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

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Purpose

• To improve diagnostic accuracy of PET/CT, more recently, PET/contrast-enhanced CT (PET/ceCT) with intravenous iodine contrast medium and sufficient radiation dose has been gradually introduced in the clinical setting.

Several reports have described the clinical usefulness of PET/ceCT, however, further analysis is necessary to raise the evidence level.

• To evaluate low-dose non-enhanced CT (ldCT) and full-dose contrast-enhanced CT (ceCT) in FDG-PET/CT studies for restaging of ovarian cancer.
Methods and Materials

• One hundred women who had undergone treatment for ovarian cancer underwent PET/CT scans consisting of intravenous non-enhanced and contrast-enhanced CT for suspected recurrence and distant metastasis between November 2007 and October 2010. • Two observers interpreted and decided in consensus on the PET/ceCT and PET/idCT images by a 3-point scale (N: negative, E: equivocal, P: positive) per patient and lesion: supraclavicula lymph node (LN), mediastinal/hilar LN, para-aortic LN, pelvic LN, lung, liver, peritoneum, and local recurrence.

• Final diagnoses were obtained by histopathological examinations, or clinical follow-up for at least six months. • Sensitivity, specificity, and accuracy were calculated defining equivocal interpretations as negativity. • Differences between the two imaging modalities were tested with McNemar test.

P values of less than 0.05 were considered to indicate statistical significance.

Patient characteristic

Stage (FIGO stage)

# 16
# 9
# 60
# 15

Ovarian tumor pathology

Serous adeno Ca 38 Clear cell Ca 15
Mucinous adeno Ca 16 Serous cystaedno Ca 10
Endometrioid Ca 16 Undifferentiated adeno Ca 5

Reason of PET/CT examination

Elevated levels of tumor marker 56
Elevated tumor marker levels and abnormal CT/MRI findings 18
Abnormal CT/MRI findings 14
Abnormal physical examination 10

Abnormal Papanicolaou smear 2

Whole-body imaging was performed using a combined PET/CT scanner (Discovery ST Elite-Performance, GE Healthcare, Waukesha, WI, USA). CT 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 a pitch of 6 (high-speed mode), a gantry rotation speed of 0.6 s, and a slice thickness of 3.75 mm.

The PET component of the combined imaging system allows 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 per bed of the PET images reconstructed for fusion were 70 and 15.9 cm, respectively, with a matrix size of 128 x 128. After at least 5 h of fasting, patients received an intravenous injection of 3.33 MBq/kg body weight of 18F-FDG. The blood glucose levels were checked in all patients before FDG injection and no patients showed a blood glucose level higher than 160 mg/dl. To avoid artifacts caused by the urinary tract, patients were asked to drink 500 ml of water 1-2 h prior to image acquisition, and to void just before the start of acquisition. No urinary bladder catheterization was used.

About 50 min post-injection of FDG, low-dose nonenhanced CT was performed at 140 kV and 40 mA with the normal expiration position for attenuation correction of PET image. A whole-body emission PET scan was performed immediately after the low-dose non-enhanced CT (ldCT), with a 2-min acquisition per bed position using a three-dimensional acquisition mode. Attenuation-corrected PET images were reconstructed with an ordered-subset expectation maximization iterative reconstruction algorithm called VUE Point Plus. Finally, diagnostic full-dose contrast-enhanced CT (ceCT) was performed for the same axial coverage at 120 kV, 350 mA, and 27.0 mm/rotation speed, during breath hold with the normal expiration position, similar to low-dose CT scanning. Intravenous
administration of a total volume of 80-100 mL of iodinated contrast agent (Iopamiron Inj, Syringe, Bayer Schering Pharma, Berlin, Germany) containing 300 or 370 mgI/mL of iodine via power injection at a rate of 2.0-2.5 mL/s was performed and the ceCT scan started at 100 s after the start of injection. 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, Waukesha, WI, USA) to access all data. No oral contrast agent was administered.
Results

Patient-based analysis showed that the sensitivity, specificity, and accuracy of PET/ceCT was 86.8% (33/38), 95.2% (59/62), and 92.0% (92/100), respectively, whereas those of PET/ldCT were 78.9% (30/38), 91.9% (57/62), and 87.0% (87/100), respectively. Sensitivity, specificity, and accuracy did not significantly differ between two methods (McNemar test, p=0.25, p=0.48, and p=0.073, respectively). There were 86 sites of lesion recurrence: 28 peritoneum, 15 pelvic lymph node (LN), 14 para-aortic LN, 11 local recurrence, 6 liver, 6 supraclavicular LN, 4 mediastinal/hilar LN, and 2 lung. The scales of detecting 86 recurrent regions were N:11, E:5, P:70 for PET/ceCT, and N:12, E:14, P:60 for PET/ldCT, respectively. Nine equivocal regions (2 local, 2 peritoneum, 2 pelvic LN, para-aortic LN, supraclavicular LN and liver) and one negative regions (liver) by PET/ldCT were correctly interpreted as positive by PET/ceCT.

Figure legends

Case. 1) A case of Peritoneal dissemination

1. Enhanced CT shows suspected peritoneal soft tissue mass.

2. PET/ceCT shows abnormal FDG uptake corresponding to the peritoneal lesion, suggesting the presence of peritoneal dissemination. Histopathological examination confirmed extensive LN involvement by cancer in this node.

3. Nonenhanced CT shows no abnormal findings.

4. PET/ldCT shows equivocal finding of peritoneal dissemination.

Case. 2) A case of Pelvic LN metastasis.

5. Enhanced CT shows a tiny left internal iliac LN.

6. PET/ceCT shows abnormal FDG uptake corresponding to the left internal iliac LN, suggesting the presence of nodal cancer spread. Histopathological examination confirmed extensive LN involvement by cancer in this node.

7. Nonenhanced CT shows no abnormal findings.

8. PET/ldCT shows equivocal finding of LN metastasis.

• an increasing number of reports have described the clinical usefulness of intravenous iodine-based contrast material for PET/CT #Ø staging malignant lymphoma 1);
Ø staging and therapy planning of non-small cell lung cancer2),
Ø staging head and neck cancer3), Ø detecting liver metastasis4),
Ø evaluating preoperative nodal status of rectal cancer5),
Ø evaluating preoperative nodal status of uterus cancer6),
Ø assessing the respectability of pancreatic cancer7),
Ø restaging ovarian cancer8),
Ø restaging uterine cancer9),
Ø restaging colon cancer10,11)

PET/contrast-enhanced CT

• Advantage

real "one-stop-shopping" examination.

reducing the frequency of equivocal interpretations, and no requirement of additional patient's burden such as additional imaging studies and biopsy.

• Disadvantage

High radiation exposure and side effect by contrast material to patients with low possibility of recurrence.

Heavy burden of medical workers.
Fig. 1: Enhanced CT shows suspected peritoneal soft tissue mass.

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**Fig. 2:** PET/ceCT shows abnormal FDG uptake corresponding to the peritoneal lesion, suggesting the presence of peritoneal dissemination. Histopathological examination confirmed extensive LN involvement by cancer in this node.

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Fig. 3: Nonenhanced CT shows no abnormal findings.

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Fig. 4: PET/IdCT shows equivocal finding of peritoneal dissemination.

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**Fig. 5:** Enhanced CT shows a tiny left internal iliac LN.

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Fig. 6: PET/ceCT shows abnormal FDG uptake corresponding to the left internal iliac LN, suggesting the presence of nodal cancer spread. Histopathological examination confirmed extensive LN involvement by cancer in this node.

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**Fig. 7:** Nonenhanced CT shows no abnormal findings.

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**Fig. 8:** PET/IdCT shows equivocal finding of LN metastasis.

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Conclusion

• PET/contrast-enhanced CT is an accurate imaging modality for the assessment of ovarian cancer recurrence with certainty, reducing the frequency of equivocal interpretations.

• PET/contrast-enhanced CT may be a real "one-stop-shopping" examination.
References


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