Radiation Oncology
What Do Pharmacists Need to Know

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Outline

• What is radiation?
  – Ionizing vs non-ionizing
  – Background exposure

• Radiation oncology procedures
  – EBRT, IMRT, SBRT, SRS
  – Brachytherapy

• Chemotherapy + RT

• Supportive drugs
Radiation
Radiation
(Electromagnetic Wave)
Ionizing Radiation

Radiation (particles, x-rays, gamma rays) with sufficient energy to cause ionization in the medium through which it passes.
Radiation
Non-Ionizing vs. Ionizing

The diagram illustrates the spectrum of radiation, distinguishing between non-ionizing and ionizing radiation. Non-ionizing radiation includes extremely low frequency, radio, THZ (Terahertz), infrared, microwave, and optical frequencies. Ionizing radiation includes visible light, ultraviolet, X-ray, and gamma rays. The diagram also categorizes radiation effects as non-thermal (induces low currents, induces high currents, heating) and thermal (excites electrons, photochemical effects, heat lamp, tanning booth), with broken bonds (damages DNA, medical X-ray) for ionizing radiation.
Effects of Ionization
Background Radiation
(Ubiquitous)

- Inhalation - Radon
  - 2.28 mSv

- Cosmic - Sun/Stars
  - 0.33 mSv

- Ingestion - Radioactive $^{40}$K and $^{14}$C
  - 0.28 mSv

- Terrestrial - Uranium, thorium, radium in soils and rocks
  - 0.21 mSv

TOTAL = ~3 mSv/year
EPA Map of Radon Zones

The purpose of this map is to assist National, State, and local organizations to target their resources and to implement radon-resistant building codes. This map is not intended to be used to determine if a home in a given zone should be tested for radon. Homes with elevated levels of radon have been found in all three zones. All homes should be tested regardless of geographic location.

IMPORTANT: Consult the EPA Map of Radon Zones document (EPA-402-R-94-007) before using this map. This document contains information on radon potential variations within counties. EPA also recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential of a specific area.

Zone designation for Puerto Rico is under development.
North Carolina
epa.gov
Radiation Exposure (Annual)

Average: 6.2 mSv
620 mrem
Increasing Exposure
Nature 2015;523:17

**RISING BACKGROUND**
A rise in medical scans over the past two decades has doubled the amount of radiation that the average American receives each year.

**Average public radiation exposure (millisieverts per year)**

- **United States**
  - 1987
  - 2006

- **Global**
  - 2000
  - 2008

- **Germany**
  - 2005

Legend:
- Other
- Consumer products
- Medical
- Ingestion
- Terrestrial radionuclides
- Cosmic rays
- Radon
Radiation Oncology
Types of Radiation Therapy

• Conventional RT
  – Electrons
  – Photons
    • 2D (simple) vs. 3D (complex)

• Intensity Modulated Radiation Therapy (IMRT)

• Stereotactic Body Radiation Therapy (SBRT)

• Stereotactic Radiosurgery (SRS)

• Brachytherapy
RT, IMRT, SBRT, SRS
Brachytherapy
Radiation Oncology

• Consultation

• Simulation

• Treatment Planning

• Treatment
Terminology

• Gy = “Gray” = unit of treatment
  – 2 Gy is a conventional dose

• Fraction = a treatment
  – 5 fractions/week standard (M-F)

• Locally-advanced lung cancer
  – 2 Gy qd to 60 Gy (1 treatment of 2 Gy a day, 5 days a week for 6 weeks, to 60 Gy)
Electrons
Primary Cutaneous ALCL
Prescription
40 Gy (2 Gy daily, 5 days/week)
Duration- 15 minutes/day
Mycosis Fungoides
Total Skin Irradiation
Photons
Primary Mediastinal B-cell Lymphoma
Conventional RT
Lung Cancer
Conventional RT
Conventional RT
IMRT
Intensity Modulated RT
Stereotactic Body Radiation Therapy (SBRT)  
(A few very big RT fractions)
Stereotactic Body Radiation Therapy
# SBRT

## Prospective Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>n</th>
<th>Dose</th>
<th>Survival (3y)</th>
<th>Local Control (3y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nagata (Kyoto, Japan)</td>
<td>45</td>
<td>12 Gy X 4</td>
<td>T1 83%</td>
<td>T1 97%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>T2 72%</td>
<td>T2 100%</td>
</tr>
<tr>
<td>Ricardi (Torino, Italy)</td>
<td>62</td>
<td>15 Gy X 3</td>
<td>57%</td>
<td>88%</td>
</tr>
<tr>
<td>Baumann (Scandinavia)</td>
<td>57</td>
<td>15 Gy X 3</td>
<td>60%</td>
<td>92%</td>
</tr>
<tr>
<td>Takeda (Tokyo, Japan)</td>
<td>63</td>
<td>10 Gy X 5</td>
<td>T1 90%</td>
<td>T1 93%</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>T2 63%</td>
<td>T2 96%</td>
</tr>
<tr>
<td>Nyman (Sweden)</td>
<td>45</td>
<td>15 Gy X 3</td>
<td>55%</td>
<td>80% (crude)</td>
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<tr>
<td>Timmerman (Indiana University)</td>
<td>70</td>
<td>20-22 Gy X 3</td>
<td>43%</td>
<td>88%</td>
</tr>
<tr>
<td>RTOG (North America)</td>
<td>55</td>
<td>18 Gy X 3</td>
<td>56%</td>
<td>98%</td>
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</tbody>
</table>
Stereotactic Radiosurgery (SRS)
(one very large treatment to brain)
Stereotactic Radiosurgery (SRS)

- Highly focused radiation treatment
- Small tumors: < 4 cm
- Margin: 1 mm
- Mask vs Frame
- High dose per fraction (up to 24 Gy x 1)
- Rarely up to 5 treatments (> 4 cm)
Brachytherapy
Radioactive Sources

• Prostate cancer
• Cervical cancer
  – EBRT/Cisplatin + brachy “boost”
• Sarcoma
• Lung cancer (endobronchial brachytherapy)
• Choroidal melanoma
• Intraoperative radiotherapy (IORT)
Brachytherapy
Choroidal Melanoma

Radioactive Plaque
Brachytherapy
Prostate Cancer

Catheter in urethra

Ultrasound probe in rectum for needle guidance

Needle, delivering seeds into prostate

Template to aid accurate placement of the needles delivering the seeds
Low-risk Prostate Cancer Brachytherapy
Brachytherapy
Intraoperative Radiotherapy (IORT)
RT and Chemotherapy
Concurrent vs. Sequential

- GI Malignancies
  - 5-FU or capecitabine

- Lung Cancer
  - Cisplatin/Etoposide or Carboplatin/Paclitaxel

- Head and Neck Cancer
  - Cisplatin

- Cervical Cancer
  - Cisplatin

- Gliomas
  - Temozolamide
RTOG 9410
Sequential vs Concurrent Chemotherapy
Caution with RT

Adriamycin- Radiation recall reaction
Caution with RT
Radiosensitization

- Gemcitabine (lung toxicity)
- Docetaxel (lung toxicity)
- Bevacizumab (esophageal fistula)

Many more
Supportive Drugs with RT

- Lung Cancer
  - Viscous lidocaine/Oxycodone (esophagitis)
  - Prednisone (radiation pneumonitis)
- Gastrointestinal
  - Ondansetron (RT-induced nausea)
  - Imodium (diarrhea)
- Brain metastases/gliomas
  - Dexamethasone (edema)/PPI (GI prophylaxis)
- Skin cancers
  - Topical lidocaine (desquamation)
Questions??