Y-90 SIRT in the Liver: Dose Calculation and Post-Therapy Imaging

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Special thanks to
David Brandon, MD
James Galt, PhD
Hamilton Reavey, MD
and David Liu MD
No COI

Will discuss non-FDA approved techniques and mention commercial names
Talk can be found at radiology.emory.edu
Department of Radiology and Imaging Sciences

Mission Statement

Emory Department of Radiology and Imaging Sciences serves the community through advanced innovation, translational research and clinical application of imaging sciences. The department is committed to excellence in scholarship and to the training of next generation of radiologists, technologists, and imaging scientists. The department’s goal is to provide the highest quality patient care with predictive, diagnostic, and therapeutic imaging-based approaches.

Recent Accomplishments

2013 Distinguished Investigator Award

Baowei Fei was one of 43 researchers that were selected as recipients of the Academy of Radiology Research (ARR) 2013 Distinguished Investigator Award. The Distinguished Investigator Award recognizes individuals for their accomplishments in the field of imaging research and significant contributions to the record of scientific progress and innovation. The ARR held an induction ceremony for members of its Council of Distinguished Investigators on Monday, December 2 at RSNA 2013.
The faculty of the Emory Division of Nuclear Medicine & Molecular Imaging offers the highest quality patient care, incorporating the latest knowledge, innovation and equipment. Nuclear Medicine not only uses the most advanced methods, but also helps set the bar for the field. All of our physicians are board certified in nuclear medicine, and some are double-boarded in other fields, particularly Radiology, many have national and international reputations in their fields.

Equipment includes PET/CT and SPECT/CT scanners at Emory University Hospital (Clifton campus) and Emory University Hospital Midtown. We offer a wide variety of specialized nuclear medicine therapies including that for thyroid cancer, bone cancer pain palliation, lymphoma, neuroendocrine tumors and Y-90 liver therapy in cooperation with Interventional Radiology. Research devices at our disposal include a high-resolution brain PET scanner, micro-PET/CT for animal research, and a research cyclotron. A full range of nuclear medicine and PET/CT services are also provided at Grady Memorial Hospital, Emory Johns Creek Hospital, and the Atlanta VA Medical Center. The Division is integrally involved in research as well as close collaboration with colleagues in Radiology, Cardiology and the Emory Winship Cancer Institute. Our faculty are principal investigators and co-investigators on many research grants including those sponsored by the NIH.

- David M. Schuster, MD
  Associate Professor of Radiology and Imaging Sciences
  Director, Division of Nuclear Medicine and Molecular Imaging

**Recent Conferences**

Lecture:  
**Molecular Imaging of Prostate Cancer: Beyond the Bone Scan**  
Lecturer: **David Schuster, MD**

35th Annual High Country Nuclear Medicine Conference in Vail  
Feb 28-Mar 5

Lecture:  
**Robert Lull Memorial Lecture: Growing into Mentorship**  
Lecturer: **David Schuster, MD**

Society of Nuclear Medicine 2013 Annual Meeting June 8-12th
Let’s Start with a Case

55 year old male with central-right lobar hepatoma.

Treated with $^{90}$Y TheraSphere.

How did we do?
$^{99m}\text{Tc MAA Planning study}$

Bremsstrahlung post-study matches very well
Fusion of MR with MAA (left) and Bremsstrahlung (right): only a small area of tumor (mostly edema) is left untreated.

Acceptable (vascular supply) and patient will be followed.
One example:
Proper imaging
Team planning

Appropriate dose delivered to the correct area

Confirmed again with imaging

In turn, useful for followup
Outline

- Background
- Basic components of successful Y90 program
- Difference between glass and resin Y90 spheres
- Methods of calculating Y90 dose
- Reduction factors
- Documentation and Billing
- What is Bremsstrahlung?
- Importance of pre and post-therapy SPECT-CT
- Extrahepatic uptake and tumor coverage
- PET vs SPECT post-therapy
- Cutting edge
HAIC
Hepatic Arterial Infusion Chemotherapy

• Briefly discuss close cousin of Y90
• Aim to increase drug concentration in tumor tissue
• Used less frequently today but understanding principles will help with MAA and Y90

– Mahnken et al. Radiology 2013;266:407
HAIC
Hepatic Arterial Infusion Chemotherapy

- Subcutaneous port linked to intra-arterial catheter in hepatic artery
- Can be done percutaneously or surgically
- Requires single hepatic artery feeding segment(s) of liver to be infused
- Careful mapping and flow remodeling to infuse proper areas and protect extra-hepatic structures such as the stomach
Hepatic Arterial Infusion Pump

- 3-5 mCi Tc-99m MAA
- LFOV, LEHR collimators
- Injected through pump by the surgeon
- Flow study: anterior flow images (5 sec per frame x 1 minute)
- Planar images to confirm correct placement of distal tip, best to use SPECT/CT
- Look for patent catheter, no leak, no uptake in gut or extrahepatic tissue
Hepatic Arterial Infusion Pump
Hepatic Arterial Infusion Pump
Cancer and the Liver

- **Primary Liver Cancer (includes IHC)**
  - 30,640 new cases in the US in 2013*
  - 21,670 deaths
- **Liver Metastasis**
  - > 80% of cancers involving the liver are secondary
  - Hepatic metastases occur in 40-50% of adult patients with extrahepatic primary malignancies
  - Colorectal, breast, lung, melanoma, neuroendocrine
  - Significant source of morbidity and mortality

* American Cancer Society
Radiotherapy Background

- External beam radiotherapy does not improve overall survival with diffuse disease

- Need at least 70 Gy to destroy solid tumor
  - Liver itself has tolerance of only 30 Gy
Radiotherapy Background

- Thus, targeted therapy has allure
  - $^{131}$I-lipiodol studied in past
  - Now $^{90}$Y microspheres
- But actually tried in 1970s in proper hepatic artery with good results
Malignancy and Vascular Supply

- **HCC**
  - Tumors > 2 cm derive > 80% of their blood supply from the hepatic arterial system
  - Normal liver: 80% from the portal venous supply

- **Liver metastases**
  - More variable blood supply
  - For hypovascular metastases the small particle size of the microsphere may aid in adequate deposition
Selective Internal Radiotherapy

• Percutaneous trans-arterial administration of micron-sized embolic particles containing a radioisotope
  – Deliver a higher dose of radiation to a small target volume
  – Low toxicity profile
  – Primarily done in non-resectable patients

• Multidisciplinary collaborative process
Problem: Unresectable liver metastases (and HCC) are the driving factor for mortality in a number of cancers

Goal

- Prolong survival
- Improve time to progression
- Bridge to transplantation for HCC

- *Kulik, J Surg Onc 2006*
Liver SIRT Agents

- FDA approved
  - SIR-Spheres (Sirtex, Lane Cove, Australia)
  - TheraSphere (MDS Nordion, Ottawa, Canada)

- Not FDA approved but used in Europe
  - Iodine-131 Lipiodol

- Experimental
  - Rhenium-188 iodized oil
  - Holmium-166 chitosan
Liver SIRT FDA Indications

- FDA approved
  - SIR-Spheres (Sirtex, Lane Cove, Australia)
    - Indication: treatment of unresectable metastatic liver tumors from primary colorectal cancer with adjuvant intra-hepatic artery chemotherapy (IHAC) of FUDR (Floxuridine)
    - Approved: 2002
  - TheraSphere (MDS Nordion, Ottawa, Canada)
    - Indication: radiation treatment or as a neoadjuvant to surgery or transplantation in patients with unresectable HCC who can have placement of appropriately positioned hepatic arterial catheters. The device is also indicated for HCC patients with partial or branch portal vein thrombosis/occlusion, when clinical evaluation warrants the treatment.
    - Approved: 2000 under HDE
Yttrium-90

- Decay product of strontium-90 or produced by neutron bombardment of Yttrium-89
- Pure beta emitter with a mean energy of 0.94 MeV, max 2.27
  - 1 GBq (27 mCi) delivers a total absorbed dose of 50 Gy/kg
  - Rare positron
- Tissue penetration range mean 2.5, max 11 mm
- 2.67 day half life (≈64 hours)
- Shelf life of the device is 24 hours
**Y-90 Microspheres Compared:**

For SIR-Spheres, draw desired dose from vial and stop at completion/stasis. For TheraSphere, give entire vial, so must order correct activity vial.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Glass TheraSphere</th>
<th>Resin SIR-Spheres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>20 - 30 µm</td>
<td>20 - 60 µm</td>
</tr>
<tr>
<td>Isotope</td>
<td>Y90 in glass matrix</td>
<td>Y90 on resin surface</td>
</tr>
<tr>
<td>Dose activity</td>
<td>Partition Model</td>
<td>Body Surface Model</td>
</tr>
<tr>
<td>Manufacture</td>
<td>Reactor (neutron flux)</td>
<td>Generator (Sr-90)</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>3.6g/dL</td>
<td>1.6g/dL</td>
</tr>
<tr>
<td>Activity/Sphere</td>
<td>150-2200 Bq</td>
<td>65-140 Bq</td>
</tr>
<tr>
<td>Right Liver Dose</td>
<td>4.75 GBq</td>
<td>1.5GBq</td>
</tr>
<tr>
<td>Status</td>
<td>HDE</td>
<td>PMA</td>
</tr>
<tr>
<td>Endpoint</td>
<td>Target Dose</td>
<td>Target Dose or Stasis</td>
</tr>
<tr>
<td># of Spheres/Dose</td>
<td>2.5 - 30 Million</td>
<td>15 - 19 Million</td>
</tr>
</tbody>
</table>
SIR-Spheres

- Data mostly with resin spheres on colorectal and also NET, breast cancer and melanoma.
- Data heterogenous and in salvage situation.
- Few randomized controlled trials.
SIR-Spheres

- Early randomized controlled trials
  - Gray compared SIR-Spheres + regional to regional chemotherapy in 74 patients and demonstrated improved tumor response and progression free survival, and overall survival difference

- Van Hazel randomized controlled trial compared SIR-Spheres + systemic chemotherapy to systemic chemotherapy in 21 patients showed a TTP (18.6 vs 3.6 months) and median survival benefit (29.4 vs 12.8 months).
Meta-analysis

  - High response rates especially if used in combination with systemic
  - But cannot reach firm conclusions on overall survival
  - Also no conclusions as to glass vs resin
  - Most studies in 2nd or 3rd line therapy
SIR-Spheres – Few of Many Trials

- SIRFLOX randomized control trial comparing FOLFOX to FOLFOX + SIR-Spheres in first line treatment in non-resectable colorectal liver metastases
  - >500 patients
  - Multinational trial
  - Estimated primary completion date April 2014
- Other Ongoing RCTs
  - FOXFIRE (metastatic colorectal cancer, 209/320 as of May 2013, open)
  - SORAMIC (for HCC, multicenter, recruiting, primary completion September 2014; 347 enrolled as of late 2013)

Murthy R et al. Radiographics 2005;25:S41-S55
Update in www.clinicaltrials.gov
Microsphere Side Effects

- Less than chemoembolization (50% vs 90%)
  - Common
    - Fatigue
    - Abdominal pain
    - Nausea
    - Fever
    - Transient elevation of transaminases
Microsphere Side Effects

– Severe (2-8%)
  • Chronic abdominal pain
  • Non-target irradiation
    » Stomach/small intestine: gastritis, ulceration, GI bleed
    » Lung: radiation pneumonitis, right pleural effusion
    » Liver: Hepatitis, hepatic fibrosis, portal hypertension
    » Cholecystitis
    » Pancreatitis

  • Nonuniform trapping of microsphere explains low hepatic toxicity per Gray (and also granular appearance on PET)
Patient Selection

- Ensure safe hepatic arterial injection
  - Exquisite detail to angiography
  - Coil embolization to prevent non-hepatic deposition

- Lung shunt resulting in greater than 30 Gy dose to the lungs in a single treatment or an expected cumulative dose of 50 Gy
How Do We Do It?

- Start with IR Consult after referral from surgical or medical oncology
- Weekly IR-NM $^{90}\text{Y}$ Conference
  - Images reviewed with IR
    - Ideally before MAA study
  - Therapy plan
  - Usually one lobe or less at a time
    - Hepatic reserve
  - Also review and critique prior cases
Weekly NM-IR $^{90}$Y Conference
How Do We Do It?

- Patient undergoes $^{99m}$Tc MAA shunt study
  - Vascular anatomy mapped
  - Pulmonary shunt or extrahepatic activity?
- Planar and SPECT-CT
How Do We Do It?

- Calculate therapy dose
  - Volumes of liver and tumor
  - Which lobe or segment and if split dose
  - Lung shunt
  - Labs (LFTs)
- Dictate NM planning note
  - Email information to attendings of day
- Written directive signed by AU
- NM faculty present during therapy
MAA Shunt Study

- 4 mCi (150 MBq) Tc-99m MAA is injected in transarterially
- Anterior and posterior images of the thorax and upper abdomen
  - Also SPECT-CT
- Region of interests drawn around the liver and the lungs
- Liver to lung ratio is calculated
Tc-99m MAA Planar Evaluation
Shunt Evaluation Prior to Y-90 Microsphere Therapy

- Male with hepatocellular carcinoma
- 4.3 mCi Tc-99m MAA
- 6.9% shunt from liver to lung
- Proceed with treatment planning

Lung counts:
- Anterior = 61.37k
- Posterior = 62.24k
- Lung geometric mean = 61.81k

Both Lung and liver counts:
- Anterior = 1722.69k
- Posterior = 463.53k
- Lung and liver geometric mean = 893.60k

Lung shunt = 6.92%

\[
\text{LungShunt} = \frac{\sqrt{\text{AnteriorLungCounts} * \text{PosteriorLungCounts}}}{\sqrt{\text{AnteriorLung & LiverCounts} * \text{PosteriorLung & LiverCounts}}}
\]
Tc-99m MAA Planar Evaluation
Shunt Evaluation Prior to Y-90 Microparticle Therapy

- 73 year old female
- 4 mCi Tc-99m MAA
- 65% shunt from liver to lung
- No Treatment

Lung counts:
Anterior = 162.24k
Posterior = 139.87k
Lung geometric mean = 150.64k

Both Lung and liver counts:
Anterior = 235.16k
Posterior = 231.92k
Lung and liver geometric mean = 233.53k

Lung shunt = 64.5%
Normal Pattern of Uptake on MAA SPECT-CT

- MAA is performed non-selectively (or selectively) with catheter in hepatic artery
- MAA distribution should be present throughout the entire infused liver area without significant extra-hepatic uptake
Gastric and Duodenal Uptake on MAA (Carcinoid)
Mesenteric, Duodenal and Pancreatic Uptake on MAA (PNET)
High Lung Shunt on MAA SPECT

The fraction of shunting was calculated to be 51.37%. Because the risk of radiation pneumonitis in this patient was so high, treatment was not performed.
## BSA or Partition?

<table>
<thead>
<tr>
<th>Ceramic Microspheres (TheraSphere)</th>
<th>Partition Model</th>
<th>Based on Liver Mass</th>
<th>High Specific Activity Particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin Microspheres (SIR-Spheres)</td>
<td>BSA Model</td>
<td>Based on body surface area, and tumor infiltration</td>
<td>Lower Specific Activity Particles</td>
</tr>
</tbody>
</table>


Alexander J. McEwan, M.D., Charles Nutting, D.O., Al Benson, III, M.D., F.A.C.R.,
Joseph Espat, M.D., M.S., F.A.C.R., Jose Ignacio Bilbao, M.D.,
Ricky A. Sharma, M.D., Ph.D., James P. Thomas, M.D., Ph.D.,
and Douglas Coldwell, M.D., Ph.D.
Other Methods

Image-Guided Personalized Predictive Dosimetry by Artery-Specific SPECT/CT Partition Modeling for Safe and Effective $^{90}$Y Radioembolization

Yung Hsiang Kao¹, Andrew Elk Hock Tan¹, Mark Christiaan Burgmans², Farah Gillian Irani², Li Ser Khoo³, Richard Hoau Gong Lo², Kiang Hiong Tay², Bien Soo Tan², Pierce Kah Hoe Chow³,⁴, David Chee Eng Ng¹, and Anthony Soon What Goh¹

¹Department of Nuclear Medicine and PET, Singapore General Hospital, Singapore; ²Department of Diagnostic Radiology, Singapore General Hospital, Singapore; ³Department of General Surgery, Singapore General Hospital, Singapore; and ⁴Office of Clinical Sciences, Duke-NUS Graduate Medical School, Singapore

Nuclear Medicine & Radiation Therapy

Patient Specific 3D Image-Based Radiation Dose Estimates for 90Y Microsphere Hepatic Radioembolization in Metastatic Tumors

Andrew Kennedy¹, William Dezarn² and Alec Weiss²

¹Co-Medical Director, Wake Radiology Oncology, 300 Asheville Ave., Suite 110, Cary, NC, 27518 USA
²Adjunct Associate Professor, Department of Biomedical Engineering, Department of Mechanical and Aerospace Engineering, North Carolina State University, Raleigh, NC, USA
³Department of Biologic Systems Engineering, Campus Box 7010, Broughton Hall 4160, North Carolina State University, Raleigh, NC 27695-7010 USA
Know Liver Anatomy

- Middle hepatic vein separates the right and left hepatic lobes
  - If the middle hepatic vein cannot be seen, use gallbladder fossa
- The portal vein separates the superior and inferior hepatic lobes

Image courtesy of Eric Jablonowski, Emory University
Let’s Start with SIR-Spheres at Most Basic Level: Empiric “Eyeball” Method

\[ A \text{ [GBq]} = \text{Liver Involvement Activity} \times \text{LSM} \times \text{LPM} \]

<table>
<thead>
<tr>
<th>Estimated degree of liver involvement</th>
<th>Standard dosage of Y-90 [GBq]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;50%</td>
<td>3</td>
</tr>
<tr>
<td>25%–50%</td>
<td>2.5</td>
</tr>
<tr>
<td>&lt;25%</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Lung shunting</th>
<th>Lung shunt modifier (LSM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10%</td>
<td>1.0</td>
</tr>
<tr>
<td>10%–15%</td>
<td>0.8</td>
</tr>
<tr>
<td>15%–20%</td>
<td>0.6</td>
</tr>
<tr>
<td>&gt;20%</td>
<td>Do not proceed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part of liver</th>
<th>Liver part modifier (LPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole liver</td>
<td>1.0</td>
</tr>
<tr>
<td>Right lobe only</td>
<td>0.7</td>
</tr>
<tr>
<td>Left lobe only</td>
<td>0.3</td>
</tr>
</tbody>
</table>

We prefer using more “objective” approach. Deconstruct to understand what we need.

**SIR-Spheres calculation:**

Dose in GBq = (BSA – 0.2) + (% tumor involvement of liver/100)

In this method, BSA is a proxy for liver volume.

If lobar therapy is used would just then multiply by that lobar fraction of entire liver (e.g. right lobe, 60%).

Then reduce per standard reduction factors.
Actually employ a more advanced variant which requires right and left lobe tumor and liver volumes to be known

Lobar dose in GBq =

\[\text{[(BSA} - 0.2) + (\% \text{ tumor involvement of lobe to be treated}/100)] \times \text{[percent of total liver that treated lobe comprises]}\]

Then apply various correction factors.
Liver and Tumor Volumes from OctreoScan SPECT-CT on an Advanced Workstation

Calculated in 3-dimensions
Another Example Using a PET-CT

Try to use molecular imaging when possible but same concepts apply to using anatomic imaging
This Method Has Higher Kappa than “Eyeballing”

• In a small study at Emory, objective approach yields better precision compared to subjective estimation.

• Factors that contributed to observed deviation:
  – Necrosis
  – Difficulty in defining margins of infiltrative tumors
  – Discrepancy between the PET and CT derived volumes
Ingredients for Equation

- BSA
- Volumes
- Lung shunt
- Recent bili, albumin
- Other factors such as recent and heavy chemotherapy

Lung counts:
Lung counts ANT = 227.02k
Lung counts POST = 214.95k
Lung average counts = 220.90k

Both lung and liver counts:
Both lung and liver counts ANT = 1628.09k
Both lung and liver counts POST = 1174.44k
Both lung and liver average counts = 1382.78k

Lung ratio = 15.98%
Common Reduction Factors

- Shunt per Sirtex online calculator
  - [http://apps01.sirtex.com/smac/](http://apps01.sirtex.com/smac/)
  - 30 Gy to lungs per session; 50 Gy cumulative
- Recent multiple or long-term chemotherapy (20%)
  - Recommend wait 2 weeks after Avastin
- Abnormal LFTs (Bili>2.0, Albumin <3.0) (30%)
- Small tumor load <5% (20%)
- Previous radiotherapy (non ⁹⁰Y) except CyberKnife (20%)
- For HCC diffuse tumor: reduce by 25%
  - (Abnormal LFTs, as above, contraindicated)
- Segmental therapy protects liver; may use higher doses
Plug Into Equation
Use: On-line System and/or Internal Spreadsheet
### Emory University Hospital

**SIRTEX Dose Calculation Sheet**

<table>
<thead>
<tr>
<th>Calculation</th>
<th>( \text{BSA} - 0.2 \times % \text{involvement}) \times 27 \times (1- \text{redux factor}) \times (% \text{liv lobe treated}) \</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date:</td>
<td>11/15/2011</td>
</tr>
<tr>
<td>Patient Last name:</td>
<td></td>
</tr>
<tr>
<td>Patient First name:</td>
<td></td>
</tr>
<tr>
<td>MRN:</td>
<td></td>
</tr>
<tr>
<td>DOB/(Age):</td>
<td></td>
</tr>
<tr>
<td>Sex:</td>
<td></td>
</tr>
<tr>
<td>Diagnosis/Tumor Type:</td>
<td></td>
</tr>
<tr>
<td>HT (cm):</td>
<td>175 (cm)</td>
</tr>
<tr>
<td>WT (kg):</td>
<td>67.9 (kg)</td>
</tr>
<tr>
<td>BSA:</td>
<td>1.8244</td>
</tr>
<tr>
<td>% Lung Shunt (3 months):</td>
<td>24.90%</td>
</tr>
<tr>
<td><strong>Volume (cc) Percentage</strong></td>
<td></td>
</tr>
<tr>
<td>Total Liver Organ Volume</td>
<td>2637.00</td>
</tr>
<tr>
<td>RT Liver Organ Volume</td>
<td>1660.00 62.95%</td>
</tr>
<tr>
<td>LT Liver Organ Volume</td>
<td>977.00 37.05%</td>
</tr>
<tr>
<td>RT Liver Tumor Load Estimate</td>
<td>436.00 26.27%</td>
</tr>
<tr>
<td>LT Liver Tumor Load Estimate</td>
<td>549.00 56.19%</td>
</tr>
<tr>
<td>Lobe to be treated (RT / LT):</td>
<td>RT Lobe</td>
</tr>
<tr>
<td>Reduction Factor</td>
<td>20.00%</td>
</tr>
<tr>
<td>Calculations:</td>
<td>(Automatic)</td>
</tr>
<tr>
<td>Calculated RT Lobe Dose:</td>
<td>25.68 mCi Y-90 0.95 GBq Y-90</td>
</tr>
<tr>
<td>Calculated LT Lobe Dose:</td>
<td>17.51 mCi Y-90 0.65 GBq Y-90</td>
</tr>
<tr>
<td>Estimated Lung Dose:</td>
<td>11.59 Gy</td>
</tr>
<tr>
<td><strong>ACTUAL THERAPY:</strong></td>
<td></td>
</tr>
<tr>
<td>Date: (mm/dd/yyyy) / Time</td>
<td></td>
</tr>
<tr>
<td>Y90 SirTex Dose Administered:</td>
<td>mCi Y-90</td>
</tr>
<tr>
<td>Lung Dose Administered:</td>
<td>0.00 Gy</td>
</tr>
<tr>
<td><strong>THERAPY HISTORY:</strong></td>
<td></td>
</tr>
<tr>
<td>Previous Y-90 SIR Dose (s):</td>
<td>mCi Y-90</td>
</tr>
<tr>
<td>Total Y-90 SIR to Date:</td>
<td>0.00 mCi Y-90</td>
</tr>
<tr>
<td>Cumulative Lung Dose:</td>
<td>0.00 Gy</td>
</tr>
</tbody>
</table>

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We carry spreadsheet through after therapy and keep running tally for future...
Special Situations

- **Hepatomegaly**
  - BSA will underestimate volume of liver (and dose).
  - Probably best to use empiric. Treat each lobe as its own liver and wait 2 months between therapies.
  - Each lobe gets about 2-3 GBq.

- **Prior Hepatectomy**
  - BSA method will overestimate remaining liver if you are treating whole liver.
  - So may:
    - Measure out pre-resection volume if available.
    - Take current volume and increase by 25-33% to get theoretical “whole” liver volume (or reduce dose similarly).
Then Dictate Planning Note

NUCLEAR MEDICINE PLANNING FOR PATIENTS RECEIVING Y-90 LABELLED MICROSPHERES

Consult Date: 4/10/2012 for Therapy on: 5/1/12

Height (cm): 176.6 cm
Weight (kg): 70.4 kg
BMI (kg/m²): 1.8 m²

DIAGNOSTIC IMAGING:

Most recent VOG PET CT on 6/17/2012 demonstrated extensive hepatic metastases, eight greater than left, with liver dominant disease.

Most recent CT abdomen on 6/17/2012 demonstrated none.

The available imaging studies were reviewed with the interventional radiologist. Hepatomegaly is present. The hepatic volume is 5900 cc, with 4230 cc right lobe and 1670 cc left lobe. Tumor burden is 3199 cc in the right lobe and 24 cc in the left lobe. The anatomic size differential is 78% from the right lobe and 22% from the left lobe, with 78% tumor involvement of the right lobe and 2% tumor involvement of the left lobe.

Tc99m-MAA hepatic perfusion study from 5/18/2012 showed a pulmonary percent about 15%. No significant extrhepatic or gastric uptake was identified. Based on the value of the pulmonary percent calculation, the dose was not reduced.

LABORATORY DATA: 4/18/2012

Albmin: 2.4 g/dL (1.8-4.8)
Total Bilirubin: 2.5 mg/dL (0.3-1.2)

Based on the laboratory values, the calculated dose was reduced. The dose is reduced by 25% secondary to abnormal LFTs, though modified by hepatomegaly and most of tumor burden on the right which will be treated, protecting the left lobe.

OTHER PERTINENT HISTORY:

Previous liver radiation: None
Chemotherapy within the past 2 weeks (especially Avastin): No

Criteria for Y-90 SIR-Spheres dose reduction:

a. Dose per Statist online calculator (http://www.statist.com/enca/

b. Recent multiple or long-term chemotherapy (20%)
c. Abnormal LFTs: Bilirubin > 1.0, Albumin < 3.0 (20%)
d. Small tumor load (< 10%)
e. Previous Radiotherapy except CyberKnife (20%)

TREATMENT PLAN:

Hepatic lobe to be treated: Right. Left lobe may be treated in the future.

The patient has not been treated with Y-90 SIR-Spheres in the past.

The total Y-90 SIR-Spheres dose delivered thus far is 0 Gy.
Y-90 SIR-Spheres lung dose limit per treatment is 30 Gy, lifetime cumulative lung dose is 50 Gy.

RECOMMENDATIONS:

Based on the above data, the amount of Y-90 SIR-Spheres to be administered was calculated in mCi. The calculated dose was reduced by 25% as above. Reduction was modified by hepatomegaly and the fact that most of tumor burden is on the right which will be treated, protecting the left lobe. The dosimetry falls within the accepted guidelines of the Y90 SIR-Spheres manufacturer and government regulatory agencies. The calculated dose to the right lobe of Y90-SIR-Spheres is 37.2 mCi, with an estimated lung dose of 10.1 Gy.

Please refer to the dose calculation form on file in Nuclear Medicine.

Script signed. Single dose confirmed.

Additional pending labs to be reviewed: None

Additional notes for day of treatment: None

J. David R. Schuster, MD, personally planned this therapy and reviewed all imaging.

Signature Line
*** Final ***

Electronically Signed By: SCHUSTER, DAVID M
on 06/24/2012 15:12

Dictated by: SCHUSTER, DAVID M
Bill for Planning

- CPT 77261: Therapeutic Radiology Treatment Planning; Simple
- CPT 77331: Special Dosimetry
- Also MAA Imaging
- *Please consult with your coding/billing department for appropriate codes in your particular situation*
Bill for Therapy NM

- CPT 77790: Supervision, handling, loading of radioelement
- CPT 77778: Interstitial radiation source application; complex.
- Also Bremsstrahlung imaging
- Please consult with your coding/billing department for appropriate codes in your particular situation
So How About TheraSphere?
Volume Analysis: Dose Based On Volume Infused, Not Tumor. Calculate for 120 Gy to Target Volume

Salem et al. JVIR (Part 1) 2006;17(8):1251-1278
Let's Look at Calculation for TheraSphere

Activity Required (GBq) =

\[
\text{Desired Dose (Gy)} \times \text{mass of liver (kg)}
\]

\[
50 \times [1 - LSF] \times [1 - R]
\]

(80-150 Gy, typically 120 Gy)

Dose is more in 2-5 GBq range
Similar Concepts But Key Differences

- Need recent LFTs and Lung Shunt from MAA
- Volume of area critical but do not need volume of tumor per se
- Other LFTs on Package Insert “Therapy Cautioned”

A retrospective study of 121 patients from 5 clinical trials has shown that the following 5 Pre-treatment High Risk Factors have been associated with at least 48% of all serious adverse events that were possibly related to use of the device and with 11 of the 12 deaths that were possibly related to use of the device:

- infiltrative tumor type
- “Bulk disease” (tumor volume > 70% of the target liver volume, or tumor nodules too numerous to count)
- AST or ALT > 5 times ULN
- bilirubin > 2 mg/dL
- tumor volume > 50% combined with an albumin < 3 g/dL

The physician should always take the above-noted Pre-treatment High Risk Factors into consideration for each patient when making decisions regarding the use of TheraSphere for treatment.
Calculate Volume of Therapy

Use anatomic or functional image.
In this case we knew area to be treated exactly from MAA distribution.
So derived volume based on MAA.
Spreadsheet to calculate dose and to time therapy. Need volume, lung shunt, and desired dose to area (typically 120 Gy).

Can now do a custom vial size (in increments of 0.5 GBq between 3 and 20 GBq) to best tailor time of administration.

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>XYZ (enter data)</th>
<th>Patient ID:</th>
<th>**** (enter data)</th>
<th>Target Tissue:</th>
<th>Lobe (enter data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Volume (cc):</td>
<td>1850.0</td>
<td>Target Liver Mass (kg):</td>
<td></td>
<td>1.030</td>
<td></td>
</tr>
<tr>
<td>Desired Dose (Gy):</td>
<td>8</td>
<td>Time Zone Variance (h):</td>
<td></td>
<td>(see Time Zones tab for details)</td>
<td></td>
</tr>
<tr>
<td>Lung Shunt Fraction (% LSF):</td>
<td>5.00%</td>
<td>Places in this Time Zone:</td>
<td></td>
<td>Ottawa Ontario</td>
<td></td>
</tr>
<tr>
<td>Anticipated Residual Waste (%):</td>
<td>1.00%</td>
<td></td>
<td></td>
<td>Optional estimated value</td>
<td></td>
</tr>
<tr>
<td>Required Activity at Administration (GBq):</td>
<td>2.63</td>
<td>Time Zone Variance (h):</td>
<td></td>
<td>0 (see Time Zones tab for details)</td>
<td></td>
</tr>
</tbody>
</table>

Use the following tables to select a dose size where the Desired Dose (above) is at a suitable treatment time.

### Dose Delivered (Gy) for a Custom Dose size:

<table>
<thead>
<tr>
<th>Dose Size Selected (GBq):</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day @ 12:00 AM</td>
<td>1.030</td>
</tr>
<tr>
<td>Day @ 12:00 PM</td>
<td>1.030</td>
</tr>
<tr>
<td>Day @ 12:00 PM</td>
<td>1.030</td>
</tr>
<tr>
<td>Day @ 12:00 AM</td>
<td>1.030</td>
</tr>
<tr>
<td>Day @ 12:00 PM</td>
<td>1.030</td>
</tr>
</tbody>
</table>

All dose vials will have Sunday calibration at 12:00 Eastern Time.

Standard dose vial sizes (3, 5, 7, 10, 15, 20 GBq) are available from inventory for next-day shipping. Order as required.

Custom dose vial sizes should be ordered by end of business Tuesday prior to Sunday calibration to ensure availability.
**Manufacturing Cycle –**
**Tuesday Order Cut-off for Custom Dose But Standard Dose Vials May Be Ordered Any Time if Available**

---

## TheraSphere® Manufacturing Cycle

Repeated Weekly

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>TheraSphere Order Cut-off</strong></td>
<td>TheraSphere Manufacturing Day</td>
<td>Ship TheraSphere</td>
<td>Ship TheraSphere</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12:00 hrs ET</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>COMPLETE PATIENT EVALUATION</strong></td>
<td><strong>TREATMENT WINDOW ILLUSTRATOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TheraSphere Calibration</td>
<td>12:00 hrs ET</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td></td>
</tr>
<tr>
<td>TREATMENT WEEK ONE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Use TheraSphere</td>
<td></td>
</tr>
<tr>
<td>TREATMENT WEEK TWO</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Ship / Use TheraSphere</td>
<td>Use TheraSphere</td>
<td>TheraSphere Expiration @ 24:00 Friday ET</td>
</tr>
</tbody>
</table>

---

**Note:**
- TheraSphere® is a registered trademark of Sirtex Medical Limited.
- TheTheraSphere® Manufacturing Cycle is repeated weekly.
- The TheraSphere® Order Cut-off is 12:00 hrs ET on Tuesday.
- Standard dose vials may be ordered at any time if available.
- The treatment window is illustrated in the chart.
- Calibration is performed at 12:00 hrs ET on a Sunday.
- Treatment weeks one and two follow the order specified in the chart.
- The TheraSphere® Expiration is 24:00 Friday ET.
Dose Calculation

• If you want to use more beads, order larger dose and let it decay longer.
On Day of $^{90}Y$ Therapy

- Procedure team effort IR, NM, RSO oversight
- Running checklist completed.
  - NM Tech and Faculty visit patient in holding area to review radiation safety precautions and “put a face to a name.”
  - NM Faculty in room when dose actually pushed by IR, but NM tech prepares all beforehand.
    - Other technical checklists and forms filled out by NM tech.
Key Team Members

Lee Nichols, NP

Hillary Karp, PA

Gerarda Sanchez, PA

IR MidLevels

Jason Roberts and Jim Fitz (Chief Tech)
NM ⁹⁰Y Team
**Checklist and Rad Safety Forms**

**SIREX ORDER OF PROCEDURE**

<table>
<thead>
<tr>
<th>Patient</th>
<th>Date</th>
</tr>
</thead>
</table>

**NUC. MED ATTENDING**

| PIC | CELL |

**READING ROOM 2: 7434**

**BACKUP NM ATTENDING**

| PIC | CELL |

**CALL TO ORDER**

This checklist should be reviewed before the patient is brought to the IR suite by the AU and Physicist or designee, as below, and orally called out in the IR suite before the procedure begins. On the evening before the therapy a copy of the Therapy Plan will be presented, along with the dose calculation sheet and Call to Order sheet, to the NM resident or if not available, the NM Physician who will be attending the therapy. (Jim Fry)

Before the dose is drawn up, Dr. Kim will notify the NM Physician is the dose is to be split. Preferably, this will be done in advance when the dose is initially calculated.

If possible, NM Physician should introduce himself/herself to the patient at which time patient ID will be reconfirmed.

**PRIOR TO PROCEDURE - Reviewed by NM Physician**

- Confirm patient’s non-pregnant status if applicable. (Female Patients >50yo with child bearing potential - serum pregnancy test)
- Confirm that any last minute lab values have been ordered
- Confirm dose calculation and written directive match. (Attending/Resident)
- Confirm dose is correct based on given volume
- Confirm which liver lobes will be treated
- Confirm total dose to that lobe matches the physician directive
- Confirm how many injection doses were requested and prepared and the vascular location for each injection

**IN PROCEDURE ROOM - Reviewed by Physicist**

- Confirm Dose Name, Isotope and Patient Name match
- Septum is not pierced until AU is available and Call to Order Sheet reviewed.
- Confirm that the flooring around the injection area has been properly covered.
- Confirm that all pre-therapy radiation measurements have been made and recorded.
- I.R. Call to order confirmed

**Authorized User Signature**

**Physicist/SSO/Designee Signature**

---

**Emory University Hospital - Division of Nuclear Medicine**

**RADIATION SAFETY INSTRUCTIONS FOR PATIENTS RECEIVING Y-90 MICROSHELVES**

**WHAT PRECAUTIONS ARE NECESSARY AFTER RECEIVING YITTRIUM-90 MICROSPHERES?**

You have received a treatment involving radioactive materials. The radioactive material that has been administered is in the form of microscopic spheres, which become trapped in the small blood vessels in the liver and remain there permanently. While the microscopic spheres remain in your liver tissue, the radioactivity decays away, so that after 14 days only 2.3% of the original amount remains and after one month virtually no radioactivity remains in your body.

- Radiation from yttrium-90 microspheres does not penetrate outside the body, but a small amount of the radioactive yttrium may become unattached from the microspheres and be present for about a week following treatment in body fluids, such as blood and urine. Certain precautions are suggested for one week after treatment to limit any potential radiation exposure to others. You should wash your hands thoroughly after urination and use a condom during sexual intercourse.

You can usually return to work and your usual activities following treatment. The following are recommended instructions after treatment with yttrium-90 microspheres:

**Recommended Instructions**

**After Treatment with Yttrium-90 Microspheres**

<table>
<thead>
<tr>
<th>Period</th>
<th>Instructions</th>
</tr>
</thead>
</table>
| Soon   | - Clean up spills now.  
- Wash hands thoroughly after using toilet.  
- No pregnant visitors.  
- Sleep alone.  
- Keep a distance of 5 feet from others.  
- Do not allow children or pets to sit on your lap. |
| 1 Week | Use condoms for sexual relations. |
| 27 Days| In the event of medical emergency or death, a family member or guardian shall notify the attending medical staff or hospital director of the date and type of radioactive material treatment. |

Please direct any questions you have to the: Nuclear Medicine Department at 404-712-3017.

I have read these instructions and agree to follow them.

**Signature**

**Date**
After the Therapy

- Bremsstrahlung scan post-procedure
  - SPECT-CT immediately
    - Can do planar and up to 24 hours
  - Look for adequacy of coverage and extrahepatic deposition
- Compared with MAA and tumor imaging
  - Especially useful to plan next therapy
Importance of SPECT-CT

• SPECT/CT
  - More accuracy than planar imaging
  - Useful in pre and post therapy imaging
    • To demonstrate $^{90}$Y microsphere uptake by region/tumor and extrahepatic uptake
  - May aid in the future for more precise personalized dosimetry
**Importance of SPECT-CT**

- **Hamami ME et. al.**

  - SPECT/CT increases sensitivity and specificity of $^{99m}$Tc MAA for detecting extrahepatic arterial shunting

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Planar</td>
<td>25%</td>
<td>87%</td>
<td>72%</td>
</tr>
<tr>
<td>SPECT</td>
<td>56%</td>
<td>87%</td>
<td>79%</td>
</tr>
<tr>
<td>SPECT/CT</td>
<td>100%</td>
<td>94%</td>
<td>96%</td>
</tr>
</tbody>
</table>
Bremsstrahlung

- Braking Radiation
- $^{90}\text{Y}$ also decays with few positrons which can be imaged with newer generation PET scanners
  - Internal pair production
  - 23/1,000,000 decays
99mTc Spectrum Made with a Scintillation Camera

- **99mTc (Technetium 99m)**
  + Internal Transition
  + 6 hour half-life
  + 140 keV gamma ray

  ![99mTc Spectrum](image1)

- **90Y (Yttrium 90)**
  + Beta Decay
  + 64 hour half-life
  + Only Bremsstrahlung Radiation

  ![90Y Spectrum](image2)
Bremsstrahlung SPECT/CT

- Collimator - medium energy collimator
  - MEAP or MEGP
    - Some trying high energy
- Energy Windows 108 keV, 32%
- No photopeak
  - If the camera usually auto-peaks on acquisition, should turn this off
Fusion Helps Post-therapy

Fused FDG and Bremsstrahlung confirms $^{90}$Y coverage of tumor
Bremsstrahlung Imaging to Prove Entire Liver Treated and No Extrahepatic Deposition

Right lobe therapy  Left lobe therapy  Fusion to complete the puzzle
Poor Coverage of Hepatic Dome on MAA (Breast Cancer) But Tumor on PET-CT
Post treatment SPECT CT and fusion of Bremsstrahlung and PET images show adequate coverage of region.

- PET-CT
- Brehm SPECT-CT
- Brehm-FDG Overlay
Incomplete Coverage on Post-Treatment Images

Fusion of Bremsstrahlung SPECT images and PET-CT images: approximately 25% of the tumor intended to be treated received Y-90 coverage.
Another Case Where Bremsstrahlung Demonstrated How Much Tumor Was Treated and That Additional Therapy Needed

Detail from OctreoScan

Post-left lobe Bremsstrahlung

Fusion shows portion of tumor (white) untreated in this session (black). (Unavoidable 2° vascular anatomy)

Residual can be quantified
Unexpected Extrahepatic Uptake
Patient with Breast Carcinoma Metastatic to Liver. MAA 10% shunt.

FDG PET-CT

Right lobe treated 36 mCi with $^{90}$Y without complication

Bremsstrahlung SPECT-CT
Unexpected Extrahepatic Uptake

But when we treated left lobe with 14.5 mCi

Activity tracking along umbilical vessels to umbilicus
Unexpected Extrahepatic Uptake

In retrospect, visible on MAA only if very highly windowed
**Unexpected Extrahepatic Uptake**

Patient developed radiation burn which later granulated and resolved.

Falciform artery may only be visible on extended contrast injection and prolonged imaging.
Unexpected uptake with $^{90}$Y Therapy post right hepatectomy. No uptake seen on MAA and GDA had been coiled. We calculated 1.7% of dose. Patient placed on Carafate and Pepcid proactively and did well.
But with Careful Planning

• Such complications are uncommon
• Post-therapy imaging is critical in detecting extrahepatic uptake and precise territory treated
• Often will not detect on planar alone
• No longer do planar post-therapy, just SPECT-CT
Cutting Edge: Calculate Absorbed Dose and Correlate with Response

Pre-treatment PET    Post-treatment PET

Adapted courtesy of
Bree Eaton, MD
Cutting Edge

  - 7 patients/30 melanoma lesions
  - Bremsstrahlung SPECT-CT convolved with $^{90}$Y Monte Carlo dose deposition kernels to create 3-D distribution
  - Mean tumor dose and percent tumor volume $\geq$ 50 Gy predicted for SUVmax response
  - Maximum tumor dose predicted for decrease in TLG
Cutting Edge

  - 18 patients HCC
  - Proof of concept semiquantitative method to estimate $^{90}\text{Y}$ dose
  - 13.2 month median survival of $\geq 100$ Gy mean dose to tumor versus 4.6 months for less than 100 Gy
Other Cutting Edge Questions:
How Do We Modify Dose for Differences In Anatomic Tumor Versus Functional Tumor?
Yttrium-90 Emission Tomography?

- SPECT/CT of $^{90}$Y Bremsstrahlung
  - Limited potential for quantitation and improved resolution

- PET/CT has more promise
  - Better resolution and low scatter
  - Better quantitation
    - Padia et al. J Vasc Interv Radiol 2013;24:1147
    - Kao et al. EJNMMI Res 2013;3:56
Yttrium-90 Emission Tomography?

But

• PET/CT is more expensive
• How long will clinical PET/CT scans take?
  – Need to cover full liver and lower lungs
    » (3 bed positions)
  – Need faster device like TOF
• SPECT/CT may be adequate
Y-90 PET/CT vs Y-90 SPECT/CT

**SPECT/CT**
- Symbia T6
- MEGP Collimation
- 20 minute acquisition

**PET/CT**
- D690 LYSO Time-of-Flight
- 5 minutes per bed
- 3+ bed positions full coverage
Cutting Edge

  – Using MAA SPECT for dosimetric calculations

  – Utilizes CT Hepatic Angiography, MAA SPECT-CT and partition modeling for dosimetric planning
Modified Partition Model to Solve for Lung and Normal Liver Dose Limits Using Ratios of Tumor Uptake to Normal Liver on MAA

\[
T/N = \left( \frac{A_{tumor}}{m_{tumor}} \right) / \left( \frac{A_{tumor}}{m_{tumor}} \right)
\]

\[
D_{\text{NormalLiver}} = \frac{49.38 A_{\text{Total}} (1 - L)}{m_{\text{NormalLiver}} + T/N \ m_{\text{Tumor}}}
\]

\[
D_{\text{Lung}} = 49.38 \frac{A_{\text{Total}}}{m_{\text{Lung}}} L
\]

Kennedy et al. J Nucl Med Radiat Ther 2011, 2.1
http://dx.doi.org/10.4172/2155-9619.1000111
Controversy: Dose Planning Using MAA SPECT/CT

Image-Guided Personalized Predictive Dosimetry by Artery-Specific SPECT/CT Partition Modeling for Safe and Effective 90Y Radioembolization

Yung Hsiang Kao, Andrew Eik Hock Tan, Mark Christinaan Burgmans, Farah Gillian Irani, Li Ser Kho, Richard Horai Gong Lo, Kiang Hsing Tay, Bien Soo Tan, Pierre Kah Hoe Chow, David Chee Eng Ng, and Anthony Soon Whatt Goh

1Department of Nuclear Medicine and PET, Singapore General Hospital, Singapore; 2Department of Diagnostic Radiology, Singapore General Hospital, Singapore; 3Department of General Surgery, Singapore General Hospital, Singapore; and 4Office of Clinical Sciences, Duke-NUS Graduate Medical School, Singapore

Compliance with radiobiologic principles of radionuclide internal dosimetry is fundamental to the success of 90Y radioembolization. The artery-specific SPECT/CT partition model is an image-guided personalized predictive dosimetric technique developed by our institution, integrating catheter-directed CT hepatic angiography (CTHA), 99mTc-macroaggregated albumin (99mTc-MAA) SPECT/CT, and partition modeling for unified dosimetry. Catheter-directed CTHA accurately delineates planning target toxicities within 3 mo after radioembolization. The median time to best imaging response was 76 d (95% CI, 55–114 d). Median time to progression and overall survival were not reached. SPECT/CT-derived mean tumor-to-normal liver rates varied widely across all planning target volumes (median, 5.4; 95% CI, 4.1–6.7), even within the same patient. Conclusion: Image-guided personalized predictive dosimetry by artery-specific SPECT/CT partition modeling achieves high clinical success rates for safe and effective 90Y radioembolization.


Response to 90Y radioembolization was found to be independent of the degree of 99mTc-MAA uptake. Therefore, therapy should not be withheld from patients with colorectal liver metastases lacking intratumoral 99mTc-MAA accumulation.

Predictive Value of Intratumoral 99mTc-Macroaggregated Albumin Uptake in Patients with Colorectal Liver Metastases Scheduled for Radioembolization with 90Y-Microspheres

Gerhard Ulrich, Oliver Dudeck, Christian Färth, Juri Ruf, Oliver S. Grosser, Daniela Adolf, Marvin Stieber, Jens Rieke, and Holger Amthauer

1Department of Radiology and Nuclear Medicine, University of Magdeburg, Magdeburg, Germany; and 2Department of Biometrics and Medical Informatics, University of Magdeburg, Magdeburg, Germany

was found to be independent of the degree of 99mTc-MAA accumulation. Therefore, therapy should not be withheld from patients with colorectal liver metastases lacking intratumoral 99mTc-MAA accumulation.

Key Words: radioembolization; perfusion scintigraphy; SIR-spheres; response prediction

DOI: 10.2967/jnumed.112.112508


Response to 90Y radioembolization was found to be independent of the degree of 99mTc-MAA uptake. Therefore, therapy should not be withheld from patients with colorectal liver metastases lacking intratumoral 99mTc-MAA accumulation.
Dose Planning Using MAA SPECT/CT

  - Of administered $^{90}$Y dose, 51.9% delivered to the targeted tumors compared with 74.1% of $^{99}$mTc-MAA with linear correlation between biodistribution of $^{99}$mTc-MAA and $^{90}$Y observed (Pearson $r = 0.774$, $P < .001$).
Take Home

- MAA T/N values may vary considerably over a tumor and tumors in a region and may not accurately reflect actual Y-90
- Sophisticated calculations are sort of “rough”
- Use company recommended for routine work
- Ultimately may have B+ spheres and can do more accurate true dosimetric planning
In Conclusion

• $^{90}$Y microsphere therapy holds great promise as part of the clinical armamentarium in the treatment of metastatic and primary hepatic carcinoma

• Dose calculations may be performed with different methods, but ultimately a practical dosimetry based approach will be important for clinical and research applications

• Currently available SPECT-CT techniques are valuable for pre and post-therapy planning and evaluation