Image Article

The Impact of a Bayesian Penalized-Likelihood Reconstruction Algorithm on a Dual-Time-Point Acquisition Protocol while Performing Ga-68-PSMA PET for Primary Prostate Cancer Detection

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Abstract

A patient performed dual-time-point Ga-68-PSMA PET/CT for prostate cancer evaluation; images reconstructed using OSEM and Q.Clear™. Early and delayed PET revealed focus of increased uptake in prostate right peripheral zone, coincident with a suspicious lesion on MRI; lesion by normal prostate tissue uptake ratios increased with time. Furthermore, delayed-time-point PET revealed another smaller focus of increased uptake in prostate left peripheral zone, not shown by MRI. Some Q.Clear™ ß values determined higher uptake ratios. Biopsy confirmed two cancer lesions. Optimization of Q.Clear™ while performing dual-time-point Ga-68-PSMA PET may further improve image-guided targeted biopsy and focal therapy for primary prostate cancer.

The Impact of a Bayesian Penalized-Likelihood Reconstruction Algorithm on a Dual-Time-Point Acquisition Protocol while Performing Ga-68-PSMA PET for Primary Prostate Cancer Detection is shown in Figures 1-3
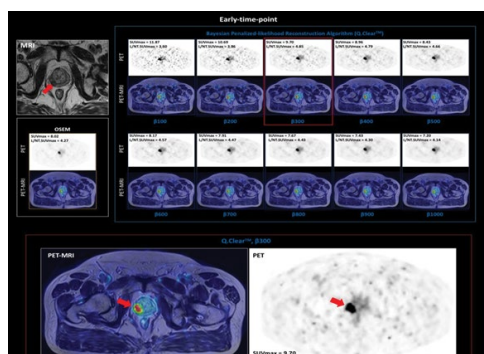

Figure 1: Ga-68-PSMA PET/CT is successfully used for recurrent prostate cancer localization and primary staging in high-risk disease, and targeted biopsy in patients with high suspicion of prostate cancer is also an emerging clinical application [1]. PET may be combined with 3D ultrasound to direct targeted biopsy of the prostate [2]. Innovations on PET scanners and the use of a Bayesian penalized-likelihood reconstruction algorithm (BPLA) such as Q.Clear™ can deliver high-quality images, which could further improve the diagnostic accuracy of PET for prostate cancer detection. Q.Clear™ includes a penalty function, a noise suppression term, controlled by a penalization factor, ß, allowing an effective convergence, and more accurate SUV quantification in contrast to OSEM, which have to be stopped before contrast convergence to prevent excessive image noise [3-7]. We present the case of a 75 years-old male who performed Ga-68-PSMA PET/CT for prostate cancer evaluation. PET/CT was acquired on a Discovery IQ4R scanner using a dual-time-point acquisition protocol, 1 hour and 2 hours after radiopharmaceutical administration; images were reconstructed applying two methods: OSEM and Q.Clear™ with ß ranging from 100 to 1000. PET was digitally fused with multiparametric MRI. Early-time-point (ETP) PET revealed a focus of increased Ga-68-PSMA uptake in prostate right peripheral zone, coincident with the finding of a lesion having 20 mm of diameter and suspicious for cancer on MRI. The SUV_{max} of this lesion in ETP was higher using Q.Clear™ with ß of 100 and the ratio of the SUV_{max} of the lesion by the SUV_{max} of normal prostate tissue $L/NT.SUV_{max}$ was higher using Q.Clear™ with ß of 300.
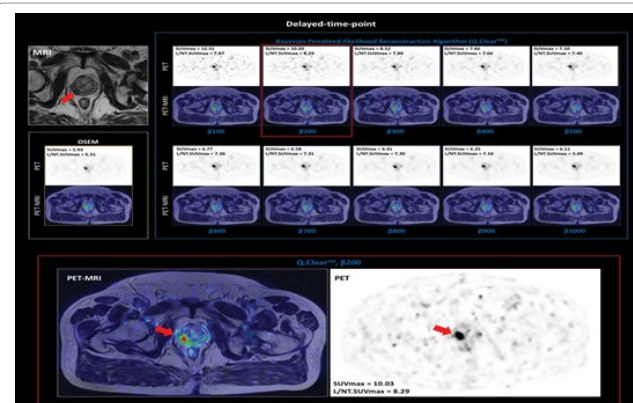

Figure 2: The images of delayed-time-point (DTP) revealed a marked temporal decrease of SUV_{max} in normal prostate tissue, resulting in a pronouncedly greater $L/NT.SUV_{max}$ in the right peripheral zone lesion on DTP than on ETP. Moreover, on DTP the $L/NT.SUV_{max}$ of this lesion was highest when using Q.Clear™ with ß of 200. This is an interesting finding since previous research revealed that lesion detectability of lung nodules is better when lower ß values are used, which is thought to relate with lower noise levels in normal pulmonary parenchyma than in tissues of other body regions [6], and as previously referred, the uptake in the normal prostatic parenchyma of this patient decreased with time.
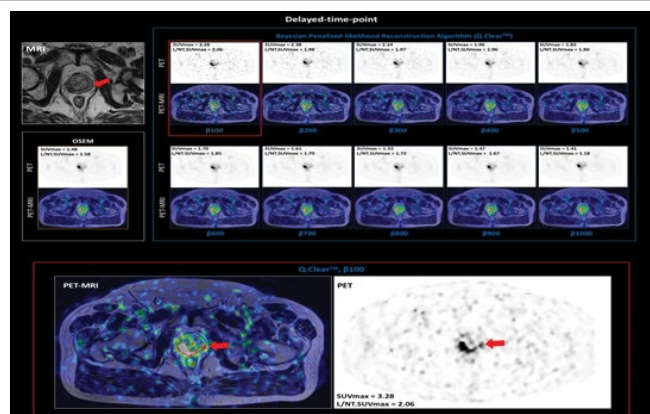
Figure 3: DTP PET revealed another smaller focus of increased uptake in prostate left peripheral zone, and L/NT.SUV$_{max}$ of this focus was higher when using ß of 100. This second focus wasn't coincident with any observable abnormality on MRI, but a biopsy confirmed the existence of two prostate cancer lesions, one in each lateral peripheral zone. In fact, Ga-68-PSMA PET/MRI proved to improve the diagnostic accuracy for primary prostate cancer [8,9], the value of DTP Ga-68-PSMA PET for the detection of primary and recurrent prostate cancer lesions has been described [10,11] and the synergistic effect of BPLA and DTP on recurrent prostate cancer detection was also shown [12]. This case suggests that the optimization of a BPLA while performing dual-time-point Ga-68-PSMA PET may further improve the capabilities of multimodality image-guided targeted-biopsy for primary prostate cancer detection and for focal therapy planning.

References

1. Fendler WP, Eiber M, Beheshti M, Bomanji J, Ceci F, et al. (2017) 68Ga-PSMA PET/CT: Joint EANM and SNMMI procedure guideline for prostate cancer imaging: Version 1.0, Eur J Nucl Med Mol Imaging 44: 1014-1024.

2. Fei B, Nieh PT, Schuster DM, Master VA (2013) PET-directed, 3D Ultrasound guided prostate biopsy Diagn Imaging Eur 29: 12-15.

3. Mumcuoglu EU, Leahy R, Cherry SR, Zhou Z (1994) Fast gradient-based methods for bayesian reconstruction of transmission and emission PET images, IEEE Transactions Med Imaging 13: 687-701.

4. Asma E, Ahn S, Ross SG, Manjeshwar R (2012) Accurate and consistent lesion quantitation with clinically acceptable penalized likelihood images. 2012 IEEE nuclear science symposium and medical imaging conference record (NSS/MIC) 4062-4066.

5. Parvizi N, Franklin JM, McGowan DR, Teoh EJ, Bradley KM, et al. (2015) Does a novel penalized likelihood reconstruction of 18F-FDG PET-CT improve signal-to-background in colorectal liver metastases? Eur J Radiol 84: 1873-1878.

6. Teoh EJ, McGowan DR, Macpherson RE, Bradley KM, Gleeson FV, et al. (2015) Phantom and clinical evaluation of the bayesian penalized likelihood reconstruction algorithm Q.Clear on an LYSO PET/CT System. J Nucl Med 56: 1447-1452.

7. Reynes-Llompart G, Gamez-Cenzano C, Romero-Zayas I, Rodríguez-Bel L, Vercher-Conejero JL, et al. (2017) Performance characteristics of the whole-body discovery iq pet/ct system. J Nucl Med 58: 1155-1161.

8. Eiber M, Weirich G, Holzapfel K (2016) Simultaneous 68Ga-PSMA HBED-CC PET/MRI Improves the localization of primary prostate cancer. Eur Urol 70: 829-836.

9. Zamboglou C, Drendel V, Jilg CA, Rischke HC, Beck TI, et al. (2017) Comparison of (68)Ga-HBED-CC PSMA-PET/CT and multiparametric MRI for gross tumour volume detection in patients with primary prostate cancer based on slice by slice comparison with histopathology. Theranostics 7: 228-237.

10. Afshar-Oromieh A, Malcher A, Eder M, Eisenhut M, Linhart HG, et al. (2013) PET imaging with a [68Ga] gallium-labelled PSMA ligand for the diagnosis of prostate cancer: Biodistribution in humans and first evaluation of tumour lesions. Eur J Nucl Med Mol Imaging 40: 486-495.

11. Sahlmann CO, Meller B, Bouter C, Ritter CO, Ströbel P, et al. (2016) Biphasic 68Ga-PSMA-HBED-CC-PET/CT in patients with recurrent and high-risk prostate carcinoma. Eur J Nucl Med Mol Imaging 43: 898-905.

12. Vieira ST, Faria DB, Silva AF (2018) The impact of a bayesian penalized-likelihood reconstruction algorithm on delayed-time-point Ga-68-PSMA PET for improved recurrent prostate cancer detection. Eur J Nucl Med Mol Imaging 45: 1461-1462.