Physics Presentation: Spherical Applicators for Non-breast Applications

Physics Aspects of Body IORT

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Cancer Treatment Centers of America®, Arizona
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Cancer Treatment Centers of America®

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Simon Lam, Matthew West, Yang Xu
Presented by: Simon C. P. Lam, MSEE, DABR, DABMP
Biophysics Research and Development
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## Physics Aspects of body IORT:

### Procedures 2013 to 2015

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Physics Aspects of body IORT:

Invasive ductal carcinoma of the left breast metastases to left upper rectus muscle

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First Non-lumpectomy IORT using Spherical Applicator on Rectus Muscle

This sparked the question of Dosimetry
Physics Aspects of body IORT:

The question of Dosimetry

Dosimetry for treatment given based on full scatter condition: 20 Gy to surface of a 3.5 cm with compression on the soft tissue tumor bed.

What happens to the dosimetry of the spherical applicator when it is not fully surrounded by tissue?

Courtesy of INTRABEAM Product Specification
Treatment Given

Dosimetry Confirmation:

Assumption: compression into the soft tissue, indenting the tissue to 5 mm depth from the tip of the applicator
Physics Aspects of body IORT: non-breast IORT application of the INTRABEAM®

The question of Dosimetry

- Lack of Scatter

Measurement:
- Scatter Factor due to amount of scatter medium covering the spherical applicator
- PDD difference between full scatter versus 5 mm scatter
Lack of Scatter Study: Dosimetry to Surface

Dose Rate Changes
As water level is lowered covering the sphere:
- Fully covered
- ¼ from the top
- ½ from the top
- ¾ from the top
- 0.5 cm to the tip
- @ the tip
- 0.5, 1.0, 1.5, 2.5, 3.5 cm below the tip

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Scatter Factor = $\frac{D_{R_d}}{D_{R_{Full}}}$

<table>
<thead>
<tr>
<th>Dose Rate Ratio lower level/full</th>
<th>Average</th>
<th>Water Level</th>
<th>Full scatter</th>
<th>Top of Sphere</th>
<th>Middle</th>
<th>5 mm from Tip</th>
<th>Tip</th>
<th>&gt;1 cm from Tip</th>
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Lack of Scatter Study:
Dose to Surface of Applicator

Cross-over WL @ mid-level

- 3 cm Sphere
- 3.5 cm Sphere
- 4 cm Sphere
- 5 cm Sphere
- Average

3.5 cm Sphere has unique shape

Scatter Factor
\[ \frac{DR_d}{DR_{Full}} \]
Lack of Scatter Study: Percentage Depth Dose

0.5 cm immersion has higher PDD from 5 mm to 4 cm at an average of 11%.
Physics Aspects of body IORT: The question of Dosimetry

Isodose distribution of the spherical applicator when it is fully immersed in water.

Courtesy of INTRABEAM® Product Specification
Physics Aspects of body IORT:

The question of Dosimetry

There is a lack of scatter which affects the dose delivered

Courtesy of INTRABEAM® Product Specification
Take Home Findings:

Dosimetry:
Dose: ~ 4.5% less than 20 Gy at surface
~ 19.1 Gy
Depth Dose from 5 mm to 40 mm:
  significantly: 11% increase in pdd

Dose Pattern:
  Fan shape semi-circular dose distribution
Physics Aspects of body IORT:

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9/12/15 CT: 2 years Post IORT
Stable examination demonstrating no evidence for local regional or distant metastatic involvement.
# Physics Aspects of body IORT:

**IORT to recurrent gastrointestinal iliac adenopathy surgical bed**

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Decision to use the Spherical Applicator

There was a need to irradiate:
Tumor bed and soft tissue around the aorta and left iliac artery

Necessary Consideration:
1. Bowel/Lt. ureter Protection
2. Radiation dosimetry
Procedural considerations

Protection of bowel

- Previous study on transmission:
  Blue lead rubber shield: < 6.3%
- Previous study of radiation exposure in air:
  at 3 cm in air from the surface
  Exposure is at about 20% of surface dose
- Shielding + distance would reduce dose to 1.2%
Procedural considerations

Decision: Distance/Shielding/Treat

- It is reasonable to pack away the bowel/ureter to >3 cm and shield them with a cylinder of blue rubber shield enclosed in sterile plastic sleeve
- Additional shield on the upper third of the spherical applicator to reduce exposure
RC Treatment setup
Rubber shield

Treatment setup
Have we made the right decision?

Concerns:

- Did we have enough shielding
- Verify our studies
Have we made the right decision?
Have we made the right decision?
Lamp Shade Shield: an alternative

➢ Exposure Pattern Study

Film Jig in water
Dosimetry Investigation

Shielding Study

Blue Shield Attenuation

Relative Depth Dose with and without shield
Dosimetry Investigation

Air space exposure (fraction of surface Dose)

At 3 cm all Dose Rate is About 20% of Surface Dose

3 cm space

Distance (mm) from surface of Applicator
Physics Aspects of body IORT:

We have enough Protection

- Blue rubber shield transmission: < 7% transmission
- Air Space: 20% exposure with > 3cm air space
- Total Protection <1.5% of target dose
Physics Aspects of body IORT:

IORT to recurrent gastrointestinal iliac lymph node surgical bed

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11/17/14 Pet-CT: 10 months post IORT
No current PET-CT evidence for residual local disease or metastatic involvement.

10/7/15 CT Abdomen & Pelvis: 22 months post IORT:
Stable appearing retro-crural and retroperitoneal lymph nodes. No new enlarged lymphadenopathy.
Physics Aspects of body IORT:

SCC Cervix left pelvic side wall

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10/7/15: 11 month Post IORT: Successful placement of bilateral percutaneous nephrostomy tubes

10/13/15: 11 month Post IORT: Fluoroscopic assistance for stent placement in the sigmoid colon.
Physics Aspects of body IORT:

Recurrent SCC Cervix left pelvic side wall

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6/15/15 : 2 months post IORT x-ray abdomen no evidence of disease
Physics Aspects of body IORT:

Sigmoidal colon Carcinoma; right lateral pelvic side wall

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10/17/15: 5 months Post IORT: Obstructed left ureter. New nephrostomy tube placed under fluoroscopic guidance.

11/19/15: 6 month Post IORT: Abdomen CT: Near complete interval resolution of anterior abdominal abscess with indwelling pigtail catheter. Satisfactory position of left percutaneous nephrostomy tube without evidence of hydronephrosis.
**Physics Aspects of body IORT:**
non-breast IORT application of the INTRABEAM®

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First time using the surface applicator.

Concern: the probability of Grade 3 end pain and fracture of the ribs.
Physics Aspects of body IORT: non-breast IORT application of the INTRABEAM®

Concern: the probability of Grade 3 end pain and fracture of the ribs.

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Courtesy of Carlos I. Alejandro of GMV Radiance IORT Simulation
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10/15/15: 5 months post IORT:

No evidence of Grade 3 pain or fracture of the ribs.

Patient developed small occipital metastases.

Received 18 Gy SRS
Physics Aspects of body IORT:
Locally invasive rectal adenocarcinoma

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1/4/16: 2 month Post IORT:
Continuing Chemotherapy
No evidence of local disease
Conclusion: We used both the spherical applicator and the flat applicator for IORT out the breast.

Dosimetry:
Dose: \(~ 4.5\% \text{ less than } 20 \text{ Gy} = 19.1 \text{ Gy}\)
Depth Dose from 5 mm to 40 mm:
\(11\% \text{ increase in pdd}\)

Dose Pattern:
Fan shape semi-circular dose distribution

Organ Protection:
Sufficient: < 7\% transmission with > 3cm air space
\(= <1.0\% \text{ of target dose}\)
Precautions: using the spherical applicator to treat flat surface lesion

Normal Tissue Protection:
Provide adequate distance and shielding

Dosimetry:
Surface Dose Reduction: \( \sim 4.5\% \) less than full scatter
Increased Depth Dose from 5 mm to 40 mm:
11\% increase in PDD

Dose Pattern:
Fan shape circular dose distribution:
covers volume larger than the forward projecting cones of the same size
Thank You!

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