Radiation Oncology for the Cancer Registrar
All You Need to Know

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Florida Oncology Tavares
FCRA 2020 Annual Meeting
July 30, 2020
Modern Oncology Treatment

Clinicians
• Medical Oncologists
• Radiation Oncologists
• Surgical Oncologists

Treatments
• Systemic therapy
• Radiation therapy
• Surgery & ablations

Eradicate tumor while sparing normal tissue
Eradicate Tumor while Sparing Normal Tissue

Radiation Biology

*How dose interacts with cells*

- Total Dose
- Dose fractionation

Radiation Physics

*How dose is positioned in the body*

- Dose delivery techniques & devices
- Patient Positioning
Patient flow through radiation treatment

• Consultation
• Additional diagnostic studies
• Simulation
• Treatment Planning
  • Target Volumes
  • Treatment techniques
  • Prescription writing
• Treatment
  • Equipment & Devices
  • Image guidance
  • Weekly management visits
• Follow Up
Treatment Planning & Target Volumes
Radiation Oncology Example workflow

Initial Consultation
Staging/Workup
Tumor Board
Evidence Based Trials/Research
Simulation

**Treatment Planning**

On Treatment Visits
Portal Imaging
Follow-up
Survivorship
Radiation Oncology

Example workflow

Initial Consultation
Staging/Workup
Tumor Board
Evidence Based Trials/Research
Simulation

Treatment Planning
On Treatment Visits
Portal Imaging
Follow-up
Survivorship

Skin

Spinal Cord
Radiation Oncology
Example workflow

Initial Consultation
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Tumor Board
Evidence Based
Trials/Research
Simulation

**Treatment Planning**

On Treatment Visits
Portal Imaging
Follow-up
Survivorship

Gross Lymph Node in Mid-Jugular Chain (Level III)
Radiation Oncology

Example workflow

- Initial Consultation
- Staging/Workup
- Tumor Board
- Evidence Based Trials/Research
- Simulation
- Treatment Planning
- On Treatment Visits
- Portal Imaging
- Follow-up
- Survivorship

**Gross Primary Tumor in Piriform Sinus/Larynx**
Radiation Oncology
Example workflow

Initial Consultation
Staging/Workup
Tumor Board
Evidence Based
Trials/Research
Simulation

Treatment Planning
On Treatment Visits
Portal Imaging
Follow-up
Survivorship

CTV to account for direct extension of gross tumor
CTV to account for microscopic Lymphatic Metastasis
Radiation Oncology
Example workflow

Initial Consultation
Staging/Workup
Tumor Board
Evidence Based
Trials/Research
Simulation
Treatment Planning
On Treatment Visits
Portal Imaging
Follow-up
Survivorship

PTV allows for daily setup error and organ motion
Radiation Oncology

Example workflow

- Initial Consultation
- Staging/Workup
- Tumor Board
- Evidence Based Trials/Research
- Simulation
- Treatment Planning
- On Treatment Visits
- Portal Imaging
- Follow-up
- Survivorship
## Radiation Oncology

### Example workflow

<table>
<thead>
<tr>
<th>Step</th>
</tr>
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<tbody>
<tr>
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<td>Trials/Research</td>
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<td>Simulation</td>
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<tr>
<td><strong>Treatment Planning</strong></td>
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<tr>
<td>On Treatment Visits</td>
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<tr>
<td>Portal Imaging</td>
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<tr>
<td>Follow-up</td>
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<tr>
<td>Survivorship</td>
</tr>
</tbody>
</table>

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![3D radiation therapy model](image)
Example workflow

Radiation Oncology

Initial Consultation
Staging/Workup
Tumor Board
Evidence Based
Trials/Research
Simulation

Treatment Planning

On Treatment Visits
Portal Imaging
Follow-up
Survivorship
Avoidance Structures

- Parotid glands
- Mandible
- Cochlea
- Brain
- Optic nerves & chiasm
- Spinal Cord
- Pharyngeal constrictors
- Upper esophagus
- Submandibular glands
- Oral cavity
- Larynx
Radiation Oncology
Example workflow

Initial Consultation
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Evidence Based
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Treatment Planning
On Treatment Visits
Portal Imaging
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Radiation Oncology
Example workflow

Initial Consultation
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Treatment Planning
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Follow-up
Survivorship
External Beam Radiation Therapy

Treatment Techniques
3-Dimensional Conformal

- Most “Standard” form of EBRT
- Three-dimensional models made through contouring CT slices
- Beams aimed from different angles for best dose distribution
- Less physics-intensive than IMRT
Intensity Modulated Radiation Therapy (IMRT)

• Technique to improve PTV coverage while lowering avoidance structure dose

• Involves input of Goals and Constraints into treatment planning computer – Inverse planning

• Treatment planning computer optimizes beam angles and dose accumulation in 3D space

• Results in concave dose distributions and steep dose gradients

• Plans are then tested by medical physicist on linear accelerator to ensure plan can be delivered as expected
Intensity Modulated Radiation Therapy (IMRT)

IMRT can make a concave isodose distribution
Variations of IMRT – Delivery Methods

• Static Gantry

• VMAT (volume modulated arc therapy)
  • RapidArc (Varian)
  • Intellibeam (Elekta)

• Helical (TomoTherapy)
SBRT/SABR

- Stereotactic Body Radiation Therapy
- Stereotactic Ablative Body Radiation
- Large doses per fraction
- Between 1 and 5 fractions
- Small tumor volumes only
- Lung, liver, spine, kidney, prostate, and others
SRS

• Stereotactic Radiosurgery
• One fraction only
• Small tumor volumes only
• Brain metastases, some benign masses
Electrons

• Charged sub-atomic particles
• Penetrate to a relatively shallow depth then stop
• Skin cancers, breast cancer boosts
Other Treatment Techniques

• Protons
• Neutron
• Carbon Ion
• Brachytherapy
Radiation Prescriptions
Radiation Prescriptions – Required Elements

- **Target volume(s)**
  - PTVs (Planning Target Volumes)
    - Visible tumors
    - At-risk spaces
- **Dose per fraction**
- **Number of fractions**
  - 6000 cGy = 200 cGy x 30 fractions
- **Total Dose**
  - Additive in sequential volume reductions
  - Maximum listed dose in simultaneous integrated boost
- **Treatment frequency**
  - QD, BID, TID, TIW, etc.
- **Treatment Technique**
  - 3D, IMRT, electrons, brachytherapy
- **Beam energy**
  - e.g. photons: 6 MV, 15 MV, 23 MV
  - e.g. electrons: 6 MeV, 9 MeV, 12 MeV
- **Image-guidance technique (IGRT)**
  - kV imaging
  - Cone-beam CT (CBCT)
  - Surface tracking
- **Special techniques**
  - Respiratory gating
  - Deep-inspiration breath hold (DIBH)
  - Surface bolus
Radiation Prescriptions – Additional Factors

Additional Factors
• Target volume reductions
  • aka “Boost”
• Re-simulation & re-planning
  • Same Phase if TVs do not change
• Multiple sites simultaneously
• Multiple modalities
• Concurrent systemic therapy
• Special set-up techniques

Within the STORE
• Each Phase is defined by
  • Target volume
  • Fraction size
  • Modality
  • Treatment technique
• Phases may be sequential or simultaneous
• New Phase if any of the above change
Variations of Multi-Phase IMRT Prescriptions

- Sequential volume reductions
  - Fraction number varies by target volume
  - Fraction size usually the same for all targets
  - Dose variation by exclusion of lower risk volumes from higher dose plans
  - Reported as separate phases

- Simultaneous integrated boost (SIB)
  - Fraction number the same for all targets
  - Fraction size varies by target volume
  - Delivered in one plan
  - Still reported as separate phases
## Radiation Prescriptions – Sequential IMRT

**Dx:** Malignant neoplasm of upper outer quadrant of right female breast

<table>
<thead>
<tr>
<th>Site</th>
<th>Technique</th>
<th>Modality</th>
<th>Fractions</th>
<th>Rx</th>
<th>Dose</th>
<th>Pattern</th>
<th>Rx Dose</th>
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<tr>
<td>Right Chestwall &amp; LN</td>
<td>IMRT - RapidArc</td>
<td>x06</td>
<td>25</td>
<td>25</td>
<td>180  cGy</td>
<td>Daily</td>
<td>4,500 cGy</td>
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<td>IMRT - RapidArc</td>
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<td>3</td>
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<td>180  cGy</td>
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<td>5</td>
<td>200  cGy</td>
<td>Daily</td>
<td>1,000 cGy</td>
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### Rx Site: Right Chestwall & LN

**Status:** Approved KEL  9/11/2019

**Technique:** IMRT - RapidArc

**Modality:** x06

**Dose Spec:** Plan

<table>
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<tr>
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**Pattern:** Daily IGRT KV Imaging

**Comment:** Boost to follow

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**Dose Limits**

**Total Cum:**

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*Radiation Rx is View Only*
Radiation Prescriptions – Simultaneous Integrated IMRT

Dx: IVA: Right Malignant neoplasm of vallecula p16 positive
Squamous cell carcinoma, NOS

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<th>Site</th>
<th>Technique</th>
<th>Modality</th>
<th>Act</th>
<th>Rx</th>
<th>Dose</th>
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<th>6,996 cGy</th>
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<td>PTV Neck 6996</td>
<td>IMRT - RapidArc</td>
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<td>212 cGy</td>
<td>Daily</td>
<td>6,996 cGy</td>
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Rx Site: PTV Neck 6996
Status: Approved JGB 12/05/2017

Technique: IMRT - RapidArc
Modality: x06

Dose Spec: Plan

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</tbody>
</table>

Pattern: CBCT aligned to Pharyngeal Air daily

Comment: PTV Neck 5445 @ 165/day concurrent chemo, Dr. Ambinder

Dose Limits
Total Cum:

Radiation Rx is View Only
Finding Prescription Information

• Consultation Notes
• Radiation prescriptions within Aria or Mosaiq EMRs
• Physics notes
• Weekly on-treatment notes
• Treatment plan from treatment planning system stored in EMR
• Treatment summaries
• Ask physician, dosimetrist, or physicist
External Beam Radiation Therapy Equipment
## External Beam Radiation Therapy

### Equipment
- Linear Accelerator (Gantry Based)
- TomoTherapy
- ViewRay MRIdian
- CyberKnife
- Gamma Knife
- Mobetron
- Particle therapy machines

### Techniques
- 3D Conformal
- Intensity Modulated (IMRT)
  - Static gantry
  - VMAT
- SBRT/SABR
- SRS
- Electron beam
- Proton
- Neutron
- Carbon Ion
Linear Accelerator – Gantry Based

- Most common RT delivery system
- Many treatment modalities
- Great versatility in treatment sites
Linear Accelerator – Gantry Based

Modalities
- 3D conformal
- IMRT
  - Static gantry
  - VMAT
- SBRT/SABR
- SRS
- Electron beam
Linear Accelerator

- Generates radiation via electricity
- Accelerates electrons to speed of light to impact tungsten target
- Photons generated by impact
- Photons directed into patient
- Target removed to treat with electrons
Linear Accelerator – Gantry Based

Some Brand Names
• Varian TrueBeam
• Varian Trilogy
• Varian EX/iX
• Varian 2100
• Elekta Synergy HD
• Elekta Infinity HD
• Elekta Versa HD
Linear Accelerator – Helical

Brand Names
• Accuray TomoTherapy
• Varian Halcyon

Modalities
• IMRT (helical)
• 3D Conformal

Particulars
• Rotating linear accelerator
• Photons only
Linear Accelerator – View Ray MRIdian

Modalities
• IMRT

Particulars
• Rotating linear accelerator
• Photons only
• Built-in MRI for IGRT & adaptive replanning
Gamma Knife

Modalities
• SRS (Gamma Knife)

Particulars
• Heads only
• Screw-on headframe
• Neurosurgeon involved
• Cobalt-60 sources (photons)
• One session
• Often multiple targets
Gamma Knife

Modalities
• SRS (Gamma Knife)

Particulars
• Heads only
• Screw-on headframe
• Neurosurgeon involved
• Cobalt-60 sources (photons)
• One session
• Often multiple targets
CyberKnife

**Modalities**
- SRS (robotic)
- SBRT/SABR

**Particulars**
- Miniature linear accelerator on robotic arm
- Stereotactic treatments only (5 fractions or less)
- Photons
Proton Therapy

Modalities
- 3D (protons)
- IMPT (protons)

Particulars
- Eliminates exit dose
- Expensive
- Limited availability
- Well suited for brain, spinal cord, children
- Sometimes combined with photons
Proton Therapy
Neutron Therapy

Modalities
• 3D

Particulars
• Only 3 centers in US
• Primarily used for salivary gland tumors
• More skin reaction
• More tissue fibrosis
Mobetron

Modalities
• Electrons

Particulars
• Intraoperative radiation delivery
• Single fraction
• Breast & pancreas most common sites
Superficial / Orthovoltage

Modalities
• kV (low energy) photons

Particulars
• Non melanoma skin cancers
• Minimal shielding required
• Used most commonly by dermatologists
• Often without radiation oncology involvement
Brachytherapy
Brachytherapy

- Use of physical radioactive material to deliver “close therapy”

- Doses cannot be added to EBRT doses for coding purposes

- HDR (High dose rate)
  - Contura/SAVI/Mammosite
  - Vaginal cylinder
  - Tandem & Ovoid/Tandem & Ring
  - Prostate
  - Skin applicator
  - Custom applications

- LDR (low dose rate)
  - Prostate seeds
  - GYN intracavitary implants
  - GYN interstitial implants
  - Retinal plaques

- Radiopharmaceuticals
  - Iodine-131
  - Strontium
  - Radium-223
  - Yttrium-90
  - Lutathera
High Dose Rate (HDR) Brachytherapy

Modalities
• HDR Intracavitary
• HDR Interstitial
• HDR Surface

Particulars
• Treatments take minutes
• Multiple fractions
• Iridium-192 radioactive source
• Uses temporary implants
• Cervix, endometrial, prostate, breast, skin, head & neck extremities
HDR Brachytherapy - Intracavitary

Accelerated partial breast irradiation
- MammoSite
- Contura
- SAVI

Tandem & ovoid
- Cervix

Vaginal cylinder
- Endometrial cancer
- Vaginal cancer
HDR Brachytherapy - Interstitial

Soft tissue implants
- Breast
- Extremity
- Head & neck

Prostate
- Often after IMRT

Gynecologic
- Endometrial cancer
- Vaginal cancer
- Cervix
- After EBRT
HDR Brachytherapy - Surface

Freiburg flap
- Non-melanoma skin

Leipzig applicator
- Non-melanoma skin

AccuBoost
- Breast cancer
- After whole breast EBRT
Low Dose Rate (LDR) Brachytherapy

Modalities
• LDR Interstitial
  • Prostate seeds
  • Gynecologic
  • Head & Neck
• LDR Intracavitary
  • Gynecologic

Particulars
• Seeds stay in for at least days
• One fraction
• Permanent in prostate cancer
• Temporary in most other applications
• Iodine-125
• Palladium-103
• Cesium-131
Radiopharmaceuticals

• Iodine-131
  • Papillary thyroid cancer
• Strontium-89 & 90
  • Bone metastases
• Radium-223 (Xofigo)
  • Prostate bone metastases
• Yttrium-90 ibritumomab (Zevalin)
  • Non-Hodgkin lymphoma
• Samarium-153 (Quadramet)
  • Osteoblastic bone metastases
• Lutetium-177 (Lutathera)
  • Gastroenteropancreatic neuroendocrine tumors (GEP-NETs)
Radioimmunotherapy with Ibritumomab-Yttrium-90

Anti-CD 20 antibody conjugated to a radioisotope
Summary - Radiation Modalities

**External Beam**
- Photons
  - 3-dimensional conformal
    - Linac
    - Source-based
  - IMRT
    - Static gantry
    - VMAT
    - Helical
  - SRS
    - GammaKnife
    - CyberKnife
    - Linac based
  - SRT
  - SBRT/SABR
  - Orthovoltage/Superficial
- Electrons
- Protons
- Neutrons

**Brachytherapy**
- HDR
  - Contura/SAVI/Mammosite
  - Vaginal cylinder
  - Tandem & Ovoid/Tandem & Ring
  - Prostate
  - Skin applicator
  - Custom applications
- LDR
  - Prostate seeds
  - GYN intracavitary implants
  - GYN interstitial implants
  - Retinal plaques
- Radiopharmaceuticals
  - Iodine-131
  - Radium-223
  - Samarium-153
  - Yttrium-90
  - Lutetium-177
Summary - STORE Coding Principles

• Phases
  • Radiation Prescription

• Total Dose
  • Sequential vs Simultaneous

• Phase N Primary Target Volume
  • Derived from Radiation Prescription

• Brachytherapy
  • No addition of EBRT and brachytherapy doses

• Documentation
Questions?

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