

PT-PET imaging during arrhythmia ablation in porcine hearts using carbon ion beams

Stephan Helmbrecht¹, Anna Constantinescu², Marco Durante², Wolfgang Enghardt^{3,4}, Anna Eichhorn², Christian Graeff², Immo Lehmann⁵, Patrick Lugenbiel⁶, Douglas Packer⁵, Matthias Prall², Dierk Thomas⁶, and Fine Fiedler¹

¹Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiation Physics, Dresden, Germany; ²GSI, Darmstadt, Germany; ³Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiation Oncology, Dresden, Germany; ⁴Oncoray, National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden-Rossendorf; ⁵Mayo Clinic/St. Marys Hospital, Rochester, MN, USA; ⁶University of Heidelberg, Heidelberg, Germany

Introduction

Scanned carbon ion beams were used for arrhythmia ablation in a porcine heart model [1]. The PET system [2] installed at GSI's medical cave M was used for treatment inspection by measurement of the activity distribution that is created as a side product during irradiation. This was the first application of the Particle Therapy-PET technique to monitor carbon ion irradiations of target volumes in the heart.

Materials and Methods

The target volumes were AV-node (AVN), LA-PV junction (PVI), and freewall LV. The doses applied were 25, 40 and 55 Gy in the AVN cases and 40 Gy in the other cases, respectively. Each animal was irradiated with two fields in one single fraction. The PET measurement was performed during the spill pauses and after the irradiation of the first field in each case. The end of the measurement was 10 to 39 min after the end of the irradiation. During the measurements the animals were kept under apnoea to avoid blurring of the activity due to breathing motion. Therefore, a conventional 3D image reconstruction and analysis regime was applied.

Results

PET imaging could be performed successfully in all investigated cases. Examples for the different target volumes are shown in the figures 1, 2 and 3. The activity distributions were obtained from the coincidences captured during the spill pauses of the irradiation. The colorwash image representations are overlaying the contrast agent enhanced X-ray CT images. The activity distribution was nicely related to the target volumes. Severe influences due to biological washout in the extremely well perfused target region was observed as expected. This holds especially true for the PVI cases.

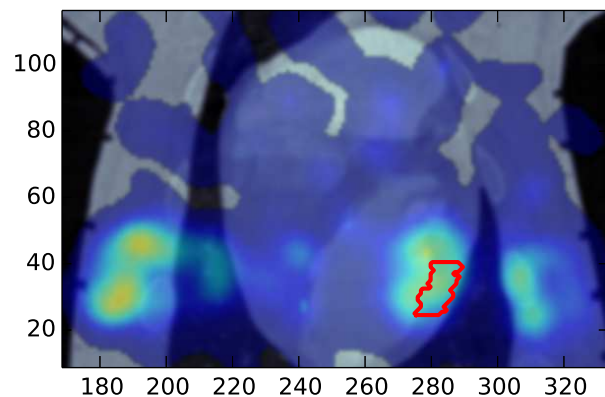


Figure 1: Activity distribution in an freewall LV case overlaying the contrast agent enhanced CT. The beam impinges from the left side of the image plane. The target volume is delineated with red color.

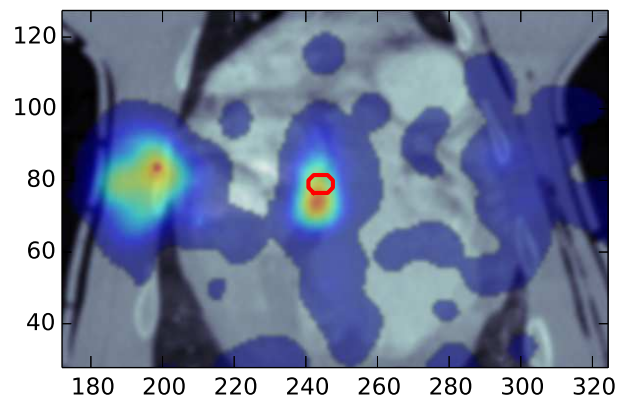


Figure 2: Frontal view of the activity distribution in an AVN case overlaying the contrast enhanced CT. The beam impinges from the left side of the image. The target volume is delineated with red color.

Conclusion

The application of carbon ion beams for treatment of volumes in the heart can be monitored by means of PET. The extreme perfusion conditions require a setup which allows

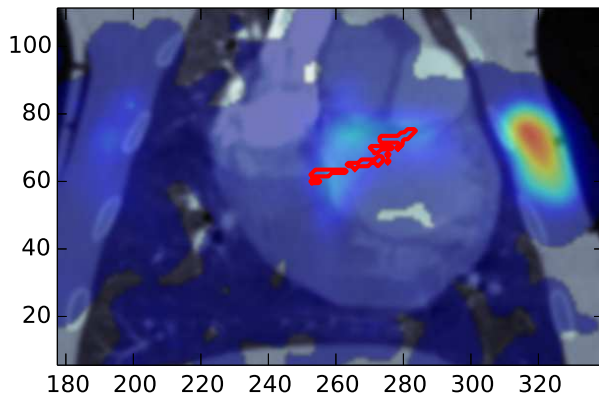


Figure 3: Frontal view of the activity distribution in a LA-PV junction case overlaying the contrast enhanced CT. The beam impinges from the right side of the image. The target volume is delineated with red color.

for a measurement during or immediately after the irradiation. Furthermore, a modeling of the washout is crucial to perform a meaningful prediction of the activity distribution.

References

- [1] C. Graeff, H. I. Lehmann, A. Constantinescu, P. Simoniello, P. Lugenbiel, M. Prall, D. Richter, M. Takami, A. Eichhorn, N. Erbelinge, C. Fournier, R. Kaderka, S. Helmbrecht, F. Fiedler, J. Debus, D. Thomas, C. Bert, M. Durante, D. L. Packer, GSI Scientific Report 2014 (2015), ?
- [2] W. Enghardt, P. Crespo, F. Fiedler, R. Hinz, K. Parodi, J. Pawelke, F. Pönisch, "Charged hadron tumour therapy monitoring by means of PET" Nucl. Instr. Meth. A, 2004, 525, 284-288