On site calibration of Ionization Chamber for ^{166}Ho at Gemelli Hospital in Rome by using the portable ENEA TDCR detector.

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INTRODUCTION

^{166}Ho is a theranostic radiopharmaceutical with interesting medical applications, due to its 80 keV gamma-ray emission and short half-life ($T_{1/2} \approx 26.8$ h).
^{166}Ho in the form of microspheres can be used in radioembolization procedures as an alternative of commonly used ^{90}Y [1]. In particular, it is applied in patients with hepatic metastases, chemorefractional and non resecable, and allows to implement an image driven treatment, displaying in vivo, with a SPECT or MRI [2], the microspheres distribution.
The use of radiopharmaceuticals in therapy and diagnostic requires an accurate and precise measurement of activities to make reliable dosimetric predictions. For this reason it is necessary to calibrate the instruments used in nuclear medicine, such as Ionization Chambers (ICs), gamma-cameras and PET imaging systems, for ^{166}Ho, after the development of a new activity primary standard for this radionuclide.

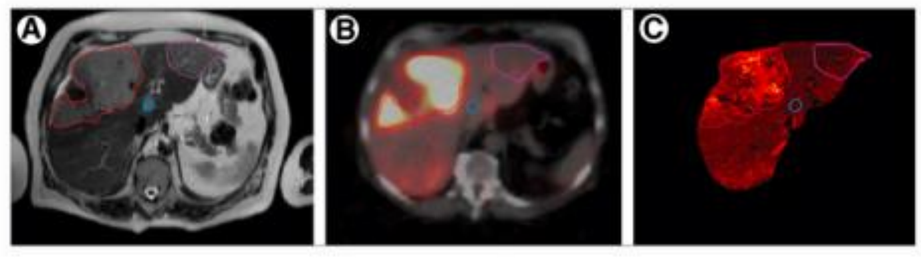

Fig.1: Intrahepatic visualisation of ^{166}Ho-microspheres after radioembolization (SIRT). MRI of the liver in a patient with several ocular melanoma liver metastases, outlined by coloured regions of interest (A). After SIRT, the distribution of microspheres within the liver was visualized by SPECT (B) and MRI (C).

EXPERIMENTAL SECTION

- A new ^{166}Ho standard was obtained, using the ENEA portable TDCR instrument [3]. It allows to characterize in activity, via direct method of measurements based on the absolute $4\pi\beta$ integral counting technique of Triple-to-Double-Coincidence-Ratio (TDCR), 10 ml of a ^{166}Ho solution (50 MBq/g roughly) dissolved in HNO^3 1 M. The measurements were carried out with two 20 ml high-performance glass vials for Liquid Scintillation Counting (LSC) filled with 10 ml of the Ultima Gold liquid scintillator.
- The realization of the standard allows to calibrate the Nuclear Medicine department of the Gemelli Hospital's IC Capintec CRC-25R for the radionuclide ^{166}Ho, which is used for routinely applications in radiopharmaceutical dispensing to the patients. The chamber was calibrated for the geometry of a luer syringe with a capacity of 10 ml, 15.5 cm long and with a diameter of 1.8 cm of the company Farmac-Zabban filled with two different volume of ^{166}Ho (3.2 and 6.2 ml). A preliminary study of IC's linearity was made, using a ^{11}C source (produced at Gemelli Hospital's Cyclotrone), to determine a range of activity within which the chamber behaves in linear way and therefor for which it is correctly calibrated.

Fig.2: Blue box contains the TDCR system, the power supply and the digitizer. It is cover, during measurements, to avoid the enter of light in the system and there is only a little hole for placing the vial. The portable TDCR is connected to the alimentation system and to the digitizer. The latter processes the pulses from the detector, recording the signal arrival time and signal amplitude in an external file. These signals are off-line analyzed by a softwere implemented in CERN ROOT frame and developed at ENEA-INMRI.

RESULTS

- Activity for double or triple coincidences signal is the ratio between the correct net count rate and the efficiency. These one is calculated by using the MICELLE code of the PTB, considering the TDCR value. From the analysis was realized the activity primary standard for the radionuclide ^{166}Ho with an uncertainty lower than 1%. This value can be used to calibrate all secondary measurement systems for this radionuclide.
- A study of the linearity range of the portable TDCR was also made (Fig.3). The law of exponential decay is exploited to describe the linearity of a measuring instrument of radioactivity. It is defined as the normalized difference between net count rates and a chosen reference value. The linearity of the TDCR instrument is evaluated considering a reference value of 2 kBq, therefore the instrument works linearly for net count rate between 100 and 9000 cps.

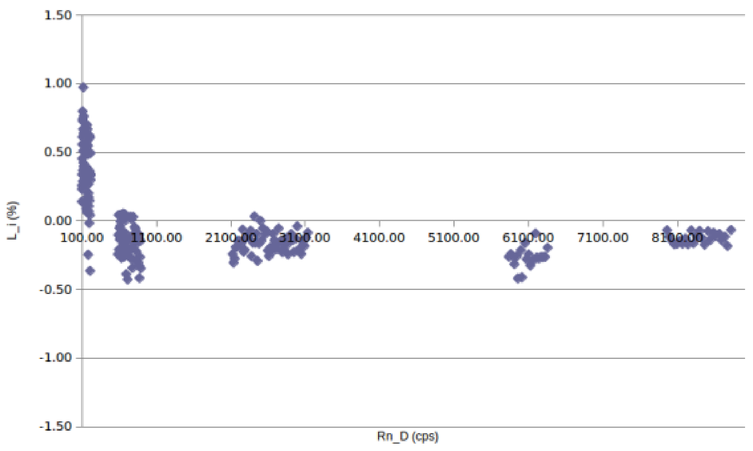

Fig.3: Study of the TDCR portable's linearity.

- The preliminary study of the Gemelli Hospital IC's linearity was made, considering an activity reference value around 2-3 MBq (Fig. 4). From this analysis results that the IC Capintec CRC-25 R has a linear behavior for a range of activity between $7.55 \cdot 10^8$ Bq and $5.35 \cdot 10^6$ Bq, with a difference between the values of activity and that of reference within 2%.
- The IC's calibration factor (CF) is calculated as the ratio between the absolute activity (obtained with the TDCR instrument) and the readings of the IC for a ^{166}Ho solution. This allows to calibrate the IC with an uncertainty lower than 2%.

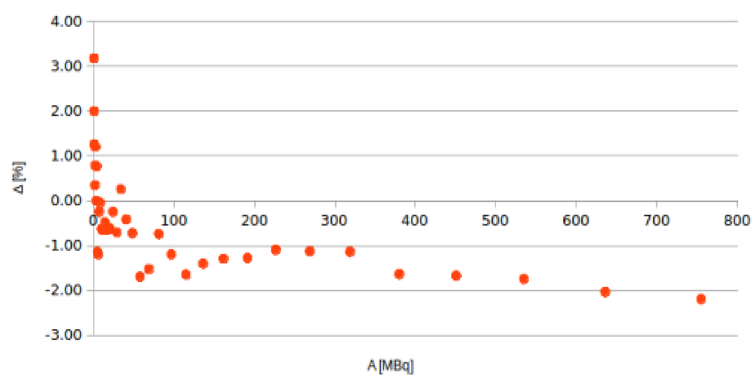

Fig.4: Linearity of the IC Capintec CRC-25R

CONCLUSIONS

In this work, a new activity primary standard was realized for the radionuclide ^{166}Ho by INMRI. The possibility to own a portable TDCR allows to realize measurements on site at the Gemelli Hospital with an uncertainty lower than 1%. This enabled to calibrate, with an uncertainty ≤ 2%, the IC used for routinely applications in radiopharmaceutical dispensing to the patients, for this radionuclide.
This work opens interesting perspectives in the field of Nuclear Medicine for calibrating instruments device used in medical fields, such as IC's, gamma-cameras and also PET imaging systems.

REFERENCES

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