Clinical Implementation of Intravascular Brachytherapy

Dae Y. Han Ph.D [1]

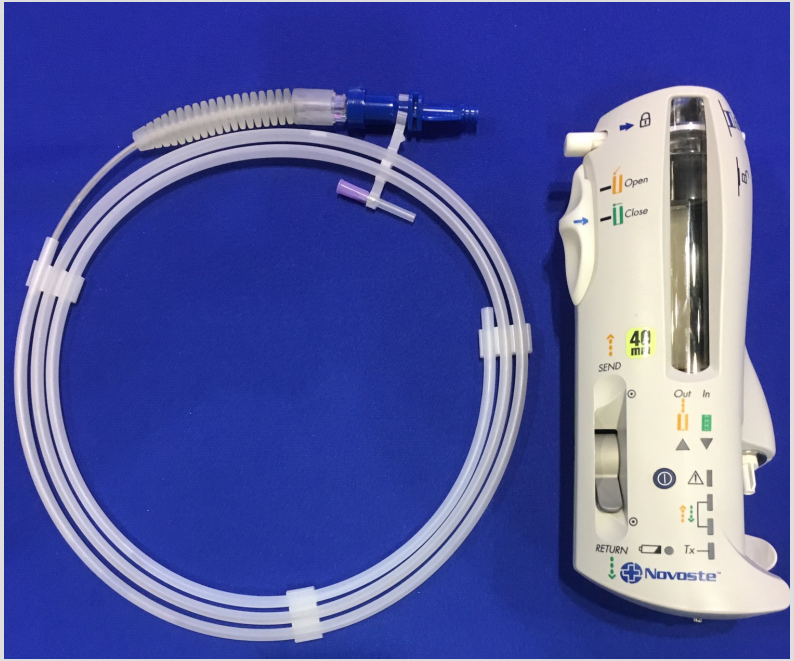
[1.] *Department of Therapeutic Radiology, Yale-New Haven Hospital, New Haven, CT*

Yale SCHOOL OF MEDICINE

Disclosure

- None

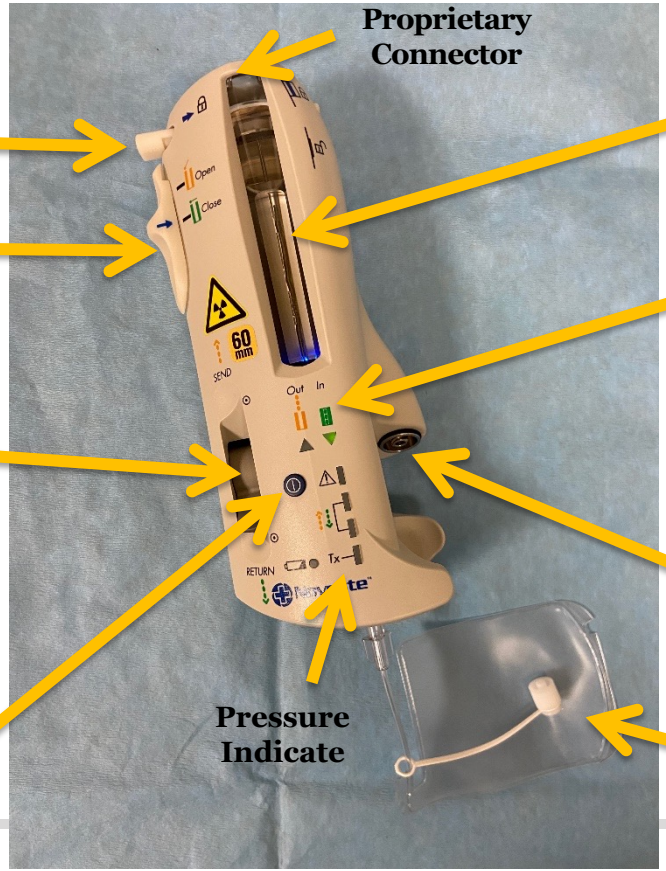
$^{90}Sr/^{90}Y$ Beta-Cath™ 3.5 F System



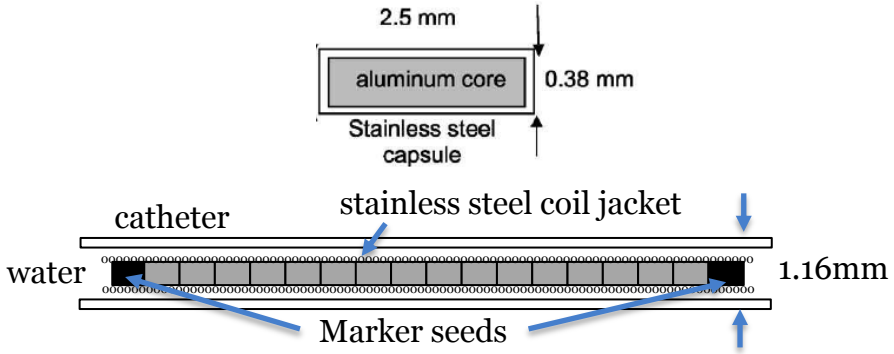
Delivery Catheter

Transfer Device

Transfer Device

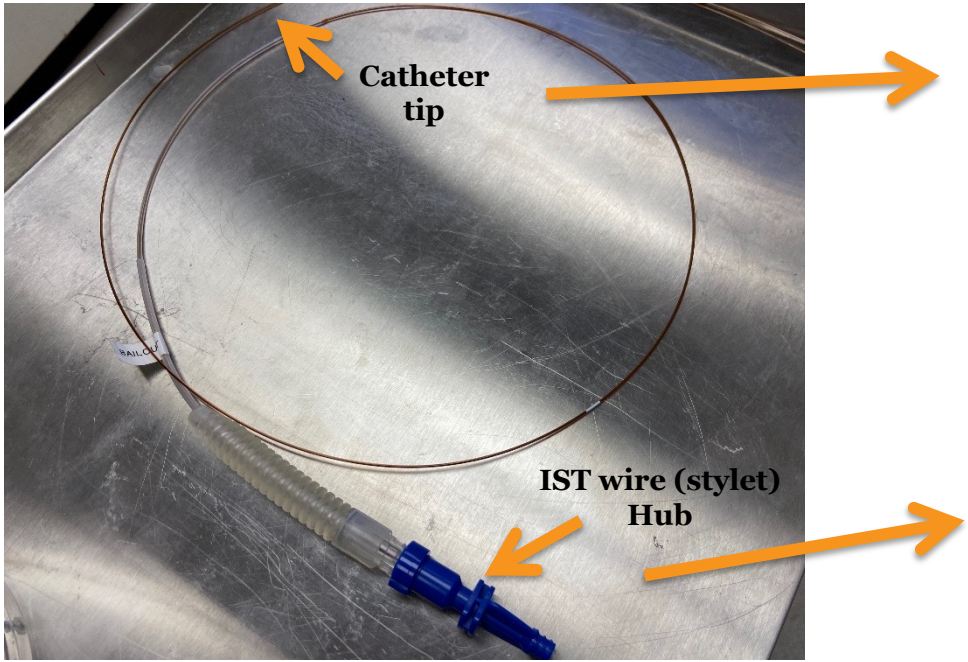


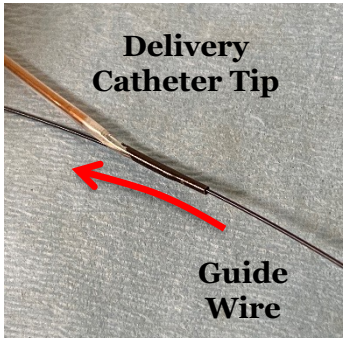
Isotope	Strontium 90 (Sr-90)
Half-life	28.8 years
Source Outer Diameter	0.38 mm
Source Length	2.5 mm
Source Train Active Length	30 mm. 40 mm. 60 mm
Radiopaque Markers	Two 2.5 mm radiopaque markers (distal and proximal end)
Source Train Activity (Maximum)	48 mCi (30 mm JRST) 64 mCi (40 mm JRST) 96 mCi (60 mm JRST)
Source Activity Range	2.7 - 4.0 mCi/source

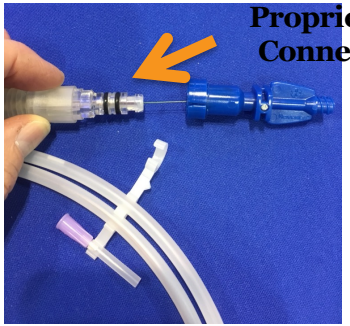


Sr-90/Y-90 40mm (16 seed) train with Pt/Ir markers at the ends in a stainless steel wire jacket (O.D. = 0.47mm)

Delivery Catheter



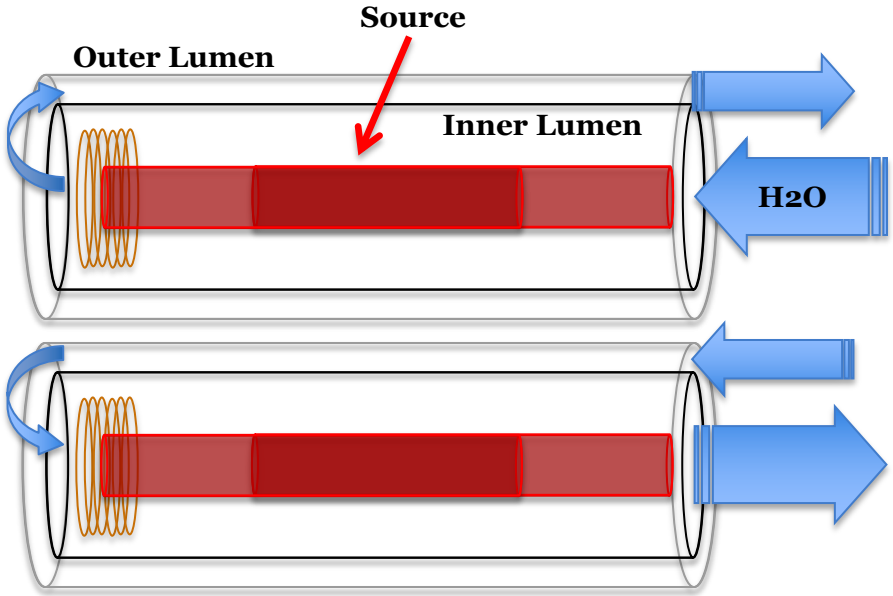


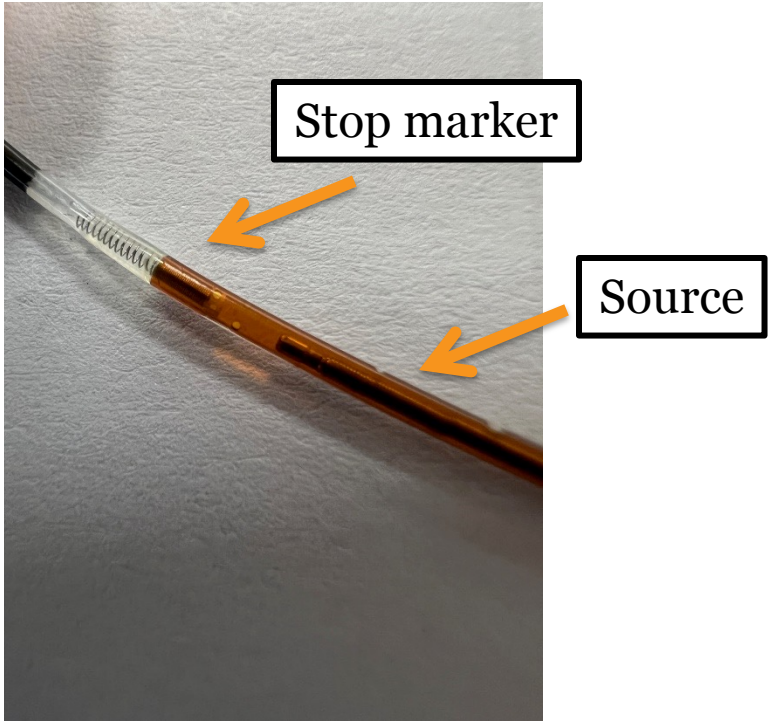


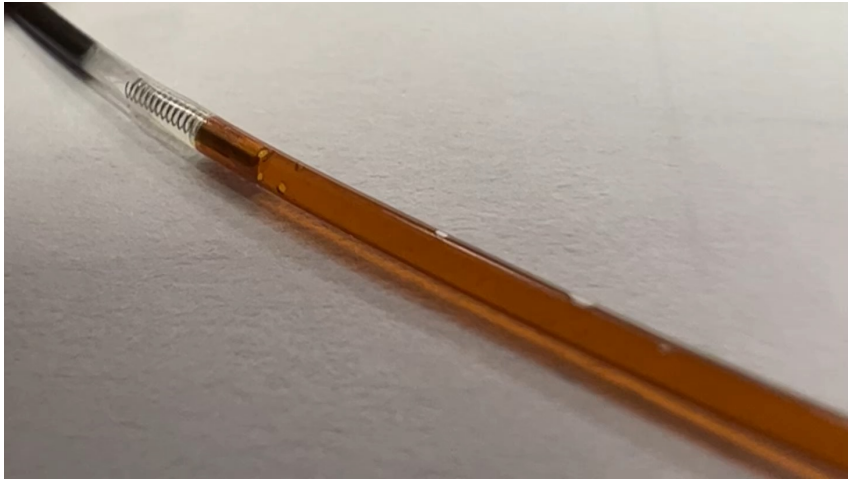
Delivery Catheter

Sending Source:

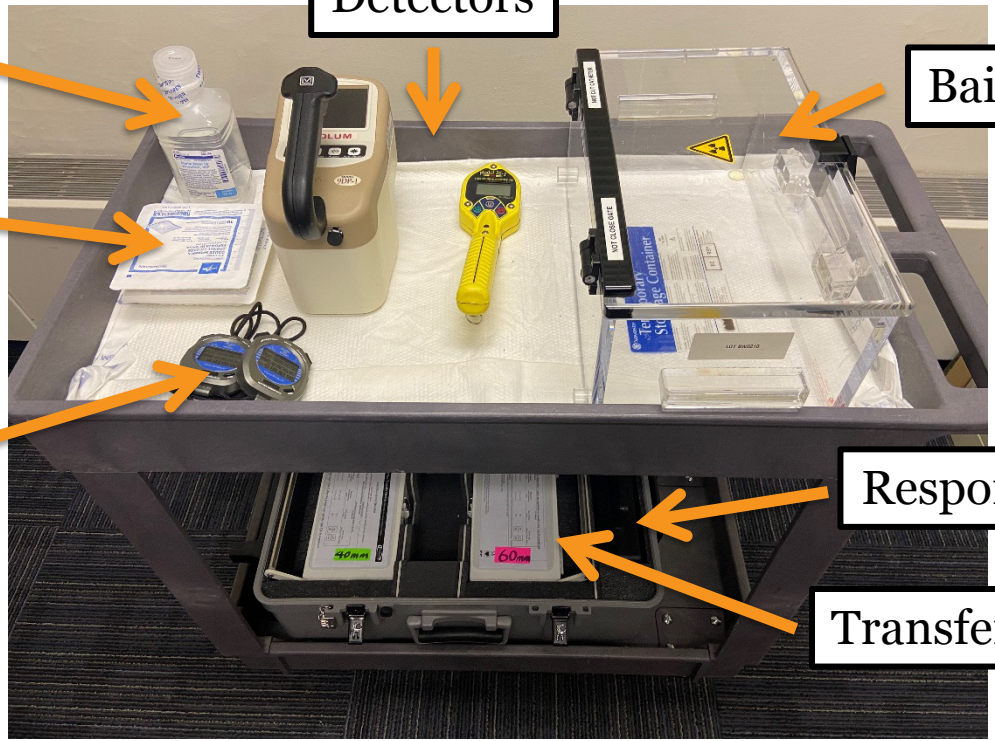
Returning Source:



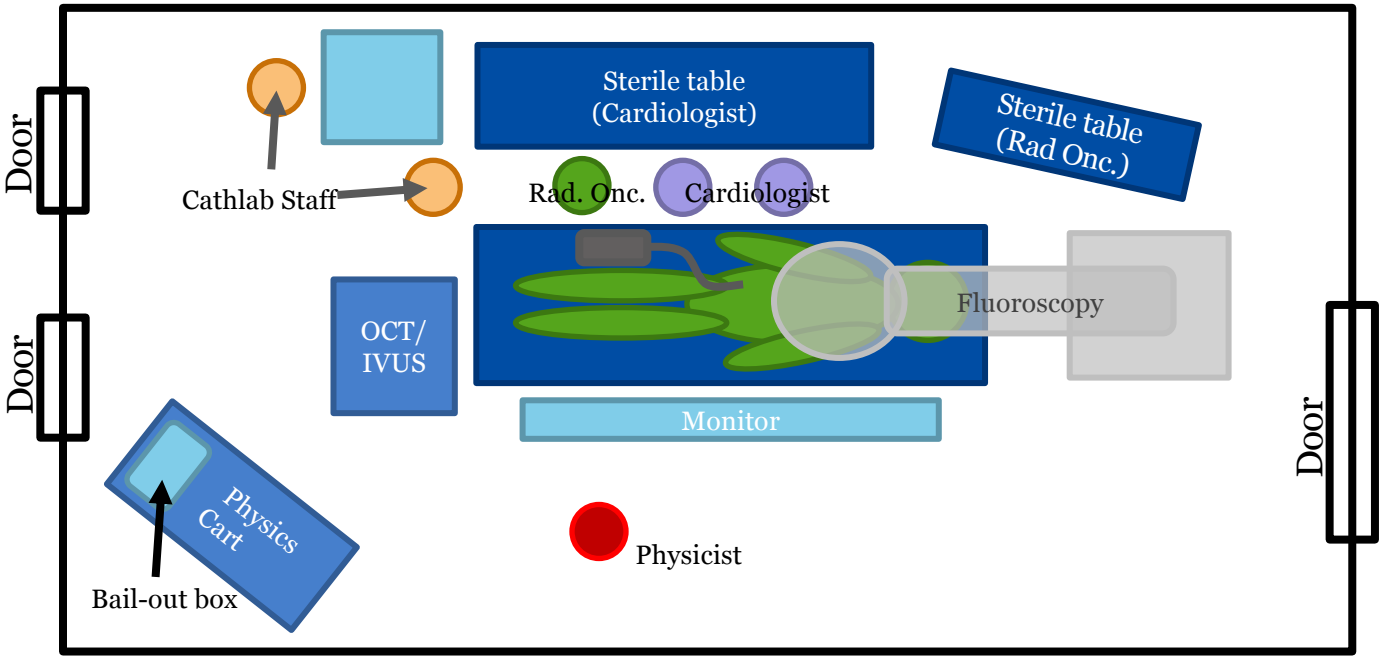

Stop marker
Source



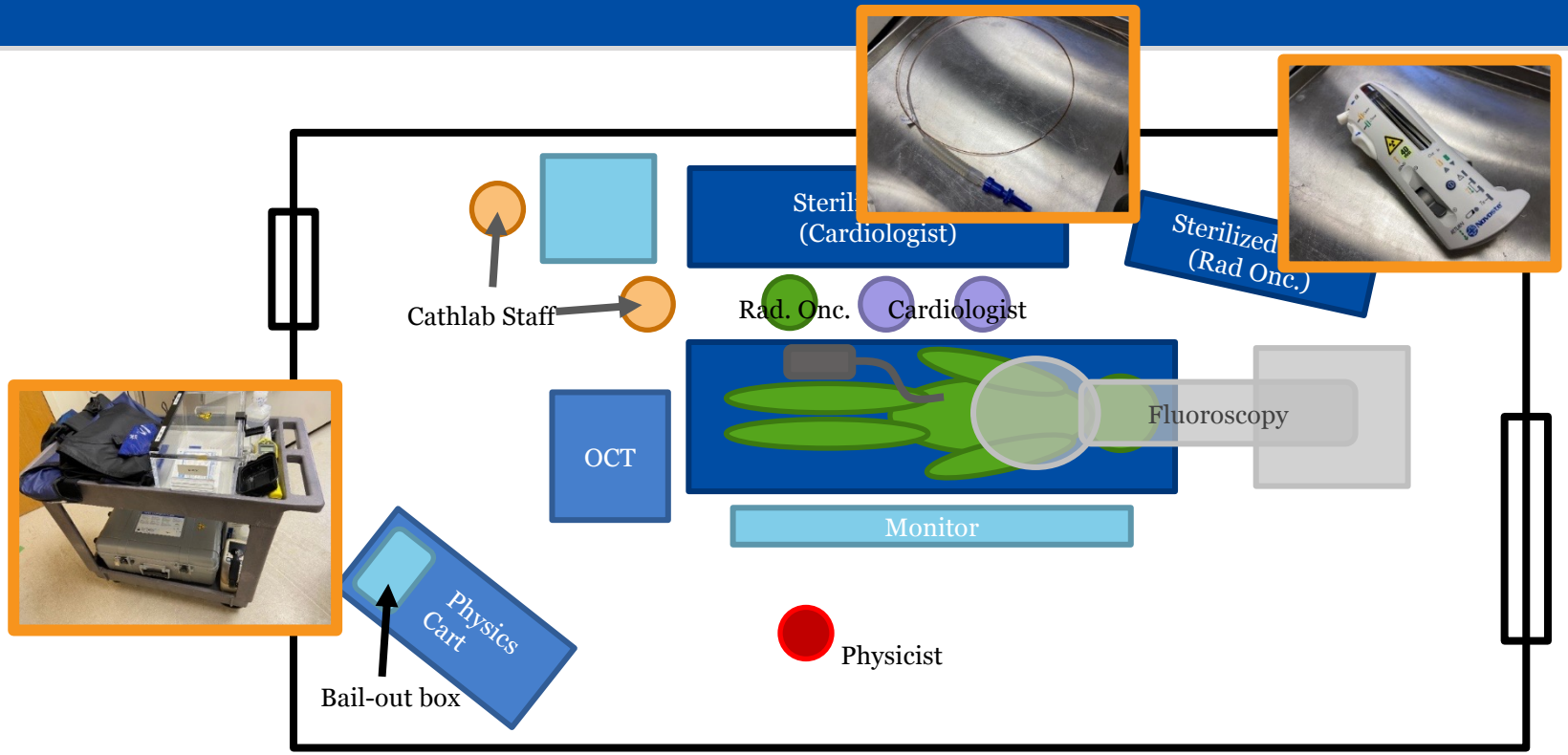
IVBT Cart


Sterile-Water/
Distilled Water
Detectors
Bailout Box
Gauzes
Stopwatches
Response Kit
Transfer Device

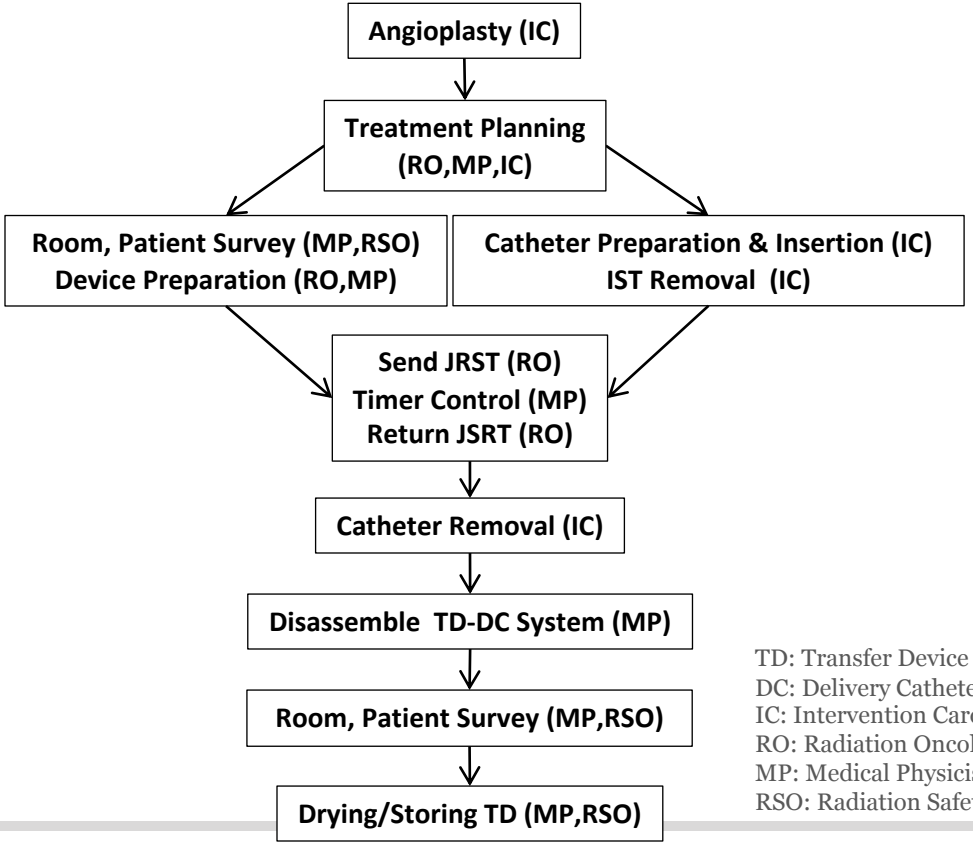
Treatment Set-up



Treatment

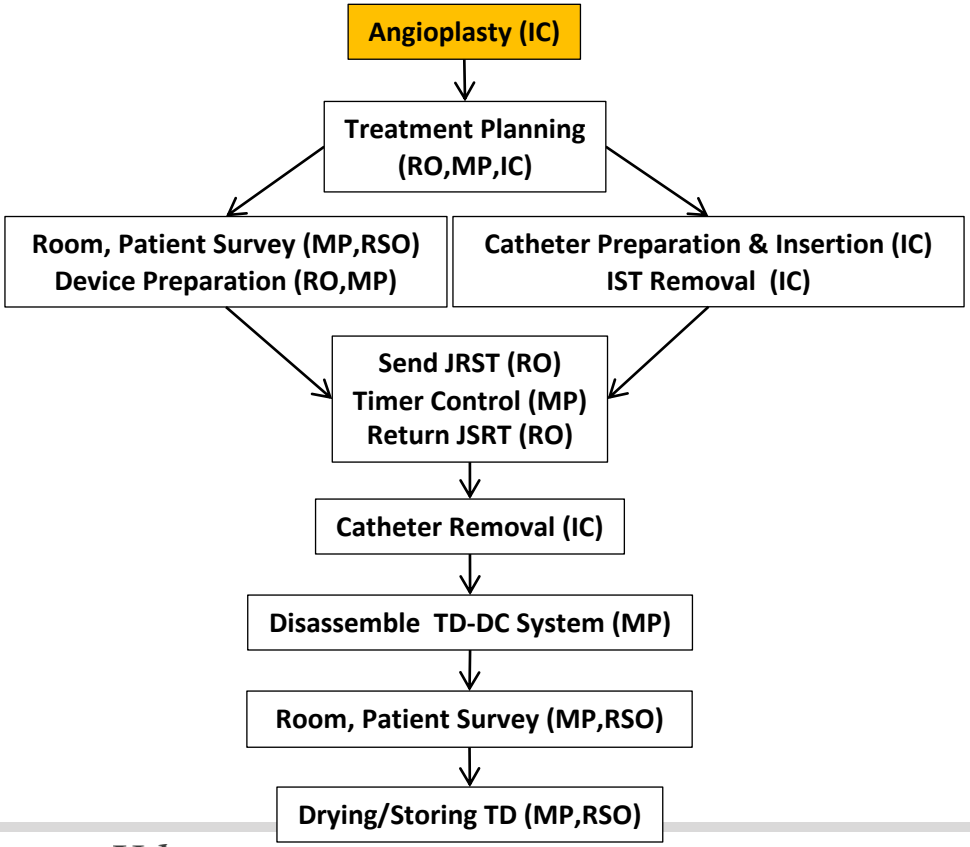

Steril
(Cardiologist)
Sterilized
(Rad Onc.)
Cathlab Staff
Rad. Onc.
Cardiologist
OCT
Fluoroscopy
Monitor
Physics
Cart
Bail-out box
Physicist

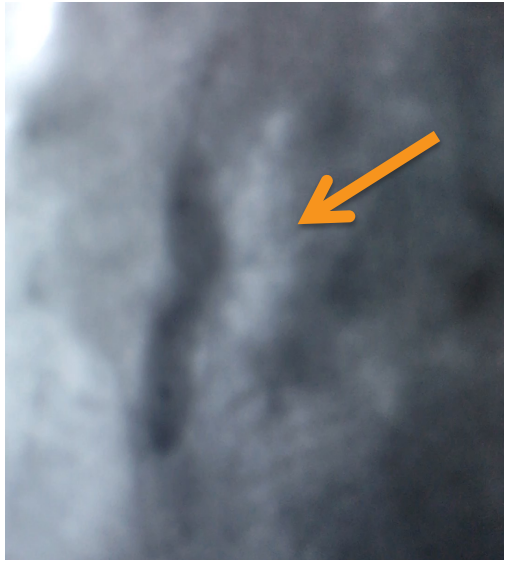
Treatment Workflow



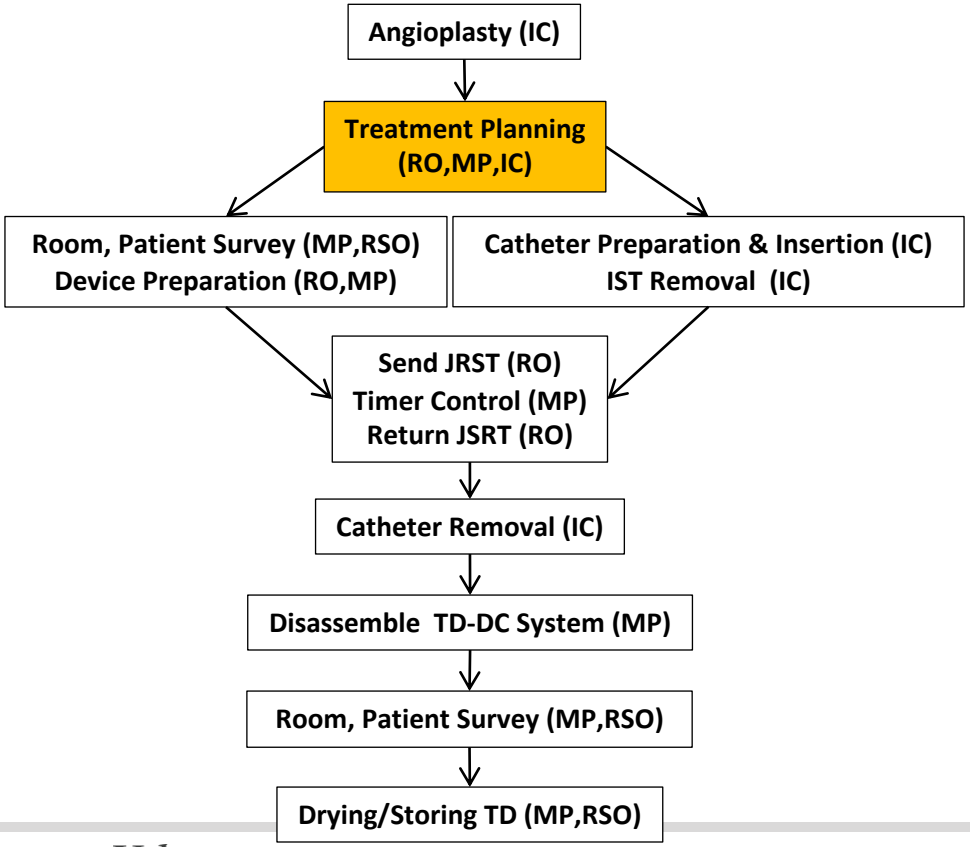
TD: Transfer Device
DC: Delivery Catheter
IC: Intervention Cardiologist
RO: Radiation Oncologist
MP: Medical Physicist
RSO: Radiation Safety Office

Treatment Workflow

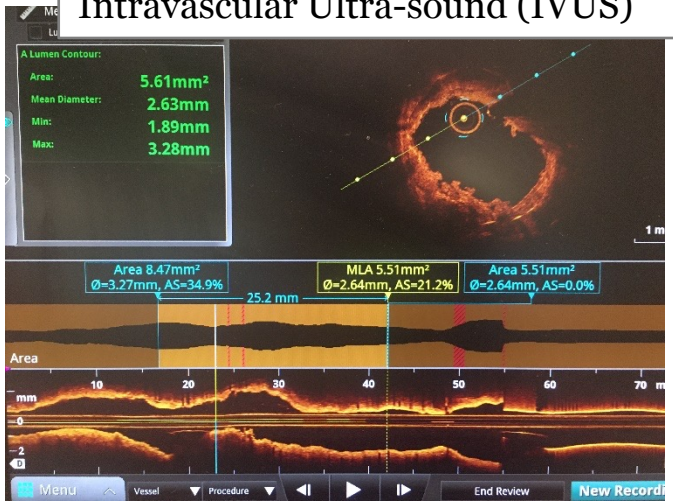




Treatment Workflow



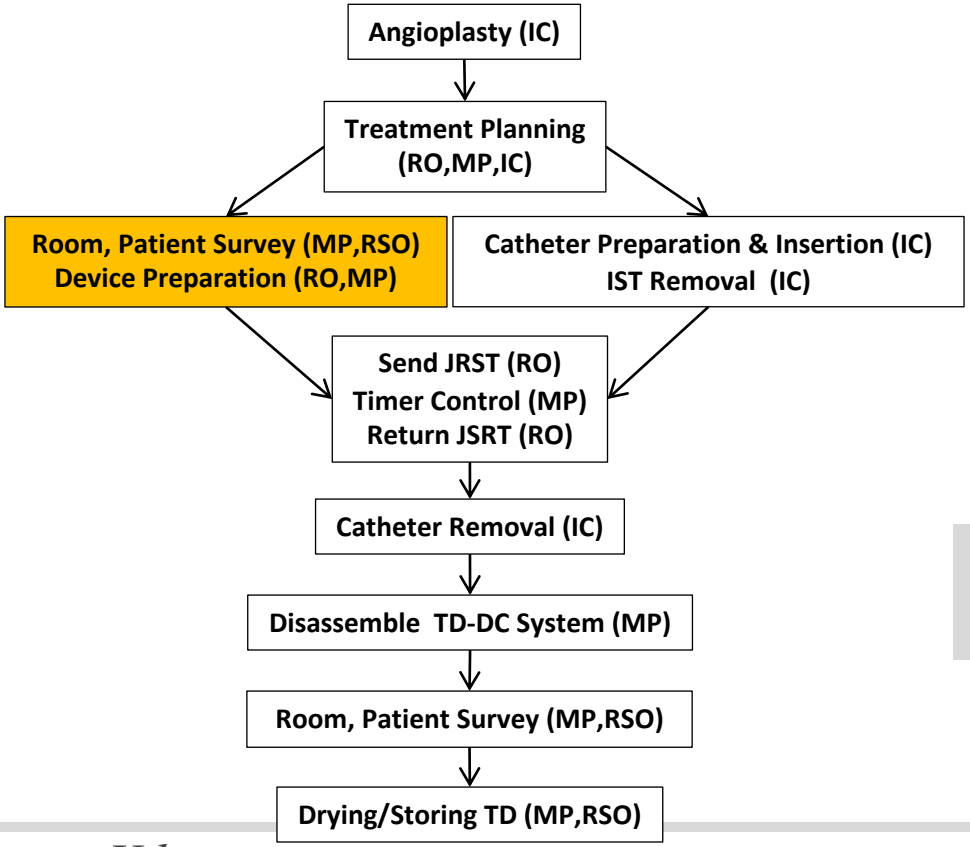
Optical Coherence Tomography (OCT) / Intravascular Ultra-sound (IVUS)

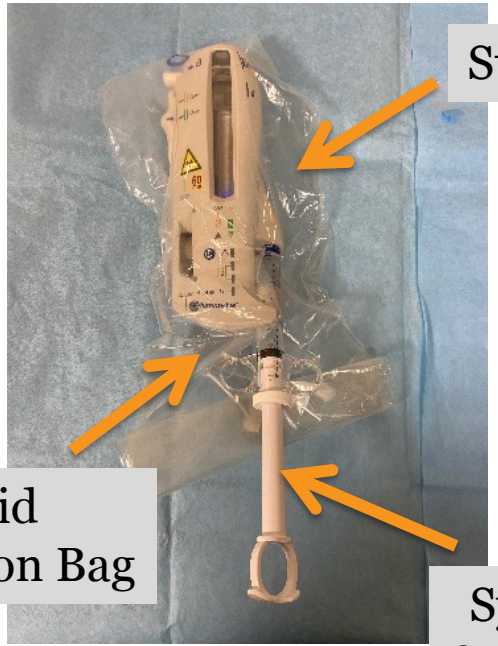


IC
Vessel Diameter
Injury Length

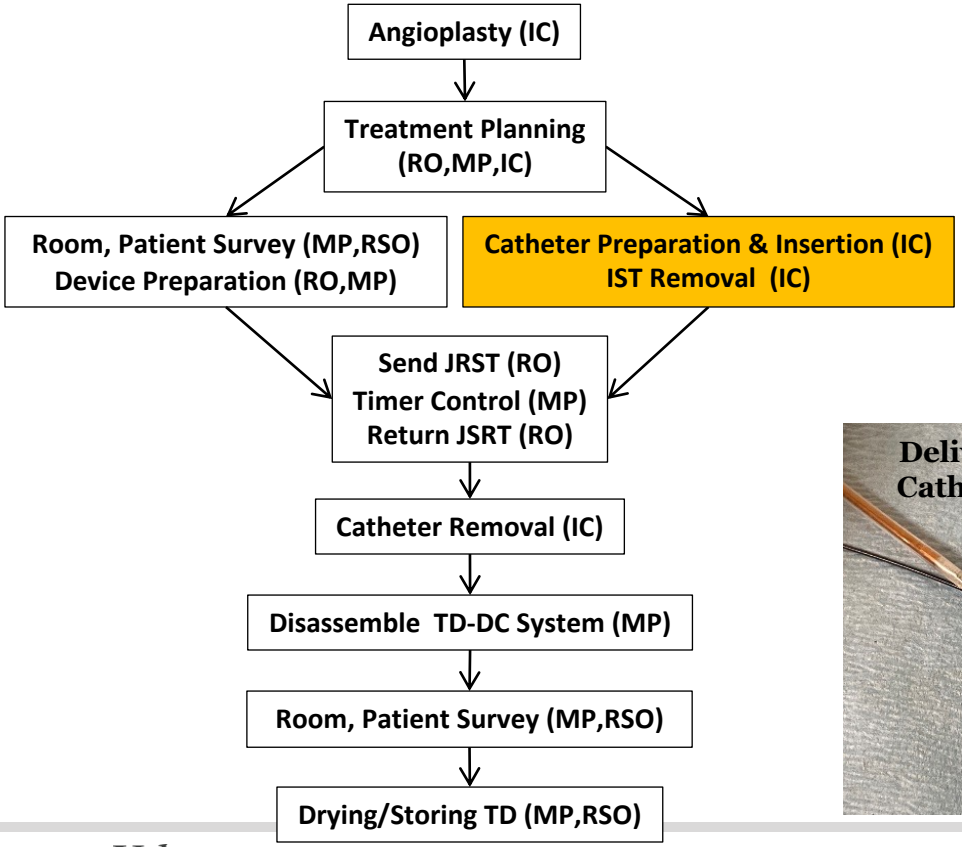
RO, MP
Dose
Source Length
Dwell time
Tx Technic

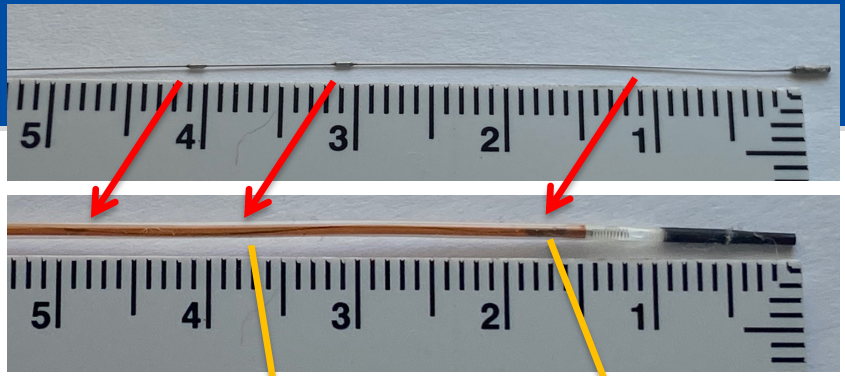
Treatment Workflow

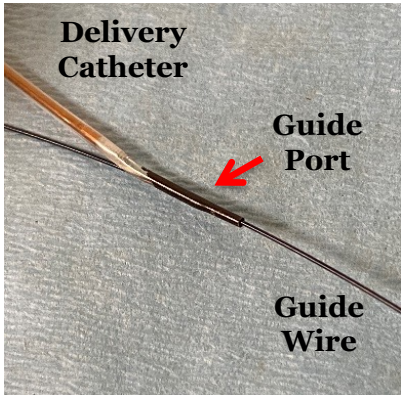


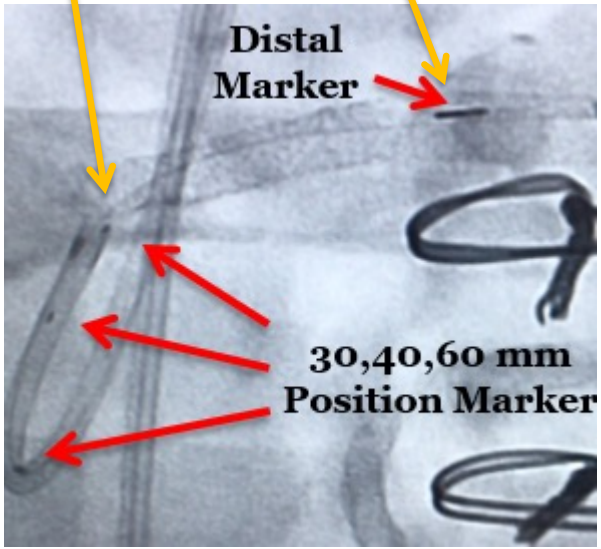


Treatment Workflow

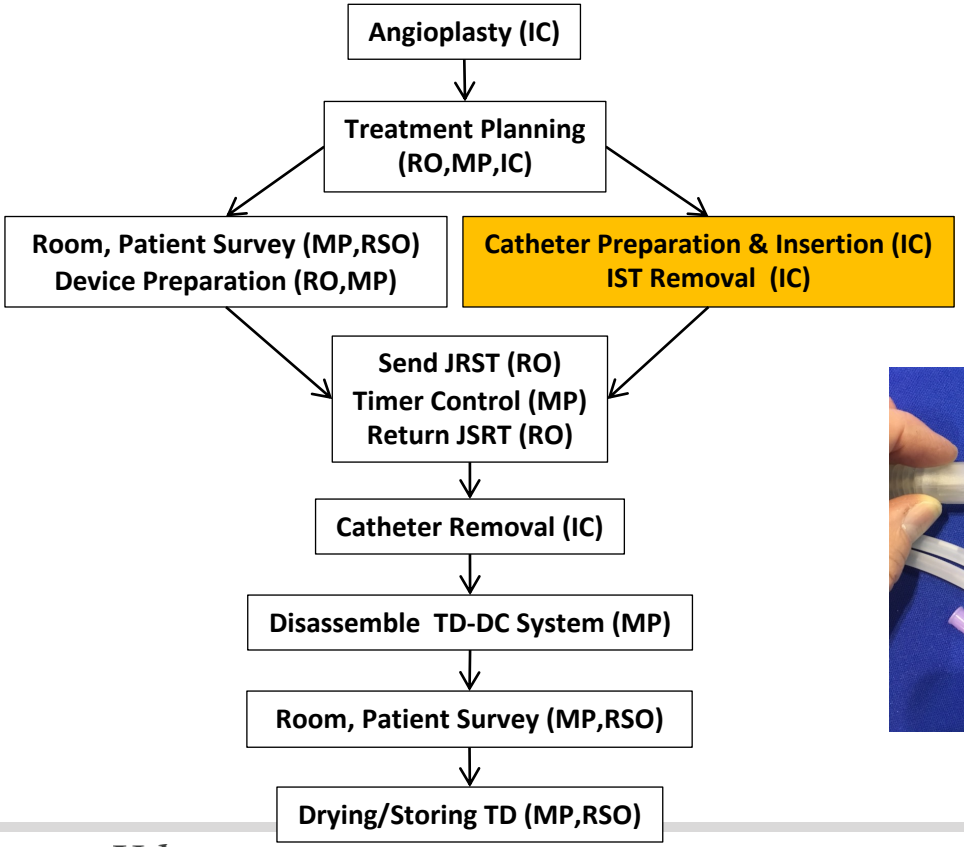


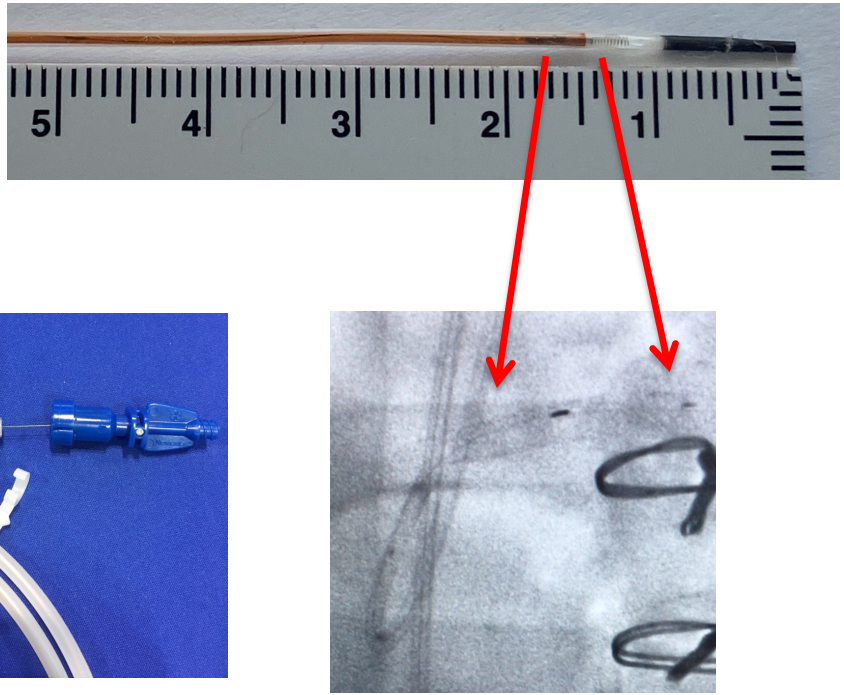




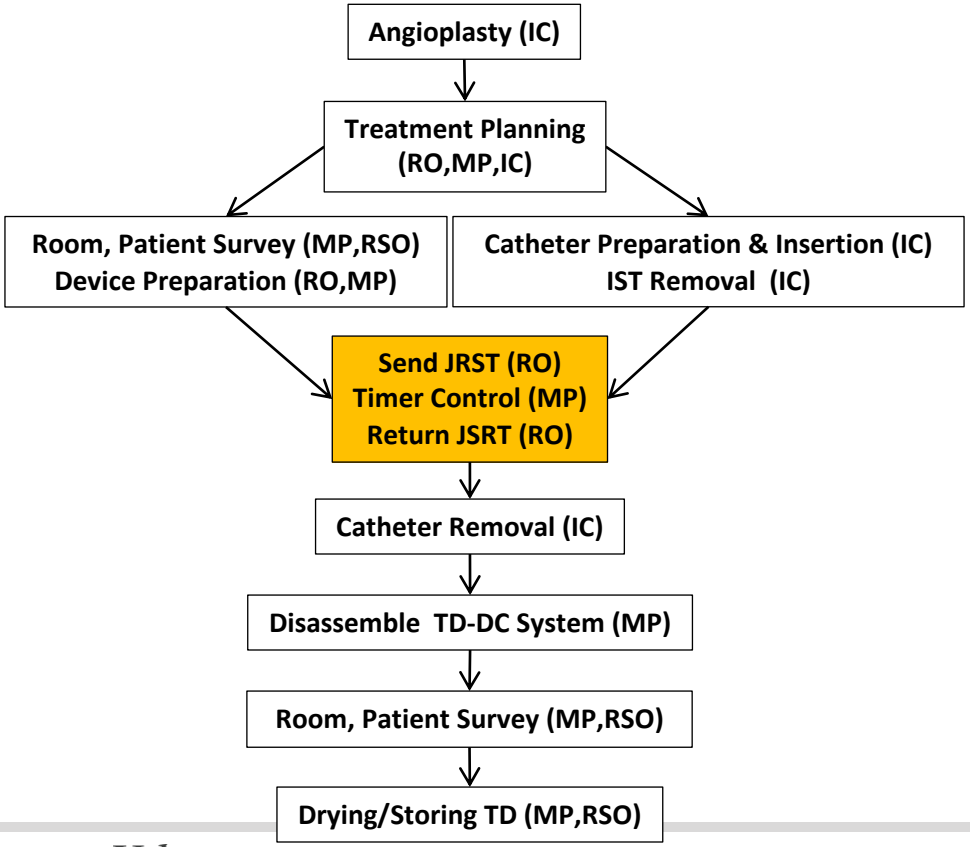


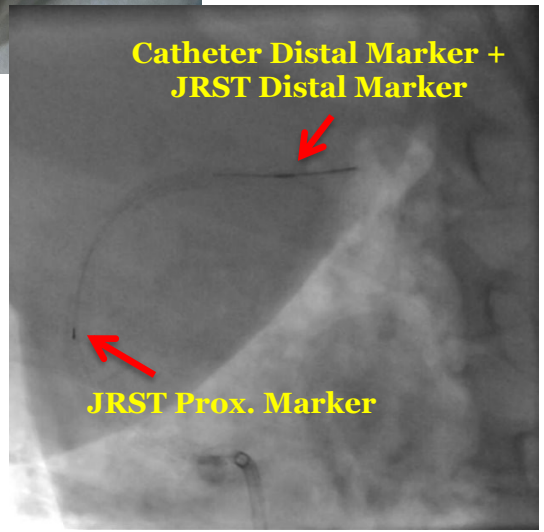
Treatment Workflow



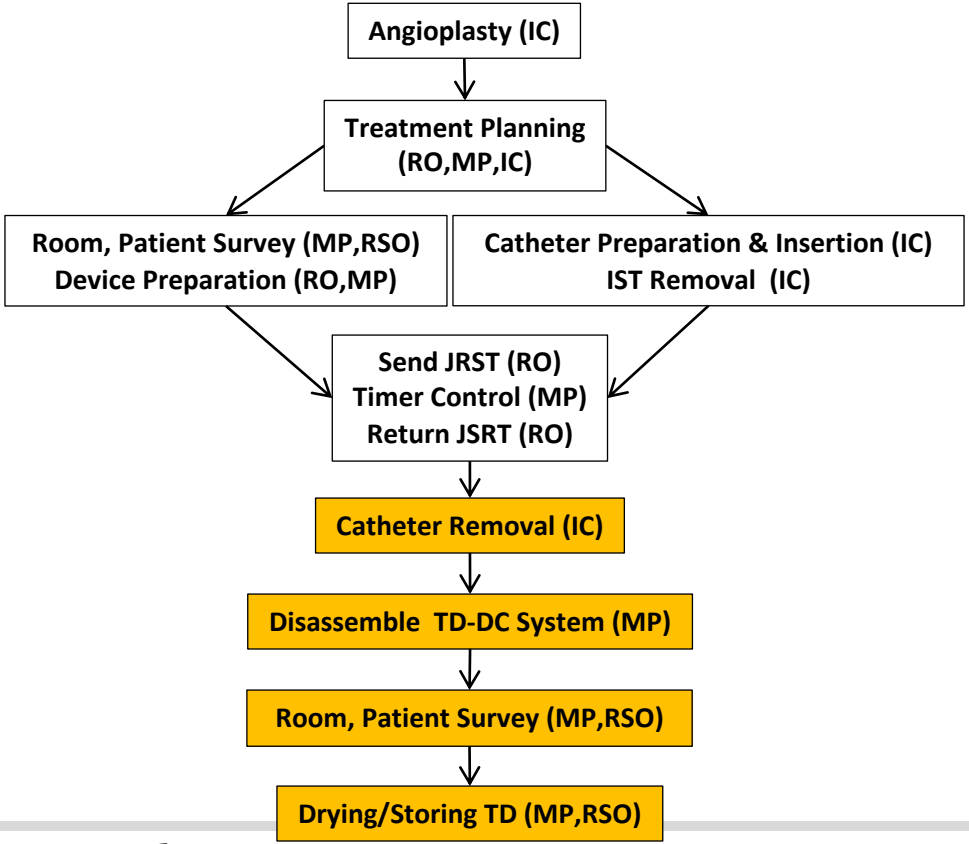


Treatment Workflow

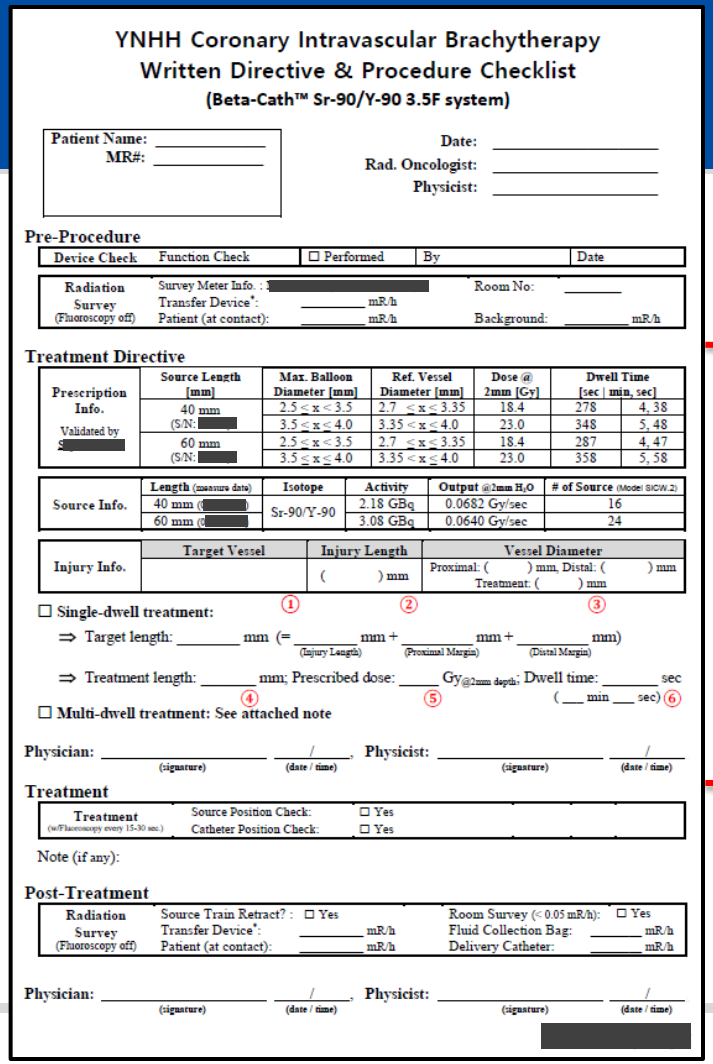




Treatment Workflow



Clinic Cases - General



YNHH Coronary Intravascular Brachytherapy
Written Directive & Procedure Checklist
(Beta-Cath™ Sr-90/Y-90 3.5F system)

Patient Name: _____
MR#: _____

Date: _____
Rad. Oncologist: _____
Physicist: _____

Pre-Procedure

Device Check	Function Check	☐ Performed	By	Date

Radiation Survey (Fluoroscopy off)	Survey Meter Info. : [redacted]	Room No: _____	
	Transfer Device*: _____ mR/h		
	Patient (at contact): _____ mR/h	Background: _____ mR/h	

Treatment Directive

	Source Length [mm]	Max. Balloon Diameter [mm]	Ref. Vessel Diameter [mm]	Dose @ 2mm [Gy]	Dwell Time [sec | min, sec]	
Prescription Info. Validated by [redacted]	40 mm (S/N: [redacted])	2.5 ≤ x < 3.5	2.7 ≤ x ≤ 3.35	18.4	278	4, 38
		3.5 ≤ x ≤ 4.0	3.35 < x ≤ 4.0	23.0	348	5, 48
	60 mm (S/N: [redacted])	2.5 ≤ x < 3.5	2.7 ≤ x ≤ 3.35	18.4	287	4, 47
		3.5 ≤ x ≤ 4.0	3.35 < x ≤ 4.0	23.0	358	5, 58

	Length (measure date)	Isotope	Activity	Output @2mm H_2O	# of Source (Model SICW.2)
Source Info.	40 mm ([redacted])	Sr-90/Y-90	2.18 GBq	0.0682 Gy/sec	16
	60 mm ([redacted])		3.08 GBq	0.0640 Gy/sec	24

	Target Vessel	Injury Length	Vessel Diameter
Injury Info.		( ) mm	Proximal: ( ) mm, Distal: ( ) mm Treatment: ( ) mm

① ② ③

☐ **Single-dwell treatment:**

⇒ Target length: _____ mm (= _____ mm + _____ mm + _____ mm)
(Injury Length) (Proximal Margin) (Distal Margin)

⇒ Treatment length: _____ mm; Prescribed dose: _____ $Gy_{@2mm\ depth}$; Dwell time: _____ sec
④ ⑤ (___ min ___ sec) ⑥

☐ **Multi-dwell treatment: See attached note**

Physician: _____ (signature) _____/_____ (date / time) Physicist: _____ (signature) _____/_____ (date / time)

Treatment

Treatment (w/Fluoroscopy every 15-30 sec.)	Source Position Check:	☐ Yes
	Catheter Position Check:	☐ Yes

Note (if any):

Post-Treatment

Radiation Survey (Fluoroscopy off)	Source Train Retract? : ☐ Yes	Room Survey (< 0.05 mR/h):	☐ Yes
	Transfer Device*: _____ mR/h	Fluid Collection Bag:	_____ mR/h
	Patient (at contact): _____ mR/h	Delivery Catheter:	_____ mR/h

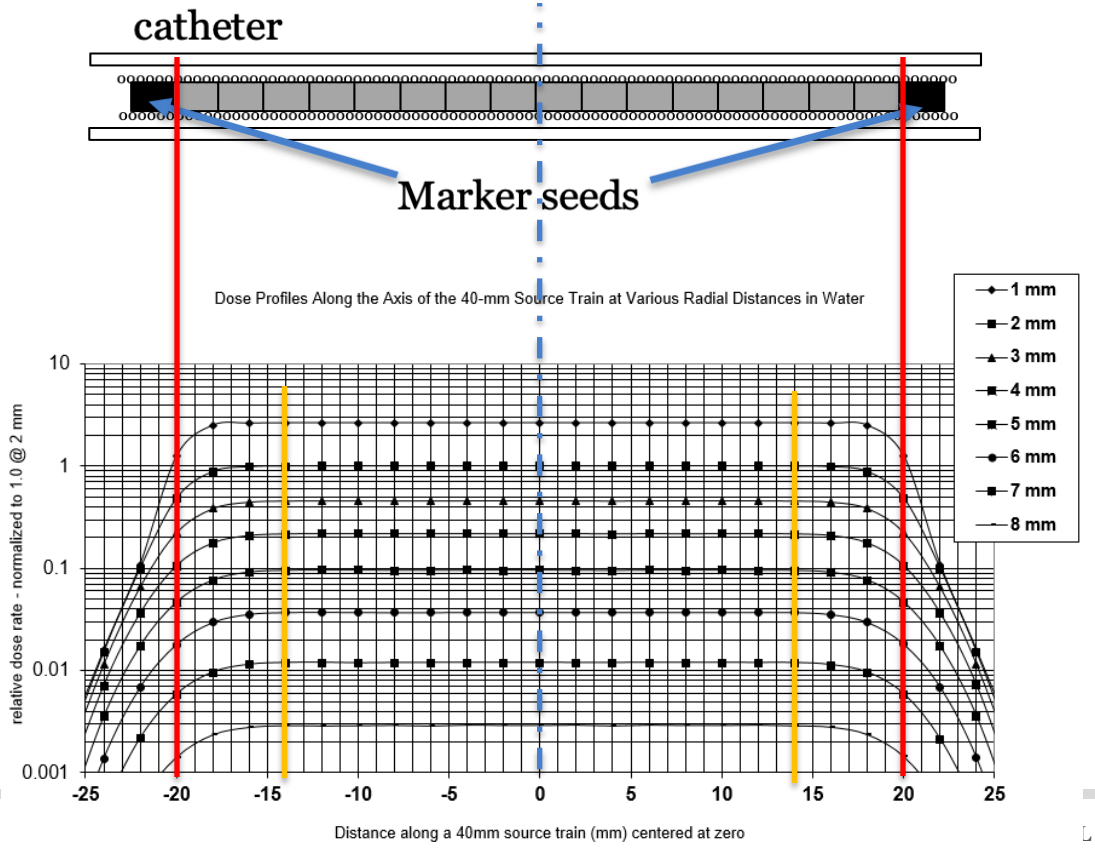
Physician: _____ (signature) _____/_____ (date / time) Physicist: _____ (signature) _____/_____ (date / time)

[redacted]

Pre/post Tx survey

Treatment Planning

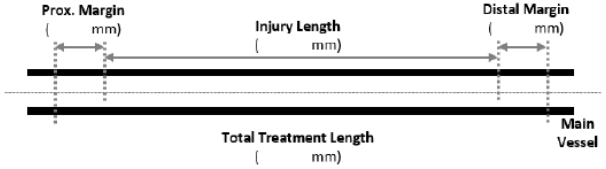
Margin


catheter
Marker seeds
Dose Profiles Along the Axis of the 40-mm Source Train at Various Radial Distances in Water
1 mm
2 mm
3 mm
4 mm
5 mm
6 mm
7 mm
8 mm
relative dose rate - normalized to 1.0 @ 2 mm
10
1
0.1
0.01
0.001
-25
-20
-15
-10
-5
0
5
10
15
20
25
Distance along a 40mm source train (mm) centered at zero

Clinic Cases – Hot Pull-Back

Treatment Directive

Treatment Lesion Diagram



	Source Length [mm]	Max. Balloon Diameter [mm]	Ref. Vessel Diameter [mm]	Dose @ 2mm [Gy]	Dwell Time [sec | min, sec]	
Prescription Info. Validated by [redacted]	40 mm (S/N: [redacted])	2.5 ≤ x < 3.5	2.7 ≤ x ≤ 3.35	18.4	278	4, 38
		3.5 ≤ x ≤ 4.0	3.35 < x ≤ 4.0	23.0	348	5, 48
	60 mm (S/N: [redacted])	2.5 ≤ x < 3.5	2.7 ≤ x ≤ 3.35	18.4	287	4, 47
		3.5 ≤ x ≤ 4.0	3.35 < x ≤ 4.0	23.0	358	5, 58

	Length (measure date)	Isotope	Activity	Output @2mm H_2O	# of Source (Model SICW.2)
Source Info.	40 mm ([redacted])	Sr-90/Y-90	2.18 GBq	0.0682 Gy/sec	16
	60 mm ([redacted])		3.08 GBq	0.0640 Gy/sec	24

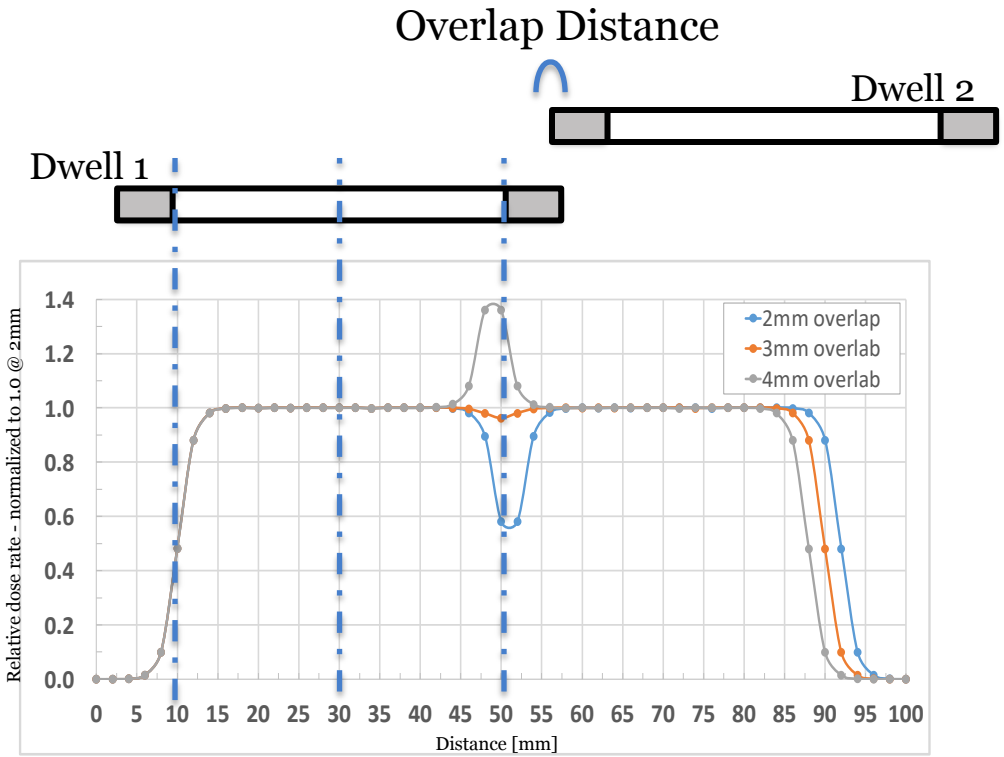
☐ **Treatment Plan:**

⇒ Target Vessel: _____ ①

⇒ Target length: _____ mm (= _____ mm + _____ mm + _____ mm)
(Injury Length) (Proximal Margin) (Distal Margin)

⇒ Total treatment length (single-sites): _____ mm ②

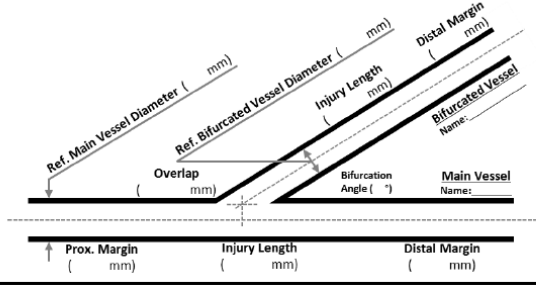
	Dwell 1	Dwell 2	Dwell 3
Source Position	(Dist. / Mid. / Prox.)	(Dist. / Mid. / Prox.)	(Dist. / Mid. / Prox.)
Injury L. (multi-sites) [mm]	②		
Ref. Vessel Diameter [mm]	③		
Prescribed Dose [Gy@2mm depth]	④		
Source Length [mm]	⑤		
Dwell Time [min, sec]	⑥		



Clinic Cases - Bifurcation

Treatment Directive

Treatment Lesion Diagram



☐ **Main Vessel Treatment Plan:** _____ ①

⇒ Main vessel target length: _____ mm (= _____ mm + _____ mm + _____ mm)
(Injury Length) (Proximal Margin) (Distal Margin)

⇒ Main vessel treatment length: _____ mm ②

	Dwell 1	Dwell 2	Dwell 3
Ref. Vessel Diameter [mm]	③		
Prescribed Dose [$Gy_{@2mm\ depth}$]	④		
Source Length [mm]	⑤		
Dwell Time [min, sec]	⑥		
Source Gap(+) / Overlap(-) [mm]			

☐ **Bifurcated Vessel Treatment Plan:** _____ ①

⇒ Bifurcated vessel target length: _____ mm (= _____ mm + _____ mm + _____ mm)
(Injury Length) (Overlap) (Distal Margin)

⇒ Total bifurcated vessel treatment length: _____ mm ②

	Dwell 1	Dwell 2	Dwell 3
Ref. Vessel Diameter [mm]	③		
Prescribed Dose [$Gy_{@2mm\ depth}$]	④		
Source Length [mm]	⑤		
Dwell Time [min, sec]	⑥		
Source Gap(+) / Overlap(-) [mm]			

Physician: _____ (signature) _____/_____ (date / time), **Physicist:** _____ (signature) _____/_____ (date / time)

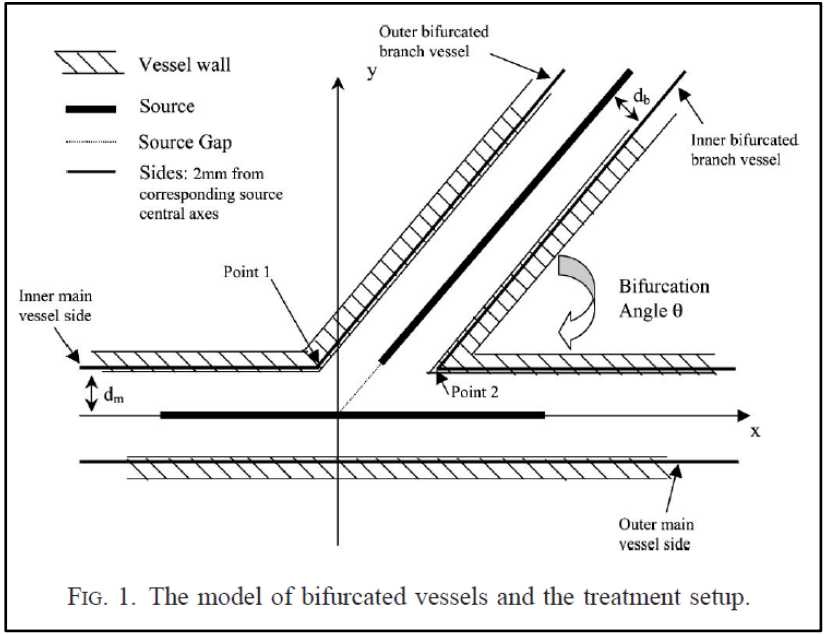


FIG. 1. The model of bifurcated vessels and the treatment setup.

Hot spots at portions of the main vessel near the junction cannot be totally avoided without severely under dosing the branch vessel.

* N. Yue, K. Roberts, S. Pfau, R. Nath, Med. Phys. 30 (7) July 2003142–150
* N. Yue, K. Roberts, S. H Son, S Khosravi, Pfau, R. Nath, Med. Phys., Vol. 31, No. 9, September 2004

Other Dosimetry Consideration

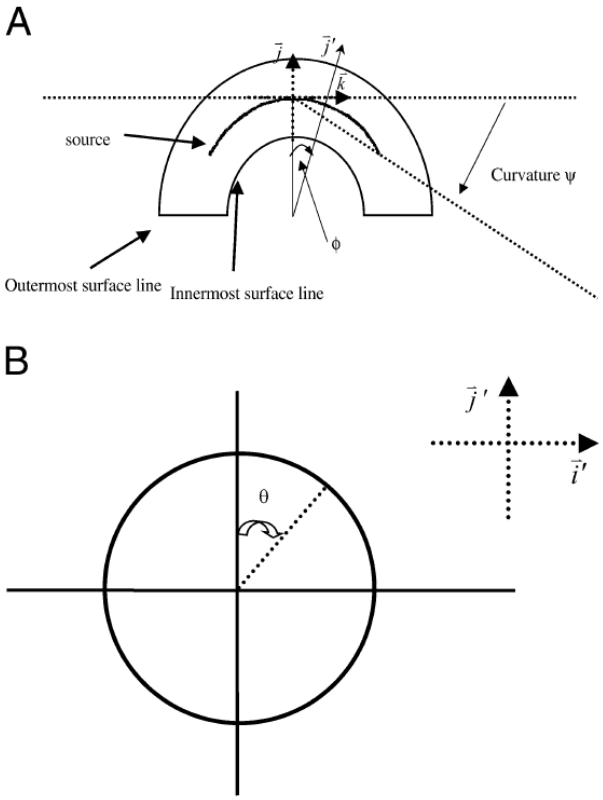


Fig. 1. (A) Lateral view of the curved blood vessel and radioactive source line. (B) Cross-section view of the blood vessel.

Although curvature-induced changes were relatively larger for the beta emitters, the differences were only within a few of percent (less than 5%).

* N. Yue, K. Roberts, R. Nath, Cardiovascular Radiation Medicine 5 (2004) 142–150

Emergency Source Recovery

Most common reasons:

1. Without IST wire support (or during treatment), push forward delivery catheter
2. Target vessel anatomy is too tortuous
3. Hemostasis valve closed too tightly
4. Hydraulic interference between delivery catheter and transfer device (e.g. by sterile bag)

Emergency Procedure

YNHH Coronary Intravascular Brachytherapy

EMERGENCY SOURCE RECOVERY PROCEDURE

BETA CATH AND BETA RAIL (3.5F) SYSTEM

CAUTION: DO NOT TOUCH A SOURCE WITH BARE HANDS.
RADIATION EXPOSURE AND/OR INJURY CAN OCCUR. ALWAYS USE REMOTE HANDLING TOOLS TO MANIPULATE SOURCES.

- **Notify personnel present of missing source**
- **No personnel allowed to enter/leave the room until the source is contained**
- **Do Not:**
  1. Grasp the catheter directly with hands
  2. Cut the catheter
  3. Pick up a source with fingers: Use saline-soaked gauze sponge (> 4 gauze sponge)

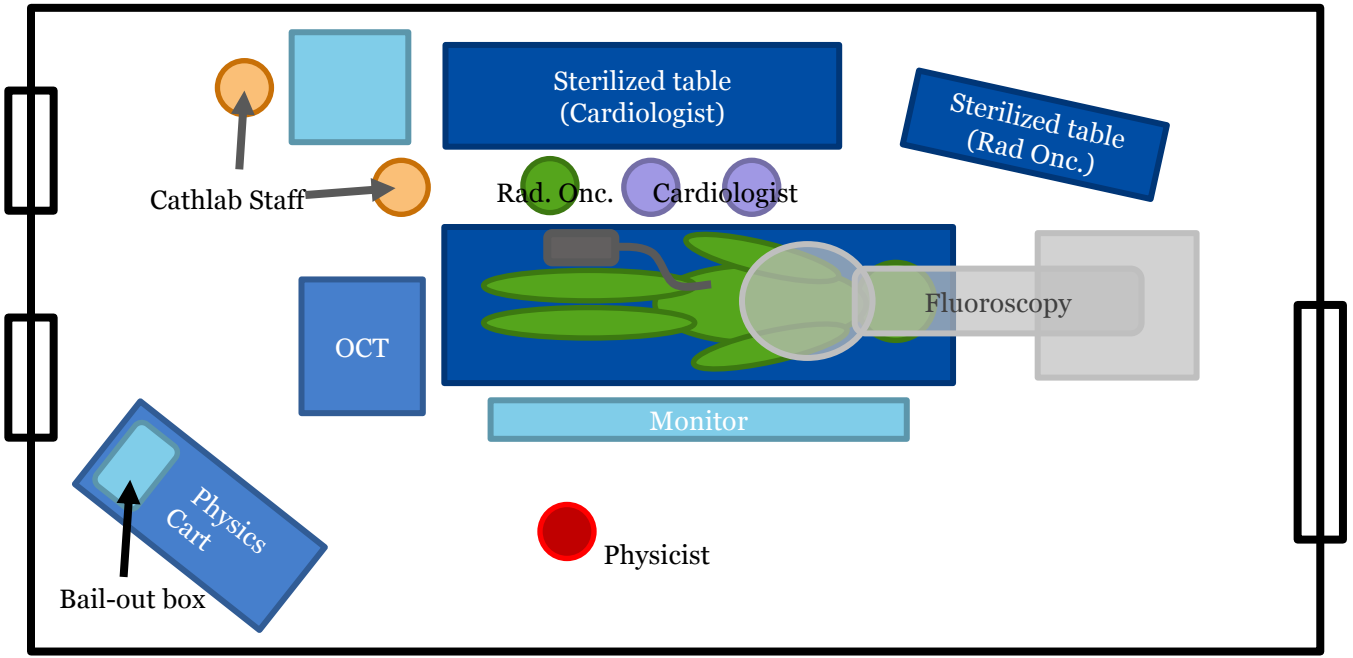
Situation considered as lodged in the Catheter:

1. If the source train does not return to the transfer device **and**
2. If the delivery catheter has not been disconnected from the transfer device.

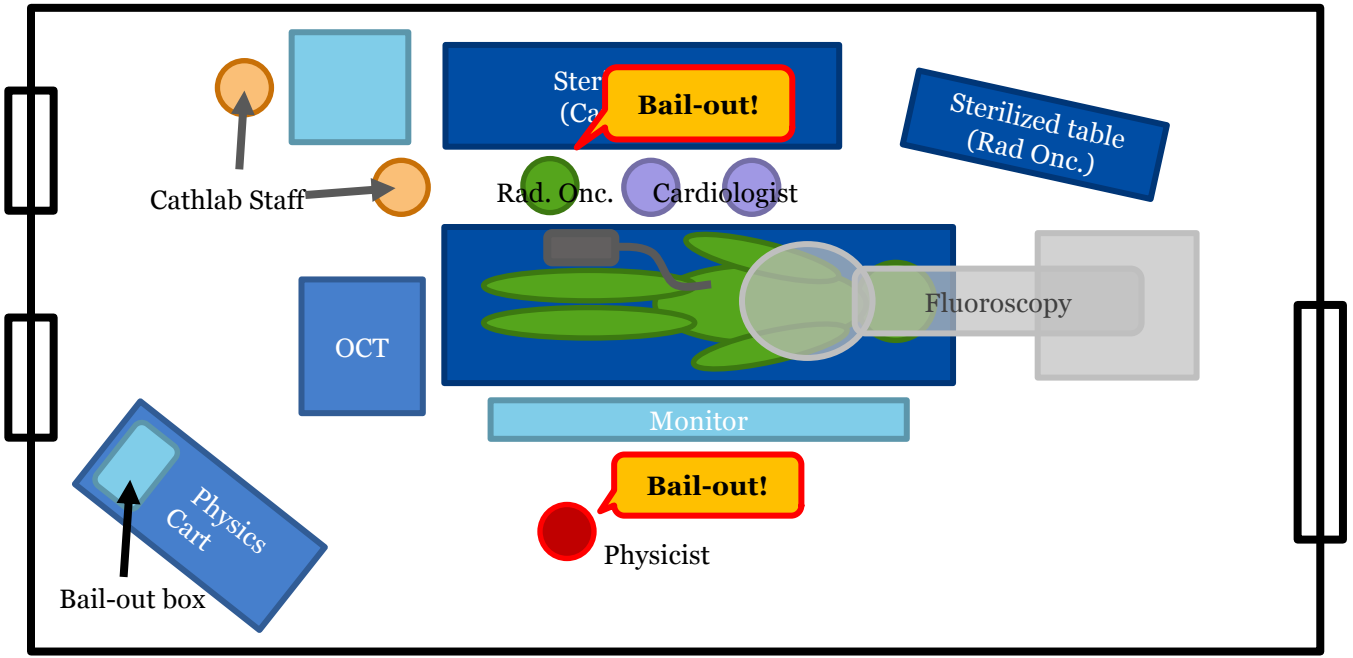
Temporary Storage Box

Response Kit

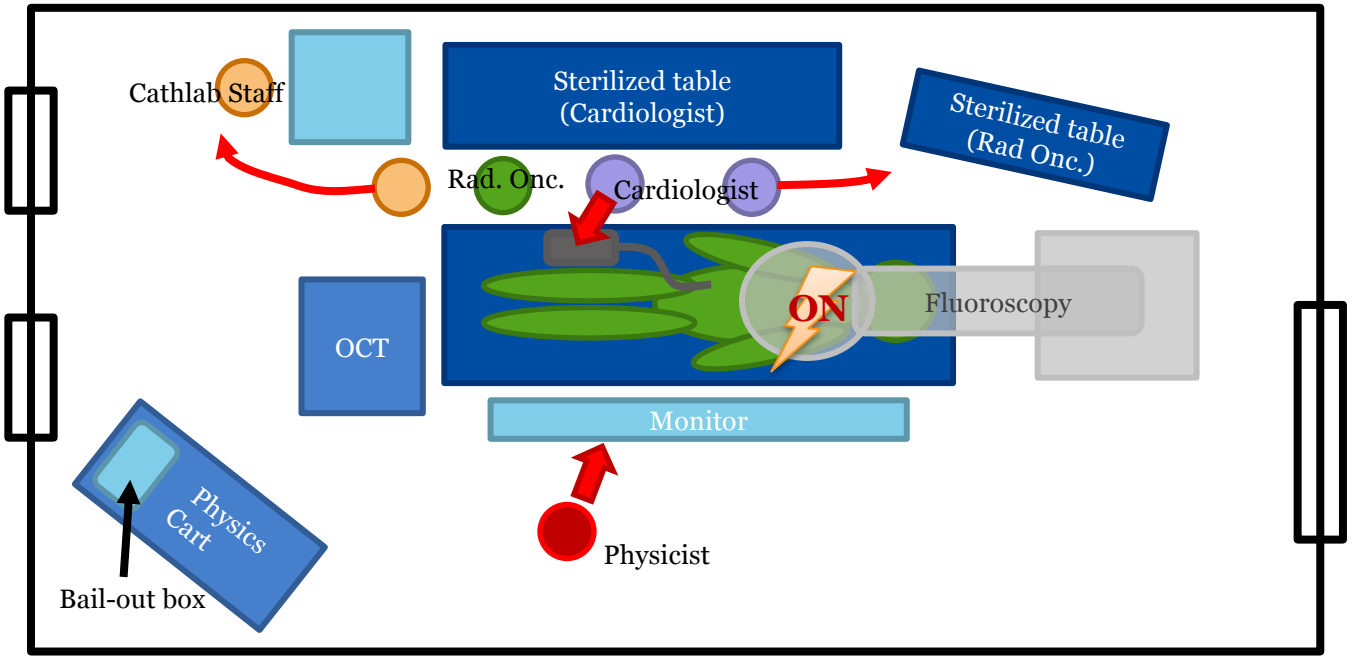
Emergency Procedure



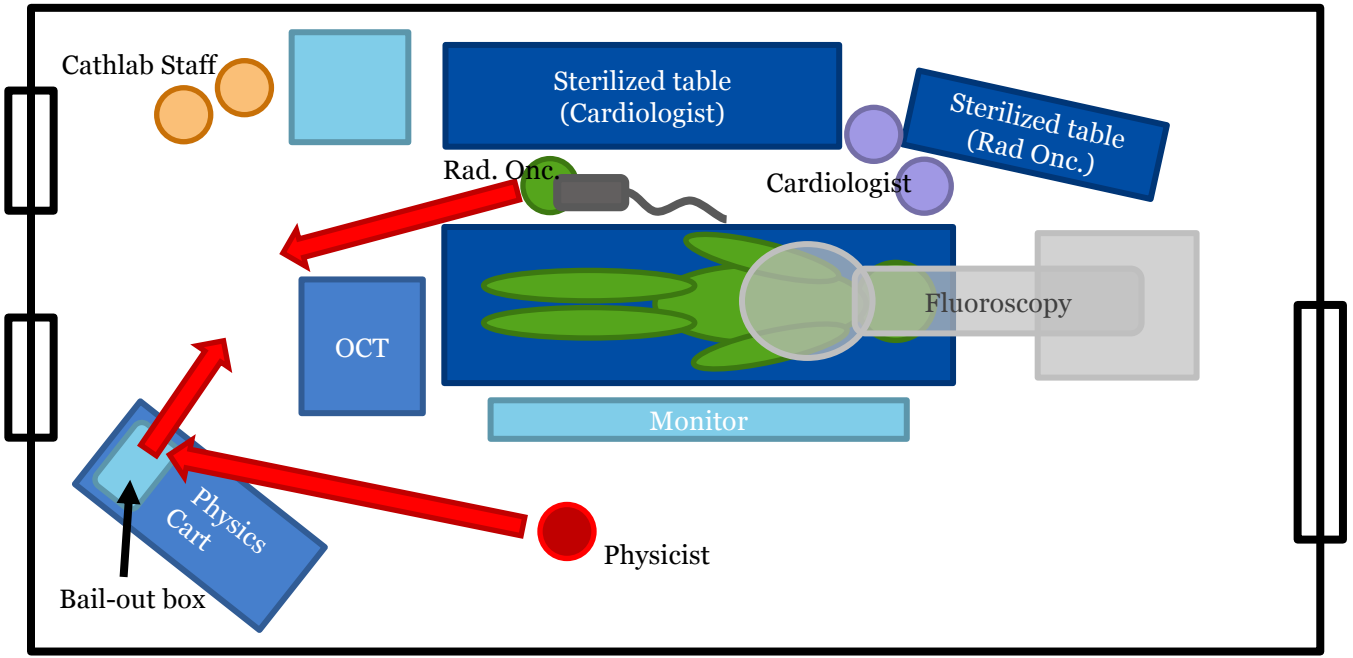
Emergency Procedure



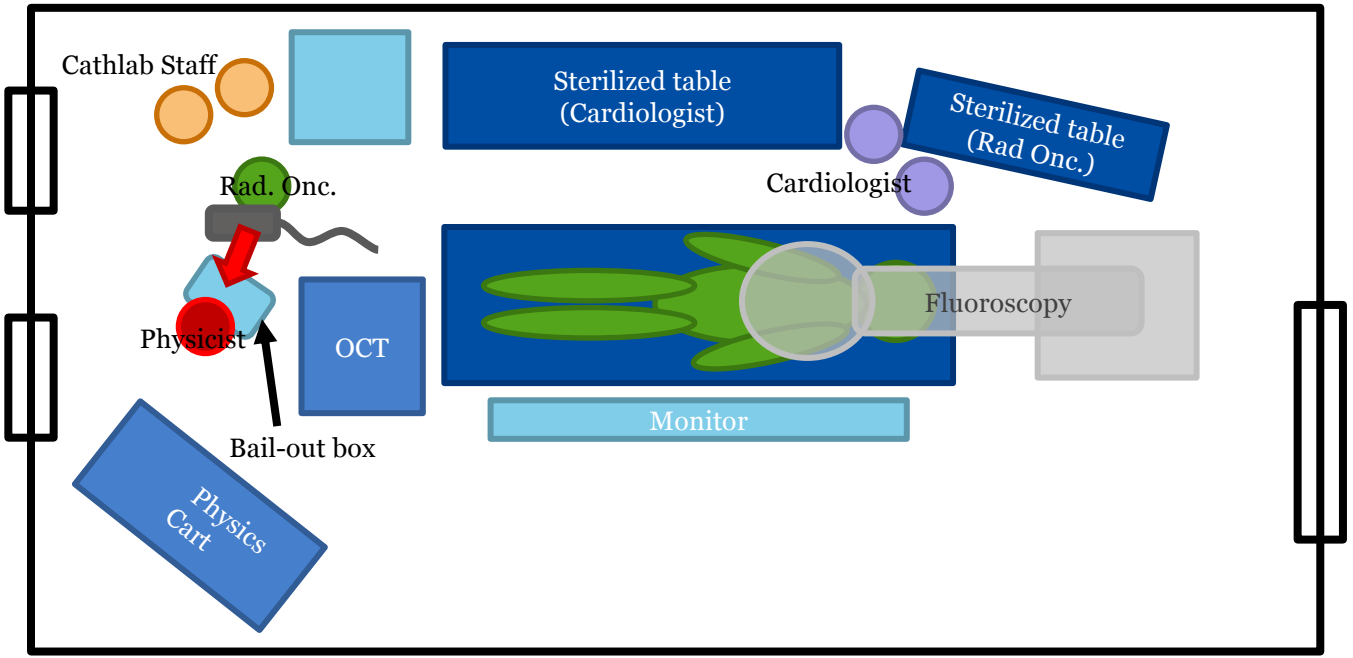
Emergency Procedure



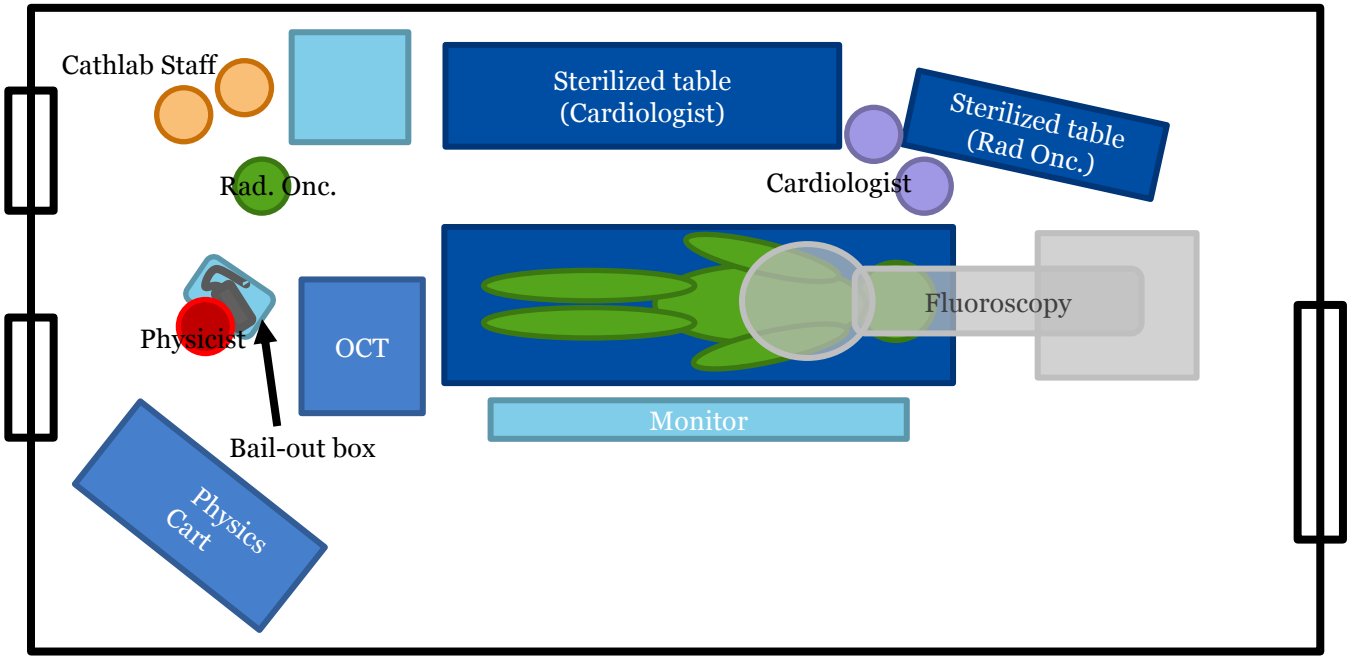
Emergency Procedure



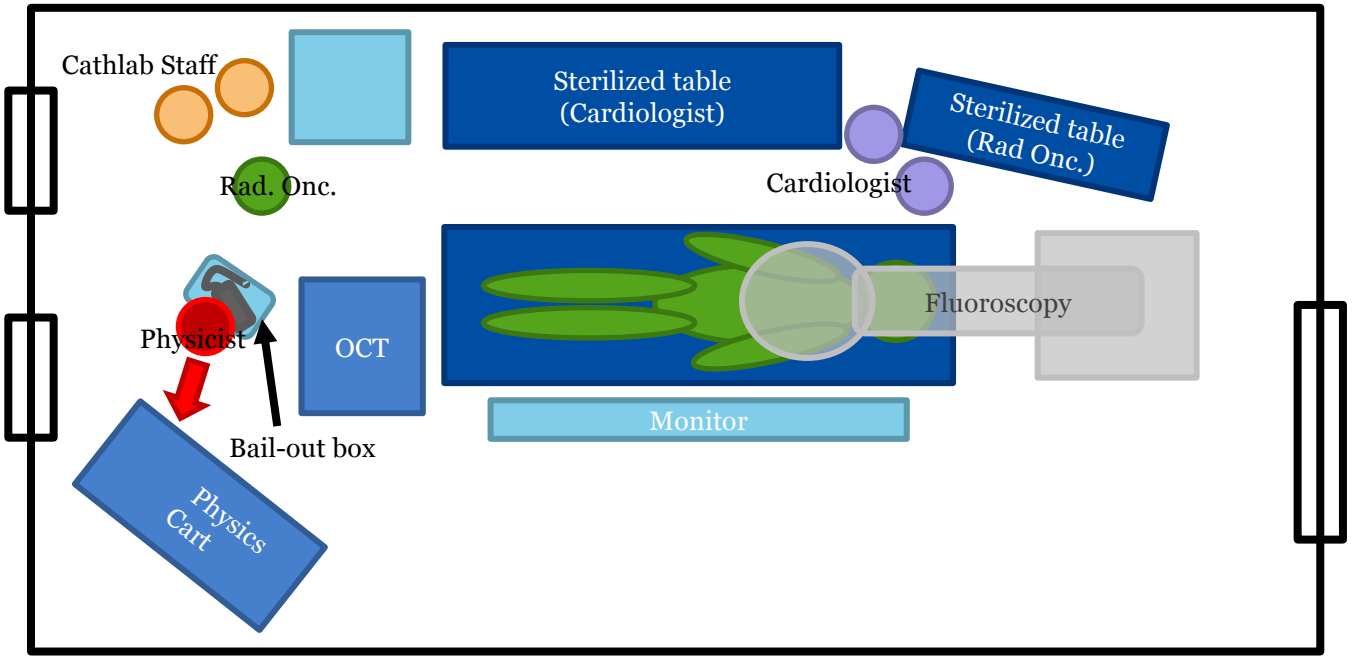
Emergency Procedure



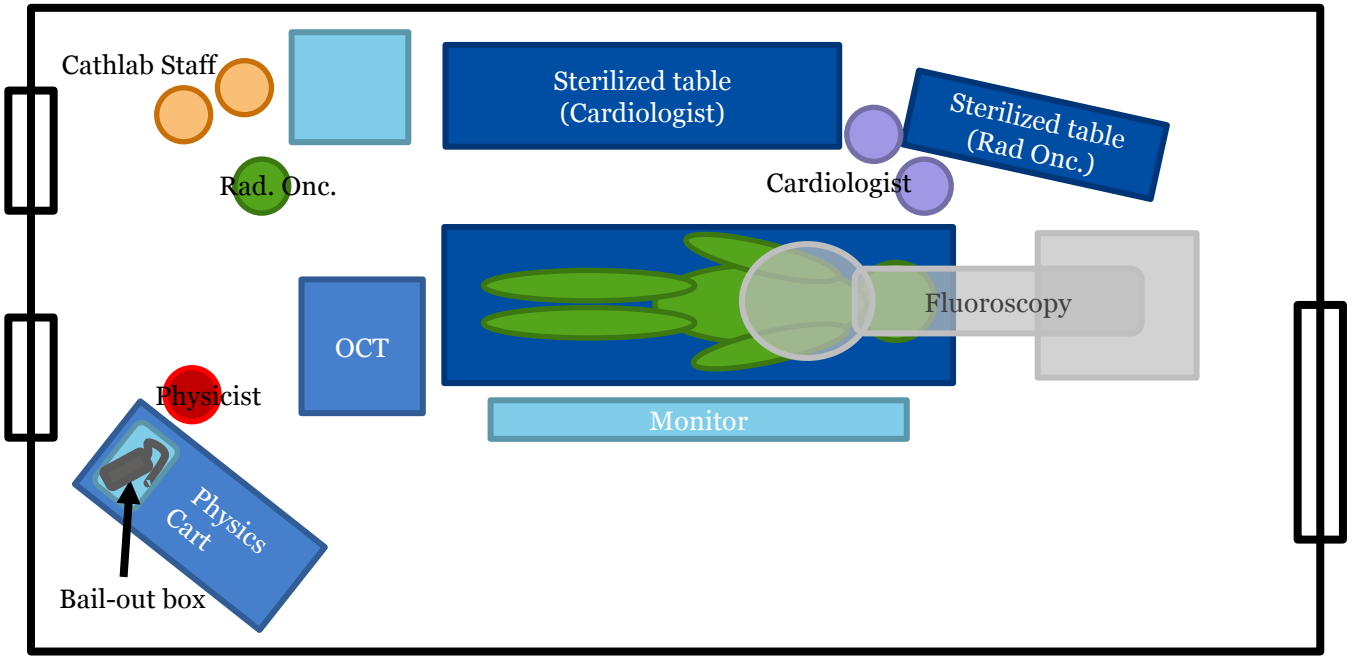
Emergency Procedure



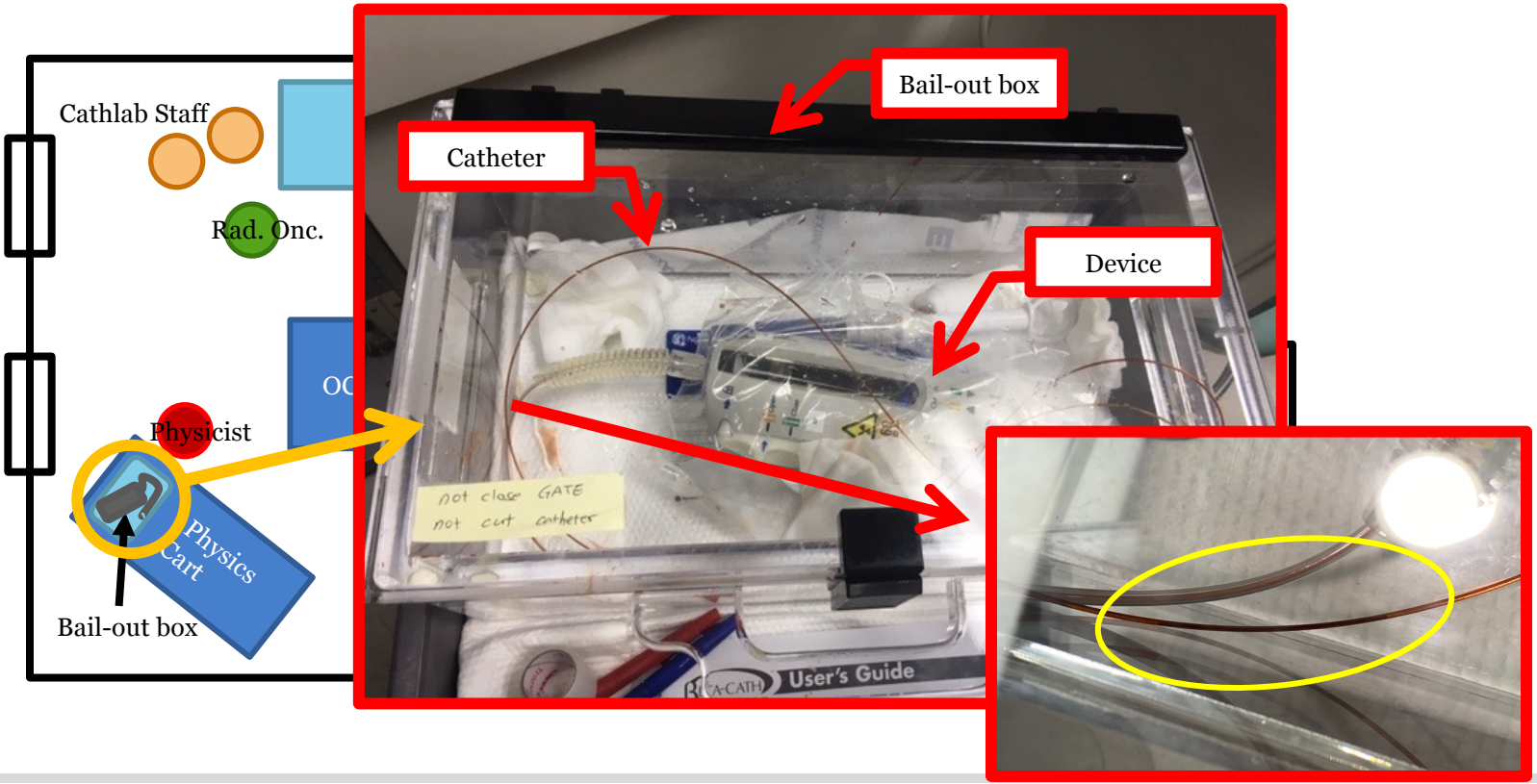
Emergency Procedure



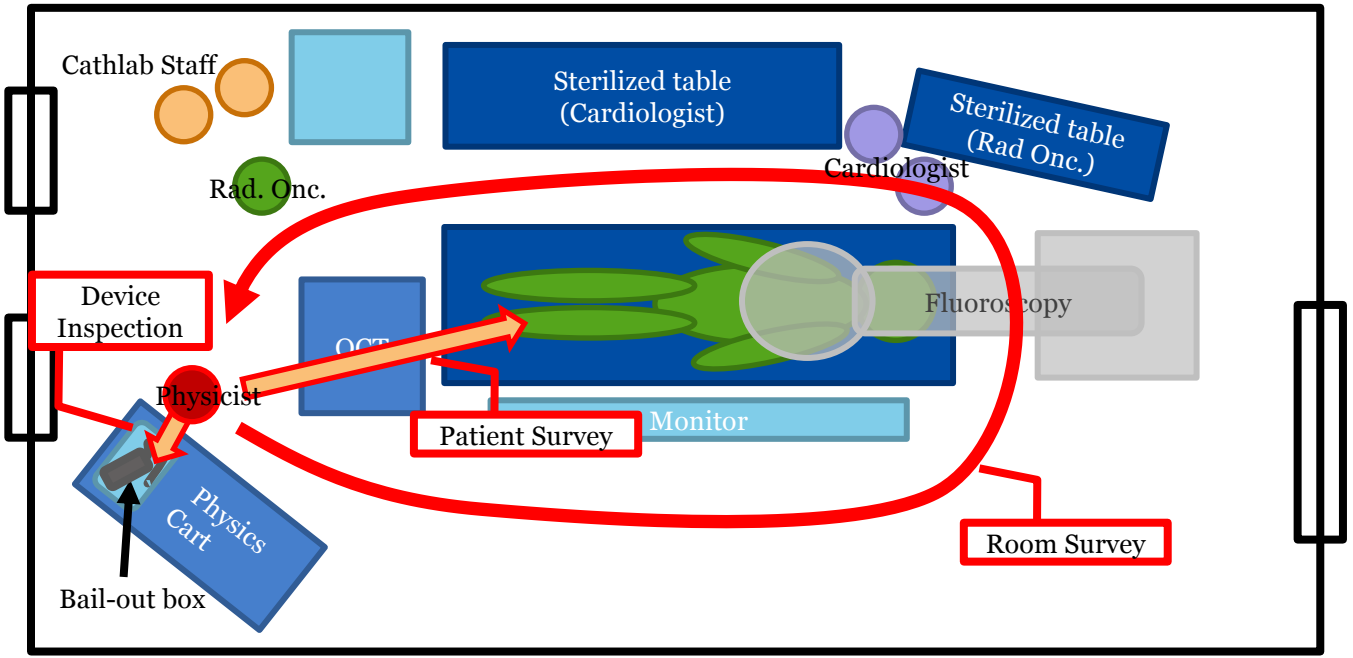
Emergency Procedure



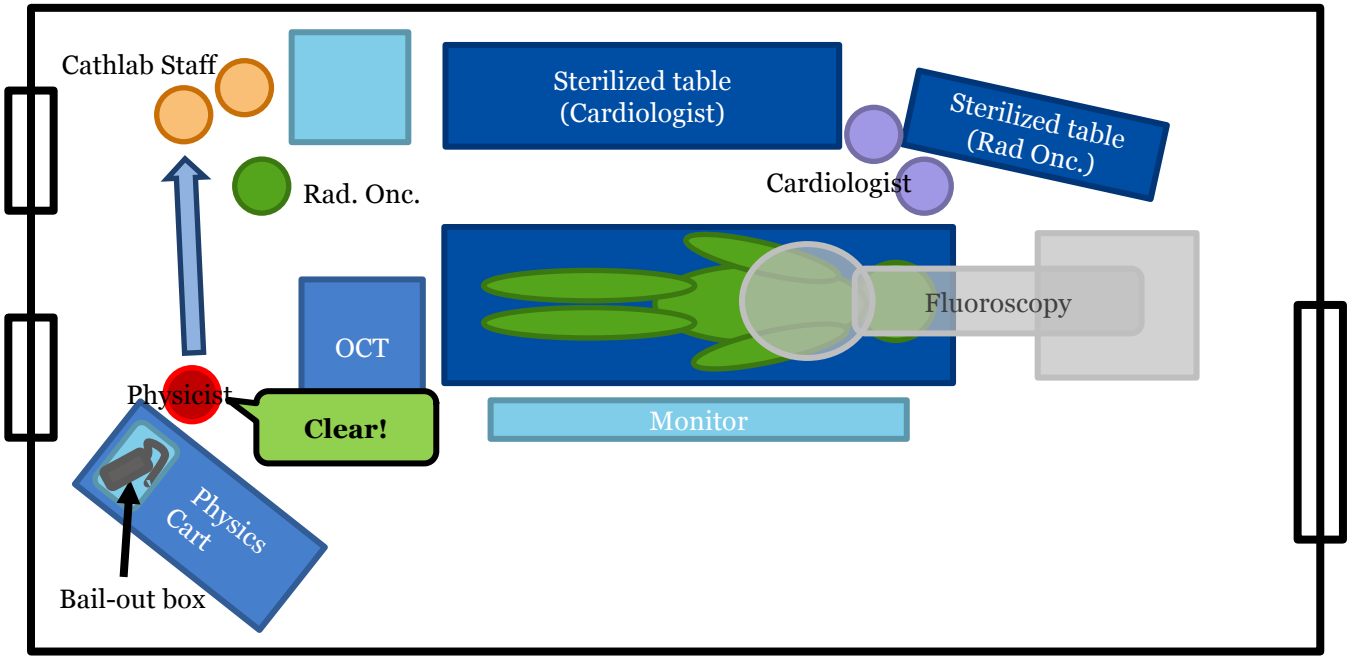
Emergency Procedure



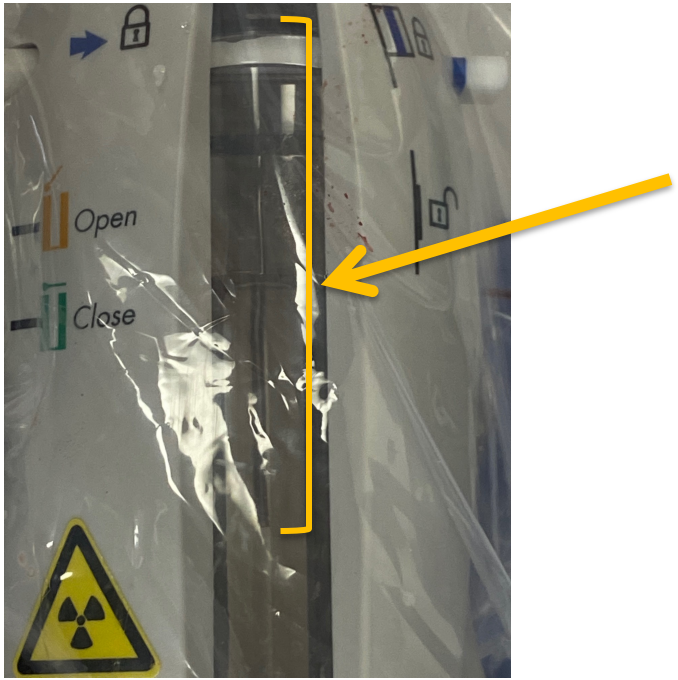
Emergency Procedure - Survey



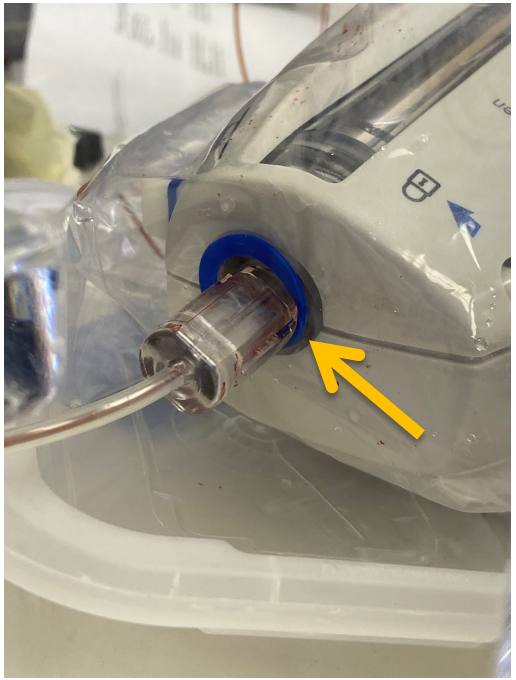
Emergency Procedure - Clear Notification



Emergency Source Recovery - Example



Source train is not moving between transfer device and catheter



Blue ring of sterile-bag wedged in between transfer device and catheter

- Fast dose fall off $^{90}Sr/^{90}Y$ Beta-emitting source has advantage to treat coronary artery with brachytherapy technic
- The hydraulic operating system sending the $^{90}Sr/^{90}Y$ Beta-emitting source to treatment lesion
- $^{90}Sr/^{90}Y$ Beta-emitting source requires less and low-Z shielding

Yale IVBT Team

Medical Physicist

Dae Han

Emily Draeger

Radiation Oncologist

Kenneth Roberts

James Hansen

Radiation Safety Officer

William Hinchcliffe

Intervention Cardiologist

Steven Pfau

Glen A Henry

Dae Han
daeyup.han@yale.edu