

ART for Cervical Cancer: Dosimetry and Technical Aspects

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Background – EBRT+CT





Increased progression-free survival. Reduced local and distant recurrence.

> Acute toxicity increased. Late toxicities?

> > Green, et al., Cochrane Review 2005:CD002225 Kirwan, et al., Radiotherapy & Oncology 2003;68:217-226

Background - IMRT



Four-Field Box

IMRT

MR-based Motion Assessment in Ca Cervix

- Inter- and Intrafractional Movement of the Uterus and Cervix in Patients with Cervix Cancer Receiving Radiotherapy: An MRI-Based Point-of-Interest (POI) Analysis
- Patients treated with radical chemo-radiotherapy imaged with serial Cine-MRI scans



Background – Morphological Changes over Tx





38 Gy







Combined Motion and Response



7 July







Challenges in IMRT for Cervix Cancer

Target Identification

- MR vs CT
- Nodal targets
- Online image quality

Organ motion

- Influence of
 - Bladder filling
 - Rectal filling
 - Normal uterus position















Aim

Use weekly imaging feedback to dosimetrically and volumetrically monitor treatment progress and adapt to ensure clinical goals are met.

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	Jul 1	2	3
			Plan A			
4	5	6	7	8	9	10
	MRI		Pla	n A		
11	12	13	14	15	16	17
	MRI		Pla	n B		
18	19	20	21	22	23	24
	MRI		Pla	n B		
25	26	27	28	29	30	31
	MRI		Pla	n B		

Aim

Use weekly imaging feedback to **dosimetrically** and volumetrically monitor treatment progress and adapt to ensure clinical goals are met.



Aim

Use weekly imaging feedback to dosimetrically and **volumetrically** monitor treatment progress and adapt to ensure clinical goals are met.



Methods

- 33 patients with stage IB-IVA cervix cancer
- Target volumes (GTV and CTV) and OARs (rectum, sigmoid, bladder, and bowel) contoured on fused MR-CT baseline image and subsequent weekly MR scans
- Primary CTV (pCTV) defined as union of:
 - GTV
 - Cervix
 - Parametria
 - 2 cm of uterus superior to GTV
 - 2 cm of upper vagina inferior to GTV



Methods – Deformable Registration



Brock, et al., Medical Physics 2005;32:1647-1659.

Methods – Dose Accumulation / ORBIT

Planned Dose



Apply planned dose at each fraction



Deform each fraction to planning geometry



Accumulate across all fractions

Accumulated Dose

Methods - ORBIT



Accumulated (where the dose was actually delivered)

Difference Did we miss the target? Were OARs compromised?

Planning Scenarios

IMRT w/ 3mm PTV margin Criteria:

- D98% GTV > 50 Gy
- D98% CTV > 49 Gy
- D98% PTV > 47.5 Gy



Initiate replan if weekly dose accumulation triggers one of the following:

1) D98% GTV < 49 Gy or D98% CTV < 47.5 Gy



2) CTV volume drops 100 cm^3

(1) Planned (2) No Replan (3) Assess Weekly





Planned

Week 2 – without Re-plan

Results – Example of Improved Target Coverage



Dose to	98%	Volum	he (Gy)	
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		Delivered		
	Planned	No Replan	Weekly Replan	
GTV	50.1	47.4	50.2	
CTV	49.1	46.5	49.1	





Planned



Week 4 / No Replan

Week 4 / Replan to reduce dose to OARs

Results – Target Coverage



Results – Replanning Workload vs Week



Results – Distribution of Triggered Plans



Limitations of the Study

- MRI scans obtained each week expanded to represent each fraction
 - For example, scan 1 at fraction 1 assumed to be representative of fractions 1-5
- Perfect bone-bone matching assumed at each fraction
- Deformable registration algorithm MORFEUS currently undergoing accuracy validation for cervix (validated in lung, prostate and liver)

Summary of Adaptive Planning Study

- A 3 mm PTV margin for cervix cancer is valid for a subset of patient (76%), but we don't know who they are until we have imaged them for ~2 weeks.
- Opportunity to reduce dose to normal tissues with this strategy while assuring target coverage.
- Dosimetric triggers of target coverage do not maximize the normal tissue dose reduction.

The Princess MRgRT Facility



Tri-use Facility based on a single 1.5T magnet and state-of-the-art delivery

MRgRT Pelvis Configuration





MRgRT Pelvis Coil: Volunteer Images



1.5 T, T2 weighted images of two volunteers.

MRgRT Pelvis Coil: Volunteer Images



1.5 T, T2 weighted images of two volunteers.

MRgRT External Beam Workflow



IGRT-guided pre-localization of MR Imaging FOV

Confirmation of delivery viability

Reference CBCT for MRguidance Robotic control of MR, table and Shielding System

Linear motion of magnet over patient.

RT present for movement.

Pre-stored MR configuration from MR-simulation Stage Critical time specification (<90s) from end of imaging to beam-on.

Image processing (distortion correction, calibration) and planning (adaptation).

Generation of couch or machine adjustment.

*MR can begin image within 5s of stopping.

Summary

- Developed an experience in the use of MR for adaptive RT of the cervix using retrospective analysis.
- Anticipate significant advantages wrt normal tissue dose reduction with reasonable workload using weekly MR imaging.
- Building a system that will enable state-of-theart MR imaging for adaptation.
- Exciting prospect for adaptive workflows that will assure coverage and reduce normal tissue dose.