Clinical Implementation of Intravascular Brachytherapy

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Disclosure

• None
$^{90}\text{Sr}/^{90}\text{Y Beta-Cath}^\text{TM} 3.5 \text{ F System}$

Delivery Catheter

Transfer Device
Transfer Device

- Catheter Lock
- Gate Control Switch
- Fluid Control Switch
- Power Button
- Proprietary Connector
- Source Chamber
- Source Position Indicator
- Syringe Connector
- Fluid Collection Bag
- Pressure Indicate
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)

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Strontium 90 (Sr-90)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Half-life</td>
<td>28.8 years</td>
</tr>
<tr>
<td>Source Outer Diameter</td>
<td>0.38 mm</td>
</tr>
<tr>
<td>Source Length</td>
<td>2.5 mm</td>
</tr>
<tr>
<td>Source Train Active Length</td>
<td>30 mm, 40 mm, 60 mm</td>
</tr>
<tr>
<td>Radiopaque Markers</td>
<td>Two 2.5 mm radiopaque markers (distal and proximal end)</td>
</tr>
<tr>
<td>Source Train Activity (Maximum)</td>
<td>48 mCi (30 mm JRST)</td>
</tr>
<tr>
<td></td>
<td>64 mCi (40 mm JRST)</td>
</tr>
<tr>
<td></td>
<td>96 mCi (60 mm JRST)</td>
</tr>
<tr>
<td>Source Activity Range</td>
<td>2.7 - 4.0 mCi/source</td>
</tr>
</tbody>
</table>
Delivery Catheter

- Catheter tip
- IST wire (stylet)
- Hub
- Delivery Catheter Tip
- Guide Wire
- Proprietary Connector
Delivery Catheter

Sending Source:

Returning Source:

Inner Lumen for source + water travel

Outer Lumen for water travel

Source

Outer Lumen

Inner Lumen

H₂O
Treatment Set-up

- Sterile table (Cardiologist)
- Sterile table (Rad Onc.)
- OCT/IVUS
- Fluoroscopy
- Monitor
- Bail-out box
- Physics Cart
- Fuji Physicist
- Door

Cathlab Staff
Rad. Onc.
Cardiologist
Treatment

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

Angioplasty (IC)

Treatment Planning (RO, MP, IC)

Room, Patient Survey (MP, RSO)
Device Preparation (RO, MP)

Catheter Preparation & Insertion (IC)
IST Removal (IC)

Send JRST (RO)
Timer Control (MP)
Return JSRT (RO)

Catheter Removal (IC)

Disassemble TD-DC System (MP)

Room, Patient Survey (MP, RSO)

Drying/Storing TD (MP, RSO)

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

- **Angioplasty (IC)**
  - Treatment Planning (RO, MP, IC)
    - Room, Patient Survey (MP, RSO)
    - Device Preparation (RO, MP)
    - Catheter Preparation & Insertion (IC)
    - IST Removal (IC)
  - Send JRST (RO)
  - Timer Control (MP)
  - Return JSRT (RO)
  - Catheter Removal (IC)
  - Disassemble TD-DC System (MP)
  - Room, Patient Survey (MP, RSO)
  - Drying/Storing TD (MP, RSO)
Treatment Workflow

**Angioplasty (IC)**

**Treatment Planning (RO, MP, IC)**

- **Room, Patient Survey (MP, RSO)**
- **Device Preparation (RO, MP)**
- **Catheter Preparation & Insertion (IC)**
- **IST Removal (IC)**

- **Send JRST (RO)**
- **Timer Control (MP)**
- **Return JSRT (RO)**

- **Catheter Removal (IC)**

**Disassemble TD-DC System (MP)**

**Room, Patient Survey (MP, RSO)**

**Drying/Storing TD (MP, RSO)**

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

**IC**
- **Vessel Diameter**
- **Injury Length**

**Dose Source Length**
- **Dwell time**
- **Tx Technic**

**RO, MP**
Treatment Workflow

Angioplasty (IC)

Treatment Planning (RO, MP, IC)

Room, Patient Survey (MP, RSO)
Device Preparation (RO, MP)

Catheter Preparation & Insertion (IC)
IST Removal (IC)

Send JRST (RO)
Timer Control (MP)
Return JSRT (RO)

Catheter Removal (IC)

Disassemble TD-DC System (MP)

Room, Patient Survey (MP, RSO)

Drying/Storing TD (MP, RSO)

Sterile-bag

Fluid Collection Bag

Syringe w/ Sterile water
Treatment Workflow

Angioplasty (IC)

Treatment Planning (RO, MP, IC)

Room, Patient Survey (MP, RSO)
Device Preparation (RO, MP)

Catheter Preparation & Insertion (IC)
IST Removal (IC)

Send JRST (RO)
Timer Control (MP)
Return JSRT (RO)

Catheter Removal (IC)

Disassemble TD-DC System (MP)

Room, Patient Survey (MP, RSO)

Drying/Storing TD (MP, RSO)

Guide Wire

Delivery Catheter

Guide Port

Distal Marker

30, 40, 60 mm Position Marker
Treatment Workflow

- Angioplasty (IC)
- Treatment Planning (RO, MP, IC)
- Catheter Preparation & Insertion (IC)
  - IST Removal (IC)
- Send JRST (RO)
- Timer Control (MP)
- Return JSRT (RO)
- Catheter Removal (IC)
- Disassemble TD-DC System (MP)
- Room, Patient Survey (MP, RSO)
- Drying/Storing TD (MP, RSO)
Treatment Workflow

Angioplasty (IC)

Treatment Planning (RO, MP, IC)

Room, Patient Survey (MP, RSO)
Device Preparation (RO, MP)
Catheter Preparation & Insertion (IC)
IST Removal (IC)
Send JRST (RO)
Timer Control (MP)
Return JSRT (RO)
Catheter Removal (IC)
Disassemble TD-DC System (MP)
Room, Patient Survey (MP, RSO)
Drying/Storing TD (MP, RSO)

Catheter Distal Marker + JRST Distal Marker
JRST Prox. Marker
Treatment Workflow

1. Angioplasty (IC)
2. Room, Patient Survey (MP, RSO)
3. Device Preparation (RO, MP)
4. Treatment Planning (RO, MP, IC)
5. Catheter Preparation & Insertion (IC) IST Removal (IC)
6. Send JRST (RO)
7. Timer Control (MP)
8. Return JSRT (RO)
9. Catheter Removal (IC)
10. Disassemble TD-DC System (MP)
11. Room, Patient Survey (MP, RSO)
12. Drying/Storing TD (MP, RSO)
Clinic Cases - General

Pre/post Tx survey

Treatment Planning
Margin
Clinic Cases – Hot Pull-Back

**Treatment Directive**

**Treatment Lesion Diagram**

- Prox. Margin (mm)
- Injury Length (mm)
- Distal Margin (mm)
- Total Treatment Length (mm)
- Main Vessel

**Prescription Info.**

<table>
<thead>
<tr>
<th>Source Length [mm]</th>
<th>Max. Balloon Diameter [mm]</th>
<th>Ref. Vessel Diameter [mm]</th>
<th>Dose @ 2mm [Gy]</th>
<th>Dwell Time [sec / min / sec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 mm</td>
<td>2.5 ≤ x ≤ 3.5</td>
<td>2.7 ≤ x ≤ 3.35</td>
<td>18.4</td>
<td>278 / 4 / 38</td>
</tr>
<tr>
<td>50 mm</td>
<td>3.5 ≤ x ≤ 4.0</td>
<td>3.5 ≤ x ≤ 4.0</td>
<td>23.0</td>
<td>348 / 5 / 48</td>
</tr>
<tr>
<td>60 mm</td>
<td>4.5 ≤ x ≤ 5.5</td>
<td>4.5 ≤ x ≤ 5.5</td>
<td>23.0</td>
<td>358 / 5 / 58</td>
</tr>
</tbody>
</table>

**Source Info.**

- Length [mm]: Sr-90/Y-90
- Isotope: Sr-90/Y-90
- Activity: 2.18 GBq
- Output [2mm]: 0.068 Gy/sec
- # of Sources (SLG-2): 16
- 3.08 GBq
- 0.064 Gy/sec
- 24

- Treatment Plan:
  - Target Vessel: __________
  - Target length: __________ mm = (Overlapping) mm + (Proximal Margin) mm
  - Total treatment length (single-site): __________ mm

**Source Position**

<table>
<thead>
<tr>
<th>Source Position</th>
<th>Dwell 1</th>
<th>Dwell 2</th>
<th>Dwell 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury L. (multi-site) [mm]</td>
<td>Dist. / Med. / Prox.</td>
<td>Dist. / Med. / Prox.</td>
<td>Dist. / Med. / Prox.</td>
</tr>
<tr>
<td>Ref. Vessel Diameter [mm]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prescribed Dose [Gy @ 2mm]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source Length [mm]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwell Time [sec / min / sec]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Overlap Distance**

- Dwell 1
- Dwell 2

**Relative dose rate - normalized to 1.0 @ 2mm**

- 2mm overlap
- 3mm overlap
- 4mm overlap

**Distance [mm]**

---

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

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.
Emergency Procedure
Emergency Procedure

- Sterilized table (Rad Onc.)
- Sterilized table (Cardiologist)
- Bail-out!
- Bail-out!
- Fluoroscopy
- OCT
- Cathlab Staff
- Rad. Onc.
- Cardiologist
- Physicist
- Bail-out box
- Physics Cart
- Monitor
- Cathlab Staff
- Sterilized table (Rad Onc.)
- Sterilized table (Cardiologist)
- Bail-out!
- Bail-out!
- Fluoroscopy
- OCT
- Cathlab Staff
- Rad. Onc.
- Cardiologist
- Physicist
- Bail-out box
- Physics Cart
- Monitor
Emergency Procedure

Sterilized table (Cardiologist)

Sterilized table (Rad Onc.)

Monitor

OCT

Rad. Onc.

Cardiologist

Cathlab Staff

Fluoroscopy

Physics Cart

Bail-out box

Physicist

ON

ON
Emergency Procedure

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

Sterilized table (Cardiologist)

Sterilized table (Rad Onc.)

Monitor

OCT

Fluoroscopy

Physics Cart

Bail-out box

Rad. Onc.

Physicist

Cardiologist

Cathlab Staff
Emergency Procedure

- Cathlab Staff
- Rad. Onc.
- Physicist
- Bail-out box
- Physics Cart
- Sterilized table (Cardiologist)
- Sterilized table (Rad Onc.)
- Cardiologist
- Physicist
- Rad. Onc.
- Oct
- Fluoroscopy
- Monitor
Emergency Procedure

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

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

- Sterilized table
- Sterilized table
- Monitor OCT
- Fluoroscopy
- Physics Cart
- Cathlab Staff
- Rad. Onc.
- Physicist
- Bail-out box
- Catheter
- Device
- Bail-out box

*not close gate, not cut catheter*
Emergency Procedure - Survey

- Sterilized table (Cardiologist)
- Sterilized table (Rad Onc.)
- Monitor
- OCT
- Fluoroscopy
- Physics Cart
- Device Inspection
- Physicist
- Patient Survey
- Room Survey
- Cathlab Staff
- Rad. Onc.
- Cardiologist
- Bail-out box
- Physicist
- Cathlab Staff
Emergency Procedure - Clear Notification

- Sterilized table (Cardiologist)
- Sterilized table (Rad Onc.)
- Monitor
- OCT
- Fluoroscopy
- Physics Cart
- Clear!
- Physicist
- Cathlab Staff
- Rad. Onc.
- Bail-out box
- Cardiologist
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 $^{90}\text{Sr}/^{90}\text{Y}$ Beta-emitting source has advantage to treat coronary artery with brachytherapy technic

• The hydraulic operating system sending the $^{90}\text{Sr}/^{90}\text{Y}$ Beta-emitting source to treatment lesion

• $^{90}\text{Sr}/^{90}\text{Y}$ Beta-emitting source requires less and low-Z shielding
Yale IVBT Team

Medical Physicist
- Dae Han

Radiation Safety Officer
- Emily Draeger
- William Hinchcliffe

Radiation Oncologist
- Kenneth Roberts

Intervention Cardiologist
- James Hansen
- Steven Pfau
- Glen A Henry