Radiation Safety Considerations in $^{90}$Y Radioembolization

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Topics

- Treatment Overview
- $^{90}\text{Y}$ characteristics
- Products
- Hot Lab/Dose Preparation Safety
- IR Lab Preparation
- Dose Administration
- Radioactive Waste
- Post Procedure Patient Care
What is $^{90}$Y Radioembolization?

- Transarterial (TARE) treatment for hepatocellular carcinoma (HCC) or hepatic metastases from colorectal cancer

- Radioactive microspheres are administered through a catheter into the blood vessel supplying the tumor

- Delivers high-dose beta radiation to the tumor while minimizing exposure to normal liver parenchyma
Tumor Vascularity - Example

Pretreatment angiogram demonstrating hepatic vein (hyperdynamic) flow


45 day post-treatment angiogram demonstrating elimination of tumor vascularity while preserving normal parenchymal flow
Large right lobe HCC
- Patient treated with 1 dose of TheraSphere®

2 months post treatment
8 months post treatment

Images provided by Philip Hilgard, Hepatologist, University of Essen, Essen, Germany (Presented at ILCA 2008)
90Y Characteristics

- Pure beta emitter
- Decay energy 0.94 MeV
- Maximum range in tissue 11 mm (2.5 mm ave)
- T_{1/2} 64.2 hours
- 2 production methods
  - Reactor
  - $^{90}$Sr/$^{90}$Y generator
<table>
<thead>
<tr>
<th>Products</th>
<th>TheraSphere®</th>
<th>SIR-Spheres®</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Nordion/BTG</td>
<td>Sirtex Medical</td>
</tr>
<tr>
<td>Material</td>
<td>Glass</td>
<td>Resin</td>
</tr>
<tr>
<td>Sphere Diameter</td>
<td>20-30 microns</td>
<td>20-60 microns</td>
</tr>
<tr>
<td>Specific Activity per Sphere</td>
<td>40 - 70 Bq</td>
<td>2400 - 2700 Bq</td>
</tr>
<tr>
<td>Spheres/3 GBq dose</td>
<td>1.2 Million</td>
<td>40-80 Million</td>
</tr>
<tr>
<td>FDA approval</td>
<td>Nonresectable hepatocellular carcinoma (humanitarian device exemption)</td>
<td>PMA for concurrent use w FUDR chemotherapy for hepatic metastases from colorectal cancer</td>
</tr>
</tbody>
</table>
Hot Lab/Dose Preparation

• Typical activity at time of treatment is 1 to 8 GBq
• Tumor target dose is 120 Gy (≤30 Gy to lungs)

• TheraSpheres
  – Unit doses
  – NMT assays the dose and records results on WD

• SIRSpheres
  – Bulk doses
  – NMT draws up the dose, assays, and records results on WD
Hot Lab/Dose Preparation

• Follow normal ALARA practices of time, distance, and shielding

• Worked better for us to limit the number of NMTs who do dose preparation for radioembolization cases. More cases per tech but techs more proficient
Surveys for Calculating Activity Delivered

• Percent activity delivered is calculated using a comparison of surveys of the pre-administration dose vial and the post administration waste container.

• Use ionization type survey meter

• Measure on template for reproducible geometry
IR Lab Preparation

• Dose taken to IR and stored securely
• Written Directive and checklist
• Signage on Door, tape roll
• Spill kit
• GM survey meter
• Pre treatment dose survey of vial
• Pre treatment survey of patient
Administration Kit Setup
Dose Administration

- Everyone in room wears lead skirt/vest/thyroid shield
- Physician wears leaded eyewear, others may also
- Use rolling and pulldown acrylic shields
- Maximize distance
- No pregnant staff in room
Survey of Staff

• Check with GM meter after procedure:
  – Staff hands and feet before they leave the room
  – Administration kit and cart
  – Floor
  – Linens
  – Fluoro Table and Footswitch
  – Trash
Radioactive Waste

- Physician puts catheters, dose vial, forceps, gloves, towels used to wrap end of catheter, and other waste into the 2L Nalgene waste container.

- Survey the container on the template and record results in WD

- Label container and log into long lived radioactive waste storage
Radioactive Waste

- $^{90}\text{Sr}/^{90}\text{Y}$ generator: carrier free Y-90

- Reactor produced: several ppm long lived impurities

<table>
<thead>
<tr>
<th>Isotope</th>
<th>T$_{1/2}$</th>
</tr>
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<tbody>
<tr>
<td>$^{88}\text{Y}$</td>
<td>106.6 d</td>
</tr>
<tr>
<td>$^{152}\text{Eu}$</td>
<td>13.6 y</td>
</tr>
<tr>
<td>$^{154}\text{Eu}$</td>
<td>8.8 y</td>
</tr>
<tr>
<td>$^{57}\text{Co}$</td>
<td>270.9 d</td>
</tr>
<tr>
<td>$^{60}\text{Co}$</td>
<td>5.27 y</td>
</tr>
</tbody>
</table>

- Store waste until exposure rate indistinguishable from background

Gundersen Lutheran Medical Center, Inc. | Gundersen Clinic, Ltd.
Post Administration Patient Care

- Bremsstrahlung radiation is given off post-treatment. Typically right after administration we measure:
  - 2 to 3 mR/hr at surface
  - 0.2 to 0.3 mR/hr at 1 m

- Patients released as outpatients w no special precautions required

- Resin microspheres may have free Y-90 on their surface, up to 0.4% of the administered activity.
  - Can be excreted in the urine in the first 24 hours
  - Special precautions may be required for inpatient care
  - Nursing instruction necessary to prevent excessive staff anxiety
Post-treatment Surgical Considerations*

- Assuming 10 GBq dose infused:

<table>
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<th>Days post calibration</th>
<th>60 days</th>
<th>180 days</th>
<th>270 days</th>
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<tr>
<td>Contact with liver (&lt;1 cm, hands)</td>
<td>0.6 mrem/h (6 µSv/h)</td>
<td>0.26 mrem/h (2.6 µSv/h)</td>
<td>0.07 mrem/h (0.7 µSv/h)</td>
</tr>
<tr>
<td>50 cm (20 inches) from center of treated volume (body)</td>
<td>0.007 mrem/h (0.07 µSv/h)</td>
<td>0.003 mrem/h (0.03 µSv/h)</td>
<td>0.001 mrem/h (0.01 µSv/h)</td>
</tr>
</tbody>
</table>

- Standard estimate of daily background dose from natural sources is 0.5-0.8 mrem/day (or 0.5-0.8 µSv/day)

- Estimated 1 hour radiation dose during surgical resection, at 60 days post TheraSphere® infusion, yields 0.8-1.2% of normal daily background dose to the body

- Another perspective: A US coast to coast flight is 4 mrem (to the body) or 667 times the dose received during the surgical procedure at 60 days.

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<tr>
<td>Dose to body</td>
<td>&lt; 667x dose from flight</td>
<td>&lt; 1500x dose from flight</td>
<td>&lt;5700x dose from flight</td>
</tr>
</tbody>
</table>

*TheraSphere® Reference Manual US, 2010
Post-Surgical Specimen Handling*

• No precautions required if surgical resection >34 days post treatment

• If <34 days post treatment, survey specimen with thin window ionization chamber. If >0.02 mSv/hr, label specimen as radioactive, shield it, and wait until 3X background before cleared for routine pathology analysis

*Recommendations are per Vanessa Gates at Northwestern
Patient Death

• Autopsy
  – If <34 days post administration and exposure time > 1 hour, surgeon may want to remove liver prior to autopsy

• Embalming and Burial
  – No special precautions required for glass microspheres
  – If <48 hours post administration of resin microspheres, embalming fluid should be saved and stored for radioactive decay
Patient Death

• Cremation
  – Some states limit the total activity that can be cremated at any individual crematorium in a year

  – Depending on state regulations, the crematorium may ask for an estimate of radioactivity in the body
Acknowledgements

• Alan Daus, Senior Diagnostic Physicist, Gundersen Health System

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Questions?

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