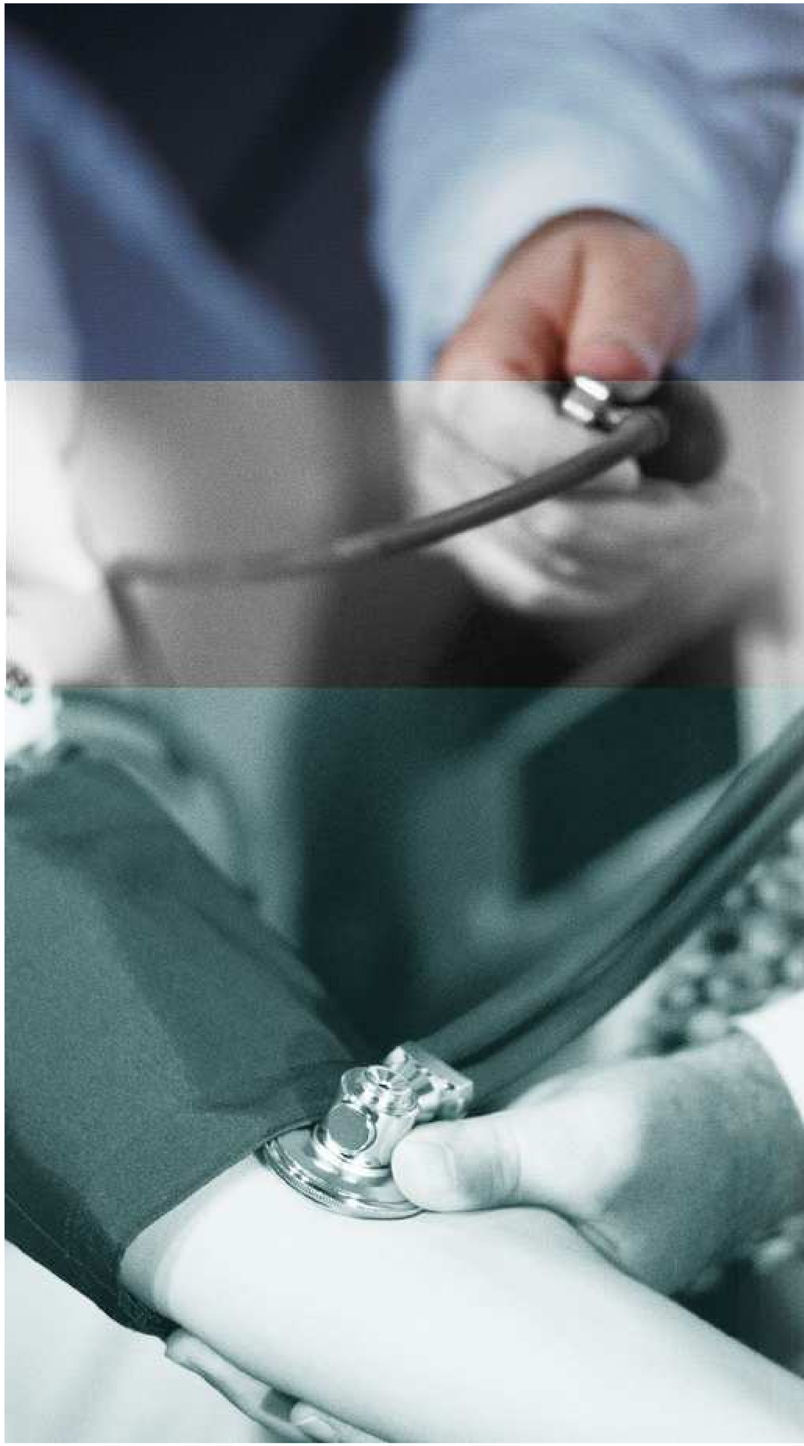

Absorbed Dose Assessment of Cardiac And Other Tissues Around The Cardiovascular In Brachytherapy With $^{90}Sr/^{90}Y$ Source By Monte Carlo Simulation

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LOGO

Introduction

The Cardiovascular Diseases

- They are the first causes of death in all over the world.
- One of the most common of these diseases is the cardiovascular stenosis.
- One of the used treatment methods for cardiovascular stenosis is angioplasty.
- The cardiovascular restenosis occurs in 30-50% of cases. Therefore in order to do an assured treatment for that, it is used of angioplasty with brachytherapy.

Introduction

Intravascular brachytherapy (IVBT) is a method in which a stent covered with a radioactive material is sent into the vessel or a train of radioactive coated seeds is embedded inside the under treatment vessel.

Some radioactive sources are used such as ^{192}Ir, ^{103}Pd, ^{32}P, ^{90}Sr/^{90}Y, … in IVBT.

Although IVBT sounds a promising method for the treatment of restenosis, its radiobiological effects haven't still known precisely for us.

In this radiotherapy method, in addition of the vessel walls the cardiac and other tissues placed near the vessel are irradiated.

Our purpose of this research is an assessment of the absorbed dose in cardiovascular and surrounding tissues in cardiovascular brachytherapy.

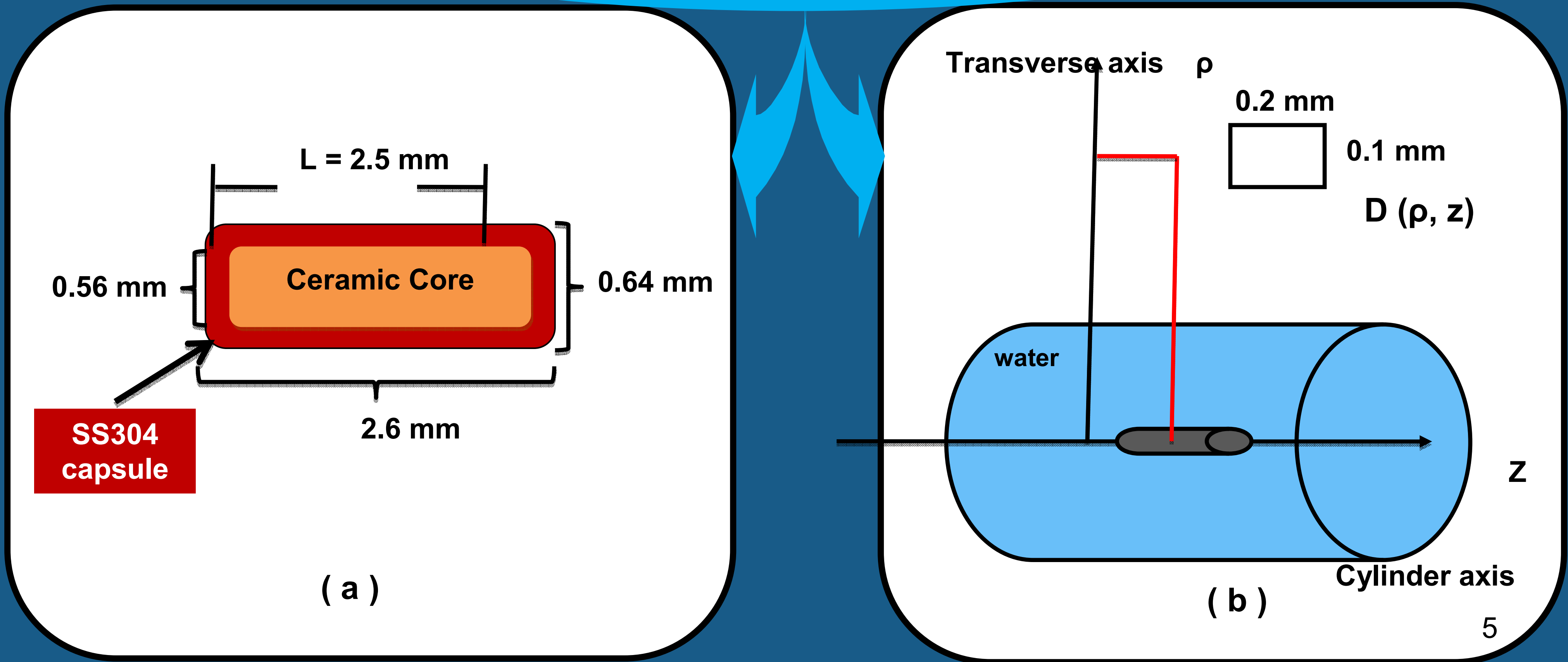
Materials and Methods

- The simulation was done by a Monte Carlo method for a 5F $^{90}Sr/^{90}Y$ single seed source with an activity of about 3.5 mCi per seed.
- $^{90}Sr/^{90}Y$ is a pure beta emitting source
  - ^{90}Sr (the parent) → E_{max} = 546 keV
  - ^{90}Y (the daughter): E_{max} = 2.28 MeV, E_{ave} = 935 keV
- ^{90}Sr and ^{90}Y have a half life of 28.8 year and 64 hour, respectively. The beta spectrum of ^{90}Y was used in the simulation.
- The seed composed of a ceramic core with a density of 2.6 g/cm^3 which is covered by a stainless steel 304 capsule with a density of 8 g/cm^3 . The cardiovascular and surrounding tissues were simulated with a cylindrical water phantom with a density of 1 g/cm^3 .
- All possible interactions between electrons and the medium including excitation, ionization, and Bremesstrahlung radiation were considered.
- Since cardiovascular has a cylindrical symmetry, the simulation was performed in cylindrical coordinate and calculations were done in this system.

Materials and Methods

Fig.1

A schematic view of (a) the 5F $^{90}Sr/^{90}Y$ single seed source used in IVBT, (b) the seed source and phantom, the point of interest, and the scoring voxel in cylindrical coordinate.



Materials and Methods

- An energy deposition tally was used in this simulation.

- The dosimetry parameters such as the dose rate and transverse (radial) dose function were calculated through the suggested formulas by AAPM Task Group No.149 as in the following :

$$g_L(\rho) = \frac{\dot{D}(\rho, z_0)}{\dot{D}(\rho_0, z_0)} \frac{G_L(\rho_0, z_0)}{G_L(\rho, z_0)}$$

Where $g_L(\rho)$ is the transverse dose function and $\dot{D}(\rho_0, z_0)$ is the absorbed dose rate at the reference point (ρ = 2mm, z = 0 in cylindrical coordinate). The origin was adopted at the center of the seed.

The G(ρ, z) is the Geometry function defined by:

$$G(\rho, z) = \frac{1}{\rho}$$

Results

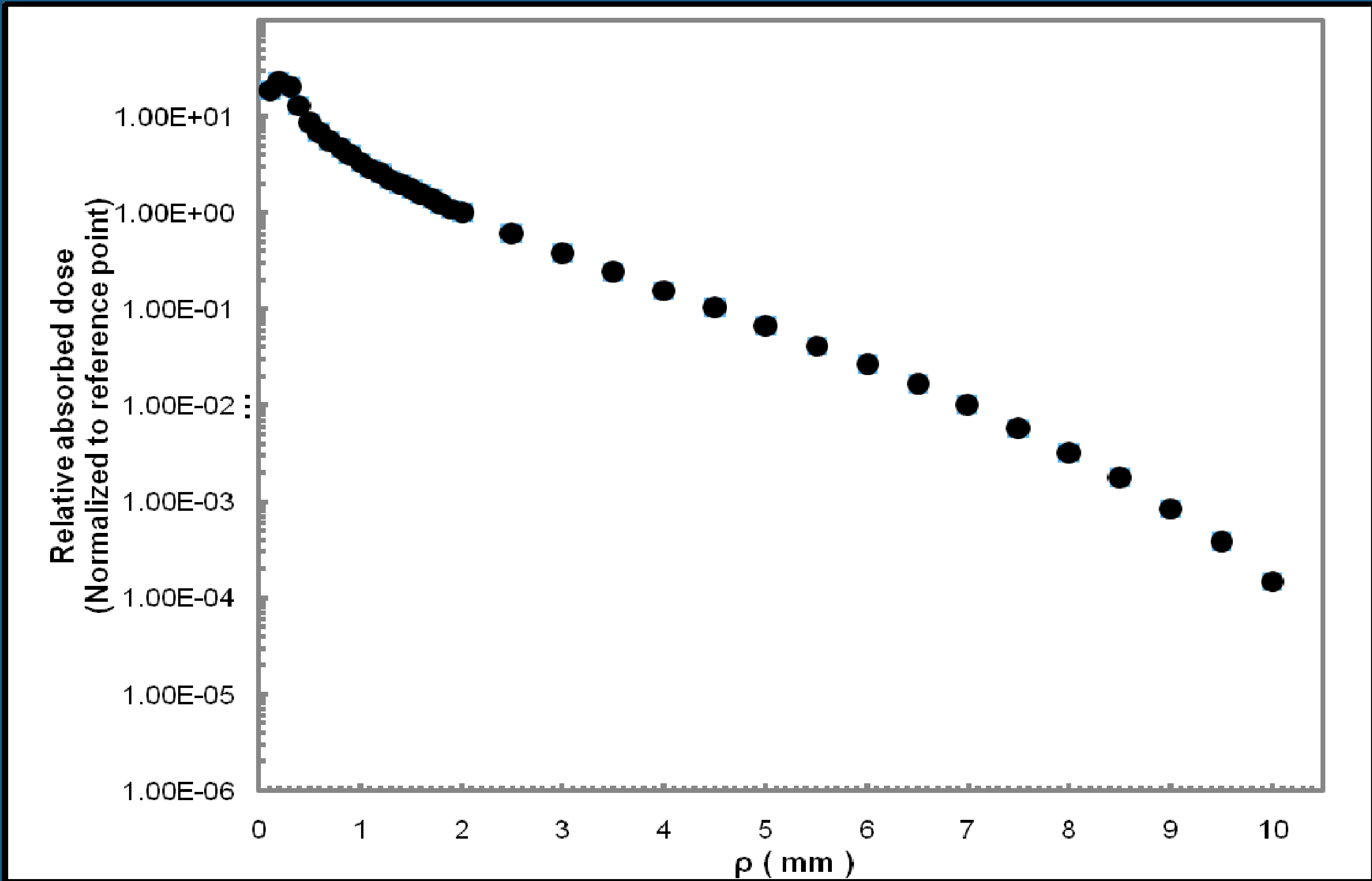


Fig. 2
The relative transverse (radial) dose distribution ($D(\rho,z_0)$, calculated for a $^{90}Sr/^{90}Y$ seed source at $z_0 = 0$)

Results

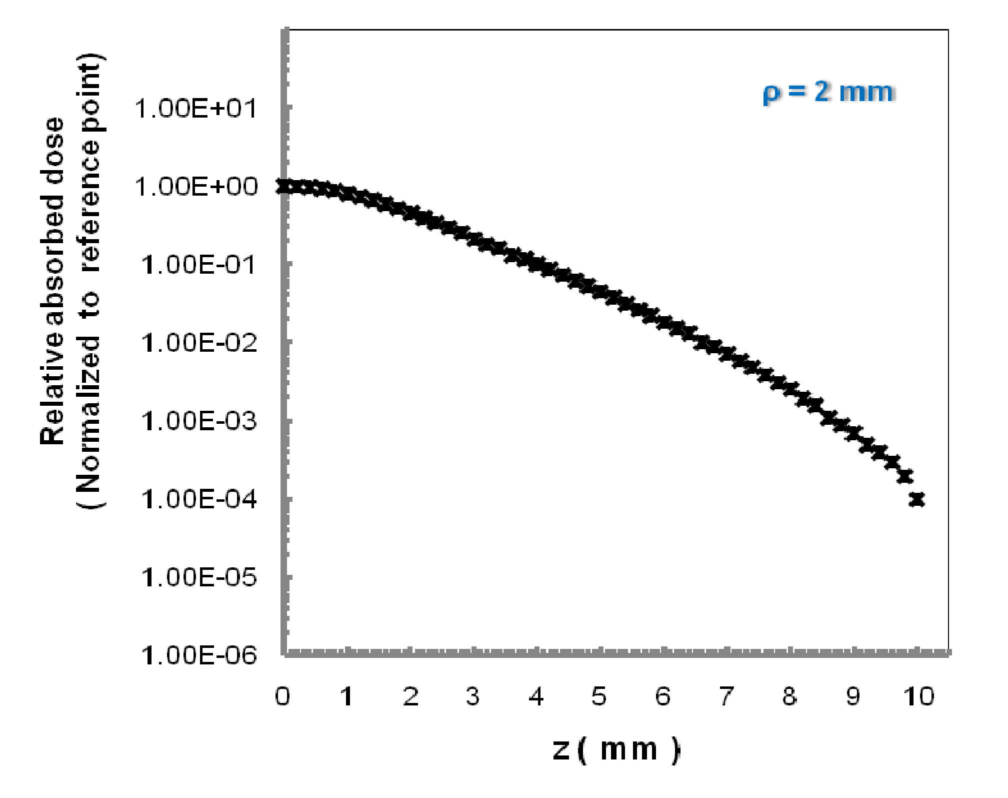


Fig. 3
The relative axial dose distribution, D(ρ_0,z), Calculated at ρ = 2 mm for a $^{90}Sr/^{90}Y$ seed source

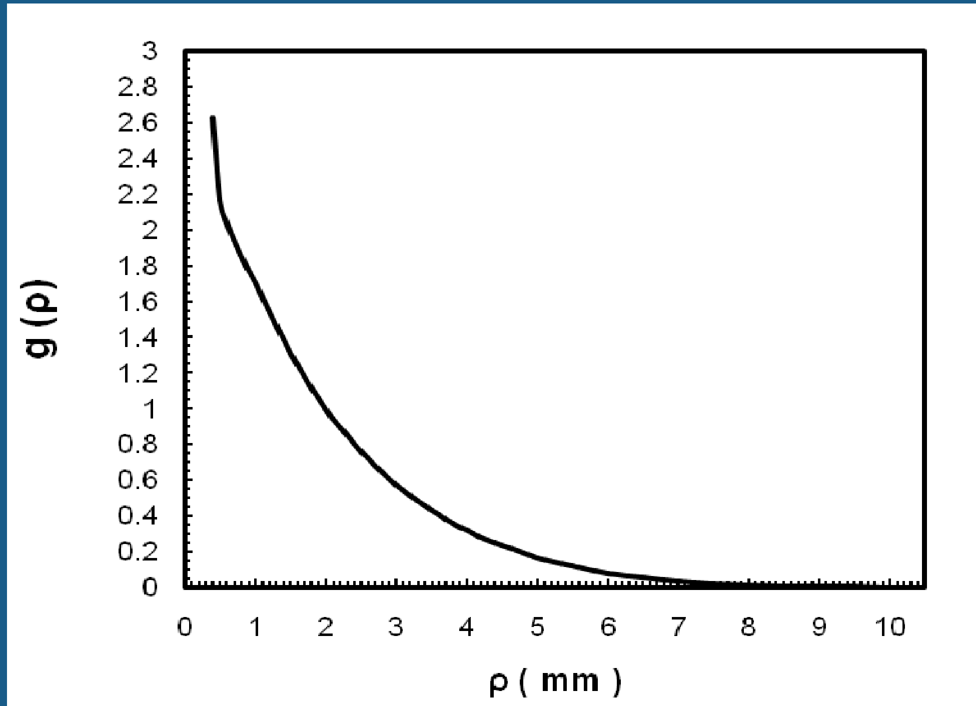


Fig. 4
The transverse (radial) dose function g(ρ) for a $^{90}Sr/^{90}Y$ seed source

Conclusions

1

Our results (Fig. 2) showed that the relative absorbed dose at $z = 0$ and depths of 0.5 –10 mm varied from 8.67 to 0.00015. By multiplying these values by the dose rate value at reference point, 1.136 (Gy/(min.mCi)), absolute dose rates varied from 9.849 to 0.00017 (Gy/(min.mCi)) along the transverse axis.

2

As shown in Fig. 3 , the relative axial dose distribution varied from 1 to 0.0001 at $\rho = 2$ mm and in the range of 0-10 mm along the cylinder axis. So absolute values were obtained 1.136 to 1.136×10^{-4} (Gy/(min.mCi)). It can be found that the relative axial dose is almost uniform up to $z < L/2$ and then approximately falls off exponentially.

3

These dosimetry results were compared with experimental data and other simulations. There was a good agreement between them so that the errors were less than 5% in most of calculated regions.

Conclusions

In the ICRP103 report, tissue weighting factors have increased for some tissues like breast and lymph nodes.

The Effective Equivalent Dose (EED) is defined by:
$W_R \times W_T \times D(\rho, z)$

The standard EED for public is 1 mSv/yr (1 μSv/hr).

In the maximum radial distance means, 10 mm, the obtained effective equivalent dose was 4.282 mSv/hr. It is clear that this value is much more than the dose limit value.
The total accmulated dose was obtained 395.5 mSv.

Therefore, If the artery vessel is in the vicinity of some radiosensitive tissues such as breast and lymph nodes, it may raise the risk of cancer in these tissues.