Proton and Photon Combination Treatments: Creating a United Front to Treat Cancer

AAMD Annual Meeting June 2019

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Disclosures: none

Dosimetry/Physics Star Wars Halloween 2018

https://www.facebook.com/ChicagoProtonCenter/
Learning Objectives

1. Identify the types of patients who can benefit from a combination of proton and photon radiation therapy.

2. Understand how metal or high Z materials affect the proton beam.

3. Gain a basic understanding of the workflow that needs to happen when treating with photons and protons and the close collaboration between the teams.

   - Bonus objective: Have fun while learning!
Protons at Northwestern Medicine Chicago Proton Center: Facility background and collaborations

Facilities

Northwestern Medicine Cancer Center Warrenville, IL

- Radiation oncology suite
  - TomoTherapy®
  - Trilogy
  - HDR brachytherapy
  - Gamma Knife

https://www.nm.org/locations/cancer-center-warrenville
Facilities

Northwestern Medicine Cancer Center Delnor, IL

- Radiation oncology suite
  - Varian IX
  - HDR brachytherapy

https://www.nm.org/locations/cancer-center-delnor

Facilities

Northwestern Medicine Chicago Proton Center in Warrenville, IL

- 2 IBL (inclined beam line) rooms:
  - 1 PBS (Pencil Beam Scanning)
  - 1 US (Uniform Scanning)
- 1 Fixed beam: PBS
- 1 Gantry: PBS

https://www.nm.org/locations/chicago-proton-center
Collaborating to Care for Proton Therapy Patients

**Preferred Provider and Referral Relationships**
- Patients referred to Proton Center physicians for treatment
- May be formalized into preferred provider relationships
- Referring physicians may participate in Proton Center activities
  - Consultation or dosimetry review meetings via Webex
  - Receive education on proton therapy and patient selection

**Clinical Affiliations**
- Formal clinical affiliations to increase access to proton therapy
- Outside physicians are credentialed and treat their patients at the Proton Center
- Initial consult and follow-up care provided at home facility
- Additional resident education and clinical research initiatives

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Proton Recap
Proton Introduction

- The proton language:
  - RANGE
  - MODULATION
  - SPREAD OUT BRAGG PEAK (SOBP)
  - SMEARING
  - UNCERTAINTY
  - ROBUST
- 1.1 RBE- an “equivalent” dose is defined as the product of absorbed dose and the proton RBE.

Proton Overview

Video

https://youtu.be/Xno7BlpFGoA
Uniform Scanning: Introduction

- Inclined beam line (IBL)
- Treatment planning system: XiO
- Target size/shape determines the range and modulation
- Special Devices used to conform the beam to the target

Uniform Scanning: Devices

Aperture
- Brass disk is “blank”
- Defines shape of field

Compensator
- Made of lucite or blue wax
- Conform isodose distribution to distal edge of target
- Smear-accounts for uncertainties
- Comp volumes-irregular shape

http://www.proton-therapy-today.com/from-cars-to-proton-therapy/
**Uniform Scanning: Uncertainty**

- Difference from photons (uncertainty)
- With uniform scanning the beams range can be systematically off by 2.5% + 2mm.
- Range Uncertainties: 2.5%
- CT conversion uncertainties: 2mm
- Plan check scenarios:
  - over-range
  - under-range
- Positional Uncertainties:
  - Setup
  - Motion
- If indicated from check, plan can be modified (range/modulation)

**Pencil Beam Scanning**

- One proton beam can stand alone to cover the target with 95-100% coverage...less beams necessary than IMRT
- SFO—single field optimization
### Pencil Beam Scanning

- **MFO** - multi field optimization
- **Beams work together to optimize plan**
- **Bonus**: PBS with Apertures (can be SFO or MFO)

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#### Metal and Protons
Implanted metals

- Hardware might lose 10-15% attenuation to the target with photons—up to 100% in protons
- Avoid structures in PBS optimization
- Strategic Beam placement

<table>
<thead>
<tr>
<th>OAR range margin</th>
<th>ROI</th>
<th>Margin [cm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoid_Metal</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

**Combo Patients**
Background of disease types that are treated with proton and photon treatments

- Are there certain disease types that indicate using a combination of protons and photons?
  - Yes!
- What diseases are these?
  - Spinal cord tumors, sarcomas with hardware
  - Nasopharyngeal
  - Paranasal sinus ex. Ethmoid

Sometimes you can choose BOTH! 😊

Should I consider a combo treatment if the patient does not have these disease types?
- Maybe, if they have another indication...

What are the indications in these cases?
- Can't meet OAR metrics
- Need a higher definitive dose or boost
- A new area to treat becomes apparent and carving needs to happen

Photon and proton

- Why do we use a combo?
  - Pros of using the photons work with the pros of using protons to make a magical treatment!

- The photons:
  - more forgiving with metal
  - Timely turn around times

- The protons:
  - precision for lower OAR dose during boost phase
  - escalate dose to target
  - Eliminate exit dose

What requires a combo to have a more special approach?
- Communicating about what checklist will be used for OARs
- Leaving “room” for the boost OARs to get some dose
- Coordinating care with clinical affiliated clinics and our own internal system to make sure the patient has a proper time slot
Consult Review

- What is consult review?
  - peer review to determine proton candidacy of a patient

- What is reviewed in consult review?
  - Patient history
  - Surgery
  - Chemotherapy
  - Previous treatment
  - Any additional testing

- Who else participates in consult review besides the Radiation oncologists?
  - Nurses
  - Radiation Therapists
  - Finance
  - Research
  - Dosimetrists
Consult Review

- What is the dosimetrist’s role in consult review?
  - Run Velocity
  - Indicate 4Fusion imaging
  - Room size
  - Snout size

- What happens after the meeting?
  - send out an email to disseminate info to all shared patient team members
  - Initiate Quality Checklist (QCL) in MOSAIQ
  - pCombinationPlanNeeded

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Stop, Collaborate, and Listen

- How do we stay organized?
  - Use a shared board
  - Intake Management System (IMS)
  - Sched. Flags from left to right: insurance, PBS, Metal, Combination

- Bonus flag: Apertures PBS

- Who can be on the shared board/have access?
  - Only Warrenville/Delnor shared patients
  - No access for other collaborating groups due to HIPAA
  - Use IMS for collaborating groups use symbol X+ to delineate the patients
IQ Scripting: “Streamline workflows”

- pCombinationPlanNeeded → cCombinationPlan → pCombinationPlan

  • Initiated from consult review
  • Goes to Dosimetry group

  • Goes to Cancer Center:
    - Dosimetry
    - Therapy
    - Nursing
    - Physics
    - Physician

  • Goes to Proton Center
    - TTA
    - Sim
    - Nursing
    - Intake
    - Physics
    - Attending physician
    - Financial counselor


Comparison plan

- pComparison plan needed

  • Why do we do comparison plans?
    - Protons relatively “new”
    - Insurance/financing for treatment (needed for insurance appeal)
    - Peer to peer review
    - Compare photons vs. protons in some scenarios
    - Proof of medical necessity
    - Self-pay
**Simulation**

- Who all is involved during the sim process?
  - Radiation Therapist, Dosimetrist, Physicist, and Physician
- Considerations for sim:
  - Review consult review notes/imaging
  - How to position
  - What room for protons
  - Multi-modality Compatible devices
  - Potential collisions
- Process Improvement:
  - BOS frame for photon center

![Simulation Image]

https://qfix.com/catalog/radiotherapy/proton-positioning

**Fusion**

- Velocity
- Pull in marked 4Fusions and complete image registrations
- MV scans for metal
- Accuracy is key for target delineation

![Fusion Image]

pMD Contours Req’d
**Contours**

- Organs at Risk
- Proton considerations for “patient” contour
  - Devices that are in beam path
- Examples
  - Vac-lock/alpha cradle
  - Bite Block
  - Mask
  - Table

[Image](https://imgflip.com/memegenerator)

**Contour: Artifact and Hardware**

- Careful considerations
  - Hardware=real
  - Artifact streaking=not real
  - Calculation accuracy
- How do we make sure we are accurate with these contours?
  - MV scan to the rescue!

[Image](https://imgflip.com/memegenerator)

dosimetrist seeing metal & artifact in their patient
Dosimetry Rounds

- Review of MD target volume delineation
- Peer review process
- Notes about plan directives
- Adjustments made based on peer review
- Time to plan!

Dosimetry Plan

Protons
- Protons have a more lengthy turn around time for calculation and extra checks
- Issues with steep gradients in tissue heterogeneities ex. metal and lung
- Escalate doses due to sharp falloff
- Apertures

Photons
- Photons are more quick to calculate
- More attenuation forgiveness

https://www.youtube.com/watch?v=N92ssGAXsjg
Physics Checks

- Proton/Photon Eval
  - DVH evaluation
  - Composite Isodose Coverage
  - Feasibility
  - Constraints (use with caution!!)

- Extended evaluation
  - Isodose coverage of each beam
  - Aperture and compensator evaluation
  - Uncertainty evaluation
  - Robustness evaluation

• Plan with Robustness to ensure target Coverage
• Ensure OAR’s do not go above tolerance with uncertainties applied

Plan is done, but wait....there’s more!

- Import into Mosaiq
- Create Plan PDF

- *If apertures or compensators are required Milling will get appropriate QCLs to indicate what devices are needed and the deadline

https://www.youtube.com/watch?v=N92ssGAXsjg
Case Studies

Metal Case Study
Metal Case Study: Introduction

- **Disease type**: Chondrosarcoma
- **Snout Size**: 18cm
- **Why do a combo?**
  - **Photons**: metal forgiveness
  - **Protons**: dose escalation...PBS apertures

- **Prescriptions**:
  - **Photon**: 1.8Gy x 28fx = 50.4 Gy
  - **Proton Boost**: 1.8 GyRBE x 12 fx = 21.6 GyRBE
  - **Total**: 72 GyRBE
GE Junction Case Study: Introduction

- **Disease type:** Adenocarcinoma Gastroesophageal Junction
- **Chemotherapy:** Yes! Concurrent
- **Snout Size:** 25cm
- **Why do a combo?**
  - **Photons:** timing
  - **Protons:** higher definitive dose
- **Prescriptions:**
  - **Photon:** 1.8 Gy x 10fx = 18 Gy
  - **Proton:** 1.8 GyRBE x 15 fx = 27 GyRBE
  - **Proton Boost:** 1.8 GyRBE x 3 fx = 5.4 GyRBE
  - **Total:** 50.4 GyRBE
Bilateral Adrenal Case: Introduction

- **Disease type:** Metastatic Lung Adenocarcinoma
- **Chemotherapy:** Yes (good response)
- **Snout Size:** 10cm
- **Why do a combo?**
  - Just treated to the right adrenal
  - Protons needed for left side due to proximity to stomach, spinal cord, kidney, bowel
- **Prescriptions:**
  - Right Adrenal: PTV 6Gy x 5 fx =30Gy
  - Left Adrenal: SIB- 7.5GyRBE x 5 fx= 37.5GyRBE
    
    PTV 6GyRBE x 5 fx= 30GyRBE

Bilateral Adrenal Case: Proton Plan
Bilateral Adrenal Case: Photon Plan

- Planning process takeways:
  - Less collaboration with photon dosimetrist
  - More collaboration with physician for proton aspect

- What could have been improved on?
  - Knowing that both adrenals were going to receive treatment from the start

How could this have helped?
- Get higher dose to the PTV for the left adrenal while keeping with the TG101 constraints
Conclusion

Future of Proton/Photon Combination Treatments

- Increase access to protons:
  - One room centers
  - More collaborations/clinical affiliations
- Process Improvement:
  - Even more communication for scheduling tx times
  - Communication, communication...communication!
- Teamwork with collaborating:
  - Clinical affiliated physicians/dosimetrist (OAR dose)
  - Med. Onc-Knowing if we are doing more aggressive treatment (ex. Adrenal bilat tx)

https://www.proton-therapy.org/map/
https://www.facebook.com/ChicagoProtonCenter/

Dancing with one of our pediatric patients
Conclusion

Dosimetry will continue to be “re-imagined” and progress with advancements in technology.

Acknowledgements
Dosimetry Team/Physics Team
Stacey Schmidt B.S. CMD R.T. (T)
William Hartsell, MD
Vinali Gondi, MD
Nasir Mohammed, MD
Stephen Mihalčík, MD, Ph.D
Philip M. Duffin

Superhero Day 2018
Thank you for listening!

Questions?

Physics/Dosimetry Despicable Me Halloween 2016

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