Head-to-head comparison of ^{68}Ga-PSMA PET/CT and ^{68}Ga-PSMA PET/MRI for restaging of biochemical recurrent prostate cancer

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Abstract

^{68}Ga-PSMA PET demonstrates promise in the assessment of prostate cancer (PC) patients with biochemical recurrence (BCR) following radical prostatectomy (RP). Imaging was performed on 34 patients with BCR, using both ^{68}Ga-PSMA PET/CT and ^{68}Ga-PSMA PET/MRI. Studies that were performed on the same day between March 2017 and March 2018 were included, and retrospectively reviewed. Patients underwent dual-imaging/single-injection protocol within 3 hours of injection. All images were interpreted by at least one experienced nuclear medicine physician, and two experienced radiologists. Conflicting outcomes were identified and resolved by consensus between the reviewing physicians. Imaging concordance was found in 91% (31/34) of patients. Ultimately, PET/MRI was not superior to PET/CT, as it resulted in significant "halo artifacts" surrounding the bladder in some cases, due to its strong organ background ratios. As a consequence, more sophisticated scatter algorithms should be implemented in the future.

Introduction

PC is one of the most frequently diagnosed cancers, and a leading cause of cancer-related death among men worldwide [1,2]. Approximately 15-30% of men treated with RP will develop BCR, as defined by the EAU-ESTRO-SIOG guidelines [3]. Prostate-specific membrane antigen (PSMA) is uniquely overexpressed in primary tumors and many metastatic lesions of the prostate, with minimal expression in any other tissue [4]. This characteristic makes it an ideal target for imaging in the setting of BCR. ^{68}Ga-PSMA PET/CT (positron emission tomography/computed tomography) is a novel imaging modality, which has shown great potential in the staging of PC patients [5-7]. The tracer (^{68}Ga-PSMA-HBED-CC) is characterized by a very high lesion-to-background signal ratio [8].

Retrospective trials demonstrate superior detection rates and higher accuracy for the localization of BCR when compared with morphologic or choline PET/CT [6,9-11]. The recent introduction of PET/MRI (PET/magnetic resonance imaging) offers the possibility to combine molecular information of PET with both the high soft-tissue contrast and the functional information of MRI. The aim of this study was to evaluate the performance of ^{68}Ga-PSMA PET/MRI compared to ^{68}Ga-PSMA PET/CT in the restaging of BCR of PC.

Material and methods

All patients with prior RP and subsequent BCR, scheduled for restaging at the Department of Nuclear Medicine of the Bundeswehr

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Central Hospital, Koblenz, between March 2017 and March 2018 were eligible for this study and gave written informed consent. BCR was defined by the EAU-ESTRO-SIOG guidelines [3]. Patients with contraindications to MRI were excluded. A total of 34 patients were included and received both imaging modalities, in a sequential fashion, using a single-injection protocol. Only a single PET/CT and PET/MRI was performed per patient. The PET/CT images were obtained using the Biograph64 TruePoint (True V HD) PET/CT scanner (Siemens, Erlangen, Germany). Whole body images (pelvis to head) were taken 60 minutes after injection of ⁶⁸Ga-PSMA (mean 176 MBq, between 157-268 MBq, depending on body weight).

Two hours following injection of the radiotracer, PET/MRI was then performed on a fully integrated, whole-body hybrid PET/MRI system (Biograph mMR, 3-Tesla hybrid system, Siemens, Erlangen, Germany).

Disease recurrence was defined as a PSMA-avid lesion, corresponding to a morphological substrate on CT or MRI imaging.

All images were interpreted by at least one experienced nuclear medicine physician, and two experienced radiologists. When conflicting interpretations were identified, they were resolved by panel discussion and consensus between all of the reviewing physicians.

Results

During the study period, 95 patients with BCR underwent restaging imaging at our institution. Of these, 24 were excluded due to MRI contraindications or refusal by the patient to have the second scan. In 37 patients the PET/MRI could not be performed after the PET/CT due to time constraints or accessibility of the PET/MRI scanner. Ultimately, a total of 34 patients met inclusion criteria and underwent both PET/CT and PET/MRI per the study protocol and were analyzed. The mean age was 67.6 (range 46-86) and the mean PSA was 3.76 ng/dl (range 6.01-16.68). Detection of local and/or distant recurrence was found in 25 of patients. Of these, 13 were local, 4 were distant, and 8 were both. Study concordance between PET/MRI and PET/CT was observed in 31 of 34 patients (91%). In these cases, there were no discrepancies of even a single lesion (local recurrence, lymph node, distant metastasis).

The 3 cases of discordant imaging results are as follows:

In 2 cases there were metabolically active PC foci on PET/CT that were indistinguishable on PET/MRI; in fact, in one case the prostate bed could not be assessed at all on the PET/MRI. In another, a clearly PSMA avid lymph node on PET/CT could not be verified in PET/MRI due to "halo artifact", a typical artifact formation in PET/MRI, which interferes with the detection of malignant lesions [12].

Conversely, in one case PET/MRI demonstrated 4 avid lymph nodes, whereas PET/CT only identified 2 lymph node-metastases.

Nine patients with BCR had a negative study with both imaging devices. The PSA level tended to be a predictor of positivity, which has been demonstrated previously.

Discussion

Detection of early recurrent prostate cancer poses several challenges. Many different modalities are being evaluated, however, few studies provide a direct comparison of the diagnostic capability between hybrid ⁶⁸Ga-PSMA PET/CT with ⁶⁸Ga-PSMA PET/MRI in a well-defined population of biochemical recurrent PC. The Department of Nuclear Medicine of the Bundeswehr Central Hospital, Koblenz has carried out nearly 200 examinations with the PSMA PET/CT since July 2015, making it an ideal center to perform a comparative study.

After first establishing a diagnostic protocol for PET/MRI, we then performed sequential imaging with PET/CT followed by PET/MRI on 34 patients with BCR. Surprisingly, we found no significant difference in diagnostic performance for local recurrence and/or lymph node findings or distant metastases.

In general, PET/MRI proved not to be superior to PET/CT, which was clearly attributed to halo artifacts surrounding the bladder, a finding that has been reported previously [12]. The bladder had a strong organ-to-background uptake ratio, which is thought to obscure potential nearby lesion. Prompt gamma decay has been discussed as co-factor for these artifacts [13]. As a consequence, more sophisticated scatter algorithms have to be implemented in the/our clinical routine in the future [14].

Conclusion

The PET-signal itself is the key factor to detect location of recurrence or metastases by PSMA PET in patients with prostate cancer, independent of the morphological device (CT or MRI).

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