Institute of Physics and Engineering in Medicine

ADVICE NOTICE:

Excretion Factors: the percentage of administered radioactivity released to sewer for routinely used radiopharmaceuticals.

Background

When a patient has a nuclear medicine investigation or undergoes radionuclide therapy, some of the administered radioactivity is excreted and discharged to sewer. The percentage excreted (the excretion factor) depends on the radiopharmaceutical used and the patient's physiology. To enable simple calculations, excretion factors have been established for commonly used radiopharmaceuticals, and are given in the Tables below. These factors should be used: when determining appropriate permit limits; demonstrating compliance with these limits; in radiological impact assessments; and to provide data on annual releases for the pollution inventory.

This advice notice is endorsed by the Environment Agency (EA), Scottish Environmental Protection Agency (SEPA), Northern Ireland Environment Agency (NIEA) and Natural Resources Wales (NRW), hereinafter collectively referred to as the UK Environmental Regulators.

The UK Environmental Regulators have previously confirmed that all of the activity excreted, even that which occurs after the patient has left the hospital premises should be included in the permitted limits. This is because much of the activity discharged after the patient has left the premises is likely to go to the same sewage treatment works, or at least the same river as the hospital's sewer, and so needs to be included to enable a simple, conservative dose assessment. In addition, the UK Environmental Regulators have to provide data on total annual releases of certain radionuclides to comply with international treaties.

The average excretion factors shown below therefore include all of the activity likely to be excreted. **Where no figure is given for a radiopharmaceutical, a precautionary value of 100% should be assumed, unless newly published evidence or locally derived excretion data are available.**

How the values were determined

In many cases, the figure is based upon the methodology briefly outlined in Appendix 1, which takes account of radioactive decay. Detailed information on excretion calculations is provided on the Medical and Dental Guidance Notes 2002[1] (MDGN) and will be included on the upcoming updated version of MDGN. Other values are taken from peer reviewed literature or manufacturer's data.

In this 2018 review of this guidance, IPEM has collaborated with the Administration of Radioactive Substances Advisory Committee (ARSAC) to identify further radiopharmaceuticals currently licensed for use in the UK and to extend the list of excretion factors where evidence was available. The 2018 review provides references for each individual excretion factor derivation to facilitate users in evaluating the quality of evidence. In some cases, the excretion factors calculated rely on limited patient data, particularly for some newer radiopharmaceuticals.

To facilitate practical use of the excretion factors, in consultation with the UK Environmental Regulators, it was agreed to retain and expand the grouping of radiopharmaceuticals, and to revise the excretion factors where required. The most notable change is that the grouped factor for Tc-99m labelled radiopharmaceuticals has been increased. This change reflects both the update to ICRP 128 Guidance [2] with bladder contents accounted for in the excreted activity, and information on average usage of all Tc-99m labelled radiopharmaceuticals around the country as described by the Health Protection Agency (HPA) Nuclear Medicine Survey [3] publication. However, Tc-99m excretion may vary from site to site, and would typically be lower for centres performing a larger proportion of cardiac scans. If required nuclear medicine departments can alternatively produce a local excretion factor for Tc-99m as outlined in Appendix 2. A conservative estimate rounded up to the nearest 10% should be used and revised according with changes in local practice such as introducing new procedures using Tc-99m or amending local DRLs.

Adjustments

If the radiological impact assessment using these excretion factors gives rise to concern, a hospital may provide evidence to demonstrate that a significant proportion of the release goes to different sewage works or rivers, and consequently the actual radiological impact is lower. This should only be considered for longer-lived radionuclides administered to outpatients where a significant proportion of the release happens after the patient has left hospital, and where patients receiving this radiopharmaceutical are drawn from a wide catchment area.

Evidence should be based upon simple, conservative assumptions about the patient population and should not require the hospital to keep records of the home locations of individual patients.

Where hospitals make use of holding tanks calculated releases to sewer will need to be adjusted to take account of these.

When a radiopharmaceutical is administered at one hospital but the patient receives ongoing treatment at another hospital, all of the excreted activity should be accounted for. In some cases, for example 131-Iodine therapy for thyrotoxicosis where a patient returns to a nursing home shortly after receiving the radiopharmaceutical, all of the excretion can be assumed to occur at the nursing home. Where a patient has a diagnostic test using a Tc-99m labelled radiopharmaceutical, and returns to another hospital after the investigation is complete, 10% of the administered activity may be attributed to the institution the patient returns to, as per the previous guidance. In other cases, RWAs should make simple, conservative assumptions.

Implementation

The UK Environmental Regulators expect that applications for variations or new permits will be based on the figures below. Revised values do not need to be applied retrospectively to releases that have already been calculated. It is expected that all hospitals will be using the amended factors to calculate releases to sewer by the end of 2020. Given that that the changes to the values are small it is unlikely that moving to the new figures would result in the calculated releases exceeding the permitted limits, but if this the case it should be discussed with the local regulator.

Excretion factors will be subject to regular review by representatives of the medical sector and the UK Environmental Regulators. The IPEM Nuclear Medicine Special Interest Group should be contacted in the first instance where new evidence is available. New published excretion factors should not trigger an application for a permit variation but should be used when the next application is made.

2. Summary

When calculating the percentage of administered activity that should be assumed to be released to the sewer following administration of a radiopharmaceutical the excretion factors in the tables below should be used. A local factor for Tc-99m can alternatively be derived as outlined in Appendix 2.

3. Excretion factors for diagnostic radiopharmaceuticals

Radionuclide	Chemical Form	Excretion Factor	Reference
Tc-99m	All forms	40%	1, 2, 3
I-123	Ioflupane	30%	1, 2, 4
I-123	MIBG	60%	1, 5
I-123	All other forms	100%	1, 5
In-111	Somatostatin analogue	90%	1, 5
In-111	All other forms	100%	1, 5
Ga-67	Gallium citrate	30%	1, 5
Tl-201	Thallous chloride	30%	1, 5
Se-75	SeHCAT	100%	1, 5
I-131	Norcholesterol	50%	1, 5
Cr-51	EDTA	100%	1, 5
F-18	FDG	20%	1, 6
F-18	All other forms	30%	1, 5, 7, 8, 9
Ga-68	Somatostatin analogue	20%	10, 11
Ga-68	PSMA	20%	12
PET tracers $T_{1/2}$<15 min	All forms	0%	1, 5, 6
I-124	MIBG	90%	1, 5

4. Excretion factors for therapeutic radiopharmaceuticals

Radionuclide	Chemical Form	Treatment	Excretion Factor	Reference
I-131	Sodium Iodide	Thyroid cancer	100%	1, 5
I-131	Sodium Iodide	Thyrotoxicosis	60%	1, 2, 5, 13
I-131	MIBG	Neuroendocrine Tumours	90%	1, 5
Sr-89	Strontium chloride	Bone metastases	70%	1, 5
P-32	Phosphate	Polycythemia vera	50%	1, 5
Er-169	Colloid	Radiosynovectomy small joints	5%	14
Re-188	Colloid	Radiosynovectomy medium joints	5%	14
Re-186	Colloid	Radiosynovectomy medium joints	5%	14
Y-90	Colloid	Radiosynovectomy large joints	5%	14
Lu-177	Somatostatin analogue	Neuroendocrine tumours	90%	15
Y-90	Somatostatin analogue	Neuroendocrine tumours	90%	16
Y-90	Microspheres	Liver Metastasis	5%	17
Sm-153	EDTMP	Bone Metastasis	50%	18
Ra-223	Radium chloride	Bone metastases	80%	19
Lu-177	PSMA	Prostate cancer	90%	20
Y-90	Ibritumomab Tiuxetan	Non-Hogdkin Lymphoma	10%	21

5. Acknowledgements

IPEM Nuclear Medicine Special Interest Group (NMSIG)
IPEM Radiation Protection Special Interest Group (RPSIG)
British Nuclear Medicine Society (BNMS)
Administration of Radioactive Substances Advisory Committee (ARSAC)
SRP Medical Sectorial Committee (SRP MSC)
Environment Agency (EA)
Scottish Environmental Protection Agency (SEPA)
Northern Ireland Environment Agency (NIEA)
Natural Resources Wales (NRW)

6. References

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Appendix 1: Use of ICRP data to estimate excreted activity[2]

Biokinetic data for commonly used Nuclear Medicine radiopharmaceutical compounds has been published by the International Committee for Radiological Protection (ICRP) in their Report 128[2].

The cumulative activity (A_s) for each radiopharmaceutical accounts for the biological clearance and physical radioactive decay of the radionuclide. If a radiopharmaceutical was not cleared biologically from the body (i.e. there is no excretion) the cumulative activity (A_{ne}) would be described only by the physical decay of the radionuclide (T_{PHYS}) as shown in Equation 1.

The difference in the cumulative activity in the absence of biological clearance (A_{ne}) and the cumulative activity quoted in ICRP Report 128 (As) is due to excretion from the body. The respective excretion factor (EF) can be calculated using Equation 2.

$$A_{ne} = \frac{T_{PHYS}}{\ln(2)} \quad (1)$$

$$EF = \frac{A_{ne} - A_S}{A_{ne}} * 100\% \quad (2)$$

Appendix 2: Tc-99m local excretion factor calculation

The excretion factors for individual Tc-99m labelled radiopharmaceuticals were calculated using the residence times from ICRP 128[2]. A local excretion factor for Tc-99m radiopharmaceuticals can be produced as the weighted average of individual excretion factors for each radiopharmaceutical taking into account the local distribution of studies and injected activity per study as follows:

$$Local\ EF = \frac{\sum_{i=1}^{n} D_i \cdot N_i \cdot EF_i}{\sum_{i=1}^{n} D_i \cdot N_i} * 100\% \quad (3)$$

where D_i is the local DRL, N_i is the number of scans for each application, and EF_i is the excretion factor for each individual Tc-99m labelled radiopharmaceutical as provided in the following table.

Application	**Chemical Form**	**Excretion Factor**
Bone	Phosphates	53%
Lung Perfusion	MAA	12%
Lung Ventilation	Technegas	6%
Myocardial Perfusion	Tetrofosmin - rest	22%
Myocardial Perfusion	Tetrofosmin - stress	15%
Myocardial Perfusion	MIBI - rest	11%
Myocardial Perfusion	MIBI - stress	9%
MUGA	RBC	8%
Renal	MAG3 - normal	97%
Renal	DMSA	22%
Renal	DTPA	77%
Thyroid	Pertechnetate	21%
WBC	Exametazime	0%
Brain Perfusion	HMPAO	25%
Gallbladder	HIDA	20%