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RADIATION PROTECTION

ADDENDUM 3 TO ICRP PUBLICATION 53

**Radiation Dose to Patients
from Radiopharmaceuticals**

A report of a Task Group of Committees 2 and 3 of the
International Commission on Radiological Protection

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PREFACE

Through the years the International Commission on Radiological Protection (ICRP) has provided information on radiation doses to patients from radiopharmaceuticals. New publications or supplements have been issued with irregular intervals (ICRP, 1971; ICRP, 1987; ICRP, 1993; ICRP, 1998).

The most recent information is now found in ICRP Publication 80 (ICRP, 1998), which was published, in late 1999. It presents biokinetic and dosimetric data for 35 radionuclides, most of them frequently used in the clinical routine. There is also the hitherto most complete list of effective doses per unit activity administered to adults and an index to all radiopharmaceuticals treated in ICRP publications. For details on dose calculations and regarding data on less frequently used radionuclides it may still be worthwhile to go back to ICRP Publication 53 (ICRP, 1987).

This new web site report presents data on ^{99m}Tc -furifosmin, ^{99m}Tc -ethylenedicysteine (EC), ^{99m}Tc - N,N'-1,2-ethylenediylbis-L-cysteinediethylester (ECD) and various monoclonal antibodies and antibody fragments labelled with ^{99m}Tc , ^{111}In , ^{123}I and ^{131}I . The web site publishing is a way to make the information available without waiting for enough additional substances to warrant another printed report. Comments and suggestions on the biokinetic and dosimetric models are welcome and should be sent directly to the Scientific Secretary of ICRP.

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The membership of the Task Group preparing the report was:

S. Mattsson (Chairman)
L. Johansson
B. Nosslin
T. Smith
D.M.Taylor

Corresponding members were:

K. F. Eckerman
S. Leide-Svegborn
J. Liniecki
M. G. Stabin

The membership of the Committees during the period of preparation was:

Committee 2

A. Kaul (Chairman)	B. B. Boecker	A. Bouville
X. Chen	G. Dietze	K. F. Eckerman
F. A. Fry	J. Inaba	I. A. Likhtarev
J. L. Lipsztein	H. Métivier	H. Paretzke
A. R. Reddy	M. Roy	J. W. Stather (Vice-Chairman)
D. M. Taylor (Secretary)		

Committee 3

F. Mettler (Chairman)	J. M. Cosset	M. J. Guiberteau
L. K. Harding (Secretary)	J. Liniecki (Vice-Chairman)	S. Mattsson
H. Nakamura	P. Ortiz	L.V. Pinillos-Ashton
M. M. Rehani	H. Ringertz	M. Rosenstein
Y. Sasaki	C. Sharp	W. Yin
W. Y. Ussov		

2. BIOKINETIC MODELS, ABSORBED DOSES AND EFFECTIVE DOSES FOR INDIVIDUAL RADIOPHARMACEUTICALS

Technetium - labelled furifosmin (Q12) ^{99m}Tc

Biokinetic model

[Trans - 1,2 - bis (dihydro-2,2,5,5 - tetramethyl - 3(2H) furanone - 4 - methyleneimino ethane) bis tris (3- methoxy -1 propyl) – phosphine] technetium (III) - ^{99m}Tc is a nonreducible complex of Tc(III). Technetium (III) - ^{99m}Tc - Q12 is prepared from a freeze - dried kit (TechneCard) and is used for studies of myocardial perfusion.

^{99m}Tc -Q12 accumulates in viable myocardial tissue in proportion to regional blood flow in a manner similar to thallos chloride. After intravenous injection, the substance is rapidly cleared from the blood (<5% left by 20 min.) and taken up predominantly in muscular tissues (including heart), liver and kidneys. Biodistribution is generally similar to that of ^{99m}Tc -MIBI (Cardiolite) (ICRP Publication 62, 1991) and ^{99m}Tc -tetrofosmin (Myoview) (ICRP Publication 80, 1998) but there are some differences, which have a bearing on diagnostic technique. ^{99m}Tc -Q12 shows a heart uptake of 1.2 to 2.4%. It is rapidly cleared from the liver (< 6.5% left by 1 hour) and lung uptake is low (4 %). More than 50% of the substance has entered excretory pathways by 24 h and the faecal:urinary excretion ratio is 60:40. It is assumed that the fractions of the substance taken up by the liver and kidneys are excreted in faeces and urine respectively. When the substance is injected in conjunction with an exercise stress test there is little change in heart uptake and biodistribution is similar to that observed at rest. The initial rate of urinary clearance is lower than at rest and the same faecal:urinary excretion ratio is assumed.

The quantitative figures for uptake and excretion in man, presented in the biokinetic data table below, are based on the rest and exercise studies of Rossetti et al., (1994) with supplementary information from the report of Gerson et al., (1994). Substance excreted by the hepatobiliary system is assumed to leave the body via the intestinal tract according to the ICRP model for GIT (ICRP, 1979).

The biodistribution and excretion data used to derive this model were based on a small number of subjects (7 at rest; 3 after exercise), with the result that significant differences between rest and exercise data could not be established. The difference between the biokinetic data tables presented for rest and exercise studies is therefore largely based on experience of models for similar ^{99m}Tc -labelled myocardial perfusion imaging agents such as MIBI and tetrofosmin.

References for ^{99m}Tc-labelled furifosmin

- Gerson MC, Lukes J, Deutsch E, Biniakiewicz D, Rohe RC, Washburn LC, Fortman C and Walsh RA (1994). Comparison of technetium 99m Q12 and thallium 201 for detection of angiographically documented coronary artery disease in humans. *J Nucl Cardiol* 1, 499 - 508.
- ICRP (1979). Limits for intakes of Radionuclides by Workers. ICRP Publication 30. Pergamon Press, Oxford.
- ICRP (1987). Radiation Dose to Patients from Radiopharmaceuticals. ICRP Publication 53. *Annals of the ICRP* 18 (1- 4).
- ICRP (1991). Radiological Protection in Biomedical Research. Radiation Dose to Patients from Radiopharmaceuticals: Addendum to ICRP Publication 53. ICRP Publication 62. *Annals of the ICRP* 22 (3).
- ICRP (1998). Radiation Dose to Patients from Radiopharmaceuticals. Addendum 2 to ICRP Publication 53. ICRP Publication 80. *Annals of the ICRP*, 28(3).
- Rossetti C, Vanoli G, Paganelli G, Kwiatkowski M, Zito F, Colombo F, Bonino C, Carpinelli A, Casati R, Deutsch K, Marmion M, Woulfe SR, Lunghi F, Deutsch E and Fazio F (1994). Human biodistribution, dosimetry and clinical use of technetium (III) - 99m - Q12. *J Nucl Med* 35, 1571 - 1580.

Biokinetic Data

Organ (S)	F_s	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
(1) Resting subject				
Heart	0.024	6 24	0.67 0.33	0.13
Liver	0.07	6	1.0	0.30
Gall bladder	0.20			0.35
<i>GI tract contents:</i>				
SI	0.60			0.72
ULI	0.60			0.94
LLI	0.60			0.46
Kidneys	0.052	1.0 24	0.5 0.5	0.21
Lungs	0.04	24	1.0	0.28
Other organs and tissues	0.814	0.42 36	0.48 0.52	3.37
Bladder contents:	0.40			
<i>Adult and 15 years</i>				0.47
<i>10 years</i>				0.40
<i>5 and 1 year</i>				0.26

Biokinetic Data (Continued)

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
(2) Exercise				
Heart	0.027	6 24	0.67 0.33	0.14
Liver	0.06	6	1.0	0.26
Gall bladder	0.20			0.29
<i>GI tract contents:</i>				
SI	0.60			0.59
ULI	0.60			0.77
LLI	0.60			0.38
Kidneys	0.08	1.3 24	0.75 0.25	0.23
Lungs	0.04	24	1.0	0.28
Other organs and tissues	0.793	1 96	0.45 0.55	4.00
Bladder contents:	0.40			
<i>Adults and 15 years</i>				0.38
<i>10 years</i>				0.32
<i>5 years and 1 year</i>				0.21

Technetium-labelled furifosmin (Q12)
Resting subject

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	4.3E-03	5.5E-03	8.3E-03	1.2E-02	2.1E-02
Bladder	2.3E-02	2.9E-02	3.7E-02	4.0E-02	7.1E-02
Bone surfaces	5.1E-03	6.2E-03	9.1E-03	1.3E-02	2.4E-02
Brain	1.6E-03	2.0E-03	3.3E-03	5.3E-03	9.3E-03
Breast	1.8E-03	2.2E-03	3.5E-03	5.6E-03	1.1E-02
Gall bladder	5.1E-02	5.7E-02	7.5E-02	1.3E-01	4.4E-01
GI tract					
Stomach	4.6E-03	6.2E-03	1.0E-02	1.5E-02	2.6E-02
SI	1.9E-02	2.4E-02	3.9E-02	6.1E-02	1.1E-01
Colon	3.2E-02	4.1E-02	6.7E-02	1.1E-01	1.9E-01
(ULI	3.6E-02	4.7E-02	7.6E-02	1.2E-01	2.2E-01)
(LLI	2.6E-02	3.3E-02	5.5E-02	8.7E-02	1.6E-01)
Heart	7.8E-03	1.0E-02	1.5E-02	2.3E-02	4.0E-02
Kidneys	1.4E-02	1.7E-02	2.3E-02	3.4E-02	5.8E-02
Liver	6.9E-03	8.8E-03	1.3E-02	1.9E-02	3.4E-02
Lungs	5.5E-03	7.8E-03	1.1E-02	1.7E-02	3.1E-02
Muscles	3.1E-03	3.9E-03	5.8E-03	8.5E-03	1.5E-02
Oesophagus	2.5E-03	3.2E-03	4.6E-03	7.1E-03	1.3E-02
Ovaries	1.0E-02	1.3E-02	1.9E-02	2.7E-02	4.6E-02
Pancreas	5.1E-03	6.6E-03	1.1E-02	1.7E-02	2.7E-02
Red marrow	3.7E-03	4.4E-03	6.4E-03	8.6E-03	1.4E-02
Skin	1.7E-03	2.0E-03	3.1E-03	5.0E-03	9.3E-03
Spleen	3.6E-03	4.7E-03	7.4E-03	1.1E-02	2.0E-02
Testes	2.7E-03	3.5E-03	5.5E-03	8.1E-03	1.5E-02
Thymus	2.5E-03	3.2E-03	4.6E-03	7.1E-03	1.3E-02
Thyroid	2.0E-03	2.6E-03	4.2E-03	6.7E-03	1.2E-02
Uterus	8.8E-03	1.1E-02	1.7E-02	2.3E-02	3.9E-02
Remaining organs	3.8E-03	4.9E-03	7.6E-03	1.2E-02	2.0E-02
Effective dose (mSv/MBq)	1.0E-02	1.3E-02	1.7E-02	2.9E-02	5.7E-02

Technetium-labelled furifosmin (Q12)

Exercise

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	4.5E-03	5.7E-03	8.7E-03	1.3E-02	2.2E-02
Bladder	1.9E-02	2.4E-02	3.1E-02	3.4E-02	6.1E-02
Bone surfaces	5.5E-03	6.6E-03	9.7E-03	1.4E-02	2.6E-02
Brain	1.9E-03	2.4E-03	3.9E-03	6.3E-03	1.1E-02
Breast	2.0E-03	2.5E-03	3.9E-03	6.2E-03	1.2E-02
Gall bladder	4.2E-02	4.8E-02	6.3E-02	1.1E-01	3.6E-01
GI tract					
Stomach	4.6E-03	6.2E-03	1.0E-02	1.5E-02	2.5E-02
SI	1.6E-02	2.1E-02	3.3E-02	5.1E-02	9.3E-02
Colon	2.7E-02	3.4E-02	5.7E-02	8.9E-02	1.7E-01
(ULI	3.1E-02	3.9E-02	6.4E-02	1.0E-01	1.9E-01)
(LLI	2.2E-02	2.8E-02	4.7E-02	7.4E-02	1.4E-01)
Heart	8.7E-03	1.1E-02	1.7E-02	2.5E-02	4.4E-02
Kidneys	1.5E-02	1.8E-02	2.5E-02	3.6E-02	6.1E-02
Liver	6.3E-03	7.9E-03	1.2E-02	1.7E-02	3.0E-02
Lungs	5.6E-03	8.0E-03	1.1E-02	1.7E-02	3.1E-02
Muscles	3.2E-03	4.0E-03	6.0E-03	8.9E-03	1.6E-02
Oesophagus	2.9E-03	3.6E-03	5.2E-03	8.1E-03	1.4E-02
Ovaries	9.3E-03	1.2E-02	1.7E-02	2.5E-02	4.2E-02
Pancreas	5.2E-03	6.7E-03	1.1E-02	1.6E-02	2.7E-02
Red marrow	3.7E-03	4.5E-03	6.6E-03	9.0E-03	1.5E-02
Skin	1.8E-03	2.2E-03	3.4E-03	5.5E-03	1.0E-02
Spleen	3.9E-03	4.9E-03	7.8E-03	1.2E-02	2.1E-02
Testes	2.8E-03	3.6E-03	5.6E-03	8.4E-03	1.5E-02
Thymus	2.9E-03	3.6E-03	5.2E-03	8.1E-03	1.4E-02
Thyroid	2.4E-03	3.0E-03	4.9E-03	7.8E-03	1.4E-02
Uterus	8.0E-03	1.0E-02	1.5E-02	2.1E-02	3.6E-02
Remaining organs	3.8E-03	4.9E-03	7.5E-03	1.2E-02	2.0E-02
Effective dose (mSv/MBq)	9.0E-03	1.1E-02	1.6E-02	2.6E-02	5.1E-02

Technetium labelled ethylenedicysteine (EC)

Biokinetic Model

The substance ^{99m}Tc -ethylenedicysteine (EC) is used for renal studies. The biokinetic behaviour of the substance is very similar to that of Hippuran with a half time in the total body of 25 minutes (ICRP, 1987). The cumulated amount found in urine at different times is as follows: 40 min - 70%, 60 min - 80%, 90 min - 95% (Liniecki, 1998). The clearance is roughly 70% of that of Hippuran.

References for ^{99m}Tc -labelled ethylenedicysteine (EC)

- ICRP (1987). Radiation Dose to Patients from Radiopharmaceuticals. ICRP Publication 53. Annals of the ICRP 18 (1- 4).
- Liniecki J. (1998). Private communication. Department of Nuclear Medicine, Medical University of Lodz, Poland.
- Surma M.J.; Wiewiora J and Liniecki J (1994). Usefulness of ^{99m}Tc -N,N'-ethylene-1-dicysteine complex for dynamic kidney investigations. Nucl Med Comm, 15, 628-635.
- Surma M.J. (1998). Verification of ^{99m}Tc -ethylenedicysteine (^{99m}Tc -EC) distribution model in the organism. Nucl. Med. Rev. 1, 29-32
- Surma M.J. (1998). ^{99m}Tc -Ethylenedicysteine (^{99m}Tc -EC) renal clearance determination error for the multiple – and single – sample methods. Nucl. Med. Rev. 1, 33-40

Biokinetic Data

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
(1) Normal renal function				
Total body (excl. bladder contents)	1.0	0.42	1.0	0.56
Kidneys	1.0			0.062
Bladder contents	1.0			
<i>Adults and 15 years</i>				2.31
<i>10 years</i>				1.97
<i>5 years and 1 year</i>				1.27
(2) Abnormal renal function				
Total body (excl. bladder contents)	1.0	4.2	1.0	3.55
Kidneys	1.0			0.20
Liver	0.04	4.2	1.0	0.14
Bladder contents	1.0			
<i>Adults and 15 years</i>				1.00
<i>10 years</i>				0.86
<i>5 years and 1 year</i>				0.58
(3) Acute unilateral renal blockage				
Total body (excl. bladder contents)	1.0	0.42 120	0.5 0.5	4.42
Normal kidney	1.0			0.033
Abnormal kidney	0.5	120	1.0	4.14
Bladder contents	1.0			
<i>Adults and 15 years</i>				1.19
<i>10 years</i>				1.02
<i>5 years and 1 year</i>				0.66

Technetium-labelled EC

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	5.7E-04	7.3E-04	1.1E-03	1.7E-03	3.2E-03
Bladder	9.4E-02	1.2E-01	1.5E-01	1.4E-01	2.6E-01
Bone surfaces	1.4E-03	1.8E-03	2.4E-03	2.8E-03	5.0E-03
Brain	2.5E-04	3.1E-04	5.1E-04	8.2E-04	1.4E-03
Breast	2.2E-04	2.9E-04	4.5E-04	7.1E-04	1.4E-03
Gall bladder	7.4E-04	1.1E-03	2.2E-03	2.1E-03	3.2E-03
GI tract					
Stomach	5.5E-04	7.0E-04	1.3E-03	1.7E-03	3.1E-03
SI	2.3E-03	2.9E-03	4.0E-03	4.3E-03	7.4E-03
Colon	3.2E-03	4.0E-03	5.5E-03	5.5E-03	8.9E-03
(ULI	1.7E-03	2.3E-03	3.3E-03	3.9E-03	6.5E-03)
(LLI	5.2E-03	6.3E-03	8.3E-03	7.6E-03	1.2E-02)
Heart	3.7E-04	4.7E-04	7.1E-04	1.1E-03	2.1E-03
Kidneys	3.4E-03	4.1E-03	5.8E-03	8.3E-03	1.4E-02
Liver	4.8E-04	6.3E-04	1.0E-03	1.5E-03	2.7E-03
Lungs	3.1E-04	4.2E-04	6.3E-04	9.6E-04	1.8E-03
Muscles	1.4E-03	1.7E-03	2.2E-03	2.4E-03	4.2E-03
Oesophagus	3.0E-04	3.9E-04	5.9E-04	9.2E-04	1.7E-03
Ovaries	4.9E-03	6.2E-03	7.8E-03	7.6E-03	1.2E-02
Pancreas	5.9E-04	7.3E-04	1.2E-03	1.8E-03	3.3E-03
Red marrow	9.9E-04	1.3E-03	1.7E-03	1.7E-03	2.6E-03
Skin	5.2E-04	6.4E-04	9.3E-04	1.2E-03	2.1E-03
Spleen	5.3E-04	6.9E-04	1.1E-03	1.6E-03	3.0E-03
Testes	3.4E-03	4.8E-03	7.2E-03	7.4E-03	1.3E-02
Thymus	3.0E-04	3.9E-04	5.9E-04	9.2E-04	1.7E-03
Thyroid	3.0E-04	3.8E-04	6.1E-04	9.9E-04	1.8E-03
Uterus	1.1E-02	1.3E-02	1.7E-02	1.6E-02	2.6E-02
Remaining organs	1.4E-03	1.7E-03	2.1E-03	2.2E-03	3.6E-03
Effective dose (mSv/MBq)	6.3E-03	8.0E-03	1.0E-02	1.0E-02	1.8E-02

Bladder wall contributes to 79 % of the effective dose when the first voiding occurs after 3.5 hours.

Effective dose if bladder is emptied the first time at:

1 hour	2.5E-03	3.2E-03	4.5E-03	5.8E-03	1.0E-02
30 min after administration	3.1E-03	4.0E-03	5.3E-03	5.7E-03	1.0E-02

Technetium-labelled EC (Abnormal renal function)

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	2.8E-03	3.5E-03	5.2E-03	7.8E-03	1.4E-02
Bladder	4.3E-02	5.4E-02	7.4E-02	9.8E-02	1.8E-01
Bone surfaces	3.8E-03	4.5E-03	6.6E-03	9.6E-03	1.7E-02
Brain	1.6E-03	1.9E-03	3.2E-03	5.1E-03	9.0E-03
Breast	1.3E-03	1.7E-03	2.4E-03	3.9E-03	7.5E-03
Gall bladder	2.8E-03	3.8E-03	6.2E-03	8.7E-03	1.1E-02
GI tract					
Stomach	2.3E-03	3.0E-03	4.9E-03	6.9E-03	1.2E-02
SI	3.2E-03	4.1E-03	6.1E-03	9.1E-03	1.6E-02
Colon	3.6E-03	4.5E-03	6.7E-03	9.8E-03	1.7E-02
(ULI	3.0E-03	3.9E-03	5.7E-03	8.9E-03	1.5E-02)
(LLI	4.3E-03	5.4E-03	8.1E-03	1.1E-02	1.9E-02)
Heart	2.2E-03	2.7E-03	4.1E-03	6.1E-03	1.1E-02
Kidneys	1.2E-02	1.4E-02	1.9E-02	2.8E-02	4.8E-02
Liver	2.8E-03	3.6E-03	5.4E-03	7.7E-03	1.3E-02
Lungs	1.9E-03	2.4E-03	3.6E-03	5.5E-03	1.0E-02
Muscles	2.2E-03	2.7E-03	4.1E-03	6.1E-03	1.1E-02
Oesophagus	1.9E-03	2.4E-03	3.5E-03	5.4E-03	9.9E-03
Ovaries	4.3E-03	5.4E-03	7.8E-03	1.1E-02	1.9E-02
Pancreas	2.8E-03	3.4E-03	5.2E-03	7.8E-03	1.4E-02
Red marrow	2.2E-03	2.7E-03	4.1E-03	5.8E-03	1.0E-02
Skin	1.4E-03	1.6E-03	2.6E-03	4.1E-03	7.6E-03
Spleen	2.5E-03	3.1E-03	4.8E-03	7.2E-03	1.3E-02
Testes	3.0E-03	4.0E-03	6.2E-03	9.2E-03	1.7E-02
Thymus	1.9E-03	2.4E-03	3.5E-03	5.4E-03	9.9E-03
Thyroid	1.9E-03	2.4E-03	3.8E-03	6.1E-03	1.1E-02
Uterus	6.8E-03	8.2E-03	1.2E-02	1.6E-02	2.8E-02
Remaining organs	2.3E-03	2.9E-03	4.4E-03	6.7E-03	1.2E-02
Effective dose (mSv/MBq)	4.6E-03	5.9E-03	8.5E-03	1.2E-02	2.1E-02

Technetium-labelled EC (Acute unilateral renal blockage)

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	1.1E-02	1.5E-02	2.3E-02	3.3E-02	5.7E-02
Bladder	4.9E-02	6.2E-02	7.7E-02	7.5E-02	1.4E-01
Bone surfaces	3.1E-03	4.1E-03	6.0E-03	8.6E-03	1.7E-02
Brain	1.3E-04	1.6E-04	2.7E-04	4.5E-04	8.7E-04
Breast	4.1E-04	5.4E-04	1.1E-03	1.7E-03	3.1E-03
Gall bladder	6.5E-03	7.5E-03	1.1E-02	1.6E-02	2.4E-02
GI tract					
Stomach	4.0E-03	4.6E-03	7.3E-03	9.6E-03	1.3E-02
SI	4.3E-03	5.5E-03	8.5E-03	1.1E-02	1.9E-02
Colon	3.8E-03	4.8E-03	7.0E-03	8.9E-03	1.4E-02
(ULI	4.0E-03	5.1E-03	7.6E-03	1.0E-02	1.6E-02)
(LLI	3.5E-03	4.4E-03	6.2E-03	7.5E-03	1.2E-02)
Heart	1.4E-03	1.7E-03	2.8E-03	4.2E-03	6.4E-03
Kidneys	2.0E-01	2.4E-01	3.4E-01	4.8E-01	8.4E-01
Liver	4.6E-03	5.6E-03	8.4E-03	1.2E-02	1.7E-02
Lungs	1.1E-03	1.7E-03	2.6E-03	4.1E-03	7.5E-03
Muscles	2.2E-03	2.7E-03	3.7E-03	5.1E-03	8.9E-03
Oesophagus	4.1E-04	5.8E-04	9.1E-04	1.6E-03	2.4E-03
Ovaries	3.6E-03	4.7E-03	6.6E-03	8.6E-03	1.4E-02
Pancreas	7.7E-03	9.3E-03	1.4E-02	1.9E-02	3.0E-02
Red marrow	3.0E-03	3.6E-03	5.0E-03	6.2E-03	8.5E-03
Skin	8.3E-04	1.0E-03	1.5E-03	2.2E-03	4.2E-03
Spleen	1.0E-02	1.3E-02	1.9E-02	2.7E-02	4.1E-02
Testes	1.8E-03	2.5E-03	3.9E-03	4.2E-03	8.4E-03
Thymus	4.1E-04	5.8E-04	9.1E-04	1.6E-03	2.4E-03
Thyroid	1.9E-04	2.7E-04	5.0E-04	1.0E-03	1.8E-03
Uterus	6.4E-03	7.8E-03	1.1E-02	1.2E-02	2.0E-02
Remaining organs	2.2E-03	2.7E-03	3.6E-03	4.3E-03	6.8E-03
Effective dose (mSv/MBq)	9.9E-03	1.2E-02	1.7E-02	2.2E-02	3.7E-02

Technetium-labelled ECD (Neurolite) ^{99m}Tc

Biokinetic Model

N,N'-1,2-ethylenediylbis-L-cysteinediethylester (ECD) labelled with ^{99m}Tc, is a neutral lipophilic complex which rapidly crosses the intact blood-brain barrier and is retained in the brain for a long time, making it possible to perform detailed tomographic studies of the regional cerebral blood flow.

Kinetic data from humans, published by Holman et al., (1989), Vallabhajosula et al., (1989) and Leveille et al., (1992) have shown that the substance is rapidly cleared from the blood after intravenous injection. Uptake in the brain reaches a maximum of 4.9-6.5% within one minute and remains relatively constant over several hours. Early whole-body imaging also shows uptake in lungs, liver, kidneys and thyroid.

In the biokinetic model it is assumed that there is an immediate cellular uptake of the substance in the brain (0.06), lungs (0.06), liver (0.20), kidneys (0.10) and thyroid (0.003). The activity in the brain is cleared biexponentially with half-times of 1 h (0.40) and 1.5 d (0.60). At 48 hours about 80% has been excreted in urine and 20% in faeces. Activity in the liver is assumed to be excreted through the intestines, partly via the gall bladder, according to the model described in Appendix Section A.9 in *ICRP Publication 53*. The rest of the activity is assumed to be excreted via the kidneys and urinary bladder.

For children the fractional uptake in the brain is higher due to the relative weight of the brain (Barthel et al., 1997).

References for ^{99m}Tc-labelled ECD

- Vallabhajosula S, Zimmerman R.E, Picard M, Stritzke P, Mena I, Hellman R.S, Tikofsky R.S, Stabin M.G, Morgan R.A and Goldsmith S.J. (1989) Technetium-99m ECD: A new brain imaging agent: In vivo kinetics and biodistribution studies in normal human subjects. *J Nucl Med* :30; 599-604.
- Holman B.L, Hellman R.S, Goldsmith S.J, Mena I, Leveille J, Gherardi P.G, Moretti J.L, Bischof-Delaloye A, Hill T.C, Rigo P.M, Van Heertum R.L, Ell P.J, Buell U, De Roo M.C and Morgan R.A. (1989): Biodistribution, dosimetry and clinical evaluation of technetium-99m ethyl cysteinyl dimer in normal subjects and in patients with chronic cerebral infarction. *J Nucl Med* :30; 1018-1024.
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- Barthel H, Wiener M, Dannenberg C, Bettin S, Sattler B and Knapp WH. (1997). Age-specific cerebral perfusion in 4- to 15-year-old children: a high-resolution brain SPET study using ^{99m}Tc-ECD. *Eur J Nucl Med* :24; 1245-1252.

Biokinetic Data

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Brain		1.0	0.4	
		36	0.6	
Adults	0.06			0.30
15 years	0.10			0.50
10 years	0.17			0.84
5 years	0.23			1.14
1 year	0.28			1.39
Lungs	0.06	0.25	0.8	0.082
		10	0.2	
Kidneys	0.10	0.50	0.9	0.13
		36	0.1	
Liver	0.20	0.50	0.9	0.27
		36	0.1	
Thyroid	0.003	1.0	0.7	0.0093
		36	0.3	
Gall bladder	0.07			0.19
<i>Gastrointestinal tract contents</i>				
SI	0.20			0.44
ULI	0.20			0.58
LLI	0.20			0.28
Bladder	0.80			
Adults				1.16
15 years				1.15
10 years				0.95
5 years				0.60
1 year				0.58
Other organs and tissues		1.0	0.7	
		36	0.3	
Adults	0.577			1.79
15 years	0.537			1.66
10 years	0.467			1.45
5 years	0.407			1.26
1 year	0.357			1.11

Technetium-labelled ECD

^{99m} Tc 6.01 hours					
Absorbed dose per unit activity administered (mGy/MBq)					
Organ	Adult	15 years	10 years	5 years	1 year
Adrenals	2.6E-03	3.2E-03	4.7E-03	6.7E-03	1.1E-02
Bladder	4.9E-02	6.1E-02	7.4E-02	7.2E-02	1.3E-01
Bone surfaces	3.4E-03	4.2E-03	6.2E-03	9.0E-03	1.5E-02
Brain	4.9E-03	8.0E-03	1.4E-02	1.9E-02	3.1E-02
Breast	8.9E-04	1.1E-03	1.6E-03	2.4E-03	4.3E-03
Gall bladder	2.7E-02	3.1E-02	4.0E-02	7.0E-02	2.3E-01
GI tract					
Stomach	2.6E-03	3.4E-03	5.4E-03	7.9E-03	1.3E-02
SI	1.2E-02	1.5E-02	2.3E-02	3.5E-02	6.3E-02
Colon	1.9E-02	2.4E-02	3.9E-02	6.0E-02	1.1E-01
(ULI)	2.1E-02	2.7E-02	4.4E-02	6.8E-02	1.3E-01
(LLI)	1.7E-02	2.1E-02	3.3E-02	5.0E-02	9.4E-02
Heart	1.6E-03	2.0E-03	2.9E-03	4.1E-03	7.1E-03
Kidneys	1.1E-02	1.3E-02	1.8E-02	2.6E-02	4.4E-02
Liver	5.0E-03	6.3E-03	9.4E-03	1.3E-02	2.4E-02
Lungs	2.1E-03	2.9E-03	4.0E-03	5.9E-03	1.1E-02
Muscles	2.2E-03	2.6E-03	3.6E-03	4.9E-03	8.6E-03
Oesophagus	1.2E-03	1.5E-03	2.0E-03	2.9E-03	5.1E-03
Ovaries	7.5E-03	9.4E-03	1.3E-02	1.7E-02	2.7E-02
Pancreas	3.0E-03	3.7E-03	6.0E-03	8.9E-03	1.4E-02
Red marrow	2.4E-03	2.9E-03	4.1E-03	5.3E-03	8.8E-03
Skin	1.1E-03	1.3E-03	1.9E-03	2.8E-03	5.2E-03
Spleen	2.1E-03	2.6E-03	4.0E-03	5.8E-03	9.7E-03
Testes	2.7E-03	3.6E-03	5.2E-03	6.1E-03	1.1E-02
Thymus	1.2E-03	1.5E-03	2.0E-03	2.9E-03	5.1E-03
Thyroid	6.1E-03	9.6E-03	1.5E-02	3.1E-02	5.8E-02
Uterus	8.9E-03	1.1E-02	1.5E-02	1.7E-02	2.8E-02
Remaining organs	2.7E-03	3.8E-03	6.6E-03	1.3E-02	2.1E-02
Effective dose (mSv/MBq)	7.4E-03	9.6E-03	1.4E-02	1.9E-02	3.9E-02

Technetium-labelled monoclonal tumour-associated antibodies ^{99m}Tc

Biokinetic model

Radiolabelled monoclonal antibodies against antigenic substances within or on the surface of malignant cells are used in medical research and for diagnosis and treatment of cancer. The antibody is an immunoglobulin, usually of type IgG₁ or IgG_{2a}, and is used either as the intact molecule (m.w. 150 kDa) or as fragments F(ab')₂ (100 kDa) and Fab' (50 kDa). Antibodies against a large number of tumour-associated antigens have been produced and investigated, but only a few are now in regular use as commercial products for diagnostic purposes.

There is a great variation in production with regard to type of antigen, kind of cells used (mouse, goat, human etc.), and possible genetic modification (chimeric, humanised). There is also variation in the mode of application of the product, with regard to amount of substance administered, possible pre-treatment with unlabelled antibody or other modifying substances, route of administration (intravenous injection or infusion, subcutaneous or intraperitoneal injection etc.), type of radionuclide used as label and method of labelling.

In spite of these variations certain common features in the behaviour of the antibodies can be distinguished. Directly after intravenous injection the highest activity is seen in organs with high vascular perfusion, such as liver, spleen, red bone marrow and kidneys. Organ uptake is mainly a function of molecular size; the intact molecule showing uptake mainly in liver and red bone marrow while smaller fragments concentrate to a higher degree in the kidneys. Also the rate of degradation and elimination is mainly a function of molecular size, being more rapid with the smaller fragments.

Based on these general properties a set of models can be defined, assuming principal uptake in the above-mentioned organs and an even distribution of the remainder in the rest of the body. The quantitative data for uptake and elimination have been defined after an extensive survey of published reports, and are to be looked upon as typical values for the intact antibody and "large" and "small" fragments.

The antibodies and fragments are metabolised within the body. The technetium thus set free is then assumed to be handled by the body according to the biokinetic model for pertechnetate (ICRP, 1987). The contribution from released technetium can be calculated as:

$$\frac{T_p - T_{eff}}{T_p}$$

where T_p is the physical half-life, and T_{eff} is the effective half-life for the antibody.

References for monoclonal tumour-associated antibodies

- Britton, K.E. and Granowska, M. (1987). Radioimmunoscinigraphy in tumour identification. *Cancer Surveys* 6, 247-267 (47 references)
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- Fishman, A.J., Khaw, B.A. and Strauss, H.N. (1989). Quo Vadis Radioimmune Imaging. *J. Nucl. Med* 20, 1911-1915 (34 references)
- ICRP (1987). *Radiation Dose to Patients from Radiopharmaceuticals*. ICRP Publication 53. *Annals of the ICRP* 18 (1-4).

Biokinetic data

Intact antibody

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Liver	0.50	24	0.5	3.78
		96	0.5	
Spleen	0.09	24	0.5	0.68
		96	0.5	
Red bone marrow	0.20	24	0.5	1.51
		96	0.5	
Kidneys	0.03	24	0.5	0.23
		96	0.5	
Other organs and tissues	0.18	24	0.5	1.36
		96	0.5	
Released technetium	1.0	-24	0.5	*
		-96	0.5	

*To obtain the contribution from released technetium the cumulated activities given in the pertechnetate model should be multiplied by 0.13.

F(ab')₂ fragments

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Liver	0.30	12	1.0	1.74
Spleen	0.06	12	1.0	0.35
Red bone marrow	0.10	12	1.0	0.58
Kidneys	0.20	12	1.0	1.16
Other organs and tissues	0.34	12	1.0	1.97
Released technetium	1.0	-12	1.0	*

*To obtain the contribution from released technetium the cumulated activities given in the pertechnetate model should be multiplied by 0.33.

Fab' fragments

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Liver	0.10	6.0	1.0	0.43
Spleen	0.02	6.0	1.0	0.09
Red bone marrow	0.03	6.0	1.0	0.13
Kidneys	0.40	6.0	1.0	1.73
Other organs and tissues	0.45	6.0	1.0	1.95
Released technetium	1.0	-6.0	1.0	*

*To obtain the contribution from released technetium the cumulated activities given in the pertechnetate model should be multiplied by 0.50.

Tc-labelled monoclonal antibodies

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	1.0E-02	1.2E-02	1.8E-02	2.4E-02	3.7E-02
Bladder	3.7E-03	4.9E-03	6.9E-03	9.6E-03	1.6E-02
Bone surfaces	1.2E-02	1.6E-02	2.6E-02	4.4E-02	1.0E-01
Brain	1.4E-03	1.7E-03	2.6E-03	4.2E-03	7.9E-03
Breast	2.1E-03	2.6E-03	4.3E-03	6.6E-03	1.2E-02
Gall bladder	1.5E-02	1.7E-02	2.4E-02	3.7E-02	6.1E-02
GI tract					
Stomach	8.4E-03	1.1E-02	1.6E-02	2.6E-02	4.6E-02
SI	5.6E-03	7.0E-03	1.1E-02	1.7E-02	2.9E-02
Colon	8.9E-03	1.1E-02	1.9E-02	3.0E-02	5.4E-02
(ULI	1.2E-02	1.5E-02	2.5E-02	4.1E-02	7.3E-02)
(LLI	4.9E-03	6.4E-03	1.0E-02	1.6E-02	2.8E-02)
Heart	5.5E-03	6.9E-03	1.0E-02	1.4E-02	2.5E-02
Kidneys	1.9E-02	2.2E-02	3.2E-02	4.5E-02	7.4E-02
Liver	4.5E-02	5.8E-02	8.5E-02	1.2E-01	2.1E-01
Lungs	4.9E-03	6.3E-03	8.7E-03	1.3E-02	2.2E-02
Muscles	2.9E-03	3.7E-03	5.4E-03	7.9E-03	1.4E-02
Oesophagus	2.5E-03	3.0E-03	4.3E-03	6.5E-03	1.1E-02
Ovaries	4.0E-03	5.1E-03	7.6E-03	1.1E-02	1.9E-02
Pancreas	1.1E-02	1.4E-02	2.0E-02	3.0E-02	4.8E-02
Red marrow	1.7E-02	1.9E-02	3.0E-02	5.2E-02	1.1E-01
Salivary glands	4.2E-03	5.4E-03	7.6E-03	1.1E-02	1.7E-02
Skin	1.6E-03	1.9E-03	3.0E-03	4.7E-03	8.9E-03
Spleen	6.0E-02	8.4E-02	1.3E-01	1.9E-01	3.4E-01
Testes	1.3E-03	1.6E-03	2.6E-03	4.2E-03	7.7E-03
Thymus	2.5E-03	3.0E-03	4.3E-03	6.5E-03	1.1E-02
Thyroid	4.0E-03	6.0E-03	9.2E-03	1.9E-02	3.5E-02
Uterus	3.3E-03	4.2E-03	6.6E-03	1.0E-02	1.7E-02
Remaining organs	3.1E-03	4.0E-03	5.8E-03	8.7E-03	1.4E-02
Effective dose (mSv/MBq)	9.8E-03	1.2E-02	1.9E-02	3.0E-02	5.4E-02

Tc-labelled F(ab')₂ fragments

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	9.1E-03	1.1E-02	1.7E-02	2.4E-02	4.0E-02
Bladder	7.3E-03	9.6E-03	1.3E-02	1.6E-02	2.8E-02
Bone surfaces	8.3E-03	1.0E-02	1.6E-02	2.6E-02	5.6E-02
Brain	1.8E-03	2.3E-03	3.6E-03	5.8E-03	1.0E-02
Breast	2.0E-03	2.6E-03	4.0E-03	6.4E-03	1.2E-02
Gall bladder	1.1E-02	1.3E-02	1.9E-02	2.9E-02	4.6E-02
GI tract					
Stomach	1.3E-02	1.6E-02	2.3E-02	3.7E-02	7.0E-02
SI	8.1E-03	1.0E-02	1.6E-02	2.4E-02	4.2E-02
Colon	1.6E-02	2.2E-02	3.6E-02	5.7E-02	1.0E-01
(ULI	2.2E-02	2.9E-02	4.8E-02	7.7E-02	1.4E-01)
(LLI	9.0E-03	1.2E-02	1.9E-02	3.0E-02	5.5E-02)
Heart	4.4E-03	5.6E-03	8.3E-03	1.2E-02	2.1E-02
Kidneys	6.2E-02	7.4E-02	1.0E-01	1.5E-01	2.5E-01
Liver	2.3E-02	2.9E-02	4.3E-02	6.1E-02	1.1E-01
Lungs	3.9E-03	5.1E-03	7.3E-03	1.1E-02	1.9E-02
Muscles	3.3E-03	4.1E-03	6.0E-03	8.9E-03	1.6E-02
Oesophagus	2.6E-03	3.3E-03	4.8E-03	7.5E-03	1.3E-02
Ovaries	5.6E-03	7.1E-03	1.1E-02	1.6E-02	2.7E-02
Pancreas	9.4E-03	1.2E-02	1.7E-02	2.5E-02	4.1E-02
Red marrow	8.7E-03	9.7E-03	1.5E-02	2.5E-02	4.8E-02
Salivary glands	6.4E-03	7.2E-03	1.1E-02	1.6E-02	2.6E-02
Skin	1.8E-03	2.2E-03	3.5E-03	5.5E-03	1.0E-02
Spleen	3.4E-02	4.7E-02	7.1E-02	1.1E-01	1.9E-01
Testes	2.0E-03	2.6E-03	4.0E-03	6.3E-03	1.2E-02
Thymus	2.6E-03	3.3E-03	4.8E-03	7.5E-03	1.3E-02
Thyroid	8.5E-03	1.3E-02	2.0E-02	4.3E-02	8.0E-02
Uterus	4.8E-03	6.0E-03	9.3E-03	1.4E-02	2.4E-02
Remaining organs	3.6E-03	4.5E-03	6.8E-03	1.0E-02	1.8E-02
Effective dose (mSv/MBq)	9.7E-03	1.2E-02	1.8E-02	2.9E-02	5.2E-02

Tc-labelled Fab' fragments

^{99m}Tc 6.01 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	8.4E-03	1.1E-02	1.6E-02	2.4E-02	4.2E-02
Bladder	1.0E-02	1.3E-02	1.7E-02	2.0E-02	3.7E-02
Bone surfaces	6.3E-03	7.5E-03	1.1E-02	1.7E-02	3.2E-02
Brain	2.0E-03	2.5E-03	4.1E-03	6.5E-03	1.2E-02
Breast	1.9E-03	2.5E-03	3.8E-03	6.0E-03	1.1E-02
Gall bladder	8.7E-03	1.1E-02	1.7E-02	2.4E-02	3.6E-02
GI tract					
Stomach	1.6E-02	2.1E-02	2.9E-02	4.6E-02	9.0E-02
SI	1.0E-02	1.3E-02	2.0E-02	3.0E-02	5.2E-02
Colon	2.3E-02	3.0E-02	4.9E-02	8.0E-02	1.5E-01
(ULI	3.1E-02	4.0E-02	6.6E-02	1.1E-01	2.0E-01)
(LLI	1.2E-02	1.6E-02	2.6E-02	4.1E-02	7.6E-02)
Heart	3.7E-03	4.7E-03	7.1E-03	1.1E-02	1.8E-02
Kidneys	8.9E-02	1.1E-01	1.5E-01	2.1E-01	3.7E-01
Liver	8.7E-03	1.1E-02	1.7E-02	2.4E-02	4.0E-02
Lungs	3.1E-03	4.2E-03	6.2E-03	9.5E-03	1.7E-02
Muscles	3.4E-03	4.2E-03	6.2E-03	9.4E-03	1.7E-02
Oesophagus	2.6E-03	3.3E-03	4.9E-03	7.8E-03	1.4E-02
Ovaries	6.8E-03	8.6E-03	1.3E-02	1.9E-02	3.3E-02
Pancreas	8.1E-03	1.0E-02	1.5E-02	2.2E-02	3.5E-02
Red marrow	4.7E-03	5.5E-03	8.1E-03	1.2E-02	2.0E-02
Salivary glands	7.9E-03	9.8E-03	1.4E-02	1.9E-02	3.1E-02
Skin	1.9E-03	2.3E-03	3.7E-03	5.9E-03	1.1E-02
Spleen	1.4E-02	1.8E-02	2.8E-02	4.1E-02	7.0E-02
Testes	2.5E-03	3.2E-03	4.9E-03	7.5E-03	1.4E-02
Thymus	2.6E-03	3.3E-03	4.9E-03	7.8E-03	1.4E-02
Thyroid	1.2E-02	1.9E-02	2.9E-02	6.2E-02	1.2E-01
Uterus	5.8E-03	7.3E-03	1.1E-02	1.7E-02	2.8E-02
Remaining organs	3.7E-03	4.6E-03	6.9E-03	1.0E-02	1.8E-02
Effective dose (mSv/MBq)	1.1E-02	1.4E-02	2.0E-02	3.2E-02	5.9E-02

Indium-labelled monoclonal tumour-associated antibodies ¹¹¹In

Biokinetic model

The models for indium-labelled monoclonal tumour-associated antibodies and fragments are the same as those used for the corresponding technetium-labelled substances, with the modification that released indium is handled by the body according to the model for ionic indium (ICRP, 1987).

N.b. This biokinetic model is not intended to apply to therapeutic use of the substance.

References for ¹¹¹In-labelled monoclonal tumour-associated antibodies

ICRP (1987). *Radiation Dose to Patients from Radiopharmaceuticals*. ICRP Publication 53. *Annals of the ICRP* **18** (1-4).

Biokinetic data

Intact antibody

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Liver	0.50	24	0.5	20.7
		96	0.5	
Spleen	0.09	24	0.5	3.73
		96	0.5	
Red bone marrow	0.20	24	0.5	8.30
		96	0.5	
Kidneys	0.03	24	0.5	1.24
		96	0.5	
Other organs and tissues	0.18	24	0.5	7.47
		96	0.5	
Released indium	1.0	-24 -96	0.5 0.5	*

*To obtain the contribution from released indium the cumulated activities given in the model for ionic indium should be multiplied by 0.58.

F(ab')₂ fragments

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Liver	0.30	12	1.0	4.41
Spleen	0.06	12	1.0	0.88
Red bone marrow	0.10	12	1.0	1.47
Kidneys	0.20	12	1.0	2.94
Other organs and tissues	0.34	12	1.0	5.00
Released indium	1.0	-12	1.0	*

*To obtain the contribution from released indium the cumulated activities given in the model for ionic indium should be multiplied with by 0.85.

Fab' fragments

Organ (S)	F_S	$T_{1/2}$ (hours)	a	\tilde{A}_S/A_0 (hours)
Liver	0.10	6.0	1.0	0.80 h
Spleen	0.02	6.0	1.0	0.16 h
Red bone marrow	0.03	6.0	1.0	0.24 h
Kidneys	0.40	6.0	1.0	3.18 h
Other organs and tissues	0.45	6.0	1.0	3.58 h
Released indium	1.0	-6.0	1.0	*

*To obtain the contribution from released indium the cumulated activities given in the model for ionic indium should be multiplied by 0.92.

In-labelled monoclonal antibodies¹¹¹In 67.92 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	3.1E-01	3.7E-01	5.3E-01	7.2E-01	1.2E+00
Bladder	7.8E-02	9.9E-02	1.6E-01	2.4E-01	4.1E-01
Bone surfaces	3.9E-01	5.1E-01	8.1E-01	1.4E+00	3.3E+00
Brain	5.7E-02	7.3E-02	1.1E-01	1.8E-01	3.3E-01
Breast	6.9E-02	8.5E-02	1.4E-01	2.1E-01	3.8E-01
Gall bladder	3.8E-01	4.3E-01	6.0E-01	9.2E-01	1.6E+00
GI tract					
Stomach	1.6E-01	2.0E-01	3.1E-01	4.8E-01	8.3E-01
SI	1.5E-01	1.8E-01	2.8E-01	4.3E-01	7.1E-01
Colon	1.4E-01	1.7E-01	2.7E-01	4.2E-01	6.9E-01
(ULI	1.6E-01	2.0E-01	3.2E-01	5.1E-01	8.4E-01)
(LLI	1.1E-01	1.4E-01	2.1E-01	3.0E-01	4.9E-01)
Heart	1.6E-01	2.0E-01	2.9E-01	4.1E-01	7.3E-01
Kidneys	8.0E-01	9.5E-01	1.3E+00	1.9E+00	3.1E+00
Liver	1.1E+00	1.4E+00	2.0E+00	2.8E+00	4.8E+00
Lungs	1.4E-01	1.8E-01	2.6E-01	3.8E-01	6.7E-01
Muscles	9.6E-02	1.2E-01	1.8E-01	2.6E-01	4.8E-01
Oesophagus	8.6E-02	1.0E-01	1.5E-01	2.2E-01	3.8E-01
Ovaries	1.2E-01	1.5E-01	2.2E-01	3.3E-01	5.5E-01
Pancreas	2.9E-01	3.5E-01	5.3E-01	8.0E-01	1.3E+00
Red marrow	5.7E-01	6.2E-01	9.7E-01	1.7E+00	3.4E+00
Skin	5.4E-02	6.5E-02	1.0E-01	1.6E-01	3.1E-01
Spleen	1.1E+00	1.5E+00	2.2E+00	3.4E+00	5.9E+00
Testes	4.8E-02	6.2E-02	9.5E-02	1.5E-01	2.7E-01
Thymus	8.6E-02	1.0E-01	1.5E-01	2.2E-01	3.8E-01
Thyroid	6.6E-02	8.2E-02	1.2E-01	2.0E-01	3.6E-01
Uterus	1.1E-01	1.3E-01	2.0E-01	3.0E-01	5.0E-01
Remaining organs	1.0E-01	1.3E-01	2.0E-01	3.0E-01	5.1E-01
Effective dose (mSv/MBq)	2.4E-01	3.0E-01	4.5E-01	6.9E-01	1.3E+00

In-labelled F(ab')₂ fragments

¹¹¹In 67.92 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	2.7E-01	3.3E-01	4.7E-01	6.6E-01	1.1E+00
Bladder	8.8E-02	1.1E-01	1.7E-01	2.6E-01	4.4E-01
Bone surfaces	3.9E-01	5.0E-01	8.0E-01	1.4E+00	3.3E+00
Brain	6.5E-02	8.3E-02	1.3E-01	2.0E-01	3.8E-01
Breast	6.6E-02	8.2E-02	1.3E-01	1.9E-01	3.5E-01
Gall bladder	2.9E-01	3.3E-01	4.6E-01	7.0E-01	1.1E+00
GI tract					
Stomach	1.4E-01	1.7E-01	2.7E-01	4.0E-01	6.8E-01
SI	1.5E-01	1.8E-01	2.8E-01	4.1E-01	6.7E-01
Colon	1.4E-01	1.7E-01	2.6E-01	3.9E-01	6.4E-01
(ULI	1.5E-01	1.9E-01	2.9E-01	4.5E-01	7.3E-01)
(LLI	1.2E-01	1.5E-01	2.2E-01	3.2E-01	5.2E-01)
Heart	1.4E-01	1.7E-01	2.5E-01	3.5E-01	6.2E-01
Kidneys	1.2E+00	1.4E+00	1.9E+00	2.7E+00	4.6E+00
Liver	6.7E-01	8.6E-01	1.3E+00	1.7E+00	3.0E+00
Lungs	1.2E-01	1.6E-01	2.3E-01	3.3E-01	5.9E-01
Muscles	9.5E-02	1.2E-01	1.8E-01	2.6E-01	4.7E-01
Oesophagus	8.7E-02	1.1E-01	1.5E-01	2.3E-01	4.0E-01
Ovaries	1.3E-01	1.6E-01	2.3E-01	3.4E-01	5.7E-01
Pancreas	2.3E-01	2.8E-01	4.1E-01	6.2E-01	1.0E+00
Red marrow	5.6E-01	6.1E-01	9.5E-01	1.6E+00	3.3E+00
Skin	5.6E-02	6.7E-02	1.1E-01	1.7E-01	3.1E-01
Spleen	4.9E-01	6.7E-01	1.0E+00	1.5E+00	2.6E+00
Testes	5.8E-02	7.3E-02	1.1E-01	1.7E-01	3.1E-01
Thymus	8.7E-02	1.1E-01	1.5E-01	2.3E-01	4.0E-01
Thyroid	7.5E-02	9.3E-02	1.4E-01	2.2E-01	4.0E-01
Uterus	1.2E-01	1.4E-01	2.1E-01	3.2E-01	5.2E-01
Remaining organs	9.9E-02	1.2E-01	1.8E-01	2.7E-01	4.8E-01
Effective dose (mSv/MBq)	2.2E-01	2.6E-01	3.9E-01	6.1E-01	1.1E+00

In-labelled Fab' fragments

¹¹¹In 67.92 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	2.6E-01	3.2E-01	4.6E-01	6.4E-01	1.1E+00
Bladder	9.0E-02	1.1E-01	1.7E-01	2.6E-01	4.4E-01
Bone surfaces	3.9E-01	5.1E-01	8.1E-01	1.4E+00	3.3E+00
Brain	6.7E-02	8.5E-02	1.3E-01	2.1E-01	3.9E-01
Breast	6.5E-02	8.0E-02	1.2E-01	1.9E-01	3.4E-01
Gall bladder	2.7E-01	3.0E-01	4.3E-01	6.5E-01	1.0E+00
GI tract					
Stomach	1.3E-01	1.6E-01	2.5E-01	3.8E-01	6.4E-01
SI	1.5E-01	1.8E-01	2.7E-01	4.0E-01	6.6E-01
Colon	1.4E-01	1.7E-01	2.5E-01	3.9E-01	6.2E-01
(ULI	1.5E-01	1.8E-01	2.8E-01	4.4E-01	7.0E-01)
(LLI	1.2E-01	1.5E-01	2.2E-01	3.2E-01	5.2E-01)
Heart	1.3E-01	1.6E-01	2.4E-01	3.4E-01	5.9E-01
Kidneys	1.3E+00	1.5E+00	2.0E+00	2.9E+00	4.9E+00
Liver	5.9E-01	7.5E-01	1.1E+00	1.5E+00	2.6E+00
Lungs	1.2E-01	1.5E-01	2.2E-01	3.2E-01	5.7E-01
Muscles	9.5E-02	1.2E-01	1.7E-01	2.6E-01	4.7E-01
Oesophagus	8.7E-02	1.1E-01	1.5E-01	2.3E-01	4.0E-01
Ovaries	1.3E-01	1.6E-01	2.3E-01	3.5E-01	5.7E-01
Pancreas	2.2E-01	2.6E-01	3.9E-01	5.8E-01	9.4E-01
Red marrow	5.7E-01	6.2E-01	9.7E-01	1.7E+00	3.4E+00
Skin	5.6E-02	6.7E-02	1.1E-01	1.7E-01	3.1E-01
Spleen	3.4E-01	4.5E-01	6.8E-01	1.0E+00	1.7E+00
Testes	5.9E-02	7.5E-02	1.1E-01	1.8E-01	3.2E-01
Thymus	8.7E-02	1.1E-01	1.5E-01	2.3E-01	4.0E-01
Thyroid	7.6E-02	9.5E-02	1.4E-01	2.3E-01	4.0E-01
Uterus	1.2E-01	1.4E-01	2.1E-01	3.2E-01	5.2E-01
Remaining organs	9.7E-02	1.2E-01	1.8E-01	2.7E-01	4.7E-01
Effective dose (mSv/MBq)	2.2E-01	2.6E-01	3.9E-01	6.0E-01	1.1E+00

Iodine-labelled monoclonal tumour-associated antibodies¹²³I ¹³¹I**Biokinetic model**

The model for iodine-labelled antibodies and fragments are the same as those used for the corresponding technetium-labelled substances, with the modification that released iodine is assumed to be handled by the body according to the model proposed for iodine with blocking of the uptake in the thyroid (ICRP,1987)

N.B. This biokinetic model is not intended to apply to therapeutic use of the substance.

References for iodine-labelled monoclonal tumour-associated antibodies

ICRP (1987). *Radiation Dose to Patients from Radiopharmaceuticals*. ICRP Publication 53. *Annals of the ICRP* **18** (1-4).

Biokinetic data*Intact antibody*

Organ (S)	F_s	$T_{1/2}$ (hours)	a	¹²³ I	¹³¹ I
				\tilde{A}_S/A_0 (hours)	\tilde{A}_S/A_0 (hours)
Liver	0.50	24	0.5	7.25	30.8
		96	0.5		
Spleen	0.09	24	0.5	1.31	5.55
		96	0.5		
Red bone marrow	0.20	24	0.5	2.90	12.3
		96	0.5		
Kidneys	0.03	24	0.5	0.44	1.85
		96	0.5		
Other organs and tissues	0.18	24	0.5	2.61	11.1
		96	0.5		
Released iodine	1.0	-24	0.5	*	**
		-96	0.5		

*To obtain the contribution from released iodine-123 the cumulated activity given in the model for iodide with blocked thyroid should be multiplied by 0.24.

**To obtain the contribution from released iodine-131 the cumulated activity given in the model for iodide with blocked thyroid should be multiplied by 0.78.

F(ab')₂ fragments

Organ (S)	F_s	$T_{1/2}$ (hours)	a	^{123}I \tilde{A}_S/A_0 (hours)	^{131}I \tilde{A}_S/A_0 (hours)
Liver	0.30	12	1.0	2.72	4.89
Spleen	0.06	12	1.0	0.54	0.98
Red bone marrow	0.10	12	1.0	0.91	1.63
Kidneys	0.20	12	1.0	1.81	3.26
Other organs and tissues	0.34	12	1.0	3.08	5.54
Released iodine	1.0	-12	1.0	*	**

*To obtain the contribution from released iodine-123 the cumulated activity given in the model for iodide with blocked thyroid should be multiplied by 0.52.

**To obtain the contribution from released iodine-131 the cumulated activity given in the model for iodide with blocked thyroid should be multiplied by 0.94.

Fab' fragments

Organ (S)	F_s	$T_{1/2}$ (hours)	a	^{123}I \tilde{A}_S/A_0 (hours)	^{131}I \tilde{A}_S/A_0 (hours)
Liver	0.10	6.0	1.0	0.59 h	0.84 h
Spleen	0.02	6.0	1.0	0.12 h	0.17 h
Red bone marrow	0.03	6.0	1.0	0.18 h	0.25 h
Kidneys	0.40	6.0	1.0	2.38 h	3.36 h
Other organs and tissues	0.45	6.0	1.0	2.68 h	3.78 h
Released iodine	1.0	-6.0	1.0	*	**

*To obtain the contribution from released iodine-123 the cumulated activity given in the model for iodide with blocked thyroid should be multiplied by 0.69.

**To obtain the contribution from released iodine-131 the cumulated activity given in the model for iodide with blocked thyroid should be multiplied by 0.97.

Iodine labelled monoclonal antibodies

¹²³ I 13.20 hours					
Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	2.7E-02	3.4E-02	5.0E-02	6.9E-02	1.1E-01
Bladder	2.4E-02	3.1E-02	4.0E-02	4.7E-02	8.5E-02
Bone surfaces	3.9E-02	5.2E-02	8.4E-02	1.5E-01	3.6E-01
Brain	4.5E-03	5.8E-03	9.0E-03	1.5E-02	2.8E-02
Breast	6.0E-03	7.4E-03	1.2E-02	1.9E-02	3.7E-02
Gall bladder	4.0E-02	4.8E-02	6.7E-02	1.0E-01	1.9E-01
GI tract					
Stomach	1.5E-02	1.9E-02	3.2E-02	5.1E-02	9.2E-02
SI	1.2E-02	1.5E-02	2.4E-02	3.9E-02	6.9E-02
Colon	1.2E-02	1.4E-02	2.4E-02	3.9E-02	6.8E-02
(ULI	1.4E-02	1.7E-02	2.9E-02	5.0E-02	8.6E-02)
(LLI	8.6E-03	1.1E-02	1.7E-02	2.5E-02	4.4E-02)
Heart	1.4E-02	1.8E-02	2.8E-02	4.2E-02	7.7E-02
Kidneys	5.9E-02	7.2E-02	1.0E-01	1.5E-01	2.5E-01
Liver	1.5E-01	1.9E-01	2.9E-01	4.0E-01	7.3E-01
Lungs	1.4E-02	1.8E-02	2.7E-02	4.0E-02	7.2E-02
Muscles	8.4E-03	1.1E-02	1.6E-02	2.4E-02	4.5E-02
Oesophagus	6.9E-03	8.6E-03	1.3E-02	1.9E-02	3.5E-02
Ovaries	9.4E-03	1.2E-02	1.8E-02	2.8E-02	5.0E-02
Pancreas	3.0E-02	3.7E-02	5.8E-02	8.9E-02	1.5E-01
Red marrow	5.3E-02	5.8E-02	9.3E-02	1.7E-01	3.4E-01
Skin	4.7E-03	5.7E-03	9.1E-03	1.5E-02	2.8E-02
Spleen	2.0E-01	2.9E-01	4.4E-01	6.7E-01	1.2E+00
Testes	4.3E-03	5.6E-03	8.7E-03	1.4E-02	2.6E-02
Thymus	6.9E-03	8.6E-03	1.3E-02	1.9E-02	3.5E-02
Thyroid	5.1E-03	6.5E-03	1.0E-02	1.7E-02	3.1E-02
Uterus	9.3E-03	1.2E-02	1.8E-02	2.7E-02	4.9E-02
Remaining organs	8.9E-03	1.1E-02	1.7E-02	2.6E-02	4.6E-02
Effective dose (mSv/MBq)	2.8E-02	3.5E-02	5.4E-02	8.4E-02	1.6E-01

Iodine labelled monoclonal antibodies¹³¹I 8.04 days

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	2.6E-01	3.2E-01	4.7E-01	6.6E-01	1.1E+00
Bladder	4.9E-01	6.4E-01	8.5E-01	9.4E-01	1.8E+00
Bone surfaces	7.2E-01	9.8E-01	1.6E+00	3.1E+00	8.0E+00
Brain	6.2E-02	7.9E-02	1.3E-01	2.1E-01	4.1E-01
Breast	8.2E-02	1.0E-01	1.7E-01	2.7E-01	5.2E-01
Gall bladder	3.5E-01	3.9E-01	5.4E-01	8.5E-01	1.6E+00
GI tract					
Stomach	1.6E-01	2.0E-01	3.1E-01	5.0E-01	9.3E-01
SI	1.3E-01	1.7E-01	2.7E-01	4.2E-01	7.5E-01
Colon	1.3E-01	1.6E-01	2.6E-01	4.0E-01	7.3E-01
(ULI	1.5E-01	1.8E-01	3.0E-01	4.8E-01	8.8E-01)
(LLI	1.0E-01	1.3E-01	2.0E-01	3.0E-01	5.4E-01)
Heart	1.5E-01	1.9E-01	3.0E-01	4.4E-01	7.9E-01
Kidneys	9.9E-01	1.2E+00	1.7E+00	2.5E+00	4.4E+00
Liver	2.4E+00	3.2E+00	4.9E+00	7.3E+00	1.4E+01
Lungs	1.4E-01	1.8E-01	2.6E-01	3.9E-01	7.2E-01
Muscles	9.8E-02	1.2E-01	1.9E-01	2.9E-01	5.5E-01
Oesophagus	8.8E-02	1.1E-01	1.7E-01	2.6E-01	4.9E-01
Ovaries	1.1E-01	1.4E-01	2.2E-01	3.4E-01	6.1E-01
Pancreas	2.7E-01	3.3E-01	5.1E-01	7.8E-01	1.3E+00
Red marrow	1.3E+00	1.4E+00	2.4E+00	4.5E+00	9.4E+00
Skin	6.8E-02	8.5E-02	1.4E-01	2.2E-01	4.3E-01
Spleen	4.0E+00	5.8E+00	9.0E+00	1.4E+01	2.6E+01
Testes	6.4E-02	8.3E-02	1.3E-01	2.1E-01	4.1E-01
Thymus	8.8E-02	1.1E-01	1.7E-01	2.6E-01	4.9E-01
Thyroid	7.0E-02	8.9E-02	1.4E-01	2.3E-01	4.5E-01
Uterus	1.1E-01	1.4E-01	2.2E-01	3.3E-01	6.0E-01
Remaining organs	1.1E-01	1.4E-01	2.2E-01	3.5E-01	6.2E-01
Effective dose (mSv/MBq)	5.0E-01	6.2E-01	9.9E-01	1.6E+00	3.1E+00

Iodine labelled F(ab')₂ fragments

¹²³I 13.20 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	2.1E-02	2.7E-02	4.2E-02	6.1E-02	1.1E-01
Bladder	4.8E-02	6.1E-02	7.8E-02	8.5E-02	1.6E-01
Bone surfaces	2.1E-02	2.7E-02	4.3E-02	7.2E-02	1.6E-01
Brain	5.6E-03	7.1E-03	1.1E-02	1.9E-02	3.5E-02
Breast	5.6E-03	7.1E-03	1.1E-02	1.7E-02	3.3E-02
Gall bladder	2.3E-02	2.8E-02	4.0E-02	6.0E-02	1.0E-01
GI tract					
Stomach	1.2E-02	1.6E-02	2.5E-02	3.8E-02	6.7E-02
SI	1.1E-02	1.5E-02	2.3E-02	3.6E-02	6.4E-02
Colon	1.1E-02	1.4E-02	2.2E-02	3.4E-02	6.0E-02
(ULI	1.2E-02	1.5E-02	2.4E-02	3.9E-02	6.7E-02)
(LLI	9.9E-03	1.2E-02	1.9E-02	2.8E-02	5.1E-02)
Heart	1.1E-02	1.4E-02	2.1E-02	3.2E-02	5.8E-02
Kidneys	1.7E-01	2.1E-01	2.9E-01	4.2E-01	7.2E-01
Liver	6.0E-02	7.7E-02	1.2E-01	1.6E-01	2.9E-01
Lungs	1.0E-02	1.3E-02	2.0E-02	3.0E-02	5.6E-02
Muscles	8.3E-03	1.0E-02	1.6E-02	2.4E-02	4.5E-02
Oesophagus	7.1E-03	9.0E-03	1.4E-02	2.1E-02	3.9E-02
Ovaries	1.0E-02	1.3E-02	2.0E-02	3.0E-02	5.5E-02
Pancreas	2.0E-02	2.5E-02	3.9E-02	6.0E-02	1.0E-01
Red marrow	2.1E-02	2.3E-02	3.7E-02	6.3E-02	1.2E-01
Skin	5.1E-03	6.1E-03	9.8E-03	1.6E-02	3.0E-02
Spleen	9.3E-02	1.3E-01	2.0E-01	3.0E-01	5.3E-01
Testes	6.4E-03	8.3E-03	1.3E-02	2.0E-02	3.7E-02
Thymus	7.1E-03	9.0E-03	1.4E-02	2.1E-02	3.9E-02
Thyroid	6.4E-03	8.2E-03	1.3E-02	2.2E-02	4.0E-02
Uterus	1.2E-02	1.5E-02	2.3E-02	3.3E-02	6.0E-02
Remaining organs	8.9E-03	1.1E-02	1.7E-02	2.7E-02	4.8E-02
Effective dose (mSv/MBq)	1.9E-02	2.4E-02	3.6E-02	5.2E-02	9.6E-02

Iodine labelled F(ab')₂ fragments

¹³¹ I 8.04 days					
Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	1.0E-01	1.3E-01	1.9E-01	2.9E-01	5.2E-01
Bladder	5.6E-01	7.3E-01	9.5E-01	1.0E+00	1.9E+00
Bone surfaces	1.3E-01	1.7E-01	2.8E-01	4.9E-01	1.2E+00
Brain	4.2E-02	5.3E-02	8.9E-02	1.5E-01	2.8E-01
Breast	4.4E-02	5.6E-02	9.1E-02	1.5E-01	2.9E-01
Gall bladder	1.0E-01	1.2E-01	1.8E-01	2.8E-01	4.9E-01
GI tract					
Stomach	7.1E-02	8.7E-02	1.4E-01	2.2E-01	4.0E-01
SI	6.9E-02	8.8E-02	1.4E-01	2.2E-01	4.0E-01
Colon	6.7E-02	8.4E-02	1.3E-01	2.1E-01	3.8E-01
(ULI	7.0E-02	8.7E-02	1.4E-01	2.2E-01	4.0E-01)
(LLI	6.4E-02	7.9E-02	1.2E-01	1.9E-01	3.5E-01)
Heart	6.3E-02	8.1E-02	1.3E-01	2.0E-01	3.7E-01
Kidneys	1.5E+00	1.7E+00	2.5E+00	3.7E+00	6.6E+00
Liver	4.0E-01	5.3E-01	8.2E-01	1.2E+00	2.3E+00
Lungs	5.8E-02	7.5E-02	1.2E-01	1.8E-01	3.5E-01
Muscles	5.4E-02	6.8E-02	1.1E-01	1.7E-01	3.3E-01
Oesophagus	5.0E-02	6.4E-02	1.0E-01	1.6E-01	3.1E-01
Ovaries	6.6E-02	8.4E-02	1.3E-01	2.0E-01	3.7E-01
Pancreas	9.8E-02	1.2E-01	1.9E-01	2.9E-01	5.1E-01
Red marrow	2.0E-01	2.2E-01	3.6E-01	6.5E-01	1.3E+00
Skin	4.2E-02	5.2E-02	8.5E-02	1.4E-01	2.7E-01
Spleen	7.3E-01	1.1E+00	1.7E+00	2.6E+00	4.8E+00
Testes	5.0E-02	6.4E-02	1.0E-01	1.6E-01	3.1E-01
Thymus	5.0E-02	6.4E-02	1.0E-01	1.6E-01	3.1E-01
Thyroid	4.7E-02	6.0E-02	9.7E-02	1.6E-01	3.1E-01
Uterus	7.6E-02	9.5E-02	1.5E-01	2.1E-01	4.0E-01
Remaining organs	5.8E-02	7.5E-02	1.2E-01	2.0E-01	3.7E-01
Effective dose	1.5E-01	1.9E-01	2.8E-01	4.2E-01	8.1E-01
(mSv/MBq)					

Iodine labelled Fab' fragments

¹²³I 13.20 hours

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	1.8E-02	2.3E-02	3.6E-02	5.5E-02	1.0E-01
Bladder	6.1E-02	7.8E-02	9.9E-02	1.0E-01	1.9E-01
Bone surfaces	1.4E-02	1.8E-02	2.7E-02	4.3E-02	8.7E-02
Brain	5.9E-03	7.4E-03	1.2E-02	2.0E-02	3.6E-02
Breast	5.2E-03	6.6E-03	9.8E-03	1.6E-02	3.0E-02
Gall bladder	1.4E-02	1.8E-02	2.6E-02	4.0E-02	6.1E-02
GI tract					
Stomach	1.1E-02	1.3E-02	2.1E-02	3.1E-02	5.3E-02
SI	1.1E-02	1.4E-02	2.2E-02	3.3E-02	6.0E-02
Colon	1.1E-02	1.4E-02	2.1E-02	3.1E-02	5.5E-02
(ULI	1.1E-02	1.4E-02	2.1E-02	3.3E-02	5.6E-02)
(LLI	1.0E-02	1.3E-02	2.0E-02	2.9E-02	5.3E-02)
Heart	8.5E-03	1.1E-02	1.7E-02	2.6E-02	4.6E-02
Kidneys	2.2E-01	2.6E-01	3.6E-01	5.3E-01	9.2E-01
Liver	1.8E-02	2.3E-02	3.5E-02	5.0E-02	8.9E-02
Lungs	7.8E-03	1.0E-02	1.6E-02	2.4E-02	4.6E-02
Muscles	8.0E-03	1.0E-02	1.5E-02	2.3E-02	4.3E-02
Oesophagus	6.9E-03	8.8E-03	1.4E-02	2.1E-02	3.9E-02
Ovaries	1.1E-02	1.3E-02	2.0E-02	3.1E-02	5.6E-02
Pancreas	1.5E-02	1.8E-02	2.9E-02	4.3E-02	7.4E-02
Red marrow	9.2E-03	1.1E-02	1.6E-02	2.5E-02	4.5E-02
Skin	5.0E-03	6.1E-03	9.7E-03	1.5E-02	2.9E-02
Spleen	3.1E-02	4.1E-02	6.4E-02	9.6E-02	1.7E-01
Testes	7.2E-03	9.3E-03	1.4E-02	2.2E-02	4.1E-02
Thymus	6.9E-03	8.8E-03	1.4E-02	2.1E-02	3.9E-02
Thyroid	6.7E-03	8.6E-03	1.4E-02	2.3E-02	4.2E-02
Uterus	1.3E-02	1.7E-02	2.5E-02	3.5E-02	6.3E-02
Remaining organs	8.2E-03	1.0E-02	1.6E-02	2.4E-02	4.3E-02
Effective dose (mSv/MBq)	1.7E-02	2.1E-02	3.1E-02	4.4E-02	7.8E-02

Iodine labelled Fab' fragments

¹³¹I 8.04 days

Organ	Absorbed dose per unit activity administered (mGy/MBq)				
	Adult	15 years	10 years	5 years	1 year
Adrenals	7.2E-02	9.1E-02	1.4E-01	2.3E-01	4.2E-01
Bladder	5.7E-01	7.4E-01	9.7E-01	1.0E+00	1.9E+00
Bone surfaces	5.1E-02	6.0E-02	9.4E-02	1.5E-01	3.1E-01
Brain	3.7E-02	4.7E-02	7.8E-02	1.3E-01	2.5E-01
Breast	3.6E-02	4.6E-02	7.4E-02	1.2E-01	2.4E-01
Gall bladder	6.3E-02	7.7E-02	1.2E-01	1.8E-01	3.1E-01
GI tract					
Stomach	5.4E-02	6.6E-02	1.1E-01	1.6E-01	3.0E-01
SI	5.7E-02	7.2E-02	1.1E-01	1.8E-01	3.3E-01
Colon	5.5E-02	7.0E-02	1.1E-01	1.7E-01	3.1E-01
(ULI	5.5E-02	7.0E-02	1.1E-01	1.7E-01	3.1E-01)
(LLI	5.6E-02	6.9E-02	1.1E-01	1.6E-01	3.0E-01)
Heart	4.7E-02	6.0E-02	9.6E-02	1.5E-01	2.8E-01
Kidneys	1.5E+00	1.8E+00	2.5E+00	3.7E+00	6.7E+00
Liver	8.7E-02	1.1E-01	1.7E-01	2.6E-01	4.7E-01
Lungs	4.3E-02	5.6E-02	8.9E-02	1.4E-01	2.7E-01
Muscles	4.5E-02	5.7E-02	9.0E-02	1.4E-01	2.8E-01
Oesophagus	4.2E-02	5.4E-02	8.6E-02	1.4E-01	2.7E-01
Ovaries	5.7E-02	7.3E-02	1.1E-01	1.7E-01	3.2E-01
Pancreas	6.6E-02	8.2E-02	1.3E-01	2.0E-01	3.6E-01
Red marrow	5.1E-02	5.8E-02	9.0E-02	1.5E-01	2.8E-01
Skin	3.6E-02	4.5E-02	7.3E-02	1.2E-01	2.4E-01
Spleen	1.6E-01	2.2E-01	3.4E-01	5.3E-01	9.7E-01
Testes	4.5E-02	5.8E-02	9.3E-02	1.4E-01	2.8E-01
Thymus	4.2E-02	5.4E-02	8.6E-02	1.4E-01	2.7E-01
Thyroid	4.1E-02	5.3E-02	8.6E-02	1.4E-01	2.7E-01
Uterus	6.8E-02	8.5E-02	1.3E-01	1.9E-01	3.5E-01
Remaining organs	4.6E-02	5.8E-02	9.2E-02	1.5E-01	2.8E-01
Effective dose (mSv/MBq)	1.1E-01	1.4E-01	2.0E-01	2.9E-01	5.4E-01