^{90}Y glass microspheres radionuclide therapy: robustness analysis with a dosimetry software

Aurélie Forbes[1,*], *Gilles* Grimon[1], *Aya* Esaki[1,2], *Jad* Farah[1], and *Emmanuel* Durand[1]

[1]APHP Bicêtre University Hospital, Biophysics and Nuclear Medicine Department, 78 rue du Général Leclerc, 94275 Le Kremlin-Bicêtre Cedex, France
[2]CentraleSupélec, 3 Rue Joliot Curie, 91190 Gif-sur-Yvette, France

1 Introduction

In diagnostic and therapeutic nuclear medicine, the administration of a fixed radionuclide activity simply adjusted to patient's weight remains a widely used practice. To perform personalized dosimetry, several home-made solutions exist [1] while new commercial solutions have been recently introduced with treatment planning and dosimetry capabilities similar to external radiotherapy.

In the present work, the PLANET® Dose (DOSIsoft, France) software was used to retrospectively compute organ doses for eight liver cancer patients treated at Bicêtre University Hospital using glass ^{90}Y Therapheres™ (BTG, Canada). The standard protocol for radioembolization involves a planning phase performed with ^{99m}Tc-macroaggregated albumin (MAA). SPECT/CT images are acquired to determine the liver tumor volume and the liver-to-lungs shunt [2]. The ^{90}Y activity is then calculated based on a simple 2-compartment model (lungs and targeted liver regions) with a planned mean absorbed dose of 80 - 150 Gy (120 Gy recommended by BTG) to the target and a maximum tolerable dose to the lungs of 30 Gy. Following ^{90}Y injection, Therapheres™ distribution is verified through PET/CT images while no organ dose calculation whatsoever is performed. This study aims at computing and comparing planned (standard approach) and delivered organ doses (PLANET® Dose).

2 Materials and methods

Using PLANET® Dose dosimetry software (DOSIsoft, France), a proper segmentation of liver and lungs organs was performed for eight patients treated between February 2016 and may 2017 using ^{90}Y Therapheres™. From the registered SPECT (functional) and CT (anatomic) planning images, tumor (TV) and non-tumor (NTV) volumes and lungs structures were identified and their volume was computed. Liver-to-lungs shunt was also computed using PLANET® Dose and compared against the standard procedure. Organ doses and Dose Volume Histograms (DVH) were next calculated using the convolution or local deposition methods. Such calculations were performed both on predictive MAA SPECT/CT acquisitions as well as on post treatment ^{90}Y PET/CT images to determine the correspondence between planned and delivered tumour and lungs doses.

* Corresponding author: aurelie.forbes@aphp.fr

3 Results

Results first show that the liver-to-lungs shunt based on planar SPECT images with low MAA lungs fixation is generally higher (on average 40 ± 10%) than the one calculated with PLANET® Dose using volumetric information. This might requires revising the standard approach since proper assessment of liver-to-lungs shunt would enable TV dose escalation. However, in the specific eight patients considered in this study, the impact on the activity administration and the standard clinical procedure remains limited since the mean liver-to-lungs shunt was low (4.2 ± 2%). In addition, some patients SPECT-CT images used with PLANET® Dose had missing upper part of lungs due to local patient positioning.

The distributions of ^{99m}Tc MAA and ^{90}Y Theraspheres™ agreed in 5/8 patients. When the distributions disagree, PLANET® Onco provides a quantitative value of the delivered TV dose; this information is strictly missing in the standard approach. Namely, predictive dosimetry was found giving a higher mean TV dose by a factor 1.44 ± 0.34; a similar finding of Gnesin et al. [3]. Such under-dosage to TV could yield a procedure failure.

Finally, convolution and local deposition calculation methods showed similar (average difference 2 ± 2%) doses to tumor and non-tumor further justifying the performance of home-made solutions which often use either algorithms.

4 Conclusion

In ^{90}Y radioembolization, the dose delivered to target and non-target organs is not quantitatively calculated with conventional treatment planning. Moreover, the predictive distribution of ^{90}Y Theraspheres™ is sometimes in disagreement with ^{99m}Tc MAA. PLANET® Dose software enables personalized dosimetry and DVH calculations.

Following this study, a systematic organ dose calculation based on ^{90}Y Theraspheres™ PET/CT images proved necessary to advise on the appropriate actions: adjunct treatment in case of TV under-dosage or follow-up for healthy organs' over-exposure.

The robustness analysis presented in this preliminary study will be integrated into the routine local practice to adjust, in future treatments, both the planning and post treatment patient follow-up.

Further studies remain to be done to assess whether this software gives better clinical evaluation than the standard method.

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References

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