WHICH PROTECTION AGAINST RADIATION FOR NEW PROTOCOLS OF INTERNAL RADIOTHERAPY BY YTTRIUM 90?

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1. INTRODUCTION

Within the field of the therapeutic applications in nuclear medicine new therapeutic agents, octreotide and anti CD20 monoclonal antibody, labelled with yttrium 90 were proposed these last years [1, 2]. These radiopharmaceuticals[1] have been used in our institution these last months. This beta emitter with a maximum energy ($E_\beta$max) of 2.284 MeV (average energy 0.942 MeV) with 100% of emission, and a 64.1 hours half-life is particularly attractive for the applications of internal radiotherapy. With this energy, the maximum range of the beta particles is 9 m in the air and 11 mm in water. R_{90}, which corresponds, in water, with the radius of the sphere in which 90% of emitted energy are deposited, is of 5.3 mm. Activity injected by patient depends on the protocol and lies between ≈ 1.2 GBq and ≈ 4.4 GBq.

Apart from some not very widespread applications also using the beta emitters like erbium 169 ($E_\beta$max ≈ 0.35 MeV) or rhenium 186 ($E_\beta$max ≈ 1 MeV), iodine 131 ($E_\beta$max ≈ 0.6 MeV) remains the radionuclide of reference in the field of radionuclide therapy. This one being used for more than 50 years for the treatment of the thyroid affections, radiation protection measurements are well known and applied, more especially as being also gamma emitter ($E_{\gamma principal}$ ≈ 0.365 MeV) the provisions concerning this radiation are largely enough for the beta radiation. Perhaps that explains why the products labelled with ^{90}Y were not the subject of thorough preliminary studies concerning radiation protection. Indeed, the users, just as the suppliers, are generally based on general concepts concerning the beta emission: a) 10 mm of PMMA are enough to stop any beta radiation, and b) protection in PMMA is preferable with protection of lead (or material more attenuating) because the bremsstrahlung emission is less important.

At the beginning of the clinical protocols, or before starting it, we decided to analyse the procedures in order to optimise it on a radiation protection point of view.

2. MATERIAL AND METHOD

According to the data on the radiation protection of yttrium 90, the exposure rate at 1 m from a glass vial is 70 $\mu Sv.h^{-1}.GBq^{-1}$, the exposure rate in contact with a 5 ml syringe is 43 $Sv.h^{-1}.GBq^{-1}$ and the total absorption of the radiation is obtained with 4.9 mm of glass or 9.2 mm of PMMA [3]. These data do not take into account the bremsstrahlung radiation which can be important with the high activities used in these clinical protocols. For this reason and because injection needs several steps of preparation a radiation protection study has been carried out. We thus made a systematic study of the exposure of the various personnel, as well as efficiency of the material of protection available.
For that each operator was provided with an electronic dosemeter[2] in complement with his legal film dosemeter and thermoluminescent dosemeters[3] located at the extremity of the thumb and index at each hand. Measurements with a ratemeter ionisation chamber[4] were also taken throughout the procedure then during the hospitalisation of the patients.

Protocol with OCTREOTHER® requires a phase of preparation of the vial containing the radioactive solution (4.44 GBq in 86 ml) and a connection of line to the patient. For the hands, the critical phase was during the handling of the line filled with ^{90}Y when one respected the protocol initially proposed by the manufacturer. A first step thus consisted in modifying this protocol to remove this phase, and to handle, if possible, only cold tubing filled with physiological serum.

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[1] OCTREOTHER®, Mallinckrodt and ZEVALIN®, Schering
[2] DOSICARD, Eurisys mesures
[3] GR 200 chip
[4] BABYLINE, Eurisys mesures and RAM DA 2000, Rotem

Protocol with ZEVALIN® requires a more important preparation before injection. It is thus essential to use the syringe shield and adapted shielding. We compared the material proposed by the supplier, a 5 mm PMMA syringe shield and a 10 mm PMMA vial shield, with the material usually used in the service, tungsten syringe shield and vial shield in lead glass used daily for the radiopharmaceutical preparations with ^{99m}Tc. The exposure of the operator was measured according to the procedure described previously.

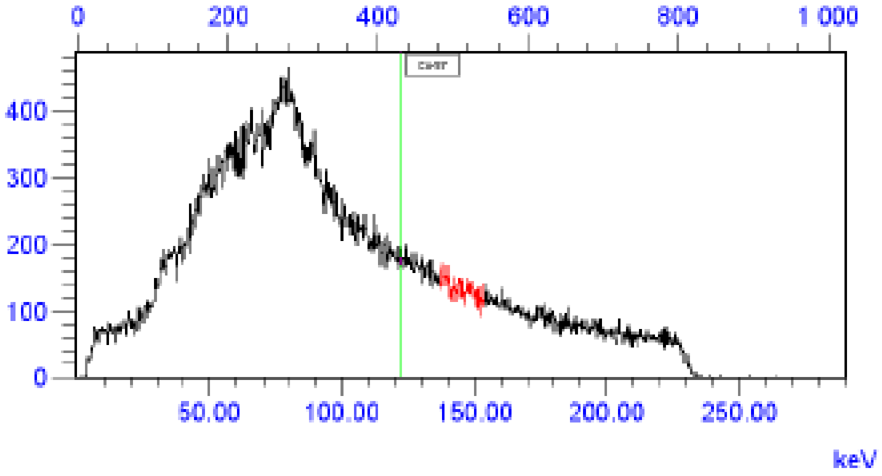
3. RESULTS

In protocol with OCTREOTERâ we measured with the ionisation chamber exposure rates up to 300 µSv/h to contact with the containers of delivery and injection, and up to 2 to 3 µSv/h at 1 m from these containers. After the injection, the exposure rate was about 30 to 40 µSv/h at 1 m of the patient, and ≈120 µSv/h close to the second pump necessary for the injection of amino acids. Concerning measurements with TLD chips table I presents the measurement of the exposure of the finger's operators (technologist and nurse) after 13 treatments.

Table I : Finger exposure in mSv/treatment (standard deviation) during the 1st treatment and for the 12 others.

Localisation	**Right thumb**	**Right forefinger**	**Left thumb**	**Left forefinger**
	1st treatment			
technologist	18.0	23.5	14.0	14.5
	Other treatments (12)			
technologist	2.81 (2.13)	2.36 (2.58)	2.12 (0.74)	1.60 (0.74)
nurse	0.40 (0.56)	0.28 (0.50)	0.42 (0.58)	0.20 (0.32)

These results show that: 1) the exposure to the chest for the most exposed person (preparation of the bottle, installation of the tubing and management of the radioactive waste) lies between 4 and 22 µSv/injection, and, 2) the exposure of the fingers decreased by more than 20 mSv to less than 5 mSv after the installation of the "cold" tubing. During the phase of injection, close to the injection pump of the ^{90}Y we measured rates as high as 700 to 1000 µSv/h at the operator position. Once the injection carried out the nurse is only exposed to the bremsstrahlung produced in the patient (≈ 20 µSv/h at 1 m from the patient). Figure 1 presents the spectrum measured by means of a NaI(Tl) probe[5] near a patient one day after the injection of 4.44 GBq. One can note the importance of low energies in this spectrum. Therefore a protection apron of 0.5 mm of lead equivalent (used classically in radiology) allowed to reduce of a factor ≥ 60 the exposure of the nurse in charge of care throughout hospitalisation (2 days) (table II).



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[5] nanoSPEC, ARIES

Figure 1 : Bremsstrahlung spectrum from patient one day after injection of 4.44 GBq of ^{90}Y (rate exposure at 1 m ≈ 1.5 to 2 µSv/h).
Table II : Rate exposure measured with an ionisation chamber near patient without and with protection (apron of 0.5 mm equiv. Pb).

	Without protection	With protection (0.5 mm eq. Pb)
Patient 1 (at 50 cm)	360	4.8
Patient 2 (at 65 cm)	59.1	1.0

For protocol with ZEVALIN® the results obtained show that: a) the exposure of the fingers could rise with several tens of mSv by preparation without protection, b) the exposure of the fingers is lower than one mSv with protection and, c) that the lead glass shielding device for vial is very effective (factor ≈500). Concerning the syringe shield, figure 2 presents the spectrum obtained for each material used. The integral of spectrum, which accounts for the efficiency of each one of them, shows an efficiency approximately 7 times better for tungsten compared to the PMMA.

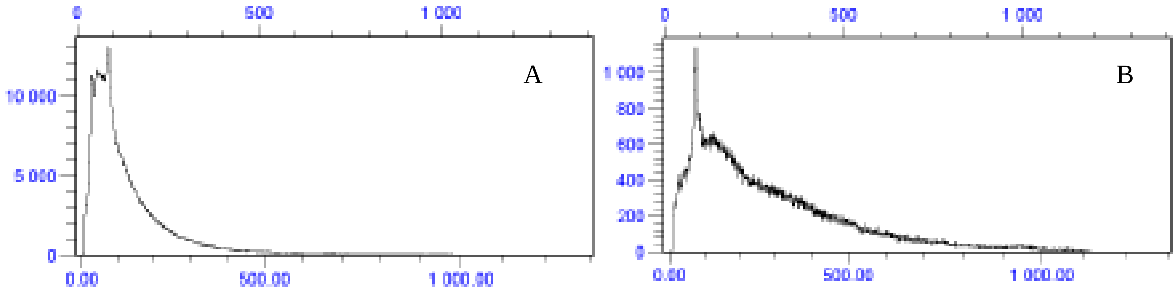

Figure 2 : ^{90}Y syringe spectrum with a syringe shield in PMMA (A) and tungsten (B). The curve integral shows the efficiency of the shielding (note the 80 keV peak due to the X ray of lead in the probe collimator and different Y-scales).

4. CONCLUSION

This study of radiation protection concerning new protocols of radionuclide therapy with ^{90}Y sources confirmed:

- need for studies of working conditions before the starting of all new clinical protocol;
- advantage of complementary dosemeters to the most exposed regions (fingers);
- interest of operational dosimetry in these situations for the direct information of the operator;
- need for electronic dosemeters adapted to the situation, i.e. sensitive to the beta radiation for this study;
- the contribution of a radiation protection culture in a hospital where the human and material means are available.

5. REFERENCES

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