OPEN
Original article

Nuclear Medicine Communications

^{18}F-FDG PET/computed tomography scan in patients with suspicion of recurrent neuroendocrine carcinoma of the cervix

Yuanyuan Jiang[a,b], Guozhu Hou[a,b], Li Huo[a,b], Fang Li[a,b], Zhaohui Zhu[a,b] and Wuying Cheng[a,b]

Objectives **The aim of this study was to investigate the value of [18F]fluoro-2-deoxy-D-glucose (^{18}F-FDG) PET/computed tomography (CT) to detect recurrent cervical neuroendocrine carcinoma and its subsequent impact on patient management.**

Methods **A total of 25 patients who had undergone 30 ^{18}F-FDG PET/CT studies for suspected recurrent cervical neuroendocrine carcinoma (18 small cells, 2 large cells, 1 atypical carcinoid, and 4 unclassified) were retrospectively analyzed. The findings of the PET/CT images were compared with the histopathologic results in 8 scans and with clinical follow-up in 22 scans.**

Results **Of the 30 PET/CT studies, 63.3% (19/30) were positive for recurrence while 36.7% (11/30) were negative. The sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of ^{18}F-FDG PET/CT for detecting recurrent disease of cervical neuroendocrine carcinomas were 90.0, 90.0, 94.7, 81.8, and 90.0%, respectively. Metastasis to distant organs was the most common (89.4%), followed by lymph node recurrence (52.6%). Lungs were the most frequent site of distant metastasis (63.1%). ^{18}F-FDG PET/CT findings led to the change of the management in 10 out of 25 patients (40%) by introducing the use of previously unplanned therapeutic procedures.**

Conclusions **^{18}F-FDG PET/CT is an efficient technique for detecting recurrent cervical neuroendocrine carcinoma, and may thus contribute to improving patient management. *Nucl Med Commun* 42: 1151–1156**

Nuclear Medicine Communications 2021, **42**:1151–1156

Keywords: cervical neuroendocrine carcinoma, FDG, PET/computed tomography, recurrence

[a]Department of Nuclear Medicine, State Key Laboratory of Complex Severe and Rare Diseases, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College and [b]Beijing Key Laboratory of Molecular Targeted Diagnosis and Therapy in Nuclear Medicine, Beijing, China

Correspondence to Zhaohui Zhu, MD, Department of Nuclear Medicine, Peking Union Medical College Hospital, No.1 Shuaifuyuan, Wangfujing, Dongcheng District, Beijing 100730, China
Tel: + 86 010 69154196; fax: +86 010 69154196;
e-mail: 13611093752@163.com

Received 13 January 2021 **Accepted** 23 March 2021

Introduction

Neuroendocrine neoplasias (NENs) derive from neuroendocrine cells of the endocrine and nervous systems. NENs are mainly located in the pancreas, the gastrointestinal tract, and the lungs [1]. Rarely, NENs may also occur in the female genital tract [2]. Cervical neuroendocrine carcinoma is a rare and aggressive histological variant of cervical cancer, representing about 1–1.5% of all cervical cancer [3]. Similar to its counterpart in the lung, cervical neuroendocrine carcinomas have been classified into four distinct histological subtypes: small cell, large cell, typical carcinoid, and atypical carcinoid [4]. Small cell neuroendocrine carcinoma is the most common histological subtype.

Cervical neuroendocrine carcinomas exhibit aggressive behavior with early hematogenous and lymphatic metastases [5]. Approximately 40–70% of cervical neuroendocrine carcinoma patients developed pelvic lymph node metastasis at the time of diagnosis [6,7]. Distant metastases to lung, liver, brain, and bone are frequently observed in patients [8,9]. Computed tomography (CT) or MRI is based on anatomical modifications, such as the detection of a new lesion or changes in the size of a known lesion. However, in the post-therapy setting, these conventional imaging techniques are of limited value in identifying recurrent lesions. Therefore, despite the widespread use of CT and MRI, a more sensitive imaging modality for the detection of local or distant recurrence is needed.

Many studies have demonstrated that [18F]fluoro-2-deoxy-D-glucose (^{18}F-FDG) PET/CT is valuable in the primary staging and restaging of cervical cancer and is significantly superior to CT/MRI in the detection of metastatic lesions [10–13]. ^{18}F-FDG PET/CT has also

been applied in small cell lung cancer [14–16]. However, data on the use of ^{18}F-FDG PET/CT in cervical neuroendocrine carcinomas are still limited. One case series of five patients with cervical neuroendocrine carcinomas have initially indicated a preliminary value of ^{18}F-FDG PET/CT in this entity [17]. A recent study by Chen *et al.* further reported the usefulness of ^{18}F-FDG PET/CT in 25 patients with untreated primary small cell neuroendocrine carcinoma of the cervix [18]. However, a study investigating the role of ^{18}F-FDG PET/CT for the diagnosis of tumor recurrence in patients with previously treated cervical neuroendocrine carcinoma is lacking. Therefore, the objective of this study was to evaluate the accuracy of ^{18}F-FDG PET/CT for the detection of suspected recurrence in patients with cervical neuroendocrine carcinoma and its subsequent impact on patient management.

Patients and methods

Patients

This retrospective study included 25 patients (all women; mean age, 44.1 ± 9.2 years; range, 30–66 years) with suspected cervical neuroendocrine carcinoma recurrence who had previously been treated for primary tumor between January 2015 and April 2020. This study was approved by the institutional review board. Due to the retrospective design of the study, written informed consent was waived. ^{18}F-FDG PET/CT scans were performed in all patients for a variety of indications, including clinical symptoms that were suspicious of a recurrence, suspicious lesions identified on surveillance conventional imaging studies, surveillance PET/CT scan for evaluation of treatment response. The International Federation of Gynecology and Obstetrics (FIGO) classification was used for tumor staging [19]. Clinical information including age, tumor stage at initial diagnosis, histopathologic type, primary treatment strategy at the time of PET/CT scans were recorded via reviewing the medical records.

^{18}F-FDG PET/computed tomography study

Prior to ^{18}F-FDG injection, all patients fasted for at least 4–6 h. Each patient received an intravenous administration of ^{18}F-FDG (5.5 MBq/kg) when blood glucose level was less than 120 mg/dL. PET/CT scans started 60 min after injection were acquired supine from the skull base to the mid-thigh using a combined PET/CT biograph (Siemens Company, Germany). A low-dose CT scan was obtained for attenuation correction and anatomical localization. PET scans were acquired in a 3D model for 2–3 min per bed position.

Image analysis

PET/CT images were retrospectively reviewed by two experienced nuclear medicine physicians. PET/CT was rated positive if the metabolic activity in the lesion was moderately or markedly increased relative to comparable normal structures or surrounding soft tissues. A lesion with no or faint FDG uptake (less or equal to the surrounding soft tissues) was defined as negative. For both ethical and practical reasons, not every suspected recurrent lesion was seen on PET/CT could be evaluated by histology. Therefore, a combination of histopathology (when available) or clinical follow-up of at least 6 months was taken as the reference standard. Lesions showing progression in number or size on clinical examination or CT or MRI, or showing a response to anticancer therapy during the follow-up were defines as recurrence. Recurrences seen on PET/CT were divided into three groups: distant organ metastasis, lymph nodal metastasis, and local recurrence (e.g. local vaginal recurrence).

Statistical analysis

All the statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 21.0. Armonk, New York, USA). Continuous data were expressed as mean ± SD. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of ^{18}F-FDG PET/CT for the detection of recurrent disease were calculated on a per-study basis.

Results

Patient characteristics

A total of 30 restaging ^{18}F-FDG PET/CT scans in 25 patients suspected of recurrent cervical neuroendocrine carcinomas were analyzed. Clinical characteristics of the enrolled patients are summarized in Table 1. All the

Table 1 Clinical characteristics of patients with suspected recurrent cervical neuroendocrine carcinoma

Characteristics	Value
Number of patients	25
Age, median (range) years	43 (30–66)
Scans performed/patient	
1 scan/patient	21
2 scans/patient	3
3 scans/patient	1
Histopathology, *n* (%)	
Small cell neuroendocrine carcinoma	18 (72%)
Large cell neuroendocrine carcinoma	2 (8%)
Atypical carcinoid	1 (4%)
Unclassified	4 (16%)
FIGO stage at initial diagnosis, *n* (%)	
I	12 (48%)
II	7 (28%)
III	2 (8%)
IV	4 (16%)
Primary treatment, *n* (%)	
Surgery	2 (8%)
Chemotherapy	2 (8%)
Chemoradiotherapy	5 (20%)
Surgery + chemotherapy	5 (20%)
Surgery + chemoradiotherapy	11 (44%)
Indications for PET/CT scans, *n* (%)	
Abnormal conventional imaging findings	10 (33.3%)
Clinical symptoms	5 (16.7%)
Monitoring treatment response	15 (50%)

CT, computed tomography; FIGO, Federation of Gynecology and Obstetrics.

patients had previously been treated with surgery or radiotherapy or chemotherapy. The majority of patients had small cell neuroendocrine carcinoma (18, 72%), 2 (8%) had large cell neuroendocrine carcinoma, 1 (4%) had atypical carcinoid, the remaining 4 (16%) were unclassified. The indications for PET/CT scans were abnormal conventional imaging findings in 10 scans, clinical symptoms in 5. And 15 PET/CT studies were performed for evaluation of treatment response. The final diagnosis was established based on the histopathologic results in 8 of 30 PET/CT studies (26.7%) and by clinical follow-up in the remaining 22 PET/CT studies (73.3%).

^{18}F-FDG PET/computed tomography results

Diagnostic accuracy

Of the 30 PET/CT studies, 63.3% (19/30) were positive for recurrence while 36.7% (11/30) were negative (Table 2). According to the final reference standard, 18 PET/CT studies were true-positive, 9 studies were true-negative, 1 study was false-positive, and 2 studies were false-negative. Thus, the per-study sensitivity, specificity, PPV, and NPV, and accuracy of ^{18}F-FDG PET/CT were 90.0, 90.0, 94.7, 81.8, and 90.0%, respectively. In two patients (one PET/CT scan per patient), the co-registered CT scan of the PET/CT revealed multiple small round nodules (<5 mm). PET scan appeared negative as the small size of the nodules made it difficult to determine the true FDG metabolism within the nodule. Follow-up diagnostic chest CT scans provided evidence of pulmonary metastasis by showing an increase in the number and size of lung nodules. These two PET/CT scans were considered false-negative. In one patient, ^{18}F-FDG PET/CT demonstrated enlarged lymph nodes in the inguinal regions with increased uptake, which was suspected to be metastatic. This was determined as a false-positive finding as the left inguinal nodal biopsy revealed the lesion to be negative for malignancy (lymphoid hyperplasia with no tumor involvement).

Comparison with conventional imaging

Comparable conventional imaging data (CT or MR) were available for 11 patients. PET/CT scan was true positive (TP) in 10, true negative (TN in 1), false positive (FP) in 0, and false negative (FN) in 0; while conventional imaging was TP in 9, TN in 1, FP in 0, and FN in 1. Patient-based sensitivity and specificity of PET/CT and conventional imaging were 100 vs. 90% and 100 vs. 100%. We separately calculated the diagnostic value of PET/CT and conventional imaging for distant organ metastases and nodal disease. The sensitivity was 90 vs. 80% for distant organ metastases and 100 vs. 80% for nodal disease.

Table 2 Performance of ^{18}F-FDG PET/computed tomography for the detection of recurrent cervical neuroendocrine carcinoma

Performance	PET/CT
True-positive (*n*)	18
True-negative (*n*)	9
False-positive (*n*)	1
False-negative (*n*)	2
Sensitivity (%)	90.0%
Specificity (%)	90.0%
PPV (%)	94.7%
NPV (%)	81.8%
Accuracy (%)	90.0%

CT, computed tomography; NPV, negative predictive value; PPV, positive predictive value.

Sites of recurrence

The sites of recurrence observed on ^{18}F-FDG PET/CT are described in Table 3. A total of 19 patients, including 17 patients with true-positive PET/CT scans and 2 with false-negative PET/CT scans, were found to have recurrences in this study. Metastasis to distant organs was the most common and was seen in about 89.4% (17/19) of patients (Fig. 1). Lungs were the most frequent site of distant metastasis (63.1%), followed by liver (31.5%), bone (21.4%), pancreas (10.5%), and brain (5.2%). Lymph node recurrence was observed in about 52.6% (10/19) of patients. Also, in two patients (10.5%) PET/CT detected local recurrence. Bone metastasis was observed in 4 patients for a total of 12 detected foci. In 11 (91.7%) lesions, focal FDG activity was not associated with any osteo-structural changes at co-registered CT images (Fig. 2), the remaining one (8.3%) corresponded to the osteolytic lesion.

Clinical impact of PET/computed tomography

The confirmation of suspected recurrence site by biopsy was not considered as the change of therapeutic procedure. The findings of the PET/CT scan resulted in the change of the treatment plan in 10 out of 25 patients (40%) by identifying previously unsuspected findings, including nodal disease in 7, bone metastases in 3, liver metastases in 6, lung metastases in 2, pancreatic metastasis in 1. One patient was treated with radiotherapy for bone metastases found on PET/CT. Two patients received chemoradiotherapy after PET/CT. One was due to the liver, pancreas, and lymph node metastases; the other due to the bone, liver, and lymph node metastases. The remaining seven patients were treated with chemotherapy after PET/CT detected multiple metastases.

Discussion

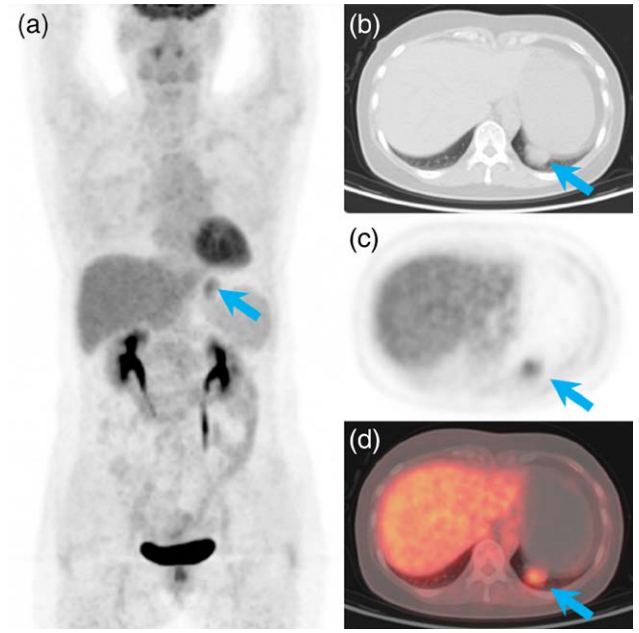
Cervical cancer is a common gynecologic malignancy with squamous cell type accounting for the majority of the disease. Rare types of cervical cancer include lymphoma, signet cell tumors, and neuroendocrine carcinomas. ^{18}F-FDG PET/CT has emerged as a useful imaging technique for the detection of recurrent cervical cancer. The reported sensitivity and specificity of ^{18}F-FDG PET/CT were 93–100% and 59–90.9%, respectively [20,21]. However, the potential of ^{18}F-FDG PET/CT in recurrent cervical neuroendocrine carcinoma was barely investigated before. The present study showed that

Table 3 Sites of recurrence on ^{18}F-FDG PET/computed tomography

Sites of recurrence[a]	Frequency (%, *n*/19)
Distant organs	17 (89.4%)
Lung	12 (63.1%)
Liver	6 (31.5%)
Bone	4 (21.0%)
Pancreas	2 (10.5%)
Brain	1 (5.2%)
Lymph nodes	10 (52.6%)
Abdominopelvic	10 (52.6%)
Supradiaphragmatic	4 (21.0%)
Local recurrence	2 (10.5%)

[a]Some of the patients had more than one site of recurrence.
CT, computed tomography.

Fig. 1



Representative images of a 41-year-old patient who was treated primarily with surgery and chemoradiotherapy for stage I small cell neuroendocrine carcinoma of the cervix. Surgical pathology showed no evidence of lymph node metastasis. Surveillance chest CT scan 1 year after primary treatment revealed a new nodule at the left lung base (size, 2.5 × 1.6 cm). Restaging ^{18}F-FDG PET/CT was then recommended for detecting potential recurrence and revealed increased FDG uptake to the lung nodule (SUVmax, 3.1; arrows) without abnormal FDG activity suggesting recurrence at other areas. The lung nodule was surgically removed and was histopathologically confirmed as metastasis of cervical neuroendocrine carcinoma. CT, computed tomography.

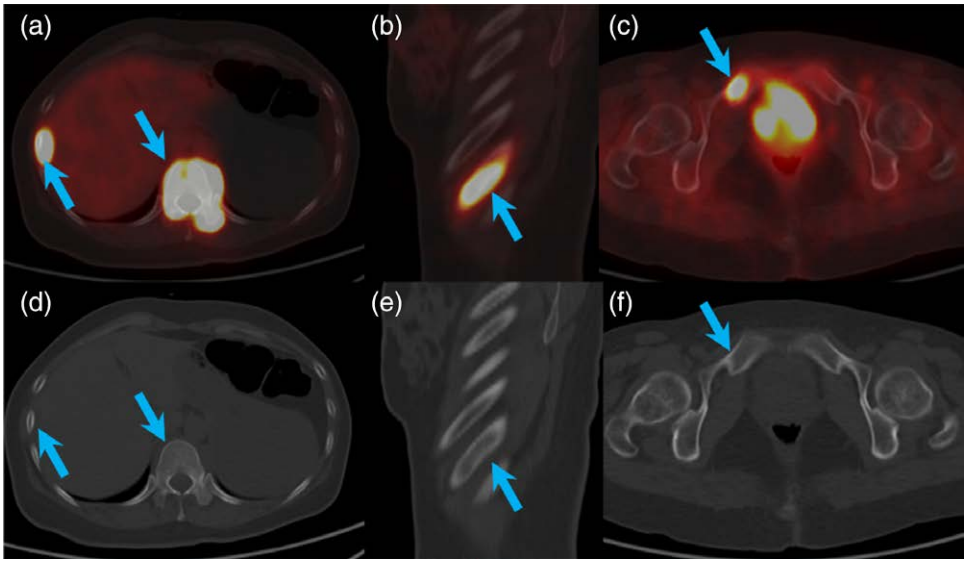
^{18}F-FDG PET/CT was also valuable in this entity by showing high sensitivity of 90% and specificity of 90% for the detection of recurrent tumors. False-negative PET/CT findings in two cases were both due to lung metastasis, which can be explained by the small size of lung nodules and low image resolution of PET scan. The only false-positive PET/CT finding was caused by the hypermetabolic lymph node in the inguinal region, which was later pathologically confirmed as a benign disease.

Staging and therapy in patients with cervical cancer greatly depend on the FIGO staging system. Squamous cell carcinoma of the cervix at the early stage may have a favorable prognosis and outcome. The dissemination of cervical cancer follows an orderly manner. They usually develop local advance and lymphatic spread initially, and by hematogenous dissemination in the late stages. This is supported by the results of several studies investigating ^{18}F-FDG PET/CT in recurrent cervical cancer, which reported that the most frequent site of recurrence was in lymph nodes [13,21,22]. However, cervical neuroendocrine carcinoma exhibits more aggressive behavior and has a different metastatic pattern from cervical cancer with early distal metastases. Our study demonstrated a similar finding that, in patients with cervical neuroendocrine carcinoma, distant organs instead of lymph nodes were the most common site of recurrence. Hematogenous dissemination of cervical neuroendocrine carcinoma could happen at an early stage even when no evidence of lymphatic spread is present. In this study, several cases developed lung metastasis without any lymph node involvement. Lung nodules with a small diameter are often affected by the partial volume effect, making it difficult to measure the true metabolic status [23]. Those lesions may appear negative on PET images. As demonstrated in our results, the lungs were the most frequent site for distant organ metastasis in cervical neuroendocrine carcinoma. Small lung nodules with suspicious CT features of metastasis but with negative PET appearance should be paid enough attention and a regular surveillance CT scan is necessary for this situation.

Approximately 30% of patients with cervical cancer eventually experienced relapse after primary treatment [24]. Cervical neuroendocrine carcinoma has an even higher recurrence rate [25]. Follow-up protocols, including ultrasonography, CT, or MRI, have certain limitations. In addition to lung, liver, bone, and lymph node were also common sites for recurrence in cervical neuroendocrine carcinoma. ^{18}F-FDG PET/CT holds the advantage of the whole-body survey in a single scan, which may be more important in the restaging of cervical neuroendocrine carcinoma for detecting the possible distant metastases.

To date, few studies have assessed the impact of ^{18}F-FDG PET/CT on the management of patients with cervical neuroendocrine carcinoma. In a study on 25 patients with primary cervical neuroendocrine carcinoma, 8 patients additionally underwent restaging ^{18}F-FDG PET/CT for suspected recurrence. Chen *et al.* reported that PET/CT had a clinical impact in 3 out 8 patients (37.5%) [18]. This was in accordance with our finding that PET/CT resulted in the change of management in 10 out of 25 patients (40%) by the introduction of previously unplanned therapeutic procedures. Our study also showed that bone metastases of cervical neuroendocrine

Fig. 2



Representative images of a 54-year-old patient who was treated primarily with surgery and chemoradiotherapy for stage I large cell neuroendocrine carcinoma of the cervix. During the follow-up, the patient developed back pain. However, diagnostic abdominopelvic CT images did not reveal any abnormalities. Restaging ^{18}F-FDG PET/CT demonstrated several highly FDG-avid bone metastases (a–c) at T10 vertebrae (SUVmax, 26.6), right eighth rib (SUVmax, 24.2), and right pubis (SUVmax, 9.0), which were not associated with any osteo-structural alterations at the co-registered CT images (d–f). After PET/CT, the patient was treated with radiotherapy for the bone metastases and the clinical symptoms of bone pain were relieved. CT, computed tomography.

carcinoma were better evaluated on ^{18}F-FDG PET/CT than CT, as they were often morphologically unchanged (91.7%). In these situations, the detection of bone metastases by ^{18}F-FDG PET/CT may lead to the change of treatment plan. In one patient, radiotherapy was decided only after ^{18}F-FDG PET/CT revealed thoracic vertebral and rib metastases, which were previously undetected at diagnostic CT scans.

This study had several limitations. First, the retrospective design of the study might have introduced a selection bias. Further prospective studies are required to confirm the results. Second, the number of patients with large cell neuroendocrine carcinoma and atypical carcinoid was too small compared to that of patients with small cell neuroendocrine carcinoma. Therefore, we could not investigate the correlation between ^{18}F-FDG PET/CT findings and histologic subtypes. Third, the ideal reference standard of histological confirmation was not obtained for each lesion seen on PET/CT scan due to ethical and practical reasons. Lastly, no functional PET/CT studies with somatostatin analog tracers were performed to compare ^{18}F-FDG uptake.

Conclusion

Our findings suggest that ^{18}F-FDG PET/CT is an effective imaging modality for detecting the recurrence of cervical neuroendocrine carcinoma. The use of ^{18}F-FDG PET/CT during the restaging process may contribute to patient management.

Acknowledgements

Conception and design were done by W.C. and Z.Z. Financial support by W.C. and Z.Z. Collection and assembly of data were done by Y.J., G.H., Z.Z., and L.H. The writing was done by Y.J.

This work is supported by the National Natural Science Foundation of China (no. 81371588 and no. 81101074) and the National Key Research and Development Program of China (2016YFC0901500).

Conflicts of interest

There are no conflicts of interest.

References

1 Tempfer CB, Tischoff I, Dogan A, Hilal Z, Schultheis B, Kern P, Rezniczek GA. Neuroendocrine carcinoma of the cervix: a systematic review of the literature. *BMC Cancer* 2018; **18**:530.
2 Gadducci A, Carinelli S, Aletti G. Neuroendrocrine tumors of the uterine cervix: a therapeutic challenge for gynecologic oncologists. *Gynecol Oncol* 2017; **144**:637–646.
3 Guadagno E, De Rosa G, Del Basso De Caro M. Neuroendocrine tumours in rare sites: differences in nomenclature and diagnostics – a rare and ubiquitous histotype. *J Clin Pathol* 2016; **69**:563–574.
4 Burzawa J, Gonzales N, Frumovitz M. Challenges in the diagnosis and management of cervical neuroendocrine carcinoma. *Expert Rev Anticancer Ther* 2015; **15**:805–810.
5 Chen J, Macdonald OK, Gaffney DK. Incidence, mortality, and prognostic factors of small cell carcinoma of the cervix. *Obstet Gynecol* 2008; **111**:1394–1402.
6 Cohen JG, Kapp DS, Shin JY, Urban R, Sherman AE, Chen LM, *et al.* Small cell carcinoma of the cervix: treatment and survival outcomes of 188 patients. *Am J Obstet Gynecol* 2010; **203**:347.e1–347.e6.
7 Lee JM, Lee KB, Nam JH, Ryu SY, Bae DS, Park JT, *et al.* Prognostic factors in FIGO stage IB-IIA small cell neuroendocrine carcinoma of the

uterine cervix treated surgically: results of a multi-center retrospective Korean study. *Ann Oncol* 2008; **19**:321–326.
8 Sato Y, Shimamoto T, Amada S, Asada Y, Hayashi T. Large cell neuroendocrine carcinoma of the uterine cervix: a clinicopathological study of six cases. *Int J Gynecol Pathol* 2003; **22**:226–230.
9 Krivak TC, McBroom JW, Sundborg MJ, Crothers B, Parker MF. Large cell neuroendocrine cervical carcinoma: a report of two cases and review of the literature. *Gynecol Oncol* 2001; **82**:187–191.
10 Gandy N, Arshad MA, Park WE, Rockall AG, Barwick TD. FDG-PET imaging in cervical cancer. *Semin Nucl Med* 2019; **49**:461–470.
11 Leblanc E, Gauthier H, Querleu D, Ferron G, Zerdoud S, Morice P, *et al*. Accuracy of 18-fluoro-2-deoxy-D-glucose positron emission tomography in the pretherapeutic detection of occult para-aortic node involvement in patients with a locally advanced cervical carcinoma. *Ann Surg Oncol* 2011; **18**:2302–2309.
12 Yen TC, See LC, Lai CH, Tsai CS, Chao A, Hsueh S, *et al*. Standardized uptake value in para-aortic lymph nodes is a significant prognostic factor in patients with primary advanced squamous cervical cancer. *Eur J Nucl Med Mol Imaging* 2008; **35**:493–501.
13 Pallardy A, Bodet-Milin C, Oudoux A, Campion L, Bourbouloux E, Sagan C, *et al*. Clinical and survival impact of FDG PET in patients with suspicion of recurrent cervical carcinoma. *Eur J Nucl Med Mol Imaging* 2010; **37**:1270–1278.
14 Kut V, Spies W, Spies S, Gooding W, Argiris A. Staging and monitoring of small cell lung cancer using [18F]fluoro-2-deoxy-D-glucose-positron emission tomography (FDG-PET). *Am J Clin Oncol* 2007; **30**:45–50.
15 Gomez DR, Gladish GW, Wei X, Kotamarti KR, Allen PK, Cox JD, *et al*. Prognostic value of positron emission tomography/computed tomography findings in limited-stage small cell lung cancer before chemoradiation therapy. *Am J Clin Oncol* 2014; **37**:77–80.
16 Vinjamuri M, Craig M, Campbell-Fontaine A, Almubarak M, Gupta N, Rogers JS. Can positron emission tomography be used as a staging tool for small-cell lung cancer? *Clin Lung Cancer* 2008; **9**:30–34.
17 Lin Y, Lin WY, Liang JA, Lu YY, Wang HY, Tsai SC, Kao CH. Opportunities for 2-[(18)F] fluoro-2-deoxy-D-glucose PET/CT in cervical-vaginal neuroendocrine carcinoma: case series and literature review. *Korean J Radiol* 2012; **13**:760–770.
18 Chen MY, Chou HH, Liu FY, Chen CY, Lin G, Yang LY, *et al*. (18)F-FDG PET in small-cell cervical cancer: a prospective study with long-term follow-up. *Eur J Nucl Med Mol Imaging* 2016; **43**:663–674.
19 Matsuo K, Machida H, Mandelbaum RS, Konishi I, Mikami M. Validation of the 2018 FIGO cervical cancer staging system. *Gynecol Oncol* 2019; **152**:87–93.
20 Zhou Z, Liu X, Hu K, Zhang F. The clinical value of PET and PET/CT in the diagnosis and management of suspected cervical cancer recurrence. *Nucl Med Commun* 2018; **39**:97–102.
21 Peng NJ, Hu C, Chiu YL, Yu CC, Li CJ, Sheu JJ, Chiang AJ. Detection of recurrent cervical cancer and prediction of its patient survival with serum squamous-cell carcinoma-antigen and 2-[18F] Fluoro-2-Deoxy-d-glucose-positron emission tomography/computed tomography. *Diagnostics (Basel)* 2020; **10**:E657.
22 Lee M, Lee Y, Hwang KH, Choe W, Park CY. Usefulness of F-18 FDG PET/CT in assessment of recurrence of cervical cancer after treatment. *Nucl Med Mol Imaging* 2011; **45**:111–116.
23 Soret M, Bacharach SL, Buvat I. Partial-volume effect in PET tumor imaging. *J Nucl Med* 2007; **48**:932–945.
24 Waggoner SE. Cervical cancer. *Lancet* 2003; **361**:2217–2225.
25 Trinh XB, Bogers JJ, Van Marck EA, Tjalma WA. Treatment policy of neuroendocrine small cell cancer of the cervix. *Eur J Gynaecol Oncol* 2004; **25**:40–44.