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Yttrium-90 positron emission tomography for qualitative and quantitative assessment of residual activity in delivery apparatus after radioembolization

RUNNING TITLE

Y90 PET for apparatus residual activity

AUTHORS AND AFFILIATIONS

Yung Hsiang KAO , MBBS, MRCP, FAMS, FRACP (1-2), yung.kao@mh.org.au
Alicia CORLETT , BAppSc(MedRad), PhD (1), alicia.corlett@mh.org.au
Katrina JORNA , BSc (2), kjorna@cabrini.com.au
Alexander RHODES , MBBS, FRANZCR, EBIR, MClinED (3), alexander.rhodes@mh.org.au
Dinesh SIVARATNAM , MBBS(Hons), BMedSci(Hons), FRACP (1-2), dinesh.sivaratnam@mh.org.au

(1) Department of Nuclear Medicine, The Royal Melbourne Hospital, Victoria, Australia
(2) Medical Imaging Department, Cabrini Hospital, Victoria, Australia
(3) Department of Radiology, The Royal Melbourne Hospital, Victoria, Australia

CORRESPONDING AUTHOR DETAILS

Dr Y.H. Kao
Department of Nuclear Medicine
The Royal Melbourne Hospital
300 Grattan Street, Parkville, Victoria 3050, Australia
Telephone: +61 (3) 9342 7480
Fax: +61 (3) 9342 7342
Email: yung.kao@mh.org.au

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CONFLICT OF INTEREST DISCLOSURE

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ABSTRACT

Assessment of residual activity is critical for quality assurance after yttrium-90 radioembolization. The resin microsphere manufacturer's indirect method of estimating the residual activity is laborious and vulnerable to inaccuracies. Furthermore, their method cannot localize the exact site of residual activity. Yttrium-90 PET/CT for qualitative and quantitative assessment of residual activity has not been described. We show an example of yttrium-90 PET/CT of residual activity in the delivery apparatus and catheters packed inside the delivery box. Focally intense residual activity was clearly localized to the stopcock junction. Residual activity was directly quantified by setting the PET volume-of-interest isocontour threshold to 1%.

KEYWORDS

Yttrium-90, PET/CT, quantification, radioembolization, selective internal radiation therapy, SIR-Spheres

INTRODUCTION

Yttrium-90 radioembolization using resin microspheres (SIR-Spheres, Sirtex Medical Limited, Sydney, Australia) is a treatment modality for inoperable hypervascular liver tumours. After radioembolization, measurement of residual activity within the delivery apparatus is critical for quality assurance and training. The presence of significant residual activity (generally >5% of prescribed activity) should trigger a procedural audit.

The manufacturer of resin microspheres has devised a method of indirectly estimating the residual activity based on relative count rates. The prepared v-vial of known activity is first placed into a standard cylindrical Perspex container. Using a dose rate meter at a fixed 30cm distance, its dose rate is averaged from 4 positions around the container. After radioembolization, all delivery apparatus and catheters are packed into the same container and the entire process repeated. The residual activity is then calculated from the percentage difference in count rates.

This method is simple, albeit laborious and vulnerable to inaccuracies. Inaccuracies may occur due to variations in geometry and positioning of items within the container, effects of self-absorption, probe directionality and backscattering (*1*). There is also radiation exposure from additional manual handing. Furthermore, this method can only determine whether significant residual activity is present, but cannot *localize* the culprit. Localizing the culprit is critical to provide specific and relevant feedback to the operators involved.

In recent years, post-radioembolisation yttrium-90 PET/CT of minuscule internal pair production has been shown to be clinically useful for the qualitative and quantitative assessment of target and non-target microsphere biodistribution (*2-4*). However, its use for residual activity assessment has not been described to date.

MATERIALS AND METHODS

Figure 1 depicts yttrium-90 PET/CT of residual activity within the delivery apparatus and catheters, packed within a plastic storage bottle and placed inside the standard Perspex delivery box. The syringe used in the transfer of microspheres from the shipping vial into the v-vial was not included but it was visually clear of microspheres, hence any residual activity was assumed negligible. Yttrium-90 PET/CT was performed within an hour of radioembolization on a Siemens Biograph Horizon (Siemens, Erlangen, Germany) scanner over 20 minutes. PET images were reconstructed using Siemens “TrueX” time-of-flight iterative algorithm, 3 iterations and 10 subsets, Gaussian filter, 180x180 matrix and full-width half maximum 5mm. Low-dose CT was performed for localisation, attenuation and scatter correction and displayed in 3mm slice thickness. Images were analysed using Siemens “SyngoVia” software. The institutional review board approved this report and the requirement to obtain informed consent was waived.

RESULTS

Qualitatively, Maximum Intensity Projection depicts mild residual activity along the tubings and catheters (Fig. 1A) with a focus of intense activity (“S”). Mild residual activity was also seen at the bottom of the v-vial (“V”; Figs. 1A and 1B). The intense activity was clearly

localized to the stopcock junction ("S"; Figs. 1C and 1D) – a common site of resin microsphere trapping (*5*).

Quantitatively, a volume-of-interest (VOI) was drawn around the entire delivery box (green circle; Figs. 1B and 1C) with the isocontour threshold set to 1%. The overall residual activity was directly calculated as the simple product of VOI radioconcentration (kBq/ml) and VOI volume (cm^3). The measurements displayed in Figs. 1B and 1C show the overall residual activity to be 35MBq. In this example, the v-vial activity prior to radioembolization was 1.93GBq, therefore the residual activity was only 2% and in keeping with quality standards. The residual activity estimated using the manufacturer's indirect dose rate meter method was <1%.

DISCUSSION

The delivery apparatus is assembled from multiple components, hence there are many potential sites for microsphere trapping. The key advantage of yttrium-90 PET/CT over the manufacturer's indirect dose rate meter method is the ability to identify the location of the trapped microspheres, in addition to its direct quantification. Such specific feedback is valuable for quality assurance and to identify technical issues in delivery apparatus preparation or microsphere injection.

CONCLUSION

Yttrium-90 PET/CT is a useful quality assurance tool for localization and direct quantification of residual activity within the delivery apparatus after radioembolization.

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FIGURE 1

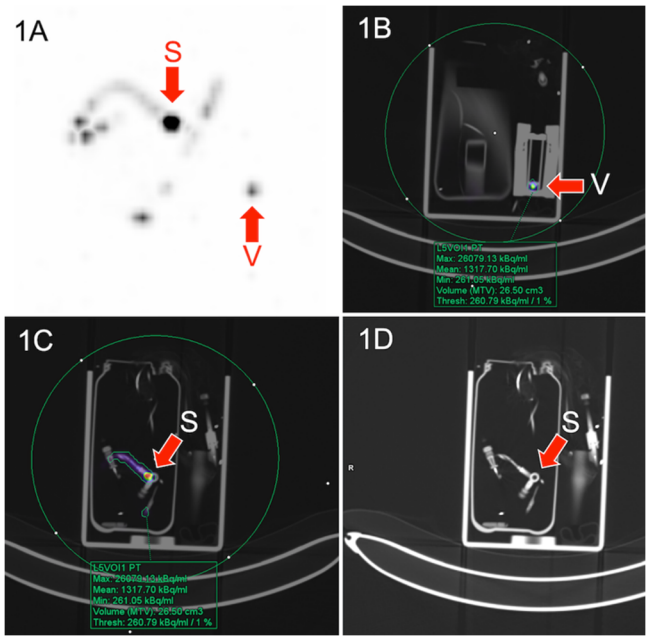

FIGURE LEGEND

Fig. 1A: Maximum Intensity Projection shows mild residual activity along the tubings and catheters with a focus of intense activity ("S"). Fig. 1B: Mild residual activity at the bottom of the v-vial ("V"). Fig. 1C: Intense residual activity was clearly localized to the stopcock junction ("S"). Fig. 1D: The stopcock junction as shown on low-dose CT.

GRAPHICAL ABSTRACT