

# A Model of the Prostate Gland for Use in Internal Dosimetry

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Several radionuclides or radiolabeled pharmaceuticals may be taken up by the prostate gland. **Methods:** A model of the prostate gland has been developed and implemented in the adult male mathematical phantom within software which calculates absorbed fractions of energy from activity in source regions within the phantom. **Results:** Specific absorbed fractions are reported for all target regions within the phantom for 12 discrete source energies from 0.01 to 4.0 MeV. S-values for all target regions for six radionuclides are also reported. **Conclusions:** This work provides another organ useful for internal dose calculations within the 70-kg phantom.

**Key Words:** prostate gland; internal dosimetry; S-values

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Several radionuclides or radiolabeled pharmaceuticals may be taken up by the prostate gland. Examples include  $^3\text{H}$ -labeled to 5- $\alpha$ -dihydrotestosterone (1),  $^{65}\text{Zn}$  (2) and  $^{111}\text{In}$ - and  $^{99\text{m}}\text{Tc}$ -labeled monoclonal antibodies against prostatic acid phosphatase (3,4). Other radionuclides have shown uptake in the prostate gland of beagle dogs, including  $^{95}\text{Nb}$  (5) and  $^{144}\text{Ce}$  (6). A model of the prostate gland has been developed and implemented in the adult male phantom (7) used in the MIRDOSE software (8) so that the radiation dose to the prostate gland and to surrounding organs from prostate gland uptake of radionuclides can be more accurately evaluated.

## MODEL DESCRIPTION

The mass of the prostate gland is approximately 16 g (9). In Morris' Human Anatomy (10), the prostate gland is shown as a small sphere or flattened ellipsoid located directly below and in contact with the urinary bladder. In the adult male phantom, the equation for the exterior surface of the urinary bladder is (7):

$$\left[ \frac{x}{4.958} \right]^2 + \left[ \frac{y + 4.50}{3.458} \right]^2 + \left[ \frac{z - 8.00}{3.458} \right]^2 \leq 1,$$

where  $x$  is the distance from the midpoint of the phantom toward the phantom's left,  $y$  is the distance from the midpoint of the phantom towards the back of the phantom, and  $z$  is the distance from the midpoint of the phantom directed upward (all units are cm). The midpoint of the phantom is at the center of the base of the trunk of the phantom (7). The model of the prostate gland employed here (Fig. 1) is described by the following equation:

$$\left[ \frac{x}{1.54} \right]^2 + \left[ \frac{y + 4.50}{1.54} \right]^2 + \left[ \frac{z - 2.93}{1.54} \right]^2 \leq 1.$$

This equation describes a sphere with a radius of 1.54 cm which is under the urinary bladder, with its upper surface in contact with the lower surface of the bladder and centered at (0, -4.5, 2.93). Although a left and a right lobe may be identified (10), separate modeling of the two lobes of the prostate gland was not done for this model. In normal states, the organ is symmetrical and radionuclide uptake will probably be uniform. If one lobe of the gland is enlarged, specific modeling of the location and degree of enlargement will be necessary. This work could be extended to cover such situations. The gland is assumed to be uniformly composed of "soft tissue" (7). The volume of the gland model is 15.3 cm<sup>3</sup> and its mass is 16 g.

## CALCULATIONS

This source region was incorporated into the ALGAMP software (11) which is used to develop specific absorbed fractions (SAFs) of energy for source and target regions within heterogeneous phantoms (7) based on Reference Man (9). For 12 discrete energies, 100,000 photons were started within the prostate as the source organ and followed through their interactions in the phantom. When very few interactions were recorded in individual target regions from the Monte Carlo histories, another source code (12) was used to estimate the SAFs by the point-source kernel method. Both codes report a coefficient of variation (COV) with their estimates of each SAF. Any Monte Carlo result for which the COV was greater than 30% was rejected as unreliable. The point-source kernel estimates were used when the Monte Carlo estimate was rejected unless the COV for the point-source kernel method was greater than 30% in which case the estimated

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**TABLE 1**  
Specific Absorbed Fractions of Energy for a Source in the Prostate Gland of the Adult Male (kg<sup>-1</sup>)\*

Target organ	Photon energy (MeV)					
	0.010	0.015	0.020	0.030	0.050	0.100
Adrenals	0.00E + 00 (0.00)	0.00E + 00 (0.00)	2.50E - 13 (0.60)	2.61E - 07 (0.47)	3.02E - 05 (0.45)	1.40E - 04 (0.44)
Brain	0.00E + 00 (0.00)	0.00E + 00 (0.00)	0.00E + 00 (0.00)	2.19E - 14 (0.33)	1.19E - 09 (0.31)	4.80E - 08 (0.30)
Gall bladder wall	0.00E + 00 (0.00)	0.00E + 00 (0.00)	6.36E - 10 (0.78)	1.07E - 05 (0.56)	2.72E - 04 (0.49)	6.66E - 04 (0.46)
Gall bladder contents	0.00E + 00 (0.00)	0.00E + 00 (0.00)	5.57E - 10 (0.70)	1.08E - 05 (0.52)	2.81E - 04 (0.47)	6.89E - 04 (0.45)
LLI wall	2.27E - 06 (3.49)	4.29E - 03 (2.19)	3.25E - 02 (1.27)	6.85E - 02 (0.83)	4.52E - 02 (0.66)	2.50E - 02 (0.61)
LLI contents	5.51E - 08 (2.58)	1.11E - 03 (2.37)	1.40E - 02 (1.38)	3.71E - 02 (0.96)	2.78E - 02 (0.74)	1.67E - 02 (0.66)
Small intestine	0.00E + 00 (0.00)	2.48E - 11 (1.90)	1.70E - 06 (1.03)	4.86E - 04 (0.64)	2.63E - 03 (0.51)	3.31E - 03 (0.46)
Stomach wall	0.00E + 00 (0.00)	0.00E + 00 (0.00)	1.80E - 10 (1.21)	4.10E - 06 (0.76)	1.35E - 04 (0.58)	3.84E - 04 (0.52)
Stomach contents	0.00E + 00 (0.00)	0.00E + 00 (0.00)	8.88E - 11 (1.21)	3.17E - 06 (0.70)	1.21E - 04 (0.55)	3.64E - 04 (0.49)
ULI wall	0.00E + 00 (0.00)	5.10E - 11 (1.82)	1.61E - 06 (1.26)	3.55E - 04 (0.85)	1.97E - 03 (0.59)	2.61E - 03 (0.51)
ULI contents	0.00E + 00 (0.00)	3.26E - 11 (2.01)	1.45E - 06 (1.27)	3.48E - 04 (0.82)	1.96E - 03 (0.59)	2.61E - 03 (0.51)
Heart wall	0.00E + 00 (0.00)	0.00E + 00 (0.00)	1.46E - 15 (1.34)	2.33E - 08 (0.59)	6.46E - 06 (0.50)	4.49E - 05 (0.47)
Heart contents	0.00E + 00 (0.00)	0.00E + 00 (0.00)	1.49E - 16 (2.52)	1.39E - 08 (0.58)	4.82E - 06 (0.49)	3.66E - 05 (0.46)
Kidneys	0.00E + 00 (0.00)	0.00E + 00 (0.00)	7.98E - 11 (0.93)	3.53E - 06 (0.59)	1.37E - 04 (0.50)	4.07E - 04 (0.47)
Liver	0.00E + 00 (0.00)	0.00E + 00 (0.00)	3.90E - 11 (1.62)	1.64E - 06 (0.87)	7.43E - 05 (0.61)	2.49E - 04 (0.53)
Lungs	0.00E + 00 (0.00)	0.00E + 00 (0.00)	9.81E - 16 (2.09)	2.02E - 08 (0.79)	4.17E - 06 (0.63)	2.58E - 05 (0.56)
Spleen	0.00E + 00 (0.00)	0.00E + 00 (0.00)	2.91E - 12 (1.00)	6.77E - 07 (0.61)	5.00E - 05 (0.50)	1.97E - 04 (0.47)
Pancreas	0.00E + 00 (0.00)	0.00E + 00 (0.00)	4.01E - 12 (0.89)	8.84E - 07 (0.55)	6.14E - 05 (0.48)	2.32E - 04 (0.45)
Prostate	5.60E + 01 (0.13)	4.19E + 01 (0.21)	2.67E + 01 (0.31)	1.08E + 01 (0.45)	3.35E + 00 (0.57)	1.80E + 00 (0.66)
Bone surfaces	0.00E + 00 (0.00)	2.71E - 08 (2.65)	3.20E - 05 (2.21)	1.50E - 03 (1.05)	5.37E - 03 (0.67)	4.71E - 03 (0.60)
Red marrow	0.00E + 00 (0.00)	9.08E - 09 (1.54)	2.35E - 05 (1.85)	9.04E - 04 (0.96)	3.11E - 03 (0.70)	4.14E - 03 (0.63)
Skin	0.00E + 00 (0.00)	6.92E - 05 (4.39)	7.98E - 04 (2.27)	2.63E - 03 (1.30)	2.86E - 03 (0.95)	2.20E - 03 (0.88)
Thyroid	0.00E + 00 (0.00)	0.00E + 00 (0.00)	0.00E + 00 (0.00)	3.81E - 12 (0.30)	3.43E - 08 (0.30)	1.00E - 06 (0.29)
Thymus	0.00E + 00 (0.00)	0.00E + 00 (0.00)	0.00E + 00 (0.00)	9.40E - 10 (0.32)	9.60E - 07 (0.30)	1.14E - 05 (0.30)
Testes	7.31E - 09 (3.68)	1.56E - 03 (1.36)	3.60E - 02 (0.73)	1.24E - 01 (0.51)	8.74E - 02 (0.45)	4.66E - 02 (0.44)
Urinary bladder wall	3.35E - 02 (0.74)	2.04E - 01 (1.86)	3.44E - 01 (1.30)	3.52E - 01 (0.89)	1.60E - 01 (0.70)	7.78E - 02 (0.71)
Urinary bladder contents	1.99E - 03 (1.04)	5.73E - 02 (1.76)	1.94E - 01 (0.97)	2.88E - 01 (0.60)	1.51E - 01 (0.49)	7.45E - 02 (0.49)
Whole body	1.36E - 02 (0.07)	1.36E - 02 (0.04)	1.35E - 02 (0.05)	1.26E - 02 (0.08)	9.69E - 03 (0.16)	7.01E - 03 (0.22)

	0.200	0.500	1.000	1.500	2.000	4.000
Adrenals	2.48E - 04 (0.43)	3.80E - 04 (0.43)	4.61E - 04 (0.43)	4.99E - 04 <sup>†</sup>	5.27E - 04 (0.43)	5.05E - 04 (0.43)
Brain	2.94E - 07 (0.30)	1.69E - 06 (0.30)	5.53E - 06 (0.29)	9.91E - 06 <sup>†</sup>	1.50E - 05 (0.29)	2.88E - 05 (0.29)
Gall bladder wall	9.00E - 04 (0.46)	1.12E - 03 (0.45)	1.20E - 03 (0.45)	1.22E - 03 <sup>†</sup>	1.23E - 03 (0.45)	1.10E - 03 (0.44)
Gall bladder contents	9.28E - 04 (0.45)	1.16E - 03 (0.44)	1.23E - 03 (0.44)	1.25E - 03 <sup>†</sup>	1.26E - 03 (0.44)	1.12E - 03 (0.44)
LLI wall	2.41E - 02 (0.64)	2.64E - 02 (0.68)	2.54E - 02 (0.70)	2.64E - 02 (0.70)	2.33E - 02 (0.71)	1.91E - 02 (0.71)
LLI contents	1.61E - 02 (0.68)	1.74E - 02 (0.71)	1.68E - 02 (0.73)	1.81E - 02 (0.73)	1.54E - 02 (0.73)	1.27E - 02 (0.73)
Small intestine	3.53E - 03 (0.46)	3.80E - 03 (0.45)	3.71E - 03 (0.45)	3.95E - 03 (0.46)	3.53E - 03 (0.45)	2.98E - 03 (0.45)
Stomach wall	5.59E - 04 (0.49)	7.41E - 04 (0.48)	8.23E - 04 (0.47)	9.03E - 04 (0.47)	8.75E - 04 (0.46)	7.99E - 04 (0.46)
Stomach contents	5.38E - 04 (0.48)	7.20E - 04 (0.47)	8.04E - 04 (0.46)	8.53E - 04 (0.46)	8.58E - 04 (0.45)	7.85E - 04 (0.45)
ULI wall	2.86E - 03 (0.49)	3.14E - 03 (0.48)	3.10E - 03 (0.48)	2.78E - 03 (0.48)	2.97E - 03 (0.48)	2.52E - 03 (0.47)
ULI contents	2.86E - 03 (0.49)	3.13E - 03 (0.48)	3.10E - 03 (0.48)	3.25E - 03 (0.48)	2.97E - 03 (0.47)	2.52E - 03 (0.47)
Heart wall	9.61E - 05 (0.46)	1.74E - 04 (0.45)	2.35E - 04 (0.45)	1.99E - 04 (0.45)	2.94E - 04 (0.45)	3.01E - 04 (0.44)
Heart contents	8.16E - 05 (0.46)	1.53E - 04 (0.45)	2.11E - 04 (0.44)	2.09E - 04 (0.44)	2.69E - 04 (0.44)	2.79E - 04 (0.44)
Kidneys	5.95E - 04 (0.46)	7.87E - 04 (0.45)	8.72E - 04 (0.45)	8.31E - 04 (0.45)	9.25E - 04 (0.45)	8.41E - 04 (0.44)
Liver	3.88E - 04 (0.50)	5.44E - 04 (0.48)	6.26E - 04 (0.47)	6.75E - 04 (0.47)	6.87E - 04 (0.46)	6.41E - 04 (0.46)
Lungs	5.90E - 05 (0.53)	1.14E - 04 (0.50)	1.63E - 04 (0.48)	1.72E - 04 (0.48)	2.14E - 04 (0.47)	2.27E - 04 (0.46)
Spleen	3.25E - 04 (0.46)	4.73E - 04 (0.45)	5.56E - 04 (0.45)	6.71E - 04 (0.45)	6.20E - 04 (0.45)	5.85E - 04 (0.44)
Pancreas	3.74E - 04 (0.45)	5.34E - 04 (0.44)	6.20E - 04 (0.44)	6.87E - 04 (0.44)	6.83E - 04 (0.44)	6.38E - 04 (0.44)
Prostate	2.02E + 00 (0.74)	2.28E + 00 (0.83)	2.18E + 00 (0.90)	2.03E + 00 (0.95)	1.85E + 00 (0.98)	1.48E + 00 (1.06)
Bone surfaces	3.06E - 03 (0.61)	2.38E - 03 (0.67)	2.16E - 03 (0.69)	2.02E - 03 (0.70)	1.90E - 03 (0.70)	1.63E - 03 (0.70)
Red marrow	3.56E - 03 (0.64)	3.05E - 03 (0.66)	2.77E - 03 (0.66)	2.73E - 03 (0.67)	2.42E - 03 (0.66)	2.05E - 03 (0.66)
Skin	2.25E - 03 (0.93)	2.37E - 03 (1.01)	2.31E - 03 (1.05)	2.71E - 03 (1.06)	2.17E - 03 (1.06)	1.83E - 03 (1.07)
Thyroid	4.33E - 06 (0.29)	1.51E - 05 (0.29)	3.12E - 05 (0.29)	4.38E - 05 <sup>†</sup>	5.57E - 05 (0.29)	7.34E - 05 (0.29)
Thymus	3.15E - 05 (0.29)	7.16E - 05 (0.29)	1.12E - 04 (0.29)	1.37E - 04 <sup>†</sup>	1.58E - 04 (0.29)	1.76E - 04 (0.29)
Testes	4.44E - 02 (0.45)	4.87E - 02 (0.46)	4.71E - 02 (0.46)	5.56E - 02 (0.46)	4.33E - 02 (0.46)	3.54E - 02 (0.46)
Urinary bladder wall	7.81E - 02 (0.81)	8.95E - 02 (0.90)	8.69E - 02 (0.94)	9.53E - 02 (0.95)	7.98E - 02 (0.96)	6.50E - 02 (0.97)
Urinary bladder contents	7.29E - 02 (0.53)	8.16E - 02 (0.57)	7.86E - 02 (0.60)	8.25E - 02 (0.60)	7.18E - 02 (0.61)	5.86E - 02 (0.62)
Whole body	6.44E - 03 (0.22)	6.29E - 03 (0.24)	5.88E - 03 (0.28)	5.45E - 03 (0.31)	5.11E - 03 (0.33)	4.29E - 03 (0.39)

\*Values in parentheses are the coefficients of variation for the listed specific absorbed fraction.

<sup>†</sup>SAF interpolated from values at other energies.

SAF was set to zero. If both the Monte Carlo and the point-source kernel methods had coefficients of variation less than 30%, the estimates were combined and weighted inversely according to their variances after the point-source kernel values were corrected as described in Cristy and Eckerman (7). SAF's set to zero remained as zeroes if they were in the low energy region, i.e., below the first acceptable SAF in the table. If a value at an intermediate energy was initially set to zero based on these statistical limitations, its value was estimated by interpolation between other accepted values. Interpolations were performed on the logarithms of the energy and SAF values.

S-values with the prostate as a source were calculated for several radionuclides using decay data (13) and the weighted average values of the SAFs:

$$S(r_k \leftarrow r_h) = \sum_i \Delta_i \Phi_i(r_k \leftarrow r_h),$$

where  $S(r_k \leftarrow r_h)$  = the S-value for source region  $r_h$  irradiating target region  $r_k$ ;  $\Delta_i$  = the mean energy per unit cumulated activity (13); and  $\Phi(r_k \leftarrow r_h)$  = the SAF of energy for source region  $r_h$  irradiating target region  $r_k$ . All electron energy is assumed to be uniformly absorbed within the gland. No electron energy is assumed to be absorbed in any other organs.

**TABLE 2**  
S-values with the Prostate as a Source for  $^{67}\text{Ga}$

Target organ	Estimated S-value	
	rad/ $\mu\text{Ci}\cdot\text{hr}$	mGy/MBq-sec
Adrenals	7.70E - 08	5.78E - 09
Brain	1.72E - 10	1.29E - 11
Gall bladder wall	2.76E - 07	2.07E - 08
Gall bladder contents	2.22E - 07	1.67E - 08
Lower large intestine wall	1.17E - 05	8.81E - 07
Lower large intestine contents	7.86E - 06	5.90E - 07
Small intestine	1.37E - 06	1.03E - 07
Stomach wall	1.38E - 07	1.03E - 08
Stomach contents	1.40E - 07	1.05E - 08
Upper large intestine wall	1.04E - 06	7.83E - 08
Upper large intestine contents	1.03E - 06	7.71E - 08
Heart wall	2.66E - 08	2.00E - 09
Heart contents	1.78E - 08	1.33E - 09
Kidneys	1.51E - 07	1.13E - 08
Liver	9.77E - 08	7.34E - 09
Lungs	1.49E - 08	1.12E - 09
Spleen	8.53E - 08	6.40E - 09
Pancreas	9.47E - 08	7.11E - 09
Prostate	5.95E - 03	4.47E - 04
Bone surfaces	1.09E - 06	8.18E - 08
Red marrow	9.32E - 07	7.00E - 08
Skin	8.75E - 07	6.57E - 08
Thyroid	1.81E - 09	1.36E - 10
Thymus	1.08E - 08	8.13E - 10
Testes	2.07E - 05	1.56E - 06
Urinary bladder wall	3.86E - 05	2.90E - 06
Urinary bladder contents	3.50E - 05	2.63E - 06
Whole body	2.14E - 06	1.61E - 07

**TABLE 3**  
S-values with the Prostate as a Source for  $^{99\text{m}}\text{Tc}$

Target organ	Estimated S-value	
	rad/ $\mu\text{Ci}\cdot\text{hr}$	mGy/MBq-sec
Adrenals	4.89E - 08	3.67E - 09
Brain	3.93E - 11	2.95E - 12
Gall bladder wall	2.03E - 07	1.52E - 08
Gall bladder contents	1.77E - 07	1.33E - 08
Lower large intestine wall	1.01E - 05	7.57E - 07
Lower large intestine contents	6.86E - 06	5.15E - 07
Small intestine	1.16E - 06	8.68E - 08
Stomach wall	1.00E - 07	7.51E - 09
Stomach contents	1.00E - 07	7.51E - 09
Upper large intestine wall	8.86E - 07	6.65E - 08
Upper large intestine contents	8.83E - 07	6.63E - 08
Heart wall	1.59E - 08	1.19E - 09
Heart contents	9.57E - 09	7.18E - 10
Kidneys	1.15E - 07	8.63E - 09
Liver	6.61E - 08	4.96E - 09
Lungs	8.95E - 09	6.72E - 10
Spleen	6.60E - 08	4.96E - 09
Pancreas	6.37E - 08	4.78E - 09
Prostate	2.81E - 03	2.11E - 04
Bone surfaces	1.08E - 06	8.09E - 08
Red marrow	7.95E - 07	5.97E - 08
Skin	7.20E - 07	5.40E - 08
Thyroid	6.26E - 10	4.70E - 11
Thymus	5.21E - 09	3.91E - 10
Testes	1.77E - 05	1.33E - 06
Urinary bladder wall	3.33E - 05	2.50E - 06
Urinary bladder contents	3.02E - 05	2.27E - 06
Whole body	1.86E - 06	1.40E - 07

**TABLE 4**  
S-values with the Prostate as a Source for  $^{111}\text{In}$

Target organ	Estimated S-value	
	rad/ $\mu\text{Ci}\cdot\text{hr}$	mGy/MBq-sec
Adrenals	2.04E - 07	1.53E - 08
Brain	3.22E - 10	2.42E - 11
Gall bladder wall	7.35E - 07	5.52E - 08
Gall bladder contents	5.53E - 07	4.15E - 08
Lower large intestine wall	3.12E - 05	2.34E - 06
Lower large intestine contents	2.07E - 05	1.56E - 06
Small intestine	3.55E - 06	2.66E - 07
Stomach wall	3.49E - 07	2.62E - 08
Stomach contents	3.79E - 07	2.85E - 08
Upper large intestine wall	2.69E - 06	2.02E - 07
Upper large intestine contents	2.70E - 06	2.03E - 07
Heart wall	7.51E - 08	5.64E - 09
Heart contents	3.64E - 08	2.73E - 09
Kidneys	3.87E - 07	2.91E - 08
Liver	2.61E - 07	1.96E - 08
Lungs	3.94E - 08	2.96E - 09
Spleen	2.15E - 07	1.61E - 08
Pancreas	2.49E - 07	1.87E - 08
Prostate	7.38E - 03	5.54E - 04
Bone surfaces	2.67E - 06	2.00E - 07
Red marrow	2.42E - 06	1.82E - 07
Skin	2.30E - 06	1.72E - 07
Thyroid	4.05E - 09	3.04E - 10
Thymus	2.70E - 08	2.03E - 09
Testes	5.48E - 05	4.12E - 06
Urinary bladder wall	1.10E - 04	8.26E - 06
Urinary bladder contents	9.62E - 05	7.22E - 06
Whole body	5.93E - 06	4.45E - 07

**TABLE 5**  
S-values with the Prostate as a Source for <sup>123</sup>I

Target organ	Estimated S-value	
	rad/ $\mu$ Ci-hr	mGy/MBq-sec
Adrenals	6.97E - 08	5.24E - 09
Brain	1.17E - 10	8.81E - 12
Gall bladder wall	2.63E - 07	1.98E - 08
Gall bladder contents	2.17E - 07	1.63E - 08
Lower large intestine wall	1.47E - 05	1.11E - 06
Lower large intestine contents	9.59E - 06	7.20E - 07
Small intestine	1.38E - 06	1.04E - 07
Stomach wall	1.29E - 07	9.69E - 09
Stomach contents	1.33E - 07	1.00E - 08
Upper large intestine wall	1.06E - 06	7.94E - 08
Upper large intestine contents	1.05E - 06	7.88E - 08
Heart wall	2.41E - 08	1.81E - 09
Heart contents	1.45E - 08	1.09E - 09
Kidneys	1.45E - 07	1.09E - 08
Liver	9.05E - 08	6.79E - 09
Lungs	1.34E - 08	1.01E - 09
Spleen	8.21E - 08	6.16E - 09
Pancreas	8.71E - 08	6.54E - 09
Prostate	5.19E - 03	3.90E - 04
Bone surfaces	1.19E - 06	8.91E - 08
Red marrow	9.50E - 07	7.13E - 08
Skin	9.84E - 07	7.39E - 08
Thyroid	1.35E - 09	1.01E - 10
Thymus	8.92E - 09	6.70E - 10
Testes	2.60E - 05	1.95E - 06
Urinary bladder wall	5.57E - 05	4.18E - 06
Urinary bladder contents	4.81E - 05	3.61E - 06
Whole body	2.76E - 06	2.07E - 07

**TABLE 6**  
S-values with the Prostate as a Source for <sup>125</sup>I

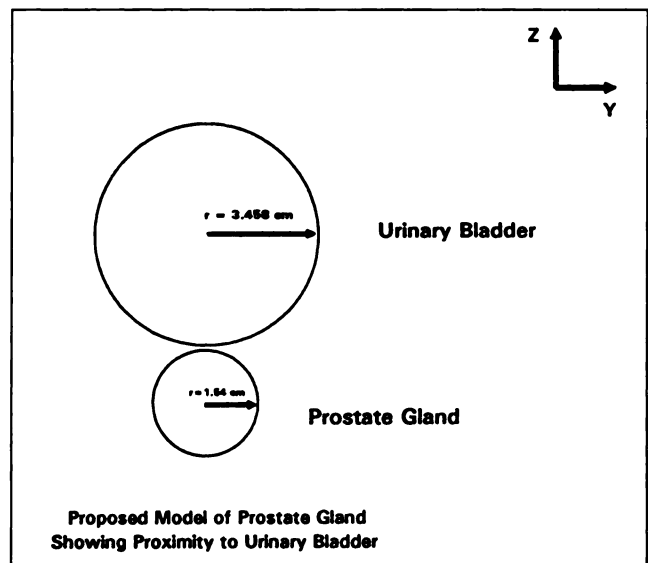
Target organ	Estimated S-value	
	rad/ $\mu$ Ci-hr	mGy/MBq-sec
Adrenals	8.79E - 11	6.60E - 12
Brain	2.76E - 15	2.07E - 16
Gall bladder wall	1.36E - 09	1.02E - 10
Gall bladder contents	1.39E - 09	1.04E - 10
Lower large intestine wall	5.63E - 06	4.23E - 07
Lower large intestine contents	3.14E - 06	2.36E - 07
Small intestine	4.90E - 08	3.68E - 09
Stomach wall	5.55E - 10	4.16E - 11
Stomach contents	3.89E - 10	2.92E - 11
Upper large intestine wall	3.97E - 08	2.98E - 09
Upper large intestine contents	3.48E - 08	2.61E - 09
Heart wall	1.66E - 11	1.24E - 12
Heart contents	1.21E - 11	9.10E - 13
Kidneys	4.22E - 10	3.17E - 11
Liver	2.77E - 10	2.08E - 11
Lungs	1.11E - 11	8.30E - 13
Spleen	1.62E - 10	1.22E - 11
Pancreas	2.03E - 10	1.52E - 11
Prostate	3.86E - 03	2.89E - 04
Bone surfaces	9.62E - 08	7.22E - 09
Red marrow	3.98E - 08	2.99E - 09
Skin	2.35E - 07	1.76E - 08
Thyroid	7.98E - 14	5.99E - 15
Thymus	2.29E - 12	1.72E - 13
Testes	9.84E - 06	7.39E - 07
Urinary bladder wall	3.12E - 05	2.34E - 06
Urinary bladder contents	2.41E - 05	1.81E - 06
Whole body	1.12E - 06	8.42E - 08

**TABLE 7**  
S-values with the Prostate as a Source for <sup>131</sup>I

Target organ	Estimated S-value	
	rad/ $\mu$ Ci-hr	mGy/MBq-sec
Adrenals	2.68E - 07	2.01E - 08
Brain	1.08E - 09	8.07E - 11
Gall bladder wall	8.36E - 07	6.28E - 08
Gall bladder contents	6.65E - 07	4.99E - 08
Lower large intestine wall	2.78E - 05	2.09E - 06
Lower large intestine contents	1.83E - 05	1.37E - 06
Small intestine	3.47E - 06	2.61E - 07
Stomach wall	4.38E - 07	3.29E - 08
Stomach contents	4.35E - 07	3.27E - 08
Upper large intestine wall	2.67E - 06	2.01E - 07
Upper large intestine contents	2.55E - 06	1.91E - 07
Heart wall	9.24E - 08	6.93E - 09
Heart contents	8.09E - 08	6.07E - 09
Kidneys	4.65E - 07	3.49E - 08
Liver	3.19E - 07	2.39E - 08
Lungs	5.59E - 08	4.20E - 09
Spleen	2.62E - 07	1.96E - 08
Pancreas	3.14E - 07	2.36E - 08
Prostate	2.72E - 02	2.04E - 03
Bone surfaces	2.14E - 06	1.61E - 07
Red marrow	2.33E - 06	1.75E - 07
Skin	2.22E - 06	1.67E - 07
Thyroid	9.41E - 09	7.06E - 10
Thymus	4.66E - 08	3.50E - 09
Testes	4.86E - 05	3.65E - 06
Urinary bladder wall	9.25E - 05	6.94E - 06
Urinary bladder contents	8.30E - 05	6.23E - 06
Whole body	5.18E - 06	3.89E - 07

**RESULTS AND DISCUSSION**

The recommended SAFs for the prostate gland as a source are given in Table 1. Entries that are zeroes usually represent cases in which both the Monte Carlo and point-source kernel methods resulted in COVs greater than 30%.



**FIGURE 1.** Diagram shows the proposed model of the prostate gland and its relationship to the urinary bladder.

Calculated S-values for  $^{67}\text{Ga}$ ,  $^{99\text{m}}\text{Tc}$ ,  $^{111}\text{In}$ ,  $^{123}\text{I}$ ,  $^{125}\text{I}$  and  $^{131}\text{I}$  are shown in Tables 2-7. S-values for the prostate gland irradiating itself were also estimated for  $^{32}\text{P}$  and  $^{90}\text{Y}$ ; the estimated S-values were  $9.26 \times 10^{-2}$  rad/ $\mu\text{Ci-hr}$  ( $6.95 \times 10^{-3}$  mGy/MBq-sec) for  $^{32}\text{P}$  and  $1.25 \times 10^{-1}$  rad/ $\mu\text{Ci-hr}$  ( $9.35 \times 10^{-3}$  mGy/MBq-sec) for  $^{90}\text{Y}$ . The S-values for the urinary bladder, testes and lower large intestine wall are larger than those for most other organs as expected from the location of the gland. S-values are reported also for the prostate gland irradiating the contents of organs with separate wall and content components. These S-values may be used to estimate dose to the prostate gland from activity in the contents of these organs by the reciprocity principle (14).

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