Image-Guided Adaptive Brachytherapy in Cervical Cancer

Clement Khoury, MD

www.hdf.usj.edu.lb/radiotherapie

Department of Radiation Oncology
Hotel Dieu de France Hospital
University of Saint Joseph
Beirut, Lebanon
Contents

• Historical data
• Rationale for Image Guidance in Gynaecological Brachytherapy
• Rationale for Adaptation: CT/MR at time of brachytherapy
• Adaptation in Brachytherapy:
  – Interstitial techniques
  – Dose adaptation
• Key points
2D Image based brachytherapy

Applicator insertion

Standard dose plan

Dose delivery
MRI-GUIDED ADAPTIVE BRACHYTHERAPY OF THE CERVIX

Planning and application

3D imaging with applicator

Contouring

Applicator reconstruction

3D dose planning

Dose delivery

Pötter et al., Acta Oncologica 2008
Rationale for image guidance in gynaecological brachytherapy

• Conventional Radiography 2D

→ No soft tissue depiction (tumor? OAR?)
Rationale for image guidance in gynaecological brachytherapy

- Conventional Radiography 2D

→ No soft tissue depiction (tumor? OAR?)
→ Transfer of clinical findings
Rationale for image guidance in gynaecological brachytherapy

- **Ultrasound**

  - Advantages:
    - Relatively inexpensive
    - Portable
    - Readily Accessible
    - Guidance for applicator/interstitial needle insertion
    - Assess tumor size and topography
    - Aid in treatment planning

Ultrasound guidance for applicator insertion

Axial

Sagittal

Sahinler I, et al. IJROBP 2004
Assess tumor size and topography

→ Decide on application technique
→ Guide interstitial needle insertion
→ Aid treatment planning

Weitmann HD et al. *Strahl Onkol* 2006
Rationale for image guidance in gynaecological brachytherapy

- **Computed tomography (CT)**

  - CT (No contrast) → Tumor size assessment and topography
  - T2W MR

→ Tumor size assessment and topography
CT: Tumor size assessment and topography

CT with contrast in bladder and rectum
CT: Tumor size assessment and topography

- Good depiction of outer contours of OAR
- Hazy pathological definition of tumors
CT: Tumor width overestimation
Rationale for image guidance in gynaecological brachytherapy

- **Magnetic Resonance Imaging (MR)**
  - Soft tissue depiction
  - Multiplanarity
  - As per GEC ESTRO recommendations
  - Available data on use in Brachytherapy
MRI at time of brachytherapy

• Systematic evaluation of MR findings at BT

Bad response

Good response

Evaluate response to EBRT and tumor regression

MRI at time of brachytherapy

- Quantitative tumor regression

\[ \text{EBRT : Tumor regression 75\%} \]
\[ \text{BT : Tumor regression 10\%} \]

MRI at time of brachytherapy

- Systematic evaluation of MR findings at BT

Predict residual pathology from initial MR
MRI at time of brachytherapy

- Systematic evaluation of MR findings at BT

- Check for uterine perforation (Reported incidence up to 15%)
- Use of ultrasound during applicator insertion helps reduce chance of perforation

Sharma DN, et al. Gynecol Oncol 2010
MRI at time of brachytherapy

• Systematic evaluation of MR findings at BT

↘ Check for other perforations
MRI at time of brachytherapy

- Systematic evaluation of MR findings at BT

Suboptimal implant  Optimal implant

Check for adequacy of the implant
MRI at time of brachytherapy

• Systematic evaluation of MR findings at BT

Unfavorable Topography

Favorable Topography

↘ Check for applicator – tumor – OAR topography
CT at time of BT

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st imaging tool in RT</td>
<td>Little spontaneous contrast</td>
</tr>
<tr>
<td>Widely available</td>
<td>Close density of adjacent structures and tumor</td>
</tr>
<tr>
<td>Low cost</td>
<td>Little improvement after contrast injection</td>
</tr>
<tr>
<td>Depiction of OAR contours</td>
<td>Confounding contrast enhancement between tumor and post-EBRT edema</td>
</tr>
</tbody>
</table>

# CT at time of BT

<table>
<thead>
<tr>
<th>Indications</th>
<th>Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 MR (diagnostic and after EBRT) should be available</td>
<td>One of the MRs is missing</td>
</tr>
<tr>
<td>2 sets of detailed clinical data should be available (before EBRT and prior to BT)</td>
<td>Incomplete clinical assessment</td>
</tr>
<tr>
<td>Clinical and MR findings should be concordant</td>
<td>Discordance between and clinical and radiological (MR) findings</td>
</tr>
<tr>
<td>Residual tumor should be well defined and limited to the cervix</td>
<td>Complex tumor – normal tissue topography</td>
</tr>
<tr>
<td></td>
<td>Persistent tumor outside the cervix</td>
</tr>
</tbody>
</table>

Adaptation in Brachytherapy: Interstitial techniques

- Detection of inappropriate coverage

→ Middle parametrial tumor growth
Adaptation in Brachytherapy: Interstitial techniques

- Detection of inappropriate coverage

→ Distal parametrical tumor growth

*GEC-ESTRO Handbook of Brachytherapy*
Adaptation in Brachytherapy: Interstitial techniques

- Detection of inappropriate coverage

→ Distal intravaginal tumor growth
Adaptation in Brachytherapy:
Interstitial techniques

- Detection of inappropriate coverage

GEC-ESTRO Handbook of Brachytherapy
Parallel implanted needles
Parallel and divergent implanted needles

low degree of freedom

Insertion depth
(distance from template)
Adaptation in Brachytherapy: Dose Adaptation

• Adapting the applicator:
  – Intracavitary
  – Interstitial

• Adaptation to size and shape of the target

• Adaptation to OAR
Key points

• Basic imaging level: eyes and finger for inspection and palpation

• Synchronous clinical and imaging findings must be assessed at diagnosis and at brachytherapy

• MR imaging is the gold standard for IGABT; CT is an alternative option if MR is not available

• Adaptation of the application technique to the topography at the time of BT is mandatory: Interstitial techniques when inappropriate topographic and dosimetric coverage with intracavitary techniques
Key points

• It is highly recommended to establish a firm and productive cooperation between the radiation oncologist, the gynecologist and the radiologist when implementing 3D image guided brachytherapy in clinical practice.

• Only by joining the complementary expertise from all specialties, the best treatment results in terms of local control, survival and treatment-related toxicities can be achieved…
Beirut!