PET/CT imaging in Gynecologic Tumors

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Adana 3 April 2015
PET/CT in Gynecologic Cancers

• FDG PET/CT
  – Cervical cancer
  – Ovarian cancer
  – Endometrial cancer
  – Vaginal cancer
  – Vulvar cancer

• Future possibilities
  – PET/MR
  – Non-FDG PET tracers
# Female Cancers in the US in 2014

<table>
<thead>
<tr>
<th>Cancer</th>
<th>Incidence</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast</td>
<td>235,030</td>
<td>40,420</td>
</tr>
<tr>
<td>Endometrial</td>
<td>52,630</td>
<td>8,590</td>
</tr>
<tr>
<td>Ovary</td>
<td>21,980</td>
<td>14,270</td>
</tr>
<tr>
<td>Cervix</td>
<td>12,360</td>
<td>4,020</td>
</tr>
<tr>
<td>Vulva</td>
<td>4,850</td>
<td>1,030</td>
</tr>
<tr>
<td>Vagina</td>
<td>3,170</td>
<td>880</td>
</tr>
</tbody>
</table>
FDG PET/CT

• Endometrial cancer
Estimated New Cancer Cases in 2015

<table>
<thead>
<tr>
<th>Disease</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prostate</td>
<td>848,200</td>
<td>810,170</td>
</tr>
<tr>
<td>Lung &amp; bronchus</td>
<td>26%</td>
<td>29%</td>
</tr>
<tr>
<td>Colon &amp; rectum</td>
<td>14%</td>
<td>13%</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Melanoma of skin</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>5%</td>
<td>6%</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Oral cavity &amp; pharynx</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Leukemia</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Liver &amp; intrahepatic bile duct</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>All other sites</td>
<td>21%</td>
<td>21%</td>
</tr>
</tbody>
</table>

Endometrial Cancer

- 97% endometrioid, clear cell, and papillary serous adenocarcinomas
- Prognosis is affected by the age of the patient, stage of the disease, the grade of the tumor, and certain histological subtypes such as papillary serous or clear cell
- Deep myometrial and cervical invasion also carry a poorer prognosis
Endometrial Cancer Detection
• FDG uptake in primary endometrial tumors is significantly and directly related with the FIGO grade

Nakamura K et al. 2010
# Endometrial Cancer: FIGO Staging

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Tumor confined to the corpus uteri</td>
</tr>
<tr>
<td>IA</td>
<td>Tumor extending to &lt;50% of myometrial depth</td>
</tr>
<tr>
<td>IB</td>
<td>Tumor extending to &gt;50% of myometrial depth</td>
</tr>
<tr>
<td>II</td>
<td>Tumor invades cervical stroma, but does not extend beyond the uterus</td>
</tr>
<tr>
<td>III</td>
<td>Local and/or regional spread of the tumor</td>
</tr>
<tr>
<td>IIIA</td>
<td>Tumor invades the serosa of the corpus uteri and/or adnexae</td>
</tr>
<tr>
<td>IIIB</td>
<td>Vaginal and/or parametrial involvement</td>
</tr>
<tr>
<td>IIIC</td>
<td>Metastases to pelvic and/or para-aortic lymph nodes</td>
</tr>
<tr>
<td>IIIC1</td>
<td>Positive pelvic nodes</td>
</tr>
<tr>
<td>IIIC2</td>
<td>Positive para-aortic lymph nodes with or without positive pelvic lymph nodes</td>
</tr>
<tr>
<td>IV</td>
<td>Tumor invades bladder and/or bowel mucosa, and/or distant metastases</td>
</tr>
<tr>
<td>IVA</td>
<td>Tumor invasion of bladder and/or bowel mucosa</td>
</tr>
<tr>
<td>IVB</td>
<td>Distant metastases, including intra-abdominal metastases and/or inguinal lymph nodes</td>
</tr>
</tbody>
</table>

*Positive cytology obtained at peritoneal washings should be recorded but does not alter any stage.*
Endometrial Cancer: Treatment

• Surgery is the mainstay of treatment followed by adjuvant radiation and/or chemotherapy based on stage of disease
• Primary radiotherapy or hormonal therapy may be employed in patients who have contraindications to surgery
Endometrial Cancer: Risk of Nodal Metastasis

• Grade
  – Grade 1 = 3%
  – Grade 2 = 9%
  – Grade 3 = 18%

• Myometrial Invasion
  – None/Superficial = <5%
  – > ½ myometrium = 20%

• Cervical Involvement
  – 15%
Staging Locally Advanced Endometrial Cancer
Staging Endometrial Cancer

• PET/CT Staging of high-grade endometrial cancer
  • Detecting lymph node involvement and distant metastases
    – Sensitivity 57.1%
    – Specificity 100%
    – Accuracy 88.5%  
      Picchio et al. 2010

• High-risk clinical early-stage endometrial cancer (grade 2 with deep myometrial invasion, grade 3 with serous and clear-cell carcinoma)
  – Sensitivity 77.8%
  – Specificity 100%
  – Accuracy 94.4%  
    Signorelli et al. 2009
Restaging Endometrial Cancer
Endometrial Cancer

- Following surgery, 64% of recurrences occur within 2 years and 87% within 3 years
- Early detection of recurrence has a significant impact on survival
- PET/CT is substantially more accurate than CT or MR in detecting recurrent disease
Endometrial Cancer Recurrence

- PET/CT for asymptomatic recurrence
  - Sensitivity 96%
  - Specificity 78%
- Earlier and additional treatment in 22% of patients

Park et al. 2008
Potential Roles For FDG PET/CT

• Initial evaluation
  – Diagnosis    Incidental only
  – Staging and prognosis High grade/Local Adv
  – Treatment planning XRT planning!!!

• Subsequent evaluation
  – Detecting recurrence Use in high risk
  – Staging recurrence Frequent use
  – Therapy assessment Frequent use
FDG PET/CT

• Endometrial cancer
• Ovarian cancer
Estimated New Cancer Deaths in 2015

<table>
<thead>
<tr>
<th>Cancer Site</th>
<th>Men 312,150</th>
<th>Women 277,280</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung &amp; bronchus</td>
<td>28%</td>
<td>26%</td>
</tr>
<tr>
<td>Prostate</td>
<td>9%</td>
<td>15%</td>
</tr>
<tr>
<td>Colon &amp; rectum</td>
<td>8%</td>
<td>9%</td>
</tr>
<tr>
<td>Pancreas</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Liver &amp; intrahepatic bile duct</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Leukemia</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Esophagus</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Urinary bladder</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>4%</td>
<td>3%</td>
</tr>
<tr>
<td>Kidney &amp; renal pelvis</td>
<td>3%</td>
<td>2%</td>
</tr>
<tr>
<td>All other sites</td>
<td>24%</td>
<td>23%</td>
</tr>
</tbody>
</table>

Ovarian Cancer

- Epithelial cancer is a disease of postmenopausal women and usually presents with advanced disease.
- Germ cell and sex cord stromal tumors are most prevalent in the second and third decades of life.
- There are two hereditary forms of ovarian cancer—breast ovarian familial cancer syndrome and hereditary non-polyposis colorectal cancer (HNPCC) or Lynch syndrome.
FDG Uptake in Ovaries
Benign FDG Uptake in Ovaries

- Normal ovulating ovaries
- Ovarian torsion
- Corpus luteal cysts
- Hemorrhagic corpus luteal cyst
- Mature ovarian teratoma
- Tamoxifen
Ovarian Cancer: Staging

• Staging is surgical
• One third with presumed stage I or II disease have stage III disease when thoroughly staged
• Spread due to exfoliation of cells in peritoneal cavity (right paracolic gutter→clockwise)
CA-125

- CA-125 elevated in 90% of epithelial ovarian cancers

- However:
  - CA-125 levels are normal in 50% of women with early stage ovarian cancer
  - CA-125 levels are elevated in 2-3% of postmenopausal women without ovarian cancer
Ovarian Cancer: Recurrence
Ovarian Cancer: Recurrence
Ovarian Cancer: Recurrence
Ovarian Cancer: Recurrence

• Meta-analysis of 34 studies of PET/CT in biochemical occult recurrence:
  – Sensitivity 72–100%
  – Specificity 40–90%
  – Accuracy 77–91%

• Additional sites of disease compared with anatomical imaging in 55–64% of patients
  – Sites: peritoneum, lymph nodes, liver capsule, and abdominal wall

• Altered clinical management in 34–59% of patients

Restaging Ovarian Cancer
Restaging Ovarian Cancer
Ovarian Cancer

- SUV--imaging biomarker of malignant viability and chemotherapeutic response
  - 3 studies have evaluated significant treatment response measured by change in tumor SUV
    - 35% decline of SUV in the most active region of the tumor
    - >20% decrease after first cycle, and 55% decrease after third cycle optimally differentiated responders from nonresponders and predicted overall survival
    - Cut-off value of 65% SUV change had 85.7% accuracy in characterizing response

Potential Roles For FDG PET/CT

• Initial evaluation
  – Diagnosis Caution
  – Staging and prognosis Seldom used
  – Treatment planning Seldom used

• Subsequent evaluation
  – Detecting recurrence Biochem recurrence
  – Staging recurrence Frequent use
  – Therapy assessment Frequent use
FDG PET/CT

- Endometrial cancer
- Ovarian cancer
- Cervical cancer
Cervical cancer

• Worldwide, second-leading cause of cancer mortality in women
• About 500,000 new cases each year
  – About 75% occur in developing countries
• Cervical cytologic testing has reduced the incidence by 70% in countries where it is easily available
Cervical Cancer: Incidence

"WHO Disease and injury country estimates". World Health Organization. 2009
Cervical Cancer

- Squamous cell carcinoma accounts for approximately two-thirds of all cases and tend to arise at the external os
- Adeno- and adenosquamous carcinomas account for 10–25% of cases
  - Increased in frequency US
- Prognosis depends on stage, histological subtype, and the presence of nodal mets
Cervical Cancer: Incidental finding on PET/CT
Cervical Cancer: FDG Primary Tumor

- All tumors have FDG uptake, majority intense
- Uptake greatest in squamous cell and poorly differentiated tumors
- Mean SUV 11.62, squamous 11.91, adenocarcinoma 8.05, adenosquamous 8.85
- 3D volumetric isocontour of 40% correlates with other primary tumor size

Kidd EA Cancer 115: 3548, 2009
Showalter TN Int J Gynecol Cancer 19:1412, 2009
Cervical Cancer: Spread

• Local Invasion
• Lymphatic
  – Risk relates to depth of invasion
  – Pelvic nodes before paraaortic or supraclavicular
• Hematogenous
  – More likely in adenocarcinoma, neuroendocrine or small cell tumors
• Intraperitoneal
  – Unknown incidence
  – Poor prognosis
# Cervical Cancer: FIGO Staging

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage I</td>
<td>Invasive carcinoma confined to the cervix</td>
</tr>
<tr>
<td>IA</td>
<td>Diagnosed only by microscopy</td>
</tr>
<tr>
<td>IA1</td>
<td>Micro-invasive carcinoma with stromal invasion ≤3 mm in depth and ≤7 mm in width</td>
</tr>
<tr>
<td>IA2</td>
<td>Micro-invasive carcinoma not exceeding 5 mm in depth or 7 mm in width</td>
</tr>
<tr>
<td>Stage IB</td>
<td>Clinically visible or microscopic lesion &gt;IA2</td>
</tr>
<tr>
<td>IB1</td>
<td>Clinical lesions not exceeding 4 cm in diameter</td>
</tr>
<tr>
<td>IB2</td>
<td>Clinical lesions larger than 4 cm</td>
</tr>
<tr>
<td>Stage II</td>
<td>Extension beyond the cervix but not to the pelvic wall</td>
</tr>
<tr>
<td>IIA</td>
<td>Without parametrial invasion</td>
</tr>
<tr>
<td>IIA1</td>
<td>Clinical lesion less not exceeding 4 cm in maximum dimension</td>
</tr>
<tr>
<td>IIA2</td>
<td>Clinical lesion larger than 4 cm maximum dimension</td>
</tr>
<tr>
<td>IIB</td>
<td>Parametrial involvement not reaching the pelvic side wall</td>
</tr>
<tr>
<td>Stage III</td>
<td>Extension to the pelvic wall or the lower third of the vagina.</td>
</tr>
<tr>
<td>IIIA</td>
<td>Hydronephrosis or non-functioning kidney, unless due to a cause other than obstruction by tumor</td>
</tr>
<tr>
<td>IIIIB</td>
<td>Involves the lower third of the vagina</td>
</tr>
<tr>
<td>IIIIB</td>
<td>Extension to the pelvic wall (includes hydronephrosis)</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Extension beyond the true pelvis or involving bladder or rectum</td>
</tr>
<tr>
<td>IVA</td>
<td>Involvement of the bladder or rectal mucosa</td>
</tr>
<tr>
<td>IVB</td>
<td>Spread outside the true pelvis or metastasis to distant organs</td>
</tr>
</tbody>
</table>
Cervical Cancer: Staging

- Clinical staging accuracy of only about 75%
- Cross-sectional imaging is not mandatory in FIGO staging classification
- Imaging frequently used for treatment decisions
Cervical Cancer: Staging

ACRIN 6651/GOG 183 intergroup studyGynecol Oncol 2009;112:95.

<table>
<thead>
<tr>
<th>FIGO staging</th>
<th>Errors in comparison to surgical staging</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>20-30%</td>
</tr>
<tr>
<td>II</td>
<td>23%</td>
</tr>
<tr>
<td>III</td>
<td>65-90%</td>
</tr>
<tr>
<td>IV</td>
<td></td>
</tr>
</tbody>
</table>
Cervical Cancer: Treatment

- Early Stage (I-IB1 [IB2-Ila])
  - Primary Surgery
  - Chemoradiation
- Locally Advanced(IB2-IVa)
  - Primary Chemoradiation
- Disease with Distant Metastases (IVB)
  - Systemic chemotherapy
Staging Cervical Cancer
## Cervical Cancer: PET/CT Staging

<table>
<thead>
<tr>
<th></th>
<th>No. of Positives /Total No.</th>
<th>PPV</th>
<th>NPV</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvic lymph nodes</td>
<td>3/27</td>
<td>75%</td>
<td>96%</td>
<td>75%</td>
<td>96%</td>
</tr>
<tr>
<td>Para aortic lymph nodes</td>
<td>15/119</td>
<td>94%</td>
<td>100%</td>
<td>100%</td>
<td>99%</td>
</tr>
<tr>
<td>Distant metastases</td>
<td>10/19</td>
<td>63%</td>
<td>100%</td>
<td>100%</td>
<td>94%</td>
</tr>
</tbody>
</table>

Loft A et al, Gyn Onc July 2007;106(1):29-34
Staging Cervical Cancer
Cervical Cancer: PET/CT Staging
Cervical Cancer: PET/CT Staging

<table>
<thead>
<tr>
<th></th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>MRI</td>
<td>30.3</td>
<td>92.6</td>
<td>72.7</td>
</tr>
<tr>
<td>PET-CT</td>
<td>57.6</td>
<td>92.6</td>
<td>85.1</td>
</tr>
<tr>
<td></td>
<td>P = 0.026</td>
<td>P=1.000</td>
<td>P=0.180</td>
</tr>
</tbody>
</table>

22 patients with stage IB - IVA

Choi HJ, Cancer. 2006 Feb 15;106(4):914-22
Cervical Cancer: PET/CT Staging

• Virtually all primary cervical cancers are FDG-avid

• PET/CT plays a major role in nodal staging
  – In locally advanced disease: sensitivity 75-100%, specificity 87-100%
  – FIGO I-IIA sensitivity 25-73%

• Unexpected sites of metastasis found

• PET/CT staging alters management in many patients

Magne N Cancer Treat Rev 34: 671, 2008
Loft A Gynecol Oncol 106:29, 2007
Chao A Gynecol Oncol 110: 172, 2008
Therapy Assessment in Cervical Cancer
Cervical Cancer: XRT Planning

Better sensitivity in detection of pelvic and para-aortic nodes

FDG Uptake After Radiotherapy

- Prospective evaluation of survival and PET/CT
- No residual activity--five-year cause-specific survival 80%
- Residual activity in primary tumor or nodes—survival 32%.
- New anatomic sites of disease demonstrated—no patients alive at 5 years
- Persistent or new FDG activity following radiotherapy predictive of tumor recurrence

Potential Roles For FDG PET/CT

• Initial evaluation
  – Diagnosis Incidental only
  – Staging and prognosis Frequent use
  – Treatment planning XRT planning!!!

• Subsequent evaluation
  – Detecting recurrence Use in high risk
  – Staging recurrence Frequent use
  – Therapy assessment Frequent use
FDG PET/CT

- Endometrial cancer
- Ovarian cancer
- Cervical cancer
- Vulvar cancer
Vulvar cancer

- 3% to 5% of all gynecological cancers
- >90% are squamous carcinomas
- 2 pathways to carcinogenesis
  – Mucosal HPV (Human Papilloma Virus) infection
  – Chronic inflammatory (vulvar dystrophy) or autoimmune processes
**Vulvar Cancer: FIGO Staging**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Tumor confined to the vulva</td>
</tr>
<tr>
<td>IA</td>
<td>Lesions ≤2 cm in size, confined to the vulva or perineum and with stromal invasion ≤1.0 mm, no nodal metastasis</td>
</tr>
<tr>
<td>IB</td>
<td>Lesions &gt;2 cm in size or with stromal invasion &gt;1.0 mm, confined to the vulva or perineum, with negative nodes</td>
</tr>
<tr>
<td>II</td>
<td>Tumor of any size with extension to adjacent perineal structures (1/3 lower urethra, 1/3 lower vagina, anus) with negative nodes</td>
</tr>
<tr>
<td>III</td>
<td>Tumor of any size with or without extension to adjacent perineal structures (1/3 lower urethra, 1/3 lower vagina, anus) with positive inguino-femoral lymph nodes</td>
</tr>
<tr>
<td>IIIA</td>
<td>(i) With one lymph node metastasis (≥5 mm), or (ii) one to two lymph node metastasis(es) (&lt;5 mm)</td>
</tr>
<tr>
<td>IIIB</td>
<td>(i) With two or more lymph node metastases (≥5 mm), or (ii) three or more lymph node metastases (&lt;5 mm)</td>
</tr>
<tr>
<td>IIIC</td>
<td>With positive nodes with extracapsular spread</td>
</tr>
<tr>
<td>IV</td>
<td>Tumor invades other regional (2/3 upper urethra, 2/3 upper vagina) or distant structures</td>
</tr>
<tr>
<td>IVA</td>
<td>Tumor invades any of the following: (i) upper urethral and/or vaginal mucosa, bladder mucosa, rectal mucosa, or fixed to pelvic bone, or (ii) fixed or ulcerated inguino-femoral lymph nodes</td>
</tr>
<tr>
<td>IVB</td>
<td>Any distant metastasis including pelvic lymph nodes</td>
</tr>
</tbody>
</table>
## Vaginal Cancer: Odds of Nodal Spread

<table>
<thead>
<tr>
<th>Depth of Tumor</th>
<th>Positive Groin Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1mm</td>
<td>0%</td>
</tr>
<tr>
<td>1-2mm</td>
<td>7%</td>
</tr>
<tr>
<td>2-3mm</td>
<td>8%</td>
</tr>
<tr>
<td>3-4mm</td>
<td>22%</td>
</tr>
<tr>
<td>4-5mm</td>
<td>25%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size of Tumor</th>
<th>Positive Groin Nodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2cm</td>
<td>19%</td>
</tr>
<tr>
<td>&gt; 2cm</td>
<td>42%</td>
</tr>
<tr>
<td>&lt; 3cm</td>
<td>18-19%</td>
</tr>
<tr>
<td>&gt; 3cm</td>
<td>29-72%</td>
</tr>
</tbody>
</table>

Extended beyond the Vulva  54%
Vulvar Cancer: 5 Year Survival

Clinical FIGO Stage

<table>
<thead>
<tr>
<th>Stage</th>
<th>Survival Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>98%</td>
</tr>
<tr>
<td>II</td>
<td>85%</td>
</tr>
<tr>
<td>III</td>
<td>74%</td>
</tr>
<tr>
<td>IV</td>
<td>31%</td>
</tr>
</tbody>
</table>

Node Status

<table>
<thead>
<tr>
<th>Status</th>
<th>Survival Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groin Negative</td>
<td>91%</td>
</tr>
<tr>
<td>Groin Positive</td>
<td>52%</td>
</tr>
<tr>
<td>Pelvic Positive</td>
<td>11%</td>
</tr>
</tbody>
</table>
Vulvar Cancer: Treatment

- Early Stage: Radical Local Excision
- More Advanced: Modified Radical Excision with Sentinel Node Biopsy
- Advanced Stage: Radiation plus Chemotherapy (chemoradiation) possibly followed by limited surgery
Vulvar Cancer: PET/CT Staging
Vulvar Cancer: PET/CT Staging

Stage III (T3N1) Squamous Cancer Vulva

inguinal node

vulva cancer
Vulvar Cancer: PET/CT Staging

• Prospective study comparing FDG PET to surgical pathology
• For nodal metastases PET sensitivity 80% and specificity of 90%
  – Positive predictive value 80%
  – Negative predictive value of 90%
• PET was more accurate in detecting extra-nodal metastases

Cohn DE et al. Gynecol Oncol 2002; 85:179
Vulvar Cancer: PET/CT Staging

- Vulvar lesion 100% detection in squamous cell carcinomas
- Nodal disease in 31% (inguinal and pelvic nodes)
- Extralymphatic involvement: 3 in lung and 1 in ischiorectal fossa
- False positive result for local invasion due to urine contamination.
- All the pathological lymph node levels detected in the PET/CT study were confirmed in the histopathology
- PET/CT changed the therapeutic management 61.5%

Potential Roles For FDG PET/CT

• Initial evaluation
  – Diagnosis Incidental only
  – Staging and prognosis Before sentinel node
  – Treatment planning XRT planning

• Subsequent evaluation
  – Detecting recurrence Strong potential
  – Staging recurrence Strong potential
  – Therapy assessment Potential
FDG PET/CT

- Endometrial cancer
- Ovarian cancer
- Cervical cancer
- Vulvar cancer
- Vaginal cancer
Vaginal Cancer

• Rare tumor--1-2% of all GYN malignancies
• Mean age 60-65 years
• Squamous cell in origin
• HPV associated
• Tumor mass can be ulcerative and infiltrating, well defined and lobulated, or annular constricting
Vaginal Cancer: Patterns of Spread
Vaginal Cancer: Patterns of Spread

- Variability in nodal drainage seen
- Inguinal nodes most often involved if lesion is in the lower 1/3 of the vagina
- Clinically apparent inguinal node mets seen in 5-20% of patients
- Incidence of pelvic nodes varies with stage and location of the tumor
Vaginal Cancer: PET/CT Staging

• FDG PET was prospectively compared to CT in evaluating 23 patients with vaginal carcinoma
  – CT found only 43%

• Primary tumor visualized by PET in 100%
  – CT found only 43%

• PET detected abnormal inguinal and pelvic nodes in 35%
  – CT found only 17%

Vaginal Cancer: Patterns of Failure

• Stage I
  – 10-20% pelvic recurrence, 10-20% distant
• Stage II
  – 35% pelvic recurrence, 22% distant
• Stage III
  – 25-37% pelvic recurrence, 23% distant
• Stage IV
  – 58% pelvic recurrence, 30% distant
Potential Roles For FDG PET/CT

• Initial evaluation
  – Diagnosis Incidental only
  – Staging and prognosis Potential
  – Treatment planningXRT planning

• Subsequent evaluation
  – Detecting recurrence Strong potential
  – Staging recurrence Strong potential
  – Therapy assessment Potential
PET/MR in Gynecologic Tumors

• FDG PET/MR intended to provide “one-stop shopping” for staging and treatment planning.
• MR strength is assessing locoregional extent of pelvic tumor
• FDG PET strength is evaluating the entire body for nodal, peritoneal, and skeletal metastases
• During the PET acquisition, whole-body Dixon, turbo spin-echo images, and fluid-sensitive inversion recovery and DWI MR images
• Dedicated pelvic MR imaging with intravenous gadolinium
• Patient table times are long, >1 hour
PET/MR: Endometrial Cancer

Thank You
Endometrial Cancer

- Fourth most common cancer in women in the U.S. behind breast, lung, and colon cancer
- Most common gynecologic malignancy
- Eighth leading cause of female mortality from cancer
- There are two major pathogenic types of endometrial cancer
  - Type I
  - Type II
Endometrial Cancer: Type I

- Younger/peri-menopausal women
- Obese
- Associated with estrogen excess
- Well differentiated endometrioid
- Superficial myometrial invasion
- Infrequent lymph node metastases
- Associated with hyperplasia
- Genetic mutations in K-ras, PTEN, MLH1
Endometrial Cancer: Type II

- Older/post-menopausal women
- Thin
- Poorly differentiated carcinoma
  - Papillary Serous
  - Clear Cell
- Deep myometrial invasion
- Frequent lymph node metastases
- Associated with atrophy
- Genetic mutations in p53, Erb-B2
Cervical Cancer and HPV

• Human papillomavirus (HPV) is central to cervical carcinogenesis
• Worldwide, the prevalence of HPV in cervical tumors is 99.7%
• High-risk HPV types include 16, 18, 31 and 41
• High-risk HPV infection is necessary but insufficient for cervical cancer
Vaginal Cancer: Patterns of Spread

• Lesions usually found in the upper vagina on the posterior wall
• Vaginal primary tumors may spread along mucosa to cervix or vulva (changes diagnosis)
• Direct extension to bladder, parametria, rectum, cardinal ligaments, uterosacral ligaments
• Nodal spread depends on primary location
## Vaginal Cancer: FIGO Staging

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 0</td>
<td>Carcinoma in situ, cervical intraepithelial neoplasia</td>
</tr>
<tr>
<td>Stage I</td>
<td>Invasive carcinoma confined to the vagina</td>
</tr>
<tr>
<td>Stage IA</td>
<td>Tumor is &lt;2 cm wide and &lt;1 mm depth of invasion</td>
</tr>
<tr>
<td>Stage IB</td>
<td>Tumor is &gt;2 cm wide and &gt;1 mm depth of invasion</td>
</tr>
<tr>
<td>Stage II</td>
<td>Tumor invades paravaginal tissues but not to the pelvic wall</td>
</tr>
<tr>
<td>Stage III</td>
<td>Extension to the pelvic wall</td>
</tr>
<tr>
<td>Stage IVA</td>
<td>Extension beyond the true pelvis or invasion of bladder or rectum</td>
</tr>
<tr>
<td>Stage IVB</td>
<td>Pelvic or inguinal lymphadenopathy, or distant metastases</td>
</tr>
</tbody>
</table>
Vaginal Cancer: Treatment and Prognosis

• Early stage carcinoma of the vaginal vault may be treated by vaginectomy and pelvic lymphadenectomy
• Inguinal lymphadenectomy is performed in tumors of the lower third of the vagina.
• Advanced stage tumors are treated by radiotherapy.
• Prognosis is stage-dependent--five-year survival
  – Stages I–II  80%
  – Stage III–IV  20%
PET Tracers in Gynecologic Tumors

• $^{11}$C-methionine—measures protein synthesis
• $^{18}$F-17-β-estradiol (FES)—measures estrogen receptor binding
• Copper-labeled diacetyl-bis (N4 methyl-thiosemicarbazone)(Cu-ATSM)—measures hypoxia
• 3-deoxy-3-$^{18}$F-fluorothymidine (18F-FLT)—measure of cellular thymidine kinase 1 activity