The New Report: New Features and Hot Topics

Augusto Giussani (BfS, Germany)
ICRP TG 36 Chair

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

RADIATION DOSE TO PATIENTS IN DIAGNOSTIC NUCLEAR MEDICINE

ICRP Digital Events

ICRP Publications with reference dose coefficients in diagnostic nuclear medicine

Terms of reference of ICRP Task Group 36

Tissue or organ	Tissue weighting factor (w_T)	
	ICRP60	ICRP103
Gonads	0.20	0.08
Bone marrow (red)	0.12	0.12
Colon	0.12	0.12
Lung	0.12	0.12
Stomach	0.12	0.12
Bladder	0.05	0.04
Breast	0.05	0.12
Liver	0.05	0.04
Oesophagus	0.05	0.04
Thyroid	0.05	0.04
Skin	0.01	0.01
Bone surface	0.01	0.01
Brain		0.01
Salivary glands		0.01
Remainder	0.05	0.12

Objective: to develop dose coefficients for radiopharmaceuticals administered to patients in diagnostic nuclear medicine.

Task: to update *Publication 128* (2015) according to the "new" recommendations

Procedure

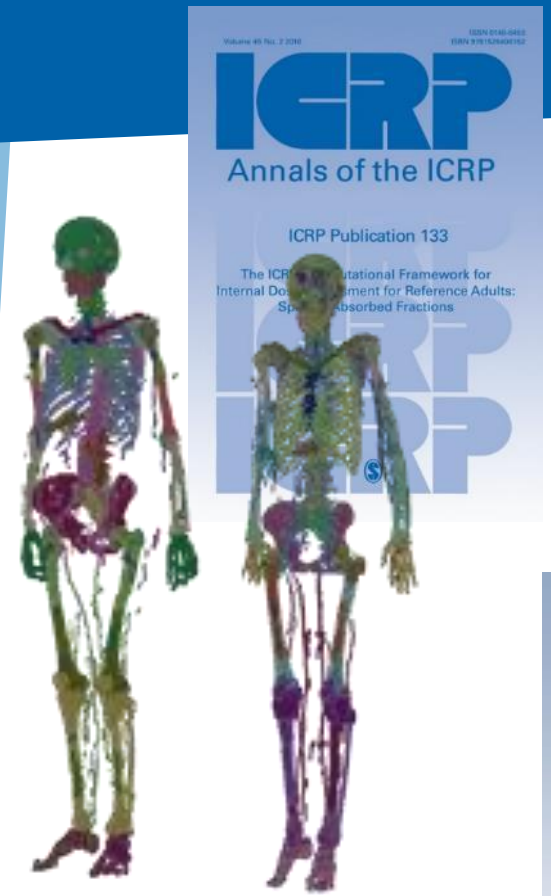
Calculation of dose coefficients according to the methodology of *Publication 103* (2007) and using the weighting factors given there.

$$E = \sum_T w_T \left[\frac{H_T^M + H_T^F}{2} \right]$$

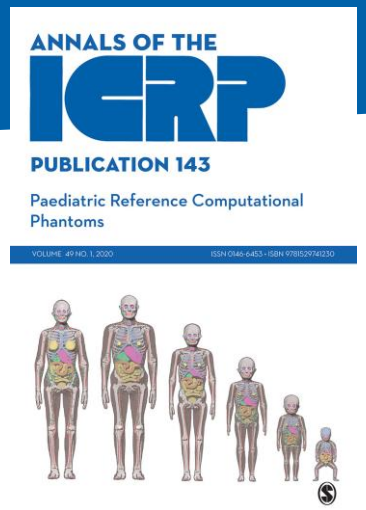
$$H_{rem}^M = \frac{1}{13} \sum_T H_T^M$$

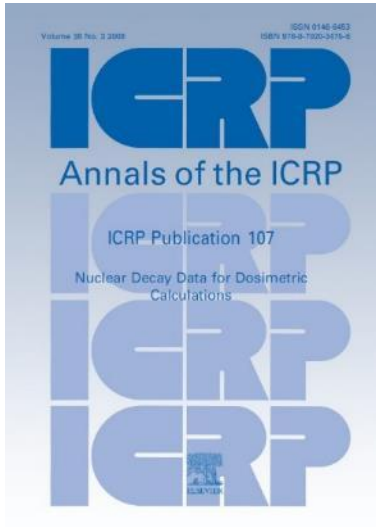
$$H_{rem}^F = \frac{1}{13} \sum_T H_T^F$$

Terms of reference of ICRP Task Group 36



ICRP Reference Computational Phantoms





Nuclear decay data

Objective: to develop dose coefficients for radiopharmaceuticals administered to patients in diagnostic nuclear medicine.

Task: to update *Publication 128* (2015) according to the "new" recommendations

Procedure

Calculation of dose coefficients according to the methodology of *Publication 103* (2007) and using the weighting factors given there

Development of biokinetic models as compartmental structures

Dynamic bladder model to describe urinary excretion

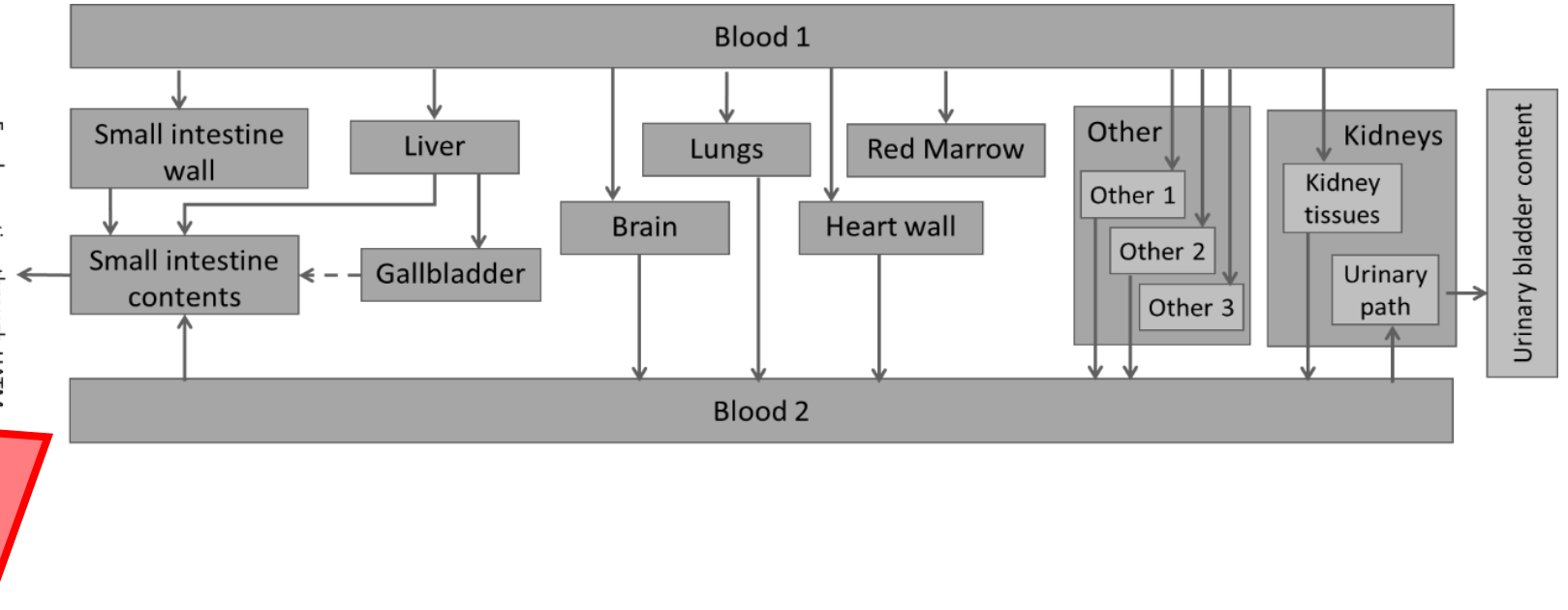
New adult and pediatric reference computational phantoms from *Publications 110* (2009), *133* (2016), *143* (2020) and *155* (2023)

Nuclear decay data from *Publication 107* (2008)

Biokinetics: from descriptive to compartmental models/1

Table C.16. Biokinetic data for ^{11}C-raclopride.

Organ (S)	F_s	T (h)	a
Liver	0.18	4.0	1.0
Kidneys	0.06	1.0	1.0
(from excretion process)			
Brain	0.03	1.0	1.0
Red marrow	0.02	∞	
Lungs	0.02	1.0	
Heart wall	0.01	1.0	
Small intestine wall	0.08	0.33	
Gallbladder contents	0.16		
Other organs and tissues	0.60	0.33	0.1
		4.0	0.45
		∞	0.45
Gastrointestinal tract contents			
Small intestine	0.40		
Upper large intestine	0.40		
Lower large intestine	0.40		
Urinary bladder contents	0.31		
Adult, 15 years, 10 years			
5 years, 1 year			



Transfer rates calculated from existing tables as ln(2)/T(h)

Transfer rates out of blood:

specific value if available from the literature

If not, a generic value is assumed

e.g. T_{blood}=0.25 h

From ICRP Publication 128

Biokinetics: from descriptive to compartmental models/2

Kamp et al. EJNMMI Physics (2023) 10:10
https://doi.org/10.1186/s40658-023-00528-9

EJNMMI Physics

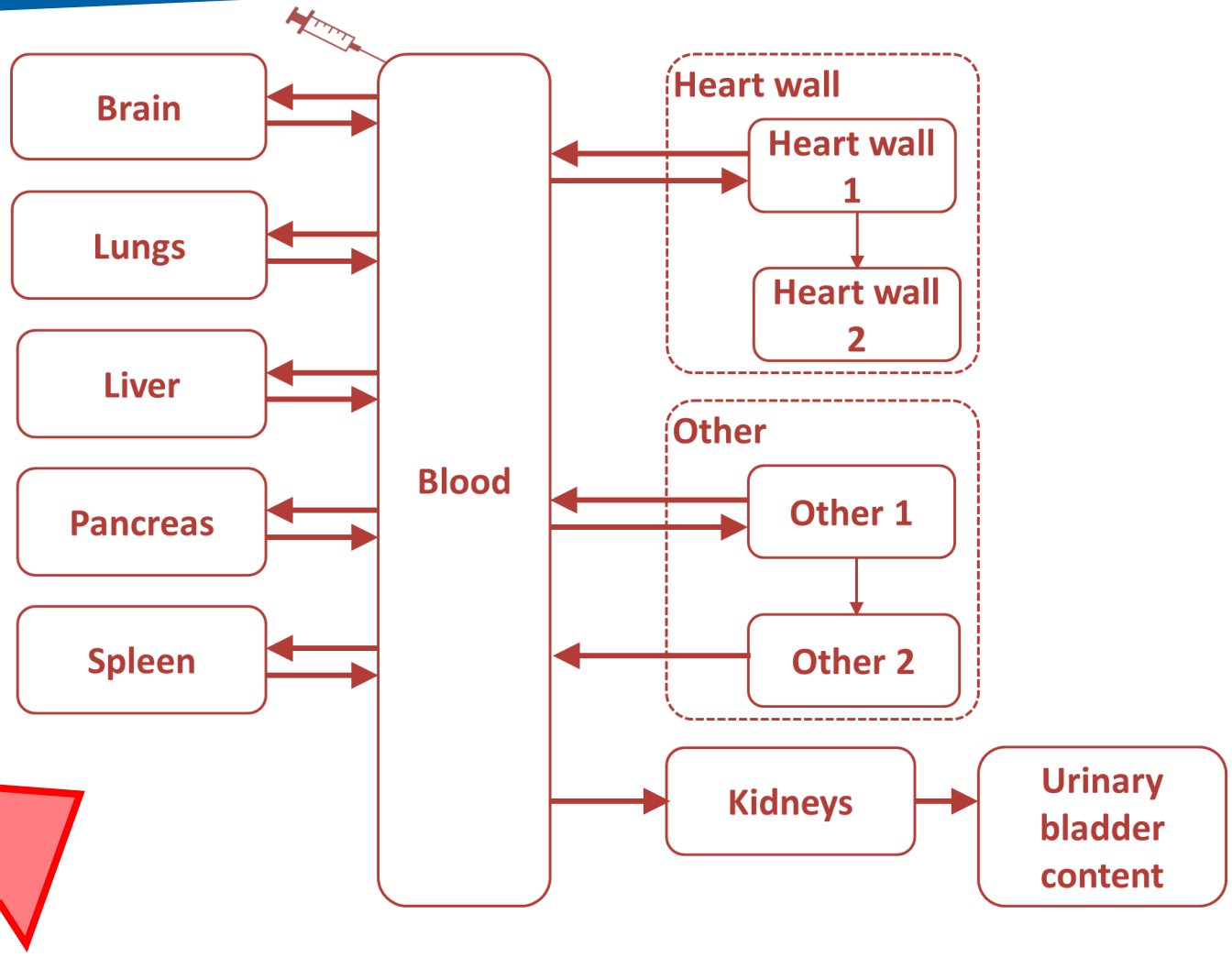
ORIGINAL RESEARCH Open Access

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

Alexandra Kamp[1*], Martin Andersson[2,3], Sigrid Leide-Svegborn[3], Dietmar Noßke[4], Sören Mattsson[3] and Augusto Giussani[1]

Table C.30. Biokinetic data for ^{18}F-fluoro-2-deoxy-D-glucose.

Organ (S)	F_s	T (h)	a
Brain	0.08	∞	1.0
Heart wall	0.04	∞	1.0
Lungs	0.03	∞	1.0
Liver	0.05	∞	1.0
Other organs and tissues	0.80	0.2	0.075
		1.5	0.225
		∞	0.70
Urinary bladder contents	0.24		



Biokinetics: from descriptive to compartmental models/3

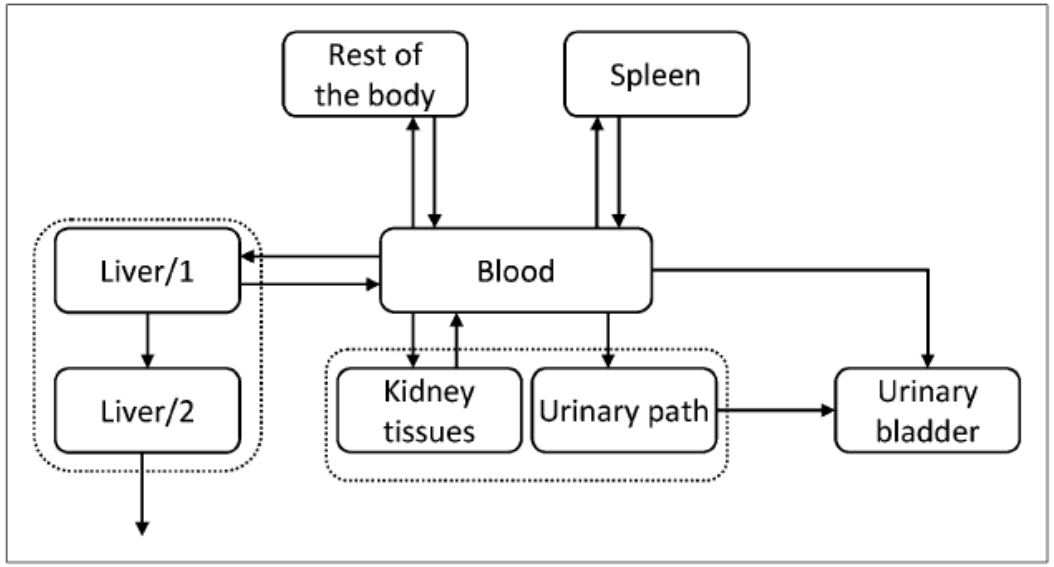


FIGURE 2. Proposed structure of compartmental model for biokinetics of ^{18}F-FCH.

TABLE 2
Values of Model Parameters (min^{-1}) as Obtained from Fits

Parameter	Mean	Population SD
Blood to liver1	1.61×10^{-2}	0.32×10^{-2}
Liver1 to blood	1.84×10^{-2}	0.40×10^{-2}
Liver1 to liver2	2.3×10^{-2}	1.7×10^{-2}
Blood to spleen	1.13×10^{-3}	0.51×10^{-3}
Spleen to blood	7.7×10^{-3}	2.6×10^{-3}
Blood to urinary bladder	5.1×10^{-4}	3.0×10^{-4}
Blood to kidney tissues	4.8×10^{-3}	1.3×10^{-3}
Kidney tissues to blood	6.2×10^{-3}	3.2×10^{-3}
Blood to urinary path	4.2×10^{-3}	1.1×10^{-3}
Urinary path to bladder	9.7×10^{-2}	2.9×10^{-2}
Blood to RoB	6.56×10^{-2}	0.91×10^{-2}
RoB to blood	4.6×10^{-3}	2.4×10^{-3}
Blood volume	1.28×10^{4}	0.83×10^{4}

A Compartmental Model for Biokinetics and Dosimetry of ^{18}F-Choline in Prostate Cancer Patients

Augusto Giussani[1], Tilman Janzen[1], Helena Uusijärvi-Lizana[2], Federico Tavola[3], Maria Zankl[1], Marie Sydoff[2], Anders Bjartell[4], Sigrid Leide-Svegborn[2], Marcus Söderberg[2], Sören Mattsson[2], Christoph Hoeschen[1], and Marie-Claire Cantone[3]

J Nucl Med 2012; 53:985–993
DOI: 10.2967/jnumed.111.099408

ICRP

Models and calculations

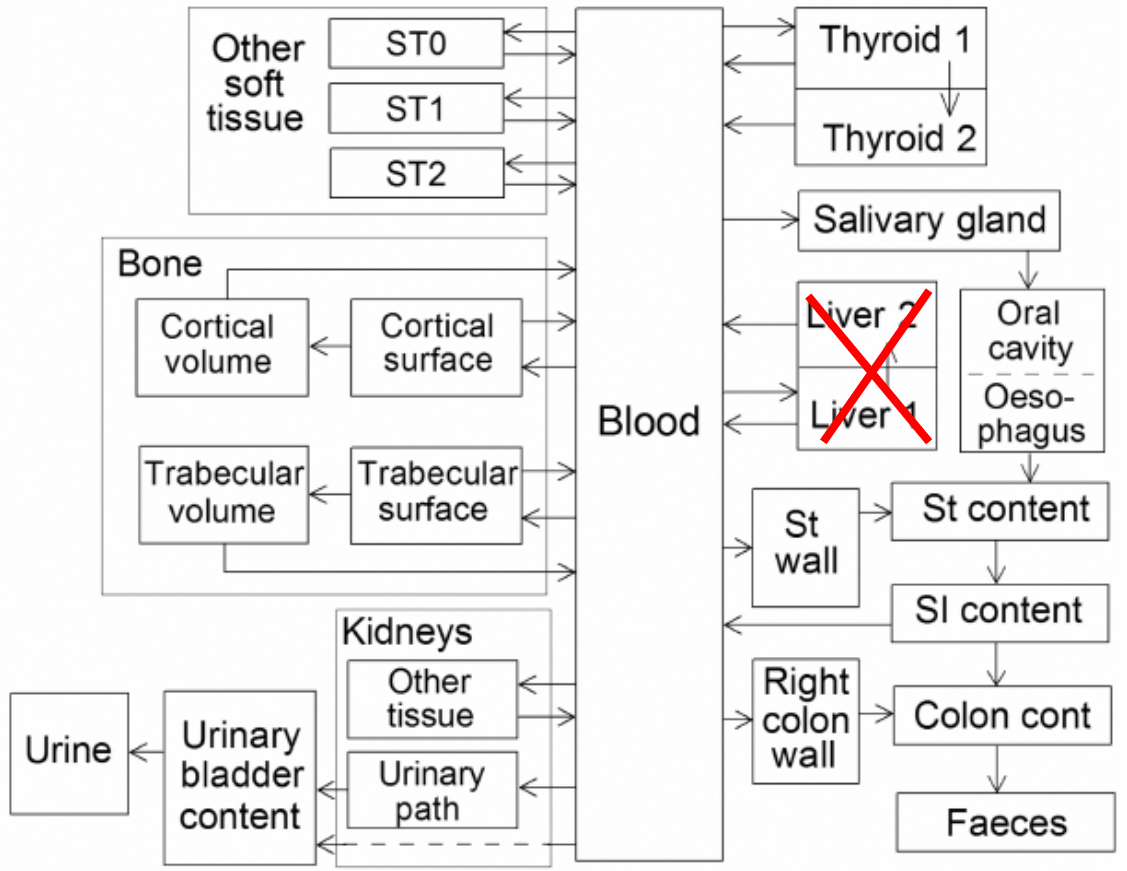
Pertechnetate (OIR model, Publ. 133)

A majority of recent literature on preclinical and clinical study doesn't show information about liver uptake. This is also consistent with daily clinical practice.

The OIR model was adjusted by removing the liver compartment and include it in "Other". Only minimal impact on the effective dose (< 1%).

Case „blocked thyroid": thyroid should be removed from the source organ „Other" (otherwise some activity will be still delivered to thyroid, contrarily to the model assumptions)

- Rename „With blocking agent"



Models and calculations

Iodine

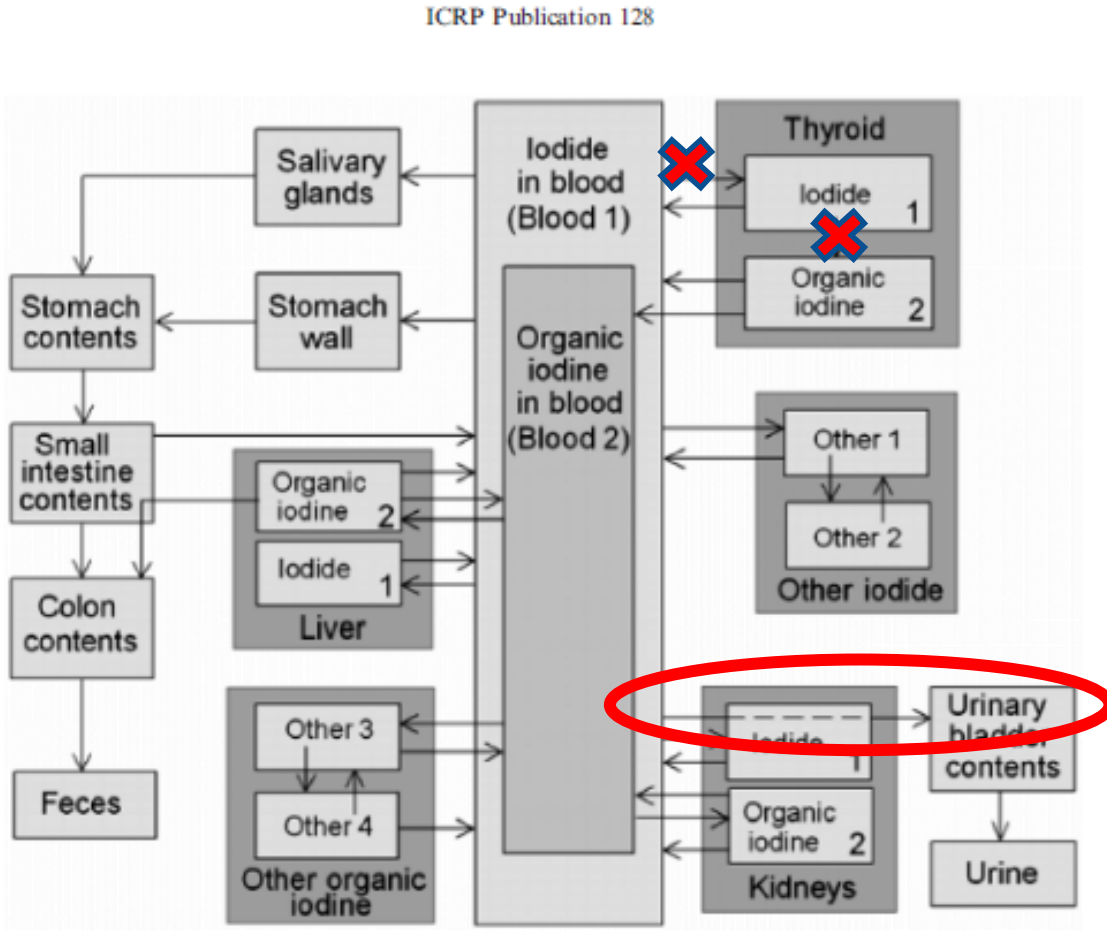
Case „blocked thyroid" = iodide is not transformed to organic iodine. In ICRP 128 this case is indicated as „Zero uptake". Zero Uptake however is when transfer from blood 1 to thyroid is set to 0 (thyroid removed).

We will have both zero uptake and blocked thyroid.

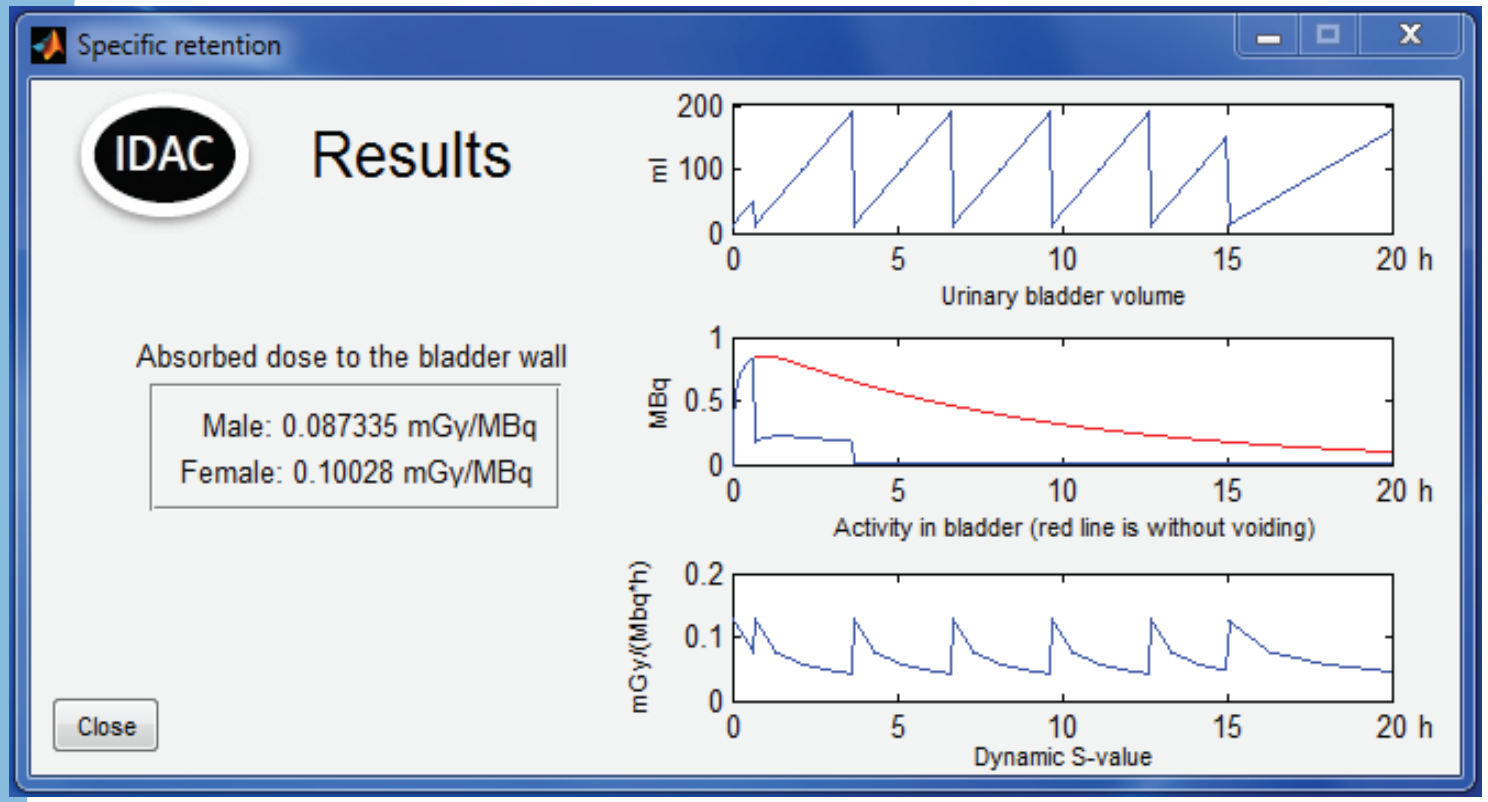
Transfer coefficients for HATM: Using "non-caloric liquids" for oral administration may be justified if radioiodine is administered in solution, but not when it is given in capsule form.

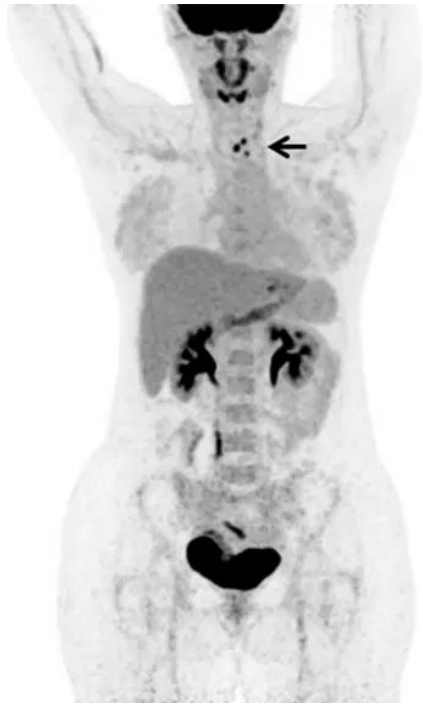
Excretion: A Kidney 3 compartment was introduced in Publication 128 in order to include the kidney bladder model used for all other radiopharmaceuticals for which no compartment model was available until now.

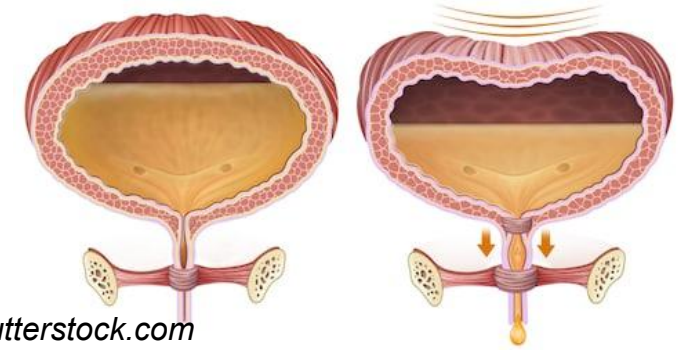
Model parsimony: we do not need a 3 kidney compartment



Dynamic bladder model







Source: shutterstock.com

Use of effective dose in (nuclear) medicine

Publication 103 (ICRP, 2007) clearly states that **effective dose is intended for use as a protection quantity on the basis of reference values and relates to reference persons and not to specific individuals**. The main uses of effective dose are in **prospective dose assessment for planning and optimisation** in radiological protection, and **retrospective demonstration of compliance for regulatory purposes**.

When using effective dose for comparing medical administrations (*Publication 147*) it "…is used **to provide a generic indicator** for classifying different types of medical procedure into broad risk categories for the purpose of communicating risks to clinicians and patients."

It can also be of practical value for **comparing doses related to stochastic effects** from: *different examinations and procedures*; the use of *similar technologies and procedures* in *different hospitals and countries*; and the use of *different alternative methodologies* for the same medical examination, provided that the *representative patients or patient populations for which the effective doses* are derived are similar with regard to age and sex.

Special cases

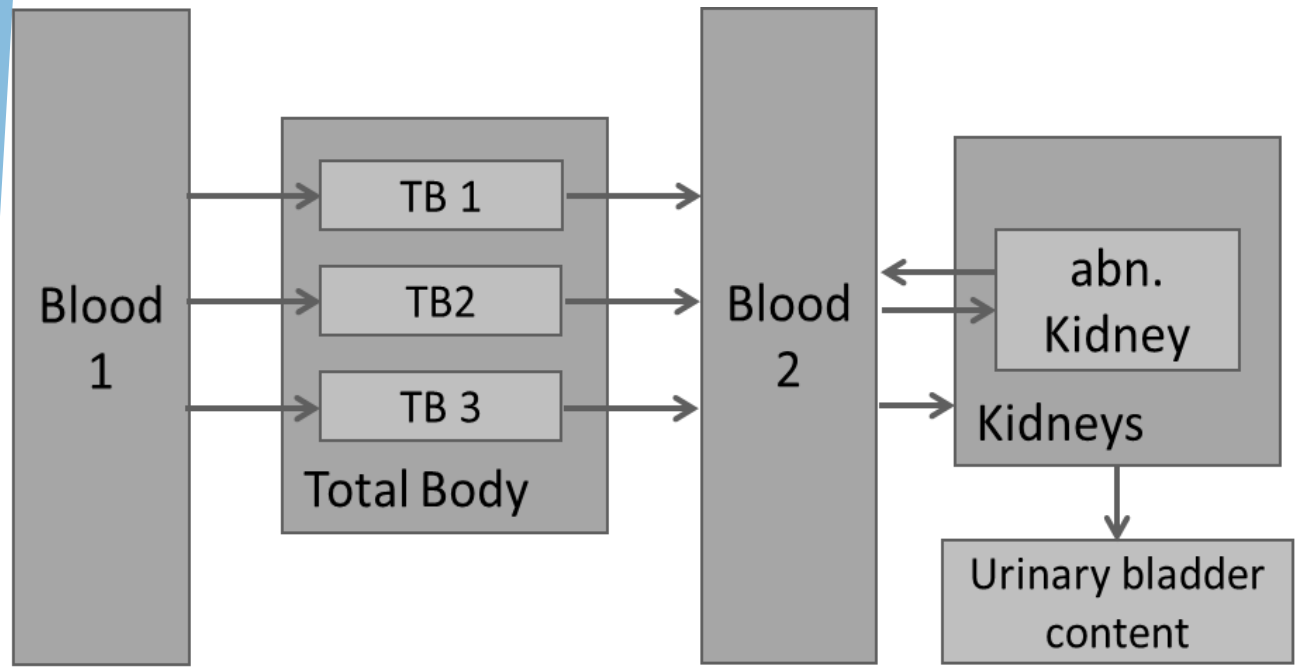
If patients of one sex only are involved, **an alternative quantity is calculated:**

$$\sum_T w_T \, H_T^F \text{ or } \sum_T w_T \, H_T^M,$$

depending on whether the examination is performed on female or male patients, respectively.

In the case where anatomical or physiological properties differ from those of the reference individual (e.g. abnormal liver masses in case of diffuse parenchymal liver disease, or ablated thyroid in thyroid cancer patients), the dose calculations are performed considering also these diverging characteristics. For these cases the missing tissue is not included or the abnormal mass is considered instead of the reference mass. This quantity is appropriately marked as $\sum_T w_T \left[\frac{H_T^F + H_T^M}{2}\right]^{\#}$ to indicate that it does not correspond to the formal definition of effective dose.

^{99m}Tc-labelled mercaptoacetyl triglycine (MAG3) - Unilateral kidney blockage



From	To	Normal renal function
Blood 1	Total Body 1	8.32E+00
Blood 1	Total Body 2	8.32e+00
Blood 1	Total Body 3	4.16E+00
Total Body 1	Blood 2	2.48E+01
Total Body 2	Blood 2	1.31E+01
Total Body 3	Blood 2	9.60E-01
Blood 2	Kidneys	1.20E+02
Blood 2	Kidney (abn.)	0.00E+00
Kidney (abn)	Blood 2	0.00E+00
Kidneys	UB Contents	1.50E+01

^{99m}Tc-labelled mercaptoacetyl triglycine (MAG3) - Unilateral kidney blockage

$$H_T^{M,F}(r_T,\tau) = \sum_{r_S \neq kidney} \tilde{A}(r_S,\tau) \cdot S_w^{M,F}(r_T \leftarrow r_S) +$$

$$\tilde{A}(kidney_{blocked},\tau) \cdot S_w^{M,F}(r_T \leftarrow kidney_{blocked}) + \tilde{A}(kidney_{normal},\tau) \cdot S_w^{M,F}(r_T \leftarrow kidney_{normal})$$

Ratio dose from left kidney/dose from right kidney

Target region	$H_{T(L)}/H_{T(R)}$
Spleen	11.6
Stomach wall	3.24
Small intestine wall	1.76
…	
Gallbladder wall	0.227
Liver	0.223

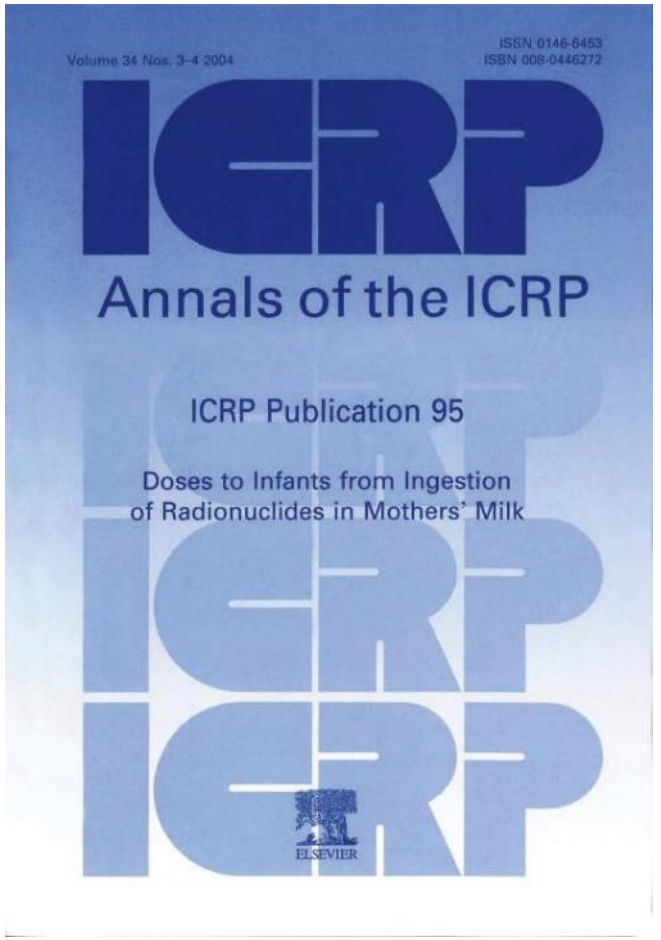
Further applications: Doses during pregnancy and breastfeeding

From M.C.Cantone: Radiation exposure of the embryo/foetus and the newborn child
In S.Mattsson and Ch.Hoeschen: Radiation Protection in Nuclear Medicine
Springer Verlag 2013

Not only doses due to intake of radionuclides contained in the mother's milk, but also external doses due to the activity in the mother's body

>

more realistic calculations using updated biokinetic models and computational phantoms



TG 130: Doses from Diagnostic Radiopharmaceuticals During Pregnancy and Breastfeeding

NEW!

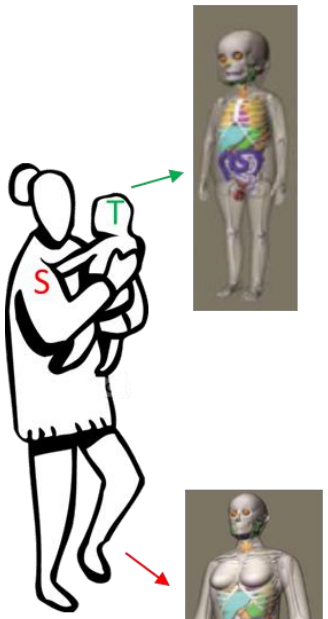
For the radiation exposure of breastfed infants **up to age 2 years**, the **internal exposure** due to secretion of radionuclides into the breast milk as well as the **external irradiation** from radionuclides in the breasts and whole body of the breastfeeding patient will be considered.

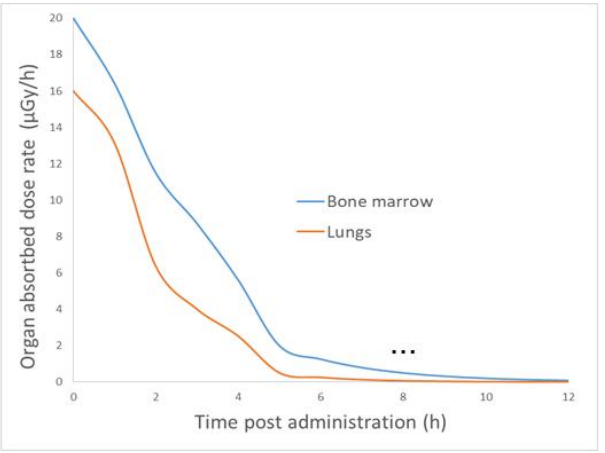
The biokinetic models presented in the **revision of Publication 128** (TG36) will be used as a starting point and **properly modified to account for the changes occurring during pregnancy and breastfeeding**, including transfer of material from the maternal to the fetal tissues.

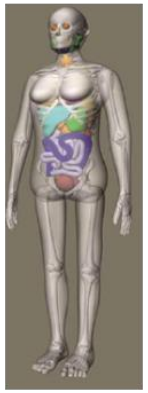
The fetal and paediatric dose coefficients will be calculated using the **ICRP paediatric reference computational models** as well as the pregnant and fetal phantoms developed by ICRP TG 96 and 103.

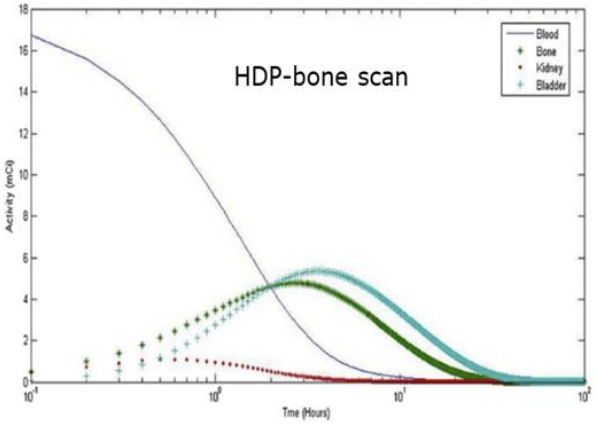
Collaboration with EURADOS: Doses during pregnancy and breastfeeding

- **Improve the assessment of external exposure with a computational approach**
- **Input**
  - Anthropomorphic computational models, both for patient and staff/caregiver(s)/family member(s)
  - Time activity curves from each relevant source organ in the patient
- **Output**
  - Organ absorbed dose rates over time for the target model









L.Struelens et al.: Joint Symposium EANM/EURADOS at the EANM 20 meeting
L.Struelens et al.: *Joint EURADOS-EANM initiative for an advanced computational framework for the assessment of external dose rates from nuclear medicine patients*, EJNMMI Physics (2024) 11:38

www.icrp.org