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Absorbed dose to the urinary bladder using dynamic S-values

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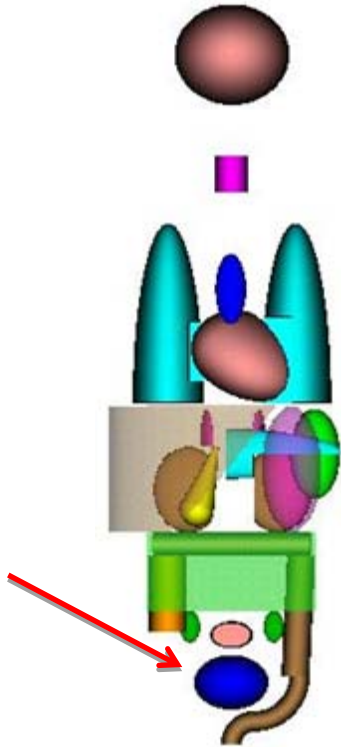
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Introduction



Radiation dose to Patients from different radiopharmaceuticals are published in ICRP publication 53, 80 and 106.

The absorbed dose to the urinary bladder wall is calculated using a fixed urinary bladder content volume of 202.6 mL.

Cristy & Eckerman (1987)
Male phantom



Background - Previous dynamic models

First model: Cloutier *et al.* (1973):

Investigated the dose to a foetus from the urinary bladder

Snyder and Ford (1976):

Started to calculate the absorbed dose to the urinary bladder wall

Latest model: Thomas *et al.* (1999):

Calculated the absorbed dose to the inner surface of the bladder wall

Cloutier RJ *et al.* 1973 Dose to the fetus from radionuclides in the bladder.

Snyder WS, Ford MR 1976 Estimation of dose to the urinary bladder and to the gonads.

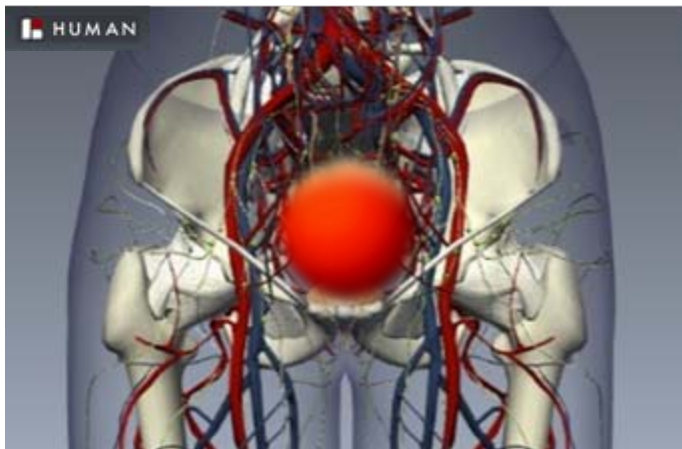
Thomas SR *et al.* 1999 MIRD Pamphlet No. 14 revised: A dynamic urinary bladder model for radiation dose calculations



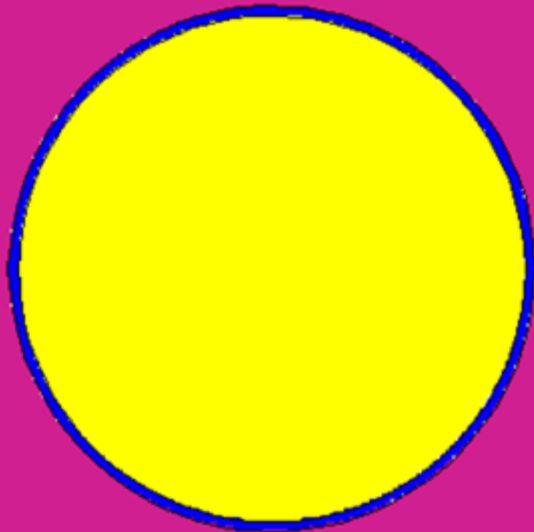
Aim

To improve the previous models with:

- Dynamic dose conversion factors (S-value)
- Monte Carlo simulated electrons
- Realistic anatomical material
- Calculating the mean absorbed dose to the urinary bladder wall



Methods -Simulation (MCNP5)



Anatomy:

- Yellow = Urine
- Blue = Bladder wall
- Magenta = Water

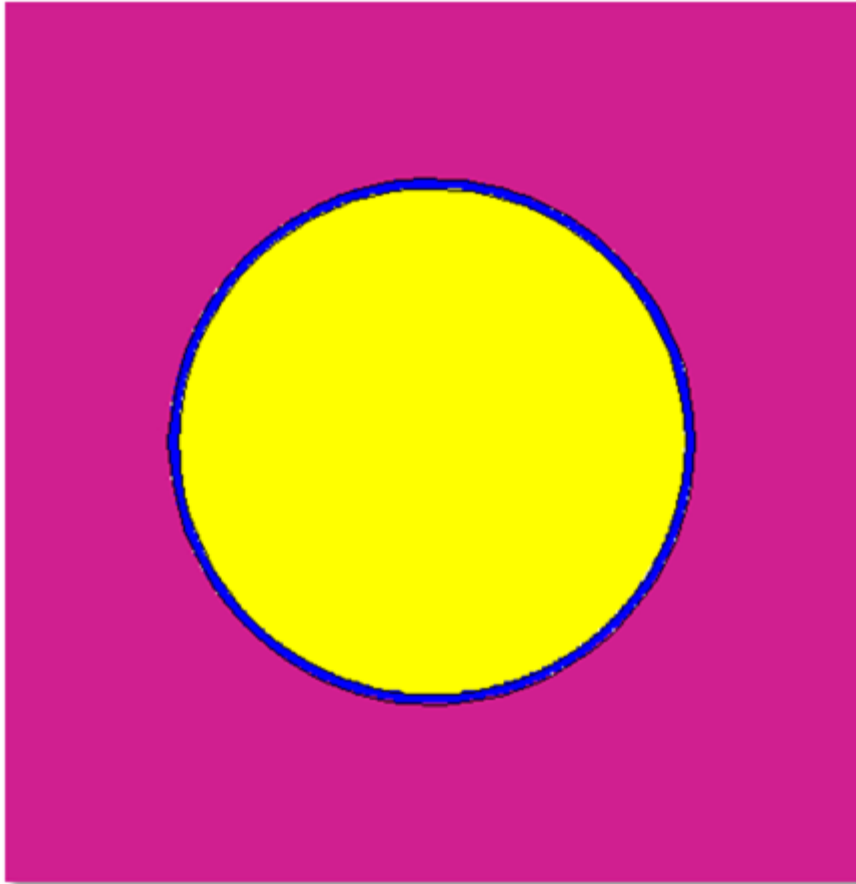
Mass of bladder wall:

- Male=50.01 g
- Female= 40.00 g

Elemental compositions from ICRP publ. 110



Methods – SAF values



- Specific absorbed fraction is the absorbed fraction divided by the mass of the target region

$$\Phi(r_T \leftarrow r_S, E_{R,i}) = \frac{\varphi(r_T \leftarrow r_S, E_{R,i})}{M_{r_T}}$$



Methods - Dynamic SAF-values

Dynamic SAF-values:

- 17 different volumes (ranging from 10 mL to 800 mL)
- 25 different mono-energetic values for both photons and electrons (ranging from 10 keV to 10 MeV)
- Source regions:
 - Urinary bladder wall
 - Urinary content

ICRP adult male - Aardvark

Adult male reference computational phantom

Photons

vol.	Traget	Source	0.010	0.015	0.020	0.030	0.040	0.050	0.060	...
10ml	UB-wa11	UB-cont	2.038e+00	3.350e+00	6.644e+00	4.384e+00	2.435e+00	3.398e+00	1.209e+00	...
150ml	UB-wa11	UB-cont	2.272e+00	2.857e+00	3.378e+00	2.329e+00	1.427e+00	6.744e+00	7.466e+00	...
1000ml	UB-wa11	UB-cont	6.991e-01	1.922e+00	2.242e+00	1.621e+00	1.030e+00	7.191e-01	3.368e-01	...
1500ml	UB-wa11	UB-cont	7.332e-01	1.509e+00	1.701e+00	1.294e+00	8.291e-01	5.880e-01	4.566e-01	...
2000ml	UB-wa11	UB-cont	6.812e-01	1.257e+00	1.384e+00	1.051e+00	7.008e-01	5.018e-01	3.967e-01	...
2500ml	UB-wa11	UB-cont	3.909e-01	1.037e+00	1.172e+00	9.051e-01	6.131e-01	4.437e-01	3.226e-01	...
3000ml	UB-wa11	UB-cont	3.258e-01	9.264e-01	1.038e+00	7.954e-01	5.493e-01	3.987e-01	3.183e-01	...
3500ml	UB-wa11	UB-cont	4.924e-01	8.251e-01	9.004e-01	7.141e-01	4.947e-01	3.843e-01	3.204e-01	...
4000ml	UB-wa11	UB-cont	4.360e-01	7.449e-01	8.100e-01	6.478e-01	4.539e-01	3.371e-01	2.707e-01	...
4500ml	UB-wa11	UB-cont	4.260e-01	6.786e-01	7.312e-01	6.911e-01	4.201e-01	3.178e-01	2.516e-01	...
5000ml	UB-wa11	UB-cont	4.001e-01	6.241e-01	6.740e-01	5.861e-01	3.838e-01	2.934e-01	2.272e-01	...
5500ml	UB-wa11	UB-cont	3.772e-01	5.781e-01	6.228e-01	5.098e-01	3.671e-01	2.768e-01	2.137e-01	...
6000ml	UB-wa11	UB-cont	3.569e-01	5.401e-01	5.788e-01	4.768e-01	3.498e-01	2.613e-01	2.074e-01	...
6500ml	UB-wa11	UB-cont	3.388e-01	5.058e-01	5.412e-01	4.478e-01	3.271e-01	2.447e-01	2.022e-01	...
7000ml	UB-wa11	UB-cont	3.271e-01	4.759e-01	5.078e-01	4.221e-01	3.008e-01	2.270e-01	1.894e-01	...
7500ml	UB-wa11	UB-cont	3.081e-01	4.494e-01	4.788e-01	4.000e-01	2.801e-01	2.298e-01	1.814e-01	...
8000ml	UB-wa11	UB-cont	2.970e-01	4.257e-01	4.527e-01	3.799e-01	2.624e-01	2.178e-01	1.766e-01	...
8500ml	UB-wa11	UB-wa11	3.826e+01	1.448e+01	1.027e+01	4.921e+00	2.899e+00	1.718e+00	1.002e+00	...
9000ml	UB-wa11	UB-wa11	3.884e+01	1.370e+01	7.624e+00	3.921e+00	3.391e+00	3.218e+00	9.174e+00	...
1000ml	UB-wa11	UB-wa11	3.561e+01	3.964e+00	6.161e+00	2.765e+00	1.509e+00	6.981e-01	7.348e-01	...
1500ml	UB-wa11	UB-wa11	1.474e+01	8.677e+00	1.147e+00	2.347e+00	3.281e+00	6.334e-01	6.500e-01	...
2000ml	UB-wa11	UB-wa11	1.399e+01	8.094e+00	4.781e+00	2.070e+00	1.331e+00	7.355e-01	5.821e-01	...
2500ml	UB-wa11	UB-wa11	1.318e+01	7.501e+00	4.369e+00	1.871e+00	1.027e+00	6.833e-01	5.257e-01	...
3000ml	UB-wa11	UB-wa11	1.284e+01	7.030e+00	4.046e+00	1.720e+00	9.388e-01	6.280e-01	4.813e-01	...
3500ml	UB-wa11	UB-wa11	1.239e+01	6.648e+00	3.780e+00	1.580e+00	8.720e-01	5.884e-01	4.338e-01	...
4000ml	UB-wa11	UB-wa11	1.198e+01	6.324e+00	3.566e+00	1.438e+00	8.174e-01	5.478e-01	4.244e-01	...
4500ml	UB-wa11	UB-wa11	1.162e+01	6.038e+00	3.378e+00	1.311e+00	7.734e-01	5.178e-01	4.021e-01	...
5000ml	UB-wa11	UB-wa11	1.129e+01	5.784e+00	3.213e+00	1.208e+00	7.327e-01	4.916e-01	3.821e-01	...
5500ml	UB-wa11	UB-wa11	1.099e+01	5.561e+00	3.071e+00	1.276e+00	6.899e-01	4.691e-01	3.638e-01	...
6000ml	UB-wa11	UB-wa11	1.071e+01	5.378e+00	2.956e+00	1.222e+00	6.091e-01	4.478e-01	3.491e-01	...
6500ml	UB-wa11	UB-wa11	1.047e+01	5.200e+00	2.849e+00	1.174e+00	6.434e-01	4.321e-01	3.373e-01	...
7000ml	UB-wa11	UB-wa11	1.024e+01	5.044e+00	2.752e+00	1.127e+00	6.171e-01	4.181e-01	3.272e-01	...
7500ml	UB-wa11	UB-wa11	1.002e+01	4.899e+00	2.661e+00	1.088e+00	5.938e-01	4.037e-01	3.181e-01	...
8000ml	UB-wa11	UB-wa11	9.818e+00	4.767e+00	2.581e+00	1.051e+00	5.748e-01	3.914e-01	3.040e-01	...

Electrons

vol.	Traget	Source	0.010	0.015	0.020	0.030	0.040	0.050	0.060	...
10ml	UB-wa11	UB-cont	1.652e-01	3.426e-01	5.107e-01	1.027e-01	1.829e-01	2.466e-01	3.493e-01	...
150ml	UB-wa11	UB-cont	8.491e-04	1.957e-03	3.242e-03	6.529e-03	1.081e-02	3.548e-02	2.128e-02	...
1000ml	UB-wa11	UB-cont	7.388e-07	1.521e-07	2.602e-07	5.122e-07	8.378e-07	1.211e-06	1.670e-06	...
1500ml	UB-wa11	UB-cont	6.249e-04	1.278e-03	2.198e-03	4.491e-03	7.211e-03	1.087e-02	1.400e-02	...
2000ml	UB-wa11	UB-cont	5.132e-04	1.187e-03	2.018e-03	4.016e-03	6.344e-03	9.746e-03	1.327e-02	...
2500ml	UB-wa11	UB-cont	4.348e-04	1.011e-03	1.726e-03	3.421e-03	5.276e-03	8.021e-03	1.079e-02	...
3000ml	UB-wa11	UB-cont	3.627e-04	8.046e-04	1.413e-03	2.744e-03	4.121e-03	6.131e-03	8.131e-03	...
3500ml	UB-wa11	UB-cont	3.024e-04	6.751e-04	1.194e-03	2.378e-03	3.447e-03	5.041e-03	6.886e-03	...
4000ml	UB-wa11	UB-cont	2.512e-04	5.634e-04	1.071e-03	2.051e-03	2.921e-03	4.041e-03	5.421e-03	...

Calculations

The time-dependent bladder content volume:

$$V(t) = V_0 + \int U(t)dt; \quad 0 \leq t < T_1$$

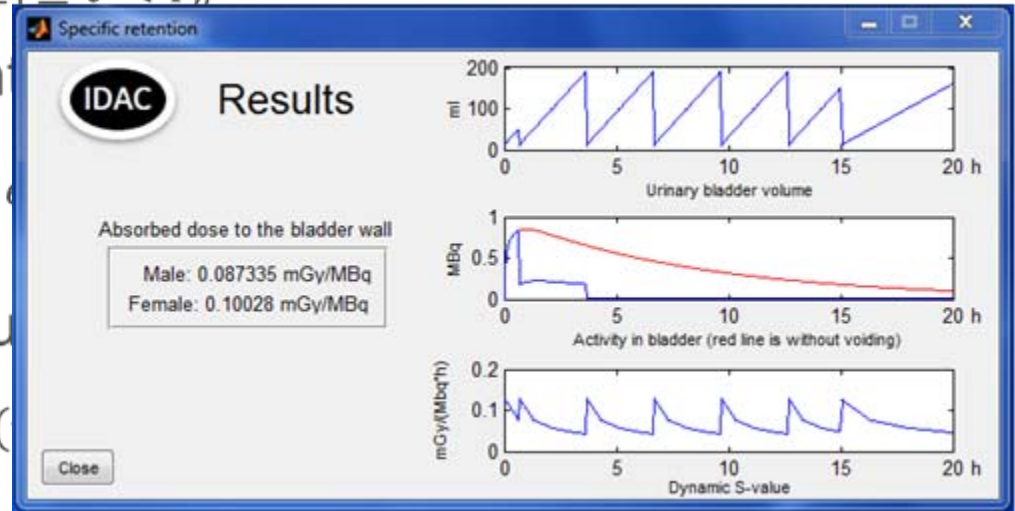
$$V_r + \int U(t)dt; \quad T_{n-1} \leq t < T_n$$

Time-dependent bladder content

$$A(t) = A_0 e^{-\lambda t} \sum_{j=1}^m \alpha_j (1 - e^{-\lambda_j t})$$

Mean absorbed dose to the u

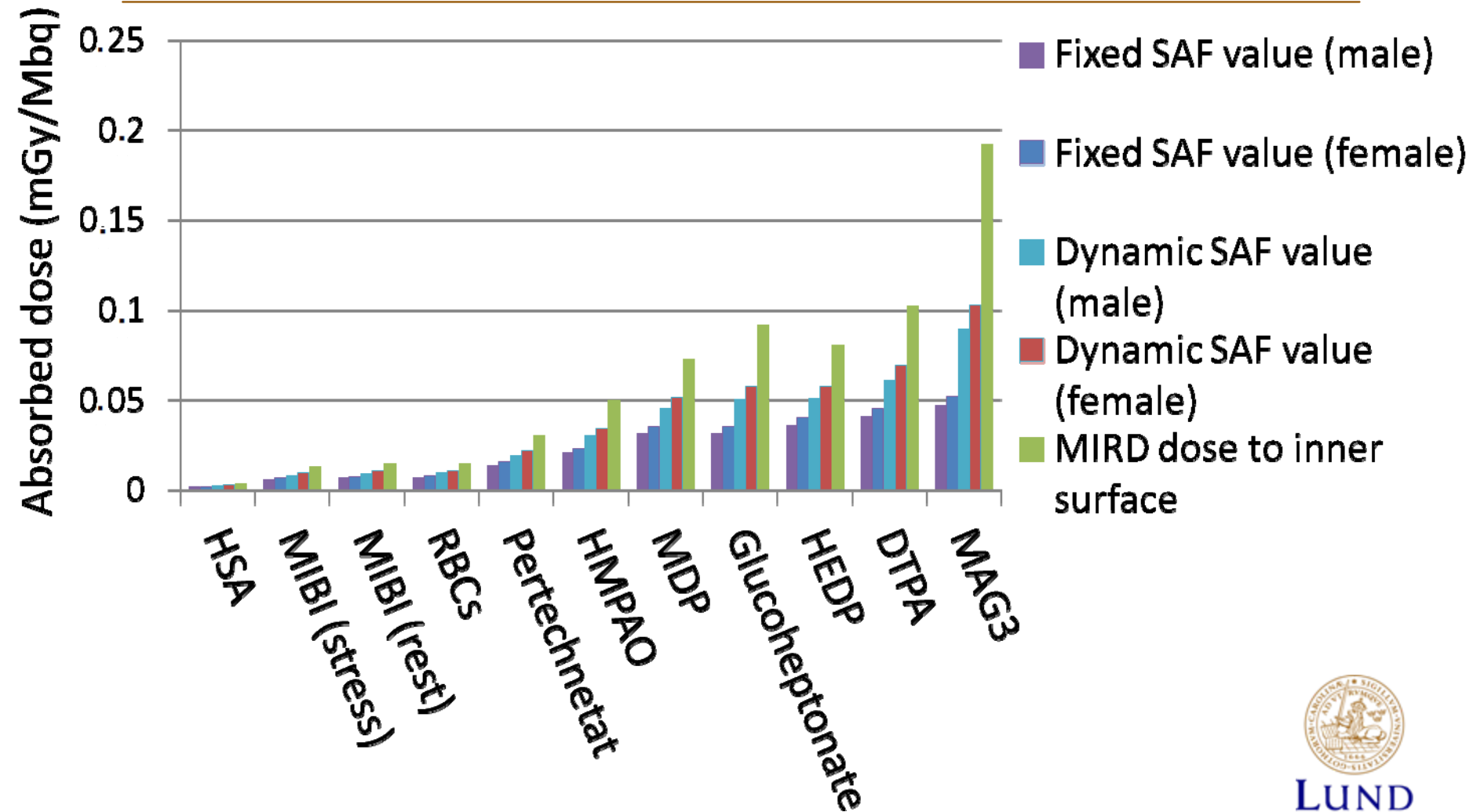
$$D(r_T, T_D) = \sum_{r_s} \int A(t) dt$$



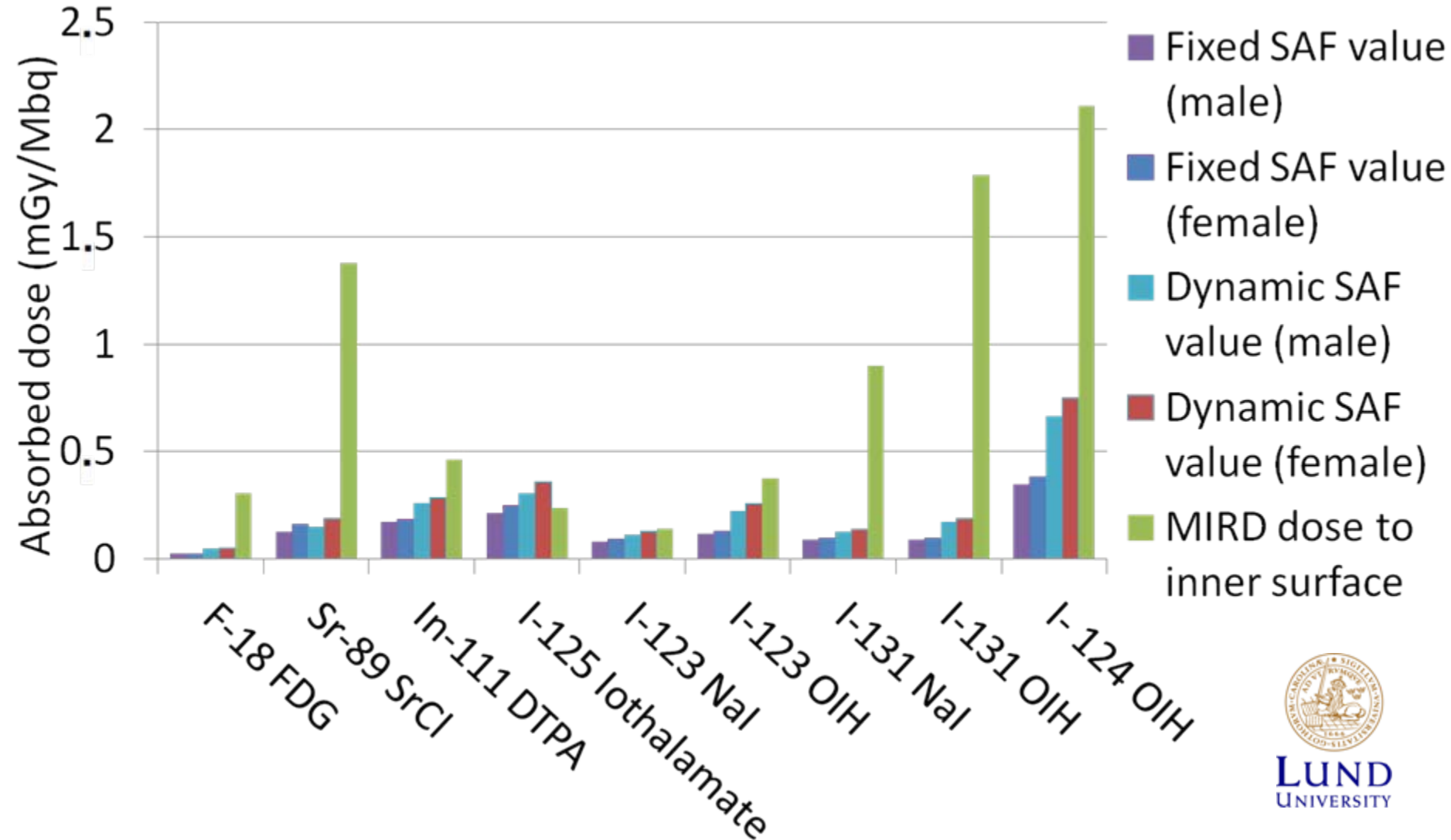
The absorbed dose for ^{99m}Tc MAG3



Results ^{99m}Tc



Results



Conclusion

- New more realistic SAF values that calculates the mean absorbed dose to the bladder wall
- An increase in absorbed dose using dynamic SAF values compared to static SAF-values.



Thank you for listening

