Absorbed dose to the urinary bladder using dynamic S-values

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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.
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
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
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

\[ \Phi(r_T \leftarrow r_s, E_{R,i}) = \frac{\Phi(r_T \leftarrow r_s, E_{R,i})}{M_{r_T}} \]
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
Calculations

The time-dependent bladder content volume:

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

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

Time-dependent bladder content:

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

Mean absorbed dose to the urinary bladder:

\[ D(r_T, T_D) = \sum_{r_s} \int A(r) dr \]

The absorbed dose for \(^{99m}\text{Tc MAG3}\)
Results $^{99m}$Tc

- Fixed SAF value (male)
- Fixed SAF value (female)
- Dynamic SAF value (male)
- Dynamic SAF value (female)
- MIRD dose to inner surface
Results

Absorbed dose (mGy/Mbq)

- Fixed SAF value (male)
- Fixed SAF value (female)
- Dynamic SAF value (male)
- Dynamic SAF value (female)
- MIRD dose to inner surface

F-18 FDG  Sr-89 SrCl  In-111 DTPA  I-123 Iodine  I-123 Nal  I-123 OIH  I-131 Nal  I-131 OIH  I-124 OIH
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