Rectal Volume Analysis in Prostate Radiation Therapy: Volumetric or Orthogonal Image Guided Radiation Therapy

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Introduction

• Dose escalation in prostate cancer (Guckenberger et al. 2010)

• Role of Intensity Modulated Radiation Therapy (IMRT) (Bauman et al. 2012)

• Image Guided Radiation Therapy (IGRT)
  – Accuracy of treatment delivery (Zelefsky et al. 2012; Chung et al. 2004)

• Achieve consistent volumes for Organs at Risk between Planning and Treatment
  – Bladder & Rectal Preparation
Introduction

• Cone Beam CT (CBCT) as a volumetric image can be considered as the gold standard

• This study assess the efficacy of employing daily orthogonal 2D/2D imaging to replace CBCT for rectal filling analysis

• Measurements of rectal size
  – CBCT Vs. Orthogonal 2D/2D images

• To inform our clinical IGRT practice
Background

At Epworth Radiation Oncology, Prostate Cancer Radiation Therapy:

- 7-field IMRT
- Bladder and Bowel Prep
- Daily Online IGRT (0mm action level)
IGRT Protocol

Prostate / Prostate-bed IMRT

Week 1

Day 1: CBCT, kV/MV  
Day 2: CBCT, kV/MV  
Day 3: CBCT, kV/MV  
Day 4: kV/MV  
Day 5: kV/MV

Week 2, 3, etc..

Day 1: kV/MV  
Day 2: kV/MV  
Day 3: CBCT  
Day 4: kV/MV  
Day 5: kV/MV
IGRT Protocol

Week 1

Week 2, 3, etc.

Prostate / Prostate - bed IMRT

Day 1

Day 2

Day 3

Day 4

Day 5
IGRT Protocol

Prostate / Prostate-bed IMRT

- Week 1
  - Day 1: CBCT (kV/MV)
  - Day 2: CBCT (kV/MV)
  - Day 3: CBCT (kV/MV)
  - Day 4: kV/MV
  - Day 5: kV/MV

- Week 2, 3, etc..
  - Day 1: kV/MV
  - Day 2: kV/MV
  - Day 3: CBCT
  - Day 4: kV/MV
  - Day 5: kV/MV
IGRT Protocol
Aim

Investigate the reliability of rectal size measurements from 2D/2D orthogonal images in comparison with CBCT
Method

- **Investigator 1**

  [Diagram showing CBCT and kV/MV on Days 1-5 for Week 1 and Week 2, 3, etc.]

- **Investigator 2**

  [Diagram showing kV/MV on Days 1-5 for Week 1 and Week 2, 3, etc.]
Method

• Investigator 1

<table>
<thead>
<tr>
<th>Patient 1</th>
<th>Week 1</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CBCT</td>
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<td>kV/MV</td>
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<table>
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<th>Week 2, 3, etc..</th>
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Method

- **Investigator 1**

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</tbody>
</table>
Method

• Investigator 1
Method

- Investigator 1

Gas
Mostly Gas
Gas/Solid
Mostly Solid
Solid
Method

- Investigator 1
  
- Investigator 2
Results

• 53 patients
  – >40 years old
  – IMRT to prostate or prostate bed
  – Treated between Aug 2012 – Jan 2013

• 242 images
  – 82 CBCT datasets
  – 78 AP projection images
  – 82 Lateral projection images
CBCT Vs. AP MV Width Comparison

CBCT Width (cm) vs. MV Width (cm) graph showing a scatter plot with a line of equality.
CBCT Vs. AP MV Width Comparison

Epworth HealthCare
CBCT Vs. AP MV Width Comparison

- CBCT Width (cm)
- MV Width (cm)
- Gas
- Mostly Gas
- gas/solid
- mostly solid
- solid
- line of equality

Epworth HealthCare
CBCT Vs. AP MV Width Comparison

CBCT Width (cm)

MV Width (cm)

- Gas
- Mostly Gas
- gas/solid
- mostly solid
- solid
- line of equality

Epworth HealthCare
CBCT Vs. Lateral kV Depth Comparison

CBCT Depth (cm) vs. kV Depth (cm) graph with a red line of equality.
Bland-Altman Plot for the two Width Measurement Methods

Width Difference (cm) vs. Average Width (cm)

UL ba: 1.84
LL ba: -1.14

Epworth HealthCare
Bland-Altman Plot for the two Width Measurement Methods

- Width Difference (cm)
- Average Width (cm)

- Gas
- Mostly Gas
- Gas/solid
- Mostly solid
- Solid
- UL ba
- LL ba

Epworth HealthCare
Bland-Altman Plot for the two width Measurement Methods - Gas

Width Difference (cm)

Average Width (cm)

Epworth HealthCare
Bland-Altman Plot for the two width Measurement Methods - Gas/Solid

- Average Width (cm)
- Width Difference (cm)

Epworth HealthCare
Bland-Altman Plot for the two width Measurement Methods - Solid

1.00
2.00
3.00
4.00

Gas
Mostly Gas
gas/solid
mostly solid
solid
UL ba
LL ba

Epworth HealthCare
Bland-Altman Plot for the two Depth Measurement Methods

Depth Difference (cm)

Average Depth (cm)

UL ba
1.99

LL ba
-1.38
Bland-Altman Plot for the two Depth Measurement Methods

Depth Difference (cm)

Average Depth (cm)

Gas
Mostly Gas
gas/solid
mostly solid
solid
UL ba
LL ba

Epworth HealthCare
Bland-Altman Plot for the two Depth Measurement Methods

- Gas

**Depth Difference (cm)**

**Average Depth (cm)**

- **Gas**
- **Mostly Gas**
- **gas/solid**
- **mostly solid**
- **solid**

UL ba: 0.63
LL ba: -0.49
Bland-Altman Plot for the two Depth Measurement Methods
- Gas/Solid

Depth Difference (cm)

Average Depth (cm)

Gas
Mostly Gas
gas/solid
mostly solid
solid
UL ba
LL ba

Epworth HealthCare
Bland-Altman Plot for the two Depth Measurement Methods

- Solid

Depth Difference (cm)

Average Depth (cm)

- Gas
- Mostly Gas
- gas/solid
- mostly solid
- solid
- UL ba
- LL ba

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Discussion

Outliers – Gas/Solid
Discussion
Outliers – Solid
Discussion

• Data “indicates” a higher level of agreement for certain rectal composition types

• Limitations of sample size
  – 250 patients (50 per fill type group) to be accrued to establish confidence in estimated trend
Discussion

Categorisation of Rectal Fill Type

- Gas
- Mostly Gas
- Gas/Solid
- Mostly Solid
- Solid

Rectal Area ( -1000 ≤ HU < -800)

\[
\text{Rectal Area ( Total)} \leq 0.5 < 0.9
\]

then “Mostly Solid”
Discussion

CBCT is our imaging modality of choice to assess rectal volume

- Higher Radiation exposure  (Walter et al. 2007)
- Difficult to model absorbed dose to treatment plan  (Gayou et al. 2007)
- ?? Move to daily CBCT for Prostate IMRT IGRT protocol
Conclusion

• Analysed CBCT Vs. Orthogonal 2D/2D imaging for rectal size measurements
• Data “suggests” decreasing reliability with 2D imaging -> solid
• 250 patients (50 per fill type group) to be accrued to establish confidence in estimated trend
• Continue research – will consider CBCT daily
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References


