2a

New developments in patient specific dosimetry

C. Chiesa (Milano)

Since the beginning of the past century, the International Commission on Radiological Protection (ICRP) established the three basic principles of radiation protection: justification, optimisation, dose constraints. Since then, such principles leaded extensively and rigorously the protection of workers, of public and of patients. Nevertheless, it is a fact that in nuclear medicine therapy the optimisation principle showed an erroneous or a relatively limited applications. The ICRP publication N° 94 ([1]) is a milestone based on a revisited optimisation principle for public, workers and patient's relative radiation protection. On the other side, the radiation protection of the patient, claimed by the European Directive 97/44 (1997) ([2]), has no other mean of quantitative optimisation than internal dosimetry, which is still very rarely performed. Although both the Directive and important reference paper (ICRU 67 ([3])) begin to show signs of time without having seen widespread applications, recent scientific publications [([4]), ([5])], and proposed software [([6]), ([7])] show that internal dosimetry is far from being forgotten.

ICRP 94

This documents concentrates on risk related to the use of ^{131}I, while other primarily beta emitters like ^{32}P, ^{89}Sr and ^{90}Y are indicated as providing "much less risk". This introduces a difference between beta+gamma and pure beta emitters which could change the current regulations about necessity of hospitalization in the second case. Higher remarks is posed to external exposure of others, so that in case the treated patient lives alone, no risk for other is in existence, and no hospitalisation is required. On the other side, since "thyroid cancer as result of radiation exposure appears to be a significant risk for fetus, infants, and those under the age of 20 years, particular care should be taken to avoid contamination of infants, children and pregnant women".

The environmental impact of ^{131}I waste is discussed , finding that "very low activities of ^{131}I are observed in the environment as a result of medical uses". The necessity of urine storage is evaluated in the light of the optimization principles, and it is remarked that "ICRP recommendations do not explicitly state that urine should be stored or that patients should be hospitalised after therapy with high activities of radiopharmaceuticals. Instead, the ICRP recommends that public dose limits and dose constraints for others should be observed. This should be followed by optimisation." The risk of accident and the dose to worker in case of high activity urine storage is another factor usually underestimated. The factor of psychological costs for the patient's hospitalisation is taken into account for the first time.

For these set of arguments, the final conclusion is that "the decision to hospitalise or release a patient should be determined on an individual basis".

From an intellectual point of view, such a statement is only apparently revolutionary if a non optimized common procedure, often translated in national law, is considered. In practice, the future will show if such a striking statement will be translated into new European Directives, and then in national laws. Guidelines will be in any case necessary to limit the possibility of individual decisions. In both Directives and Guidelines, the EANM role will be decisive.

Optimization of nuclear medicine therapy

The patient radiation protection has no other way that individual internal dosimetry. This has to be regarded as a part of radionuclide therapy (like happens in external beam radiotherapy), rather than a separate science. In this respect the well known ICRU 67 publication could is a reference paper. Starting from biological considerations, it poses particular attention to the case of non uniform spatial distribution of radioactivity. Up to now, the most common dosimetric evaluation is for uniform activity distribution, which gives a mean organ dose (MIRD methods). Neglecting the nonuniform distribution could cause large impairment between dosimetric previsions and real biological effects. In this respect, modern hybrid system like PET/CT but even the more accessible SPET/CT (now produced by all the major gammacamera builders) become essential tools for dosimetry. For PET, long or medium lived positron emitters start to become commercially available (^{124}I, 4.18 dd halflife, ^{86}Y 14.74 h halflife). The inter-

national trend towards an implementation and improvement of dosimetric methods is visible from the number of published paper in the last year proposing simple software tools for MIRD planar dosimetry, but also high level ultra specialised studies [([8]), ([9])] .

Along with the spatial distribution of activity, we find that the biological effect of the time distribution of irradiation is taken from the past works [([10])], in order to explain recent dosimetry failure. Barone et al [([11])], were able to demonstrate a correlation between kidney dose and creatinine loss per year in ^{90}Y DOTATOC therapy only introducing the dose rate effect in the dosimetric calculation (i.e. using of Biological Effective Dose, BED). No correlation arose from simple absorbed dose approach, even with the most sophisticated methods (^{86}Y PET dosimetry).

The number and the quality of recently published papers show that, hopefully, the way towards the optimisation of the nuclear medicine therapy is at least desired.

References

1 International Commission for Radiological Protection Publication N° 94 Radiological protection after nuclear medicine procedures (2004)

2 Nuis A. Health protection of individuals against the dangers of ionising radiation in relation to medical exposure: Council directive 97/43 EURATOM. 30-6-1997

3 International Commission on Radiation Units and Measurements (ICRU) Report n° 67 Absorbed dose specification in nuclear medicine (2002)

4 Brans B, Bodei L, Giammarile F, Linden O, Luster M, Oyen WJ, Tennvall J Clinical radionuclide therapy dosimetry: the quest for the "Holy Gray". Eur J Nucl Med Mol Imaging ,2007 May;34(5):772-86

5 Flux G, Bardies M, Chiesa C, Monsieurs M, Savolainen S, Strand SE, Lassmann M Letters to the editor to be published on Eur J Nucl Med Mol Im

6 Sjögreen K, Ljungberg M, Wingårdh K, Minarik D, Strand SE The LundADose method for planar image activity quantification and absorbed-dose assessment in radionuclide therapy. Cancer Biother Radiopharm ,2005 Feb;20(1):92-

7 Visser E, Postema E, Boerman O, Visschers J, Oyen W, Corstens F Software package for integrated data processing for internal dose assessment in nuclear medicine (SPRIND). Eur J Nucl Med Mol Imaging ,2007 Mar;34(3):413-21

8 Sgouros G, Kolbert KS, Sheikh A, Pentlow KS, Mun EF, Barth A, Robbins RJ, Larson SM Patient-specific dosimetry for 131I thyroid cancer therapy using 124I PET and 3-dimensional-internal dosimetry (3D-ID) software. J Nucl Med ,2004 Aug;45(8):1366-72

9 Song H, He B, Prideaux A, Du Y, Frey E, Kasecamp W, Ladenson PW, Wahl RL, Sgouros G Lung dosimetry for radioiodine treatment planning in the case of diffuse lung metastases. J Nucl Med ,2006 Dec;47(12):1985-94

10 ale R. Dose-rate effects in targeted radiotherapy. Phys Med Biol 41,1996; 1187-1884

11 Barone R, Borson-Chazot F, Valkema R, Walrand S, Chauvin F, Gogou L, Kvols LK, Krenning LP, Jamar F, and Pauwels S. Patient-Specific Dosimetry in Predicting Renal Toxicity with ^{90}Y-DOTATOC: Relevance of Kidney Volume and Dose Rate in Finding a Dose–Effect Relationship. J Nucl Med 2005 46: 99S-106S