PET/CT scan improves detection of metastatic disease compared with CT scan alone in women with high-grade neuroendocrine cervical cancer: a NeCTuR study

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ABSTRACT

Objective To determine the optimal imaging modality for women with high-grade neuroendocrine carcinoma of the cervix.

Methods Women with high-grade neuroendocrine carcinoma of the cervix who had undergone a computed tomography (CT) scan and combined positron emission tomography with computed tomography (PET/CT) scan within 4 weeks of each other were identified from the NeCTuR Cervical Tumor Registry. One radiologist reviewed all CT scans, and another radiologist reviewed all PET/CT scans. The radiologists denoted the presence or absence of disease at multiple sites. Each radiologist was blinded to prior reports, patient outcomes, and the readings of the other radiologist. With findings on PET/CT used as the gold standard, sensitivity, specificity, and accuracy were calculated for CT scans.

Results Fifty matched CT and PET/CT scans were performed in 41 patients. For detecting primary disease in the cervix, CT scan had a sensitivity of 85%, a specificity of 46%, and an accuracy of 74%. For detecting disease spread to the liver, CT scan had a sensitivity of 80%, a specificity of 89%, and an accuracy of 86%. For detecting disease spread to the lung, CT had a sensitivity of 89%, a specificity of 68%, and an accuracy of 77%. Of the 14 patients who had scans for primary disease work-up, 4 (29%) had a change in their treatment plan due to the PET/CT scan. Had treatment been prescribed on the basis of the CT scan alone, 2 patients would have been undertreated, and 2 would have been overtreated.

Conclusion A CT scan is inferior to a PET/CT scan in assessment of metastatic disease in women with high-grade neuroendocrine carcinoma of the cervix. Almost one-third of patients with newly diagnosed high-grade neuroendocrine cervical cancer would have received incorrect therapy had treatment planning been based solely on a CT scan. We recommend a PET/CT scan for both initial work-up and surveillance in women with high-grade neuroendocrine carcinoma of the cervix.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Due to the extreme rarity of high-grade neuroendocrine carcinoma of the cervix, very little is known about the optimal imaging modality for initial work-up and surveillance of patients with this disease.

WHAT THIS STUDY ADDS

⇒ This study shows that CT is inferior to PET/CT for initial work-up and surveillance in patients with high-grade neuroendocrine carcinoma of the cervix. Furthermore, a PET/CT scan prompted changes in the treatment plan compared with the plan based on a CT scan alone in 29% of patients with newly diagnosed disease.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ We recommend a PET/CT scan for both initial work-up and surveillance in women with high-grade neuroendocrine carcinoma of the cervix.

INTRODUCTION

High-grade neuroendocrine cervical cancer is uncommon, accounting for less than 1.5% of cervical cancer cases.[1] Of the 14 480 new cases of cervical cancer in the United States this year, only roughly 200 will be of the high-grade neuroendocrine subtype.[2] It is fortunate that this malignancy is rare as it is extremely aggressive, with very high rates of recurrence and death. Stage for stage, patients with high-grade neuroendocrine cervical cancer are two to three times more likely to die from their disease as women with the more common squamous cell subtype.[3]

There are multiple guidelines for upfront treatment of neuroendocrine cervical cancer.[4–6] These guidelines are largely based on treatment of small cell lung cancer as high-grade neuroendocrine cervical cancer mimics small cell lung cancer in both appearance and clinical course. The published guidelines, however, do not offer much guidance regarding surveillance after upfront therapy.[4 5] At our institution, we follow up patients every 3 to 4 months in the first 2 years and then every 6 months for the next 3 to 4 years.[6] Patients undergo imaging at each appointment. Although we prefer a combined positron emission tomography with computed tomography (PET/CT) scan, insurance companies often will not reimburse for this test, requiring us to order a CT scan instead.

Our preference for PET/CT is based on imaging practices for small cell lung cancer, which, as mentioned above, is similar to high-grade neuroendocrine cervical cancer in appearance and clinical course. In treating patients with small cell lung cancer, PET/CT is part of the standard of care. A recent meta-analysis of nine published studies including 721 patients with small cell lung cancer showed that PET/CT detected more disease sites than standard CT, and PET/CT findings changed the CT-based stage in 15% of patients.[7] The addition of PET/CT to standard imaging improves the management of patients with small cell lung cancer and may improve oncologic outcomes.[8] Furthermore, incorporation of a PET/CT scan into treatment planning for patients with small cell lung cancer probably reduces healthcare costs by revealing previously occult metastases and thereby preventing inappropriate therapies.[9]

That said, there are no studies comparing CT scan with PET/CT in women with high-grade neuroendocrine carcinoma. The objective of this study was to determine whether a PET/CT scan is more sensitive than a standard CT scan in detecting metastatic disease in women with newly diagnosed or recurrent high-grade neuroendocrine cervical cancer. We hypothesized that a PET/CT scan would detect more metastatic sites of disease than a CT scan alone.

METHODS

After approval was obtained from the institutional review board at The University of Texas MD Anderson Cancer Center, which waived the requirement for informed consent, the NeCTuR Database was searched to identify patients with high-grade neuroendocrine cervical cancer who had both CT and PET/CT scans to assess their disease from 2011 through 2022. A total of 181 patients were identified who met the inclusion criteria. From these 181 patients, those who had a contrast-enhanced CT scan and a follow-up PET/CT scan within 4 weeks after CT because of equivocal findings on CT or clinical suspicion of recurrent disease were selected for inclusion in this study. The patients were required to have either a contrast-enhanced CT scan or a PET/CT scan follow-up at least 6 months after enrollment.

The contrast-enhanced CT scans and the PET/CT scans were interpreted by two experienced radiologists specializing in oncological imaging. A radiologist (PB) with 24 years of experience exclusively interpreted the contrast-enhanced CT scans, and a radiologist (ACM) with 16 years of experience exclusively interpreted the PET/CT scans. The radiologists were blinded to prior reports and patient outcomes. The radiologists were also blinded to each other's interpretation—that is, the radiologist who read the CT scans was unaware of the findings on the PET/CT scans and vice versa. A research intern presented the imaging studies to the radiologists on the picture archiving and communication system. The research intern documented the findings in an Excel spreadsheet and recorded the exact location for metastatic adenopathy, solid organ metastases, pulmonary metastases, and peritoneal disease on both CT and PET/CT scans. On CT, lymph nodes that measured *at least* 10 mm in the short axis were considered malignant, those that measured *at least* 6 mm but less than 10 mm were considered indeterminate, and those that measured *less than 6 mm* were considered benign. Centrally necrotic lymph nodes on CT were considered malignant. If the central area of low attenuation within a lymph node was less than 0 Hounsfield units, the node was considered benign regardless of the node size. On PET/CT, any lesion with fluorodeoxyglucose uptake greater than the background was considered metastatic.

After documentation of radiology findings in the Excel sheet, the radiologists' findings on the two imaging studies were compared, and any disagreement was settled by consensus between the radiologists. Findings of malignant disease on the contrast-enhanced CT scan or the PET/CT scan were considered true positive if the findings were confirmed on pathologic evaluation or the lesion had increased in size on the follow-up imaging. Findings of malignant disease were considered false positive if the lesion was stable or disappeared at 3 months without treatment. Findings of lack of malignancy on CT were considered true negative if no malignant lesion was identified on follow-up PET/CT, and false negative if a malignant lesion was detected on follow-up PET/CT. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy for detection of disease by CT scan were calculated for both the cervix and metastatic sites .

Patient demographics were summarized using median and range. Imaging readings were compared between CT and PET/CT scans using exact McNemar's test. Overall survival curves were estimated using the Kaplan-Meier method. Statistical analysis was carried out using R (version 3.6.3, R Development Core Team).

In accordance with the journal's guidelines, we will provide our data for independent analysis by a team selected by the editorial team for the purposes of additional analysis or for the reproducibility of this study in other centers if such is requested.

RESULTS

Fifty pairs of matched CT and PET/CT scans were performed in 41 patients. The median age at diagnosis was 42 years (Table 1). At diagnosis, 25 patients (61%) had pure neuroendocrine tumors, while 16 patients (39%) had mixed tumors with neuroendocrine and non-neuroendocrine components (eg, squamous cell carcinoma or adenocarcinoma). Fourteen pairs of scans (28%) were performed for the work-up of newly diagnosed disease, 26 pairs of scans (52%) were performed to assess response to therapy, and 10 pairs of scans (20%) were performed for routine surveillance in patients with no known evidence of disease. For the 41 patients in the study, the median overall survival was 4.4 years. The 2-year and 5- year overall survival rates were 66% and 40%, respectively.

For detecting disease in the cervix, CT scan had a sensitivity of 85%, a specificity of 46%, a positive predictive value of 80%, a negative predictive value of 55%, and an overall accuracy of 74% (Table 2). CT scan had high sensitivity (100%), specificity (100%), and accuracy (100%) in the evaluation of disease in the adrenal glands but did not perform as well in the evaluation of other potential sites of disease. For example, in the evaluation of pelvic nodes, CT scan had a sensitivity of 80%, a specificity of 83%, and an accuracy of 82%. Liver and lung are common sites of metastatic and recurrent disease in patients with high-grade neuroendocrine carcinoma of the cervix. For detecting disease spread to the liver, CT had a sensitivity of 80%, a specificity of 89%, and an accuracy of 86%. For detecting disease spread to the lung, CT had a sensitivity of 89%, a specificity of 68%, and an accuracy of 77%.

Table 1 Patient demographic and clinicopathologic characteristics (n=41)

Characteristics	Value
Age, median (range), years	42 (24–75)
BMI, median (range), kg/m^2	27.7 (18.1–47.3)
Race and ethnicity, n (%)	
White	34 (83)
Black or African American	2 (5)
Hispanic or Latino	3 (7)
Not reported	2 (5)
FIGO stage at diagnosis, n (%)	
IA1	1 (2)
IB1	4 (10)
IB2	1 (2)
IB3	3 (7)
IIB	2 (5)
IIIC1r	6 (15)
IIIC1p	4 (10)
IIIC2r	2 (5)
IVA	4 (10)
IVB	14 (34)
Histologic subtype, n (%)	
Small cell	23 (56)
Large cell	5 (12)
Small and large cell	2 (5)
High-grade neuroendocrine, NOS	11 (27)
Pure or mixed neuroendocrine tumor, n (%)	
Pure	25 (61)
Mixed	16 (39)
Reason for scans, n (%)*	
Work-up of new diagnosis	14 (28)
Assessment of response to therapy	26 (52)
Surveillance	10 (20)

*Sums to 50 as some patients had multiple paired CT and PET/CT scans during treatment.
BMI, body mass index; FIGO, International Federation of Gynecology and Obstetrics; NOS, not otherwise specified.

Among the 14 patients who had scans done for primary disease work-up, four (29%) had a change in their treatment plan due to the PET/CT scan. In two patients (50%), the CT scan missed metastatic disease detected on PET/CT (false negative), and in two patients (50%), the CT scan indicated malignancy but no malignancy was detected on PET/CT (false positive). One patient had radiologic stage IIIC2 disease on CT scan and therefore probably would have received extended-field chemoradiation; however, PET/CT scan revealed liver metastases, and therefore the patient had stage IVB disease and received palliative chemotherapy. Another patient had radiologic presumed stage IB3 disease on CT scan and therefore probably would have received pelvic chemoradiation; however, PET/CT scan revealed peritoneal disease, and therefore the patient had stage IVB disease and received palliative chemotherapy. The third and fourth patients had radiologic stage IVB disease on CT scan (liver metastases in one patient and peritoneal spread in the other) and therefore probably would have received palliative chemotherapy; however, PET/CT scan revealed no evidence of liver metastases or peritoneal spread, and therefore the patients had stage IIIC2 disease and received extended-field radiation therapy with intent to cure.

DISCUSSION

Summary of Main Results

This study showed that compared with PET/CT scan, CT scans had only moderate sensitivity in detecting both primary disease in the cervix and disease in the most common sites of metastasis, including pelvic nodes, liver, and lungs. Furthermore, in patients with newly diagnosed, untreated high-grade neuroendocrine cervical cancer, reliance on CT scan alone would have led to overtreatment in 14% of patients and undertreatment in an additional 14%. The cases of potential undertreatment in our study are particularly concerning as women with possibly curable disease would have been prescribed only palliative therapy. Our finding that PET/CT scan prompted a change in treatment in almost one-third of patients with newly diagnosed high-grade neuroendocrine cervical cancer is consistent with findings in other high-grade neuroendocrine cancers, including small cell lung cancer, in which PET/CT scan prompts change in the treatment plan in up to 40% of patients.[10]

Results in the Context of Published Literature

Incorporation of PET scan in treatment planning and surveillance for women with high-grade neuroendocrine cervical cancer makes sense as this disease is highly aggressive with high proliferation rates and therefore likely to have high glucose metabolism. PET/CT scans in other high-grade neuroendocrine cancers show higher fluorodeoxyglucose uptake than low-grade neuroendocrine tumors like carcinoids.[11] Furthermore, PET/CT detects functional abnormalities before morphologic alterations are seen on CT scans, leading to earlier detection of recurrent disease.[8]

In patients with small cell lung cancer, use of a PET/CT scan in initial treatment planning has been shown to increase the accuracy of staging and optimize treatment planning, which has led to improved overall survival.[12] In women with squamous and adenocarcinomas of the cervix, PET is also the preferred imaging modality for initial work-up and treatment planning as it is more sensitive than a CT scan in identifying extracervical disease.[13] Identifying whether a patient has cervix-limited disease is of particular importance as this determines whether a patient is a surgical candidate or needs definitive radiation. Furthermore, detection of pelvic and aortocaval lymph node metastases may prompt changes in radiation treatment planning to avoid overtreatment or undertreatment. The addition of PET/CT scan to the initial work-up of patients with locally advanced cervical cancer has significantly improved overall survival in women undergoing definitive radiation therapy for their disease.[14]

A PET/CT scan has also been shown to detect recurrence in asymptomatic women who have a history of cervical cancer. In

Table 2 Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy for CT scan in detecting primary tumor and metastatic sites in patients with high-grade neuroendocrine carcinoma of the cervix

Site of disease	TP	FP	TN	FN	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	Accuracy (95% CI)
Cervix	28	7	6	5	0.85 (0.68 to 0.95)	0.46 (0.19 to 0.75)	0.80 (0.63 to 0.92)	0.55 (0.23 to 0.83)	0.74 (0.59 to 0.86)
Pelvic nodes	16	5	25	4	0.80 (0.56 to 0.94)	0.83 (0.65 to 0.94)	0.76 (0.53 to 0.92)	0.86 (0.68 to 0.96)	0.82 (0.69 to 0.91)
Aortocaval nodes	9	4	32	5	0.64 (0.35 to 0.87)	0.89 (0.74 to 0.97)	0.69 (0.39 to 0.91)	0.86 (0.71 to 0.95)	0.82 (0.69 to 0.91)
Mediastinal nodes	7	8	35	0	1.00 (0.59 to 1.00)	0.81 (0.67 to 0.92)	0.47 (0.21 to 0.73)	1.00 (0.90 to 1.00)	0.84 (0.71 to 0.93)
Supraclavicular nodes	4	4	39	3	0.57 (0.18 to 0.90)	0.91 (0.78 to 0.97)	0.50 (0.16 to 0.84)	0.93 (0.81 to 0.99)	0.86 (0.73 to 0.94)
Adrenal glands	3	0	47	0	1.00 (0.29 to 1.00)	1.00 (0.92 to 1.00)	1.00 (0.29 to 1.00)	1.00 (0.92 to 1.00)	1.00 (0.93 to 1.00)
Peritoneal disease	4	9	33	4	0.50 (0.16 to 0.84)	0.79 (0.63 to 0.90)	0.31 (0.09 to 0.61)	0.89 (0.75 to 0.97)	0.74 (0.60 to 0.85)
Liver	12	4	31	3	0.80 (0.52 to 0.96)	0.89 (0.73 to 0.97)	0.75 (0.48 to 0.93)	0.91 (0.76 to 0.98)	0.86 (0.73 to 0.94)
Lung	17	9	19	2	0.89 (0.67 to 0.99)	0.68 (0.48 to 0.84)	0.65 (0.44 to 0.83)	0.90 (0.70 to 0.99)	0.77 (0.62 to 0.88)
Bone	5	9	36	0	1.00 (0.48 to 1.00)	0.80 (0.65 to 0.90)	0.36 (0.13 to 0.65)	1.00 (0.90 to 1.00)	0.82 (0.69 to 0.91)
Vagina	1	1	43	5	0.17 (0.00 to 0.64)	0.98 (0.88 to 1.00)	0.50 (0.01 to 0.99)	0.90 (0.77 to 0.97)	0.88 (0.76 to 0.95)

Total for cervix is less than 50 because some patients had primary tumor resection before scans; total for lung is less than 50 because some patients did not have CT of the chest.
FN, false negative; FP, false positive; TN, true negative; TP, true positive.

a study of 249 patients, routine PET/CT scanning as surveillance detected recurrence in 28 asymptomatic women (11%).[15] Furthermore, among women with recurrent cervical cancer, those with early detection of recurrence before symptom onset may experience a significant improvement in overall survival of over 2 years compared with the survival in women who have their disease detected after onset of symptoms.[16] Due to the extreme rarity of high-grade neuroendocrine carcinoma of the cervix, it is unknown if similar results will be seen with PET/CT-based surveillance of women with this disease; however, our study does show the poor sensitivity of a CT scan in detecting recurrence compared with a PET/CT scan.

For patients with low-grade neuroendocrine tumors of the gastrointestinal system, PET scans with ^{68}Ga-labeled octreotide derivatives such as DOTATOC, DOTATATE, and DOTANOC are standard of care. These radionucleotides bind with high affinity to the somatostatin receptors expressed in these low-grade neuroendocrine tumors. The usefulness of these scans in high-grade neuroendocrine carcinoma of the cervix is thought to be of limited value as these tumors only express the somatostatin receptor 5% of the time.[17]

Strengths and Weaknesses

This study does have some limitations. First is the retrospective design and the biases inherent in retrospective studies. The study also has a small sample size of 50 patients. However, this is a relatively large population in a disease that is exceedingly rare. Another limitation of the study is the long duration of accrual (11 years). During that time new equipment was probably purchased which could have effected the detection rates, favoring those whose scans were more recent. Also, as high-grade neuroendocrine carcinoma is an aggressive tumor, we cannot know with certainty that there was no disease progression between the CT scan and subsequent PET/CT scan, although as all scans were done within 4 weeks of each other (and often only 1–2 weeks apart), we do not believe this confounded our results. Finally, not all patients had biopsy confirmation of their PET/CT-detected recurrence. However, due to the retrospective nature of this study, biopsy confirmation in all patients was not possible. In an effort to account for our inability to obtain a tissue diagnosis in all patients, findings on the contrast-enhanced CT scan and the PET/CT scan were considered positive only for malignant disease in patients without a biopsy if the lesions increased in size on follow-up imaging. Lesions were classified as benign or false positive if they were stable or disappeared at 3 months without treatment. Furthermore, PET/CT scanning without biopsy has consistently been used in the literature as a gold standard for radiologic studies in both cervical cancer and small cell lung cancer.

Implications for Practice and Future Research

As a PET/CT scan detects more sites of metastatic disease than a CT scan, we have adopted it as our standard imaging modality for patients with newly diagnosed disease, patients receiving active treatment, and those who are under surveillance. Admittedly, due to the rarity of the disease it is not known if use of PET/CT scanning improves survival, but it has been shown to do so in patients with small cell lung cancer.[8] As the NeCTuR registry continues to expand (currently it has detailed data for >550 patients), we hope to potentially address how use of PET/CT may effect survival in women with high-grade neuroendocrine cervical cancer. Furthermore, emerging imaging technologies, such as PET/MRI, may also improve detection of recurrence and metastatic disease and should be evaluated in the future.

CONCLUSIONS

In conclusion, a CT scan is inferior to a PET/CT scan for the evaluation of newly diagnosed high-grade neuroendocrine cervical cancer, and in more than one-quarter of patients, PET/ CT leads to a change in the CT-based treatment plan. Furthermore, PET/CT detects sites of malignancy not detected on a standard CT scan in both women with newly diagnosed high-grade neuroendocrine cervical cancer and women with recurrent disease. We recommend use of PET/CT scanning in initial staging, evaluation for response in women undergoing treatment for recurrent disease, and surveillance in asymptomatic women after completion of therapy.

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REFERENCES

1 Tempfer CB, Tischoff I, Dogan A, *et al*. Neuroendocrine carcinoma of the cervix: a systematic review of the literature. *BMC Cancer* 2018;18:530.
2 Islami F, Guerra CE, Minihan A, *et al*. American Cancer Society's report on the status of cancer disparities in the United States, 2021. *CA Cancer J Clin* 2022;72:112–43.
3 Margolis B, Tergas AI, Chen L, *et al*. Natural history and outcome of neuroendocrine carcinoma of the cervix. *Gynecol Oncol* 2016;141:247–54.
4 Satoh T, Takei Y, Treilleux I, *et al*. Gynecologic Cancer InterGroup (GCIG) consensus review for small cell carcinoma of the cervix. *Int J Gynecol Cancer* 2014;24(9 Suppl 3):S102–8.
5 Winer I, Kim C, Gehrig P. Neuroendocrine tumors of the gynecologic tract update. *Gynecol Oncol* 2021;162:210–9.
6 Salvo G, Gonzalez Martin A, Gonzales NR, *et al*. Updates and management algorithm for neuroendocrine tumors of the uterine cervix. *Int J Gynecol Cancer* 2019;29:986–95.
7 Martucci F, Pascale M, Valli MC, *et al*. Impact of (18)F-FDG PET/CT in staging patients with small cell lung cancer: a systematic review and meta-analysis. *Front Med (Lausanne)* 2019;6:336.
8 Sager O, Dincoglan F, Demiral S, *et al*. Utility of molecular imaging with 2-deoxy-2-[fluorine-18] fluoro-Dglucose positron emission tomography (18F-FDG PET) for small cell lung cancer (SCLC): a radiation oncology perspective. *Curr Radiopharm* 2019;12:4–10.
9 Ruben JD, Ball DL. The efficacy of PET staging for small-cell lung cancer: a systematic review and cost analysis in the Australian setting. *J Thorac Oncol* 2012;7:1015–20.
10 Quartuccio N, Salem A, Laudicella R, *et al*. The role of 18F-fluorodeoxyglucose PET/CT in restaging patients with small cell lung cancer: a systematic review. *Nucl Med Commun* 2021;42:839–45.
11 Lococo F, Treglia G, Cesario A, *et al*. Functional imaging evaluation in the detection, diagnosis, and histologic differentiation of pulmonary neuroendocrine tumors. *Thorac Surg Clin* 2014;24:285–92.
12 Hong JC, Boyer MJ, Spiegel DY, *et al*. Increasing PET use in small cell lung cancer: survival improvement and stage migration in the VA Central Cancer Registry. *J Natl Compr Canc Netw* 2019;17:127–39.
13 Marth C, Landoni F, Mahner S, *et al*. Cervical cancer: ESMO clinical practice guidelines for diagnosis, treatment and follow-up. *Ann Oncol* 2017;28(suppl_4):iv72–83.
14 Su CH, Chen WM, Chen M, *et al*. Survival effect of pre-RT PET-CT on cervical cancer: image-guided intensity-modulated radiation therapy era. *Front Oncol* 2023;13:1012491.
15 Ryu SY, Kim MH, Choi SC, *et al*. Detection of early recurrence with 18F-FDG PET in patients with cervical cancer. *J Nucl Med* 2003;44:347–52.
16 Peters PN, Pierson WE, Chen LM, *et al*. PET-detected asymptomatic recurrence is associated with improved survival in recurrent cervical cancer. *Abdom Radiol (NY)* 2021;46:341–50.
17 Carroll MR, Ramalingam P, Salvo G, *et al*. Evaluation of PARP and PDL-1 as potential therapeutic targets for women with high-grade neuroendocrine carcinomas of the cervix. *Int J Gynecol Cancer* 2020;30:1303–7.