Gynecologic Cancers: E-Contouring

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University of California San Diego
Gynecologic IMRT

Growing in popularity

2002 IMRT Survey- 15% respondents using IMRT in gynecology patients

2004 IMRT Survey- 35% using IMRT in gynecology patients


Mell LK, Mundt AJ. Survey of IMRT Use in the USA- 2004 *Cancer* 2005;104:1296
Cumulative IMRT Adoption (USA)

Mell LK, Mundt AJ. Survey of IMRT Use in the USA Cancer 2005;104;1296
<table>
<thead>
<tr>
<th>Site</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prostate</td>
<td>85%</td>
</tr>
<tr>
<td>Head and Neck</td>
<td>80%</td>
</tr>
<tr>
<td>CNS Tumors</td>
<td>64%</td>
</tr>
<tr>
<td>Gynecology</td>
<td>35%</td>
</tr>
<tr>
<td>Breast</td>
<td>28%</td>
</tr>
<tr>
<td>GI</td>
<td>26%</td>
</tr>
<tr>
<td>Sarcoma</td>
<td>20%</td>
</tr>
<tr>
<td>Lung</td>
<td>22%</td>
</tr>
<tr>
<td>Pediatrics</td>
<td>16%</td>
</tr>
<tr>
<td>Lymphoma</td>
<td>12%</td>
</tr>
</tbody>
</table>

Mell LK, Mundt AJ. Survey of IMRT Use in the USA- 2004
*Cancer* 2005;104:1296
Gynecologic IMRT
Rationale

• Improved delivery of conventional doses
  – $\downarrow$ Dose to normal tissues
  – Small bowel, bladder, rectum, marrow

• Dose escalation in high risk patients
  – Node positive
  – Gross residual disease

• Replacement for Brachytherapy
Contouring
Contouring

• Target Delineation

• Normal Tissue Delineation
Target Delineation in Gynecology Patients

- Postoperative Cervix/Endometrial
- Intact Cervix
- EFRT, Pelvic-Inguinal, WART
- Volume-Directed Brachytherapy
Intact Cervix

The intact setting has much less of almost everything compared to the postop setting:

Much less experience
Much less consensus
Much less acceptance
Much less comfort
ONE THING WE DO HAVE IS OUTCOME DATA!
## Cervical Cancer

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>FU</th>
<th>Stage</th>
<th>DFS</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intact Cervix</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kochanski</td>
<td>44</td>
<td>23 m</td>
<td>I-IIA</td>
<td>81%</td>
<td>93%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IIB-IIIB</td>
<td>53%</td>
<td>67%</td>
</tr>
<tr>
<td>Beriwal</td>
<td>36</td>
<td>18 m</td>
<td>IB-IVA</td>
<td>51%</td>
<td>80%</td>
</tr>
<tr>
<td>Kidd</td>
<td>135</td>
<td>22 m</td>
<td>IA2-IVB</td>
<td>70%</td>
<td>86.7%</td>
</tr>
<tr>
<td>Hasselle</td>
<td>89</td>
<td>27 m</td>
<td>I-IIA</td>
<td>69.8%</td>
<td>94.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>IIB-IVA</td>
<td>51.4%</td>
<td>70.8%</td>
</tr>
<tr>
<td><strong>Postoperative Cervix</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kochanski</td>
<td>18</td>
<td>21 m</td>
<td>I-II (node+)</td>
<td>79%</td>
<td>94%</td>
</tr>
<tr>
<td>Chen</td>
<td>35</td>
<td>35 m</td>
<td>I-II (node+)</td>
<td>NS</td>
<td>93%</td>
</tr>
<tr>
<td>Hasselle</td>
<td>22</td>
<td>27 m</td>
<td>I-II (node +/-)</td>
<td>95.2%</td>
<td>100%</td>
</tr>
<tr>
<td>Folkert</td>
<td>34</td>
<td>44 m</td>
<td>I-II (node +/-)</td>
<td>91.2%</td>
<td>94%</td>
</tr>
</tbody>
</table>

Kochanski et al. *IJROBP* 2005;63:214  
Beriwal et al. *IJROBP* 2007;68:166  
Chen et al. *IJROBP* 2001;51:332  
Folkert et al. *Gyne Oncol* 2013;128:288  
Kidd et al. *IJROBP* 2010;77:1080  
Hasselle et al. *IJROBP* 2011;80:1436
135 cervical cancer IMRT pts
All underwent PET/CT simulation
Comparison group = 317
conventional RT pts
Pelvic +/- PA IMRT + Brachy
Median FU (72 months conventional, 22 months IMRT)
Reduction in chronic toxicity
Improvements in relapse-free (p=0.07) and cause-specific survivals (p<0.0001).
Recurrence-free Survival

Cause-Specific Survival
111 cervical cancer pts
89 intact cervix, 22 postop
Pelvic IMRT +/- Brachy
Median FU = 27 months
Excellent pelvic control
  – IB-IIA intact = 94.7%
  – IIB-IVA intact = 70.8%
  – Postop patients = 100%
Grade ≥ 3 chronic toxicity = 7%
And we are starting to get at least some consensus
Consensus guidelines for CTV design for the intact cervical cancer patient

Preparation for a planned Phase II RTOG Trial

Meant to supplement the consensus guidelines for postoperative patients

Red Journal 2011;79:348
Intact Cervix CTV

- June 2008 RTOG Meeting
- 16 representatives from the GYN IMRT Consortium: RTOG, NCIC, Japan Clinical Oncology Group, EORTC
- Questionnaire regarding CTV definitions, imaging used, prevalence of IMRT use etc.
- Each contoured using MR (sagittal T2-weighted) and axial CT images
- Statistical software to generate consensus volumes
Intact Cervix Consensus

- General agreement on which structures to include but less agreement regarding their definition for the purposes of contouring
- CTV structures: GTV, cervix, uterus, parametria, vagina and regional lymph nodes
- Delineation of the *parametrium* was particularly controversial
- All agreed that the lateral boundary should be the pelvic sidewall and the medial boundary should abut the GTV, cervix, uterus, and vagina
But little consensus about the superior and inferior extents
Amount of normal tissues to include in the CTV also differed considerably

- 42% of respondents felt it was not always necessary to include the entire fundus

- Length of vagina included in the CTV varied from 1.5 cm to the bottom of the pubic symphysis (~4 cm below tumor)
Other interesting observations

• 91% used CT for target delineation
  • 55% also used MRI
  • 46% also used PET

• Also large variations in recommended PTV margins
  • Tumor: 1-5 cm
  • Nodes: 0.5-1 cm
## Consensus Recommendations

### Table 2. CTV components

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTV</td>
<td>Entire GTV; intermediate/high signal seen on T₂-weighted MR images</td>
</tr>
<tr>
<td>Cervix</td>
<td>Entire cervix; if not already included within GTV contour</td>
</tr>
<tr>
<td>Uterus</td>
<td>Entire uterus</td>
</tr>
<tr>
<td>Parametrium</td>
<td>Entire parametrium, including ovaries; include entire mesorectum if uterosacral ligament involved</td>
</tr>
</tbody>
</table>
| Vagina    | Minimal or no vaginal extension: upper half of the vagina  
|           | Upper vaginal involvement: upper two-thirds of the vagina  
|           | Extensive vaginal involvement: entire vagina |
Fig. 2. Axial and reconstructed sagittal and coronal views of T$_2$-weighted MR images from a clinical contouring case showing 95% agreement contours for GTV (red), cervix (pink), vagina (yellow), parametria (green), and uterus (blue).
Fig. 3. $T_2$-weighted MR axial (left) and sagittal (right) images of one patient demonstrating GTV (red), cervix (pink), uterus (blue), vagina (yellow), parametrium (green), bladder (purple), rectum (light blue), and sigmoid (orange). Arrow heads refer to uterosacral ligaments and mesorectal fascia. Arrows refer to the broad ligament and top of the fallopian tube. Dashed white lines represent the CTV.
Parametria Delineation

- Parametrial tissue is encompassed by the broad ligament but is often poorly seen on axial imaging.

<table>
<thead>
<tr>
<th>Location</th>
<th>Anatomic structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteriorly</td>
<td>Posterior wall of bladder or posterior border of external iliac vessel</td>
</tr>
<tr>
<td>Posteriorly</td>
<td>Uterosacral ligaments and mesorectal fascia</td>
</tr>
<tr>
<td>Laterally</td>
<td>Medial edge of internal obturator muscle/ischial ramus bilaterally</td>
</tr>
<tr>
<td>Superiorly</td>
<td>Top of fallopian tube/broad ligament. Depending on degree of uterus flexion, this may also form the anterior boundary of parametrial tissue.</td>
</tr>
<tr>
<td>Inferiorly</td>
<td>Urogenital diaphragm</td>
</tr>
</tbody>
</table>
Fig. 4. Coronal T₂-weighted MR image of a patient with a relatively upright uterus, demonstrating the superior and inferior boundaries of parametria. Top of broad ligament (blue), pelvic diaphragm (yellow), parametria (green).
Posteriorly, the parametrial tissue is bounded by the mesorectal fascia and uterosacral ligaments.

The entire uterosacral ligament should be included in patients with disease involvement.

Patients with IIIB disease and/or extensive nodal involvement should also have the entire mesorectum included.

Fig. 5. Axial T2-weighted MR image of a patient showing the GTV (red contour), modified parametrium (green), and rectum (light blue); red arrows indicate right proximal uterosacral ligament invasion.
Laterally, the parametrial volume should extend to the pelvic sidewall (excluding bone and muscle).

There should be some overlap of this volume with the nodal CTV, particularly along the obturator strip.

Fig. 6. Axial T2-weighted MR image showing overlap (purple-shaded region) between nodal clinical target volume (orange contour) and lateral portion of parametrial volume (green contour).
CTV Delineation

Vagina
• Minor/no vaginal involvement: Upper ½ vagina
• Upper involvement: Upper 2/3rds of the vagina
• Extensive involvement: Entire vagina

Nodal CTV
• Identical to the postop setting
Cautionary Figure

Fig. 7. Sagittal T2-weighted MR images obtained 1 week apart from the same patient, demonstrating the marked difference between uterus and cervix positions, with altered bladder filling. Primary tumor CTV (red contour) and nodal CTV (green) contours overlaid. Solid lines represent targets at week 1, dashed lines represent the targets at week 2 if a direct translational shift is made to compensate for the change in the primary tumor CTV position. Nodal CTV and portions of tumor CTV in week 2 are missed.
A Consensus-based Guideline Defining Clinical Target Volume for Primary Disease in External Beam Radiotherapy for Intact Uterine Cervical Cancer

Takafumi Toita1*, Tatsuya Ohno2, Yuko Kaneyasu3, Tomoyasu Kato4, Takashi Uno5, Kazuo Hatano6, Yoshiki Norihisa7, Takahiro Kasamatsu4, Takeshi Kodaira8, Ryoichi Yoshimura9,10, Satoshi Ishikura11 and Masahiro Hiraoka7 for the JCOG Radiation Therapy Study Group

- RT Study Group Japan Clinical Oncology Group
- Nodal CTV atlas (Toita et al. JJCO 2010; 40:456)
- 10 radiation oncologists, 2 gynecologic oncologists
- Contoured on CT/MRI of 2 patients
- Reached consensus by discussion
CTV Consensus

Components
GTV, cervix, uterus, parametria, vagina and ovaries

Definitions
GTV: Gross disease on a T2-weighted MRI and any palpable lesions
Cervix: Entire cervix (if not already included)
Uterus: Visualized corpus
Study Case: IIIB Cervix
Bilateral parametrial invasion with right pelvic fixation
CTVs by Working Group Members

Consensus CTV
# Parametrial Definition

## Table 1. Anatomical boundaries of clinical target volume for parametrium

<table>
<thead>
<tr>
<th>Margin</th>
<th>Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial</td>
<td>Isthmus of uterus (level where uterine artery drains into)</td>
</tr>
<tr>
<td></td>
<td>* Contouring would stop at the level where bowel loops are seen</td>
</tr>
<tr>
<td>Caudal</td>
<td>Medial border of levator ani (Fig. 5)</td>
</tr>
<tr>
<td>Anterior</td>
<td>Posterior border of bladder or posterior border of external iliac vessels</td>
</tr>
<tr>
<td>Posterior</td>
<td>Anterior part (semicircular) of mesorectal fascia</td>
</tr>
<tr>
<td></td>
<td>* In case with bulky central tumor or significant parametrial invasion, some modification would be considered (Figs 3 and 4)</td>
</tr>
<tr>
<td>Lateral</td>
<td>Medial edge of internal obturator muscle, piriformis muscle, cocygeus muscle and ischial ramus</td>
</tr>
</tbody>
</table>
Figure 3. Stage-specific delineation schemes for the posterior border of the parametrium (solid red line). (a) Non-bulky early-stage (IB1 or IIA1) disease. (b) Bulky early-stage (IB2 or IIA2) disease. (c) Stage IIB disease (slight parametrial involvement). (d) Stage IIIB disease (massive parametrial involvement).
Figure 4. Actual delineations of the primary CTV (solid orange line) and posterior border of the parametrium (solid red line) according to disease status. Dotted orange lines indicate the anterior border of the perirectum. (a) A case with non-bulky Stage IB1 disease. (b) A case with bulky Stage IB2 disease. (c) A case with Stage IIB disease (bilateral parametrial involvement on pelvic exam). (d) A case with Stage IIIB disease (massive parametrial involvement with fixation to the left pelvic wall on pelvic exam).
Normal Tissues
Organs at Risk (OAR)
Normal Tissues

- Normal tissues depend on the clinical case
- In most patients:
  Small bowel, rectum, bladder
- In pts receiving concomitant or sequential chemotherapy, bone marrow may be included
- Some centers include the femoral heads*
- Kidneys and liver included only if treating more comprehensive fields

*I only do in pelvic-inguinal RT cases
Normal Tissues

• Be consistent with contouring
  – Helps with DVH interpretation
• Rectum: Outer wall (anus to sigmoid flexure)
• Small bowel: Outermost loops from the L4-5 interspace
  – Include the colon above the sigmoid flexure as well in the “small bowel” volume
Bone Marrow Contouring

- Controversial subject
- Initial attention focused on sparing the iliac crests
- More recent data suggests that this might not be optimal
Intact Cervix

• What is needed is a CT-based atlas* for target delineation since obtaining a MRI may be difficult

• MRI is also needed at the time of brachytherapy and two MRIs may not be approved

*under development
Intact Cervix Target Delineation

- Remains a work in progress
- Debate whether intact cervix IMRT is ready for primetime
Intact Cervix Target Delineation

INTERTECC Trial
International Phase II/III Gyne IMRT Study

Loren Mell MD
Director, Clinical and Translational Research
UC San Diego
– University of California San Diego
– Tata Memorial Hospital (Mumbai)
– Peking Union Medical College (Beijing)
– Instituto do Cancer do Estado de Sao Paulo
– King Chulalongkorn Univ. (Bangkok)
– Artemis Health Institute (Delhi)
– University of Chicago
– Loyola University (Chicago)
– University of Miami
– University of South Florida (Tampa)
– University of Pittsburgh
– University of Iowa (Iowa City)
– Istanbul Bilim University (Istanbul)
– University Hospital Hradec Keálové
– Far Eastern Memorial Hospital (Taipei)
– Leiden University Medical Center (Leiden)
INTRODUCTION

International Evaluation of Radiotherapy Technology Effectiveness in Cervical Cancer (INTERTECC)

Phase II/III Clinical Trial of Intensity Modulated Radiation Therapy with Concurrent Cisplatin for Stage I-IIA Cervical Carcinoma

http://radonc.ucsd.edu/research/irtoc/Pages/videos.aspx

### INTERTECC Videos

<table>
<thead>
<tr>
<th>Video</th>
<th>YouTube Viewing Link</th>
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<tbody>
<tr>
<td>Normal Tissue Delineation</td>
<td>View</td>
</tr>
<tr>
<td>Bone Marrow Delineation</td>
<td>View</td>
</tr>
<tr>
<td>Target Delineation (Intact)</td>
<td>View</td>
</tr>
<tr>
<td>Treatment Planning</td>
<td>View</td>
</tr>
</tbody>
</table>
Intact Cervical Cancer

- A GTV and 3 CTVs are outlined
  - GTV Primary Tumor
  - CTV1 GTV + Uterus + Uninvolved Cervix
  - CTV2 Paravaginal/parametrial/parauterine tissues
    Adenexa, proximal vagina
  - CTV3 Pelvic lymph nodes
Table 1. Target Volumes Used in Intact Cervical Cancer Patients Undergoing IMRT

<table>
<thead>
<tr>
<th>Target Volumes</th>
<th>Definition and description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTV</td>
<td>Primary tumor defined on PET or PET/CT imaging</td>
</tr>
<tr>
<td>CTV₁</td>
<td>GTV + uterus + cervix (if not already encompassed in the GTV)</td>
</tr>
<tr>
<td></td>
<td>Entire uterus should be delineated including the uterine fundus</td>
</tr>
<tr>
<td>CTV₂</td>
<td>Parametrial/paravaginal tissues, paraterine fat, ovaries and proximal vagina</td>
</tr>
<tr>
<td></td>
<td>If there is only minimal or no vaginal tumor extension, the upper ½ of the vagina is included</td>
</tr>
<tr>
<td></td>
<td>In patients with involvement of the upper vagina, the proximal two-thirds of the vagina should be treated</td>
</tr>
<tr>
<td></td>
<td>If there is more extensive vaginal involvement, the entire vagina should be included in the CTV₂</td>
</tr>
<tr>
<td>CTV₃</td>
<td>Soft tissues to the medial edge of internal obturator muscle/ischial ramus should be included.</td>
</tr>
<tr>
<td></td>
<td>Includes common iliac*, external and internal iliac nodal regions and pre-sacral regions</td>
</tr>
<tr>
<td></td>
<td>The common iliac, external and internal iliac regions are defined by including the pelvic vessels plus a 7 mm expansion (excluding bone, muscle and bowel) as well as all suspicious lymph nodes, lymphocele and pertinent surgical clips.</td>
</tr>
<tr>
<td></td>
<td>Soft tissues between the internal and external iliac vessels along the pelvic sidewall are included.</td>
</tr>
<tr>
<td></td>
<td>The pre-sacral area consists of the soft tissues anterior (minimum 1.0 cm) to the S1-S2 vertebrae</td>
</tr>
<tr>
<td></td>
<td>Upper extent: 7 mm inferior to L4-5 interspace</td>
</tr>
<tr>
<td></td>
<td>Lower extent: Superior aspect of femoral head (lower extent of external iliacs) and paravaginal tissues at level of vaginal cuff (lower extent of internal iliacs)</td>
</tr>
<tr>
<td>PTV₁</td>
<td>CTV₁ + 15 mm</td>
</tr>
<tr>
<td>PTV₂</td>
<td>CTV₂ + 10 mm</td>
</tr>
<tr>
<td>PTV₃</td>
<td>CTV₃ + 7 mm</td>
</tr>
</tbody>
</table>

IMRT = Intensity modulated radiation therapy, GTV = gross tumor volume, PET = positron emission tomography, CT = computed tomography, CTV = clinical target volume, PTV = planning target volume

The final PTV is then generated by the union of the PTV₁, PTV₂ and PTV₃: PTV = PTV₁ U PTV₂ U PTV₃

* to the level of L4-5 which will not include the entire common iliac nodal region in many patients
Stage IIB Cervix Case

GTV
PTV Design

- Planning target volumes (PTVs) are created for each CTVs
- The final PTV used for treatment planning is generated by combining the individual PTVs
- Different CTV-PTV expansions are used for each CTV based on its degree of internal organ motion and setup uncertainty.

<table>
<thead>
<tr>
<th>PTV1</th>
<th>CTV1 + 15 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV2</td>
<td>CTV2 + 10 mm</td>
</tr>
<tr>
<td>PTV3</td>
<td>CTV3 + 7 mm</td>
</tr>
</tbody>
</table>
“Gyn IMRT Insurance Package”

Dosimetric Studies
Heron D et al. Gynecol Oncol 2003;91:39

Outcome Studies
Mundt AJ et al. Red Journal 2003;56:1354
Hasselle M et al. Red Journal 2011;80:1436
Kidd EA et al. Red Journal 2010;77:1085
Thank you for your attention
Contouring the Female Pelvis

Beth Erickson, MD, FACR, FASTRO
Medical College of Wisconsin

Arno Mundt, MD, FASTRO
University of California San Diego

2013
Disclosures

• Non-paid consultant to Nucletron and Varian
• Varian and Nucletron Travel Grants
• Chart Rounds participant
Learning Objectives

1. Review pelvic anatomy
2. Define pelvic targets
3. Contour post-op endometrial/cervix cancer cases
4. Discuss volumes and challenges for intact cervix cancer
To Eradicate Cancer You Must “Hit the Target”
Knowledge of the anatomy is essential, especially in the era of IMRT. If you don’t define it, it might not get treated or spared.
What Are the Targets?

- Vagina
- Cervix/uterus/parametria
- Pelvic lymph nodes
Where Are the Pelvic Nodes?

- Most “normal-sized” lymph nodes are too small to be visualized directly with standard imaging.
- Anatomic studies demonstrated that pelvic lymph nodes lie adjacent to major blood vessels.

Where Are the Pelvic Nodes?

- Use the blood vessels with a margin as a surrogate target for lymph nodes

Mell et al. Gynecologic Tumors IMRT: A Clinical Perspective BC Decker 2005
Contouring Guidelines

RTOG Gynecologic Atlas

http://www.rtog.org/gynatlas/main.html
RTOG Revised Post Op Gynecologic Atlas

- Under construction
- Better coverage of the obturator LNs
- More reasonable sculpting of the CTV around bowel and rectum
- Use vessels rather than boney landmarks to define the common iliacs and upper field border
- Encourage IV and oral contrast

RTOG Prostate Atlas-obturator nodes
Common Iliac Lymph Nodes

- Common iliac nodes lie in lateral and posterior spaces
- Margins (CTV) of 7 mm around vessels except near vertebral body (10 mm)

Taylor et al; IJROBP 63(5):1604-1612, 2005
Vi Larino-Varela et al; Radiother Oncol 89:192-196, 2008

*Iron Oxide particles (USPIO) in the lymph nodes - black
Common Iliac Lymph Nodes

3D conformal fields

• Avoid splitting vertebral bodies on lateral fields to avoid underdosing common iliac lymph nodes
• Common iliac nodes can be as high as L3

Park; Radiographics 14:1994
Common Iliac Lymph Nodes

- Common iliac CTV should include a minimum of 1.5 cm of soft tissue anterior to the vertebral body at the midline
- Should exclude vertebral body, psoas muscle, and bowel

Mid-Common Iliac Lymph Nodes

Common Iliac Lymph Nodes
Images 40-58
Presacral Lymph Nodes

- Anterior to sacrum/coccyx
- Divided into subaortic below the aortic bifurcation over the sacral promontory and the perirectal nodes within the mesorectal fascia in the sacral hollow

Netter F. Atlas of Human Anatomy 4th Ed
Presacral Lymph Nodes

- A 10 mm strip over sacral prominence connecting the common iliac/EI/II contours would include the subaortic presacral nodes

Taylor et al. IJROBP 63(5):1604-1612, 2005
Presacral Lymph Nodes

Presacral Lymph Nodes

- Includes 1-2 cm of tissue anterior to S1, S2, S3 between the anterior border of CTV and the vertebral body or sacrum
  - Should not extend into sacral foramina
  - Presacral nodal coverage should discontinue when piriform muscle becomes clearly visible (approximately inferior border S2/S3)
- The lower presacral (perirectal) nodes would be included in the mesorectal/lower pelvic CTV contours as in the RTOG anorectal atlas
Presacral Lymph Nodes

- Include in patients with cervical cancer or stage II endometrial cancer
- Subaortic (S1-S3) Typically included in Gyn cases
- Perirectal (S4, S5, mesorectal) typically included in anorectal cancers but may also be needed for intact cervix
Pre Sacral Lymph Nodes
Slices (40)63-70
Home work

Pelvic Lymph nodes

Slices 63, 69
Pelvic Node Delineation

- Nodal CTV – vessel, perinodal tissue and any pertinent clips
- ? Lymphoceles
- CTV should be bounded by the piriform muscle even when internal iliac vessels disappear
- Average margin 7 – 10 mm (CTV) around vessels

External Iliac Lymph Nodes

- Divided into lateral, medial, and anterior divisions

**El lat**-lateral to external iliac artery

**El ant**-anteromedial to external iliac vein

**El med**-medial and posterior to external Iliac vein

Taylor et al. IJROBP 63(5):1604-1612, 2005
Pelvic Node Delineation

- Extend contours to pelvic wall but exclude bone and muscle (psoas and piriform)

Taylor et al. IJROBP 63(5):1604-1612, 2005
Pelvic Node Delineation

- Extend contours 10 mm (CTV) around lateral external iliac lymph nodes and 7 mm around the medial and anterior iliac lymph nodes.

Taylor et al. IJROBP 63(5):1604-1612, 2005

Psoas and piriform muscles, pelvic bones, small bowel and rectum help define the CTV.
Obturator Lymph Nodes

- Lie between internal and external iliac vessels
- Next to obturator internis muscle
- End near top of pubic symphysis

Taylor et al. IJROBP 63(5):1604-1612, 2005
Obturator Lymph Nodes

• Need a strip of tissue 17 mm wide between internal-external iliacs to cover the obturator nodal region

Taylor et al. IJROBP 63(5):1604-1612, 2005
Obturator Lymph Nodes

Obturator Lymph Nodes

Taylor et al. IJROBP 63(5):1604-1612, 2005
Obturator Lymph Nodes
RTOG Pelvic LN Atlas-prostate

Above the top of pubic symphysis

Lawton et al. IJROBP 74(2)383-387,2009
Where Do the External Iliac Nodes End and the Inguinal Nodes Begin?

1. Inguinal ligament

Richter et al, Normal Lymph Node Topography 2nd Ed, 2004
Where Do the External Iliac Nodes End and the Inguinal Nodes Begin?

2. Femoral head or superior pubic ramus

Small et al; IJROBP 71(2): 428-434; 2008
Pelvic Lymph Nodes
Slices 71-89
Home Work

Pelvic Lymph Nodes

Slice 75,89
Vaginal Contouring

- Draw vaginal volume on bladder full CT and empty CT.
- Fuse together and create an ITV
- **ITV** – internal target volume to account for daily variation in location of vaginal cuff related to variation in the daily bladder filling (not rectal)
- Fused vaginal contours are encompassed by a common PTV
Vaginal Contouring

- Include tissue from the vaginal cuff to the medial edge of the internal obturator muscle/ischial ramus on each side (parametrial and paravaginal tissues)
- Maintain a distance of 15 mm tissue between anterior and posterior borders of CTV

Vaginal Contouring

- Include at least 3 cm of vagina or at least 1 cm above obturator foramen
- Add 7 mm superiorly, inferiorly, laterally and 5-7 mm posteriorly to create the PTV

Avoid tight margins around the vaginal cuff.
Include a rim of bladder and rectum in the CTV.

Mell et al, Gynecologic Tumors
IMRT: A Clinical Perspective
BC Decker 2005
Vaginal contours
Slices 80-101
Slice 88, 94-Bladder full
Slice 89, 91-Bladder empty
Is IMRT Ready for Prime Time in the Therapy of Cervical and Endometrial Cancer?

For post-operative therapy?

- Encouraging published data from RTOG 0418-IMRT safe and effective
- Use of an ITV reassuring relative to bladder filling and vaginal motion
- Rectal filling/motion remains a concern
Is IMRT Ready for Prime Time in the Therapy of Cervical and Endometrial Cancer?

For definitive therapy in cervical cancer??

• CTV and PTV definitions remain controversial
• Consensus guidelines are building
• Organ motion and volume changes during therapy remain a significant issue.
• “unpredictable organ dynamics”
GYN IMRT International Consortium (RTOG, NCIC, ESTRO, JCOG)

CTV Definition

CONSENSUS GUIDELINES FOR DELINEATION OF CLINICAL TARGET VOLUME FOR INTENSITY-MODULATED PELVIC RADIOTHERAPY FOR THE DEFINITIVE TREATMENT OF CERVIX CANCER

Karen Lim, M.B.B.S.,* William Small, M.D.,† Lorraine Portelance, M.D.,‡ Caren Creutzberg, M.D., Ph.D., Ina M. Jürgenliemk-Schulz, M.D., Ph.D., Arno Munding, M.D., Loren K. Mell, M.D., Nina Mayr, M.D., Akila Viswanathan, M.D., Anuja Jhingran, M.D., Beth Erickson, M.D., Catherine Yashar, M.D., Beth Erickson, M.D., Jennifer De Los Santos, M.D., David Gaffney, M.D., Ph.D., Catheryn Yashar, M.D., Sushil Beriwal, M.D., Aaron Wolfson, M.D., Alexandra Taylor, F.R.C.R., Walter Bosch, Ph.D., Issam El Naqa, Ph.D., and Anthony Fyles, M.D. for the Gyn IMRT Consortium.

Lim IJROBP 79(2): 348-355 2011
Definitive Cervix Contouring

**Table 2. CTV components.**

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GTV</td>
<td>Entire GTV; intermediate/high signal seen on T2-weighted MR images</td>
</tr>
<tr>
<td>Cervix</td>
<td>Entire cervix; if not already included within GTV contour</td>
</tr>
<tr>
<td>Uterus</td>
<td>Entire uterus</td>
</tr>
<tr>
<td>Parametrium</td>
<td>Entire parametrium, including ovaries; include entire mesorectum if uterosacral ligament involved</td>
</tr>
<tr>
<td>Vagina</td>
<td>Minimal or no vaginal extension: upper half of the vagina</td>
</tr>
<tr>
<td></td>
<td>Upper vaginal involvement: upper two-thirds of the vagina</td>
</tr>
<tr>
<td></td>
<td>Extensive vaginal involvement: entire vagina</td>
</tr>
</tbody>
</table>

Lim et al IJROBP 79(2): 348-355 2011
Parametrial/Paracervical Tissue

- Fat and loose connective tissue and smooth muscle around the uterus and cervix
  - Contains blood vessels and lymph nodes

Netter F. Atlas of Human Anatomy 4th Ed
Definition of Parametria

Borders:
- Anterior – bladder
- Posterior – perirectal fascia
- Medial – tumor/cervical rim
- Lateral – Pelvic wall

Dimopoulous et al IJROBP 64(5):1380-1388, 2006
<table>
<thead>
<tr>
<th>Location</th>
<th>Anatomic structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteriorly</td>
<td>Posterior wall of bladder or posterior border of external iliac vessel</td>
</tr>
<tr>
<td>Posteriorly</td>
<td>Uterosacral ligaments and mesorectal fascia</td>
</tr>
<tr>
<td>Laterally</td>
<td>Medial edge of internal obturator muscle/ischial ramus bilaterally</td>
</tr>
<tr>
<td>Superiorly</td>
<td>Top of fallopian tube/ broad ligament. Depending on degree of uterus flexion, this may also form the anterior boundary of parametrial tissue.</td>
</tr>
<tr>
<td>Inferiorly</td>
<td>Urogenital diaphragm</td>
</tr>
</tbody>
</table>

Fig. 4. Coronal T₂-weighted MR image of a patient with a relatively upright uterus, demonstrating the superior and inferior boundaries of parametria. Top of broad ligament (blue), pelvic diaphragm (yellow), parametria (green).

Lim et al IJROBP, 2010
Uterus Contouring

- Include whole uterus?
- International consortium-yes
- Interconnecting lymphatics
- Hard to know where cervix ends and uterus begins
- Account for motion?-Varies with bladder filling
Challenges for IMRT

Mobile uterus

Courtesy of Karen Lim, Princess Margaret Hospital
Challenges for IMRT

Another mobile uterus

Courtesy of Karen Lim, Princess Margaret Hospital
IMRT Challenges

Parametria & change depending on volume of bladder

Courtesy of Karen Lim, Princess Margaret Hospital
Rectal Sparing

• May be dangerous due to need to include presacral nodes (mesorectal), uterosacral ligaments, and internal iliac nodes

• Rectal filling may vary
Mesorectal Lymph Nodes

Fig. 5. Axial T$_2$-weighted MR image of a patient showing the GTV (red contour), modified parametrium (green), and rectum (light blue); red arrows indicate right proximal uterosacral ligament invasion.

Lim et al, IJROBP, 2010
The Challenge of the PTV

Are we really sparing bowel and other tissues if our PTV is too large?

PTV of 1.0 – 2.0 cm around non-nodal CTV (Uterus/cervix, vagina, parametria) if IGRT

PTV > 2.0 cm if no IGRT???

Nodal PTV of 7-10 mm

- The nodal PTV and non-nodal PTV may move in different directions
INTERTECC
International Evaluation of Radiotherapy Technology Effectiveness in Cervical Cancer
Phase II/II trial of IMRT with CDDP

Phase II
• Eligible – Stage I-IVA Cervical carcinoma
• IMRT (Bone Marrow Sparing-BMS) + Cisplatin
• 35/90 planned patients enrolled
• Primary outcome is grade 2+ GI or grade 3+ Heme toxicity

Phase III

- Stage IB2-IVA
- Conventional RT/CDDP
- BMS IMRT/CDDP
- BMS IMRT/CDDP/Gemzar

Courtesy of Catheryn Yashar
IMRT for Intact Cervix

INTERTECC gives guidelines for PTV and dose constraints in the trial setting

Full protocol available on the UCSD web
Traditional Field Design
Boney Anatomy is Not Enough!

- Most inclusive- "Through and Through"
- Irradiated all tissue in the field
- Could miss external iliac LNs anteriorly
- Could miss pre-sacral, perirectal and internal iliac LNs posteriorly

Contemporary Field Design

- CT-based field design is intelligent!

- MR-based field design may even be better for cervical and vaginal cancers
IMRT improved target coverage (93% vs 76%) when compared to a conventional 4 field technique in post-op endometrial patients

“We” have not done a good job of **identifying** and **hitting** the targets
Pelvic Lymph Nodes

- Common iliac
- Internal iliac (hypogastric)
- External iliac/obturator
- +/- presacral
- +/- inguinal

Park; Radiographics 14:1994
CLINICAL INVESTIGATION

CONSensus Guidelines for delineation of Clinical Target Volume for intensity-modulated pelvic radiotherapy in postoperative treatment of endometrial and cervical cancer

3D Conformal External Beam Field Design

- **Posterior Border** Laterals

  – Need to include entire sacrum to cover disease in uterosacral and cardinal ligaments and superior rectal and sacral nodes

Park; Radiographics 14:1994

Greer; Gyn Onc 38:1990
3D Conformal External Beam Field Design

- **Posterior Border Laterals**
  - Need to include **entire rectum** to avoid missing perirectal tumor extensions or internal iliac lymph nodes (most rectal complications are on the anterior rectal wall).

  - [Image of CT scan showing posterior border laterals with arrows indicating tumor spread]

  - [Image of CT scan showing anterior rectal wall]

  - [Image of CT scan showing perirectal tumor]

  - [Image of CT scan showing internal iliac lymph nodes]

  - [Reference: Park; Radiographics 14:1994]
  - [Reference: Kim; Radiother Oncol 30:1994]