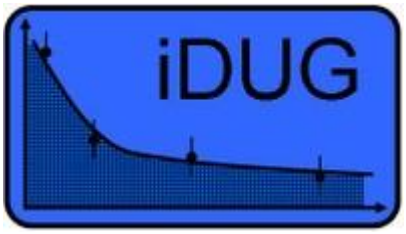
Internal Dosimetry Users Group

Whole Body Dosimetry Guidance



Introduction

Practical guidance is presented on answering the need to perform dosimetry for Molecular Radiotherapy (MRT) [1] in the context of increasing MRT episodes [2] and financial constraint. It is also anticipated that standardisation of this process will increase the feasibility of building an evidence base for dosimetry, based on a common, multi-centre dosimetry database.

This document has been written as the first step for performing dosimetry and it is hoped will allow and encourage an increasing number of centres to do this. This document is intended as a protocol for data acquisition and the calculations necessary to perform whole-body dosimetry and to supplement the existing guidance on whole-body dosimetry which can be found in the EANM Guidelines [3] and Stabin et al [4].

The absorbed dose to the whole body is often used as a surrogate for the absorbed dose to the bone marrow and has been applied in investigations of the relationship between the absorbed dose and the toxic effect on the bone marrow. This has been demonstrated in several studies of mIBG patients and I-131 labelled antibodies [5,6] which determined a reasonable correlation between ETBD (blood toxicity) and the MIRD whole body dose. Although a useful surrogate, such estimates will be subject to the limitations of the MIRD technique, namely:

• Standard models (not patient specific) must be adjusted for each patient mass
• It is assumed that the activity is distributed uniformly within each organ and that the energy is uniformly deposited throughout the organ
• Local radionuclide concentrations can be much higher than average calculations might suggest. Depending on assumptions there may be an overestimation

Protocol

1. Acquire background reading prior to administration
2. Ensure geometry is the same for all readings
3. Acquire first patient reading immediately following administration and before first void
4. Acquire additional measurements (timing depends on local conditions)
5. Put data and patient weight into a spreadsheet which plots activity-time data
6. Check fitting of data and do a manual fit where required
7. Provide the calculated whole body dose and associated error to your oncologist

Notes

1. Equipment

Meters used should measure dose rate (or counts, depending on measurement units) using a standard, calibrated meter (for example, an energy-compensated Geiger-Muller-based probe (eg Berthold LB 6500-H10), SmartIon or equivalent system) at a fixed distance and geometry from the patient. The distance should be such that dead-time is negligible (typically 2-5 m for this patient group) and should be recorded and kept constant throughout the measurement series.

The sensitivity range of the equipment must be appropriate for the expected count rates. If necessary a dead time correction should be applied, but should (ideally) be avoided by increasing patient – monitor distance.

If the probe is ceiling mounted, appropriate shielding may be needed, but the probe field of view must cover the whole body

Option 1: Geiger counter/dose rate monitor held at a fixed distance with patient in a reproducible position.
It is recommended as large a distance as possible is used for this (ensuring lead is not in the way). A wall mount or holder (e.g. created from an old clamp stand) can be used to ensure reliable and consistent positioning of both height and distance

Option 2. Fixed Geiger counters with a digital read out. The accuracy with which whole-body dosimetry can be determined is largely dependent on the reproducibility of the patient-counter configuration (geometry). It is therefore advisable that the counter is fixed on to the ceiling above the patient's bed. Care must be taken to ensure reproducibility of the patient position for each reading. Bed settings must be confirmed before each reading to ensure they are at the same height and set flat (e.g. lowest bed position, flat with one pillow).

2. Patient voiding

For long administration times (e.g. mIBG) it is important that the patient voids immediately prior to administration so that the first measurement post administration is taken before a patient voids. The first patient reading should be acquired immediately after administration and before the patient voids. If the patient has to void during administration the **activity in the urine must be measured** and taken into account in subsequent calculations.

The patient should be asked to void before all subsequent readings.

3. Data collection

Statistics

The total acquisition time for each measurement should ideally be chosen such that the background- and dead time corrected number of counts is higher than 1×10^4 so that the statistical error is less than 1%. Some meters have variable integration times. These should be set to give the required accuracy for the levels expected.

Background

Background readings should be measured before any administration has commenced. As these are considerably lower, a longer integration /counting time should be used to achieve adequate statistics.

It may be necessary to acquire more frequent background readings. These may be timed to coincide with when the patient leaves the room for a scan, for example. If the background is constantly changing, as may be the case when the waste is kept in the patient room, background measurements should be acquired for each reading, for these the patient will need to be outside the detector field of view (e.g. the patient could move to a shielded ensuite bathroom).

Timing of readings

The number of readings taken will depend on local staffing, facilities and patient condition. However the more readings that can be taken, especially during the first 48 hours, the better the fit of the multiphase excretion modelled

Readings should be acquired regularly while the patient is in hospital, at least once a day until discharge.

If the patient is due to return for scanning, then a reading with a SmartIon or equivalent should be taken (with a pre-determined geometry that can be replicated in the out-patient area) at the same time as the final ceiling monitor reading to ensure a cross comparison for any extra readings taken outside the patient room.

- ***Minimum level*** – a reading taken at least once a day

- ***Ideal level*** There should be a minimum of one set of readings roughly every two hours on day of administration, and one set of readings every 4-6h thereafter. The second patient reading should to be taken immediately after the first void. It is unreasonable to wake the patient for readings overnight. Therefore readings should be taken last thing at night before the patient retires, as soon as they awake in the morning and at any time they happen to wake up during the night. In practice this is achievable if parents, carers or nurses are trained to take readings whenever the patient voids.

Patient position during readings.

If possible readings should be taken of both Anterior and Posterior dose rate and the geometric mean of these measurements used in calculations. If the patient is on a bed this requires readings taken with the patient both supine and prone

Two supine readings should be taken and the counts averaged if a prone position is difficult for the patient to achieve and this same position used for the remainder of the measurements.

Dose calculations

Whole-body absorbed dose calculations are made according to standard MIRD methodology [7]. If automatic fitting is used the phases must be visually checked. A spreadsheet has been developed [8] which incorporates these calculations. This spreadsheet has been provided purely as a training tool and an example of what calculations can be easily achieved. It must not be used in connection with any clinical activity. Each centre is strongly recommended to confirm their calculations using an established dosimetry package such as Olinda/EXM [9]

The background corrected activity-time data are plotted and integrated to determine cumulated activity $\tilde{A}$. The number of phases to which the data fit should be chosen interactively. The potential error on this decreases with the number of data points.

The MIRD S value (wb -> wb) is determined according to the patient's weight. MIRD S values are available for newborn, 1 year old, 5 year old, and adults. From these an (empirical) equation may be generated to determine a patient-specific S value [10]:

$$S = 1.34 \times 10^{-4} \times W^{-0.921}\, Gy\,(MBq\,h)^{-1}$$

where W is the patient's weight (kg). The absorbed dose is then given by:

$$D = \tilde{A}\, S$$

4. Error analysis

The accuracy of the absorbed dose estimate will depend largely on the accuracy of the measurements. The uncertainty on the absorbed dose can be determined according to methodology available in the literature [11]; This is included in the developed spreadsheet. It is recommended an estimate of the error be given with the calculated whole body dose.

References

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The production of guidance for MRT dosimetry is a key component of IDUG's aim of delivering practical MRT dosimetry within the NHS.

Version History
1.0 June 2015

To be reviewed June 2017