Good afternoon and thank you for the opportunity to share with you at this year’s meeting

I would like to Thank Christopher J Moore for sharing about his personal experience receiving RT

I appreciate how he sought out specific professionals based upon the care he needed. From the surgeon who saved his leg from possible amputation because of his expertise. To selecting the RT center with the better equipment.

And the wisdom to not make tweaks to his own plan that he knew were insignificant
I have no disclosures with this presentation

Today I’d like to invite you into the Miami Cancer Institute to explain our concept of **Multi-Technology RT**

MTRT is the use of any and all RT delivery systems to provide a tailored course of treatment using the techniques best suited for the individual patient’s needs.

This can be from…

- Tumor size and location
- Fractionation schema based on pathology
- Underlying conditions such as ability to hold breath or not move
- Prior treatments or other health conditions
- Severe claustrophobia
Personal Message

The important thing here is…
Whichever equipment you have, I’m sure you are doing your best to get the most out of it’s benefits
This is Good!!!

This presentation touches the adage that when you only have a hammer everything looks, and possibly get’s treated, like a nail

Miami Cancer Institute

An entire “tool box” to skillfully use according to their unique properties.
Our goal is customized delivery for each patient’s unique circumstances

Varian® True Beam™
CyberKnife® M6™
Radixact™
Gamma Knife® Icon™
Viewray® MRIdian™
Linac
Brachytherapy & HDR
Proton Therapy - PBS
MCI RadOnc Leadership

Minesh Mehta, MD
Alonso Gutierrez, PhD, MBA

Miami Cancer Institute

Miami metro area, gateway to Central and South America And beyond

Baptist Health South Florida (Non-profit) (Faith based)

Physics/Dosimetry Team
Easy transportation between rooms

Photon Hallway

Miami Cancer Institute

- MCI is one of only a few cancer treatment centers in the world to provide every available radiation therapy technology in one location. Dedicated to using all technologies to the fullest extent in compliment with one another.
Miami Cancer Institute

- Multidisciplinary patient care, Cutting-edge technology and Innovative cancer treatments
- Genomic Medicine Laboratory complimenting: diagnosis, uniquely customized targeted therapy, clinical trials and research
- Dedicated Pediatric support services with a Children’s Infusionarium designed by an Imagineer
- International outreach for clinical education and collaboration
- Alliance with Memorial Sloan Kettering
- Gourmet teaching kitchen
- Meditative Gardens and Massage Therapy for patients

Unique Opportunity

We believe we may be the only center to have the complete freedom to use any and all technologies, not only to compare in a moments notice but the ability to also select and delivery on multiple units depending on the best solution for the patient. Not only about isodose lines.

Multi-Technology RT approach for the best “lifespan results”!

*Long (and short) term side effects
Pillars of RT Planning

Target Coverage
The reason for RT

Target

OAR

OAR

Pillars of RT Planning

Target Coverage
The reason for RT

Target

OAR

OAR

OAR

OAR protection
“Do no harm”
Pillars of RT Planning

Target Coverage
The reason for RT

OAR

Dose Homogeneity
*except for Stereotactic RT

Target

OAR

OAR protection
“Do no harm”

Pillars of RT Planning

Target Coverage
The reason for RT

OAR

Dose Homogeneity
*except for Stereotactic RT

Target

OAR

Dose conformity
ALARA, Integral dose

OAR protection
“Do no harm”
Therapeutic Index

- Methods to modulate TI:
  - Radiosensitizers/Radioprotectors
  - Fractionation
  - Dose rate
  - Technology

The maximum radiation dose by which death of cancer cells is locally controlled and the minimum radiation dose by which cells in normal tissues have low acute and late morbidity (Thoms J, Bristow RG)

Ratio: Effective dose to Toxic dose
Integral Dose = the mean dose times the volume

Long term side effects carried for a Lifetime

Most of the physicians we work with want to see the dose conforming around the target, especially when abutting a critical structure with dose limits that are lower than the targeted Rx dose
Plan specific dose distributions

<table>
<thead>
<tr>
<th>4 Field Box</th>
<th>VMAT, yet dose bath</th>
<th>Protons, integral dose</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

But which is better?

Fastest treatment because patient cannot hold still…3D (shortest beam-on times)
Conformal tissue sparing for a 70yo…VMAT or Proton
Lowest Integral dose for a 40yo…Proton

Plan specific dose distributions

<table>
<thead>
<tr>
<th>4 Field Box</th>
<th>VMAT, yet dose bath</th>
<th>Protons, integral dose</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>

If your only criteria is high to intermediate conformal doses which would you choose?

Which is the best backup when the primary machine needs maintenance?
# MCI – RT Technology

![MCI – RT Technology images]

## First Impressions...

<table>
<thead>
<tr>
<th>Radiation type</th>
<th>TrueBeam Linac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple MVs</td>
<td>MVCT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Isocenter</th>
<th>Tomo CyberKnife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isocentric</td>
<td>6MV 6MV Co-60</td>
</tr>
<tr>
<td>Non-isocentric</td>
<td>Gamma Knife</td>
</tr>
<tr>
<td>Isocentric</td>
<td>Isocentric</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IGRT: Inter-fraction</th>
<th>Gamma Knife</th>
</tr>
</thead>
<tbody>
<tr>
<td>KV-CBCT, MV/MV/SIG</td>
<td>Stereoscopic</td>
</tr>
<tr>
<td>KV/CBCT</td>
<td>MVCT</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ideal clinical indications</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Universal</td>
<td>Universal, lower integral dose, pediatrics, re-irradiation</td>
</tr>
<tr>
<td>H&amp;N, Comp. Breast, Long Tx Fields, Junction fields</td>
<td>Diaphragmatic motion, adaptive capability</td>
</tr>
<tr>
<td>Motion tracking, non-coplanar delivery</td>
<td>Infrared Marker Planar Cine MR SIG</td>
</tr>
</tbody>
</table>
TrueBeam Varian
3 Linear Accelerators (one HD120)

- Linear Accelerator (6X, 10X, 15X and electrons)
- Millenium MLC 120 leaves (central 20cm FS with 5mm and peripheral with 10mm)
- 40 X 40 field size
- HD MLC 120 leaves (central 8cm FS with 2.5mm and peripheral with 5mm)
- 34 X 22 max FS
- IGRT:
  - CBCT
  - Vision RT (SGRT)
- High Doserate Output (MU/min) for TBI, TBE, Grid Therapy (.decimal), etc.

TPS: Eclipse and RayStation

Multifunctional, sufficient and efficient for most cases
Relatively quick treatment for high throughput
3D, IMRT, VMAT, SBRT

First Impressions...

<table>
<thead>
<tr>
<th>TrueBeam Linac</th>
<th>Tomo</th>
<th>CyberKnife</th>
<th>Gamma Knife</th>
<th>MR Linac</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation type</td>
<td>Multiple MVs</td>
<td>6MV</td>
<td>6MV</td>
<td>Co-60</td>
<td>6MV</td>
</tr>
<tr>
<td>Isocenter</td>
<td>Isocentric</td>
<td>Non-isocentric</td>
<td>Non-isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
</tr>
<tr>
<td>IGRT: Inter-fraction</td>
<td>kV-CBCT, kV/kV, MV/MV, SIG, Calypso</td>
<td>MVCT</td>
<td>Stereoscopic kV/kV</td>
<td>kV-CBCT</td>
<td>MR</td>
</tr>
<tr>
<td>IGRT: Intra-fraction</td>
<td>kV triggered imaging, Calypso, SIG</td>
<td>Surface Image Guidance</td>
<td>Cine kV</td>
<td>Infrared Marker</td>
<td>Planar Cine MR</td>
</tr>
<tr>
<td>Ideal clinical indications</td>
<td>Universal</td>
<td>H&amp;N, Comp. Breast, Long Tx Fields, Junction fields</td>
<td>Motion tracking, non-coplanar delivery</td>
<td>Cranial Stereo.</td>
<td>Diaphragmatic motion, adaptive capability</td>
</tr>
</tbody>
</table>
TomoTherapy Radixact Helical Linac

- Linac based helical delivery system (6X)
- MLC 64 Binary, 6mm width
- Jaws settings 1cm, 2.5cm, 5cm
- No collimator rotation
- All axial-helical delivery (co-planar)
- 85cm bore
- Couch lateral shift and roll
- MVCT (artifact reduction) 10rpm
- 1000 MU/min dose rate
- Shift from outside lasers to treatment position is 70cm

TPS: Precision and RayStation (MCO)

Larger, longer, more convexed targets especially abutting OARs (H&N, Breast, Pelvis, Spine, Pediatrics)
IMRT, Tomo Direct

First Impressions...

<table>
<thead>
<tr>
<th>TrueBeam Linac</th>
<th>Tomo</th>
<th>CyberKnife</th>
<th>Gamma Knife</th>
<th>MR Linac</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation type</td>
<td>Multiple MVs</td>
<td>6MV</td>
<td>6MV</td>
<td>Co-60</td>
<td>6MV</td>
</tr>
<tr>
<td>Isocenter</td>
<td>Isocentric</td>
<td>Non-isocentric</td>
<td>Non-isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
</tr>
<tr>
<td>IGRT: Inter-fraction</td>
<td>kV-CBCT, kV/kV, MV/MV, SIG, Calypso</td>
<td>MVCT</td>
<td>Stereoscopic kV/kV</td>
<td>kV-CBCT</td>
<td>MR</td>
</tr>
<tr>
<td>IGRT: Intra-fraction</td>
<td>kV triggered imaging, Calypso, SIG</td>
<td>Surface Image Guidance</td>
<td>Cine kV</td>
<td>Infrared Marker</td>
<td>Planar Cine MR</td>
</tr>
<tr>
<td>Ideal clinical indications</td>
<td>Universal</td>
<td>H&amp;N, Comp. Breast, Long Tx Fields, Junction fields</td>
<td>Motion tracking, non-coplanar delivery</td>
<td>Cranial Stereo.</td>
<td>Diaphragmatic motion, adaptive capability</td>
</tr>
</tbody>
</table>
CyberKnife M6
Robotic Linac

- Linac on a Robotic pedestal and Robo-couch (6X)
- Aperture attachment:
  - Cones (12 fixed collimators from 5mm to 60mm)
  - Iris (Double layered offset hexagonal leaves)
  - MLCs (3.85mm at 80cm SAD with 10cm X 11.5cm max FS, Step and Shoot)
- Stereotactic Realtime Image Guidance
- Target tracking
- Non-Isocentric with variable SAD per beam

TPS: Precision
Can be very conformal
SBRT: Intracranial, Spine, Lung
Trackable solid tumors or a surrogate (if you see it, you can track it)
Synchrony tracking

CyberKnife M6 Tracking
CyberKnife M6 Tracking

First Impressions…

<table>
<thead>
<tr>
<th>Radiation type</th>
<th>TrueBeam Linac</th>
<th>Tomo</th>
<th>CyberKnife</th>
<th>Gamma Knife</th>
<th>MR Linac</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isocenter</td>
<td>Multiple MVs</td>
<td>6MV</td>
<td>6MV</td>
<td>Co-60</td>
<td>6MV</td>
<td>Multiple p+ MeVs</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IGRT: Inter-fraction</th>
<th>MVCT</th>
<th>Stereoscopic kV/KV</th>
<th>kV-CBCT</th>
<th>MR</th>
<th>kV-CBCT, kV/kV, SIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isocentric</td>
<td>Non-isocentric</td>
<td>Non-isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IGRT: Intra-fraction</th>
<th>kV triggered imaging, Calypso, SIG</th>
<th>Surface Image Guidance</th>
<th>Cine kV</th>
<th>Infrared Marker</th>
<th>Planar Cine MR</th>
<th>SIG</th>
</tr>
</thead>
</table>

| Ideal clinical indications | Universal | H&N, Comp., Breast, Long Tx Fields, Junction fields | Motion tracking, non-coplanar delivery | Cranial Stereo. | Diaphragmatic motion, adaptive capability | Universal, lower integral dose, pediatrics, re-irradiation |
GammaKnife Icon Radiosurgery

- Radiosurgery delivery system
- 192 Cobalt-60 sources in a circular array to focus the radiation
- Collimator spot sizes are 4mm, 8mm and 16 cm
- Frame-based for single fraction treatment
- Frameless treatment (mask) for fractionated treatment
- CBCT

TPS: GammaPlan
Planned with pre-treatment imaging then evaluated with CBCT to make adjustments to coordinates with Adaptive DoseControl

High precision in the Brain
Smaller targets in the Brain
Very conformal

First Impressions...

<table>
<thead>
<tr>
<th>Radiation type</th>
<th>TrueBeam Linac</th>
<th>Tomo</th>
<th>CyberKnife</th>
<th>MR Linac</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isocenter</td>
<td>Multiple MVs</td>
<td>6MV</td>
<td>6MV</td>
<td>Co-60</td>
<td>6MV</td>
</tr>
<tr>
<td>IGRT: Inter-fraction</td>
<td>KV-CBCT, MV/MV, SIG, Calypso</td>
<td>MVCT</td>
<td>Stereoscopic kV/kV</td>
<td>Co-60</td>
<td>KV-CBCT, kV/kV, SIG</td>
</tr>
<tr>
<td>IGRT: Intra-fraction</td>
<td>kV triggered imaging, Calypso, SIG</td>
<td>Surface Image Guidance</td>
<td>Cine kV</td>
<td>Infrared Marker</td>
<td>Planar Cine MR</td>
</tr>
</tbody>
</table>

Ideal clinical indications
- Universal
- H&N, Comp. Breast, Long Tx Fields, Junction fields
- Motion tracking, non-coplanar delivery
- Cranial Stereot. Diaphragmatic motion, adaptive capability
- Universal, lower integral dose, pediatrics, re-irradiation
MRIdian – MR Linac ViewRay

- This is the Linac based system (6MV FFF)
  - legacy model was Cobalt
- 138 MLCs (5mm at isocenter) double stacked
- 24 X 27 field size
- No collimator rotation
- All co-planar beam arrangement
- Static Step and Shoot
- 90cm SAD

0.35 Tesla MR for IGRT with Gating
Promising pretreatment Adaptive planning
Shift from outside lasers to treatment position is 155cm
Couch has capacity for a +/- 7cm lateral shift

IMRT Lung, Liver, any target with motion or abutting an OAR

MRgRT

- 0.35T MR
- 6MV, FFF linear accelerator
- Adaptive radiotherapy
"Normal Tissue" Gating

<table>
<thead>
<tr>
<th>TrueBeam Linac</th>
<th>Tomo</th>
<th>CyberKnife</th>
<th>Gamma Knife</th>
<th>MR Linac</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation type</td>
<td>Multiple MVs</td>
<td>6MV</td>
<td>6MV</td>
<td>Co-60</td>
<td>6MV</td>
</tr>
<tr>
<td>Isocenter</td>
<td>Isocentric</td>
<td>Non-isocentric</td>
<td>Non-isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
</tr>
<tr>
<td>IGRT: Inter-fraction</td>
<td>kV-CBCT, kV/kV, MV/MV, SIG, Calypso</td>
<td>MVCT</td>
<td>Stereoscopic kV/kV</td>
<td>kV-CBCT</td>
<td>MR</td>
</tr>
<tr>
<td>IGRT: Intra-fraction</td>
<td>kV triggered imaging, Calypso, SIG</td>
<td>Surface Image Guidance</td>
<td>Cine kV</td>
<td>Infrared Marker</td>
<td>Planar Cine MR</td>
</tr>
<tr>
<td>Ideal clinical indications</td>
<td>Universal</td>
<td>H&amp;N, Comp. Breast, Long Tx Fields, Junction fields</td>
<td>Motion tracking, non-coplanar delivery</td>
<td>Cranial Stereo.</td>
<td>Diaphragmatic motion, adaptive capability</td>
</tr>
</tbody>
</table>

First Impressions...

IGRT:
- Inter-fraction: kV-CBCT, kV/kV, MV/MV, SIG, Calypso
- MVCT
- Stereoscopic kV/kV
- kV-CBCT
- MR
- kV-CBCT, kV/kV, SIG

IGRT:
- Intra-fraction: kV triggered imaging, Calypso, SIG
- Surface Image Guidance
- Cine kV
- Infrared Marker
- Planar Cine MR
- SIG

Ideal clinical indications:
- Universal
- H&N, Comp. Breast, Long Tx Fields, Junction fields
- Motion tracking, non-coplanar delivery
- Cranial Stereo.
- Diaphragmatic motion, adaptive capability
- Universal, lower integral dose, pediatrics, re-irradiation
Proton Therapy PBS
IBA - 3 Gantry system

- 3 Beam-matched treatment rooms with identical environments
- PBS
- 6D robotic patient positioning
- IGRT: CBCT
- C-Rad Catalyst and 4D Sentinel (SIGRT)
- Ambient lighting from Philips
- Validating a Script generated Grid and Lattice Therapies

SFUD, IMPT, Hybrid techniques

Ambient Patient Experience
Philips
First Step…

<table>
<thead>
<tr>
<th></th>
<th>TrueBeam Linac</th>
<th>Tomo</th>
<th>CyberKnife</th>
<th>Gamma Knife</th>
<th>MR Linac</th>
<th>Proton - PBS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiation type</td>
<td>Multiple MVs</td>
<td>6MV</td>
<td>6MV</td>
<td>Co-60</td>
<td>6MV</td>
<td>Multiple p+ MeVs</td>
</tr>
<tr>
<td>Isocenter</td>
<td>Isocentric</td>
<td>Non-isocentric</td>
<td>Non-isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
<td>Isocentric</td>
</tr>
<tr>
<td>IGRT: Inter-fraction</td>
<td>kV-CBCT, kV/kV, MV/MV, SIG, Calypso</td>
<td>MVCT</td>
<td>Stereoscopic kV/kV</td>
<td>kV-CBCT</td>
<td>MR</td>
<td>kV-CBCT, kV/kV, SIG</td>
</tr>
<tr>
<td>IGRT: Intra-fraction</td>
<td>kV triggered imaging, Calypso, SIG</td>
<td>Surface Image Guidance</td>
<td>Cine kV</td>
<td>Infrared Marker</td>
<td>Planar Cine MR</td>
<td>SIG</td>
</tr>
<tr>
<td>Ideal clinical indications</td>
<td>Universal</td>
<td>H&amp;N, Comp. Breast, Long Tx Fields, Junction fields</td>
<td>Motion tracking, non-coplanar delivery</td>
<td>Cranial Stereo.</td>
<td>Diaphragmatic motion, adaptive capability</td>
<td>Universal, lower integral dose, pediatrics, re-irradiation</td>
</tr>
</tbody>
</table>

Technology Triage

Early Stage Lung Cancer

- TrueBeam
  - Breath-hold?
  - Compression (ITV)?
  - Fast delivery?
  - Volumetric imaging?
  - Yes?
- Tomotherapy
  - Claustrophobic Volumetric imaging?
  - Non-coplanar?
  - Yes?
- CyberKnife
  - Trackable?
  - Fiducials?
  - Arms restriction?
  - Large motion
  - Yes?
- MR Linac
  - Breath-hold?
  - FB gating?
  - Claustrophobic?
  - Lateral lesion?
  - Volumetric imaging?
  - Yes?
- Proton-IMPT
  - Large motion?
  - Insurance?
  - Volumetric imaging?
  - Breath-hold?
  - Yes?

Comparative Plans
Treat patient with best quality plan
Prostate SBRT

Clinical Objectives

<table>
<thead>
<tr>
<th>Structure</th>
<th>Constraint</th>
<th>TrueBeam/RapidArc</th>
<th>IBA Proton PBS</th>
<th>CyberKnife M6</th>
<th>ViewRay MR Linac</th>
<th>Radixact (TomoTherapy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectum</td>
<td>D_{max} ≤ 43.2 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>D_{1cc} ≤ 38.5 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>V_{25Gy} ≤ 25%</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>V_{50Gy} ≤ 36.4 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>V_{1cc} ≤ 8 cc</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Urethra</td>
<td>D_{max} ≤ 42 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Bladder</td>
<td>D_{max} ≤ 40 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>V_{10Gy} ≤ 30%</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Large Bowel</td>
<td>D_{max} ≤ 29 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Small Bowel</td>
<td>D_{max} ≤ 25 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Femoral Heads</td>
<td>D_{max} ≤ 31 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>V_{1cc} ≤ 10 cc</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td>Penile Bulb</td>
<td>D_{max} ≤ 40 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
<tr>
<td></td>
<td>D_{3cc} ≤ 21.6 Gy</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
<td>✔ ✔ ✔ ✔ ✔</td>
</tr>
</tbody>
</table>
Protons vs. IMRT: Head and Neck

Tomotherapy vs. 3 field IMPT

20-25 Gy “savings” to the oral cavity:

What Does This Mean?

Widesott et al, IJROBP 2008

*25 Gy (25 Sv) of Unnecessary Radiation

Slide courtesy of Steve Frank, MDACC

12,500 H&N CTs (2 mSv) 5,000,000 Intraoral X-Rays (0.002 mSv) 25,000x General Public Annual Limit (1.0 mSv) +83% Additional Cancer Risk* (12,500 CTs, 65 yo)

Proton Therapy

Protons to the Vertex of the head for Meningioma 54Gy / 30fx

Orig Diag ALL at age 2 (Cobalt) remission
34yo Multifocal Meningioma, 3 surgeries
Recurrent Atypical Meningioma Lt Cavernous sinus
42yo Male
Atypical Meningioma

Dose difference

Life long consequences of Radiation and Chemo

Near optic apparatus

Multifocal lesions

CK to Lt Temporal Lobe lesion
25Gy / 5fx
MTRT

Vertex Too large for CK (Proton)

Lesion in the Cavernous Sinus (CK) 25Gy / 5fx

Proton (solid) Cyberknife (dots)
Cyberknife SBRT

Max Dose=0.03cc
100% D covers 95% PTV
100% D covers 99% GTV

<table>
<thead>
<tr>
<th>Proton</th>
<th>CyberKnife</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Dose (Gy)</td>
<td>Mean Dose (Gy)</td>
</tr>
<tr>
<td>Brain</td>
<td>25.9</td>
</tr>
<tr>
<td>Hippocampus_R</td>
<td>0.0</td>
</tr>
<tr>
<td>Hippocampus_L</td>
<td>12.7</td>
</tr>
<tr>
<td>Hippocampi</td>
<td>11.1</td>
</tr>
<tr>
<td>Optic Nerve_R</td>
<td>5.4</td>
</tr>
<tr>
<td>Optic Nerve_L</td>
<td>24.2</td>
</tr>
<tr>
<td>Optic Chiasm</td>
<td>15.8</td>
</tr>
<tr>
<td>Brainstem</td>
<td>11.0</td>
</tr>
<tr>
<td>Cochlea_L</td>
<td>10.6</td>
</tr>
<tr>
<td>Pituitary</td>
<td>20.2</td>
</tr>
</tbody>
</table>

Integral dose and Cognitive performance

![Images of brain scans with color-coded dose distributions]
Best technology is not easily evident...

Comparison Esophagus

3DCRT: 4-field static photons; IMRT: 5-field modulated photons; PBT: 2-field passive scatter protons (PA/LPO)
Liver Comparison

Proton

X-ray

For early stage breast cancer, prone photon RT is a good option to lower heart dose

Left Breast

Right Breast

Most patients treated to breast only are suitable for prone setup and will not require Protons

Ares et al., JROBP 2009
Comparison Breast Pectus Excavatum

3D, Breath-hold  VMAT, Free-B  Protons, Free-B

Mean heart dose
3D: 302 cGy  VMAT: 1075 cGy  IMPT: 4 cGy

On going lessons…

• Difficult to guess the best technology for some cases so we methodically work through the best solutions for the patient and continue learning from it
• Multi-technology RT approach appears to be beneficial in a non trivial number of cases
• MCI’s array of technology provides a unique environment that allow us to determine and provide the highest quality care to our patients
Credits: Thank you for your help

Alonso Gutierrez  
Grayden MacLennan  
Gus Luciani  
Minesh Mehta  
Marcio Fagundes  
Michael Chuong  
Rupesh Kotecha  
Matt Hall  
Kevin Greco  

Armando Acha  
Fazal Khan  
Man Yam  
David DeBlois  
Curtis Wilgenbusch  
Craig Kozarek  
Rene Hernandez  
Hayden Guerrero  
Jairo Mercado

Thanks for your attention