Original Article | Genitourinary Imaging

http://dx.doi.org/10.3348/kjr.2014.15.1.72
pISSN 1229-6929 · eISSN 2005-8330
Korean J Radiol 2014;15(1):72-79

Korean Journal of Radiology
KJR

Multidetector Computed Tomography for the Assessment of Adnexal Mass: Is Unenhanced CT Scan Necessary?

Sung Il Jung, MD, Hee Sun Park, MD, Young Jun Kim, MD, Hae Jeong Jeon, MD

All authors: Department of Radiology, Research Institute of Medical Science, Konkuk University School of Medicine, Seoul 143-729, Korea

Objective: To compare the diagnostic performance and radiation dose between contrast-enhanced CT (ECT) alone, and combined unenhanced and contrast-enhanced CT (UE + ECT) for the assessment of adnexal mass.

Materials and Methods: This retrospective study was approved by the Institutional Review Board. A total of 146 consecutive patients (mean age, 41.1 years) who underwent preoperative unenhanced and contrast-enhanced multidetector CT of the pelvis and had adnexal masses found at surgery were included. Two readers independently evaluated the likelihood of adnexal malignancy on a 5-point scale on two different imaging datasets (ECT alone and UE + ECT). The area under the receiver operating characteristic curve (AUC) was used to evaluate diagnostic performance. Radiation dose to patients was calculated by the volume CT dose index ($CTDI_{vol}$) and the dose length products (DLP) on each dataset.

Results: Of the total 178 adnexal masses, 133 masses were benign and 45 masses were malignant. For both readers, there is no significant difference of AUC values between ECT alone and UE + ECT for the detection of adnexal malignancy (reader 1, 0.93 vs. 0.95; reader 2, 0.92 vs. 0.91) ($p > 0.05$). The mean $CTDI_{vol}$ (12.6 ± 2.2 mGy) and DLP (641.2 ± 137.2 mGy) of ECT alone was significantly lower than the mean $CTDI_{vol}$ (21.5 ± 2.7 mGy) and DLP (923.6 ± 158.8 mGy) of UE + ECT ($p <$ 0.0001).

Conclusion: The use of unenhanced CT scan in addition to contrast-enhanced CT scan does not improve the detection of adnexal malignancy, but increases radiation exposure.

Index terms: *CT; Adnexa; Radiation; Unenhanced scan*

INTRODUCTION

The main goal of imaging in the characterization of adnexal mass is to differentiate malignant and benign disease. A reliable imaging technique for the evaluation of adnexal mass would allow for optimal management options, including radical surgery for ovarian malignancy, cystectomy for benign neoplasm, and the avoidance of surgery.

Ultrasonography (US) is considered the primary imaging modality for the evaluation of suspected adnexal mass because of its widespread availability and high sensitivity in the detection of mass (1, 2). Magnetic resonance imaging has generally served as a problem solving modality for indeterminate adnexal mass on US (3).

Recent innovations in multidetector computed tomography (MDCT), which allows thinner sections, faster imaging, and good spatial resolution, has led to its more common use for further characterization of adnexal mass and staging work-up of ovarian malignancy (4-6). Along with an increased number of CT examinations, there is no doubt that radiation exposure from CT has been increasing

Received May 13, 2013; accepted after revision September 16, 2013.
This work was supported by Konkuk University.
Corresponding author: Sung Il Jung, MD, Department of Radiology, Konkuk University School of Medicine, 120-1 Neungdong-ro, Gwangjin-gu, Seoul 143-729, Korea.
• Tel: (822) 2030-5544 • Fax: (822) 2030-5549
• E-mail: radsijung@kuh.ac.kr

rapidly (7-14). In addition, CT protocol for the evaluation of abdomen and pelvis has even adopted multiphase CT scans, including scanning before and after contrast administration in several institutions. Considering the dose-multiplication effect of extra phase, it is certain that inappropriate multiphase CT can be an important source of excess radiation exposure (7). In the era of multiphase CT, the question can be posed whether the addition of unenhanced CT scan to enhanced CT scan is needed to significantly improve the characterization of adnexal mass.

The purpose of this study is to compare the diagnostic performance and radiation dose of contrast-enhanced CT (ECT) alone with that of combined unenhanced and enhanced CT (UE + ECT), for the assessment of adnexal mass.

MATERIALS AND METHODS

Patient Population

The study was approved by the Institutional Review Board of X hospital/university, and a waiver of informed consent was received for the use of patient's data. Clinical and pathologic records from our institution were referenced to identify patients who underwent preoperative CT examination and subsequent surgical exploration in the department of gynecology within 30 days after CT examination, and in whom adnexal mass was histologically confirmed between January 2008 and July 2010. The search yielded 146 consecutive patients (age range, 10-72 years; mean age, 41.1 ± 13.4 years). The mean time from CT examination and to surgical exploration was 14.3 ± 2.1 days. The indications for CT examination of all patients were as follows: evaluation of known ovarian tumor or adnexal mass (n = 86), evaluation of pelvic mass of unknown origin (n = 4), large amount of ascites (n = 4), lower abdominal or pelvic pain (n = 47), staging of non-ovarian malignancy (n = 5). Non-ovarian malignancy included cervix cancer (n = 2), endometrial cancer (n = 2) and pancreatic cancer (n = 1).

CT Imaging

CT scans were obtained on MDCT (LightSpeed VCT XT; GE Healthcare, Milwaukee, WI, USA); or LightSpeed Pro 16; GE Healthcare, Milwaukee, WI, USA). In all patients, unenhanced scans were obtained from the iliac crest to the lower vagina, and enhanced scans covered the region from the dome of the liver to the lower vagina. Immediately after the unenhanced scan was performed, intravenous contrast (Iopromide, Ultravist 370; Schering, Berlin, Germany) was given at a flow rate of 3 cc/sec and a total volume of 130 mL through the antecubital vein via a mechanical injector. Bolus tracking was not applied and enhanced scans started 90 seconds after the beginning of contrast injection. No oral contrast agent was applied. Both the LightSpeed VCT XT scanner and Pro 16 scanner in the enhanced scans were set to the following parameters: detector collimation, 64 x 0.625 mm and 16 x 1.25 mm; helical pitch, 0.984 and 0.938; section thickness/interval, 3.75/3.75 mm and 3.75/3.75 mm; 0.5 second rotation time; 120 kVp/300-500 mA and 120 kVp/200-400 mA, respectively. Both scanners used automatic exposure control. In the unenhanced scans, all parameters were the same as that of enhanced scans, except 120 kVp/200 mA without automatic exposure control. Radiation dose to the patients was monitored for each scan by means of volume CT dose index ($CTDI_{vol}$) and dose length products (DLP), which were calculated by the CT scanner and were automatically saved to a dose report.

Imaging Analysis

The CT images were reviewed retrospectively on a picture archiving and communication system workstation (Centricity; GE Healthcare, Milwaukee, WI, USA) by two radiologists (with seven and five years experience, respectively, in genitourinary and abdominal imaging) independently. The readers were aware that the patients had undergone surgery for adnexal mass, but they were blinded to the laterality of the surgery and any other clinical, pathologic, or radiologic findings of all patients. Both readers independently reviewed ECT images alone and UE + ECT images. The two data sets in each patient were randomly interpreted in different sessions at 4-week intervals. In each patient, both adnexa were evaluated for the presence of mass and the presence or absence of a mass in each adnexae was recorded. If an adnexal mass was regarded as being present, the size of the largest dimension at transverse scan was measured. The readers also assessed the adnexal mass following imaging findings suggestive of malignant adnexal mass (3, 5, 6, 15): mass size larger than 4 cm, heterogeneity for a solid lesion, multilocularity (> 3 locules), irregular and thickened (> 3 mm) cystic septations or walls, and the presence of internal vegetations for a cystic lesion. In addition, the presence of ancillary imaging findings such as ascites, peritoneal implants, and pelvic lymphadenopathy, were recorded (3, 5). Each reader gave an overall impression of the likelihood of malignancy, using a rating scale of 1 to 5 (1, definitely benign; 2, probably benign; 3, indeterminate; 4, probably malignant; 5, definitely malignant).

Statistical Analysis

Descriptive variables were reported as the mean and standard deviation, and categorical variables were reported as frequencies and percentages. The two-tailed paired t test with exact *p* values was used for comparison of the radiation dose between ECT images alone and UE + ECT images. The area under the receiver operating characteristic curves (AUC) with confidence intervals (CIs) was estimated for reader performance. The sensitivity and specificity were estimated with a score of 3 or greater as positive for malignancy. The AUC for ECT images alone and UE + ECT images was compared using a nonparametric method proposed by Obuchowski (16). Differences with *p* values of 0.05 or less were considered statistically significant. Inter-reader agreement was assessed by using weighted or unweighted κ statistics with quadratic weights for the detection of adnexal mass or for the evaluation of adnexal malignancy. Weighted and unweighted κ statistics were interpreted using the following scale: slight agreement, < 0.20; fair agreement, 0.21-0.40; moderate agreement, 0.41-0.60; substantial agreement, 0.61-0.80; and almost perfect agreement, 0.81-1.0 (17). Ninety-five percent CIs were reported for the estimated κ statistics. All statistical analyses were performed with a statistical software package (MedCalc Software; MedCalc, Mariakerke, Belgium).

RESULTS

Histopathologic Results

We found 178 adnexal masses in 146 patients; 133 masses were benign and 45 masses were malignant. Thirty two patients underwent bilateral salpingo-oophorectomy and 114 patients underwent unilateral salpingo-oophorectomy. One hundred and fourteen (78.1%) patients had no malignant tumor in the adnexa, 20 patients (13.7%) had unilateral malignant tumor, and 12 patients (8.2%) had bilateral malignant tumor. The histopathologic diagnoses of the 178 masses are detailed in Table 1. The most common malignant tumor was endometrioid adenocarcinoma (9/45 malignant tumors; 20%) and the most common benign tumor was teratoma (43/133 benign tumors; 32.3%).

Table 1. Histopathologic Diagnoses in 178 Adnexal Masses

Diagnosis	No.
Benign (n = 133)	
Teratoma	43
Endometrioma	27
Mucinous cystadenoma	18
Corpus luteal cyst	11
Serous cystadenoma	9
Paratubal cyst	8
Follicular cyst	4
Hydrosalpinx	4
Struma ovarii	3
Fibroma	2
Pseudocyst	2
Tuboovarian abscess	2
Malignant (n = 45)	
Endometrioid adenocarcinoma	9
Clear cell carcinoma	6
Serous carcinoma	4
Serous papillary adenocarcinoma	4
Borderline serous tumor	4
Borderline seromucinous tumor	4
Borderline serous cystadenoma	3
Borderline mucinous tumor	2
Lymphoma	2
Krukenberg tumor	2
Small cell carcinoma	1
Dysgerminoma	1
Granulosa cell tumor	1
Fibrosarcoma	1
Fallopian tube serous adenocarcinoma	1

Lesion Detection

For detecting the presence of an adnexal mass, reader 1 detected 174 of 178 (97.8%) adnexal masses on ECT images alone and 177 of 178 (99.4%) adnexal masses on UE + ECT images. Reader 2 detected 166 of 178 (93.3%) adnexal masses on ECT images alone and 177 of 178 (99.4%) adnexal masses on UE + ECT images. There was no statistical difference in the detection rate between UE + ECT images and ECT images alone for both readers ($p > 0.05$). Readers 1 or 2 failed to detect 12 adnexal masses on ECT images alone. The benign adnexal masses that were not detected on ECT images alone (n = 8) were mucinous cystadenoma (n = 3), endometrioma (n = 2), teratoma (n = 1), paratubal cyst (n = 1), and fibroma (n = 1). The malignant adnexal masses that were not detected on ECT images alone (n = 4) were serous carcinoma (n = 1), clear cell carcinoma (n = 1), lymphoma (n = 1), and borderline seromucinous tumor (n = 1). Both readers failed to detect 1 adnexal mass

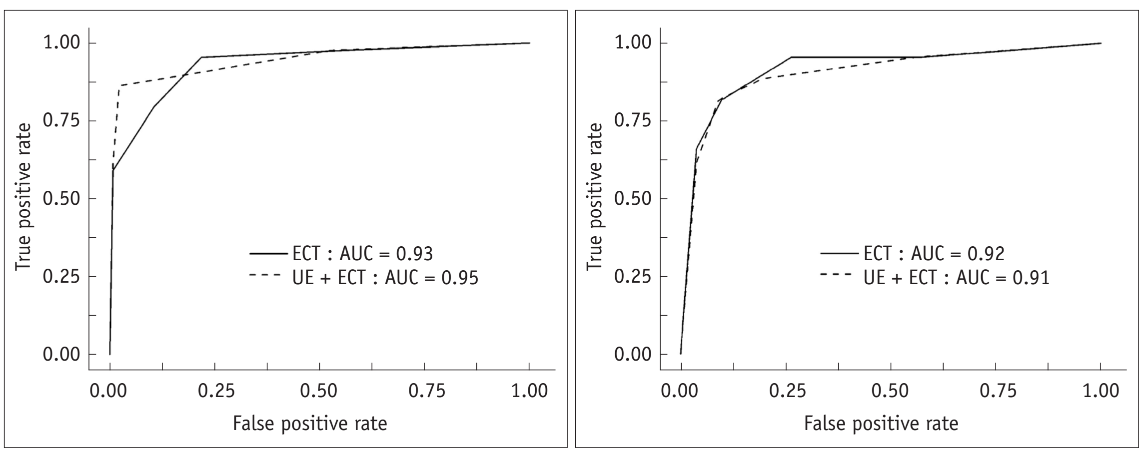
Korean Journal of Radiology KJR

on UE + ECT images, which was clear cell carcinoma. The patient with adnexal mass not detected by both readers had bilateral ovarian malignancies, where an obvious mass was preoperatively identified in one adnexa, whereas due to the very small size of the tumor in the other adnexa, it was only confirmed based on pathology. Inter-reader agreement for the detection of adnexal mass was moderate, with unweighted κ statistics of 0.54 for both ECT images alone and UE + ECT images.

Lesion Characterization

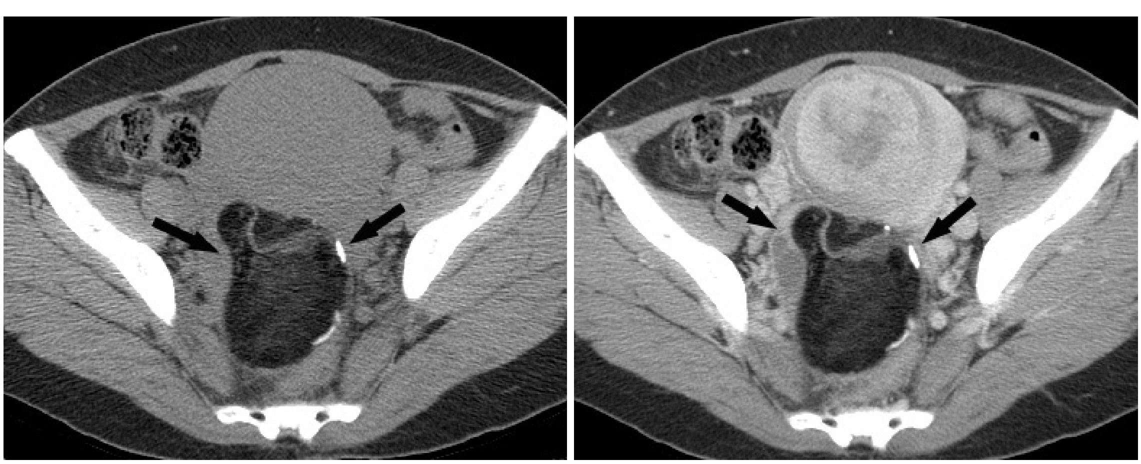
For the detection of malignant adnexal mass, the AUC of reader 1 was 0.94 (95% CI: 0.89-0.97) on ECT images alone and 0.95 (95% CI: 0.90-0.97) on UE + ECT images (Fig. 1A). The AUC of reader 2 was 0.92 (95% CI: 0.87-0.95) on ECT images alone and 0.91 (95% CI: 0.85-0.94) on UE + ECT images (Fig. 1B). Both readers had no significantly greater AUC for UE + ECT images than for ECT images alone (Figs. 2-5). Sensitivity, specificity, positive and negative predictive values of ECT images alone and UE + ECT images for the detection of malignant adnexal mass are shown in Table 2. Inter-reader agreement for the detection of malignant adnexal mass was moderate, with weighted κ statistics of 0.60 for ECT images alone, and 0.59 for UE + ECT images.

In 120 patients, reader 1 did not identify any ancillary findings as ascites, peritoneal implants, and pelvic lymphadenopathy on UE + ECT images. In 127 patients, reader 2 did not identify any ancillary findings on UE + ECT images. The κ statistic was 0.58, indicating a moderate



A B

Fig. 1. Receiver operating characteristic curve for readers 1 (A) and 2 (B) for detection of adnexal malignancy on ECT images alone and UE + ECT images. ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT



A B

Fig. 2. 46-year-old woman with complaint of pelvic mass.
Unenhanced CT scan **(A)** and contrast-enhanced CT scan **(B)** show large fatty mass with calcification (arrows) in pelvic cavity. Likelihood of malignancy was assigned score 1 (definitely benign) to this adnexal mass both on ECT images alone and UE + ECT images. Surgical pathology confirmed right ovarian teratoma. ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT

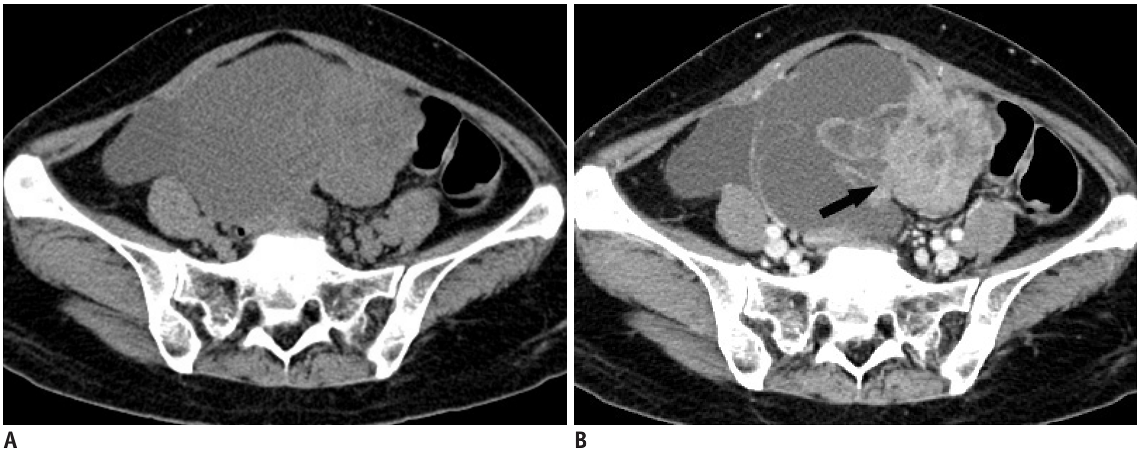


Fig. 3. 54-year-old woman with complaint of pelvic mass.
Unenhanced CT scan **(A)** and contrast-enhanced CT scan **(B)** shows multilocular cystic mass with well-enhanced sold component (arrow) in pelvic cavity. Likelihood of malignancy was assigned score of 5 (definitely malignant) to this adnexal mass, both on ECT images alone and UE + ECT images. Surgical pathology confirmed endometrioid adenocarcinoma of right ovary. ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT

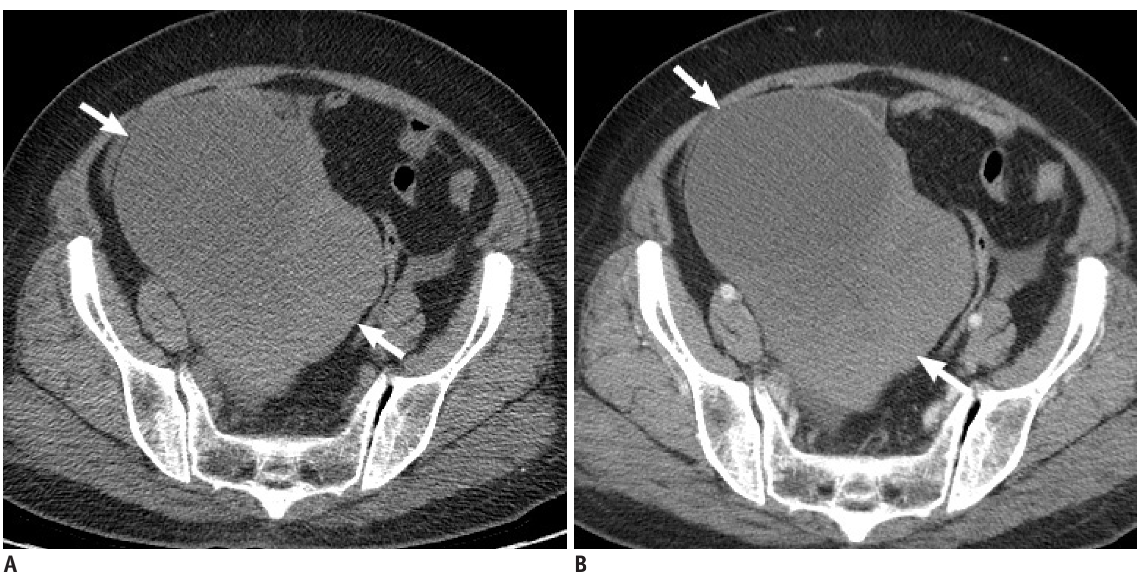


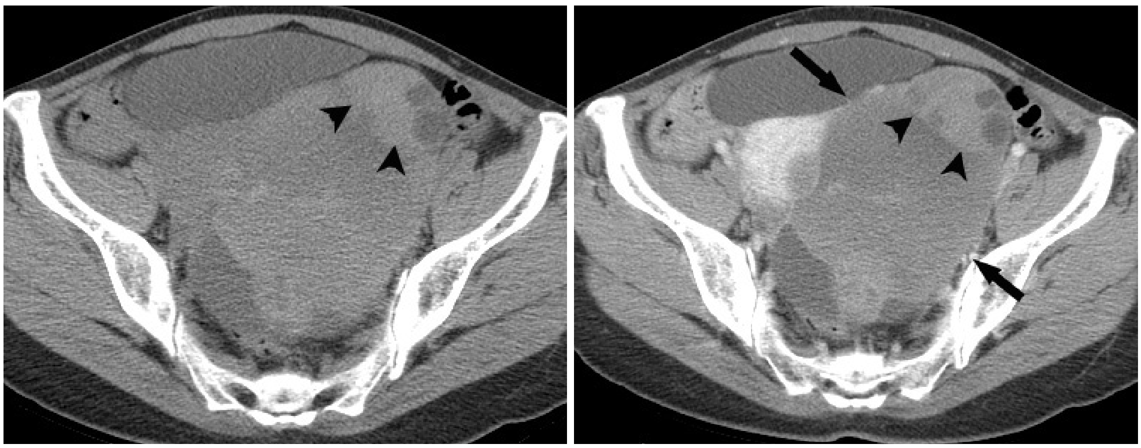
Fig. 4. 63-year-old woman with complaint of pelvic mass.
Unenhanced CT scan **(A)** and contrast-enhanced CT scan **(B)** show large complex mass containing both cyst and solid components in right pelvic cavity (arrows). Solid component seems to be homogeneous and lacking in contrast-enhancement. Likelihood of malignancy was assigned score of 3 (intermediate) to this adnexal mass on ECT images alone, and score of 2 (probably benign) on UE + ECT images. Surgical pathology confirmed right ovarian fibroma. ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT

agreement between readers in identifying patients without ancillary findings. For assessing adnexal malignancy in patients without ancillary findings, the AUC of reader 1 on ECT images alone was 0.92 (95% CI: 0.86-0.96), the same value as that on UE + ECT images (Fig. 6A). The AUC of reader 2 was 0.89 (95% CI: 0.83-0.93) on ECT images alone and 0.87 (95% CI: 0.80-0.92) on UE + ECT images (Fig. 6B). Sensitivity, specificity, positive and negative predictive values of ECT images alone, and UE + ECT images, for the detection of malignant adnexal mass without ancillary findings are shown in Table 3.

Radiation Dose

In the patients that underwent CT examination in the 16-channel MDCT scanner (LightSpeed Pro 16 CT) (n = 49), the mean $CTDI_{vol}$ was 12.5 ± 2.7 mGy (95% CI: 11.3-13.7) and the mean DLP was 627.3 ± 149.1 mGy·cm (95% CI: 562.8-691.7) of ECT scan alone, whereas, the mean $CTDI_{vol}$ was 22.5 ± 2.7 mGy (95% CI: 21.3-23.6) and the mean DLP was 943.9 ± 158.4 mGy·cm (95% CI: 562.8-691.7) of UE

+ ECT scan. Mean $CTDI_{vol}$ and DLP of ECT scan alone was significantly lower than those of UE + ECT scan ($p < 0.0001$). In the patients that underwent CT examination in the 64-channel MDCT scanner (LightSpeed VCT XT) (n = 97). The mean $CTDI_{vol}$ was 12.6 ± 2.0 mGy (95% CI: 12.2-13.2) and the mean DLP was 645.8 ± 133.9 mGy·cm (95% CI: 613.7-678.0) of ECT scan alone, whereas, the mean $CTDI_{vol}$ was 21.2 ± 2.6 mGy (95% CI: 20.6-21.9) and the mean DLP was 916.8 ± 159.6 mGy·cm (95% CI: 878.5-955.2) of UE + ECT scan. Mean $CTDI_{vol}$ and DLP of ECT scan alone was also



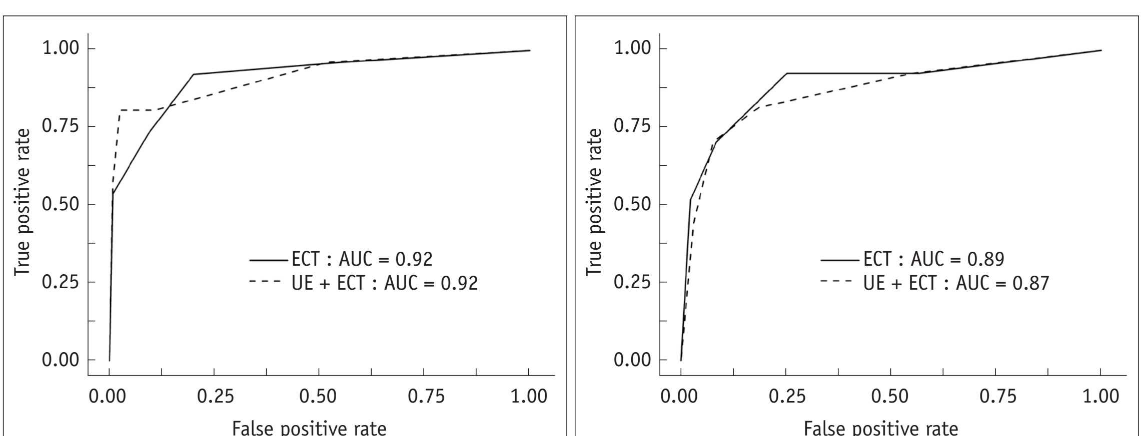
A B

Fig. 5. 49-year-old woman with complaint of pelvic mass.
Unenhanced CT scan **(A)** and contrast-enhanced CT scan **(B)** shows large multilocular cystic mass with solid component in left pelvic cavity (arrows). Solid component has high attenuation on unenhanced CT scan (arrowheads). Likelihood of malignancy was assigned score of 4 (probably malignant) to this adnexal mass on ECT images alone, and score of 3 (intermediate) on UE + ECT images. Surgical pathology confirmed mucinous borderline tumor of left ovary. ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT

Table 2. Diagnostic Performance of 2 Readers for Detection of Malignant Adnexal Mass

	Reader 1			Reader 2		
	ECT	UE + ECT	*P*	ECT	UE + ECT	*P*
AUC	0.93 (0.89-0.97)	0.95 (0.90-0.97)	0.50	0.92 (0.87-0.95)	0.91 (0.85-0.94)	0.30
Sensitivity	0.95 (0.84-0.99)	0.89 (0.76-0.96)	0.25	0.95 (0.84-0.99)	0.89 (0.76-0.96)	0.25
Specificity	0.78 (0.70-0.84)	0.87 (0.80-0.92)	0.006	0.74 (0.66-0.80)	0.80 (0.73-0.86)	0.007
Positive predictive value	0.59 (0.48-0.70)	0.70 (0.57-0.80)	0.27	0.55 (0.43-0.65)	0.60 (0.48-0.71)	0.67
Negative predictive value	0.98 (0.93-0.99)	0.96 (0.90-0.98)	0.62	0.98 (0.93-0.99)	0.96 (0.90-0.98)	0.66

Note.— Data in parentheses are 95% CIs. AUC = area under curve, ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT, CIs = confidence intervals



A B

Fig. 6. Receiver operating characteristic curve for readers (A) 1 and (B) 2 for detection of adnexal malignancy without ancillary findings on ECT images alone and UE + ECT images. ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT

Table 3. Diagnostic Performance of 2 Readers for Detection of Malignant Adnexal Mass without Ancillary Findings

	Reader 1			Reader 2		
	ECT	UE + ECT	*P*	ECT	UE + ECT	*P*
AUC	0.92 (0.86-0.96)	0.92 (0.86-0.96)	0.98	0.89 (0.83-0.93)	0.87 (0.80-0.92)	0.19
Sensitivity	0.92 (0.75-0.99)	0.81 (0.62-0.92)	0.25	0.93 (0.76-0.99)	0.81 (0.63-0.92)	0.25
Specificity	0.80 (0.72-0.86)	0.89 (0.82-0.94)	0.006	0.75 (0.67-0.82)	0.82 (0.74-0.87)	0.008
Positive predictive value	0.50 (0.36-0.63)	0.62 (0.45-0.76)	0.39	0.43 (0.31-0.56)	0.48 (0.34-0.62)	0.76
Negative predictive value	0.98 (0.92-0.99)	0.96 (0.90-0.98)	0.66	0.98 (0.93-0.99)	0.96 (0.90-0.99)	0.66

Note.— Data in parentheses are 95% CIs. AUC = area under curve, ECT = enhanced CT, UE + ECT = combined unenhanced and enhanced CT, CIs = confidence intervals

significantly lower than those of UE + ECT scan ($p < 0.0001$). In the overall comparison of mean $CTDI_{vol}$ and DLP between ECT scan alone and UE + ECT scan, irrespective of CT scanner, mean $CTDI_{vol}$ (12.6 ± 2.2 mGy; 95% CI: 12.2-13.1) and DLP (641.2 ± 137.2 mGy; 95% CI: 612.8-669.6) of ECT scan alone was significantly lower than mean $CTDI_{vol}$ (21.5 ± 2.7 mGy; 95% CI: 21.0-22.1) and DLP (923.6 ± 158.8 mGy; 95% CI: 890.7-956.5) of UE + ECT scan ($p < 0.0001$).

DISCUSSION

Several studies have suggested that contrast-enhanced MDCT can be highly accurate in the detection and characterization of adnexal mass, and can have an important role in the diagnosis of malignant ovarian tumor (4-6, 18, 19). Zhang et al. (5) reported that MDCT shows a sensitivity of 86-90% and specificity of 77-84% for differentiating benign and malignant adnexal masses. Tsili et al. (4) also described that MDCT can accurately categorize adnexal mass into benign and malignant for 89-93% of cases. Our result demonstrated that ECT alone has a sensitivity of 92-95%, and a specificity of 74-80% for the diagnosis of malignant adnexal mass, which is comparable to the results of previous literature.

Since widespread acceptance of MDCT for the scanning of abdomen and pelvis, various multiphase CT imaging protocol have been used (20-22). Although general guidelines recommend that pelvis CT with or without contrast is usually inappropriate for clinically suspected adnexal mass, due to the associated radiation hazard (23), some institutions have used a UE + ECT protocol for the evaluation of adnexal mass or lower abdominal pain in routine clinical practice (24-26). In these circumstances, as Guite et al. (26) suggested, un-indicated multiphase CT scans can add excess radiation dose, the clinical usefulness of added unenhanced CT images for the evaluation of adnexal mass need to be verified. This study is the first comparative study about diagnostic performance for the evaluation of adnexal mass between ECT images alone and UE + ECT images. It was obvious that UE + ECT scan increases 58.6% of $CTDI_{vol}$ and 69.4% of DLP, when compared with ECT scan alone. Otherwise, in terms of detection and characterization of adnexal mass, our results demonstrated ECT images alone can provide comparable diagnostic information to UE + ECT images. Even in the case of adnexal mass without ascites, peritoneal implants, and pelvic lymphadenopathy, which can indicate the early stage of ovarian cancer, unenhanced CT images also could not add significant diagnostic value to enhanced CT images.

There were a few limitations to our study. First, our study, as a retrospective study, may have selection and verification biases, especially in the proportion and stage of adnexal malignancy, which mainly depend on the status of the institution, community, and/or referral hospital. Notably, in the advanced stage of adnexal malignancy, the characterization of adnexal masses could be affected by extra-adnexal findings as ascites, peritoneal implants, and pelvic lymphadenopathy. Second, non-uniform CT scanners were used in the study, although this reflects actual clinical practice. Finally, we could not validate various methods for exhaustive calculation of radiation dose; however, the methods used in this study have been used in many peer-reviewed publications.

In summary, using unenhanced CT scan in addition to contrast-enhanced CT scan did not improve the detection of adnexal malignancy, but increased radiation exposure.

REFERENCES

1. Salem S, White LM, Lai J. Doppler sonography of adnexal masses: the predictive value of the pulsatility index in benign and malignant disease. *AJR Am J Roentgenol* 1994;163:1147-1150
2. Spencer JA, Ghattamaneni S. MR imaging of the sonographically indeterminate adnexal mass. *Radiology* 2010;256:677-694

3. Hricak H, Chen M, Coakley FV, Kinkel K, Yu KK, Sica G, et al. Complex adnexal masses: detection and characterization with MR imaging--multivariate analysis. *Radiology* 2000;214:39-46
4. Tsili AC, Tsampoulas C, Charisiadi A, Kalef-Ezra J, Dousias V, Paraskevaidis E, et al. Adnexal masses: accuracy of detection and differentiation with multidetector computed tomography. *Gynecol Oncol* 2008;110:22-31
5. Zhang J, Mironov S, Hricak H, Ishill NM, Moskowitz CS, Soslow RA, et al. Characterization of adnexal masses using feature analysis at contrast-enhanced helical computed tomography. *J Comput Assist Tomogr* 2008;32:533-540
6. Tsili AC, Tsampoulas C, Argyropoulou M, Navrozoglou I, Alamanos Y, Paraskevaidis E, et al. Comparative evaluation of multidetector CT and MR imaging in the differentiation of adnexal masses. *Eur Radiol* 2008;18:1049-1057
7. Greess H, Nömayr A, Wolf H, Baum U, Lell M, Böwing B, et al. Dose reduction in CT examination of children by an attenuation-based on-line modulation of tube current (CARE Dose). *Eur Radiol* 2002;12:1571-1576
8. Tack D, De Maertelaer V, Gevenois PA. Dose reduction in multidetector CT using attenuation-based online tube current modulation. *AJR Am J Roentgenol* 2003;181:331-334
9. Paterson A, Frush DP, Donnelly LF. Helical CT of the body: are settings adjusted for pediatric patients? *AJR Am J Roentgenol* 2001;176:297-301
10. Divrik Gökçe S, Gökçe E, Coşkun M. Radiology residents' awareness about ionizing radiation doses in imaging studies and their cancer risk during radiological examinations. *Korean J Radiol* 2012;13:202-209
11. Goo HW. CT radiation dose optimization and estimation: an update for radiologists. *Korean J Radiol* 2012;13:1-11
12. Hur S, Lee JM, Kim SJ, Park JH, Han JK, Choi BI. 80-kVp CT using Iterative Reconstruction in Image Space algorithm for the detection of hypervascular hepatocellular carcinoma: phantom and initial clinical experience. *Korean J Radiol* 2012;13:152-164
13. Moritz JD, Hoffmann B, Sehr D, Keil K, Eggerking J, Groth G, et al. Evaluation of ultra-low dose CT in the diagnosis of pediatric-like fractures using an experimental animal study. *Korean J Radiol* 2012;13:165-173
14. Park EA, Lee W, Kang JH, Yin YH, Chung JW, Park JH. The image quality and radiation dose of 100-kVp versus 120-kVp ECG-gated 16-slice CT coronary angiography. *Korean J Radiol* 2009;10:235-243
15. Stevens SK, Hricak H, Stern JL. Ovarian lesions: detection and characterization with gadolinium-enhanced MR imaging at 1.5 T. *Radiology* 1991;181:481-488
16. Obuchowski NA. Nonparametric analysis of clustered ROC curve data. *Biometrics* 1997;53:567-578
17. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159-174
18. Togashi K. Ovarian cancer: the clinical role of US, CT, and MRI. *Eur Radiol* 2003;13 Suppl 4:L87-L104
19. Liu J, Xu Y, Wang J. Ultrasonography, computed tomography and magnetic resonance imaging for diagnosis of ovarian carcinoma. *Eur J Radiol* 2007;62:328-334
20. O'Malley ME, Halpern E, Mueller PR, Gazelle GS. Helical CT protocols for the abdomen and pelvis: a survey. *AJR Am J Roentgenol* 2000;175:109-113
21. Killius JS, Nelson RC. Logistic advantages of four-section helical CT in the abdomen and pelvis. *Abdom Imaging* 2000;25:643-650
22. Urban BA, Fishman EK. Tailored helical CT evaluation of acute abdomen. *Radiographics* 2000;20:725-749
23. Johnstone PA. ACR appropriateness criteria. *Int J Radiat Oncol Biol Phys* 2008;70:1303-1304
24. Gatreh-Samani F, Tarzamni MK, Olad-Sahebmadarek E, Dastranj A, Afrough A. Accuracy of 64-multidetector computed tomography in diagnosis of adnexal tumors. *J Ovarian Res* 2011;4:15
25. Tsushima Y, Yamada S, Aoki J, Motojima T, Endo K. Effect of contrast-enhanced computed tomography on diagnosis and management of acute abdomen in adults. *Clin Radiol* 2002;57:507-513
26. Guite KM, Hinshaw JL, Ranallo FN, Lindstrom MJ, Lee FT Jr. Ionizing radiation in abdominal CT: unindicated multiphase scans are an important source of medically unnecessary exposure. *J Am Coll Radiol* 2011;8:756-761