A practical measure in personnel dose reduction for ^{90}Y-micropsheres liver-directed radioembolization: from radiology department to patient ward

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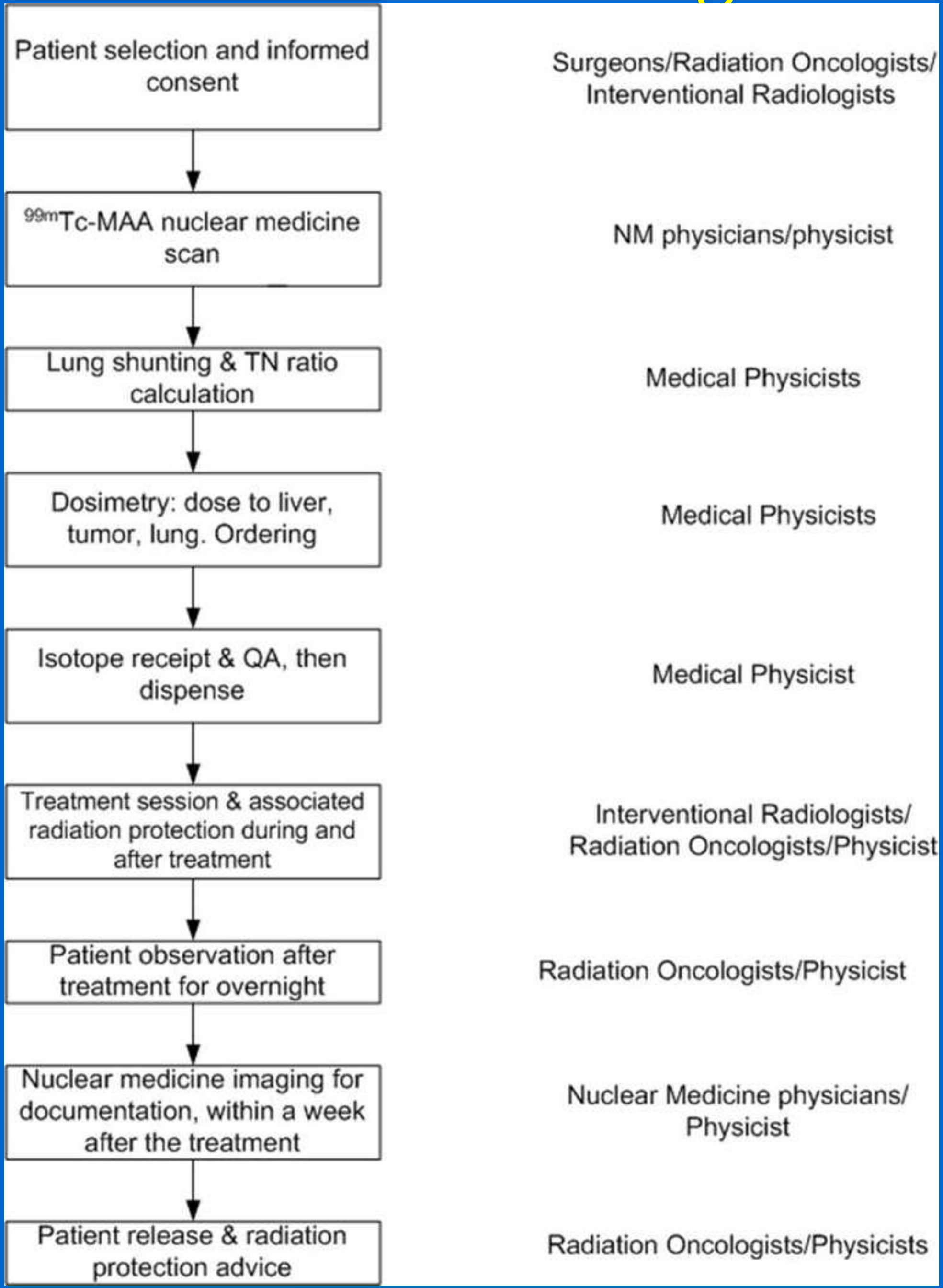
What is Radioembolization?

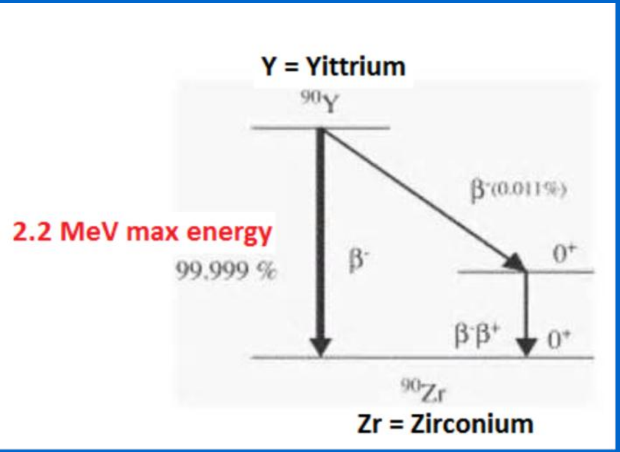
- Radiation therapy and embolization to treat cancer of the liver, also known as Selective Internal Radiation Therapy (SIRT)
- Embolization is used to occlude blood flow.
- Radiation therapy uses ionizing radiation to kill cancer cells and shrink tumors.
- Radioembolization involves placing a radioactive material, tiny glass or resin beads called **microspheres** directly at the tumor site.
- ***Multidisciplinary nature involving oncologist, nuclear medicine physician, interventional radiologist & medical physicist***

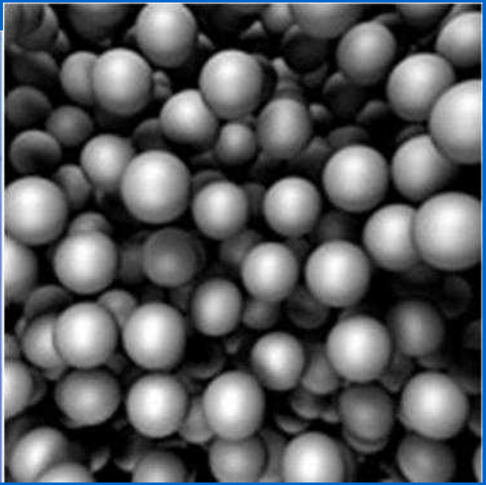
Flow chart to begin with

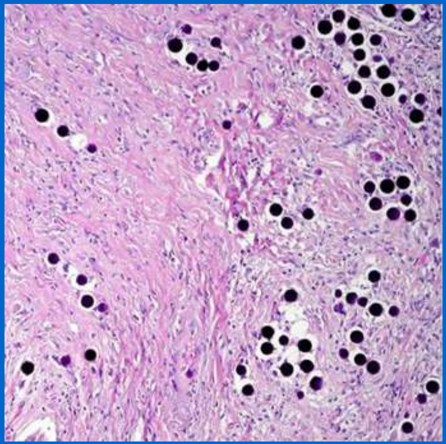


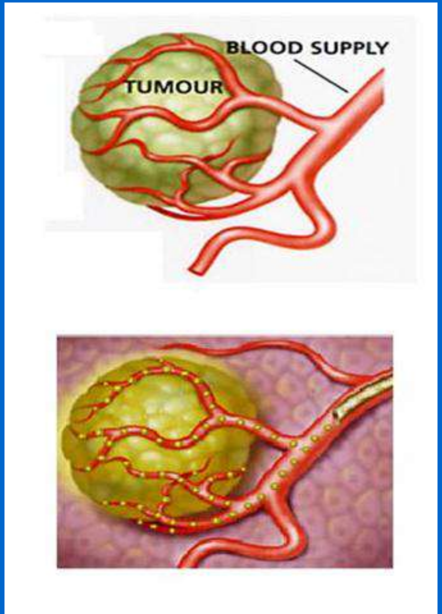
Some basics of 90Y & µ-spheres

- Yttrium-90 is a high energy ‘pure’ beta emitting isotope: good for therapy; no good for imaging
- Mean energy: 0.93 MeV (2.27 MeV maximum)
- Half-life time: 64.1 hours
- Range max: 11 mm in tissue
- **pair production abundance of ^{90}Y (32×10^{-6})**







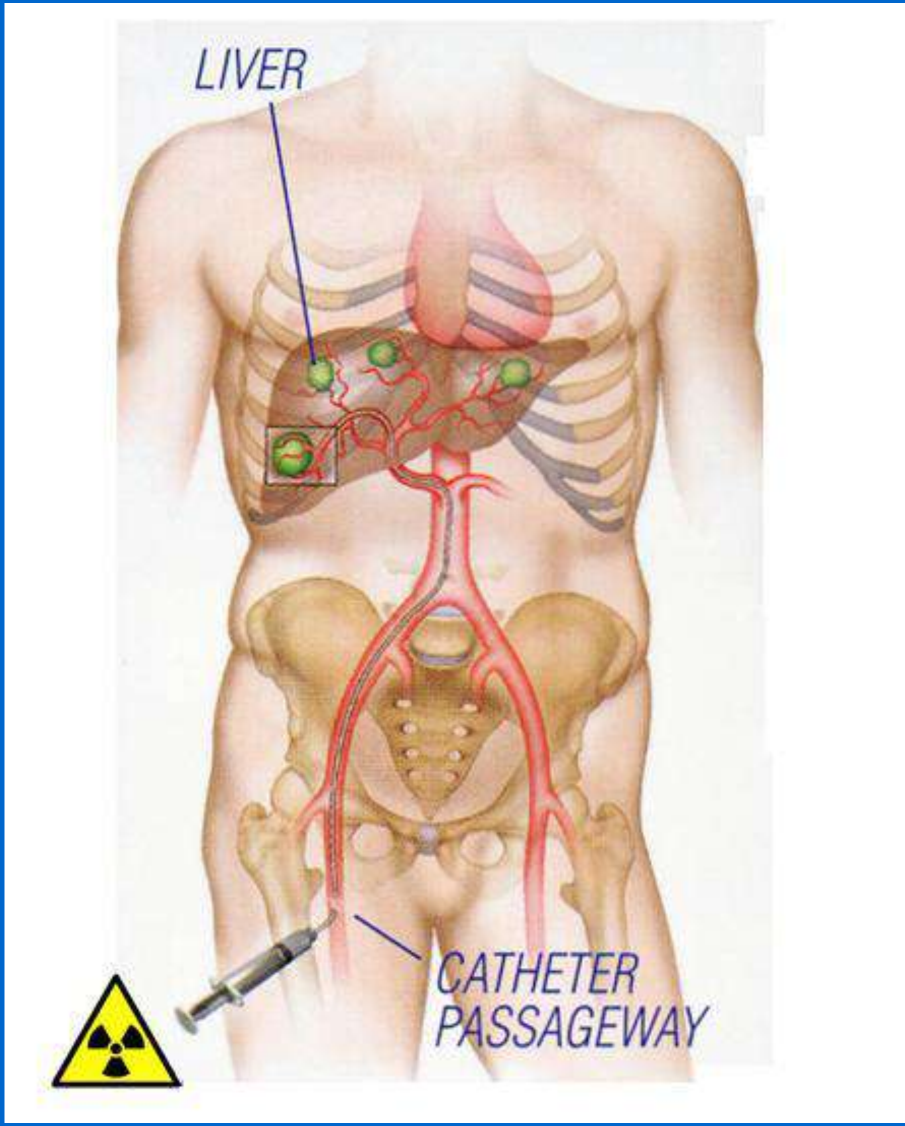


Y-90 agents currently available: TheraSphere (glass) & SIR-Sphere (resin)

	TheraSphere	SIR-Sphere
Delivery agent	Glass beads	Resin beads
Particle size	20-30 µm	20-60 µm
Energy per particle	2500 Bq	50 Bq
Typical dose	1-4 GBq (120 Gy)	1-2 GBq (30-50 Gy)
Particles per dose	0.4-0.8 million	20-40 million
Embolic effect	Minimal	Variable
FDA approval	HCC[1]	Colorectal metastases
Manufacturer	Nordion (Canada)	Sirtex Medical (Australia)

Experience in QMH: max activity SIR-Sphere=2.5 GBq; max acitivty of TheraSphere= 4.5 GBq

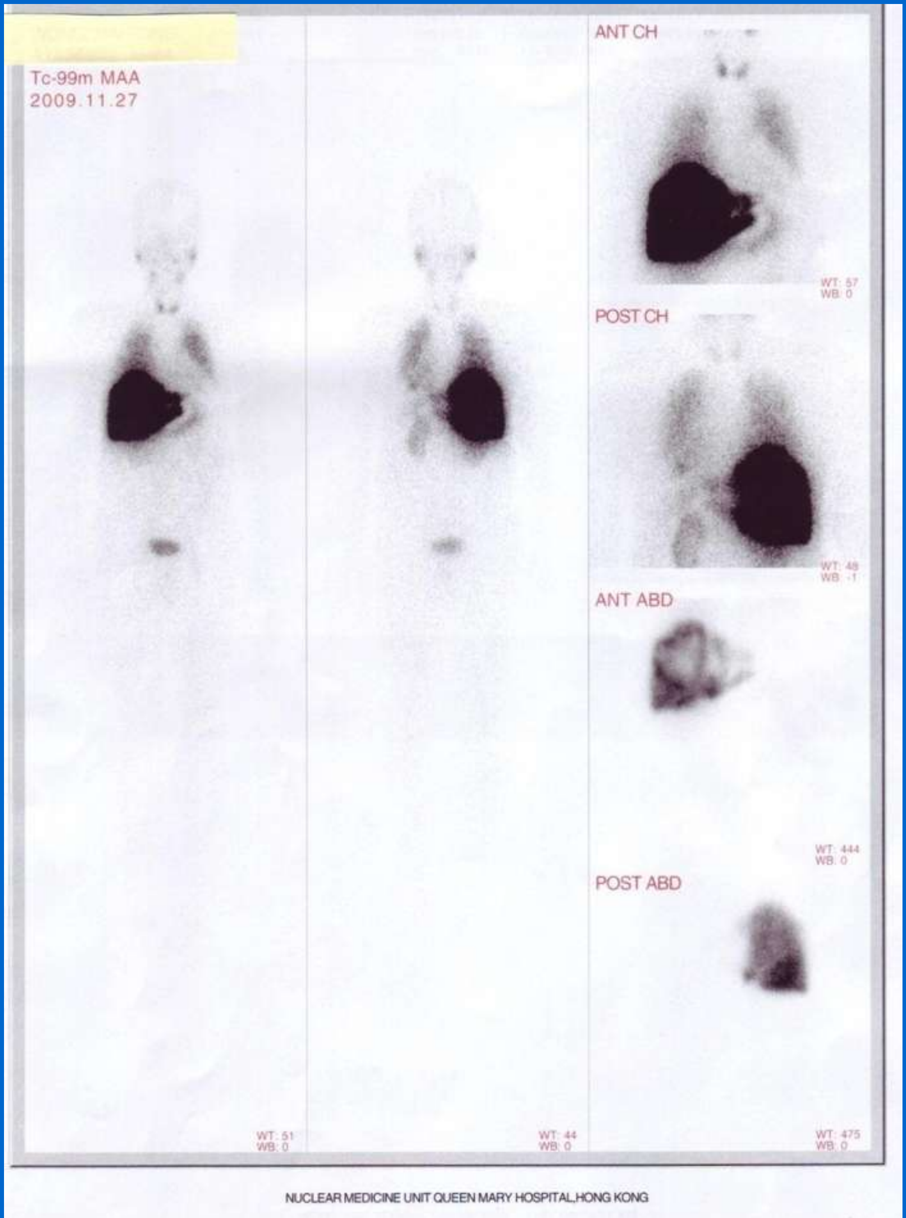
How it works?



- Local delivery of the MAA (diagnostic) or μ-particles (therapy) into the tumor bed via hepatic artery
- For ^{99m}Tc-MAA, mean particle size 50 μm, for ^{90}Y-sphere 30 μm, so they are comparable in size
- These particles are small enough to reach the capillary bed, but large enough to be trapped there.
- The same procedure is repeated for ^{99m}Tc-MAA and ^{90}Y-sphere

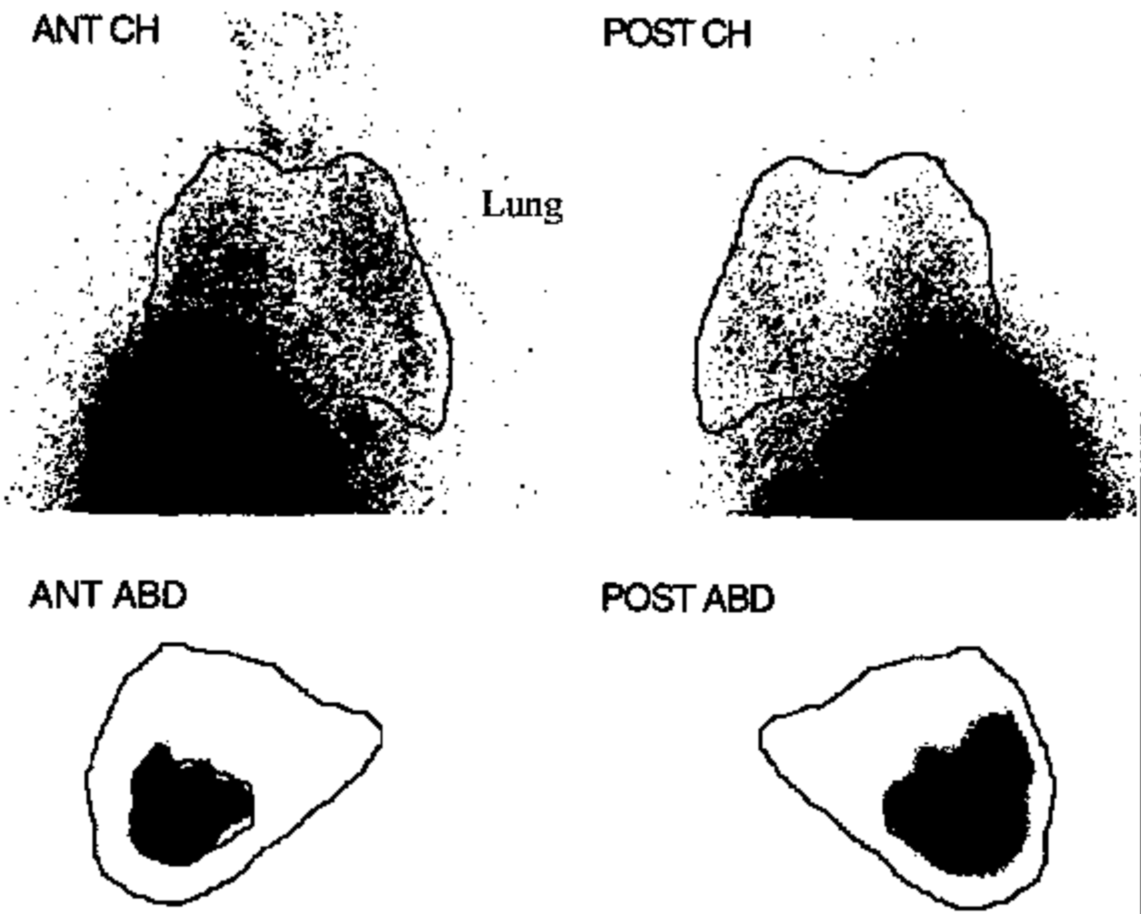
Use of 4 mCi ^{99m}Tc-MAA diagnostic NM scan

Suggest to NM image right after the Tc99m-MAA infusion.



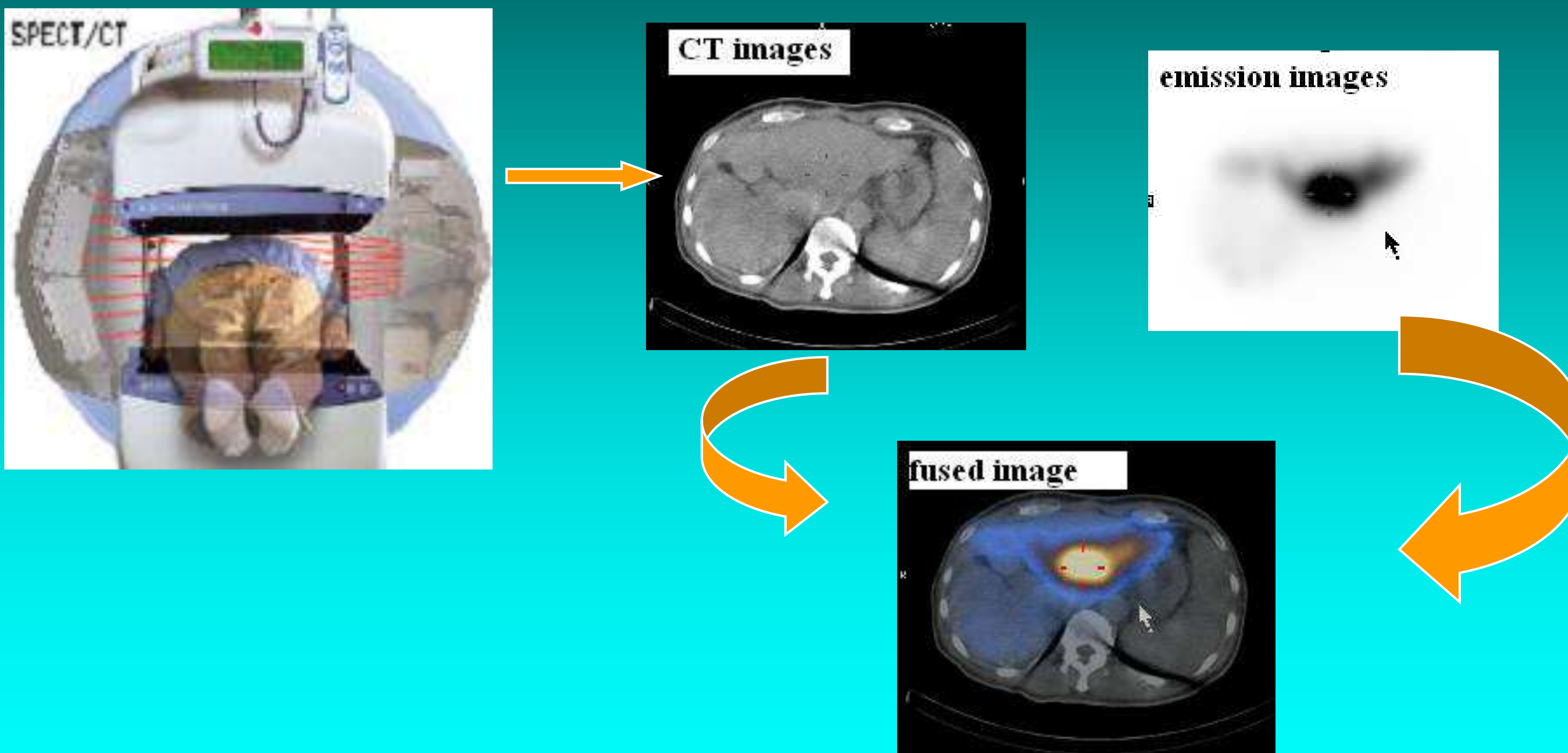
- Geometric mean
- Lung shunting=
  Lungs/(Lungs+Liver)*100%
- TN ratio=
  Tumor/(normal liver)
- For a suitable patient candidate: low lung shunting and high TN ratio

Example of lung shunting & TN ratio calculation



Ant Lung Counts:	18658
Post Lung Counts:	18766
Geometric Lung Counts:	18711
Ant Liver Counts:	1253663
Post Liver Counts:	556942
Geometric Liver Counts:	835594
Liver Area:	10600
Ant Tumour Counts:	961418
Post Tumour Counts:	357027
Geometric Tumour Counts:	585877
Tumour Area:	1916
Normal Liver Counts:	249717
Normal Liver Area:	8684
Tumour Count Density:	305.78
Liver Count Density: (Exclude Tumour)	28.75
Lung Shunting:	2.19%
Tumour-to-Liver Ratio:	10.63

SPECT/CT is used nowaday:



SIRT dose calculation (BSA method)

$$Radioactivity(GBq) = (BSA - 0.2) + \frac{\text{tumor volume}}{\text{tumor volume} + \text{normal liver volume}}$$

$$BSA(m^2) = 0.20247 * Height(m)^{0.725} * Weight(kg)^{0.425}$$

Dose Calculations for SIR-Sphere Microspheres Implant Procedure

Please do not in anything in the [cyan] column

1. Body Surface Area (BSA) Method

Height = 1.71 m

Weight = 78.2 kg

Volume of tumour (cc) = 158.47

Volume of normal liver (cc) = 1275.45

BSA = 1.9050 m^2

Activity = **1.8155** GBq

BSA method calculation

2. Partition Model for Calculation of Dose/Activity of SIR-Spheres Microspheres

2.1 Breakthrough Scans

A'_{lung} = kBq

A'_{tumor} = kBq

A'_{liver} = kBq

m_{lung} = g

m_{tumor} = g

m_{liver} = g

L =

T/N =

2.2 Lung

D_{lung} = Gy

Activity = GBq

2.3 Liver

D_{liver} = Gy (cirrhosis) **Activity =** GBq

D_{liver} = Gy (normal liver parenchyma) **Activity =** GBq

Patient radioactivity calculation for TheraSphere

Patient Name:		Patient ID:	Target Tissue:	whole liver
Target Volume (cc):	953.4		Target Liver Mass (kg):	0.982
Desired Dose (Gy):	99			
Time Zone Variance (h):	-12	(see Time Zones tab for details)	Places in this Time Zone:	Indonesia Thailand
Lung Shunt Fraction (% LSF):	10.45%			
Anticipated Residual Waste (%):	1.00%	Optional estimated value		
Previous Dose to the Lungs (Gy):	0			
Required Activity at Administration (GBq):	2.19	This value is corrected for LSF and Residual Waste if values are entered above.		

Calculated Dose to Lungs (Gy):	11.35	Dose Limit to the Lungs per treatment (Gy):	30	See Package Insert Instructions for Us
Lung Dose within recommended limit for treatment				
Cumulative Dose to Lungs (Gy):	11.35	Cumulative Dose Limit to the Lungs (Gy):	50	
Lung Dose within recommended cumulative limit for treatment				

To prepare the Tx session

Dose package & dispense

Items needed for SIRT Tx session

Steps to dispense the μ-spheres patient dose in lab

Assume 3 GBq in 5 ml on Tx day.

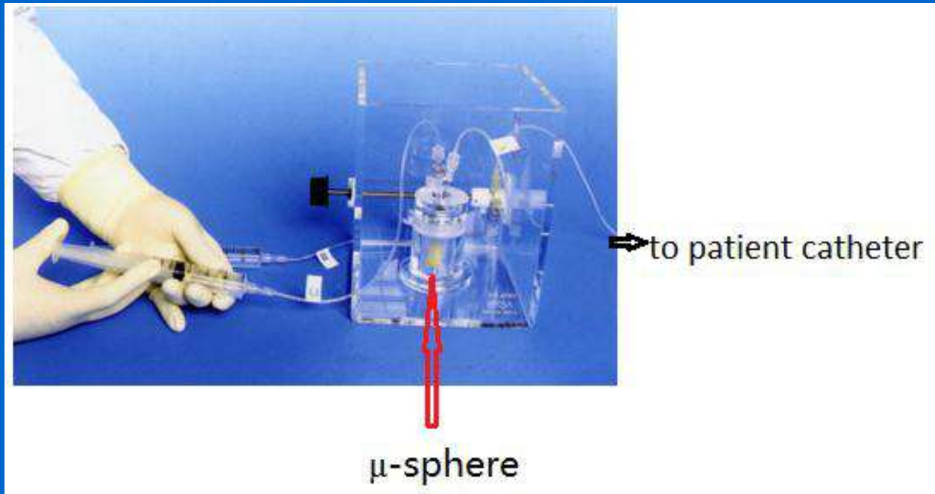
Patient prescription = 2 GBq

I need to draw (5*2/3 ml) =3.33 ml

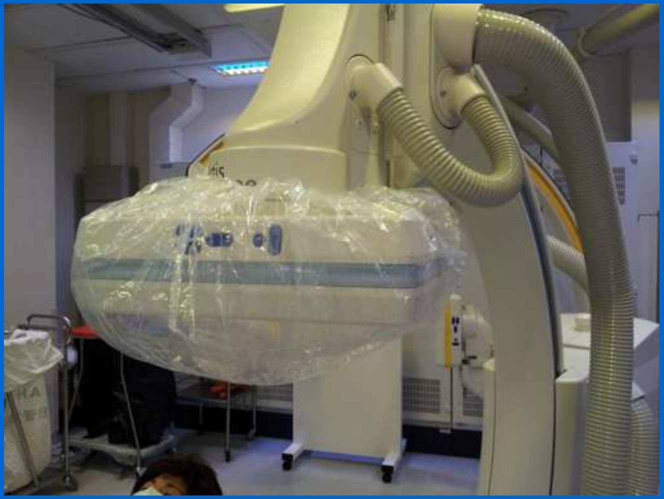
Then I draw just a bit more than 3.33 ml.

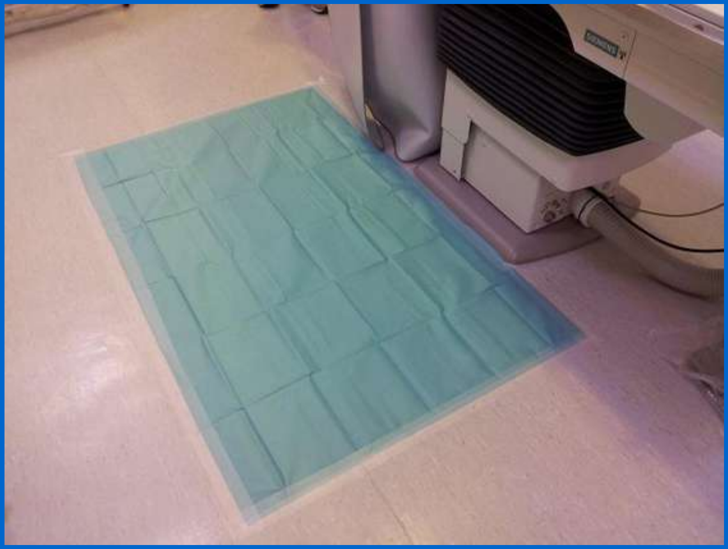
Slowly infuse into the v-vial

Actual radioactivity in v-vial =(initial act of glass vial - remaining act of glass vial - act of the syringe)



IR room radiation protection: before the SIRT session

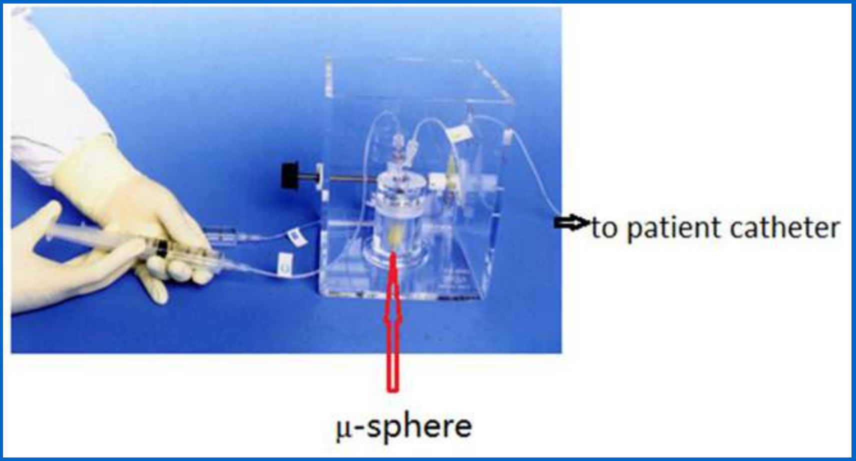




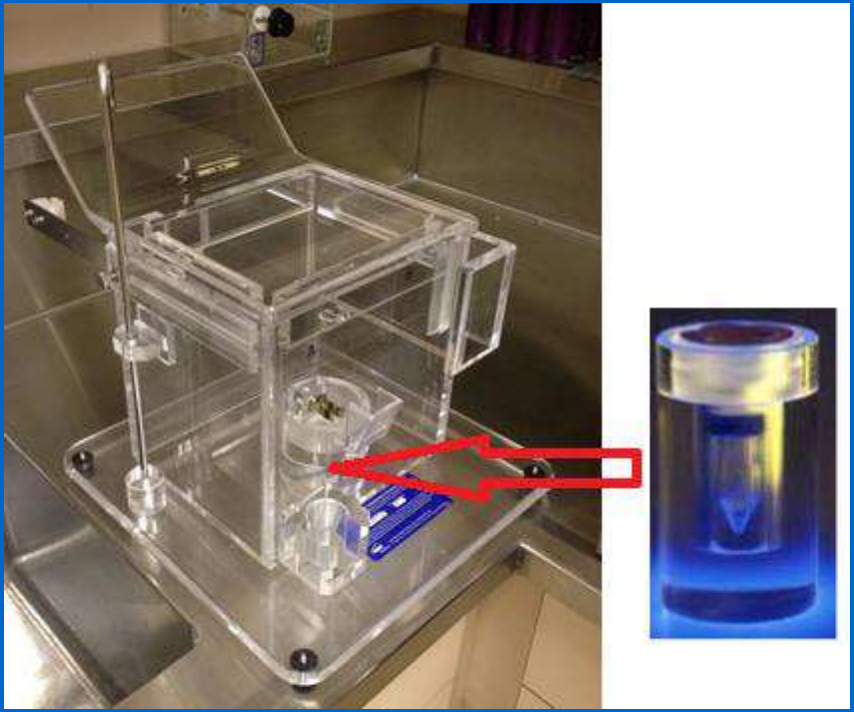
- Protective wrap around the x-ray head & detector
- Place an absorbent paper where the injetion trolley is located to localize any possible radiation spillage

Delivery technique about the same for the two types of spheres

SIR-Sphere delivery box



TheraSphere delivery box



Personnel radiation protection in IR room: immediately after SIRT infusion: use of lead lined blanket

Dose measurement for radiologist with and without using the blanket

	Normalized average dose rate [μSv/(hr•GBq)]	
Use of lead lined blanket	**Radiologist position**	**At 10 cm above patient abdomen**
No	**2.91**	**8.41**
Yes	**1.32**	**3.10**
p-value	**< 0.01**	**< 0.01**

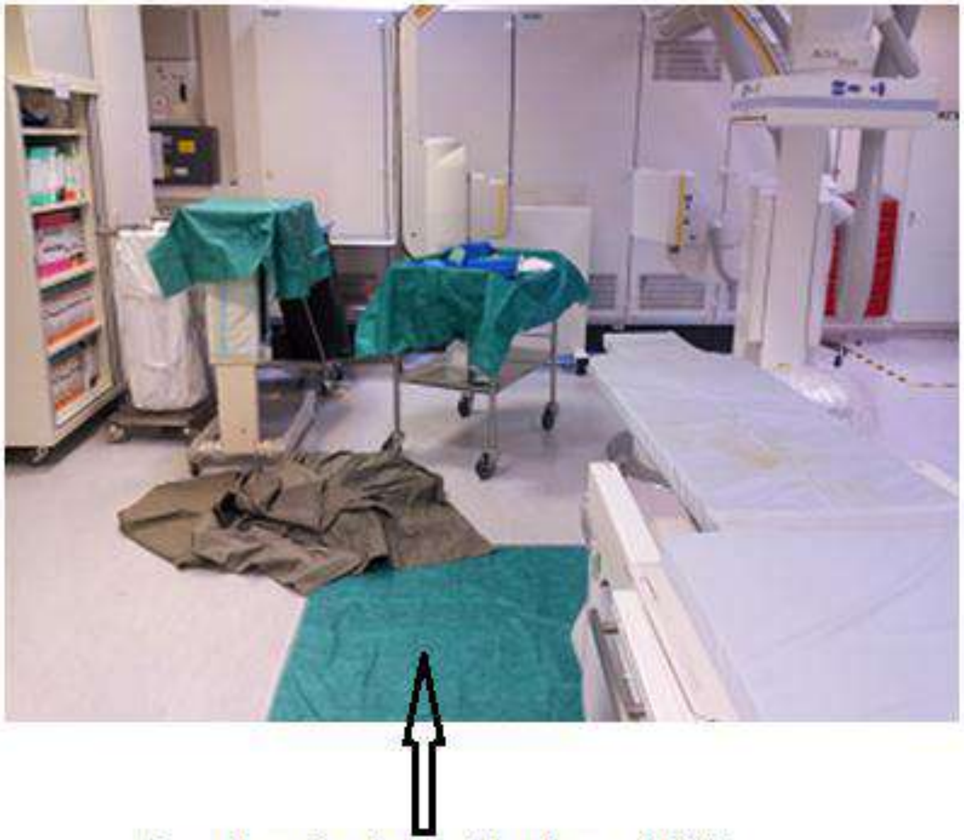
Occupation dose for different hospital personnel handling the Y90 patient

Staff	Procedure	Estimated time spent (min)	Occupational dose (μSv)
Radiologist	Puncture site pressing	20	0.92 on hand 0.4 under apron
Nurse	Patient transfer	5	0.52
Porter	Patient transport	5	0.22

Background about 6 μSv in QMH area

Personnel radiation survey after treatment: any contaminated items are collected for ‘store & decay’

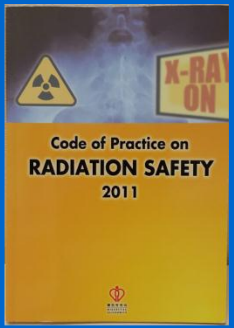
Radiation survey the IR room after treatment



absorbent placed before SIRT

What radiation protection to patients after SIRT?

- Patients will be under clinical observation after SIRT
- If infused Y90 ≥ 1.5 GBq, patient has to stay in isolation ward with private toilet facility according to HA Code of Practice on radiation safety 2011.
- Patient will stay in isolation ward until his/her remaining Y90 < 1.5 GBq

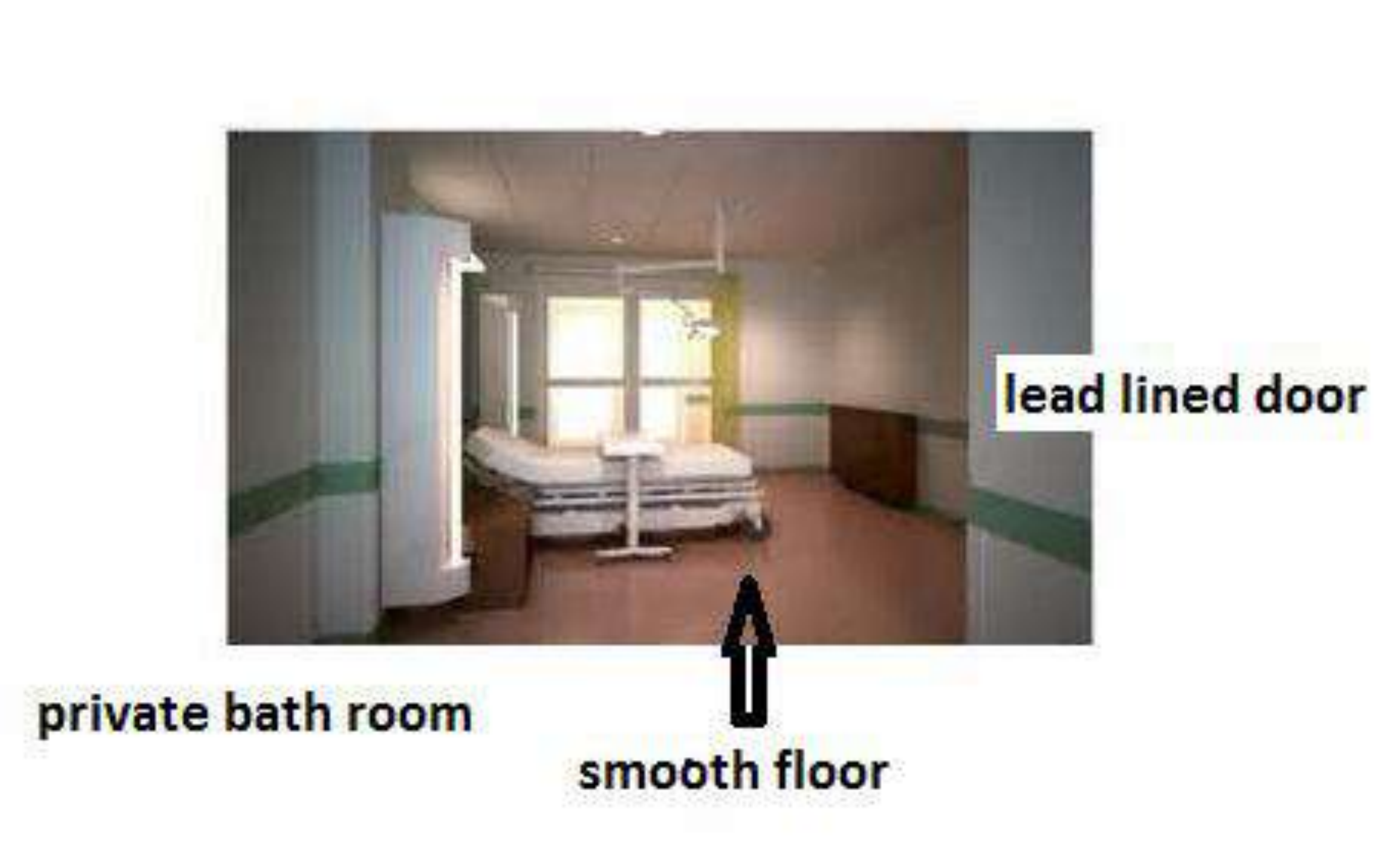


An example: patient given 4.75 GBq on 5/May/15 noon (Tue)

This patient Y90 reduced to 1.5 GBq after 4.5 days on 9/May Sat late night (4.5 days)

The patient was discharged from isolation ward on Sunday 10/May/15 9:00 am.

An example of isolation room for radiation protection purpose



Another example of isolation room: patient is confined in the room

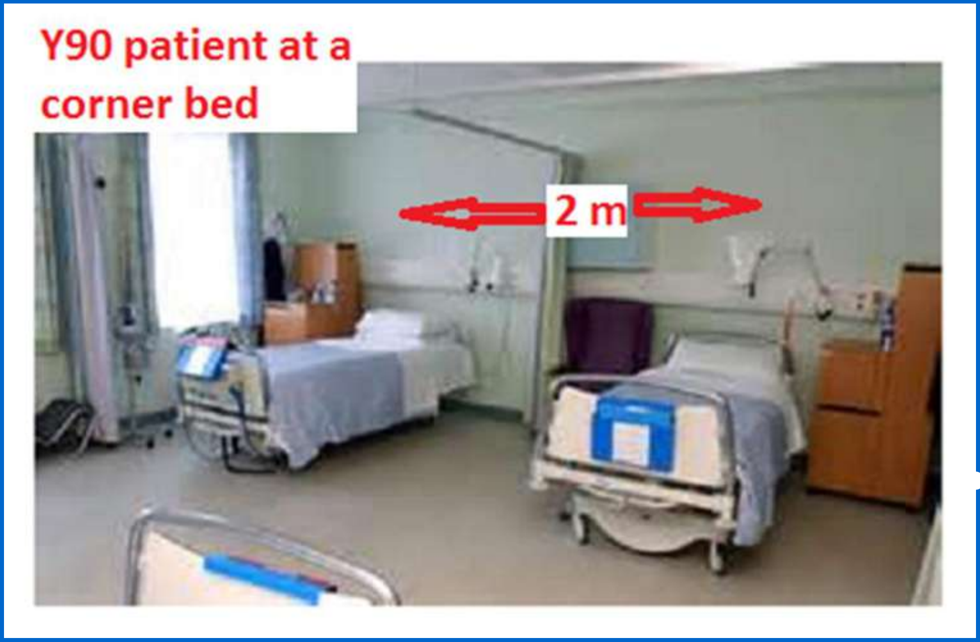
Isolation room really tight in booking!!! What to do?

- Similar Y90 of about 5 GBq is quite common in TheraSphere
- In this, patient has to be staying in isolation room for about 5 days!!

- If a Centre is without isolation room and SIRT has to be done, what should be done?
- If the isolation room, currently occupied by the SIRT patient, has to be used for other urgent needs, what should be done?

A possible solution & justification:

- by allocating the ^{90}Y treated patient at a corner bed in a common ward.
- the lead lined blanket is used to cover the radioembolized region.



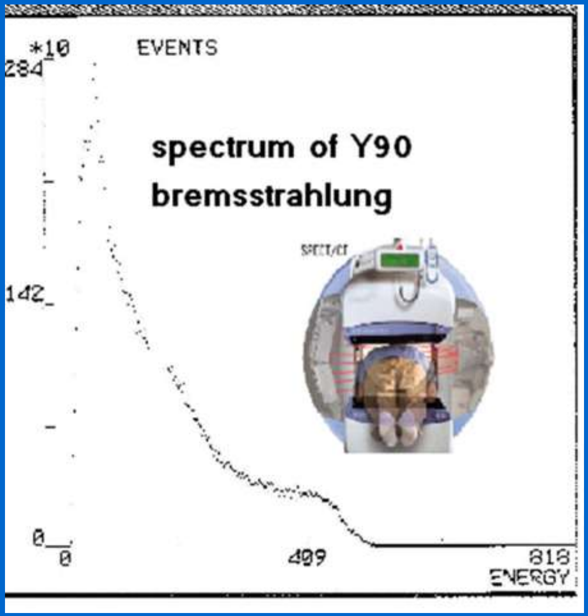
- The dose rate at 1m is calculated to be 1 µSv/hr (assumed 2.1 GBq infusion).
- Patient separation about 2 m in ward, dose rate at the next patient will be about 0.25 µSv/hr (bkg level in most HKG locations)
- SIRT patient will not expose the next patient significantly.

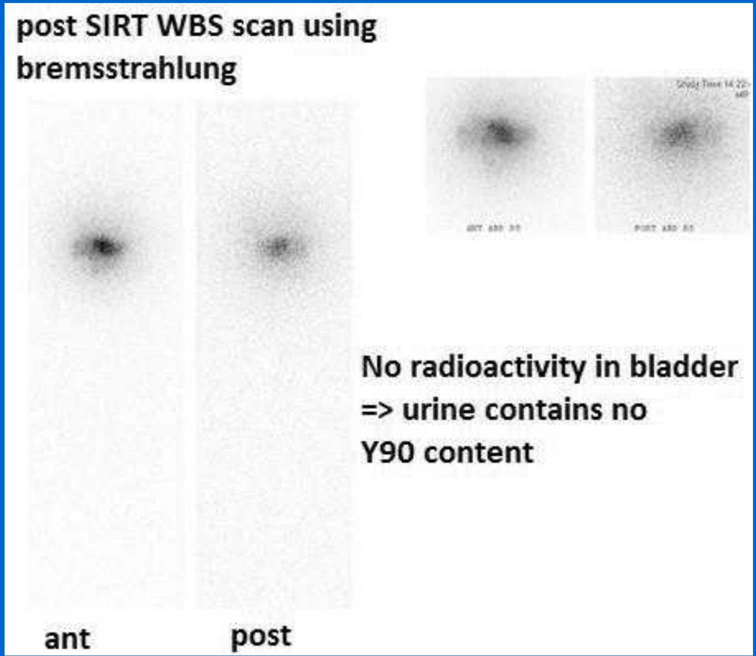
Patient urine

- No observable Y90 urine content from post Tx WBS (literature quotes very little in the resin spheres for the 1st 24 hours post SIRT; the glass spheres are not known to be present in any body fluid)
- Advise patient to flush toilet twice after use
- **In other words, radioembolized patients can use common toilet facility as other non-radiation patients do.**

What do we learn from the post Tx scan? Radioactive urine?

- For documentation purpose
- Use bremsstrahlung scan emitted from patient
- Dual head gamma camera using medium energy parallel hole collimators
- Whole body scan and localized abdominal view (conventional gamma camera before and now SPECT/CT)
- **NO OBSERVABLE Y90 IN BLADDER, URINE IS COLD!**





Conclusion for radiation protection in SIRT:

- To understand the basics of Y90, delivery method & patient management procedures
- To understand the personnel concern about radiation in SIRT procedures
- How to prepare for the contamination in IR room
- To understand bremsstrahlung emission from patient
- How to reduce the bremsstrahlung irradiation to personnel
- personnel dose measurement
- How to apply the radiation protection measure in patient ward

Thank you