Special case: the dynamic bladder model

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TG36 WORKSHOP | 29 JULY 2025 | 12:00 - 14:00 UTC

RADIATION DOSE TO PATIENTS IN DIAGNOSTIC NUCLEAR MEDICINE

ICRP Digital Events

Introduction

The urinary bladder wall can receive a high amount of the absorbed dose

- Many radiopharmaceuticals have a high excretion through urine
- E.g. in 7 of the 60 models in ICRP Publication 128 the urinary bladder wall contributes more than 50 % of the effective dose.

Tissue weighting factor for urinary bladder wall: w_T =0.04

Changes from previous ICRP publication 128:

- Fixed shape of urinary bladder (200 mL) -> dynamic shape of bladder (10->500 mL)
- Static specific absorbed fraction (SAF) -> SAF changes with bladder volume
- Fixed age specific voiding periods -> biologic based voiding intervals
- Descriptive modelling -> Compartmental model

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. Dose to the fetus from radionuclides in the bladder. *Health Phys.* 25:147-61 (1973)
Snyder WS, Ford MR 1976 Estimation of dose to the urinary bladder and to the gonads. *Proc. Radiopharmaceutical Dosimetry Symposium* 313-350(1976)
Thomas SR et al. MIRD Pamphlet No. 14 revised: A dynamic urinary bladder model for radiation dose calculations. *J. Nucl. Med.* 40:102S-123S (1999)

Method – Biological parameters

ICRP Publication 89 gives daily urinary excretions

a) Excretion rate
b) Initial volume
c) Voiding volume
d) Residual volume

Table 2.41. Reference values for daily urinary excretion (Section 8.3.2)

	Excretion (ml/day)	
Age	Male	Female
Newborn	300	300
1 year	400	400
5 years	500	500
10 years	700	700
15 years	1200	1200
Adult	1600	1200

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Voiding periods in ICRP Publication 128

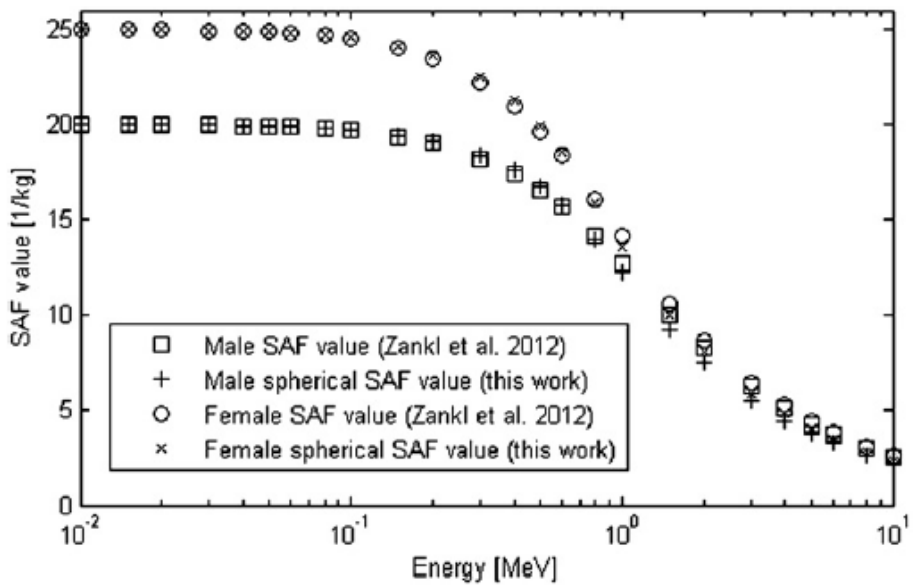
Age (years)	Adult	15 years	10 years	5 years	1 year	Newborn
Voiding period (h)	3.5	3.5	3.5	3.0	2.0	2.0

Monte Carlo-simulated spheres

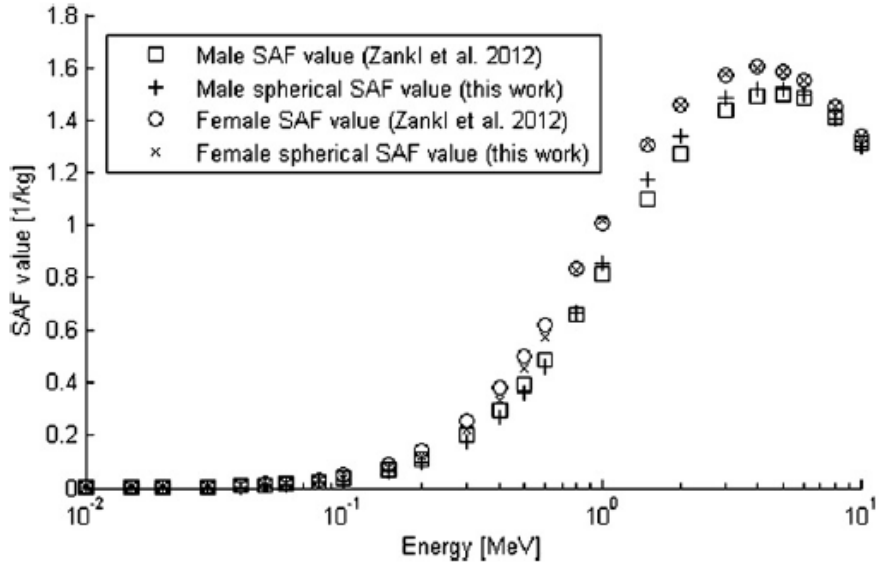
- Anatomical data from ICRP89 (mass of urinary wall)
- Elemental compositions from ICRP publ. 110
- 27 monoenergetic α, β and γ radiations between 0.001 MeV and 10 MeV
- 26 spherical volumes: 10, 20, 40, 60 (…) 480, 500 mL
- 7 anatomical data depending on sex and age

- Total 15 687 simulations

Validation of SAF-values



Photon SAF compared with the adult ICRP reference phantoms (200mL)

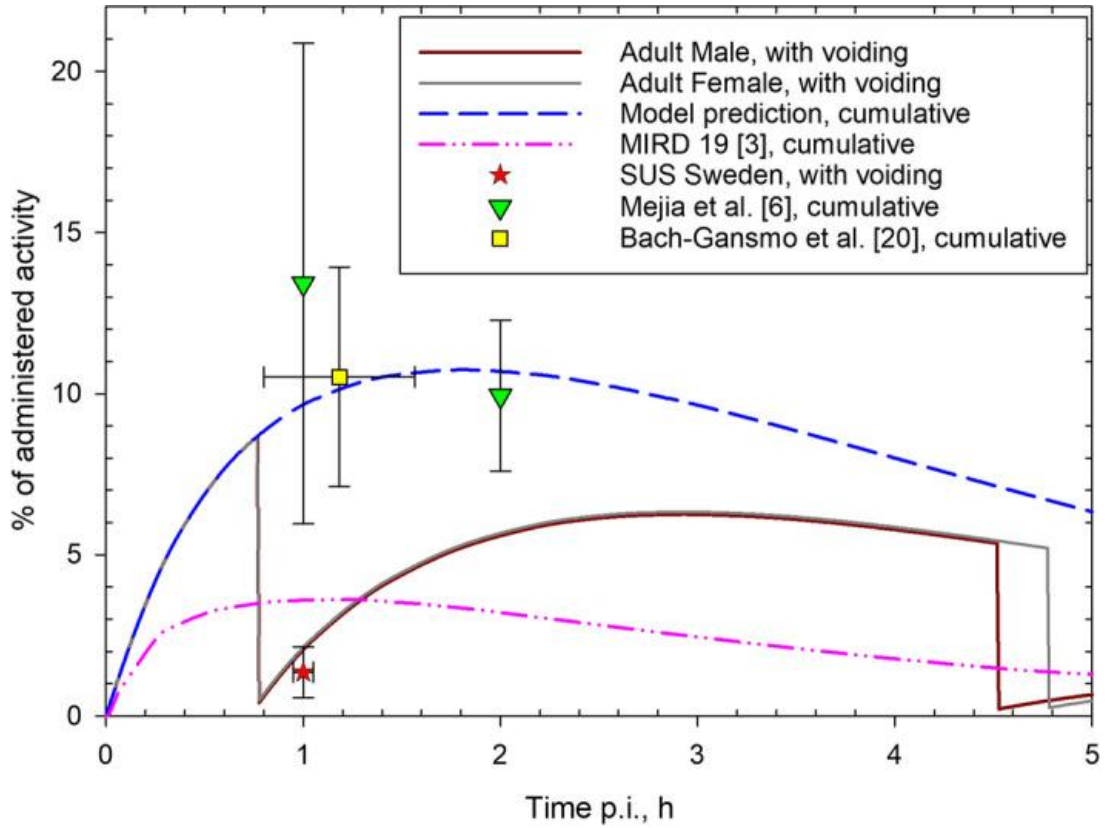


Electron SAF compared with the adult ICRP reference phantoms (200mL)

Zankl M et al. Electron specific absorbed fractions for the adult male and female ICRP/ICRU reference computational phantoms *Phys. Med. Biol.* 57:4501-4526 (2012)

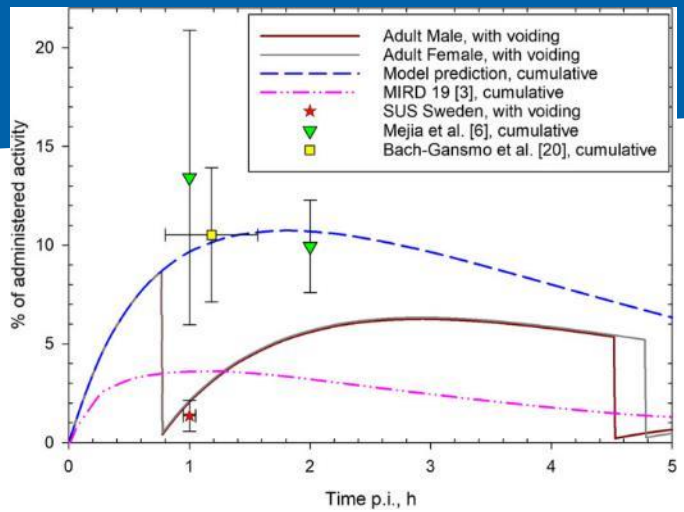
Andersson M et al Improved estimates of the radiation absorbed dose to the urinary bladder wall Phys. Med. Biol. 59 2173 (2014)

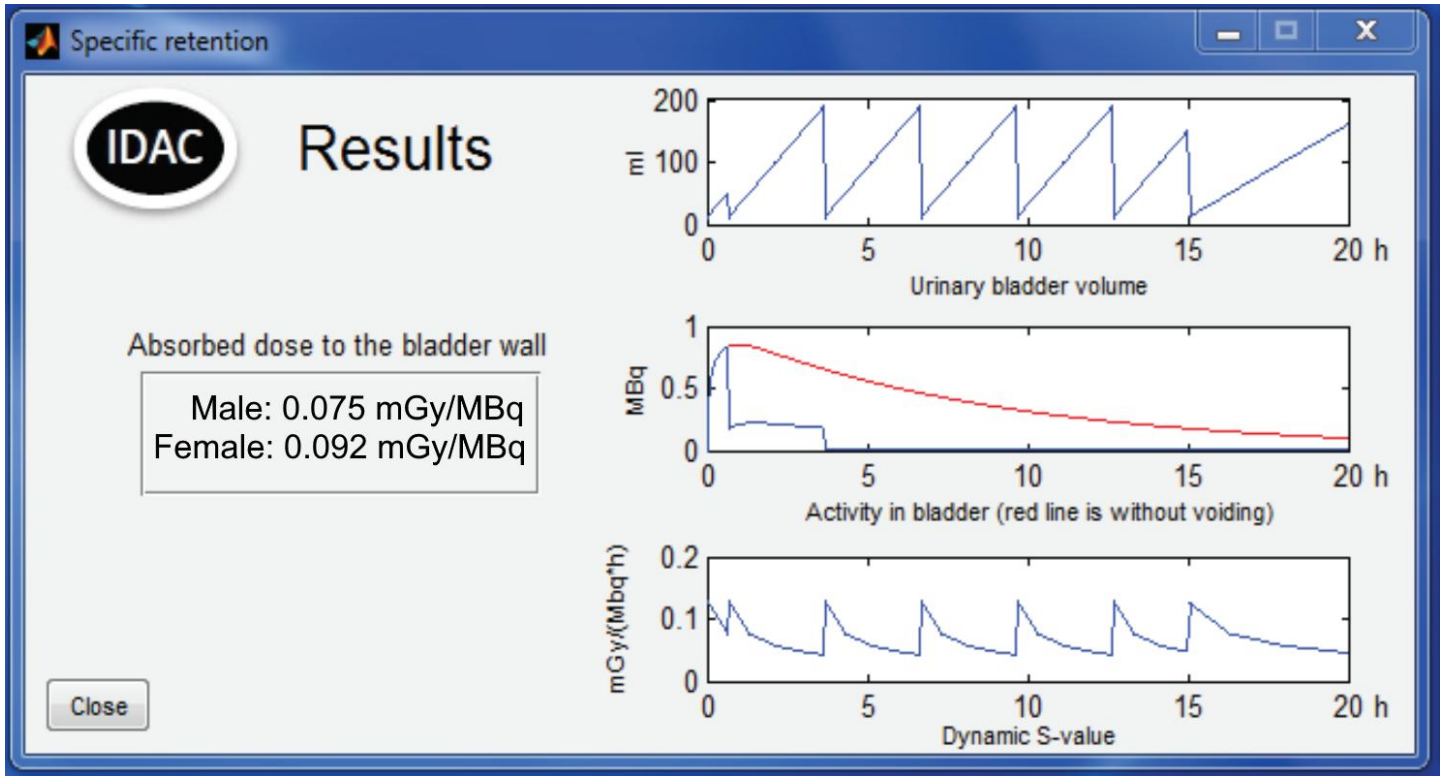
A revised compartmental model for biokinetics and dosimetry of 2-[18F]FDG



Kamp A, Andersson M, Leide-Svegborn S, Noβke D, Mattsson S, Giussani A. A revised compartmental model for biokinetics and dosimetry of 2-[^{18}F]FDG. EJNMMI Phys. 10:10 (2023)

Results for 2-[18F]FDG





Results from Kamp A, Andersson M, Leide-Svegborn S, Noβke D, Mattsson S, Giussani A. A revised compartmental model for biokinetics and dosimetry of 2-[^{18}F]FDG. EJNMMI Phys. 10:10 (2023)

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