Continuing Education Course MO-A-150A

IVB-1 Intro: Restenosis, Techniques, Radionuclides

Ravinder Nath and Ning Yue
Yale University School of Medicine

RESTENOSIS PROBLEM
Due to Arterial Wall Injury after Angioplasty

Angioplasties in USA……450,000 / year
Restenosis after angioplasty……35 – 40%
Restenosis after stenting…….. 22 – 32%
Direct cost per restenosis……$4 - $7 K
Societal cost per year…….$800 - $2,000 M
Weintraub et al., Circulation, 1995

INTRAVASCULAR BRACHYTHERAPY SYSTEMS UNDER DEVELOPMENT

Catheter-based delivery systems
Radioactive stents
Radioactive liquids in a balloon

SCRIPPS-1 Trial

Teirstein et al New Eng J Med 336,1697-1703(1997)
Teirstein et al Circulation 99,243-247(1999)
Teirstein et al Circulation 101,360-365(2000)

Single –center, prospective, randomized study
In-stent restenosis patients
Patient enrollment in 1995

6- Month Results
TLR: 23% Placebo vs. 17% IVB
Late Thrombosis : 0% in both

3-year results
TLR: 48% Placebo vs. 15% IVB

Gamma-1 Trial

Teirstein et al, Scripps meeting 2000

Multi–center, prospective, randomized study
In-stent restenosis patients

9- Month Results
TLR: 45% Placebo vs. 24% IVB
Late Thrombosis : 1% Placebo vs. 5% IVB

START Trial

Popma et al, ACC meeting 2000

Multi–center, prospective, randomized study
In-stent restenosis patients

8- Month Results
TLR: 22% Placebo vs. 13% IVB
Geometric Miss: 30% of total cases

Dosimetric Requirements for IVB

Target Dose: 14 Gy at a radial distance of 2 mm from the source center
Minimum adventitial dose: 8 Gy
Treatment time : 3-10 min.
Maximum Dose to lumen wall: 30 Gy

Rationale of Dosimetry Evaluation

Understanding failures of IVB
Understanding complications of IVB
Comparing different clinical systems
Implementing IVB programs in the wider cardiology community
Improving and extending the clinical uses of IVB

Depth Dose Comparison

Ravinder Nath, Ning Yue and Lizhong Liu
Yale University
Cardio. Radiat. Med. 1,72-79(1999)

	Ir-192	Sr-90	P-32
Lumen wall	23	53	67
1 mm depth	12	16	27
2 mm depth	8	8	8
3 mm depth	6	3	2

30 mm long linear source
14 Gy at 2 mm
3 mm dia. vessel

Dose Gradient in the Radial Direction: Centering Issues

Ning Yue and Ravinder Nath
Yale University

In preparation for Cardio. Radiat. Med. (2001)

Gamma vs. beta
Vessel diameter
Photon energy
Beta energy
Delivery system

Ir-192 Versus P-32
Centered in the lumen
14 Gy at 2 mm

	Ir-192	P-32
Luminal Wall	9-14	14-47
1 mm depth	9-14	5-14
2 mm depth	6-9	1-5

Ir-192 versus P-32
Non-centered in the lumen
14 Gy at 2 mm

	Ir-192	P-32
Luminal wall	14-62	8-116
1 mm depth	7-19	3-25
2 mm depth	6-11	1-8

Conclusions

Ir-192 provides lesser dose variation in the target volume than P-32, especially for a non-centered delivery system using linear sources. This effect is even larger for larger vessels.

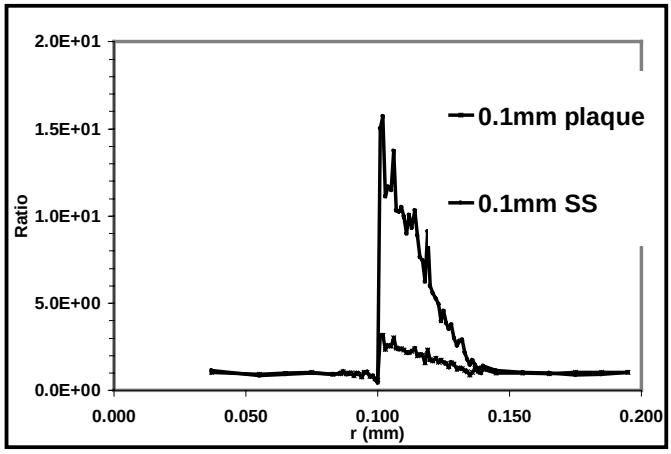
Dose Perturbations by High Atomic Number Materials in Intravascular Brachytherapy

Ravinder Nath, Ning Yue
and Judah Weinberger

Cardio. Radiat. Med. 1,144-153(1999)

Photoelectric Effect

- varies as Z^3/E^3
- Photoelectron production is higher in high Z
- Photoelectrons have a finite range in tissue



Conclusions

In intravascular brachytherapy using photons, the presence of high atomic number materials could introduces significant dose enhancement at the interface.

Dose enhancement is energy dependent. It peaks at 60 keV reaching a maximum value of about 20.

The dose enhancement decreases exponentially and is less than a factor of 2 beyond a distance of about 70 µm.

The maximum enhancement observed for 60 keV photons persists over a distance of less than 30 µm.

Shielding Effects of Metallic Encapsulations and Radiographic Contrast agents for Catheter-based Intravascular Brachytherapy

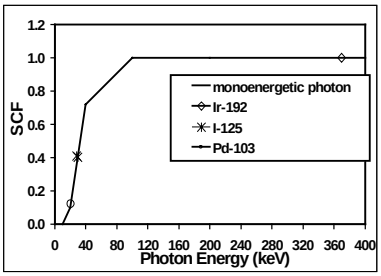
Ravinder Nath and Ning Yue
Yale University

Cardio. Radiat. Med. 2,93-103(2001)

Shielding Correction Factor, SCF

Photon energy
Atomic number
Density
Shape
Size

SCF vs. Photon Energy



Reduction of penetration depth

Shielding of ^{32}P Betas by Hypaque

Atomic number
Density
Size
Shape

Conclusions

Metallic encapsulation of IVB sources attenuates significantly the dose output. Therefore, each design of an encapsulated source must be individually calibrated.

For betas, the high Z materials reduce the depth of penetrations. A linear correction on the penetration depth is needed to account for the shielding effects of stents, guide wires, contrast agents and calcifications.