MRI – based brachytherapy for cervical cancers

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Outline

• Introduce our service
• Why Image guided brachytherapy (IGBT)?
• IGBT results and case sharing
• Future directions
Introduction

- Pamela Youde Nethersole Eastern Hospital
- New cervical cancer case per year ~ 50
- Brachytherapy cervical cancer case (per patient) per year ~ 20-25
- HDR since 2005
- Image guided brachytherapy since 20 Jan 2015
  - New system upgrade in Sep 2014 (Oncentra TPS 4.3)
Applicators (MR compatible)

- Utrecht Interstitial CT/MR applicator (2 sets)
  - Plastic needles
- Vaginal CT/MR applicator (1 set)
- Vienna ring with interstitial needles (1 set)
  - Metal needles (not yet in use)
Why IGBT?
Problems in 2D

• Do we know the real geometry of the tumor?
• Do the point bladder and rectal dose points reflect the whole situation? Concern over normal organ toxicity
• Possible complication unknown for orthogonal films based
  – Uterine perforation
• Can we do better to improve disease outcome especially for more advanced stages/bulky tumors?
Potential benefits of image guidance (IGBT)

• 1. Verification of applicator position
• 2. Accurate delineation of OAR doses
• 3. Conformation of dose distribution
• 4. Dose escalation
• 5. Improve clinical outcome

Tan et al  RCR guidelines 2008
1. Verification of applicator position

- Uterine perforation
## 2. Accurate delineation of OAR dose

Is ICRU accurate?

<table>
<thead>
<tr>
<th>Author</th>
<th>Bladder ICRU vs. D2cc</th>
<th>Rectal ICRU vs. D2cc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wachter Gerstner et. al (2003)</td>
<td>ICRU underestimates dose (wrong balloon position)</td>
<td>ICRU overestimates (mean ratio 1.5)</td>
</tr>
<tr>
<td>Pelloski et. al (Red 2005)</td>
<td>ICRU underestimates dose (mean difference 6.8 Gy)</td>
<td>ICRU good estimate (mean 21cGy difference)</td>
</tr>
<tr>
<td>Yaparpalvi et. al (200)</td>
<td>Poor correlation</td>
<td>Strong correlation</td>
</tr>
</tbody>
</table>
3. Dose conformity – reduce dose to normal organs; improve tumor dose
4. Dose escalation can improve tumor control

- Dimopoulos et al. (Red 2009)
- 141 cervix cancer patients with chemoradiation
- HRCTV D90 > 87Gy resulted in much improved local control (LC 4% vs 20%)
Vienna series: MRI planning improved survival and local control in tumors > 5cm

Cancer Specific Survival

Local control

Potter et al R&O 2007
Favorable outcome with IGBT

<table>
<thead>
<tr>
<th>Location/Study</th>
<th>Local control</th>
<th>Survival</th>
<th>G3+ Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2D</td>
<td>3D</td>
<td>2D</td>
</tr>
<tr>
<td>Vienna (Potter et. al)</td>
<td>70%</td>
<td>95%</td>
<td>-</td>
</tr>
<tr>
<td>Denmark (Lindegaard et. al)</td>
<td>-</td>
<td>91% (3 yr)</td>
<td>63%</td>
</tr>
<tr>
<td>Addenbrooke (Tan et. al)</td>
<td>76%</td>
<td>96%</td>
<td>67%</td>
</tr>
<tr>
<td>France STIC trial (Charra-Brunaud et. al)</td>
<td>-</td>
<td>-</td>
<td>74%</td>
</tr>
</tbody>
</table>

P<0.05*
Guidelines for image guided brachytherapy

European GEC-ESTRO 2005-06

UK – RCR guidelines 2008


Implementing image-guided brachytherapy for cervix cancer in the UK
Our progress
Development needs collaborative efforts

- Oncologists
  - Within department
    - Radiation therapist
    - Physicist
    - Nurses
- Radiology (MRI)
- Anesthesiology (sedation method: spinal vs GA)
- Gynecology (guidance of applicator insertion)
Points to consider

- Imaging CT or MRI
- Dose/fractionation schedule
- Anesthesia (GA, spinal, sedation)
- Patient care (pain, inpatient)
Our Treatment schedule

WPI = whole pelvic irradiation
API = additional paramettrial irradiation
HDR = high dose rate brachytherapy

Week 5 MRI

Week 6 MRI

Week 7 MRI

Week 1-5

Week 6-7

Week 6 (fraction 1,2)
Week 7 (fraction 3,4)
Treatment schedule

- **Whole pelvic irradiation (WPI):** week 1-5 (45Gy)
- **Additional parametrial irradiation (API):** week 6-7 (10-16Gy; intercalate with HDR)
- **HDR brachytherapy:** week 6 (Day 1-2, 2 fractions); week 7 (Days 1-2, 2 fractions)
- **MRI arrangements:**
  - Week 5 (pre-planning before brachytherapy)
  - Week 6 (applierator in-situ)
  - Week 7 (applierator in-situ)
Week 5 pre-planning MRI is important

• Arrow images made by radiologist to delineate tumor, good reference for weeks 6 and 7
• Crucial information to plan for type of applicator (tube + ovoid vs. tube + tandem; size, angulation)
• Guide for interstitial needle insertion
Week 5 preplanning workflow

- Week 5 scan obtained
- Oncologist contour HRCTV
- Oncologist decides size of tube and ovoid for virtual planning
- Physicist uploads week 5 image with contour to Oncentra
- Create virtual applicator and isodose
- Review suboptimal dose coverage and decide needle position and depth
Workflow (Day 0)

- Admit patient one day before procedure (Day 0 - Monday)
- Anesthesiologist assessment
- HDR brachytherapy on Day 1 and 2 (Tues, Wed)
- Patient stay overnight after applicator insertion
Workflow (Day 1)

Applicator insertion at main theatre

To MRI scanning (radiology)

*bladder control 30ml NS by ward nurse*

To CT scanning (ONC)

*crossed out: bladder control by ward nurse*

Patient waits at day treatment centre (ONC)

*Clinic nurse monitoring*

Brachytherapy suite for treatment (ONC)

*bladder control by clinic nurse*
Equipments
Utrecht applicators
EUA
Gynecology and ultrasound assessment
Ultrasound assessment
Immobilization
Workflow Day 1 (treatment planning)

- MRI planning
- Contour targets and OAR
- Applicator reconstruction
- Dose optimization
- Review DVH, plan approval and prescription
Contouring (MRI)
Day 2

ward to CT simulator

Treatment planning

Patient waiting for day treatment center

*Clinic nurse monitoring*

To brachytherapy suite

*Bladder volume control by clinic nurse*

Remove applicator, discharge same day
Treatment planning Day 2
CT simulation, fuse with day 1 MRI
Contouring on CT
PYNEH experience – our initial results
Our patients

• First IGBT case on 20 Jan 2015
• 16 patients completed treatment
• 14 out of 16 patients (88%) completed all 4 fractions of HDR brachytherapy
  – One omitted fraction 4 for exceeding tolerance dose to normal organs
  – 2 omitted fraction 3 and 4 (replace with IMRT boosting) due to extensive disease (stage IIIB and IVA)
Tumor characteristics

FIGO staging

Histology

- adenocarcinoma: 69%
- squamous cell carcinoma: 19%
- others: 12%
Response to chemoradiation

**Clinical response (average size)**

- **Baseline**: 4.93 cm
- **Week 6**: 2.72 cm (-45%)
- **Week 7**: 2 cm (-26%)

**MRI response (average 3 dimension volume)**

- **Baseline**: 117 cm³
- **Week 5**: 31 cm³ (-74%)
- **Week 6**: 23 cm³ (-26%)
- **Week 7**: 20 cm³ (-14%)
Outcome

• 14 out of 16 patients (88%) are disease-free
  – Average HRCTV volume (per fraction) 29.6cm³
  – Average HRCTV D90 96.1Gy (range 84-113)
  – Exception: 2 patients received IMRT boosting for IVA and IIIB disease (66.6Gy total)

• 2 patients suffered from local and distant relapse

<table>
<thead>
<tr>
<th>Patient</th>
<th>FIGO stage</th>
<th>HRCTV volume</th>
<th>HRCTV D90 dose</th>
<th>Time of relapse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IIB</td>
<td>50cm³</td>
<td>63.3Gy</td>
<td>7 months post RT</td>
</tr>
<tr>
<td>2</td>
<td>IIIB</td>
<td>87cm³</td>
<td>58.5Gy</td>
<td>6 months post RT</td>
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</table>
Case 1 FIGO IIB with good response
Brachytherapy dose
<table>
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<th>#2</th>
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<th>#4</th>
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<tbody>
<tr>
<td>Point A</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>HRCTV D90</td>
<td>10.5</td>
<td>10.6</td>
<td>9.2</td>
<td>9.2</td>
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</table>
Case 2 FIGO IIB good response

Baseline

Week 5
Week 5 pre-planning
Good 100% dose coverage
D90 HRCTV 8Gy
Brachytherapy dose
<table>
<thead>
<tr>
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<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
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</thead>
<tbody>
<tr>
<td>Point A</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>HRCTV D90</td>
<td>8.5</td>
<td>8.6</td>
<td>8.2</td>
<td>8.2</td>
</tr>
</tbody>
</table>
Case 3 - FIGO IIB poor response

Baseline

Week 5
Brachytherapy dose – week 6 (cylinder)
Case 4 FIGO IIB, dose optimization for OAR tolerance
Dose optimization to reduce dose to bladder and sigmoid
<table>
<thead>
<tr>
<th></th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>#4</th>
<th>Total (Gy)</th>
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<tbody>
<tr>
<td>HRCTV D90</td>
<td>9.4</td>
<td>9.2</td>
<td>11.1</td>
<td>11.2</td>
<td>113</td>
</tr>
<tr>
<td>Bladder</td>
<td>5.3</td>
<td>6.0</td>
<td>6.3</td>
<td>6.2</td>
<td>86</td>
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<tr>
<td>Sigmoid</td>
<td>5.3</td>
<td>3.7</td>
<td>5.2</td>
<td>4.7</td>
<td>73</td>
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</tbody>
</table>
Case 5 FIGO IIB for interstitial needle insertion

Baseline

Week 5
Without needle

HRCTV D90 4.5Gy
With needle insertion

HRCTV D90 7.8Gy
Future directions

• Acquire skills for transrectal ultrasound-guided applicator and needle insertion
• Implement needle case with Vienna ring
• Develop post radiotherapy follow up protocol – serial MRI assessment and review need of biopsy
Thank you for the efforts!