

# Low-dose non-enhanced CT versus full-dose contrast-enhanced CT in integrated PET/CT studies for the diagnosis of uterine cancer recurrence

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## Abstract

**Purpose** To evaluate low-dose non-enhanced CT (ldCT) and full-dose contrast-enhanced CT (ceCT) in integrated  $^{18}\text{F}$ -fluorodeoxyglucose (FDG) PET/CT studies for restaging of uterine cancer.

**Methods** A group of 100 women who had undergone treatment for uterine cervical ( $n=55$ ) or endometrial cancer ( $n=45$ ) underwent a conventional PET/CT scans with ldCT, and then a ceCT scan. Two observers retrospectively reviewed and interpreted the PET/ldCT and PET/ceCT images in consensus using a three-point grading scale (negative, equivocal, or positive) per patient and per lesion.

Final diagnoses were obtained by histopathological examination, or clinical follow-up for at least 6 months.

**Results** Patient-based analysis showed that the sensitivity, specificity and accuracy of PET/ceCT were 90% (27/30), 97% (68/70) and 95% (95/100), respectively, whereas those of PET/ldCT were 83% (25/30), 94% (66/70) and 91% (91/100), respectively. Sensitivity, specificity and accuracy did not significantly differ between two methods (McNemar test,  $p=0.48$ ,  $p=0.48$ , and  $p=0.13$ , respectively). There were 52 sites of lesion recurrence: 12 pelvic lymph node (LN), 11 local recurrence, 8 peritoneum, 7 abdominal LN, 5 lung, 3 supraclavicular LN, 3 liver, 2 mediastinal LN, and 1 muscle and bone. The grading results for the 52 sites of recurrence were: *negative* 5, *equivocal* 0 and *positive* 47 for PET/ceCT, and *negative* 5, *equivocal* 4 and *positive* 43 for PET/ldCT, respectively. Four equivocal regions by PET/ldCT (local recurrence, pelvic LN metastasis, liver metastasis and muscle metastasis) were correctly interpreted as positive by PET/ceCT.

**Conclusion** PET/ceCT is an accurate imaging modality for the assessment of uterine cancer recurrence. Its use reduces the frequency of equivocal interpretations.

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## Introduction

Despite continuing advances in surgical and nonsurgical therapeutic strategies, cancer recurrence and distant metastasis after initial treatment are often a major problem for women with gynaecological cancer. Early and accurate detection of recurrence in patients with uterine cancer has

an important influence on therapy, and selection of appropriate treatment strategies can be expected to have a significant impact on overall survival [1, 2].

In the late 1990s, positron emission tomography (PET) with  $^{18}\text{F}$ -fluorodeoxyglucose (FDG), which exploits the increased utilization of glucose by malignant cells and thereby their high uptake of glucose, has opened a new field in clinical imaging and is widely used for staging, restaging, therapeutic response monitoring and prognostication in patients with various cancers. PET makes it possible to diagnose cancer recurrence and distant metastasis in the preclinical stage before it becomes evident by conventional imaging modalities such as CT and MRI. However, PET does not provide anatomical information and precise localization of any suspicious lesions may be difficult. Recently, an integrated PET/CT system, in which a full-ring detector clinical PET scanner and multidetector row helical CT scanner are combined, has made it possible to acquire both metabolic and anatomical imaging data using a single device in a single diagnostic session, and provides precise anatomical localization of suspicious areas of increased FDG uptake and rules out false-positive PET findings [3].

Today, different approaches are adopted for PET/CT scanning, with the CT protocol positioned between two possible extremes: (1) CT is used as a fast transmission source for attenuation correction and approximate anatomical mapping and is performed with a low radiation dose (“low-dose CT”), and (2) CT is used for attenuation correction and diagnostic purposes, being performed with a standard radiation dose and administration of intravenous contrast agent (“diagnostic CT”).

There have been several studies of FDG PET/CT [4–11] that have shown its usefulness for restaging uterine cancer and all of these studies except one [10] used low-dose non-enhanced CT (ldCT) for the CT component. However, the one study that used full-dose contrast-enhanced CT (ceCT) did not compare the diagnostic difference between PET/ceCT and PET/ldCT, and therefore the usefulness of intravenous contrast medium in PET/CT examination was strictly not clarified [10]. The purpose of the present study was to compare the diagnostic performance of PET/ceCT and PET/ldCT for restaging patients previously treated for uterine cancer, and to investigate the clinical value of intravenous contrast agent in the PET/CT scan.

## Materials and methods

### Patients

A group of 100 patients (age range 32–88 years, mean 60 years) who had undergone treatment for histopathologically

proven uterine cervical ( $n=55$ ) or endometrial cancer ( $n=45$ ) underwent PET/CT scans with intravenous contrast agent for suspected recurrence at our institution between December 2007 and February 2009 were included in this study with the approval of the institutional review board. Informed consent was obtained from each patient after the procedures were fully explained. Further details of these patients and their demographic data are listed in Table 1. Recurrence was suspected on the basis of physical examination, elevated tumour marker levels, abnormal CT and/or MR imaging findings, and an abnormal Papanicolaou (Pap) smear.

### FDG-PET/CT study

Whole-body imaging was performed using a combined PET/CT scanner (Discovery ST Elite-Performance, GE Healthcare, Waukesha, WI). The CT scan covered a region ranging from the meatus of the ear to the mid-thigh. The technical parameters of the 16-detector row helical CT scanner were: pitch 6 (high-speed mode), gantry rotation speed 0.6 s and slice thickness 3.75 mm. The PET component of the combined imaging system allowed simultaneous acquisition of 47 transaxial PET images with an interslice spacing of 3.75 mm in one bed position and provided an image from the meatus of the ear to the mid-thigh with seven or eight bed positions. The transaxial field of view and axial field of view of the PET images reconstructed for fusion were 70 cm and 15.9 cm, respectively, with a matrix size of  $128 \times 128$ . To avoid artefacts caused by the urinary tract, patients were asked to drink 500 ml of water 1 to 2 h prior to image acquisition, and to void just before the start of acquisition. No urinary bladder catheterization was used. After at least 4 h of fasting, patients received an intravenous injection of 3.33 MBq/kg body weight of  $^{18}\text{F}$ -FDG. The blood glucose levels were checked in all patients before FDG injection and no patients showed a blood glucose level of more than 160 mg/dl.

About 50 min later, initially a ldCT scan was performed at 140 kV and 40 mA with the normal expiration position for attenuation correction of PET images. A whole-body emission PET scan was performed immediately after the ldCT scan, with a 2-min acquisition per bed position using a three-dimensional acquisition mode. If the body mass index exceeded  $30 \text{ kg/m}^2$ , the acquisition time for the PET scan was 2.5 min. Finally, a diagnostic ceCT scan was performed with the same axial coverage at 120 kV, 350 mA, and 27.0 mm/rotation, during breath hold with the normal expiration position, similar to the ldCT scan. Iodinated contrast agent (Iopamiron Inj, Syringe; Bayer Schering Pharma, Berlin, Germany) containing 300 or 370 mg of iodine was administered intravenously via a power injector at a rate of 2.0–2.5 ml/s to a total volume of 80–100 ml, and the scan was started 100 s after injection.

**Table 1** Patient and tumour characteristics

Characteristic	Uterine cervical cancer	Endometrial cancer	Total
Number of patients	55	45	100
Age (years)			
Median	61	50	60
Range	39~82	32~88	39~88
FIGO stage (no. of patients)			
I	27	18	45
II	12	5	17
III	7	15	22
IV	9	7	16
Primary treatment (no. of patients)			
Surgery	25	23	48
Surgery + chemotherapy	9	15	24
Surgery + radiotherapy	4	2	6
Surgery + chemoradiotherapy	5	5	10
Chemoradiotherapy	12	0	12
Time between last treatment and PET/CT scan (months)			
Median	20	19	19
Range	4~89	5~80	4~70

FIGO: International Federation of Gynecology and Obstetrics

For image fusion, 3.75-mm slices were reconstructed. The IdCT, ceCT and PET images were transferred to a commercially available workstation (Xeleris, GE Healthcare) to access all the data. Attenuation-corrected PET images were reconstructed with an ordered-subset expectation maximization iterative reconstruction algorithm called VUE Point Plus. No oral contrast agent was administered.

#### Image analysis

Two experienced radiologists (reader A and reader B with 4 and 6 years of experience in PET/CT, respectively) who had knowledge of neither the other imaging results nor the clinical data retrospectively interpreted the PET/ceCT images and PET/IdCT images in consensus using a three-point scale (negative, equivocal or positive) per patient and per lesion. These two datasets were reviewed after a minimum interval of 1 month to avoid decision threshold bias due to reading-order effects. Two experienced radiologists (reader C and reader D with 8 and 18 years of experience in CT, respectively) who had knowledge of neither the other imaging results nor the clinical data retrospectively interpreted ceCT images in consensus using a three-point scale per patient and per lesion. Diagnostic ability was determined on a patient basis and on the basis of nine lesion sites: supraclavicular lymph node (LN), mediastinal and hilar LN, abdominal LN (including paraaortic, mesenteric and retrocrural LN), pelvic LN, lung, liver, peritoneum, muscle and bone, and pelvic local recurrence. On PET/ceCT and PET/IdCT, recurrent or metastatic lesions were

diagnosed when abnormal focal FDG uptake observed on PET images corresponded to an abnormal mass on CT. LNs with increased glucose uptake were deemed positive for metastatic spread even if their short-axis diameter was less than 1 cm. Conversely, LNs with no detectable tracer uptake were deemed negative for metastatic spread, even if their short-axis diameter was more than 1 cm. Semiquantitative analysis was not done in this study. This method of PET/CT image analysis was based on previous studies [4–7, 9, 10]. On ceCT, LNs with a short-axis diameter of 10 mm or more, between 6 and 9 mm, and 5 mm or less were defined as malignant, equivocal and benign, respectively. Furthermore, the presence of a central unenhanced area suggesting central necrosis was considered a sign of malignancy, and the presence of peripheral low attenuation suggesting a fatty hilum within a LN was considered a benign sign, regardless of node size [12].

The final diagnosis was obtained from the results of histopathological examination after surgery or biopsy, or clinical follow-up of at least 6 months (range 6–20 months, mean 14 months) on the basis of tumour marker levels, ceCT findings and PET/ceCT findings. Cases were classified as recurrence and/or metastasis if: (1) the present study revealed highly suspected recurrence without pathological evidence, and the patient underwent chemotherapy resulting in a decrease or disappearance in size and/or FDG uptake in the follow-up study; and (2) the follow-up study revealed tumour recurrence by CT and/or PET/CT in a place where a tiny lesion without FDG uptake was imaged at the time of the initial (present) study.

## Statistical analysis

Patient-based and lesion site-based analyses of the PET/ceCT results were performed based on the consensus verdict in general, compared with the PET/ldCT and ceCT findings. Sensitivity, specificity and accuracy were calculated defining equivocal interpretations as negativity for the sensitivity and positivity for the specificity to evaluate the diagnostic ability with certainty. Differences between the two imaging modalities (PET/ceCT vs. PET/ldCT and PET/ceCT vs. ceCT) were tested with the McNemar test. *P* values less than 0.05 were considered to indicate statistical significance.

## Results

### Patient-based analysis

In 30 (30.0%) of the 100 patients, recurrence and/or distant metastasis was confirmed by pathological examination and a clinical follow-up study and imaging. In the other 70 patients (70.0%), no recurrence was confirmed by the clinical follow-up study of tumour markers and imaging for at least 6 months. The grading results for detecting the 30 patients with recurrence were: *negative* 3, *equivocal* 0 and *positive* 27 for PET/ceCT; *negative* 3, *equivocal* 2 and *positive* 25 for PET/ldCT; and *negative* 7, *equivocal* 2 and *positive* 21 for ceCT (Table 2). Two patients with equivocal findings on PET/ldCT (one patient with local recurrence, and the other with liver metastasis) were correctly interpreted as positive on PET/ceCT. There were three patients with false-negative findings on both PET/ceCT and PET/ldCT, of whom two had a tiny local recurrence and one had tiny pelvic LN metastasis.

**Table 2** Patient-based diagnostic results

	Modality	Negative	Equivocal	Positive
All patients ( <i>n</i> =100)	PET/ceCT	71	0	29
	PET/ldCT	69	4	27
	CeCT	73	4	23
Patients with recurrence ( <i>n</i> =30)	PET/ceCT	3	0	27
	PET/ldCT	3	2	25
	CeCT	7	2	21
Patients without recurrence ( <i>n</i> =70)	PET/ceCT	68	0	2
	PET/ldCT	66	2	2
	CeCT	66	2	2

PET/ceCT: PET/full-dose contrast-enhanced CT

PET/ldCT: PET/low-dose non-enhanced CT

CeCT: contrast-enhanced CT

The imaging results in the 70 patients without recurrence were: *negative* 68, *equivocal* 0 and *positive* 2 for PET/ceCT; *negative* 66, *equivocal* 2 and *positive* 2 for PET/ldCT; and *negative* 66, *equivocal* 2 and *positive* 2 for ceCT. Two patients had false-positive findings on PET/ceCT, one focus being physiological FDG uptake in the ovary that was misinterpreted as pelvic LN metastasis and the other focus being physiological FDG uptake in the liver that was misinterpreted as liver metastasis. Two patients had false-positive findings on PET/ldCT, one focus being physiological FDG uptake in the ovary that was misinterpreted as pelvic LN metastasis and the other focus being physiological FDG uptake in the intestine that was misinterpreted as peritoneal dissemination. Two patients had equivocal findings on PET/ldCT, one focus being physiological FDG uptake in the liver that was misinterpreted as liver metastasis and the other focus being physiological FDG uptake in the inner iliac vessel that was misinterpreted as pelvic LN metastasis.

In the patient-based analysis the sensitivity, specificity and accuracy of PET/ceCT were 90.0% (27/30), 97.1% (68/70) and 95.0% (95/100), respectively, and of PET/ldCT were 83.3% (25/30), 94.3% (66/70) and 91.0% (91/100), and of ceCT were 70.0% (21/30), 94.3% (66/70) and 87.0% (87/100), respectively. Although PET/ceCT offered a little better sensitivity, specificity and accuracy than PET/ldCT, the sensitivity, specificity and accuracy did not significantly differ between the two imaging modalities (McNemar test, *p*=0.4795, *p*=0.4795, and *p*=0.1336, respectively). PET/ceCT offered significantly better sensitivity and accuracy than ceCT (McNemar test, *p*=0.0412 and *p*=0.0133, respectively) and there was no significant difference in specificity (*p*=0.4795).

For patients with cervical cancer, patient-based sensitivity, specificity and accuracy of PET/ceCT were 88.2% (15/17), 97.4% (37/38) and 94.5% (52/55), respectively, and for patients with endometrial cancer, those of PET/ceCT were 92.3% (12/13), 96.9% (31/32) and 95.6% (43/45), respectively.

### Lesion site-based analysis

Nine lesion sites, including the retrovesical region, lung, liver, muscle, peritoneum, supraclavicular LN, mediastinal and hilar LN, abdominal LN, and pelvic LN, were evaluated in each patient. There were 52 sites of lesion recurrence: 12 in pelvic LNs, 11 in the retrovesical regions, 8 in the peritoneum, 7 in paraaortic LNs, 5 in the lung, 3 in the liver, 3 in supraclavicular LNs, 2 in mediastinal and hilar LNs, and 1 in muscle. The grading results for detecting the 52 recurrent regions were: *negative* 5, *equivocal* 0 and *positive* 47 for PET/ceCT; *negative* 5, *equivocal* 4 and *positive* 43 for PET/ldCT; and *negative* 14, *equivocal* 6 and *positive* 32 for ceCT (Table 3). Four regions interpreted as equivocal on PET/ldCT (local recurrence, pelvic LN metastasis, liver metastasis, and muscle metastasis) were correctly interpreted

**Table 3** Lesion site-based diagnostic results

Site	Modality	Negative	Equivocal	Positive	Sensitivity
Retrovesical region ( <i>n</i> =11)	PET/ceCT	2	0	9	81.8% (9/11)
	PET/ldCT	2	1	8	72.7% (8/11)
	CeCT	2	2	7	63.6% (7/11)
Pelvic LN ( <i>n</i> =12)	PET/ceCT	1	0	11	91.7% (11/12)
	PET/ldCT	1	1	10	83.3% (10/12)
	CeCT	3	1	8	66.7% (8/12)
Abdominal LN ( <i>n</i> =7)	PET/ceCT	1	0	6	85.7% (6/7)
	PET/ldCT	1	0	6	85.7% (6/7)
	CeCT	2	1	4	57.1% (4/7)
Mediastinal and hilar LN ( <i>n</i> =2)	PET/ceCT	0	0	2	100% (2/2)
	PET/ldCT	0	0	2	100% (2/2)
	CeCT	0	1	1	50% (1/2)
Supraclavicular LN ( <i>n</i> =3)	PET/ceCT	0	0	3	100% (3/3)
	PET/ldCT	0	0	3	100% (3/3)
	CeCT	2	0	1	33.3% (1/3)
Peritoneum ( <i>n</i> =8)	PET/ceCT	1	0	7	87.5% (7/8)
	PET/ldCT	1	0	7	87.5% (7/8)
	CeCT	3	1	4	50% (4/8)
Liver ( <i>n</i> =3)	PET/ceCT	0	0	3	100% (3/3)
	PET/ldCT	0	1	2	66.7% (2/3)
	CeCT	1	0	2	66.7% (2/3)
Lung ( <i>n</i> =5)	PET/ceCT	0	0	5	100% (5/5)
	PET/ldCT	0	0	5	100% (5/5)
	CeCT	0	0	5	100% (5/5)
Muscle and bone ( <i>n</i> =1)	PET/ceCT	0	0	1	100% (1/1)
	PET/ldCT	0	1	0	0% (0/1)
	CeCT	1	0	0	0% (0/1)
Total ( <i>n</i> =52)	PET/ceCT	5	0	47	90.4% (47/52)
	PET/ldCT	5	4	43	82.7% (43/52)
	CeCT	14	6	32	61.5% (32/52)

PET/ceCT: PET/full-dose contrast-enhanced CT

PET/ldCT: PET/low-dose non-enhanced CT

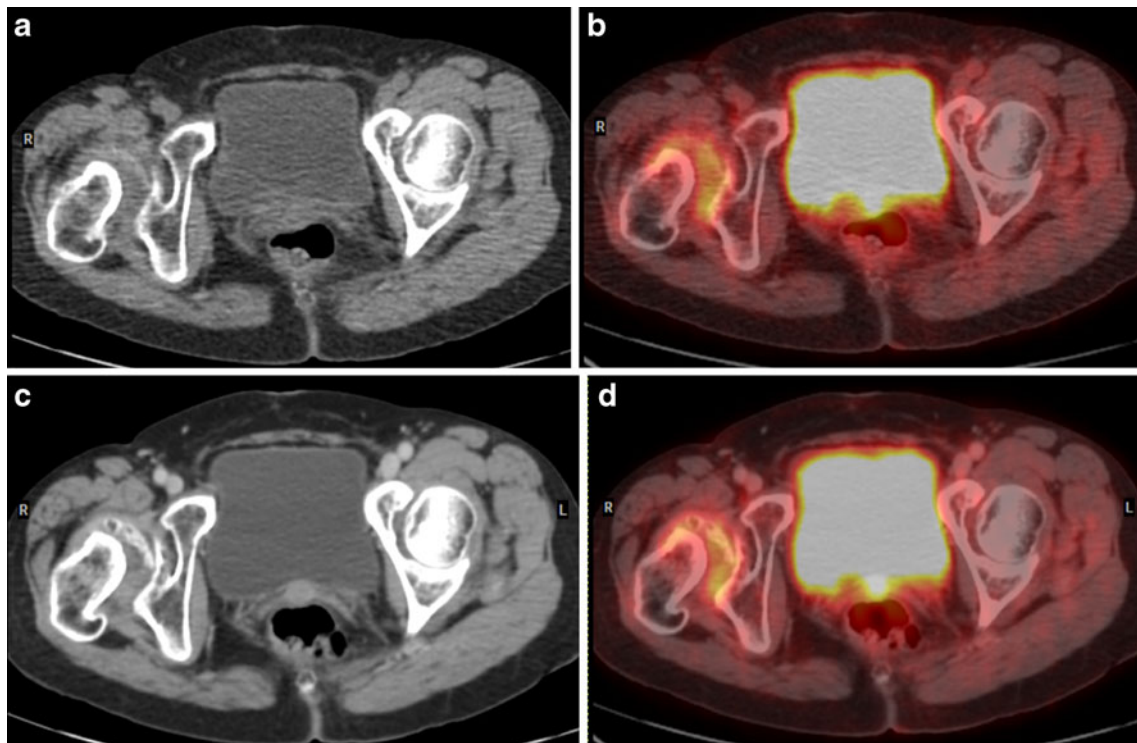
CeCT: contrast-enhanced CT

as positive on PET/ceCT. Five regions were interpreted as false-negative on both PET/ceCT and PET/ldCT: two local recurrence, one pelvic LN metastasis, one paraaortic LN metastasis, and one peritoneum. Overall sensitivity for LN metastasis including supraclavicular LNs, mediastinal and hilar LNs, abdominal LNs and pelvic LNs, on PET/ceCT, PET/ldCT and ceCT were 91.7% (22/24), 87.5% (21/24) and 58.3% (14/24), respectively. Two representative cases are shown in Figs. 1 and 2.

## Discussion

To our knowledge, this is the first study to have investigated the additional diagnostic value of integrated

PET/ceCT over PET/ldCT for diagnosis of uterine cancer recurrence. Our results showed that patient-based sensitivity, specificity and accuracy of PET/ceCT were 90%, 97% and 95%, respectively, whereas those of PET/ldCT were 83%, 94% and 91%, respectively. The difference, although not statistically significant, between the two methods in sensitivity, specificity and accuracy occurred because of the way “equivocal” was defined as positive or negative as described in the [Image analysis](#) section. Further study in a large population is required to obtain more evidence. Moreover, with PET/ceCT, the proportion of equivocal findings on the per patient basis decreased by 4.0% (from 4 of 100 patients to 0 of 100) and on the per lesion basis decreased by 7.7% (from 4 of 52 lesions to 0 of 52). PET/ceCT led to fewer or no equivocal interpretations and



**Fig. 1** A 56-year-old woman with local recurrence. **a** Low-dose non-enhanced CT image shows no abnormal findings. **b** PET/IdCT image shows abnormal FDG uptake corresponding to a soft-tissue density mass, suggestive of local recurrence. The image was interpreted equivocal. **c** Full-dose contrast-enhanced CT image shows an enhanced

soft-tissue density mass in the resected region. The image was interpreted positive. **d** PET/ceCT image shows abnormal FDG uptake corresponding to an enhanced soft-tissue density mass, and therefore the image was interpreted as local recurrence (positive). Histopathological examination of the surgical specimen revealed local recurrence

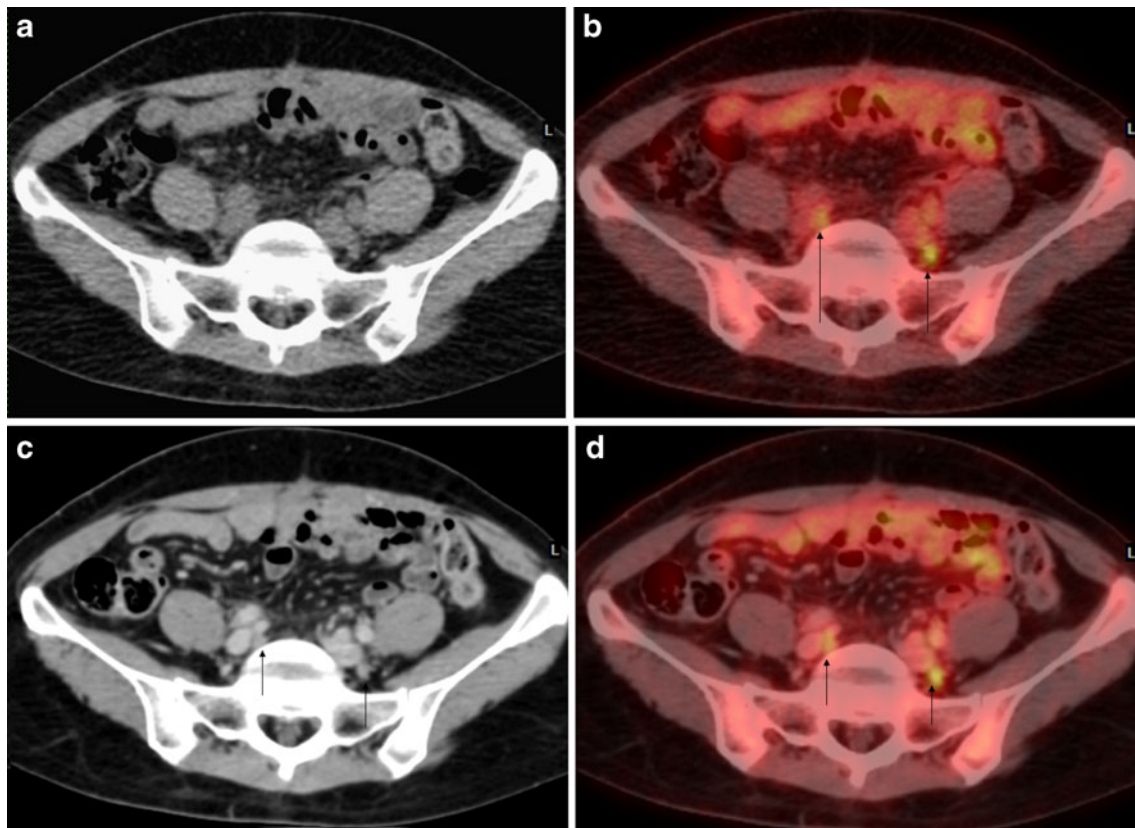
accurate diagnostic performance with more certainty. As in our series, conventional PET/CT scans without intravenous contrast agent often leads to some equivocal interpretations. Depending on the level of clinical suspicion, equivocal interpretations may require further evaluation with additional imaging studies such as ceCT and MRI, and biopsy. This may be associated with additional costs for the health-care system and an emotional burden on the patient involved. In contrast, the use of iodine-based intravenous contrast material allows more accurate and confident interpretations, and PET/ceCT reduces the frequency of equivocal interpretations, and therefore minimizes the burden on the patient. The significant decrease in the number of equivocal interpretations afforded by PET/ceCT, associated with consistently high accuracy in image interpretation, is therefore of immediate clinical relevance. Although PET/ceCT is a real “one-stop-shop” examination, the use of intravenous contrast agent in the PET/CT scan may not be justified for clinical routine examinations in the view of the prevalence and cost.

Even PET/ceCT could not detect several tiny lesions in our series. The spatial resolution of PET scans is insufficient for the detection of small lesions. With spatial resolutions of 4 to 6 mm for currently available PET and PET/CT systems, the detection of microscopic lesions remains challenging. Improving the spatial resolution and sensitivity of PET and PET/

CT scanners and developing new, more specific radioactive tracers may help to overcome this limitation in the future.

With regard to posttherapy surveillance, in several studies integrated PET/IdCT has shown a sensitivity of 90–100%, a specificity of 81–100% and an accuracy of 87–97% in the clinical diagnosis of uterine cervical cancer [4, 5, 9, 11] and endometrial cancer [5–8], and in one study integrated PET/ceCT has shown a sensitivity of 91%, a specificity of 94% and an accuracy of 92% in the clinical diagnosis of uterine cervical cancer and endometrial cancer [10]. Our results were almost the same. In the previous studies, false-negative findings included local recurrence and paraaortic LN metastasis, and false-positive findings included local recurrence, lung metastasis, bone metastasis, peritoneal dissemination, mediastinal and hilar LN metastasis, and axillary LN metastasis [4–11].

The use of CT intravenous contrast agents in PET/CT is still controversial. Some have argued that CT image data should be used only for attenuation correction of PET, for reduction of acquisition times, to prevent overestimation of PET attenuation factors by intravenous contrast media, and to localize hypermetabolic lesions with a low radiation dose (“low-dose CT”) [13–15], whereas others advocate the need to perform full-dose, contrast-enhanced, and high-resolution CT (“diagnostic CT”) [16, 17]. As an integrated



**Fig. 2** A 41-year-old woman with bilateral pelvic LN metastases. **a** Low-dose non-enhanced CT image shows no abnormal findings. **b** PET/IdCT image shows abnormal FDG uptake corresponding to two small nodules near the bilateral inner iliac vessels, suggestive of bilateral pelvic LN metastases (*arrows*). The image was interpreted as equivocal. **c** Full-dose contrast-enhanced CT image shows bilateral

small iliac LNs 7 and 8 mm in short axis diameter with mild enhancement (*arrows*). The image was interpreted as equivocal. **d** PET/ceCT image shows abnormal FDG uptake corresponding to bilateral small inner iliac LNs and therefore bilateral pelvic LN metastases was interpreted (*arrows*). Histopathological examination of the surgical specimen revealed bilateral pelvic LN metastases

PET/CT scanner has been installed in many institutions, an increasing number of reports describing the clinical usefulness of iodine-based contrast material for PET/CT scanning have appeared. There have been several reports of the superiority PET/ceCT over PET/IdCT in staging malignant lymphoma [18], staging and therapy planning of non-small-cell lung cancer [19], evaluating the preoperative nodal status of rectal cancer [20], evaluating the nodal status of pelvic and retroperitoneal lymphatic pathways in malignant lymphoma [21], assessing the resectability of pancreatic cancer [22], restaging ovarian cancer [23], and restaging colon cancer [24, 25]. A recent study has demonstrated that although there is an increase in standardized uptake values in normal and pathological regions of high contrast agent concentration when ceCT is used for attenuation, this increase is clinically insignificant, and ceCT can be used in combination with PET in the evaluation of patients with cancer [26]. We used IdCT for attenuation correction in our series to prevent overestimation of PET attenuation factors by intravenous contrast media because when ceCT is used for attenuation, the

problem of high radiation exposure can occur. Further study in a larger patient population is needed to elucidate the efficacy, radiation exposure, and cost-effectiveness of PET/ceCT.

This study had certain limitations. First, the gold standard for any analysis would be histological confirmation of the findings. However, clinical follow-up is a valid way to evaluate diagnostic accuracy and response to therapy, and it would have been unethical to investigate all PET/CT-detected lesions using invasive procedures. Positive findings are easy to confirm, but negative findings only mean that it is not possible to acquire positive findings during the follow-up period, making it uncertain whether the findings are truly negative. Therefore, sensitivity in this series may have been overestimated. Second, the study population was relatively small. Therefore, further studies are required to validate the present results in a larger population. Third, we did not strictly compare PET/CT with contrast agent and PET/CT without contrast agent, but compared PET plus low-dose CT without contrast agent and PET plus full-dose CT with contrast agent. It would have been more appropriate to compare PET plus full-dose

CT without contrast agent and PET plus full-dose CT with contrast agent in order to investigate the clinical value of intravenous contrast agent. Fourth, no oral contrast materials were used in this series. Adding an oral contrast agent would probably have helped to better delineate normal bowel activity and demonstrate pathological intraabdominal activity (peritoneal implantation). Fifth, the follow-up period (minimum 6 months) was relatively short which may have been one reason for the relatively low percentage recurrence (30%) in our series. Furthermore, some true-negative findings could have been found to be false-negative if the follow-up period had been longer.

In conclusion, integrated PET/ceCT is an accurate imaging modality for the assessment of uterine cancer recurrence. Its use reduces the frequency of equivocal interpretations.

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