Advisory Committee on the Medical Uses of Isotopes

Spring Meeting
April 5, 2022

Meeting Handout

MEETING AGENDA
ADVISORY COMMITTEE ON THE MEDICAL USES OF ISOTOPES
April 5, 2022
Virtual Meeting

NOTE: Sessions of the meeting may be closed pursuant to 5 U.S.C. 552(b) to discuss organizational and personnel matters that relate solely to internal personnel rules and practices of the ACMUI; information the release of which would constitute a clearly unwarranted invasion of personal privacy; information the premature disclosure of which would be likely to significantly frustrate implementation of a proposed agency action; and disclosure of information which would risk circumvention of an agency regulation or statute.

	TUESDAY, APRIL 5, 2022 **OPEN SESSION**	
10:00am to 12:15pm EST	**1. Opening Remarks** Mr. Einberg will formally open the meeting and Mr. Williams will provide opening remarks.	**C. Einberg, NRC** **K. Williams, NRC**
	2. Old Business Mr. Lowman will review past ACMUI recommendations and provide NRC responses.	**D. Lowman, NRC**
	3. Open Forum The ACMUI will identify medical topics of interest for further discussion.	**ACMUI**
	4. Medical Related Events Mr. Dimarco will provide an overview of the NRC staff's assessment of FY21 medical events.	**D. Dimarco, NRC**
12:15pm to 12:45pm EST	**LUNCH**	
12:45pm to 3:15pm EST	**5. ACMUI Reporting Structure** Mr. Lowman will provide an overview of the current reporting structure. Members will discuss the reporting structure of the Committee and provide feedback to the NRC.	**D. Lowman, NRC**
	6. Special Presentation to Dr. Vasken Dilsizian	**J. Lubinski, NRC**
	7. TheraSphere™ Y-90 Glass Microspheres A representative from Boston Scientific will provide an overview of the TheraSphere™ Y-90 glass microspheres.	**Ashley Cockerham, Boston Scientific**
	8. SIR-Spheres® Y-90 Resin Microspheres A representative from Sirtex Medical will provide an overview of the SIR-Spheres® Y-90 resin microspheres.	**Diana Thompson, Sirtex Medical**
	9. Minimizing Risk of Medical Events Dr. Angle will provide an overview institutional processes and team approaches to reducing errors.	**J. Angle, NRC**

	10. CORAR Comments on the NIST Radioisotope Measurement Assurance Program Mr. Guastella will discuss CORAR's request that NIST facilitate the restart of NRMAP and provide sufficient resources to NRMAP and Radioactivity Measurement Group.	**M. Guastella, CORAR**
	11. Update on NIST Radioisotope Measurement Assurance Program Dr. Zimmerman will provide an update on the NRMAP program and an overview of NIST's plan to reorganize the program.	**B. Zimmerman, PhD, NIST**
3:15pm to 3:30pm EST	**BREAK**	
3:30pm to 5:00pm EST	**12. Non-Medical Events** Mr. Sheetz will provide an analysis of FY20-FY21 non-medical events reported by medical use facility and commercial pharmacies.	**M. Sheetz, NRC**
	13. Medical Team Updates Dr. Valentin-Rodriguez will provide an update on Medical Radiation Safety Team activities.	**C. Valentin-Rodriguez, PhD, NRC**
	14. Open Forum The ACMUI will continue discussion on medical topics of interest.	**ACMUI**
	15. Administrative Closing Mr. Lowman will provide a meeting summary and propose dates for the fall 2022 meeting.	**D. Lowman, NRC**
5:00pm EST	**ADJOURN**	

2019 ACMUI Recommendations and Action Items

	ITEM	DATE	STATUS		Target Completion Date for NRC Action
17	The ACMUI endorsed the Appropriateness of Medical Event Reporting Subcommittee report and the recommendations provided therein.	9/10/2019	*Propose to Close*	Open	May 2022
18	The ACMUI endorsed the Evaluation of Extravasations Subcommittee Report, as amended, to note that under future revisions to Part 35 rulemakings, extravasations be captured as a type of passive patient intervention in the definition of patient intervention.	9/10/2019	*Accepted*	Open	Spring 2023

2020 ACMUI Recommendations and Action Items

	ITEM	DATE	STATUS		Target Completion Date for NRC Action
4	The ACMUI endorsed the Patient Intervention subcommittee report, as presented, and the recommendations provided therein to re-interpret current definition of patient intervention and to report medical events resulting from patient intervention which result in unintended permanent functional damage under 10 CFR 35.3045(b).	3/30/2020	*Accepted*	Open	Spring 2023
11	As part of the Non-Medical Events report, the ACMUI recommended to the NRC staff and/or NMP to evaluate the issue of detection of short-lived medical isotopes in municipal waste (waste from nuclear medicine patients that might be triggering the landfill alarms) and provide some level of guidance, best practices, or additional instructions.	9/21/2020	*Accepted*	Open	Spring 2023

2021 ACMUI Recommendations and Action Items

	ITEM	DATE	STATUS		Target Completion Date for NRC Action
1	The ACMUI tentatively scheduled the fall meeting for October 4-5, 2021. The alternate meeting date is September 13-14, 2021. A virtual or in-person meeting for fall 2021 is to be determined.	3/16/2021	*Propose to close*	Open	October 2021
2	The ACMUI endorsed the ACMUI Abnormal Occurrence Subcommittee report, and the recommendations provided therein.	5/27/2021	*Propose to close*	Open	May 2022
3	The ACMUI formed a new subcommittee on the Radionuclide Generator Training and Experience. The subcommittee is expected to provide a draft report and any recommendations at the fall 2021 ACMUI meeting.	5/27/2021	*Propose to close*	Open	Fall 2021
4	The ACMUI formed a new subcommittee on Emerging Radionuclide Therapy Training. The subcommittee is expected to provide a draft report and any recommendations at the fall 2021 ACMUI meeting.	5/27/2021	*Propose to close*	Open	Fall 2021
5	The ACMUI formed a new subcommittee on the Diffusing Alpha-emitter Radiation Therapy (DaRT) Manual Brachytherapy Source. The subcommittee is expected to provide a draft report and any recommendations at the spring 2022 ACMUI meeting.	9/02/2021	*Propose to Close*	Open	December 2021

6	The ACMUI endorsed the Extravasation Subcommittee report, as amended, to support option 4 of the Subcommittee Report.	9/02/2021	*Accepted*	Open	Spring 2023
7	The ACMUI formed a new subcommittee on the Liberty Vision Y-90 Manual Brachytherapy source. The subcommittee is expected to provide a draft report and any recommendations at the spring 2022 ACMUI meeting.	10/04/2021	*Accepted*	Open	Fall 2022
8	The ACMUI tentatively scheduled the spring meeting for April 4-5, 2022. The alternate meeting date is March 21-22, 2022. The Spring 2022 meeting is planned to be in-person.	10/04/2021	*Propose to close*	Open	Spring 2022
9	The ACMUI formed a new subcommittee to review the NRC staff's draft proposed revision to Regulatory Guide (RG) 8.39, "Release of Patients Administered Radioactive Materials" and review and comment on the NRC's staff additional draft patient release licensing guidance for CivaDerm. The subcommittee is expected to provide a draft report and any recommendations at the spring 2022 ACMUI meeting.	10/04/2021	*Propose to close*	Open	December 2021
10	The ACMUI endorsed the Radionuclide Generator Knowledge and Practice Requirements Subcommittee Report and the recommendations provided therein.	10/04/2021	*Accepted*	Open	March 2026
11	The ACMUI endorsed the Medical Event Subcommittee report and the recommendations provided therein.	10/04/2021	*Propose to close*	Open	Spring 2022

12	The ACMUI formed a new subcommittee on Y-90 microspheres in medical events. The subcommittee is expected to provide a draft report and any recommendations at the spring 2022 ACMUI meeting.	10/04/2021	*Accepted*	Open	Fall 2022
13	The ACMUI endorsed the Emerging Radiopharmaceutical Therapy Knowledge Requirements in Theranostics Subcommittee report and the recommendations provided therein.	10/04/2021	*Propose to close*	Open	October 2021
14	The ACMUI endorsed the ACMUI Alpha DaRT Subcommittee report and the recommendations therein.	12/15/2021	*Propose to close*	Open	March 2022
15	The ACMUI endorsed the ACMUI RG. 8.39 Subcommittee report on CivaDerm and the recommendations therein.	12/15/2021	*Accepted*	Open	Summer 2022
16	The ACMUI endorsed the ACMUI RG. 8.39 Subcommittee report on the proposed revision to RG 8.39 and the recommendations therein.	12/15/2021	*Accepted*	Open	Fall 2022

OPEN FORUM

(No Handout)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Status of Medical Events FY 2021

Daniel DiMarco
Medical Radiation Safety Team
April 5, 2022

Medical Events

The dose threshold for diagnostic events precludes reportable events most years.

Each year, there are approximately 150,000 therapeutic procedures performed utilizing radioactive materials.

Medical Events FY 2016 - 2018

- **50 Medical events reported - FY 2016**
- **43 Medical events reported - FY 2017**
- **48 Medical events reported - FY 2018**

	FY16	FY17	FY18
35.200	4	0	0
35.300	4	4	2
35.400	6 (18*)	7	11 (13*)
35.600	6	8 (14*)	10
35.1000	30	24	25 (26*)

* The total number of patients involved if greater than the number of reports

Medical Events FY 2019 - 2021

- **56 Medical events reported - FY 2019**
- **48 Medical events reported - FY 2020**
- **64 Medical events reported - FY 2021**

	FY19	FY20	FY21
35.200	1 (8*)	0	4
35.300	9	2	10
35.400	5	6	4
35.600	9 (10*)	13	5
35.1000	32	27	41

* The total number of patients involved if greater than the number of reports

Medical Events 2021

35.200 Medical events	**4**
FDG Overdose	1
Wrong radiopharmaceutical	3

35.200 FDG

- Patient overdose
  - Prescribed 0.37 GBq (10 mCi), administered 3.85 GBq (104 mCi)
  - Technician realized he administered the wrong dosage after the treatment

35.200 I-123

- Wrong Drug
  - Prescribed 7.4 MBq (200 μCi) of I-123, administered 5.55 GBq (150 mCi) of I-131
  - Patient called back to the hospital and given KI
  - Stayed at hospital for four days under I-131 safety protocols
  - Planned dose to thyroid was 2.37 cGy (rad)
  - Early estimates of the dose received ranged from 1,220 cGy (rad) to 155,000 cGy (rad)
  - Dose estimates could not accurately account for KI administration
  - Patient lost sense of taste and was given Synthroid medication

35.200 I-123 (cont)

- Root cause determined to be several errors by NMT
  - Appearance and size of I-123 and I-131 capsules are very different
  - The containers are also very different and are kept in separate rooms
  - Patient's name and DOB are visible on outside labels for all doses
  - Doses are checked in a dose calibrator to ensure correct dosage
- All iodine procedures now require two NMTs to sign off before administration
- NMT initial competency will be evaluated between diagnostic and therapeutic doses
- Involved NMT had their employment terminated
- Safety Event Analysis was scheduled to review the incident

35.200 Tc-99m

- Wrong Drug
  - Patient was prescribed 1.11 GBq (30 mCi) of Tc-99m Sestamibi, administered 4.42 GBq (119.49 mCi) of Tc-99m Sodium Pertechnetate
  - Effective dose estimated to be 5.7474 cSv (rem)

35.200 MDP

- Wrong Radiopharmaceutical
  - Anonymous allegation that patient injected with MDP during a stress test
  - The same patient was also injected with Tc-99m Sestamibi at a later time
  - More information has been requested

Medical Events 2021

35.300 Medical events	**10**
Targeted Thorium Therapy	1
Lutetium-177	3
I-131 NaI	3
I-131 Iomab-B	2
Xofigo	1

35.300 Targeted Thorium Therapy

- Wrong Drug
- Prescribed 0.0405 mCi of Th-227 epidermal growth factor receptor 2 (HER-2) Target Thorium Conjugate (TTC), received 0.046 mCi of Th-227 mesothelin (MSLN) TTC
  - Investigative study involving novel TTC intended to deliver radioisotope to HER-2 antigen expressing tumor tissue
  - Incorrectly labelled by manufacturer
  - Both drugs are processed the same in the body
  - Estimated doses are : 609 cGy (rad) to liver, 164 cGy (rad) to small intestine, 174 cGy (rad) to kidneys, and 85.3 cGy (rad) to red marrow
  - No toxicities were noted after six weeks of monitoring

35.300 I-131 NaI

- Patient overdose
  - Patient prescribed 1.11 GBq (30 mCi), received 3.7 GBq (100 mCi)
  - Expected whole body dose of 26.64 cSv (rem) and dose to the bladder wall of 225.7 cGy (rad)
  - Dosage of 3.7 GBq (100 mCi) was verbally given to technologist
  - Did not check written directive prescription of 30 mCi
  - NMT was using a worksheet with the incorrect dosage of 100 mCi
  - Root cause was determined to be human error
  - Corrective actions included new personnel hires, improved supervision, and procedure modifications

35.300 I-131 NaI

- Patient underdose
  - Patient prescribed 7.4 GBq (200mCi), received 2.22 GBq (60 mCi)
  - Dose was divided into two capsules
  - Patient only received one of two capsules
  - Second capsule stuck in shipping vial, discovered by radiopharmacy in the returned vial
  - Subsequent dose was administered to complete thyroid cancer treatment

35.300 I-131 NaI

- Patient underdose
  - Patient prescribed 3.7 GBq (100mCi), received 0.7215 GBq (19.5 mCi)
  - Dose prescribed was 10,000 cGy (rad), dose administered was 3,900 cGy (rad)
  - Patient only received one capsule of a two-capsule treatment
  - Remaining capsule was accounted for in the original vial
  - Root cause determined to be human error, did not follow written handling and survey procedures
  - Procedures were updated for radiotherapy isotope administrations
  - DOT/HAZMAT training and supplementary radiation protection training was administered to all technologists

35.300 Lu-177 Dotatate

- Patient underdose
  - Patient prescribed 7.4 GBq (200 mCi), received 5.06 GBq (136.64 mCi)
  - Leakage in adaptor/needle connection
  - No personnel or area contamination
  - No adverse effects to the patient were expected
  - Root cause determined to be defective part of the assembly, specifically the dual male adaptor
    - » Lack of vacuum seal at the septum from re-puncturing with the new assembly setup was also a contributing factor

35.300 Lu-177 Lutathera

- Patient underdose
  - Patient was prescribed 7.4 GBq (200 mCi) of Lu-177
  - Patient received 1.04 GBq (28 mCi), 14% of prescribed
  - Procedure stopped after the patient stated they had a chemotherapy injection the day before, instead of after the radiopharmaceutical therapy
  - The prescribed dose was 479 cGy (rad) but estimated delivered dose to the kidney was 67 cGy (rad)
  - No medical impact expected
  - Root cause was determined to be inadequate review of patient records by authorized user

35.300 Lu-177 Lutathera

- Patient underdose
  - Patient prescribed 7.4 GBq (200 mCi), received 0.666 GBq (18 mCi)
  - Technician had difficulty establishing IV injection site and flow
  - No adverse effects were noted and none were expected
  - Cause was determined to be poor venous access and incorrect gauge needle

35.300 I-131 Iomab-B

- Patient underdose
  - Prescribed 414.4 MBq (11.2 mCi) (measured at 388.5 MBq (10.5 mCi) prior to administration)
  - Delivered 212.38 MBq (5.74 mCi); 51% of the prescribed dose (residual activity in vial and tubing was 176.12 MBq (4.76 mCi))
  - Considerable air in tubing required replacement of infusion set
  - Problem persisted with the second set of tubing, so the administration was stopped

35.300 I-131 Iomab-B (cont.)

- 38 mL of the 43 mL dosage was administered
- Approximately 0.111 Sv (11.1 rem) difference in prescribed and actual effective dose
- No re-administration of diagnostic dose was required, and the therapy dose was readministered without incident
- Corrective actions included procedure modifications

35.300 I-131 Iomab-B

- Patient underdose
  - Patient prescribed 35.11 GBq (949 mCi), received 18.76 GBq (507 mCi)
  - Dose administered was 1,900 cGy (rad)
  - Leaking tube from infusion system, nurse inadvertently removed a tube occluding clamp and opened the roller clamp on the flush bag line at the beginning of the infusion
  - No adverse effects expected, bone marrow dose was considered to be sufficient
  - Supplemental training was provided to the radiopharmacist and nuclear medicine supervisor on operating and setting up the infusion pump
    - » Solely responsible for setting up and operating the pump for all future patients
  - Checklist developed for pump operation

35.300 Ra-223 Xofigo

- Patient underdose
  - Patient prescribed 3.47MBq (93.65 µCi), received 0.63 MBq (17.1 µCi)
  - Procedure was cancelled due to low blood pressure, dose kept in hot lab for decay
  - New dose ordered, however the decayed, original dose was delivered
  - Patient brought back after the event; remaining dose delivered
  - Administrative actions taken to prevent reoccurrence

Medical Events 2021

35.400 Medical events	**4**
Prostate	3
Mammosite	1

35.400 I-125 Prostate

- Wrong Site
  - Prescribed 1.013 GBq (27.378 mCi), 54 seeds, prescribed dose of 14,500 cGy (rad)
  - Follow-up CT revealed that all seeds were implanted in penile bulb
  - Malfunction of ultrasound ruled out
  - Review indicated that if the foley catheter was not fully visible on images it could result in incorrect implantation
  - Root cause was human error
  - Changes to prostate brachytherapy protocol implemented an additional step to ensure clear identification of prostate gland and surrounding anatomy
  - Follow-up scans from previous cases involving this type of procedure indicated this was not a repeated event

35.400 Cs-131 Prostate

- Wrong site
  - Patient prescribed 7.34 GBq (198.26 mCi), received 1.41 GBq (38.12 mCi)
  - Prostate D90 dose was 26.26% of the prescribed dose
  - Perineal region received a V100 dose of 11,500 cGy (rad)
  - Urethra and rectum received approx. 50% of expected dose
  - Plan to insert stranded seeds around the prostate periphery and individual seeds at the apex, base, and interior of the prostate
  - Ultrasound probe was not accurately advanced on sagittal imaging to see the prostate
  - 63 of 78 stranded seeds were implanted in the perineum below the prostate, 15 loose seeds were implanted in the prostate

35.400 Cs-131 Prostate (cont.)

- Corrective actions included frame of reference establishing using the stepper position to identify base and apex of prostate
- During the procedure, a timeout will be performed to identify both the prostate and the bladder
- Retraining program was planned to include retraining and proctoring by a qualified radiation oncology physician and physicist
- External beam radiotherapy was performed to boost treatment to areas that received less dose
- Patient was scheduled for long-term follow-up

35.400 I-125 Prostate

- Patient Overdose
  - Patient prescribed 845.38 MBq (22.848 mCi) total activity for 64 prostate brachytherapy seeds
  - Authorized user discovered a mistake when entering the source strength into the treatment planning system
  - Inadvertently entered the seed strength of 13.21 MBq (0.357 mCi) into the air-kerma strength field
  - Prescribed dose was 110,000 cGy (rad), delivered dose was 140,000 cGy (rad)
  - No negative effects were expected, start of a two-part treatment plan
    - » Second part was a linear accelerator treatment, which was adjusted to accommodate the overdose
  - Corrective actions included procedure revision

35.400 Mammosite

- Wrong Patient
  - Wrong patient received breast cancer treatment
  - Determined not to be medical event in 2001, reevaluated after inspection
  - No details of the event were saved except that the patient dose exceeded 5 cSv (rem) EDE, or 50 cSv (rem) to an organ or tissue, or 50 cSv (rem) SDE to the skin
  - No related records could be obtained, past record retention period

Medical Events 2021

35.600 Medical events	**5**
Gynecological	4
Skin	1

35.600 HDR

- Patient overdose
- 216.56 GBq (5.853 Ci) Ir-192 HDR unit
- Patient prescribed 5000 cGy (rad) in 20 fractions at 250 cGy (rad) per fraction
  - Treatment for skin cancer using 35mm cone
  - Treatment occurred at correct site but without the 35mm cone for one fraction
  - Unintended skin dose was approx. 70 cGy (rad) above expected
- No effects were expected to the patient
- Corrective actions included
  - Advance preparation of treatment room with correct cone sizes
  - Physicist verification of applicator size and treatment site
  - Cone placed on skin and outline drawn by physician or physicist
  - Treatment outline and placement of applicator re confirmed before treatment is administered

35.600 HDR

- Wrong site
- Patient was treated with fraction 2 of 3 with a vaginal cylinder
  - After treatment, the physician noted that the cylinder had been displaced 6 cm
  - Exact cause was unknown but could have been due to patient movement or loosening of the cylinder holder
  - Estimated dose difference of approximately 558 cGy (rad)
  - Patient did not experience any irregular toxicities
  - Corrective actions included removing the device from service

35.600 Ir-192 HDR

- Wrong site
- Patient being treated with a 190.04 GBq (5.14 Ci) Ir-192 source
  - Source transfer tube was 12 cm too long, maximum shallow dose of 800 to 900 cGy (rad) to vagina
  - Root cause was determined to be failure of medical staff to follow established procedures
  - Also a failure to identify a difference in planned and measured transfer tube lengths
- No adverse health effects are expected

35.600 Ir-192 HDR (cont.)

- Corrective actions included addition of expected lengths of different channels in the HDR pre-treatment delivery checklist
- Also added measured length with the source position check ruler for each channel to checklist, to be completed and signed off on by the treating RTT prior to physicist review for all HDR cases
- Checklist approved by physicist prior to treatment to allow enough time for physician to verify accuracy

35.600 HDR

- Wrong site
- 256.41 GBq (6.93 Ci) Ir-192 HDR unit
- Patient prescribed five fractions of 600 cGy (rad) during an HDR gynecological treatment
  - After the third treatment, it was determined that a 125 cm transfer tube was used instead of the expected 113 cm transfer tube
  - Dose was delivered 12 cm away from expected site
  - Exposed tissue was largely fatty tissue, max dose to any tissue was 600 cGy (rad)
  - Authorized medical physicist did not identify the correct tube length during the verification process
- Corrective actions included removal of all 113 cm transfer tubes, only 125 cm tubes will be used for all future treatments
- All physicists were reminded of mandatory checks before all treatments and re-educated on procedural process

35.600 HDR

- Underdose
- 462.87 GBq (12.51 Ci) HDR unit
- Patient prescribed single 700 cGy (rad) fraction, received 525 cGy (rad)
  - Sometime during planning process dose scalar was adjusted by 25%
  - Most likely occurred when user was rotating/panning through images
  - Root cause was determined to be human error
- No adverse effects are expected
- Corrective actions included modifying procedures to include an additional step in the pre-check procedure to verify the correct dose and dwell times
- Training was also conducted on the incident and procedure changes with all staff and users

Medical Events 2021

35.1000 Medical events	**41**
Y-90 Microspheres	
– TheraSphere™	31
– SIR-Spheres®	10

35.1000 TheraSphere™

- Y-90 TheraSphere™ wrong location
  - Patient prescribed 2.55 GBq (68.92 mCi) to the left lobe, received 2.48 GBq (66.96 mCi) to right lobe
  - Catheter placement was verified prior to treatment by angiography and fluoroscopy
  - AU believes the catheter was kicked out during treatment, but no definitive cause was determined
- No adverse effects were expected
- Corrective actions included a new written procedure

35.1000 TheraSphere™

- Y-90 TheraSphere™ overdose
  - Patient prescribed 3.841 GBq (103.8 mCi), received 4.751 GBq (128.4 mCi)
  - Event was discovered by the RSO after a records review
  - Dose was calibrated for administration the day after the administration took place
    - Resulting activity was higher at administration
  - Root cause was determined to be human error
  - Corrective actions included secondary review of written directive, addition of another pre-administration form, and updated procedures

35.1000 TheraSphere™

- Y-90 TheraSphere™ overdose
  - Patient prescribed 1.75 GBq (47.3 mCi), received 2.224 GBq (60.11 mCi)
  - Event discovered after treatment by RSO during a review of therapies
  - Dose was administered a day too early, calibrated for the day after

35.1000 TheraSphere™

- Y-90 TheraSphere™ overdose (cont.)
  - Several corrective actions were taken
    - Operating procedures were revised to clarify responsibilities of involved participants
    - Dose will not be ordered until a microsphere treatment window illustrator is received, a complete written directive is received, there are no discrepancies between to two, NM verifies that the written directive is complete, and NM confirms the dose is appropriate for the date and time of administration
    - Second verification after receipt of dose
    - Time-out process was formalized
    - NM staff and AUs were trained on the changes
    - All AUs received a memo reminding them of their reporting responsibility
    - Office of Radiation Safety continued quarterly audits
    - Refresher training was performed

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.73 GBq (46.7 mCi), received 0.9324 GBq (25.2 mCi)
  - During treatment the physician noted that microspheres were visibly clogged in the catheter, discontinued the administration
  - Physician requested a larger catheter but was only able to find a smaller catheter
    - Noted the full dose might not be able to be delivered but elected to continue
  - Manufacturer review of the equipment found microspheres throughout the device and high back pressure and low flow rate
  - No adverse effects were expected, and follow-up treatment was successfully delivered

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 72,000 cGy (rad), received 36,620 cGy (rad)
  - Remaining microspheres remained in microsphere kit
  - Physician stated the patient received an adequate therapeutic dose

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.23 GBq (mCi), received 0.88 GBq (mCi)
  - No personnel or area contamination was noted
  - Leaky connections ruled out and no root cause was determined
  - Later inspections showed that the microspheres likely clumped in the vial
    - Saline was administered successfully, and scans showed bulk of material remained in the vial
  - May be due to inadequate tilting of the vial, tapping on a firm surface, or not taking those actions immediately prior to administration

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 12,000 cGy (rad), received 9,200 cGy (rad)
  - No personnel or area contamination was noted
  - Suspected kink in delivery system
  - Later inspection determined the root cause to be tortuous anatomy of the patient
  - The patient was also receiving chemotherapy treatment simultaneously, which was not recommended by the vendor representative
  - No corrective actions were taken

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 4.05 GBq (109.5 mCi) to liver lobes 5 and 8, 5.66 GBq (153 mCi) to lobes 6 and 7
  - Patient only received 2.53 GBq (68.5 mCi) to lobes 6 and 7
  - Blockage occurred in the microcatheter, unable to be cleared
  - Post procedure survey indicated residual activity in the microcatheter
  - Microcatheter used (d = 0.49mm) was smaller than recommended size (d = 0.5mm)
  - Corrective actions included using a larger catheter for subsequent treatment

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 547.6 MBq (14.8 mCi), received 344.84 MBq (9.32 mCi)
  - No adverse effects expected, likely the tumor was adequately treated
  - Investigation identified possible kink in microcatheter as root cause
  - Corrective actions included additional checks for kinks in catheters and tubing

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2.876 GBq (77.73 mCi), received 1.34 GBq (36.22 mCi)
    - Also 0.027 GBq (0.73 mCi) to lungs
  - Prior to treatment saline flush had slight resistance but all the flush went through
  - Pressure increased appreciably during the procedure and administration was stopped
  - Post-treatment survey of the catheter indicated greater than normal radioactivity
  - Cause determined to be kink in catheter, but AU stated the treatment area was tortuous
  - No corrective actions taken because proper procedures were followed

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.14 GBq (30.8 mCi), received 0.8094 GBq (21.868 mCi)
  - Mechanical blockage occurred in the delivery system
  - All material contained in delivery system, lines, and patient
  - Post treatment imaging indicated activity in the vial
  - No adverse effects were anticipated

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.067 GBq (28.84 mCi), received 0.522 GBq (14.11 mCi)
  - Microsphere vial was empty, likely held up in microcatheter
  - AU also believed that the high residual waste reading was due to a slower infusion of treatment dose and flushing saline
  - Normal flow rate was not able to be attained due to small patient vasculature
  - Investigation determined the delivery set worked as intended

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2.31 GBq (62.43 mCi), received 1.572 GBq (42.49 mCi)
  - Microsphere vial was empty, likely held up in microcatheter
  - Needed more saline flushes than normal to complete procedure (4 vs. 1-2)
  - Microsphere apparatus was new, first-time use
  - Manufacturer issued a product advisory concerning a possible leak point near catheter connection

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2 doses of 2.4 GBq (64.86 mCi), received 1.067 GBq (28.84 mCi) and 2.374 GBq (64.16 mCi)
  - During first administration the AU noticed leakage from the microcatheter and stopped the infusion to check the connection
  - Continued with the procedure and performed surveys around the room
  - Contamination was found on their hands, performed decontamination procedures and continued with second dose
  - Second dose delivered without incident

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose (cont.)
  - RSO contacted to ensure containment of radioactive material
  - Personnel were surveyed and access to the room was restricted in order to decontaminate
  - Decontamination of room proceeded without incident

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.067 GBq (28.86 mCi), received 0.799 GBq (21.62 mCi)
  - Pinch clamp remained online during infusion, discovered after AU noticed more pressure when pushing syringe
  - Clamp removed and treatment resumed
  - Flushed five times to ensure no microspheres remained in tubing
  - Images of the waste container indicated microspheres in inlet and outlet lines
  - AU believes the patient was delivered a clinically effective dose

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose (cont.)
  - Root cause was determined to be failure to follow procedures
    - Checklist was not followed to remove clamp prior to treatment
  - Corrective actions included procedure modification

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2.46 GBq (66.36 mCi), received 0.47 GBq (12.8 mCi)
  - Microspheres became visually clumped in tubing distal to the box prior to microcatheter connection
  - Multiple saline flushes were not effective in clearing the clump
  - Infusion was stopped after 33 minutes
  - Measurement of the tubing and microcatheter indicated only 20% of dose was delivered to the patient

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2.95 GBq (79.73 mCi), received 1.15 GBq (31.08 mCi)
  - During treatment, the dosimeter used to measure the spheres remaining in the container indicated a lower than expected rate of decrease in microspheres remaining in the container
  - The device and tubing were flushed more times than normal to remove any residual activity
  - Post-treatment surveys indicated the remaining activity remained in tubing
  - Suspected blockage in the tubing due to small portion of the septum lodged in needle after being pierced

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2 doses of 0.79 GBq (21.35 mCi) to left lobe segments 4A and 4B, received 0.465 and 0.594 GBq (12.57 and 16.05 mCi) to segments 4A and 4B
  - Radiation surveys of the vials post treatment revealed that some microspheres adhered to the tubing
  - Standard protocol was followed yet no root cause was identified during discussions with the manufacturer
    - Flushing with saline 3 times
  - Known risk that microspheres can be stuck in device in rare occasions

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 640.1 MBq (17.3 mCi), received 401.82 MBq (10.86 mCi)
  - Root cause was leakage of microspheres at the connection between tubing and microcatheter
  - Leakage resulted in personnel and area contamination
  - Addressed by Radiation Safety staff, no skin effects were reported or expected
  - No adverse effects to the patient
  - Corrective actions included procedure modifications

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.33 GBq (35.9 mCi), received 0.75 GBq (20.2 mCi)
  - Two doses were prepared for two separate sites of the liver
  - Doses were correctly labeled and prepared, but the smaller dose was administered to the site that needed the higher dose
  - The second dose was not administered
  - Root cause was determined to be miscommunication between NMT and AU

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose (cont.)
  - No adverse effects occurred, and the dose was determined to be clinically effective
  - Corrective actions included updates to the administration checklist, discussion of the use of a “closed loop” communication between the administrator of the dose and the physician requesting the dose, and increased training for applicable personnel

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 888 MBq (24 mCi), received less than 710.4 MBq (19.2 mCi)
  - A significant amount of microspheres leaked out of the tubing/catheter connection during the procedure
  - Sterile, non-radioactive solution was able to be pushed through the tubing without incident
  - Several drops were noticed at the connection during the administration and were cleaned off
  - Contamination was detected on the gloves, patient's drape, and towels after the treatment
  - No contamination was detected on the floor, patient, or staff

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose (cont.)
  - Imaging indicated radioactivity in the patient's liver
  - No adverse effects were expected
  - Physician stated connecting the catheters took more force than normal, indicating a possible defect
  - Corrective actions included update procedures so two people check the connection between catheters
  - The procedure was repeated at a later date to accomplish the prescribed dose

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 828 MBq (22.379 mCi), received 624 MBq (16.865 mCi)
  - No contamination was detected in the room or on staff members
  - No issues were found with the delivery system or setup
  - No unusual resistance was felt on the syringe during treatment
  - On the day of the treatment an angiogram demonstrated brisk arterial supply to the tumor and verified catheter position
  - No cause was identified
  - No adverse effects were expected

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 688.2 MBq (18.6 mCi), received 144.5 MBq (3.9 mCi)
  - Patient received 21% less dose than prescribed
  - Residual activity remained in delivery system

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2.36 GBq (63.7 mCi), received 0.074 GBq (2 mCi)
  - Connection between delivery apparatus and catheter failed when the injection started
  - All contamination was contained in the pads below the connection
  - No adverse effects were expected

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose (cont.)
  - Inspection revealed a manufacturing defect in the administration kit
    - Leakage at the Leur outlet
  - Product advisory was issued, and all kits associated with the involved lot numbers were disposed of
  - Corrective actions included staff training

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 2.76 GBq (74.46 mCi), received 1.32 GBq (35.6 mCi)
  - Microcatheter disconnected from the Luer lock during injection
  - Lock was tightened and treatment was completed
  - Leaked microspheres were contained in absorbent towels
  - Underdose was estimated from measurement of tubing, towels, and microcatheter
  - Patient was scheduled for imaging to determine if follow-up treatment was necessary
  - Corrective actions included checklist training, with a focus on the Luer lock connection

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 860 MBq (23.24 mCi), received 359.738 MBq (9.72 mCi)
  - Patient prescribed same dose to four lobes of liver
  - Three lobes received correct dose; one was underdosed
  - Analysis of the delivery kit found residual microspheres in the last few inches of tubing, in the microcatheter hub, and in the initial length of the microcatheter
  - Indication of obstruction downstream of administration set
  - Catheter was in good condition but only a limited flow rate could be achieved

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose (cont.)
  - Microcatheter did not meet size requirements for TheraSphere™ administration
  - No adverse effects were expected
  - Follow-up imaging determined the treatment was clinically effective
  - Corrective actions included use of correct microcatheters, and notification of physicians of the correct microcatheter to use

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.79 GBq (48.38 mCi), received 0.716 GBq (19.35 mCi)
  - Root cause was not clear but likely due to selection of a distal arterial branch for administration
  - 3 hairpin turns may have resulted in “ovalization” of the microcatheter lumen
  - Location was checked multiple times during treatment and flow was established with saline and contrast
  - Ovalization may have resulted in greater pressure on administration set
  - Corrective actions included cessation of treatment on patients with a significant number of tight turns

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 592 MBq (16 mCi), received 368 MBq (9.95 mCi)
  - Leak was identified between administration kit and microcatheter
  - Spill was confined to patient drape, confirmed by follow-up surveys of the room and staff
  - Root cause was determined to be mismatch between the administration set received from manufacturer and previous kits used, resulting in a leaky junction

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 594.94 MBq (16.08 mCi), received 270.1 MBq (7.3 mCi)
  - Treatment appeared to be correct, survey of items used determined the patient had been underdosed
  - Experiments to find the root cause determined that if the connection between the delivery set and the microcatheter was not vertically oriented, the microspheres would become stuck
  - These findings were communicated to all AUs
  - Corrective actions included amending checklist to specify that the connection must be oriented vertically
  - Patient will be followed to determine if further treatment is needed

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 1.56 GBq (42.24 mCi), received 1.04 GBq (28.1 mCi)
  - Treatment appeared to be correct, survey of catheter indicated higher than normal residual activity
  - Experiments to find the root cause determined that if the connection between the delivery set and the microcatheter was not vertically oriented, the microspheres would become stuck
  - These findings were communicated to all AUs
  - Corrective actions included amending checklist to specify that the connection must be oriented vertically
  - Patient will be followed to determine if further treatment is needed

35.1000 TheraSphere™

- Y-90 TheraSphere™ underdose
  - Patient prescribed 13.65 GBq (368.92 mCi), received 10.51 GBq (284.07 mCi)
  - Patient received 77% of expected dose, which was determined to be medically appropriate
  - No spill or contamination was detected after surveys
  - Root cause was decay of dose due to multiple treatment reschedules
  - The healthcare center has implemented a program to review accuracy prior to patient scheduling and dose ordered

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® wrong site
  - Patient prescribed 0.29 – 0.83 GBq (7.84 – 22.43 mCi) to left lobe of liver
    - The activity was a range because treatment would be stopped if the left lobe became saturated
  - Post treatment survey indicated the right lobe had received between 33% and 67% of the dose intended for the left lobe
    - Treatment was not intended for the right lobe (patient had been treated for the right lobe previously)
  - Periodic flushing and fluoroscopy was performed and indicated the catheter had moved during the treatment
  - Suspected respiratory motion and vascular pulsations moved the catheter to the right branch
  - No adverse effects were anticipated

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® overdose
  - Patient prescribed 489.14 MBq (13.22 mCi), received 1,168.09 MBq (31.57 mCi)
  - Two different treatments were prepared for different lobes of the liver
  - Higher dose was administered to the wrong lobe
  - Error discovered after treatment of the first lobe
  - The other lobe was correctly treated
  - Root cause was determined to be incorrect labelling and failure to compare dosage to written directive

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® overdose (cont.)
  - Corrective actions included revised procedure that specifies labelling to only include patient initials, radionuclide, activity, and date
  - A time-out was also incorporated to compare each dose to the written directive, signed by the AU

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Prescribed 13,000 cGy (rad) to lobes 2,3 and another 13,000 cGy (rad) to lobes 4,5
  - Complex vascular flow pattern complicated the treatment delivery
  - Microspheres intended for lobe 2,3 went to segment 4
  - Dose intended for lobes 4 and 5 only went to lobe 5
  - Segment 4 received a dose of 2,500 cGy (rad), and segemtn 5 received a dose of 13,500 cGy (rad)
  - Root cause determined to be incorrect placement of delivery catheter
  - Corrective actions included a review by a quality control committee

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 599.4 MBq (mCi), received 140.6 MBq (mCi)
  - During treatment a microcatheter almost immediately clogged
  - No adverse effects were expected
  - Root cause was determined to be clogs in the microcatheter
  - Imaging of the delivery system determined the potential clumping was in the delivery box or the microcatheter

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 2.697 GBq (72.9 mCi), received 0.93 GBq (25.16 mCi)
  - No contamination was reported
  - Delivered dose was clinically effective
  - No changes to the catheter or procedures during this administration from prior administrations
  - Root cause was determined to be a clog in the catheter
  - Corrective actions taken included procedure modifications

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 3.5 GBq (94.6 mCi), received 2.66 GBq (71.9 mCi)
  - Catheter clogged due to high volume of microspheres
  - Catheter was replaced and no stasis was observed, treatment continued
  - No adverse effects on patient, no additional treatment was required

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 1.6 GBq (43.2 mCi), received 0.17 GBq (4.53 mCi)
  - Procedure was stopped after encountering resistance, intended to complete administration at a later time
  - AU disconnected the line before releasing pressure
  - Microspheres were expelled onto administration table and floor covering
  - All coverings were disposed of and the room was decontaminated
  - Root cause was suspected to be clogged microcatheter
  - No adverse effects to the patient, follow-up treatment was administered

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 299.7 MBq (8.1 mCi), received 229.4 MBq (6.2 mCi)
  - Root cause was determined to be retention of microspheres in delivery device
  - The relatively large percentage of activity retained in the delivery apparatus may be related to the small activity and volume prescribed
  - No adverse effects were expected; the procedure was expected to be clinically effective
  - Corrective actions included drawing low activity doses (555 MBq [15mCi] or less) using a delivery fraction of 0.90 instead of 0.095
    - Better accommodate the larger residual percentages observed for low activities

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 3.6 GBq (97.3 mCi), received 2.46 GBq (66.5 mCi)
  - Full dose was separated into 2 administrations through 2 arteries
  - First administered successfully, second encountered catheter occlusion
  - Root cause was determined to be a deformed catheter with a significant kink point on the inner catheter body
    - Reduced flow rate and allowed for full occlusion of the proximal segment of the catheter

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose (cont.)
  - No adverse effects were expected
  - Patient returned for remainder of the dose at a later time

35.1000 SIR-Spheres®

- Y-90 SIR-Spheres® underdose
  - Patient prescribed 1.1174 GBq (30.2 mCi), received 0.8854 GBq (23.93 mCi)
  - NMT encountered increasing resistance during treatment, leading them to believe stasis had been achieved
  - Root cause was a clogged microcatheter discovered post treatment
  - Subsequent treatment was given to make up for underdose
  - Corrective actions included obtaining new equipment

Acronyms

- µCi – microcurie
- AMP – authorized medical physicist
- AU – Authorized User
- Cs-131 – Cesium-131
- cGy – centiGray
- CT – Computed tomography
- FY – Fiscal Year
- GBq – Giga Becquerel
- Gy – Gray
- HDR – High Dose Rate Remote Afterloader

Acronyms

- I-125 – Iodine-125
- I-192 –Iridium-192
- IVB – Intravascular Brachytherapy
- Lu-177 – Lutetium-177
- MBq – Mega Becquerel
- µCi - microcurie
- mCi – millicurie
- NMT – Nuclear Medicine Technologist
- RSO – Radiation Safety Officer
- SI units – International System of Units
- Y-90 – Yttrium-90

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

QUESTIONS?

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

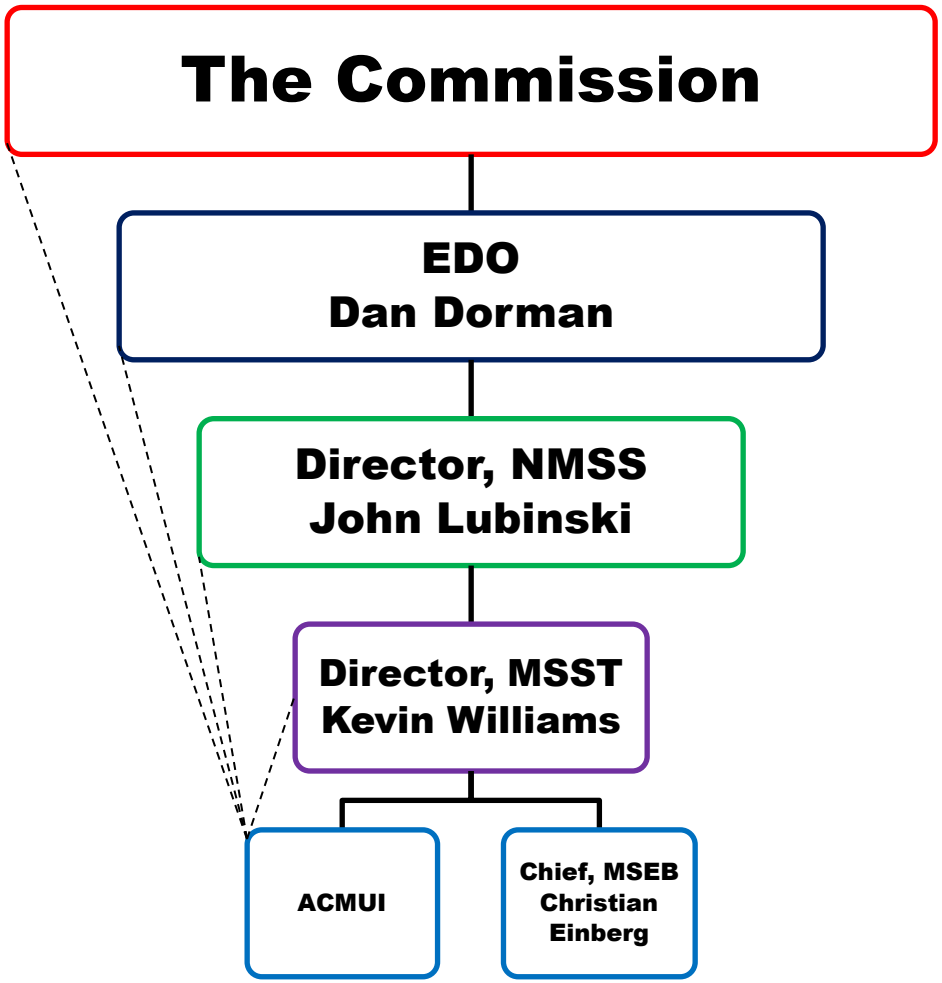
ACMUI
Reporting Structure

Don Lowman, ACMUI Coordinator
Medical Radiation Safety Team
April 5, 2022

Outline

- **Current Reporting Structure**
- **Annual Review**
- **Meetings**
- **Discussion**

Current Reporting Structure



Annual Review

In September 2012, the ACMUI recommended to have an annual review of reporting structure.

Meetings

Two meetings each year

- March/April
- September/October

Approximately 2-3 teleconferences (as needed)

ACMUI Discussion

Points of Contact

- **Kevin Williams – MSST Director**
  - **Kevin.Williams@nrc.gov**
- **Christian Einberg – Designated Federal Officer (DFO), Chief, MSEB**
  - **Christian.Einberg@nrc.gov**
- **Don Lowman –ACMUI Coordinator (acting)**
  - **Don.Lowman@nrc.gov**

Acronyms

- **ACMUI – Advisory Committee on the Medical Uses of Isotopes**
- **DFO – Designated Federal Officer**
- **EDO – Executive Director for Operations**
- **MSST – Division of Materials Safety, Security, States, and Tribal Programs**
- **MSEB – Medical Safety and Events Assessment Branch**
- **NMSS – Office of Nuclear Material Safety and Safeguards**

Boston Scientific

Advancing science for life™

TheraSphere™ Yttrium-90 Glass Microspheres

Ashley Cockerham

Advisory Committee on the Medical Uses of Isotopes Meeting

April 5, 2022

Disclosure

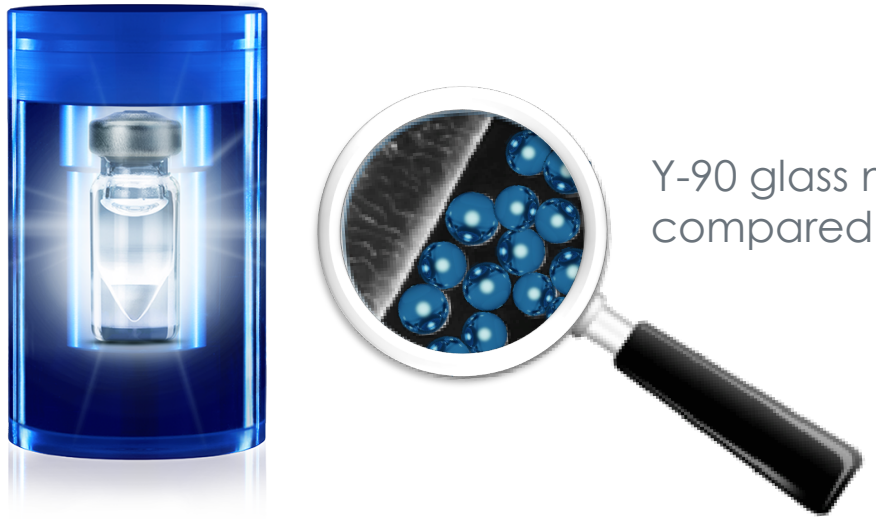
- Consultant for Boston Scientific

Overview

- Product Information
- Ordering
- Setup
- Administration
- Disassembly
- Waste
- Written Directive

What is TheraSphere?

- Insoluble glass microspheres with a mean diameter of 15-35 µm[1]
- Y-90 is an integral constituent of the glass

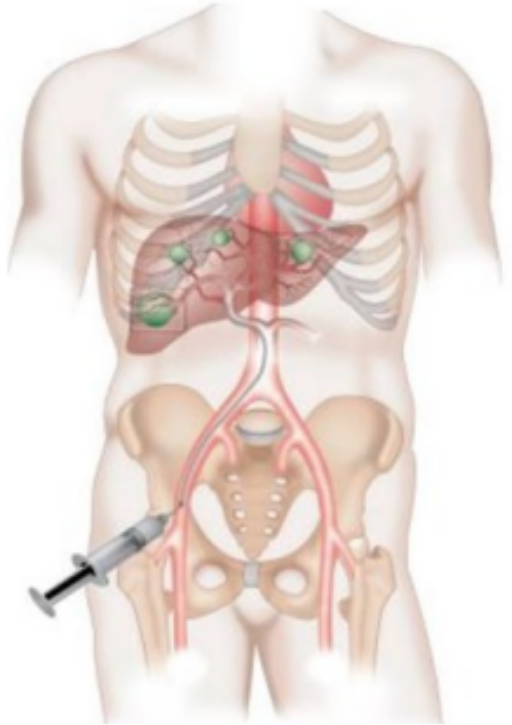


Y-90 glass microspheres compared to human hair[2]

1. Package Insert - TheraSphere Yttrium-90 Glass Microspheres - Rev.1. Biocompatibles UK Ltd, a BTG International group company.
2. Kennedy A et al. Int J Radiat Oncol Biol Phys 2007;68(1):13–23.

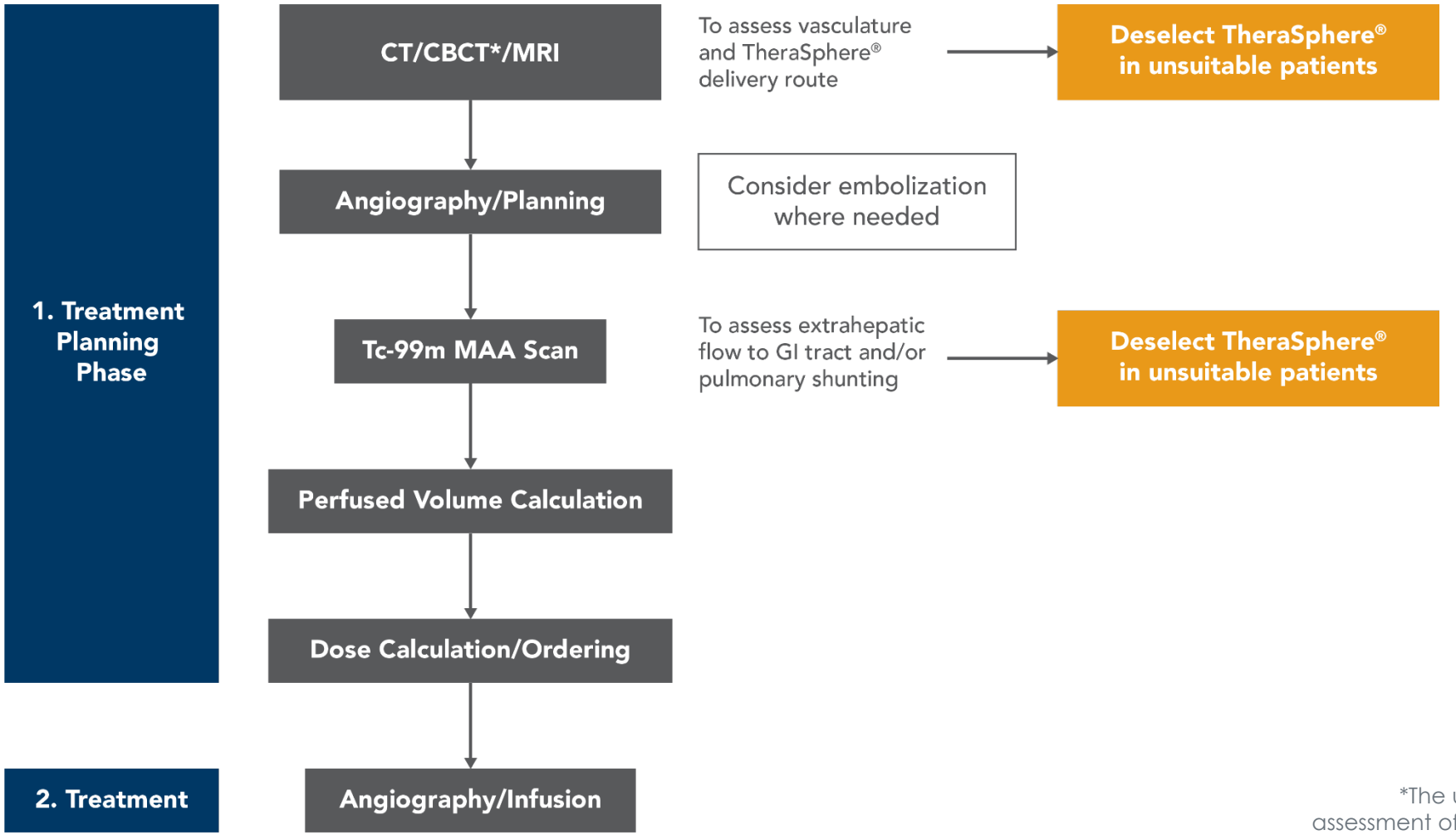
How does TheraSphere work?

- Delivered to tumor vasculature through the hepatic artery[1,3]
- 100% pure beta emitter
- Half-life of 64.1 h
- Average tissue penetration range of 2.5 mm



1. Package Insert - TheraSphere Yttrium-90 Glass Microspheres - Rev.1. Biocompatibles UK Ltd, a BTG International group company.
3. U.S. TheraSphere Reference Manual (PI-1001304-AA).

Recommended Treatment Algorithm



*The use of CBCT can improve assessment of tumor perfusion with the intent to minimize non-target deposition

CBCT = Cone-Beam Computed Tomography; CT = Computed Tomography; GI = Gastrointestinal; MRI = Magnetic Resonance Imaging; Tc-99m MAA = Technetium-99 Macroaggregated Albumin

Ordering – Treatment Window Illustrator

Patient Name:		**Patient ID:**	123456	**Target Tissue:**	Right Lobe
Target Volume (cc):	1160.0			**Target Liver Mass (kg):**	1.195
Desired Dose (Gy):	120				
Time Zone Variance (h):	0	(see Time Zones tab for details)	**Places in this Time Zone:**	Ottawa Ontario New York NY	
Lung Shunt Fraction (% LSF):	5.00%				
Anticipated Residual Waste (%):	1.00%	Optional estimated value			
Previous Dose to the Lungs (Gy):	0				

Required Activity at Administration (GBq): **3.05** This value is corrected for LSF and Residual Waste if values are entered above.

Calculated Dose to Lungs (Gy):	7.55	Dose Limit to the Lungs per treatment (Gy):	30	See Package Insert or Instructions for Use
Lung Dose within recommended limit for treatment				
Cumulative Dose to Lungs (Gy):	7.55	Cumulative Dose Limit to the Lungs (Gy):	50	
Lung Dose within recommended cumulative limit for treatment				

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

Dose Size Selected (GBq):	11 GBq, cal 8/30	Optional field for Medical Professional to document treatment dose selected
Date & Time for Administration:	9/4 @ 10am	Optional field for Medical Professional to document treatment window selected

Tables below show the dose to perfused target tissue, accounting for target mass, time zone variance, lung shunt fraction and residual waste.

Dose Delivered (Gy) for: 3 GBq dose size

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	95	73	57	44	34	26	20	15	12	9	7	5
12:00 PM		91	70	54	42	32	25	19	15	11	9	7	5
4:00 PM		87	67	52	40	31	24	18	14	11	8	7	5
8:00 PM		84	64	50	38	30	23	18	14	10	8	6	5

Dose Delivered (Gy) for: 5 GBq dose size

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	159	**122**	94	73	56	43	33	26	20	15	12	9
12:00 PM		152	**117**	90	70	54	41	32	25	19	15	11	9
4:00 PM		145	**112**	87	67	51	40	31	24	18	14	11	8
8:00 PM		**139**	**107**	83	64	49	38	29	23	17	13	10	8

Dose Delivered (Gy) for: 7 GBq dose size

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	222	171	**132**	**102**	79	61	47	36	28	21	17	13
12:00 PM		213	164	**126**	**98**	75	58	45	35	27	21	16	12
4:00 PM		204	157	**121**	93	72	56	43	33	26	20	15	12
8:00 PM		195	150	**116**	89	69	53	41	32	24	19	15	11

Dose Delivered (Gy) for: 10 GBq dose size

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	317	245	189	146	**112**	87	67	52	40	31	24	18
12:00 PM		304	234	181	**139**	**108**	83	64	49	38	29	23	17
4:00 PM		291	224	173	**133**	**103**	79	61	47	36	28	22	17
8:00 PM		278	215	166	**128**	**99**	76	59	45	35	27	21	16

Dose Delivered (Gy) for: 15 GBq dose size

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	476	367	283	218	168	**130**	**100**	77	60	46	35	27
12:00 PM		455	351	271	209	161	**124**	96	74	57	44	34	26
4:00 PM		436	336	260	200	154	**119**	92	71	55	42	33	25
8:00 PM		418	322	249	192	148	**114**	88	68	52	40	31	24

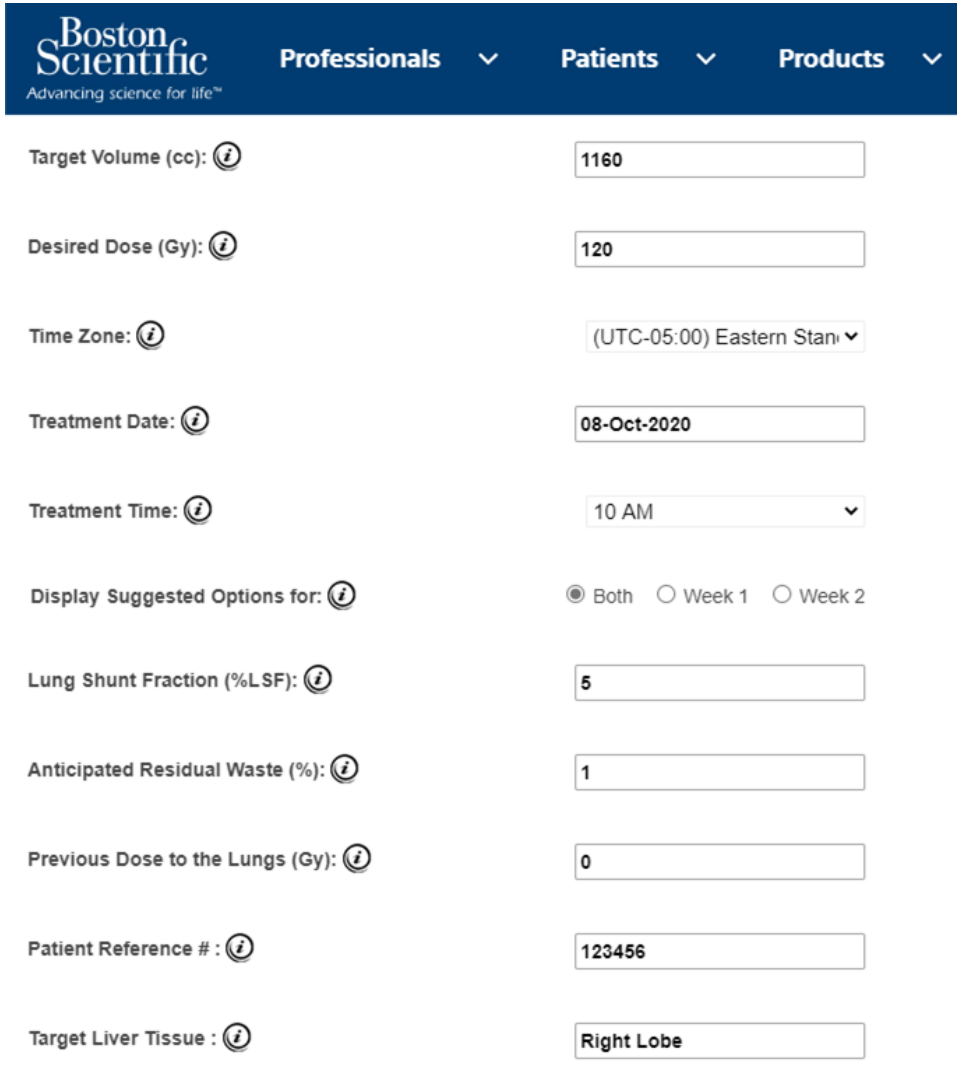
Dose Delivered (Gy) for: 20 GBq dose size

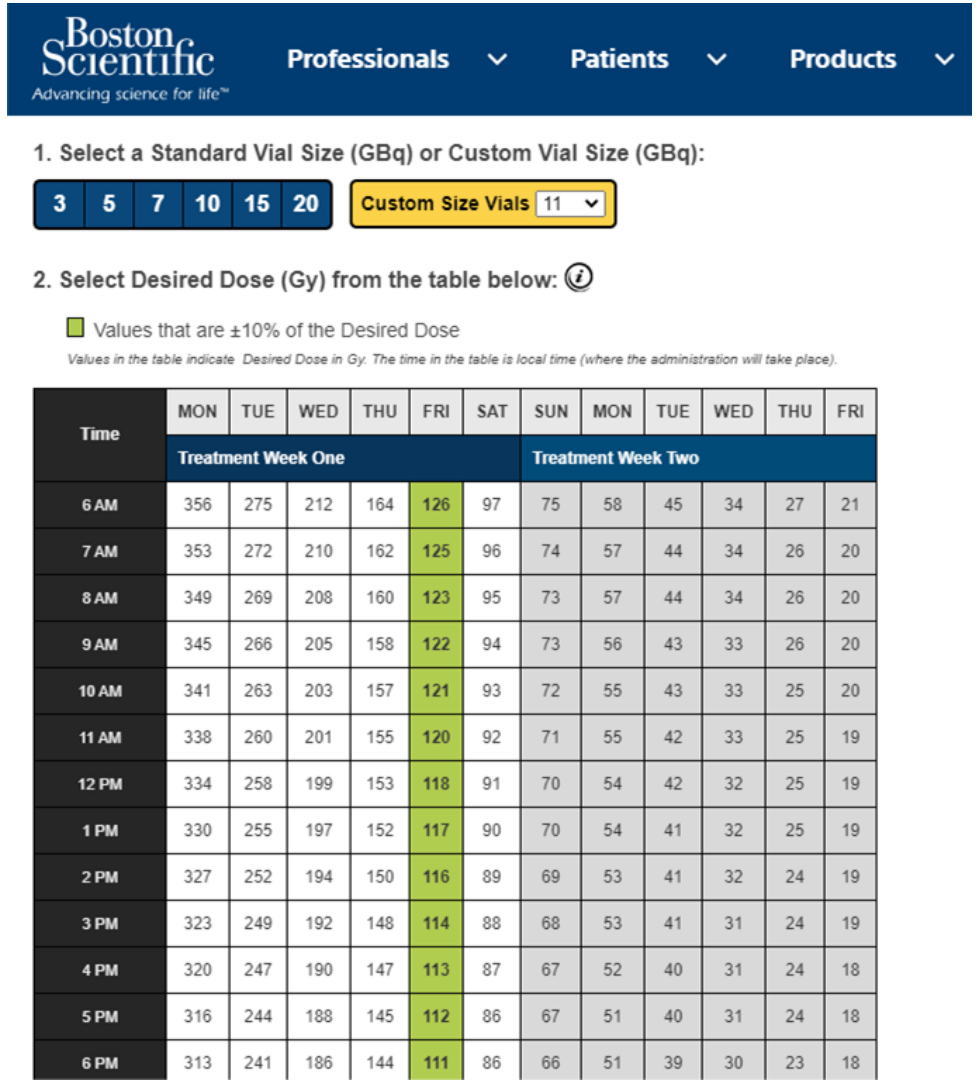
Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	634	489	377	291	225	173	**134**	**103**	80	61	47	37
12:00 PM		607	468	361	279	215	166	**128**	**99**	76	59	45	35
4:00 PM		582	449	346	267	206	159	**123**	95	73	56	43	33
8:00 PM		557	430	331	256	197	152	**117**	91	70	54	42	32

Dose Delivered (Gy) for a Custom Dose size: 11 GBq dose size

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Week 2 treatment: Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM	Calibration Day @ 12:00 Eastern Time	349	269	208	160	**123**	95	73	57	44	34	26	20
12:00 PM		334	258	199	153	**118**	91	70	54	42	32	25	19
4:00 PM		320	247	190	147	**113**	87	67	52	40	31	24	18
8:00 PM		306	236	182	**141**	**108**	84	65	50	38	30	23	18

Ordering – Online





Time	MON	TUE	WED	THU	FRI	SAT	SUN	MON	TUE	WED	THU	FRI
	Treatment Week One						Treatment Week Two					
6 AM	356	275	212	164	126	97	75	58	45	34	27	21
7 AM	353	272	210	162	125	96	74	57	44	34	26	20
8 AM	349	269	208	160	123	95	73	57	44	34	26	20
9 AM	345	266	205	158	122	94	73	56	43	33	26	20
10 AM	341	263	203	157	121	93	72	55	43	33	25	20
11 AM	338	260	201	155	120	92	71	55	42	33	25	19
12 PM	334	258	199	153	118	91	70	54	42	32	25	19
1 PM	330	255	197	152	117	90	70	54	41	32	25	19
2 PM	327	252	194	150	116	89	69	53	41	32	24	19
3 PM	323	249	192	148	114	88	68	53	41	31	24	19
4 PM	320	247	190	147	113	87	67	52	40	31	24	18
5 PM	316	244	188	145	112	86	67	51	40	31	24	18
6 PM	313	241	186	144	111	86	66	51	39	30	23	18

Setup

1. Administration Set (Tubing)
2. Administration Accessory Kit (Acrylic Box)
3. Nalgene® Waste Container w/ Beta Shield
4. Radiation Meter
5. Saline Bag
6. RADOS Meter
7. TheraSphere Dose Vial
8. Additional Supplies

Administration Checklist

THERASPHERE™ Y-90 Microspheres | ADMINISTRATION CHECKLIST

Boston Scientific
Advancing science for life™

Patient Name:

TheraSphere Vial Size (GBq) (Labelled quantity at Calibration):

MRN / Reference:

Dose Vial Lot and Vial#:

Treatment Date:

Y-90 Activity at TX (GBq mCi) (Activity at time of treatment; indicate units):

Target Tissue (Liver lobe, sements to be perfused):

Admin. Set Lot # and Expiry:

Catheter Information (Place catheter sticker here)
(Microcatheter inner diameter must be ³0.5mm (0.020 inch) Do not use catheter extension tubing.

1. PREPARE THE PATIENT

- ○ Confirm the patient identity for treatment (2 methods)
- ○ Confirm patient prescription for TheraSphere™ and plan for treatment
- ○ Measure radiation from the patient before treatment with ionization survey meter: _____

Explanation / Best Practice:

- Ensure Written Directive /Prescription is signed
- Measured radiation from patient is to confirm implantation and for patient release
- Ionization survey meters provide stable measurement of gamma/bremsstrahlung fields; recommended for patient measurements

2. PREPARE THE TREATMENT ROOM, EQUIPMENT

- ○ Geiger-Mueller (GM) contamination meter
- ○ Spill kit
- ○ Post signs for RADIOACTIVE MATERIAL IN USE, as required
- ○ Apply a floor cover under the treatment area in the angiography suite

Prepare a moveable cart with the following items:

- ○ Small sterile towels/drapes
- ○ Sterile gauze
- ○ 0.9% Saline bag or bottl
- ○ TheraSphere Administration Set(s)
- ○ TheraSphere Accessory Kit (acrylic box)
- • Open the IV

- 1 Administration Set for each dose vial; Open at Priming step
- Accessory Kit is an acrylic box to provide radiation shielding and containment. Fully extend stainless steel arm when cart is inside the IR suite.
- Ensure dosimeter alarms are turned off
- 1 saline bag or bottle for each dose vial; minimum 200 mL size
- Alcohol can be swab or spray
- 1 waste container for each dose vial

Setup – Contamination Precautions

Three Separate Contamination Barriers:

- Drape/absorbent pad on floor underneath TheraSphere table/delivery path
- Second drape beneath outline line and catheter hub
- Third drape bridging administration box and patient

Other Precautions:

- Recommend use of double gloves/shoe covers for staff involved in administration
- Establish contamination control point at exit of room to monitor hands and feet of all personnel
- Wrap catheter tip in gauze/small towel to control contamination when removing from patient

Setup – Administration Set Priming

Flush tubing set with saline, ensuring **two** steady streams through needle system

Once primed, connect needle system to dose vial

Place tubing set through labeled slots in acrylic box

Administration – Optimize Delivery

Dose Vial Handling

- Dose vial may have been inverted during shipment causing microspheres to become lodged around septum
- Gently rock lead pot 90° to wet microspheres and firmly tap bottom on hard surface
- Maintain vial in upright position until infused into patient

Pinch Clamps

- Relieve dent in pinch clamp when opening prior to administration
- Minimize potential for air bubbles in outlet line

Infusion Pressure

- Constant syringe pressure is important
- Recommended flow rate ≥20 cc/min
  (appropriate to flow of native vessel; slower rate may decrease delivery efficiency)

Administration – Optimize Delivery

- Infuse TheraSphere dose vial by pushing on syringe plunger
- Applying pressure >30 psi will cause saline to divert into 20 mL overflow vial (reduce pressure, if seen)
- Once completed, refill syringe by pulling plunger back
- A minimum of **three** flushes of 20 cc of saline are recommended

Administration – RADOS Meter

- Allow RADOS meter to stabilize for **15-30 seconds** following delivery or x-ray use
  - RADOS meter should be measuring in **mR/h**
  - Typically reads **0.0 mR/h** when all microspheres have cleared the vial

Disassembly – Waste Containment

- On final disassembly, pull microcatheter into base catheter and slowly remove both from the patient while controlling the tip with gauze or a towel
- Carefully cut and remove TheraSphere tubing, including attached catheters and acrylic dose vial, along with top set of gloves into waste container
- Survey remaining TheraSphere system materials for contamination

Waste Measurement

All waste components inserted in 2L Nalgene® waste jar

- Handling treatment waste involves mitigating:
  - Hazards of patient blood
  - High radiation fields
  - Potential radioactive contamination
- Radiation safety considerations have driven the approach to estimating residual waste activity

Waste Template Measurement (mR/h)

- Measure waste at 30 cm (12 in) from detector at **four rotational positions**
- Average these four measurements and subtract background radiation
- Calculate % difference between pre- and post-treatment template measurements to determine % vial delivered

Written Directive

The **written directive** captures all pre- and post-treatment measurements and automatically tracks and calculates TheraSphere **% delivery**

Pre-Treatment Planning	*This section must be approved by the Authorized User.*		
Target Tissue (Treatment site)		Lung Shunt Fraction (%LSF)	
Target Volume (cc)		Cumulative Previous Dose to the Lungs (Gy)	
Mass (kg)		Contract Manufacturer: Nordion	Device: Y-90 TheraSphere
Desired Dose to Target Volume (Gy)			
Treatment date and time		Required Total Activity at time of Treatment (GBq)	
Time zone of Hospital		Number of vials to be administered to Target Tissue	

	Dose Vial A		
Ordered/Received Dose Size (GBq)			
Calibration Date			
Hours from Calibration to Treatment (hrs)			
Nominal Activity in Vial at time of Treatment (GBq)			
Sum of Nominal Activity in Vial(s) at time of Treatment (GBq)			
Calculated dose to lungs at Treatment time, assuming 1kg lungs (Gy)		Cumulative dose to lungs (Gy)	
Dose to Target Volume at Treatment, accounting for lung shunt (Gy)		Authorized User signature & date	

Pre-treatment Dose Calibrator (DC) Measurement	*Measure the received dose vial(s) in a dose calibrator using TheraSphere setting and correction factor*		
	Dose Vial A		
Manufacturer's Lot Number and Vial Number			
Date and Time of DC measurement			
DC Measured Activity, with correction factor (GBq)			
Hours from Calibration to DC Measurement (hrs)			
DC Measured Activity referenced to Calibration time (GBq)			
OPTIONAL: Manufacturer's Activity at Calibration (GBq)			
Value to be used in Delivery calculations below:		Measured by (Initials):	

Pre-treatment Template Measurement	*Measure the dose vial (no lead pot) @ 30 cm with ion chamber meter on Template*		
	Dose Vial A		
Date and Time of Template measurement			
Measurement of Dose vial on Template (mR/h)			
Background Measurement (mR/h)			
Net dose rate of Dose vial on Template (mR/h)			
		Measured by (Initials):	

Treatment / Administration			
Methods used to confirm Patient Identity (select two)			
	Dose Vial A		
Confirm Lot number and Vial number (on label) matches Line 23 above	☐ Check if Lot # & Vial # match	☐ Check if Lot # & Vial # match	☐ Check if Lot # & Vial # match
Administration Start Date & Time			
Patient dose rate, maximum on contact (mR/h)		Measured by (Initials):	
Patient dose rate, maximum at 1 meter (mR/h)			
AU / ADMINISTERING PHYSICIAN comments (sign & date):	☐ None		

Post-treatment Template measurements	*Measure the waste jar in beta shield @ 30 cm with ion chamber meter on Template*			
		Waste Jar - Vial A		
Date and Time of Template measurement				
Waste Container Measurement in Beta shield (mR/h), 4 Cylinder Orientations on Template	Background Measurement (mR/h)			
	0°			
	90°			
	180°			
	270°			
Average of 4 Orientations minus Background (mR/h)				
Hours between Pre- and Post- Treatment Measures (hrs)				
Pre-Treatment Net Rate decayed to Post- Treat time (mR/h)				
Percent delivery per Vial (%)				
Hours between Calibration and Treatment (hrs)				
Activity Administered per Vial at time of Treatment (GBq)				
Ratio: Actual Radiation Dose to Target Tissue vs. Desired Dose			Measured by (Initials):	

Final Calculations	*Calculated values below use formulas from the TheraSphere package insert. The AU must confirm accuracy.*		
Total Activity Delivered to Patient at time of Treatment (GBq)		Lung shunt fraction (%)	
(mCi)		Activity to Lungs (GBq)	
Activity Delivered to Perfused Liver Tissue (GBq)		(mCi)	
(mCi)		Radiation to Lungs (Gy)	
Radiation dose to Perfused Liver Tissue (Gy)		Cumulative radiation to Lungs (Gy)	
Physicist/RSO/CNMT signature & date		Authorized User signature & date	

SIR-Spheres® Y-90 Resin Microspheres

An Overview

SIRTeX

Overview

- Preparation
- Delivery Box set up
- Delivery principle and infusion
- Potential abort points
- Post-procedure information

Training Resources – New Account Resource Kit

SUMMARY

We have completed RSC
microspheres, covering t

- Radiation safety
  - Beta emission, bre
  - SIR-Spheres Y-90
- Regulatory issues
  - Guidance, Inventor
    commitments, writt
    release
- Emergency procedu
  - Spill prevention, de

27

Post Implant Imaging Protocol

Overview

- Within 48 hours following treatment with SIR-Spheres® Y-90 resin microspheres, imaging can be performed to assess deposition of the SIR-Spheres Y-90 resin microspheres to verify the dose was delivered to the desired location.

Patient Position & Imaging Field

- Imaging field: upper abdomen
- Patient position: supine.
- Patients must be closely monitored by technology staff while being imaged. Once in position for imaging, the patient may be secured to the imaging pallet by wrapping the security wrap around the patient's chest in a manner such that the patient is protected from falling from the table but can breathe easily.

Acquisition Protocols

Bremsstrahlung SPECT/CT (parameters were derived from Seimens camera with medium energy collimator)	
Primary Energy Window	90-125 keV (e.g., 107.5 ± 16%)
Background Energy Window	310-410 keV (e.g., 360 ± 14%)
Reconstruction	OSEM, 8 subsets, 16 iterations
Scatter Window Scaling	Disabled + 1.06 additional scale factor
Corrections	AC + SC + RR
Transverse Image Array Size	128x128

Note: for Siemens camera you have the opportunity to re-peak and since there is no peak in the Bremsstrahlung Y90 spectrum **DO NOT DO THIS**

Y-90 PET/CT			
	GE Healthcare (Discovery 690, 710)	Phillips (Gemini TF)	Siemens (Biograph mCT)
Reconstruction	3D OSEM with all-pass filter: 2i24s + RR + ToF	3D OSEM (BLOB OS TF) with no filter: 4i8s + ToF	3D OSEM with all-pass filter: 2i21s + RR + ToF
Acquisition Duration	~20 min	~20 min	~20 min
Transverse Image Array Size	128x128 (maximum voxel dimension: 4.8)	128x128 (maximum voxel dimension: 4.8)	128x128 (maximum voxel dimension: 4.8)

SIR-Spheres® Y-90 resin microspheres Dose Preparation Worksheet

Patient Name/ID: _____

Treatment Site: _____

or Affix Sticker

libration

ecalculate shipping activity and re-as

t. Place in D-Vial in holder and transp
and D5W volume as described below

GBq x 27 = mCi)

l Activity per Unit Volume [L]

Volume [L] = Volume to Draw [M]

dd to D-Vial.

] = Calculated Residual Activity [N]

_____ mCi

Measured Shipping Activity [H] – **Measured Residual Activity [BB]** = **Prepared Activity [CC]** _____ mCi

Table of Contents

SIRTeX

Training Education and Certification Program

A Sirtex program designed to ensure site and users are adequately trained to use SIR-Spheres® yttrium-90 resin microspheres, designed to mitigate risk to patients, users, the environment.

- Spills (Nuclear Medicine Technologists/Radiopharmacist/IR techs)
- Users (how to use Sirtex shielding devices (i.e. box, syringe shield, v-vial shield, SIROS)
- Patient (significance of patient selection, mapping and catheter placement to Adverse Events (i.e. REILD, RILD, Radiation pneumonitis))

Preparation

TRN-TEC-001 rev # : 1 (CR 2860) Issued: 28 Sept 2021

Preparation

- Unpack SIR-Spheres microspheres, leaving the glass shipping vial in its lead pot and place it on the bench top.
- Remove the V-Vial from it's packaging, then remove the center of the aluminium seal with forceps and wipe the rubber septum with an alcohol swab.
- Place the V-Vial in the acrylic V-Vial Holder (provided) and screw on the V-Vial Holder lid for stability and shielding.
- Insert a short 25 gauge needle through the rubber septum of the V-Vial until it just pierces the septum to create a vent. It is recommended that either a purpose-designed venting needle, or a separate filter attached to the short 25 gauge needle is used in order to prevent fluid leakage.

- Invert the lead pot and shake vigorously before opening to re-suspend the SIR-Spheres microspheres, which will have settled during shipping.

Preparation

- Quickly open the lead pot and remove the shipping vial using forceps.

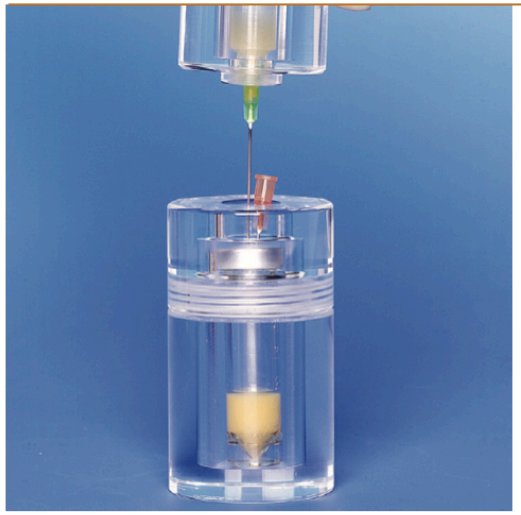
- Insert a 25 gauge needle through the septum of the shipping vial to create a vent, ensuring that the tip of the needle is well clear of the contents in the shipping vial. Again, it is recommended that either a purpose-designed venting needle, or a separate filter attached to the short 25 gauge needle is used in order to prevent fluid leakage.

Preparation

- Attach a lubricated 21 gauge needle at least 50mm in length to a 5 ml Luer lock syringe and place it in the acrylic syringe shield (provided).
  - Unscrew the top of the acrylic Syringe Shield and place the syringe inside.
  - Place the top of the Syringe Shield back on and tighten securely.
- Using the shielded syringe and lubricated 21 gauge needle, puncture the septum of the SIR-Spheres microspheres shipping vial and quickly draw back and forth at least six (6) times in order to re-suspend the SIR-Spheres microspheres thoroughly.
- Quickly withdraw the volume of SIR-Spheres microspheres that will provide the intended patient-specific activity, being careful of needlestick injuries, re-cap the needle safely and set aside syringe assembly in the prepared radiation work area.

SIRTeX

Preparation



- Gently agitate the shipping vial to re-dispense the microspheres and measure the activity remaining in the shipping vial with the dose calibrator; subtract the activity remaining in the shipping vial from the starting total activity in the shipping vial to determine the amount of activity that has been drawn up into the 5 ml syringe.
- If the amount of activity that has been drawn up into the 5 ml syringe is not correct, then transfer the SIR-Spheres microspheres back into the shipping vial and redraw the necessary volume of SIR-Spheres microspheres (either less or more).
- Once the correct activity has been drawn up, transfer the SIR-Spheres microspheres from the 5 ml syringe into the vented V-Vial in the acrylic V-Vial Holder. If the total volume in the 5 ml syringe is less than 3 ml, draw up enough sterile water for injection to make up to a total volume 3–5 ml before transferring the SIR-Spheres microspheres into the V-Vial. Ensure that the distance between any puncture holes in the septum of the V-Vial are at least 2 mm apart. **This step should be done ONCE only.**

Preparation

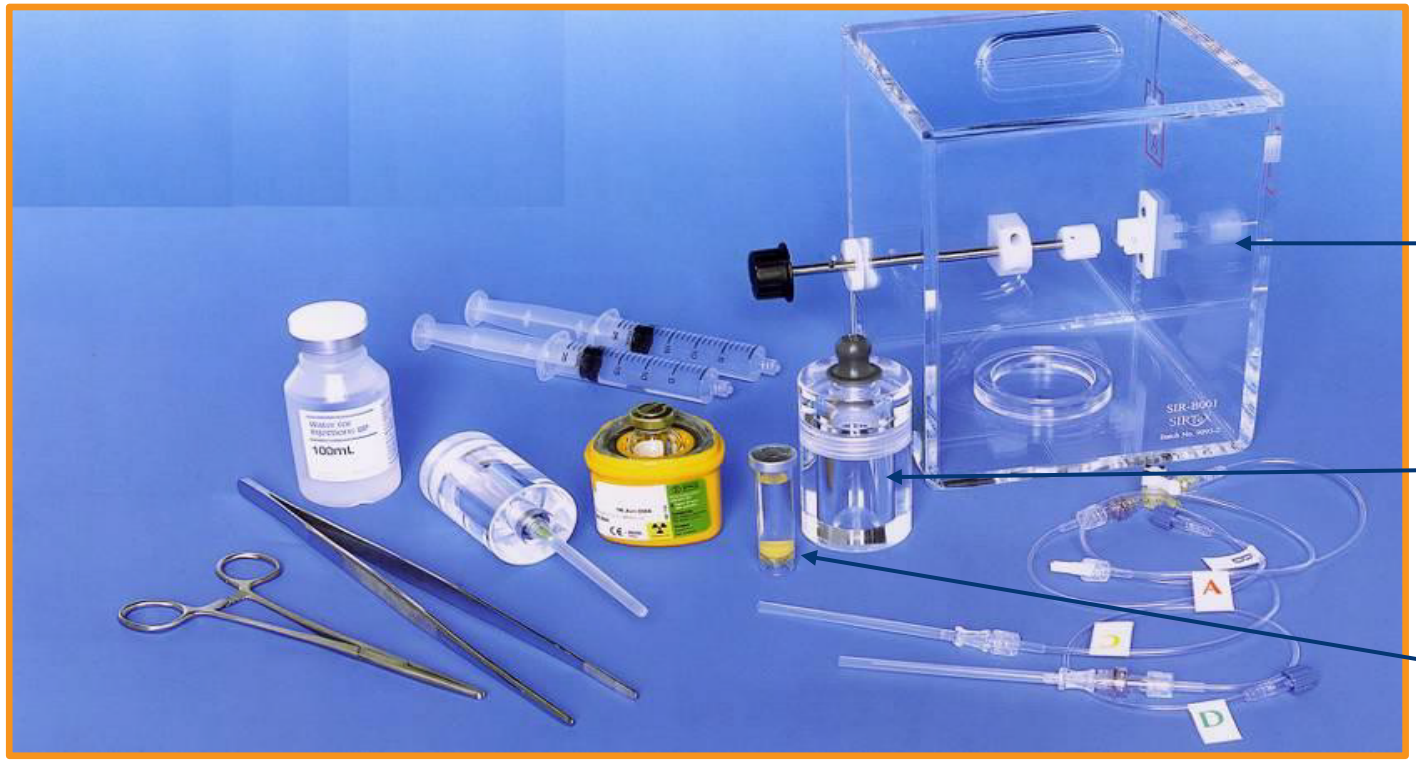
- Remove the vent needle from the V-Vial; ensure screw on lid of the V-Vial Holder is secure and sit (do not force) the plug into place.
- Remove the vent needle from the shipping vial and replace the lid of the lead pot.
- The patient-specific activity of SIR-Spheres microspheres is now ready for transport to the angiography suite in which the implantation will be performed.

Delivery Box Set Up

TRN-TEC-001 rev # : 1 (CR 2860) Issued: 28 Sept 2021

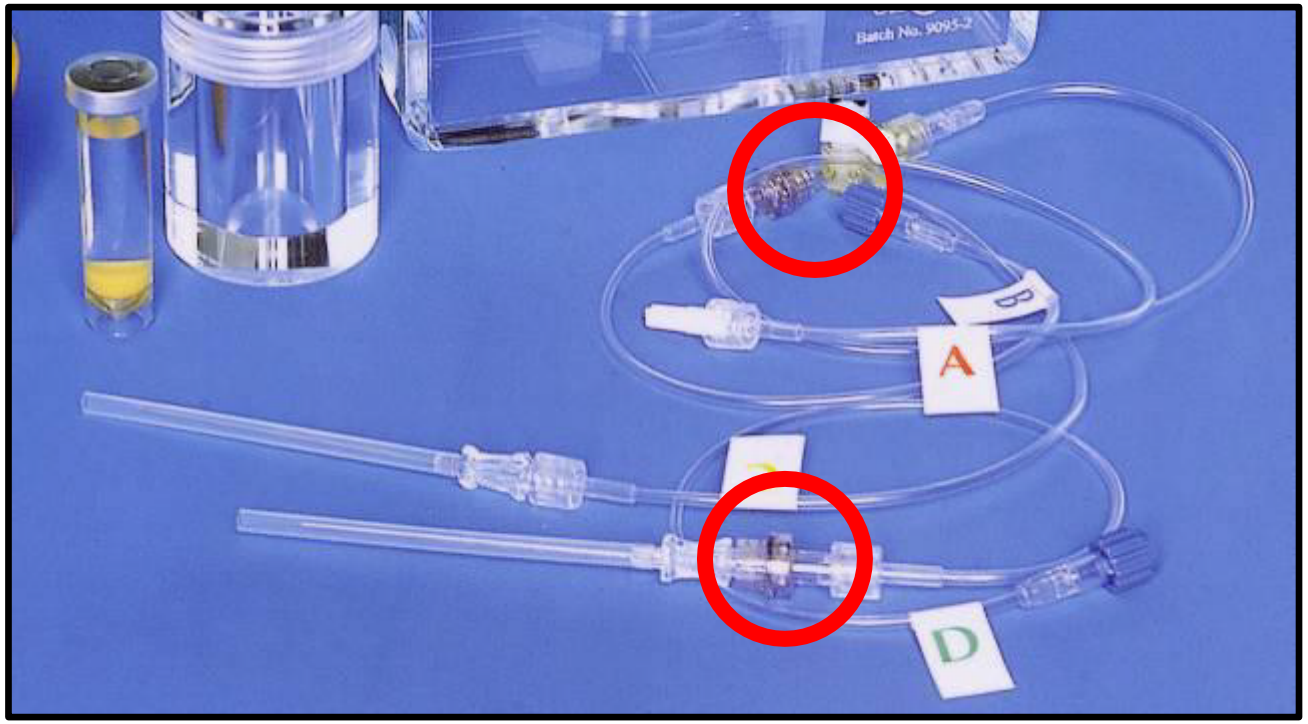
Delivery Box Components

SIR-Spheres Y-90 resin microspheres are delivered using a specialized Delivery Box. This box shields from beta radiation and prevents contamination in the unlikely event of a spill.



TRN-TEC-001 rev # : 1 (CR 2860) Issued: 28 Sept 2021

Delivery Box Components Continued



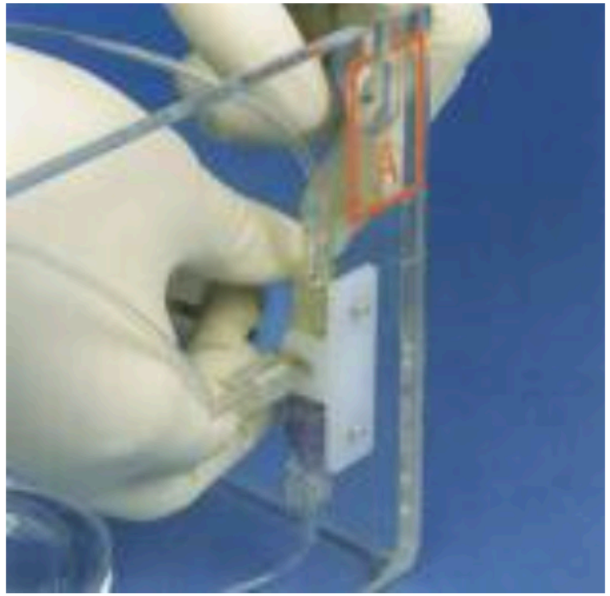
Delivery Set

There are one-way valves fitted to the tubes ‘B’ and ‘D’ to prevent any possibility of SIR-Spheres microspheres being injected back into either of the syringes with water for injection or D5W.

TRN-TEC-001 rev # : 1 (CR 2860) Issued: 28 Sept 2021

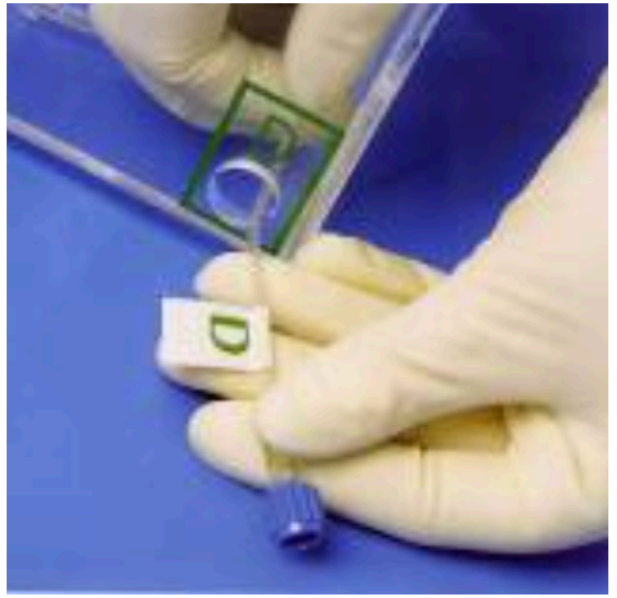
Delivery Box Assembly

Delivery Box Assembly



Place 3-way stopcock into bracket

From inside the box insert tubes A and B through corresponding holes

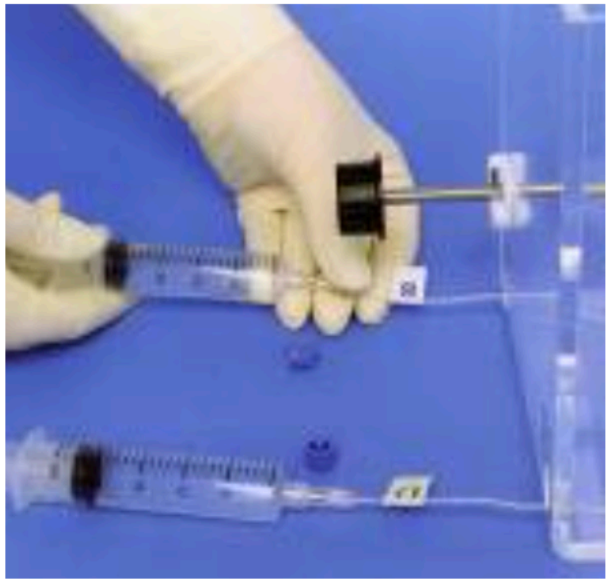


From inside the box insert tube D through corresponding hole

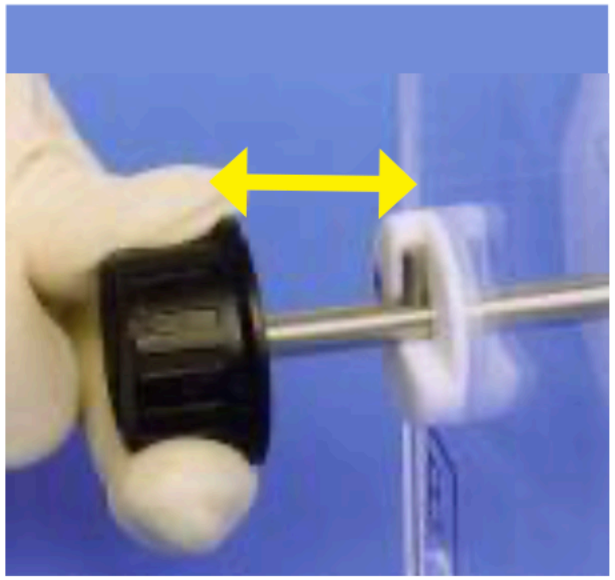
SIRTeX

Delivery Box Assembly

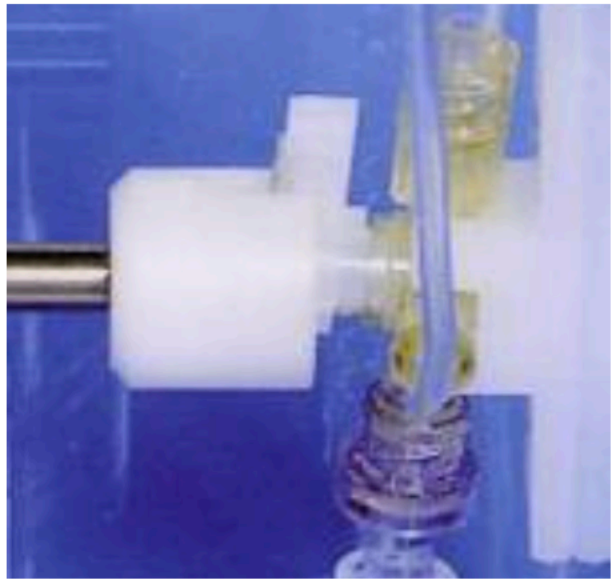
Delivery Box Priming



Attach 20 mL syringes with water for injection or D5W

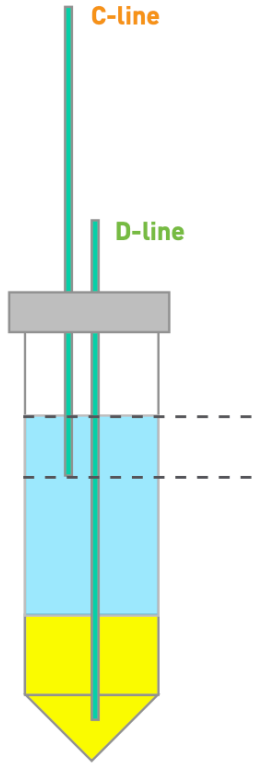


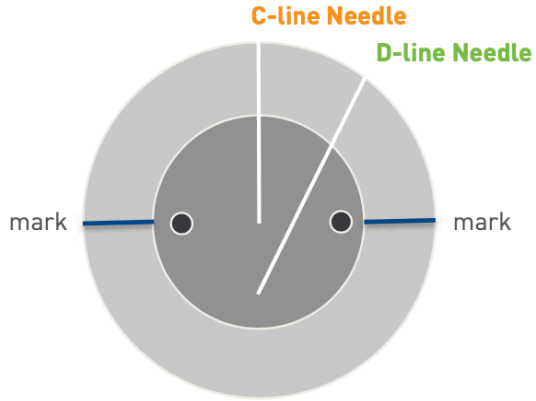
Flush lines D, B, and A



To flush line C partially disengage stopcock control knob

Needle Positions

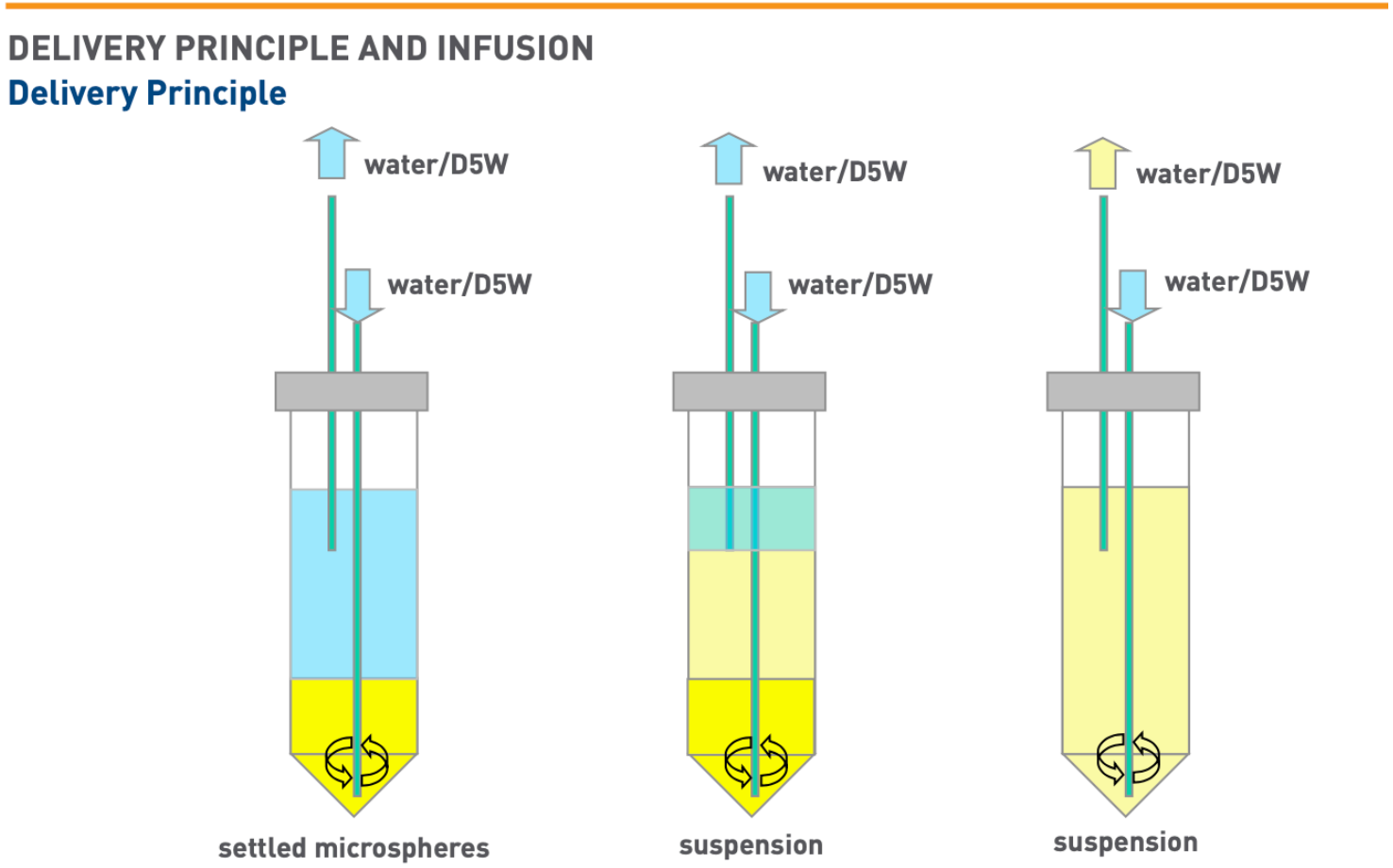




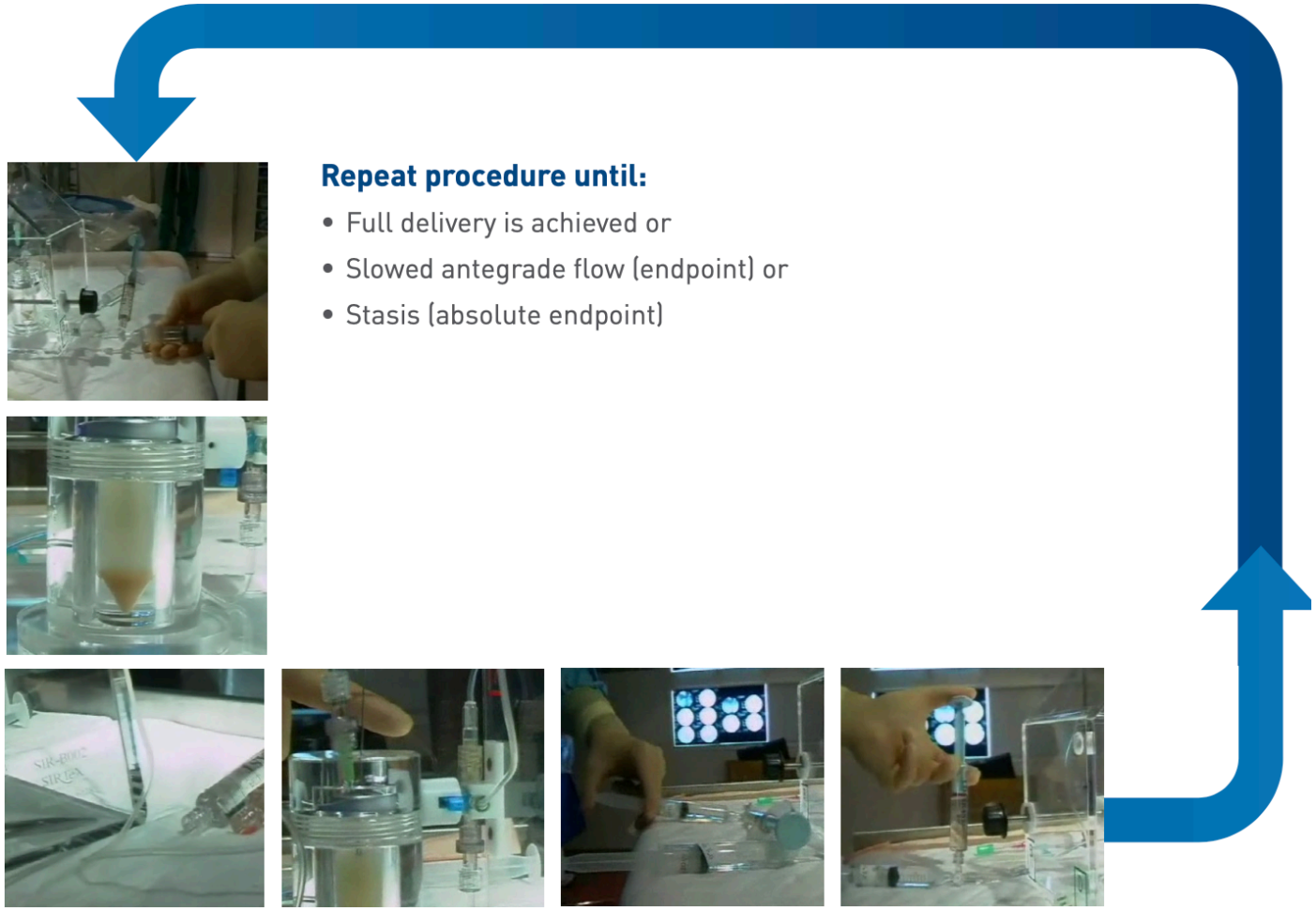
Ensure punctures are at least 2 mm from each other and opposite to the punctures made during dose preparation.

SIRTeX

Delivery Principle and Infusion



Infusion



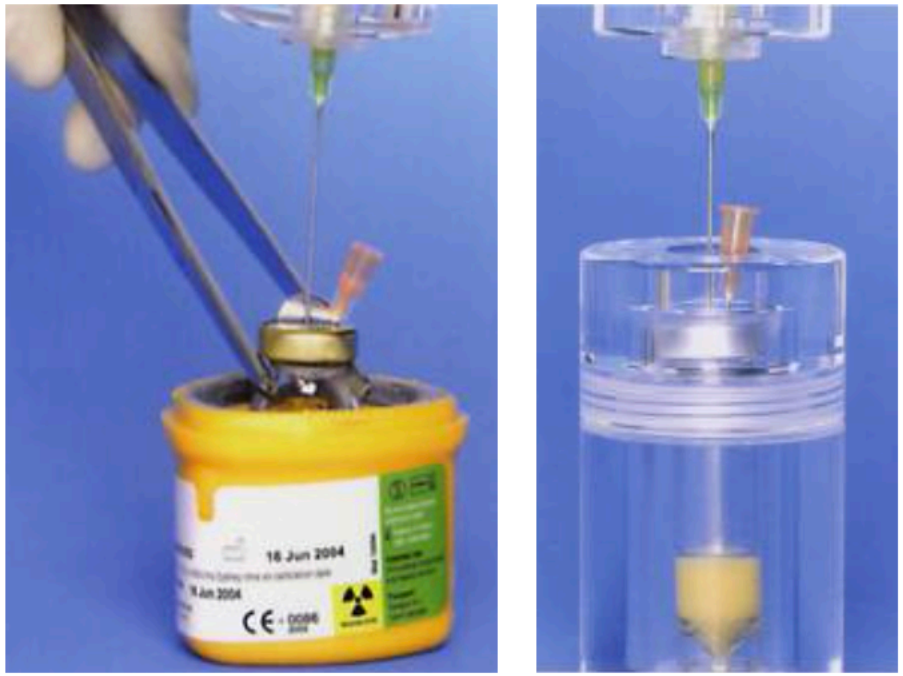
Repeat procedure until:

- Full delivery is achieved or
- Slowed antegrade flow (endpoint) or
- Stasis (absolute endpoint)

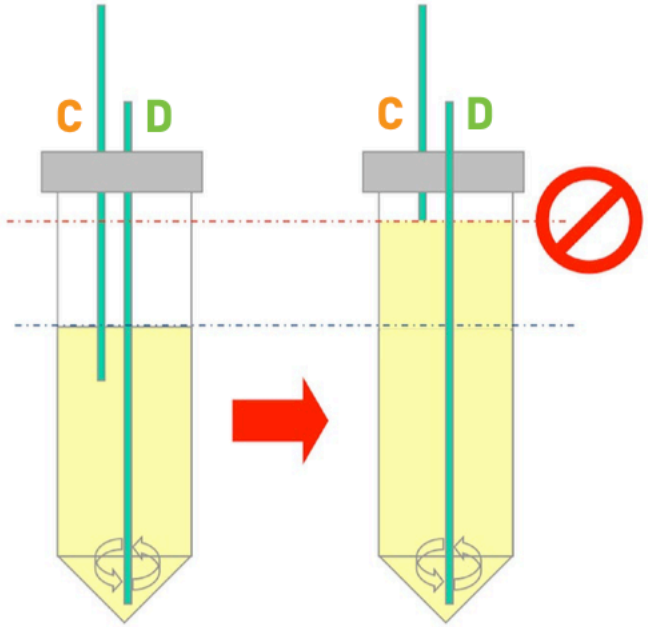
Potential Abort Points

POTENTIAL ABORT POINTS

Contamination or Large Leak in Hot Lab



Rising Meniscus Inside the V-vial

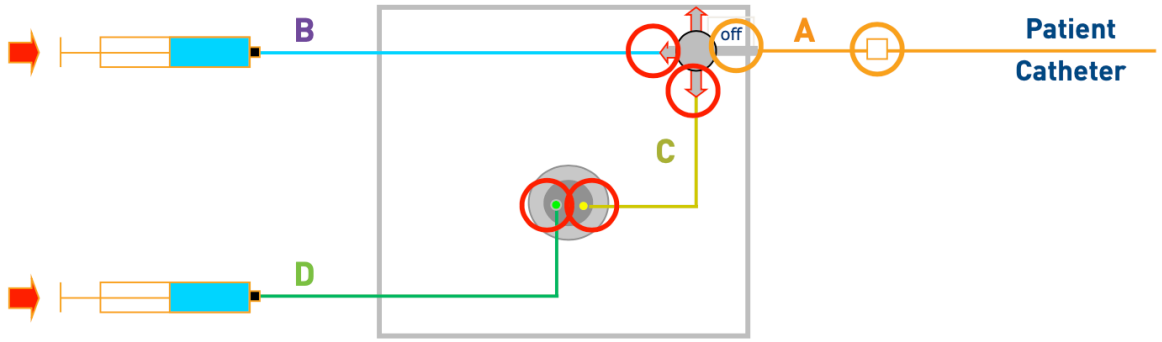


Indication of increased outflow pressure and impending leak around needles through septum.

SIRTeX

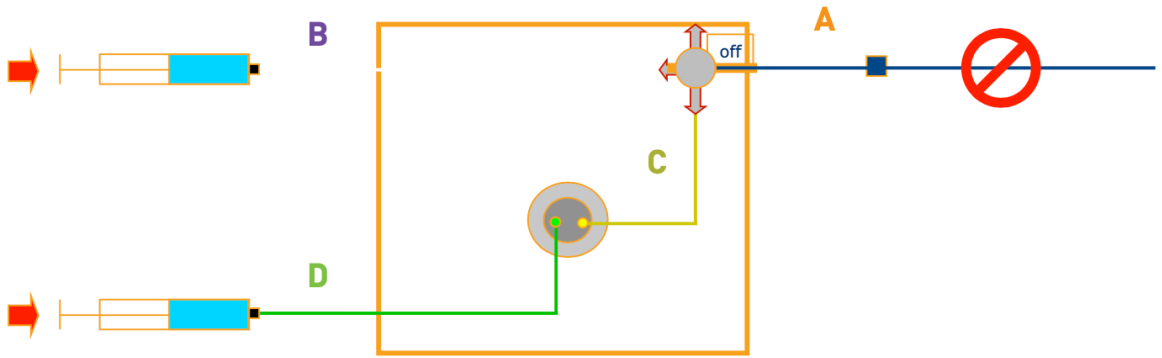
Potential Abort Points

Catheter Connection and Syringe Connection



Check for any leaks in the system before and during infusion.

Clogged Catheter



Monitor resistance during infusion.

Post-Procedure Checklist

TRN-TEC-001 rev # : 1 (CR 2860) Issued: 28 Sept 2021

Post-Procedure Checklist

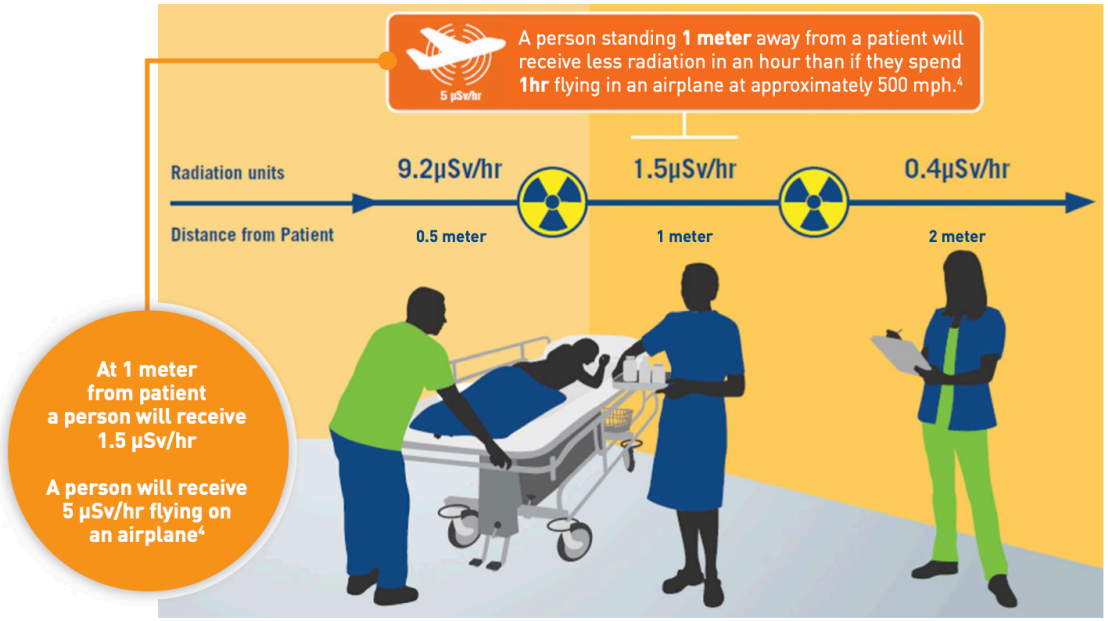
Collect v-vial and other residually contaminated materials in mayo jar and measure residual.

Check personnel for contamination before leaving suite.

Check suite for contamination after patient leaves.

TRN-TEC-001 rev # : 1 (CR 2860) Issued: 28 Sept 2021

Patient Release



- Bodily fluids, such as blood and urine, may be slightly radioactive for 24 hours after the procedure.[5,6]
- Radiation Safety Golden Rules:
  - Decrease Time
  - Increase Distance
- Gloves should be worn.
- Pregnant staff may elect to be reassigned.

Questions?

Thank you for your attention!

Checklists: Reducing Mis-Administration and Other Events During Y90 Radioembolization

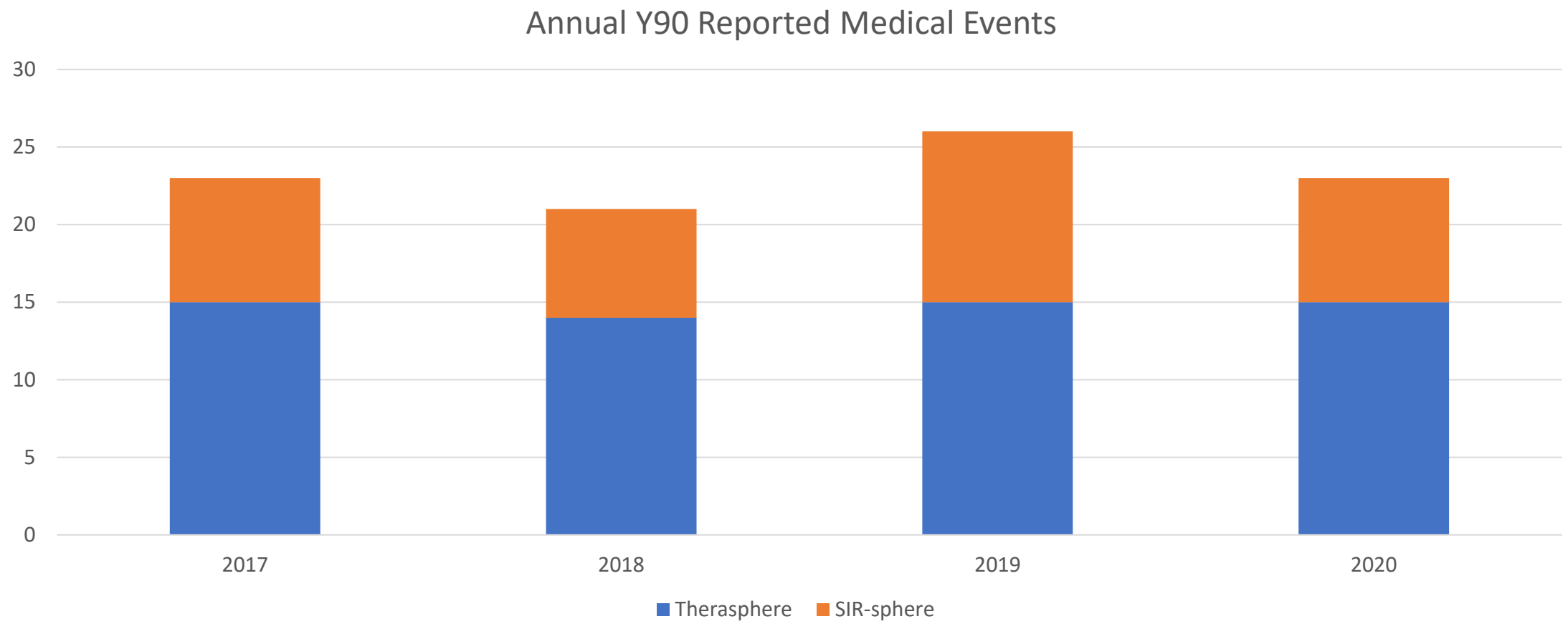
J. Fritz Angle, M.D.

University of Virginia

Collaborators

- Robert Mulder, PhD
- Andrew Polemi, PhD
- Paul W. Read MD, PhD
- Einsley-Marie Janowski MD, PhD

Stubborn Floor To The Number of Reportable Events in USA



Dr .Ronald D. Ennis, ACMUI Fall Meeting. October 4, 2021

The Most Common Unexpected Events Are A Relatively Short List

- Incomplete delivery of prescribed dose (device or technique related)
- Delivered dose larger than planned or desired for intended target
- Administration into the wrong lobe or segment
- Treatment does not adequately treat all feeding arteries (planning or delivery)
- GI or other extra-hepatic mesenteric dose delivery (planning or delivery)
- Arterial-venous shunting with lung injury
- Arterial-portal shunting with liver, GI or lung injury
- Wrong patient
- Spills, splashes, or improper disposal
- Unexpected exposure to fetus, family, caregivers, Y90 team members or pathologists (autopsy)

Breaking The Medical Hierarchy

- Speak up for safety (event reporting without repercussion)
- Chain of command responds to reporting
- Events lead to durable change
- Institutions can also be relatively isolated in implementing safety measures

Peadon R (R), Hurley J, Hutchinson M. Safety Sci. 2020;125:104648

Common Medical Error Reduction Methodology

- Team approach to identifying steps in the process and high-risk steps
- Review of events (internal and external) with process analysis
- Develop actions and outcome measures
  - Time out
  - Checklists
  - Data collection with regular analysis, communication, and process updates

Chiossa ML, Ponzetti C. FMEA: a model for reducing medical errors. Clnca Chimica Acta 2009; 404: 75-78

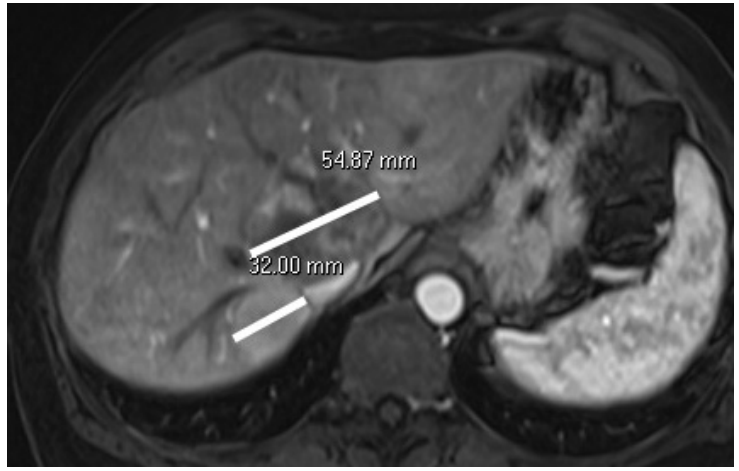
UVA Y90 Planning Initiation

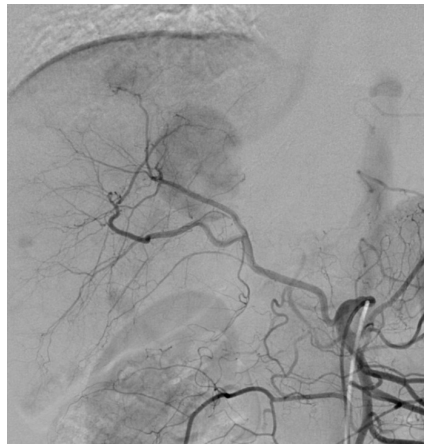
Identification of potential patient by liver tumor board

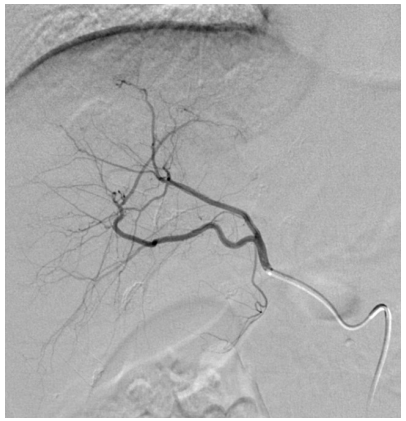
MAA study with hepatic artery branch “pruning”

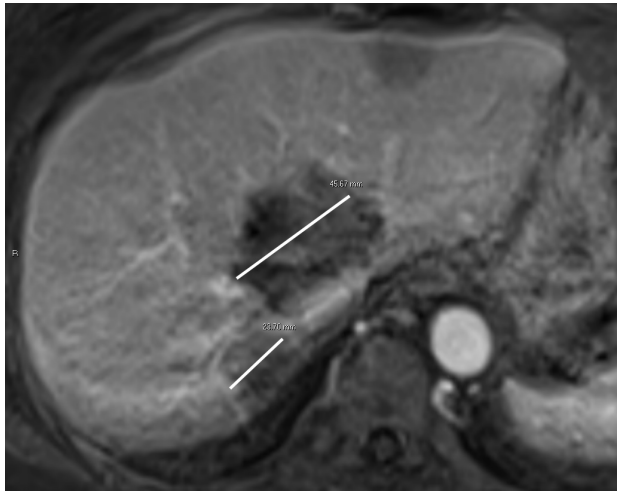
If shunt fraction low and anatomy favorable: Y90 team activation

Standardized Y90 administration









Y90 Planning Initiated by Interventional Radiologists

- Defines tumor vascularity
- Measures liver, lobar and tumor volumes (stored in PACS)
- Defines which segments or lobes to be treated and in what sequence
- Suggest a target dose
- Suggests Therasphere or SIR-sphere (mostly based on desired number of particles)
- Forwards the tentative plan to radiation oncology and radiation physics

UVa Departments of Radiation Oncology and Radiology & Medical Imaging

^{90}Y THERASPHERE LIVER THERAPY TREATMENT PLANNING FORM

FOR USE BY INTERVENTIONAL RADIOLOGY

(VERSION OCTOBER 1, 2021)

Form to be completed & signed by Interventional Radiologist and forwarded to Maria Daw in IR

Patient Name: _____ **MRN:** _____ **DOB:** ___/___/_____

Number of treatment sessions planned? ☐ 1 Session ☐ 2 Sessions ☐ 3 Sessions

Current Plan is for the: ☐ First ☐ Second ☐ Third Y-90 TheraSphere TARE Procedure

If Lobar Treatment then specify only:

Liver Lobe(s) to be treated: ☐ All Lobes ☐ RT Lobe ☐ LT Lobe ☐ MID Lobe

LOBAR VOLUMES: Tumor _____ cc *Total* _____ cc

IR recommended average radiation dose (or dose range) to lobar volume: _____ Gy (±~10%)

If Segmental Treatment, additionally specify Segment(s) to be treated: _____

*SEGMENTAL VOLUME: Total*_____ *cc (Tumor volume will be same as for Lobar Treatment)*

IR recommended radiation dose (or radiation dose range) to segment(s) _____ Gy (±~10%)

Note: The average radiation dose to lobar volume will be prescribed in the Written Directive and will be back-calculated as the variable dependent on the specified radiation dose to segment(s).

Volumes determined by IR Staff Member: _____ _____ Date: ___/___/_____

Additional Patient Information:

Liver Tumor Vascularity: ☐ Low ☐ Medium ☐ High Lung Shunt Fraction (LSF) = _____ %

WasTc-99m MAA Shunting to *gastric, intestinal or other non-target regions* observed on LSF Gamma Camera Planar Images?: ☐ NO ☐ YES, GDD and/or other non-target vessels will be embolized by:

☐ Coil implant or ☐ Use of Surefire" Catheter

For women patients ages 11-70 years:

☐ N/A { Date of last (negative) βHCG test: ___/___/_____}

{ Or Date of hysterectomy: ___/___/_____}

Signature of *IR Attending* completing form: _____ Date: ___/___/_____

TO BE COMPLETED BY AN IR RN: *Date* ___/___/_____ *and value of most recent T. Bili:*_____

Has medical insurance been approved for this patient? ☐*YES* ☐*NO*

Once this form has been processed by Ms.Maria Daw in IR, please forward it by email to Radiology Physicists A. Polemi (amp3as@virginia.edu, x44925) and R. Mulder (rum@virginia.edu, x49424).

Checklists As Essential As For Flying A Plane

Atul Gawande, 2009. Metropolitan Books

- Set pause points at which the checklist is supposed to be used
- DO-CONFIRM versus READ-DO checklist:
  - READ-DO tasks are checked off as they are performed
  - In DO-CONFIRM tasks are performed from memory and then confirmed at key stopping points
  - We started with READ-DO and evolved to DO-CONFIRM

Pre-Procedure Checklist

Authorized User: _____ **Interventional Radiologist: _____**

Medical Resident in Training: _____ **IR Operating Room No.: _____**

Catheter Name: _____

NOTE: Be careful when using a Direxxion catheter (also used for TARE) as kinking due to its external metal braiding is possible. Pay special attention to the catheter course beyond its connection with the radio-embolic Y-90 source. Test catheter flow worthiness before connecting to the Y-90 delivery device tubing.

(Catheter Sticker Goes Here!)

NOTE: Internal diameter of the micro-catheter should not be less than 2.8 French so as to avoid Y-90 microspheres blockage.

Catheter w/ ID >= 0.5 mm (0.02 inch) is required to deliver Y-90 microspheres without plugging

❑ Catheter used is approved for Y-90 TS procedure

1. *Materials Required for TheraSphere Administration:*

- ☐ Written Directive for a *TheraSphere* Procedure signed by a TS-authorized AU
- ☐ MP's Survey Meter: _____, S/N _____, Cal. Due Date: _____
- ☐ Rados Detector: S/N _____, Cal. Due Date: _____
- ☐ Survey Meter: Battery level OK, Op Check completed & Calibration Date verified
- ☐ EH&S's Radioactivity Spill Kit is present in the OR control room
- ☐ Floor drapes have been placed beneath patient table on correct side for patient treatment
- ☐ Everyone in the IR are wearing radiation badges, lead aprons, double gloves & double booties
  - ❑ Confirmed by MP through his verbal call-out "Please confirm you have dosimetry on you!"
  - ❑ All medical personnel in the OR must declare "CHECK!" or leave at this point.
  - ❑ Personnel directly handling Y-90 TS will confirm verbally they are wearing dosimetry rings
- ☐ 2 Empty Radwaste Trash Bags/Boxes for discarded drapes, booties & gloves are at OR door
- ☐ Plexy-glass Shielded Mayonnaise Jar for Radwaste is positioned near TS Delivery Device

2. *Preparing Angiography Suite for TheraSphere Administration:*

- ☐ Draping has been placed on OR floor next to patient table and under catheter connection area
- ☐ Sterile drape is covering cart on which acrylic Delivery Box is placed

Sterile side of cart:	***Non-sterile side of cart:***
❑ Hemostat))	❑ *TheraSphere* Acrylic Box → remove top shield & fully extend steel arm
❑ Scissors	❑ Bag Hook → install on Acrylic Box
❑ Steri-strips	❑ Saline Bag 0.9% (V = 250mL minimum) → hang on hook
❑ Sterile Towels	❑ Electronic Dosimeter (RADOS RAD 60R or equivalent) ☐ turn on, set to **mR/h,** clip to bracket on Delivery Box
❑ Sterile Gauze	❑ 2L Nalgene Radwaste Container w/ Beta Shield, w/ Lid Removed
❑ TS Administration Set (includes 20mL Syringe & 20mL Waste Vial)	❑ *TheraSphere* Dose Vial (in capped lead pot) → Vigorously shake lead pot containing TS vial back and forth through 90° then "slam" down several times on a hard surface to settle spheres → Place lead pot inside Delivery Box holder
	❑ Alcohol Swabs

❑ All items listed above have been placed on draped cart.

3. *Administration Set Priming:*

- ❑ Open sterile TS Administration Set over the sterile section of cart
- ❑ Check that all connections associated with administration tubing are connected tightly
- ❑ Insert non-vented white piercing spike (**CLEAR CAP**) into Saline Bag port (bag on hook)
- ❑ Insert vented white piercing spike (**near Label 'A'**) into empty 20mL glass Waste Vial
- ❑ Remove (**RED RUBBER**) shield cap from Needle Injector Assembly & place Needle Injector Assembly on a sterile towel. Needle Injector Assembly tip must stay sterile.
- ❑ Prime Administration Set Tubing by slowly filling & discharging syringe to remove air in tubing & syringe
- ❑ **Prime with saline until no bubbles are present in syringe & lines *and two continuous streams of saline flow out of both needle holes in the Needle Injector Assembly***
- ❑ Re-fill syringe with 20mL sterile saline once priming is complete
- ❑ Re-check that tubing is completely primed and that there are no kinks or obstructions to flow.

6. *Final Assembly (Immediately before TS Administration):*

- ❑ ***Close WHITE pinch clamp on tubing near label 'E' (certify tube centered inside clamp)***
- ❑ **NOW push both YELLOW tabs together all the way down, locking needles into Dose Vial (*hear or feel 2 clicks or snaps at bottom of travel*)**
- ❑ Place Side Shield Wall back into its acrylic Delivery Box slot
- ❑ Place Top Shield Cover on acrylic Delivery Box w/ sloped shield facing towards catheter
- ❑ **AU & IR ensure by visual examination & verbally declare tubing is neither pinched or kinked**
- ❑ **IR Check: Was embolization of non- target vessels needed?**
- ❑ **NO, embolization was NOT needed**
- ❑ **YES, and ❑ Coil(s) and/or ❑ Special Catheter were used**
- ❑ Lower patient table to lowest position and move cart close to patient
- ❑ AU and/or IR place first sterile towel across gap between Delivery Box & patient, under extension arm holder "E" and under holder "C", wedging one towel end under Delivery Box
- ❑ AU and/or IR place second sterile towel across gap between Delivery Box & patient, running towel up against non-sterile side about 2"
- ❑ ***Prevent catheter connection from hitting non-sterile side of box***
- ❑ **AU and IR inspect visible portion of tubing and catheter for kinks or damage. Correct as possible (perhaps replace catheter) or abort procedure if tubing is found damaged.**
- ❑ IR flushes catheter to ensure fluid flows freely in infusion catheter and reports results of flush
  1. Replace catheter if flow is too low or catheter is too short
  2. NEVER use catheter extensions or extra fittings to lengthen catheter
- ❑ IR flushes with catheter with contrast to re-verify catheter tip position within patient liver
- ❑ IR confirms which lobe (and segment if applicable) that catheter tip is placed in:

Post Procedure Checklist

8. Delivery Device Disassembly:

- ❑ Close the pinch clamp on the outlet tube at ‘E’
- ❑ AU cuts inlet line with scissors at position indicated by 2 tape strips, between ‘A’ and ‘B’
- ❑ ***NEVER EVER DISCONNECT the catheter from the tubing at ‘E’ (to avoid leakage)***
- ❑ AU removes Delivery Box’s Top Shield & Side Shield Wall from Box and sets them on cart
- ❑ AU and IR lift catheter connection out of extended holder ‘**E**’
- ❑ IR pulls catheter tip inside guide catheter, then simultaneously removes both from patient

  NOTE: Use gauze or a small towel to handle catheters & control catheter tip.

  Any blood splatter may contain a small number of radioactive Y-90 microspheres
- ❑ AU & IR place all radwaste consisting of:
  - ❑ Catheters, attached tubing and catheter & towels/gauze
  - ❑ TS Dose Vial with attached Needle Injector Assembly
  - ❑ All rad-contaminated items - gauze, towels + AU & IR’s outer gloves

  Into Beta-shielded Nalgene Radwaste Container
- ❑ MP caps Nalgene Radwaste Container inside its Beta Shield & places lid on Beta Shield
- ❑ MP places Top & Side Shields back on acrylic Delivery Box
- ❑ MP retracts extension arm & removes bag hook
- ❑ MP turns RADOS dosimeter off and later stores it in the MP’s TS rolling equipment cart
- ❑ Once HP has declared Delivery Box and its components clean of radioactivity, MP returns Delivery Box to Rolling IR Cabinet for storage and future re-use

Troubleshooting

5. Excessive fluid flow resistance is experienced during infusion or Difficulty achieving the desired dosimeter reading.	If the 20mL syringe is marked "VacLok": Verify that the syringe is not in a locked position. Verify that the pinch clamp is open. Verify that the tubing between the syringe and dose vial are not pinched or kinked. Verify that the tubing between the dose vial and catheter are not pinched or kinked. Verify that the yellow tabs are pushed all the way down. Apply sufficient pressure on the syringe to cause fluid to flow into the pressure relief vial. Apply and release pressure on the syringe several times rapidly. This may clear a collection of microspheres at the tip of the outlet needle. Close the pinch clamp before performing any actions with the catheter. Verify that there is no blood coagulation or damage in the catheter. **Attention:** There may be microspheres in the outlet line and catheter. Use standard radiation safety methods to assess the components before handling. Use remote handling tools as appropriate.

Troubleshooting Checklist

- Current list of problems at our institution was developed from personal experience, NRC notifications, and communication at meetings
- Ideally, we would also have a process for all commonly encountered problems
- Check lists remain a great opportunity to standardize how we manage known problems

Summary

- Most important tool to preventing adverse events is having a defined team with established communication
- Checklists seem ideally suited to Y90 planning and administration
- Opportunity for standardization of these checklists across institutions
- Maintaining compliance with check lists presents a challenge

CORAR *Council on Radionuclides and Radiopharmaceuticals, Inc.*

CORAR ACMUI Presentation Comments to NIST – re: NRMAP

April 5, 2022

CORAR

- The Council on Radionuclides and Radiopharmaceuticals, Inc. (CORAR) is a Washington, DC based trade association of companies that manufacture radiopharmaceuticals, radionuclides, and other radioactive products used in medicine, research, and industry.

CORAR Comments to NIST

- On January 13, 2022, CORAR submitted comments to James K. Olthoff, PhD, Acting Director, National Institute of Standards and Technology (NIST).
  - Restart of the NIST Radioisotope Measurement Assurance Program (NRMAP) and provide sufficient resources for the NRMAP and the NIST Radioactivity Group.
- The NRMAP has provided Standard Reference Materials (SRMs) and Reference Materials (RMs) to medical and industrial stakeholders for the past 47 years.
  - Participants in the NRMAP receive SRMs and RMs to ensure their radiation measurements are NIST traceable.

CORAR Comments to NIST

- An extended interruption in the NRMAP service began in late 2019.
  - The NRMAP was unable to provide the required calibration standards for more than 24 months; and
  - no clear resolution to the ongoing shutdown of the NRMAP.
- In nuclear medicine, radiopharmaceuticals are used in the diagnosis and treatment of disease.
  - Devices that measure the radioactivity of a dose must use calibration sources that can be traced to NIST SRMs and RMs that have been provided by the NRMAP.
  - Accurate dose measurement could have Medicare reimbursement implications for radiopharmaceutical dose payment based on activity (e.g. mCi, uCi).

CORAR Comments to NIST

- The NRMAP shutdown occurs at a time when exciting new radiotherapies are being developed exploiting alpha-emitting and beta-emitting characteristics such as:
  - lutetium-177 (Lu-177) - actinium-225 (Ac-225)
  - copper-67 (Cu-67) - lead-212 (Pb-212)
- Clinical research metrology should be traceable to NIST SRMs and RMs.
- Medical and industrial licensees require NIST traceability making the restart of the NRMAP a high priority for radiopharmaceutical and industrial radioisotope industries.

CORAR Comments to NIST

- CORAR expressed concerns that further delays in restarting the NRMAP could result in several challenges:
  - complying with FDA and NRC regulatory requirements (10 CFR 32.72(c), 10 CFR 35.60, and 10 CFR 35.63);
  - providing radiation detection measurement standards that ensure patient and worker safety;
  - supplying short-lived diagnostic and therapeutic standards traceable to NIST SRMs and RMs;
  - having NIST traceable SRMs and RMs available in the development of new radiopharmaceuticals.

CORAR Comments to NIST

- CORAR closed with an urgent request; … that NIST facilitate the restart of the NRMAP as soon as safely possible and re-invigorate with sufficient resources both the Radioactivity Measurement Group and the NRMAP, to ensure that required NIST traceability needed by U.S. healthcare and industry is consistently available in CY 2022 and beyond.

NIST Response to CORAR

- Dr. Olthoff responded on February 2nd and thanked CORAR for its comments. With regard to the NRMAP services, Dr. Olthoff mentioned:
  - NIST remains fully committed to delivering high quality radioactivity metrology services;
  - NIST has embarked on a restructuring of the existing the NRMAP; and
  - NIST is working expeditiously to restore the essential functions of the NRMAP.
- CORAR appreciates the follow-up from Dr. Olthoff, and we look forward to learning more about the return of services provided by the NRMAP.

Acronyms

- ACMUI - Advisory Committee on the Medical Uses of Isotopes
- CORAR - Council on Radionuclides and Radiopharmaceuticals
- FDA - Food and Drug Administration
- NIST - National Institute of standards and Technology
- NRC – Nuclear Regulatory Commission
- NRMAP - NIST Radioisotope Measurement Assurance Program
- RMs - Reference Materials
- SRMs - Standard Reference Materials

Changes to the NRMAP Program

Brian E. Zimmerman, PhD
Leader, Radioactivity Group
Radiation Physics Division, Physical Measurement Laboratory
National Institute of Standards and Technology

NRC Advisory Committee on Medical Uses of Isotopes
5 April 2022
via Teams

NIST National Institute of Standards and Technology U.S. Department of Commerce

PML PHYSICAL MEASUREMENT LABORATORY

Why?

- Decision made by NIST Senior Management after complete review of program following a safety-related incident
- Many considerations, but overarching one is that establishing and maintaining standards is an *inherently Governmental function that must be done by Federal employees*
- Program has grown in complexity
  - Increased administrative burden
  - Greater need for Government oversight to ensure safety and integrity of traceability chain
- Changes in Program will provide:
  - Increased safety
  - Enhanced integrity
  - Greater accountability

Planning Considerations

- At its height in late 1990's, the Program supported **2 FT professionals**, **a FT technician**, and **0.5 secretary/shipping clerk** (shared with Radioactivity Group) .
- Gas standards were distributed through the Program, but were conducted by NIST staff (without compensation back to NIST).
- Gamma-ray spectrometry support was provided (uncompensated) by NIST staff dedicated 100 % to those types of measurements (and metrology research in that field).
- Ongoing commitment to development of new standards (^{89}Zr, ^{212}Pb, ^{227}Th, ^{225}Ac).

Important legal factors

- Establishing and maintaining standards is a government function
  - US Constitution, Article 1, Sec. 8.
  - Organic Act and National Institute of Standards and Technology Act (15 USC 271, *ff*)
- Promoting *transfer* is specifically called out in the above, but mechanism is not defined
- Federal Policy (OMB Circular A-76) prohibits NIST from competing directly with private industry for same services
- NIST must recover all costs associated with its programs (Antideficiency Act (Pub. L. 97–258, 96 Stat. 923))

How we will proceed

- All-Fed program
  - Support for changes from NIST Office of Associate Director for Laboratory Programs
  - Direct Government supervision, funding of program/cost recovery
- Safety and security are paramount
  - Reduction in risk to NIST re: radiation hazards
  - Source accountability
  - Sufficient staff to perform duties
- Steps will be taken slowly and deliberately in order to ensure safety and compliance with Federal law
- Continue to meet customer needs to whatever degree possible, given current constraints

Immediate significant changes

- Blind distributions are suspended
- Traceability instead through Radioactivity Group's Calibrations Program
- Reports of Traceability are suspended
  - Information needed for traceability claims will be provided in calibration reports
  - NIST policy states:
    - Entity making traceability claim is responsible for documenting, providing proof
    - Interpretation of traceability claim is responsibility of customer
    - NIST only provides data to support claims, but makes no judgement

Phase 1

- *T*=0 to *T*=6 months (approximate)
- Communicate plan to stakeholders
- Address critical calibration needs
  - Clear backlog of outstanding certificates, reports
  - Work with stakeholders to prioritize submissions
  - Shift existing personnel to calibrations as much as possible
  - Make necessary changes to QMS
- Begin hiring process for new personnel
- Goal: enable essential services using existing mechanisms
- Realistic throughput: max 2 calibrations/month

Phase 1: Assumptions

- **The level of rigor will be raised since the NIST Radioactivity Group is directly making the measurements, therefore the time required for calibrations will initially be greater.**
- NRMAP submissions will be done through 43010C, 43020C, 43060S, or 43090S* as appropriate
- We can currently only accept submission rate of up to 2 sources per month
- Standard Reports of Test can be modified to include difference from NIST value for traceability documentation

*Service is currently suspended, but is being restarted

Phase 2

- *T*=6 to *T*=18 months (approximate)
- Complete hiring process
- Training of new personnel
- Gradually increase throughput as new personnel become independent
  - Continue to work with stakeholders to prioritize submissions
  - Previously re-assigned personnel gradually return to former duties
  - Continue to make necessary changes to QMS
- Realistic throughput: max 4 calibrations/month
- Investigate use of new measurement geometry for this program
- Investigate secondary calibrations lab concept to extend traceability with need for direct NIST calibrations

Phase 3 (overlap with Phase 2)

- *T*=12 to *T* = 24+ months (approximate)
- Continue training of new personnel
- Gradually increase throughput as new personnel become independent
  - Develop new Measurement Service to cover all MAPs, including environmental
  - Some limited samples may be sent as blinds
- Realistic throughput: max 6 calibrations/month
- Implement inclusion of second measurement geometry

Major changes to Program

- Greater reliance on companies' internal QA/QC capabilities (1 site providing standards to subsidiaries)
- Most work will be done as calibration, not distribution; calibrations may be coordinated so work is done on 1 or 2 radionuclides at a given time
- Number of SRMs offered across all programs will likely decrease
- Limited number of nuclides may be sent as blinds (mid-Year 2 at earliest)
- Costs to participants may increase due to overhead on government salaries
- Gases will finally be re-incorporated into the Program
- Special Test may be created specifically for NRMAP and other PT/MAP programs during Year 2
- Program will now be completely covered fully under NIST QMS, compliant with ISO 17025, ISO 17034, and ISO 17043

This program is a critical component of our mission

- NIST Management has indicated their commitment to this transition
- We are not getting out of the calibrations/SRM business
  - Not competing with private industry
  - Providing new opportunities for business to provide traceability
- Success in transition relies on program members prioritizing their needs
- Expanding capabilities
  - Gases
  - More convenient geometry
  - More flexibility for members

Questions?

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Non-Medical Byproduct Material Events: FY20 and FY21

ACMUI Meeting
April 5, 2022

Michael Sheetz

Non-Medical Events Reported by Medical Licensees

- NMED events reported by medical licensees
- Does not include medical events under 10 CFR 35.3045 or 35.3047
- Includes event types reported under:
  - Leaking sealed source (10 CFR 35.3067)
  - Lost, abandoned, or stolen material (10 CFR 20.2201)
  - Radiation over exposure (10 CFR 20.2202)
  - Release of material or contamination (10 CFR 30.50)
  - Equipment malfunction (10 CFR 30.50)
  - Transportation incidents (49 CFR 171.15)

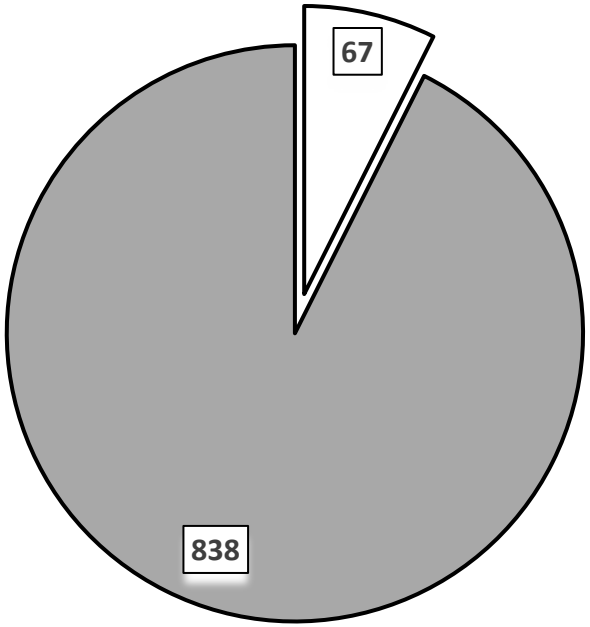
Non-Medical Event Categories

Identified in FY20 and FY21

Category	FY20	FY21
Lost, Abandoned, or Stolen Material	17	23
Leaking Sealed Source	2	5
Equipment Malfunction	5	2
Transportation of Radioactive Material	1	4
Radiation Overexposure	1	3
Radioactive Contamination	3	1
Total	**29**	**38**

Total NMED Events (All Categories)

FY20 and FY21



Lost, Abandoned, or Stolen Sources

FY20 and FY21

- Lost I-125 RSL seeds – 19
- Licensee lost medical sources – 6
- Missing I-125/Pd-103 brachy seeds – 3
- Temporary loss of RAM shipment – 3
- Incomplete shipment of I-125 brachy seeds – 2
- Lost RAM shipment – 2
- Delivery vehicle stolen – 2
- Abandoned calibration sources – 1
- Ir-192 sources delivery to wrong location – 1
- Lu-177 vials in medical waste – 1

Leaking Sealed Source

FY20 and FY21

- Cs-137 dose calibrator vial – 6
- I-125 RSL seed – 1

Equipment Malfunction

FY20 and FY21

- Sr-90 IVB device source retraction failure – 4
- Ir-192 HDR device source retraction failure – 1
- Ir-192 HDR device source unloading problem – 1
- Co-60 Gamma Knife device treatment interruption – 1

Transportation of Radioactive Material

FY20 and FY21

- Contaminated package – 4
- Delivery vehicle accident – 1

Radiation Overexposure

FY20 and FY21

- Interventional radiologist using Y-90 microspheres – 2
  - (>150 mSv LDE, 1.2 Sv SDE)
- PET radiochemist researcher – 1
  - (800 mSv SDE)
- Non-patient nuclear medicine procedure – 1
  - (8.5 mSv EDE)

Radioactive Contamination

FY20 and FY21

- Inpatient room contamination from patient receiving I-131 MIBG – 1
- Hot lab contamination from breaking open I-131 capsules – 1
- Nuc med tech contamination during administration of Tc-99m – 1
- Rb-82 generator system contamination – 1

Other Events – Landfill Alarms

- Detection of short-lived medical isotopes in municipal waste
- No standard reporting requirement
- Varying number of events reported

FY17	FY18	FY19	FY20	FY21
18	17	6	9	9

- Can result in significant response effort

Conclusions

- Relatively small number of Non-Medical events
- Type of events occurring have minimal health and safety impact
- Need for continued effort to address short-lived medical isotope landfill alarm responses to reduce burden on regulators, licensees, and patients

Acronyms

- ACMUI – Advisory Committee on the Medical Use of Isotopes
- CFR – Code of Federal Regulations
- Co-60 – cobalt-60
- Cs-137 – cesium-137
- EDE – Effective Dose Equivalent
- F-18 – flourine-18
- FY – Fiscal Year
- Ge-68 – germanium-68
- HDR – High dose-rate

Acronyms

- I-125/131 – iodine-125/131
- Ir-192 – iridium-192
- IR – Interventional Radiology
- IVB – Intravascular Brachytherapy
- LDE – Lens Dose Equivalent
- Lu-177 – lutetium-177
- MIBG – metaiodobenzylguanidine
- mSv – milliSievert
- NMED – Nuclear Material Events Database

Acronyms

- Pd-103 – palladium-103
- PET – Positon Emission Tomography
- RAM – Radioactive Material
- Rb-82 – rubidium-82
- RSL – Radioactive Seed Localization
- SDE – Shallow Dose Equivalent
- Sr-90 – strontium-90
- Sv – Sievert
- Tc-99m – technetium-99 metastable
- Y-90 – yittruim-90

Updates from the Medical Radiation Safety Team

Celimar Valentin-Rodriguez, Ph.D.
Medical Radiation Safety Team Leader (acting)
Medical Safety and Events Assessment Branch
Division of Materials Safety, Security, State, and Tribal Programs
Office of Nuclear Material Safety and Safeguards

Abnormal Occurrence Criteria

- SECY-22-0009, “Proposed Limited Revision to Policy Statement on Criteria for Reporting Abnormal Occurrences”, February 1, 2022 (ML21217A201)
  - Proposed revisions to medical AO criteria:
    - Step 1: Quantitative (dose-based) Assessment Criterion
    - Step 2: Qualitative (deterministic effects) Assessment Criterion

Abnormal Occurrence Criteria

Step 1 – Quantitative Assessment (Criterion III.C.1)

Dose-based threshold values remain the same. Proposed revisions:

- Clarify that AO include medical events reported under 10 CFR 35.3045 and in specific license conditions.
- Clarify dose to be “unintended” rather than “expected”.
- Removed written directives as a necessary requirement for an AO since some medical administrations do not require it.
- Include unintended dose that would have resulted from delivery of prescribed dose, prescribed dosage, or prescribed activity.

Abnormal Occurrence Criteria

Step 2 – Qualitative Assessment (Criterion III.C.2)

Add qualitative consideration based on physiological harm which promptly manifests following treatment (deterministic effects)

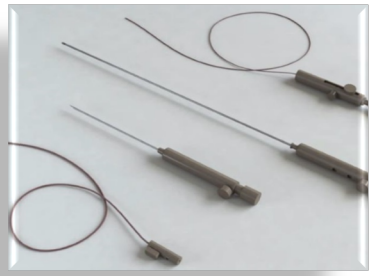
- Explored in SECY-19-0088
- Compared NRC approach to HHS

Extravasations

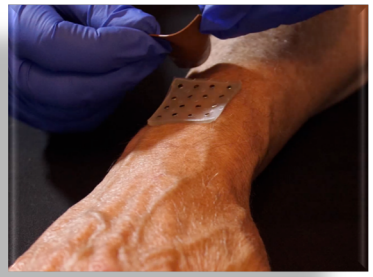
- Medical Team staff provided its evaluation of whether extravasations should be reported as medical events to the ACMUI.
- The ACMUI supported the staff's recommended option 4, to report "extravasation events that require medical attention."
- The NRC staff will provide a package to the Commission in April 2022 to disposition PRM-35-22.

Emerging Medical Technologies

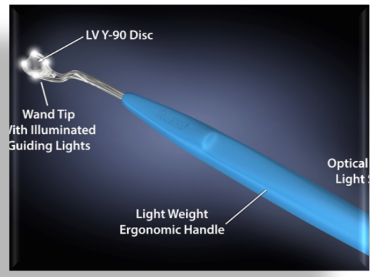
- The Medical Team continues to implement a streamlined review and guidance development process.
- The staff has evaluated several EMTs with this streamlined process.



Alpha DaRT™



CivaDerm



Liberty Vision Y-90 Disc Source

Emerging Medical Technologies Rulemaking

The staff established a joint NRC/Agreement State working group in February 2022.

SCHEDULE

REGULATORY BASIS	PROPOSED RULE	FINAL RULE
March 2023	AND DRAFT GUIDANCE	AND GUIDANCE
90-day public comment period	**August 2024**	**August 2026**

Training and Experience Rulemaking

- SRM-SECY-20-0005, “Training and Experience Requirements for Unsealed Byproduct Material”, January 27, 2022 (ML22027A519)
- The Commission maintained the NRC’s current T&E requirements for use of unsealed byproduct material in 10 CFR Part 35.

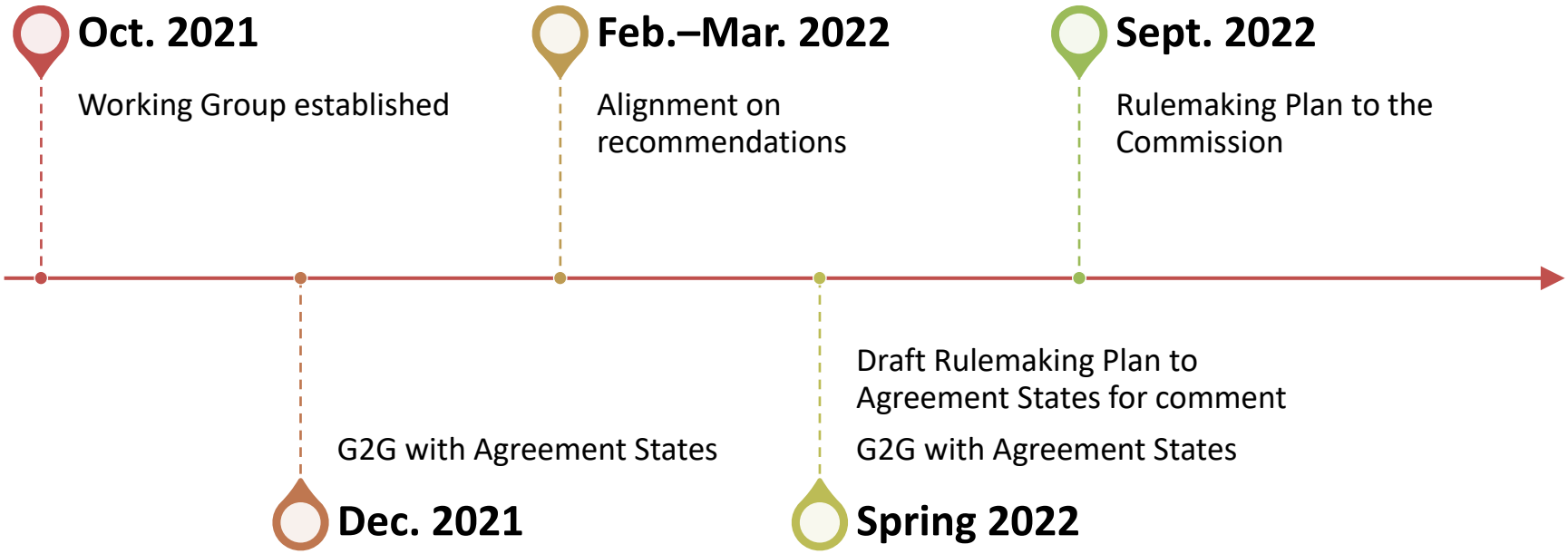
Training and Experience Rulemaking

Reconsider the full complement of T&E requirements and obtain stakeholder comments, as part of the EMT/Rb-82 Generator Rulemaking

Complete an evaluation of whether each specialty board still satisfies the board recognition criteria

Develop implementation guidance to clarify expectations on how individuals fulfill T&E requirements and clarify the roles and responsibilities of persons subject to T&E requirements.

Veterinary Release



ACRONYMS

- ACMUI – Advisory Committee on Medical Uses of Isotopes
- AO – Abnormal Occurrence
- CFR – Code of Federal Regulations
- EMT – Emerging Medical Technologies
- G2G – Government-to-Government Meeting
- HHS – US Department of Health and Human Services
- PRM – Petition for Rulemaking
- Rb-82 – Rubidium-82
- T&E – Training and Experience

OPEN FORUM

(No Handout)

ADMINISTRATIVE CLOSING

September 2022

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

November 2022

SUN	MON	TUES	WED	THUR	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

December 2022

SUN	MON	TUES	WED	THUR	FRI	SAT
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31