^{223}Ra dichloride incidental inhalation: recommendations to estimate the committed effective dose

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1 Introduction

^{223}Ra dichloride - Xofigo® (Bayer AG, Germany) - is a therapeutic alpha particle-emitting pharmaceutical used in nuclear medicine for patients with metastatic castration-resistant prostate cancer (mCRPC). The radiopharmaceutical is formulated as a ready-to-use solution (unsealed source) and is administered to patients as an intravenous injection [1-2]. As it is an alpha-emitter, internal contamination is feared. If inhalation contamination is suspected, an adequate special monitoring programme needs to be provided to estimate the committed effective dose. ^{223}Ra internal contamination monitoring can be performed by two methods: *in vivo* measurements and *in vitro* measurements (urine of faeces). The purpose of our study was to determine the most appropriate method for individual monitoring of nuclear medicine staff who could have inhaled ^{223}Ra and propose recommendations for committed effective dose assessment.

2 Materials and methods

First, minimum detectable activities (MDA) and scattering factors (SF) of these methods were estimated according, respectively, to the French working group number 5 (GTN5) and EURADOS Guidelines [3-4]. Concerning *in vitro* analysis, due to the ^{223}Ra short half-life (11.4 d), an adjusted MDA was calculated at the end date of the 24-h sampling to consider transport and sample pre-treatment times (~48h for urine and ~96h for faeces). *In vivo* measurements were obtained by a bed-type whole-body counter equipped with two coaxial p-type high purity germanium (HPGe) detectors. The counting time was set to 45 min. *In vitro* measurements were obtained by direct measurement using a gamma spectrometer equipped with one coaxial n-type HPGe detector on 500-mL aliquot portion of the true 24-h

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urine samples or complete 24h-faeces ashed and dissolved in acid. The counting time was set to 10800 s.
Then, the minimum detectable effective dose (MDED), which is the committed effective dose at time *t* after incorporation corresponding to the MDA was calculated by the following equations:

$$MDED(t) = \frac{MDA}{F(t)} * e(50) \quad (1)$$

in which e(50) is the effective dose coefficient (5.7 x 10^{-6} Sv Bq^{-1}) following a unit intake of ^{223}Ra for inhalation (pulmonary absorption parameter "Moderate" and AMAD set to 5 µm by default), F(*t*) is the value of the retention or excretion function at time *t* (in days).

3 Results and discussion

Special monitoring programmes should provide enough data to assess the committed effective dose. That's why a suitable combination of *in vivo* measurements and *in vitro* analyses according to the appropriate biokinetic model would be used.
Figure 1 compares the MDED to an effective dose limit of 1 mSv (workers recording level). It appears that whole body counting (WBC) is sensitive enough only the day following incorporation. Although urine samples analysis has a low SF, it should be used only in a case of a major contamination (>15 mSv). Thus, due to its rapidity and its non-invasiveness, WBC (with HPGe detector) should be the first choice to estimate the committed effective dose. However, after 24 h, sufficient sensitivity can only be reached by true 24-h faeces samples analyses (up to 8 days after contamination). Thus, in that case, despite its main drawbacks (excretion fluctuation, staff reluctance, higher SF…), this method should be associated with WBC to estimate the committed effective dose.

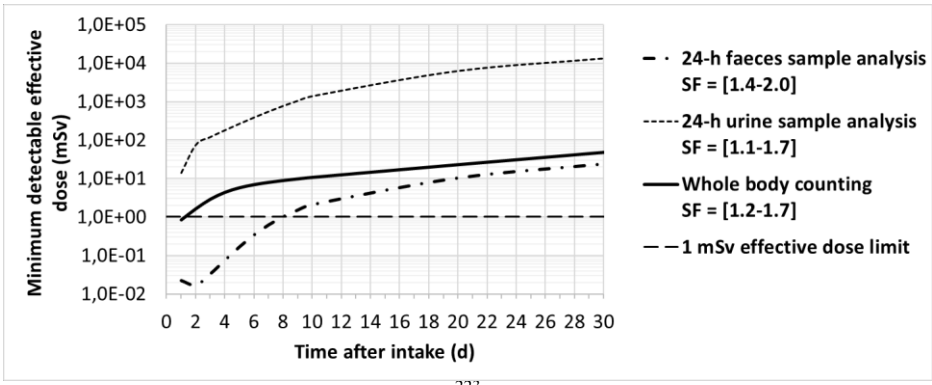

Figure 1: MDED after acute inhalation of ^{223}Ra as aerosol (type M; 5µm AMAD) with whole-body counting, urinary or faecal analyses and SF associated to each method.

References

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