CT Guided Contouring:
“Challenges and Pitfalls”

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GYN GEC – ESTRO NETWORK MEMBER AND FACULTY
Vienna Applicator

- Applicators
- Imaging
- Planning systems

w = 7 cm
h = 5 cm
t = 4 cm

“GOLD STANDARD”
Why CT for “At Brachy Contouring”

Pros & Cons of CT Imaging: Alina

- Brachytherapy - Conventionally Point Based
- GEC-ESTRO Recommendations - 2005
  - Defined target and Organ at Risk
  - MRI – Imaging of choice

Then Why CT?

- CT Imaging: Gold STD for RT planning!
- Vast experience with CT based contouring!
- Wide acceptability due to its use in XRT!
- Availability: CT Vs MR in RT dept.
CT Guided Contouring
Pre-Requisites: Do’s and Don’ts

- Do not use the metallic applicators made of stainless steels
- Do not use contrast agents in foley’s bulb / rectum / sigmoid
- Do not use radio-opaque gauze / rectal separator (SS) for vaginal packing
- Do not use dummies meant for X-rays based planning

- CT / MR Compatible Brachy Applicators
- Use saline/ water as contrast in foley’s bulb & dilute urografin for rectum/ sigmoid/ bladder
- CT protocol: 2-3 mm slice axial sections with / without IV Contrast
- Dummies : Copper / low density metal
- Proper Documentation and mapping: Clinical / Imaging
CT Artifacts
Applicators, Folley’s catheter, Dummies, Rectal retractors
CT Guided Contouring

• Delineation Target & OARs

• Dosimetric Implications
  – Optimized plans Vs Un-optimized plans

• Logistical Alternatives
  – Single fraction MRI
  – Pre Brachy MRI
  – Evidence
  – Learning Curve etc...
Delineation of Target on CT

- Experience of MR Based Approach: Mandatory

- Target at brachytherapy
  - GTV: poor visualization of residual tumor on CT
  - HRCTV: Clinical Drawing at Diagnosis and Brachy + CT imaging findings
  - IRCTV: margins to HR-CTV

- HR-CTV: Practical & feasible contour possible on CT Imaging

- Defined conceptually as
  - GTV-B + Whole of Cervix
  - With presumed extensions at brachy in:
    - Parametrium
    - Endocervical
    - Vagina
HRCTV Delineation On CT

A) Whole Cervix

- Inferior extent
  - At superior level of Ring/Ovoid
HRCTV Delineation On CT

A) Whole Cervix

- Inferior extent
- Superior extent
  - Level of uterine vessels first abut cervical tissue (need i/v contrast)
  - Point of volume expansion
  - Point of uterine cavity appearance
  - Conical cervical apex or the isthmus
HRCTV Delineation On CT

A) Whole Cervix
   - Inferior extent
   - Superior extent
   - Lateral: clinical assessment / MR assessment
     • CT poor estimate of lateral cervical boundary & Para extension
     • Clinical / MR imaging findings at Pre Rx and at Brachy

B) Extensions: Clinical examination + CT findings
   - Parametrium + Endocervical + Vaginal Disease
Abnormal Parametrium???
B) Extensions: Clinical examination + CT findings

- Parametrium: over-estimated
- Endocervical: under-estimated
- Vagina: no reports

- none can be truly estimated on CT
- Best clinical examinations defined delineation or may be assisted with pre brachy MRI
### Dimensions Different

DVH No difference??!??!

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HR-CTV_MRI</th>
<th>HR-CTV_CT</th>
<th>HR-CTV_CT_Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>4.6 ± 1.5</td>
<td>4.4 ± 1.5</td>
<td>4.2 ± 1.0</td>
</tr>
<tr>
<td>Width at Point A (cm)</td>
<td>4.5 ± 1.0</td>
<td>5.1 ± 1.8</td>
<td>5.5 ± 1.3 (p = 0.05)*</td>
</tr>
<tr>
<td>Thickness at Point A (cm)</td>
<td>3.6 ± 0.6</td>
<td>3.5 ± 1.1</td>
<td>3.8 ± 1.3</td>
</tr>
<tr>
<td>Volume (cm³)</td>
<td>47.3 ± 28.5</td>
<td>43.3 ± 20.5</td>
<td>47.6 ± 23</td>
</tr>
<tr>
<td>V_100 (%)</td>
<td>96 ± 4</td>
<td>91 ± 11</td>
<td>86 ± 9 (p = 0.01)*</td>
</tr>
<tr>
<td>D_100 (Gy)</td>
<td>5.4 ± 1.5</td>
<td>4.1 ± 1.7 (p = 0.03)*</td>
<td>3.4 ± 1.0 (p &lt; 0.01)*</td>
</tr>
<tr>
<td>D_90 (Gy)</td>
<td>8.7 ± 1.5</td>
<td>7.6 ± 1.9</td>
<td>6.7 ± 1.6 (p &lt; 0.01)*</td>
</tr>
</tbody>
</table>

**Table 2.** Comparison of HR-CTV dimensions and dose parameters (calculated using EQD2) between MRI and CT

<table>
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<tr>
<th>Parameter</th>
<th>HR-CTV_MRI</th>
<th>HR-CTV_CT</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Length sagittal, cm</td>
<td>2.7 (0.5)</td>
<td>2.2 (0.8)</td>
<td>0.006*</td>
</tr>
<tr>
<td>Length coronal, cm</td>
<td>3.7 (0.7)</td>
<td>4.5 (0.9)</td>
<td>0.004*</td>
</tr>
<tr>
<td>Length axial, cm</td>
<td>3.0 (0.6)</td>
<td>3.3 (0.8)</td>
<td>0.157</td>
</tr>
<tr>
<td>D_100 (EQD2)</td>
<td>77.2 (2.3)</td>
<td>75.9 (1.5)</td>
<td>0.182</td>
</tr>
<tr>
<td>D_90 (EQD2)</td>
<td>81.9 (2.5)</td>
<td>80.4 (2.0)</td>
<td>0.110</td>
</tr>
<tr>
<td>PtA dose; EQD2, Gy</td>
<td>82.9 (3.6); 93.2 (2.1)</td>
<td>82.0 (3.5); 93.3 (2.8)</td>
<td>1.00</td>
</tr>
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</table>

**Table 1.** Mean values and comparison of volume and dose parameters among high-risk clinical target volume resonance imaging, computed tomography, and after formulating standardized computed tomography.

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Viswanathan et al IJROBP 2007

Eskander et al IJGC 2010

Krishnatry et al JJCO 2012
Overall Volume: HRCTV

- No significant Difference in all reports
- Over-estimation in one dimension compensates for underestimation in other direction
  - Implication
    - Dosimetric: none
    - Clinical: not known

Under estimation of
- Height
- Thickness at Point A

Over-estimation of
- Width
- Maximum Thickness

Compensated Total Volume
Dosimetric Implications CT /MRI

Optimized plans Vs Un-optimized plans Comparison

Table 1. Mean values and comparison of volume and dose parameters among high-risk clinical target volume obtained on magnetic resonance imaging, computed tomography, and after formulating standardized computed tomography contours

<table>
<thead>
<tr>
<th>Parameter</th>
<th>HR-CTV&lt;sub&gt;MRI&lt;/sub&gt;</th>
<th>HR-CTV&lt;sub&gt;CT&lt;/sub&gt;</th>
<th>HR-CTV&lt;sub&gt;CTSMI&lt;/sub&gt;</th>
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<td>5.5 ± 1.3&lt;sub&gt;(p = 0.05)*&lt;/sub&gt;</td>
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</tr>
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<td>86 ± 9&lt;sub&gt;(p = 0.01)*&lt;/sub&gt;</td>
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<tr>
<td>D&lt;sub&gt;100&lt;/sub&gt; (Gy)</td>
<td>5.4 ± 1.5</td>
<td>4.1 ± 1.7&lt;sub&gt;(p = 0.03)*&lt;/sub&gt;</td>
<td>3.4 ± 1.0&lt;sub&gt;(p &lt; 0.01)*&lt;/sub&gt;</td>
</tr>
<tr>
<td>D&lt;sub&gt;90&lt;/sub&gt; (Gy)</td>
<td>8.7 ± 1.5</td>
<td>7.6 ± 1.9</td>
<td>6.7 ± 1.6&lt;sub&gt;(p &lt; 0.01)*&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Viswanathan: optimized to HRCTV plans

- No difference in small series of patient
- May have importance in large series or individual patient data
- Especially when two HRCTV volume dimensions not comparable on CT & MR

Table 2. HR-CTV and IR-CTV DVH analysis

<table>
<thead>
<tr>
<th></th>
<th>MRI</th>
<th>CT</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR-CTV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;100&lt;/sub&gt; (%)</td>
<td>90.57%</td>
<td>91.16%</td>
<td>0.849</td>
</tr>
<tr>
<td>D&lt;sub&gt;100&lt;/sub&gt; (Gy)</td>
<td>6.57 ± 3.86</td>
<td>5.07 ± 1.79</td>
<td>0.148</td>
</tr>
<tr>
<td>D&lt;sub&gt;90&lt;/sub&gt; (Gy)</td>
<td>10.6 ± 2.9</td>
<td>10.5 ± 2.9</td>
<td>0.946</td>
</tr>
<tr>
<td>IR-CTV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V&lt;sub&gt;100&lt;/sub&gt; (%)</td>
<td>77.07%</td>
<td>77.07%</td>
<td>1</td>
</tr>
<tr>
<td>D&lt;sub&gt;100&lt;/sub&gt; (Gy)</td>
<td>4.9 ± 11.01</td>
<td>4.6 ± 1.67</td>
<td>0.493</td>
</tr>
<tr>
<td>D&lt;sub&gt;90&lt;/sub&gt; (Gy)</td>
<td>7.3 ± 1.93</td>
<td>7.4 ± 1.95</td>
<td>0.78</td>
</tr>
</tbody>
</table>

Krishnatry: Non-optimized STD plans
Summary of Studies

• Small series
• Individual patient data more important than diff in mean
• Comparison of optimized & unoptimized plans
• Compensation effect
OARs Delineation on CT

- All studies show equivalent results for standard OARs
  - Rectum
  - Bladder
  - Sigmoid
Special situations but daily difficulties
Ant/Post boundaries

- At the level of ring/ovoids & cervix difficult boundaries
- Especially in empty Bladder & Rectum
  - Need good information of anatomy, correlation, scroll up & down images
  - MRI image studies can help in experience.
Bowel/ovary/else?
Pre Brachy MRI Vs Clinical contouring

• Similar efficacy results in both type of studies
• Viswanathan et al
  – Showed Pre Brachy MR helped improve HRCTV Volumes
  – Guidelines using pre brachy MRI
• No Other direct comparison
• Clinical based contouring may be more widely usable.
Evidence: few prospective series

• Tan et al, UK (N=28)
  – HRCTV D90 >74 Gy,
  – 7/24 patient modification for OAR dose
  – 2/24 for tumor
  – 3 yr OS: 81%, Pelvic control rate of 96%, overall actuarial risk of serious late morbidity 14%. 20 improvement over conventional cohort.

• Kang et al, Korea (N= 2D/3D=133/97)

<table>
<thead>
<tr>
<th></th>
<th>2D</th>
<th>3D</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQD2 Tumor</td>
<td>72.3</td>
<td>81.8</td>
</tr>
<tr>
<td>Local Control</td>
<td>91%</td>
<td>97%</td>
</tr>
<tr>
<td>Severe Late rectal Bleeding</td>
<td>13%</td>
<td>2%</td>
</tr>
</tbody>
</table>
MR for selected cases only

- Large disease residual
- No residual disease
- Previous CT planning difficulties
PROSPECTIVE ONGOING STUDY AT TMH

PROTOCOL

Evaluation of CT Imaging Assisted Contouring for Image Based Brachytherapy in Carcinoma of the Uterine Cervix

DATA SET - I
- Pre Rx Clinical Cartoon and Clinical measurements
- Pre Rx MR Pelvis: Primary tumor topography and measurements
- Dimensions of Disease: GTV-D and IRCTV Concept

DATA SET - II
- Clinical Cartoon at 1st Brachytherapy
- CT Imaging: 3mm slices (Contrast)
- MR planning
- GTV, HR-CTV, IR-CTV at 1st Brachytherapy on CT and MR

END POINTS
- Correlation between CT vs MR Based HR-CTV & IR-CTV contouring
- Correlation between CT vs MR Based OAR contouring
Patient: SM
MUM 072

Clinical Drawing
FIGO IIIB

Infiltrative
Exophytic

Cervix

Vagina

Parametria

Rectum or Bladder

At Diagnosis

w = 7 cm
h = 4 cm
t = 5 cm

Vagina Involvement = 2 cm

dd/mm/yy
06.12.2012

umesh
Signature
Screen shots at diagnosis - MUM 072
Clinical Drawing

Infiltrative Exophytic

Cervix

Vagina

Parametria

Rectum or Bladder

At Brachytherapy

\[ w = 5 \text{ cm} \]
\[ h = 3 \text{ cm} \]
\[ t = 3 \text{ cm} \]

Vagina Involvement = 0.5 cm

Patient: SM MUM 072

At Brachytherapy

\[ w = 5 \text{ cm} \]
\[ h = 3 \text{ cm} \]
\[ t = 3 \text{ cm} \]

Vagina Involvement = 0.5 cm

dd/mm/yy
22.02.2013

umesh
Signature
Vagina Involvement = 2 cm

Patient: BD  
MUM 073

Clinical Drawing
FIGO IIB

At Diagnosis

w = 8 cm
h = 5 cm
t = 6 cm

Vagina Involvement = 2 cm

Infiltrative Exophytic

Cervix
Vagina
Parametria
Rectum or Bladder

dd/mm/yy
17.12.2012

umesh  
Signature
Screen shots at diagnosis - MUM 073

Representative sagittal cut

Representative Cor cut

Representative axial cut
Patient: BD MUM 073

Clinical Drawing

- Infiltrative
- Exophytic

- Cervix
- Vagina
- Parametria
- Rectum or Bladder

At Brachytherapy

- W = 6 cm
- h = 4 cm
- t = 4 cm

Vagina Involvement = 0.5 cm

dd/mm/yy
12.03.2013

umesh
Signature
SUMMARY AND CONCLUSIONS

• MR Based Approach: Gold Standard for IGBT Practice

• CT Guide Contouring is feasible provided
  - MR Based Approach Experience
  - Assisted by at least one MR series
  - Standardized CT Protocol: IV contrast, slice thickness etc.
  - HR-CTV & OAR’s only

• No robust clinical data with the CT Image Guided Brachytherapy

• Ongoing Clinical studies
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- Departments of Radiation Oncology & Medical Physics
- Department of Radio-diagnosis
- GYN Disease Management Group  TMC
- GYN GEC – ESTRO Research Network