germ cell tumor (n=7)	1 (0.7) Serous cystadenocarcinoma (n=1)	
3	16 (42.1) Other benign lesions (n=2) Endometriotic cyst (n=4) Serous cystadenoma (n=2) Mucinous cystadenoma (n=7) Struma ovarii (n=1)	9 (5.9) Serous borderline tumor (n=2) Mucinous borderline tumor (n=4) Mucinous cystadenocarcinoma (n=3)	
4	6 (15.8) Endometriotic cyst (n=3) Mucinous cystadenoma (n=2) Fibroma (n=1)	37 (24.2) Serous cystadenocarcinoma (n=11) Mucinous borderline tumor (n=2) Mucinous cystadenocarcinoma (n=6) Endometrioid carcinoma (n=7) Clear cell carcinoma (n=9) Malignant germ cell tumor (n=2)	
5	1 (26) Normal ovarian tissue (n=1)	106 (69.3) Serous cystadenocarcinoma (n=59) Mucinous cystadenocarcinoma (n=17) Ovarian collision tumor (mucinous adenocarcinoma and dermoid cyst) (n=1) Endometrioid carcinoma (n=8) Clear cell carcinoma (n=10) Granulosa cell tumor (n=3) Metastasis (n=6) Malignant germ cell tumor (n=2)	

CT=computed tomography
Values are expressed as number (percentage); unless otherwise specified
Calculated using Fisher's exact test
‡p-value<0.05 was considered to indicate a statistically significant difference

CT scoring system

Table 5 presents a comparison of CT scores with pathologic findings for benign and malignant ovarian tumors, and provides the distribution of CT scores. Overall, the CT scores significantly differed between benign and malignant ovarian tumors (p-value<0.001).

Interobserver agreement

Interobserver agreement was substantial for grouping on the basis of locularity (K=0.75), septate thickness (K=0.71), and fluid content (K=0.61). Interobserver agreement was almost perfect for grouping on the basis of the other seven CT features; namely laterality (K=0.99), component characteristics (K=0.91), wall thickness (K=0.81), enhancement (K=0.82), calcification (K=0.93), ascites (K=0.92), and metastasis (K=0.89) as well as the CT scoring system (K=0.87).

Diagnostic performance of the CT scoring system

For differentiation between benign and malignant ovarian tumors, the diagnostic performance of the CT scoring system, by using the cutoff CT score of 4, showed the sensitivity and specificity of the CT score as 93.5% and 81.6%, respectively. The positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), and negative likelihood ratio (NLR) were approximately 95.3%, 75.6%, 5.07, and 0.08, respectively. The PPV of each CT score is provided in Table 2.

Discussion

Most women with ovarian cancer present with non-specific symptoms and are usually diagnosed at an advanced stage. Gynecologists usually combine laboratory results, clinical examinations and imaging findings to determine whether a mass is benign or malignant before referring the patient to a general gynecologist or onco-gynecologist.

In this study, it was found that laboratory test results; including CA-125 level, HE-4 level, and ROMA score, differed significantly between patients with benign and malignant ovarian tumors. These findings appear similar to those of a previous meta-analysis by Cui et al., who reported that the ROMA score can provide a reliable and accurate diagnosis of ovarian cancer (sensitivity, 90.0% and specificity, 91.0%)[17].

With regard to imaging modalities, ultrasound examination is usually the initial imaging modality; however, it is operator-dependent. In case the nature of the mass cannot be determined using ultrasound, a MRI is helpful for further characterization, due to superior soft-tissue characterization[18]; however, CT is more widely accessible than MRI.

In 2014, Santoso et al. developed a CT scan-based model for predicting the probability of cancer using information regarding patient age, CA-125 level and CT scan findings (solid adnexal mass component and presence of ascites, omental lesion, or lymphadenopathy)[19]. In 2022, the ACR developed O-RADS MRI for risk stratification of ovarian tumors on a scale of 1–5[11]. To our knowledge, there is no CT scoring system for risk stratification of ovarian tumors.

Among all CT features, component characteristics, septate thickness, and the presence of ascites and metastasis were significantly different between benign and malignant ovarian tumors. In terms of component characteristics, any ovarian masses with a solid component favored malignant tumors; whereas, cystic masses favored benign tumors. This finding correlated with the results of previous studies by Saha et al. and Thomassin et al., who reported that the solid portion showed statistical significance in indicating malignant tumors (p-value<0.001)[4,20].

In terms of the septate thickness, thick septation indicated malignant tumors; whereas, thin septation indicated benign tumors. This result was also correlated with the findings of a previous study by Thomassin et al., who reported that thick septation showed statistical significance in indicating malignant tumors (p-value<0.001)[4].

Correspondingly, the presence of ascites and metastasis indicated malignant tumors, consistent with a previous study in which the presence of peritoneal fluid and peritoneal implants were significantly associated with malignant tumors (p-value=0.006 and p-value<0.001, respectively)[4]. Another previous study by Saha et al. also reported that ascites and peritoneal, or omental deposits could significantly indicate malignant tumors (p-value<0.001)[21].

In the multivariate logistic regression analysis, the presence of a solid component and metastasis could significantly and independently differentiate between benign and malignant ovarian tumors. This correlated with the findings of a previous study by Jung et al., who reported that the presence of a solid component and peritoneal implant indicated a malignant tumor[20].

Furthermore, the CT scoring system with a cutoff CT score of 4 showed statistically significant differences between benign and malignant ovarian tumors: a CT score <4 indicated benign tumors; whereas, the CT scores ≥4 indicated malignant tumors. This correlated with the findings of a previous study by Thomassin et al. who reported that O-RADS MRI scores of 4 and 5 indicated a high likelihood of malignant tumors (PLR=4.42 and 38.8, respectively)[12].

The findings were retrospectively reviewed for one case that was wrongly classified as CT score 5, but was found to have normal ovarian tissue in the pathological assessment. This case showed a mixed multiloculated cystic-solid mass in one side of ovary with peritoneal metastasis, while another side had thick enhancing septation mimicking a solid portion. Hence, a CT score of 5 was assigned for both sides (Figure 3). In such cases, a further MRI could be helpful for differentiation between the solid portion and septation.

The findings in malignant cases (CT score 4 and 5) were also retrospectively reviewed, with components of mixed cystic and fatty masses, mixed cystic, solid, and fatty masses. Four cases were found, with pathologic proven malignant germ cell tumor, and one case with pathologic proven collision tumor (mucinous cystadenocarcinoma and dermoid cyst) (Figure 3).

The assessments of locularity, septate thickness, and fluid content showed substantial interobserver agreement; whereas, assessments of the other seven CT features, namely: laterality, component characteristics, wall thickness, enhancement, calcification, ascites, and metastasis, as well as CT score showed almost perfect interobserver agreement. Finally, the diagnostic performance of the CT scoring system to differentiate between benign and malignant ovarian tumors showed good results with high sensitivity (97.0%) and specificity (81.0%).

The strength of this study was that this was the first study to use a CT scoring system to differentiate between benign and malignant ovarian tumors by using pathologic findings as the reference standard. This is expected to be beneficial in low-to-middle income countries where CT is often more accessible than MRI. Identification of malignant tumors is important to ensure prompt referral to gynecologic oncologists for complete surgical staging. Furthermore, the CT scoring system showed good diagnostic performance, indicating its suitability for clinical practice.

Nevertheless, this study had several limitations. First, it was a retrospective study. Second, the small sample size may have reduced the statistical power of our results; although it was sufficient to calculate the outcome. Third, only patients who showed pathologic findings were included, which may have caused selection bias. Fourth, the data for some laboratory investigations were missing. Therefore, the analysis of demographic data may have been underestimated. Fifth, this CT score cannot be used for post-hysterectomy patients. Sixth, according to the O-RADS MRI lexicon, dynamic contrast enhancement with time intensity curves or non-dynamic contrast enhancement at 30–40 s post-injection is used for mass enhancement; however, in our protocol enhancement of the mass in the portal venous phase (70 s post-injection)14 is used. Finally, the Kappa value for interobserver agreement in this study was calculated only for radiologists with 7 and 14 years of experience. Therefore, we recommend validation of the CT score in assessments performed by other radiologists with variable levels of experience for better accuracy.

Conclusion

The findings of this study indicate that the CT scoring system can be used to differentiate between benign and malignant ovarian tumors, with high sensitivity and specificity. Furthermore, the presence of a solid component and metastasis are the CT features to differentiate between benign and malignant ovarian tumors.

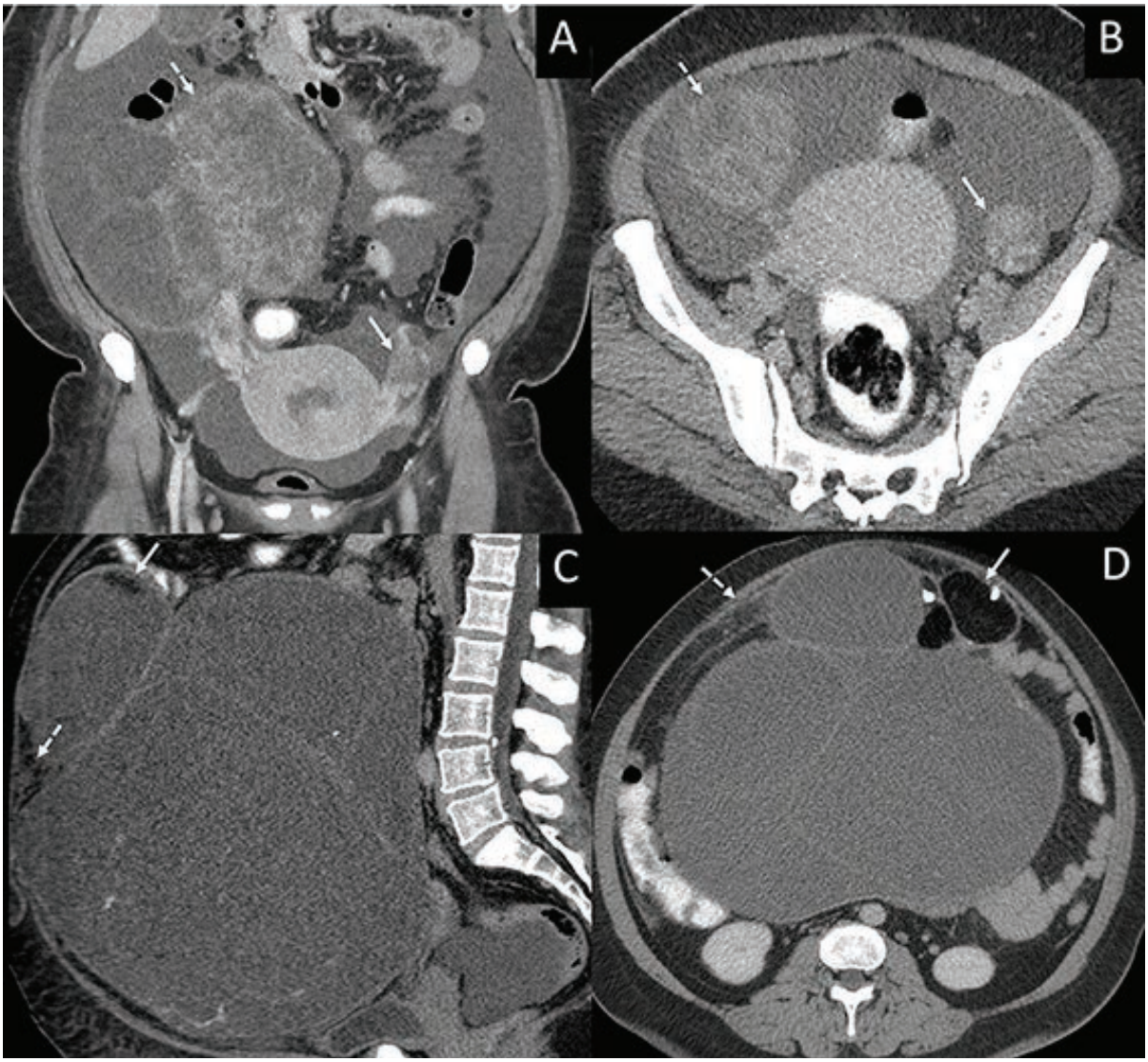


Figure 3 A case of a benign ovarian tumor that was wrongly classified as CT score 5, and a case of mixed cystic and fatty mass with pathologic proven for ovarian collision tumor

A 40-year-old female presenting with abdominal distension. (A) Coronal venous phase and (B) axial delayed phase of CT; showing a well-defined mixed multiloculated cystic-solid mass (dash arrow) arising from the right ovary. Another smaller mixed cystic-solid mass (arrow) arising from the left ovary with ascites. A CT score of 5 was assigned to both sides. Pathologic proven endometrioid carcinoma in the right ovary and normal left ovarian tissue. Another case of a 49-year-old female, presenting with abdominal distension. (C) Sagittal venous phase and (D) axial delayed phase of CT; showing a large multiloculated mixed cystic-fatty mass (arrow) with calcifications and nodular peritoneal fat reticulation (dashed arrow). Pathologic proven mucinous adenocarcinoma and dermoid cyst.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors.

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Conflict of interest

There are no potential conflicts of interest to declare.

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