Imaging and Radiation Safety Considerations for ^{32}P Radionuclide Therapy of Inoperable Pancreatic Primary Cancer

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Introduction

OncoSil Medical Ltd (Sydney, Australia) have a novel therapeutic approach to treating inoperable primary pancreatic cancers by injecting the tumour directly with particles of silicon impregnated with phosphorus-32 (^{32}P), "OncoSil". The OncoSil particles in solution are administered via an endoscopic procedure with ultrasound guidance. Typical amounts required for treatment are of the order of tens of MBqs with 40 MBq being thought to be a typical dose *(1)*.

Figure 1: OncoSil treatment delivered by endoscopic ultrasound guidance. Endoscopist and Nuclear Medicine Physician are in close proximity to OncoSil treatment.

The considerable high energy bremsstrahlung photons produced presents a dichotomy in terms of radiation protection and imaging. The question of the exposure levels of treating physicians in close proximity to the OncoSil radiation source has been raised.

After an implantation procedure, it is highly desirable to be able to measure the distribution of implanted radioactive microspheres *(1)*. Imaging can be used to confirm appropriate implantation of the therapy as well as being potentially quantifiable to be used in dosimetric analysis of surrounding tissues assuming no redistribution of the microspheres *(2)*. However, the lack of radiation emitted from the nucleus in the form of gamma rays or positrons makes imaging of ^{32}P challenging.

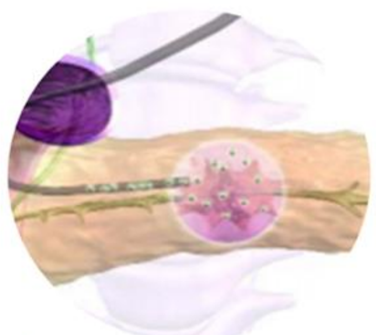


Figure 2: Schematic of distribution of OncoSil in pancreatic tumour

Aims: The purpose of this work was to determine (a) the potential radiation exposure to staff during the OncoSil treatments (b) the image quality of ^{32}P bremsstrahlung imaging.

Methods

A water-filled IEC body phantom (Data Spectrum Corp, Hillsborough, NC) containing an internal spherical component of 35 mls located off the central axis was used to simulate the body situation. A representative upper therapeutic limit of approximately 60 MBq of OncoSil solution filled the spherical compartment. A Radeye B20-ER (Thermo Fisher Scientific Messtechnik GmbH) survey meter was used for radiation exposure assessments. Measurements were done at several locations about the phantom where caregivers would typically be positioned during a treatment. The attenuation effect of a lead apron was assessed. A Siemens Intevo.6 SPECT/CT gamma camera system (Siemens Healthineers, Hoffman Estates, USA) was used to image the phantom with medium energy collimators. Energy spectra were acquired after removing the collimator from the detector. Images were reconstructed using ordered subset ML-EM (OSEM) reconstruction algorithm *(7)*.

Figure 3: OncoSil solution added to the largest sphere in the phantom.

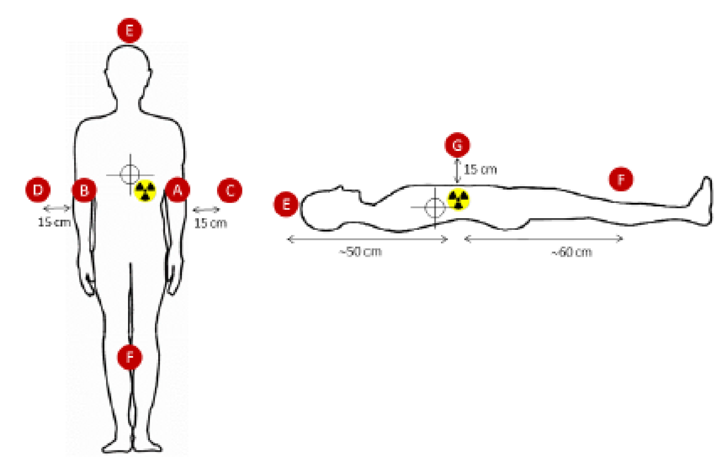


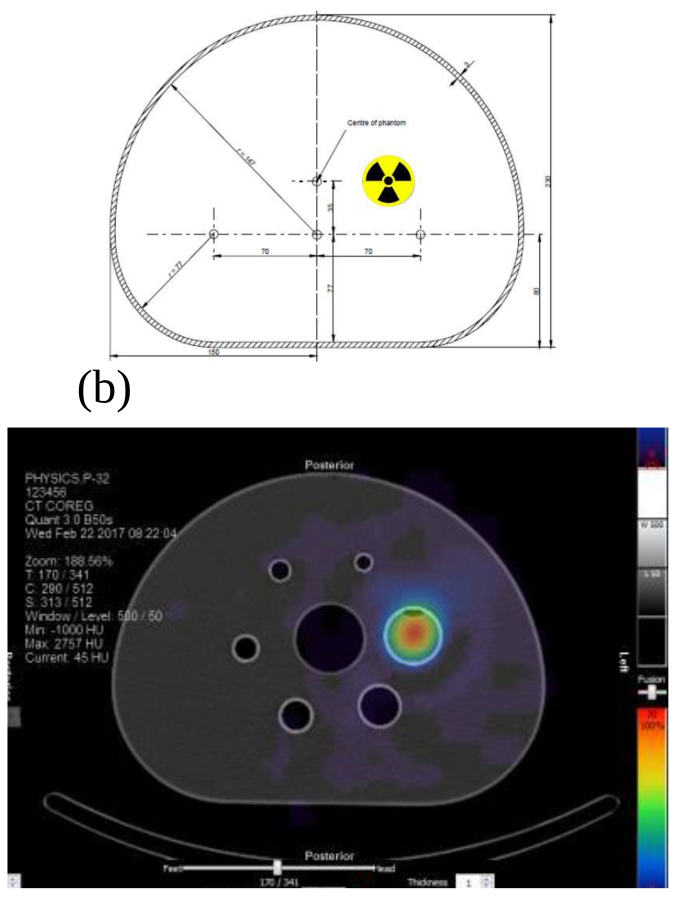
Figure 4: OncoSil solution added to the largest sphere in the phantom.

Results

The exposure rate from an upper therapeutic limit of 60 MBq in-vivo is approx. 10 µSv.hr^{-1} and that from a typical treatment of 40 MBq in-vivo is 6.4 µSv.hr^{-1}. A caregiver would need to stand at the side of a patient closest to the implanted OncoSil microspheres in the pancreas, in close proximity, for 100 hours to approach 1 mSv.

(a)

(b)



(c)

Measurement Location	Without lead apron	With lead apron*
Bkg	0.3	0.3
A	13.5	3.2
B	1.4	0.3
C	1.3	-
D	0.6	-
E	0.4	-
F	0.3	-
G	1.3	0.3

**Measurements not taken as at the level of Background*

Figure 5: (a) Cross section of IEC body phantom showing the approximate location of the sphere containing the OncoSil solution (radiation symbol). Distances are in mm; (b) SPECT/CT fused image of body phantom with ^{32}P in the largest sphere; (c) Exposure measurement (µSv.hr^{-1}) simulating a patient treatment scenario for 85MBq of ^{32}P in the radiation source.

The PHA spectrum acquired on the gamma camera showed that the majority of photons were below 150 keV, however there was an appreciable tail extending beyond 200 keV. The imaging window was thus set to 50-100 keV. Successful imaging has been obtained in the currently active clinical trial.

(a) (b)

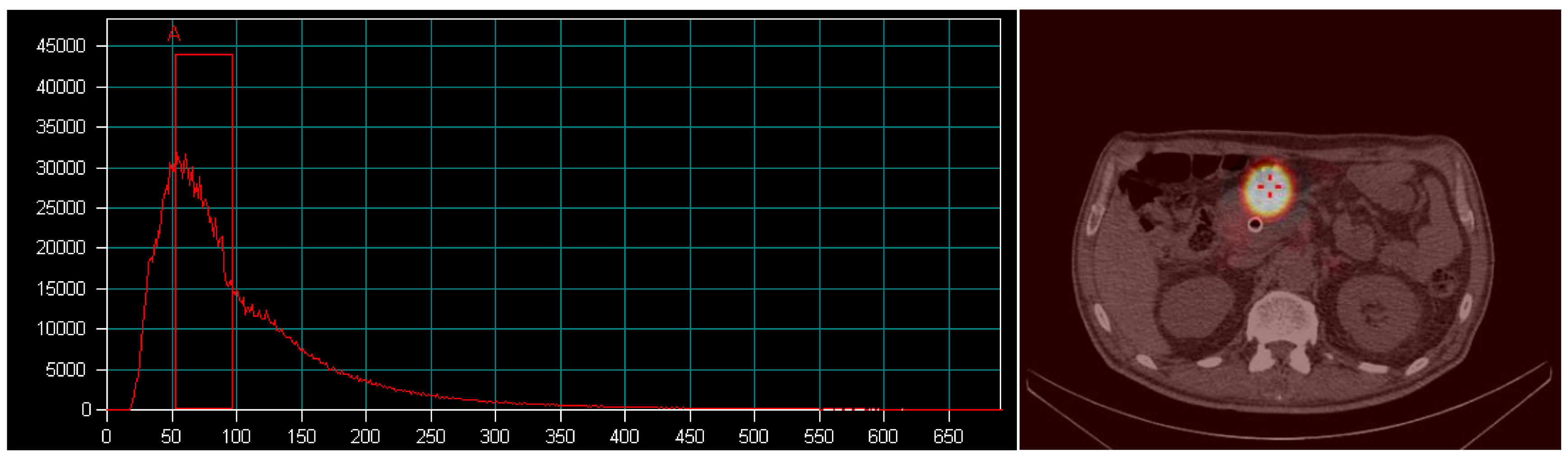


Figure 6: (a) Photon spectrum from gamma camera (uncollimated) for ^{32}P in the filled IEC body phantom. The window is set from ~50 – 100 keV (75% keV centerline with a 60% window); (b) a SPECT/CT fused image from a patient treated with OncoSil on the currently active trial.

Conclusions

The exposure of staff in close proximity to the OncoSil radiation source during treatment is very small based on these phantom measurements, however, while the exposure rates that we have measured are indicative, actual values may be higher or lower depending on the operator and dose used. Electronic personal dosimeters which provide an instantaneous read-out would be a suitable option. Similarly, exposure of nuclear medicine staff involved in the dose preparation *(which has not been measured here)* should also be considered. Acceptable image quality of [^{32}P]-OncoSil has been demonstrated on an unmodified, conventional gamma camera using medium energy collimation. The use of a more sophisticated reconstruction algorithm could improve both image quality and qualitative accuracy further, although, the ultimate quantification potentially achievable when imaging bremsstrahlung radiation remains questionable.

Bibliography

1. Private correspondence – OncoSil Medical Ltd
2. Lhommel R, van Elmbt L, Goffette P, et al. Feasibility of 90Y TOF PET-based dosimetry in liver metastasis therapy using SIR-Spheres. Eur J Nucl Med Mol Imaging. 2010;37:1654-1662.
3. Willowson K, Forwood NJ, Jakoby B, Smith AR, Bailey DL. Quantitative 90Y image reconstruction in PET. Med Phys. 2012;39:7153-7159.
4. Willowson KP, Tapner M, Quest_Investigator_Team, Bailey DL. A multicentre comparison of quantitative 90Y PET/CT for dosimetric purposes after radioembolization with resin microspheres: The QUEST Phantom Study. Eur J Nucl Med Mol Imaging. 2015;42:1202-1222.
5. Willowson KP, Bernard EJ, Maher R, Clarke SJ, Bailey DL. Changing Therapeutic Paradigms: Predicting mCRC Lesion Response to Selective Internal Radionuclide Therapy (SIRT) based on Critical Absorbed Dose Thresholds: A Case Study. Asia Oceania J Nucl Med Biol. 2017;5:66-69.
6. Hudson HM, Larkin RS. Accelerated image reconstruction using ordered subsets of projection data. IEEE Trans Med Imag. 1994;MI-13:601-609.