

**223**\(^{\text{Ra}}\) dichloride incidental inhalation: recommendations to estimate the committed effective dose

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**1 Introduction**

**223**\(^{\text{Ra}}\) dichloride - Xofigo\(^{\circledR}\) (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**\(^{\text{Ra}}\) 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**\(^{\text{Ra}}\) 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**\(^{\text{Ra}}\) 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...
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:

$$MDED(t) = \frac{MDA}{F(t)} \times e(50)$$

in which $e(50)$ is the effective dose coefficient ($5.7 \times 10^{-6}$ Sv Bq$^{-1}$) following a unit intake of $^{223}\text{Ra}$ 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 $^{223}\text{Ra}$ as aerosol (type M; 5µm AMAD) with whole-body counting, urinary or faecal analyses and SF associated to each method.](image)

## References