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Original article

(^{18}F)-PSMA-1007PET/CT in patients with biochemical recurrence after radical prostatectomy: Diagnostic performance and impact on treatment management

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ABSTRACT

Objective: To evaluate the diagnostic performance of (^{18}F)-PSMA-1007 PET/CT in prostate cancer patients with biochemical recurrence (BCR) after radical prostatectomy and the effect of (^{18}F)-PSMA-1007 PET/CT on treatment strategy.

Methods: A total of 114 patients with BCR after radical prostatectomy who performed (^{18}F)-PSMA-1007 PET/CT were retrospectively analyzed. The Gleason scores (GS), maximum standardized uptake values (SUV_{max}) and the diagnostic performance were compared according to different prostate-specific antigen (PSA) groups. To evaluate the impact of (^{18}F)-PSMA-1007 PET/CT on treatment management, we also collected subjects' therapy before and after PET/CT. The PSA value was monitored to evaluate the biochemical response.

Results: (^{18}F)-PSMA-1007PET/CT was positive in 92/114 patients (80.7%). The detection rates were 20/34 (58.8%), 13/17 (76.5%), 15/17 (88.2%) and 44/46 (95.7%) for PSA levels of 0.2-<0.5, 0.5-<1, 1-<2, ≥2 ng/ml. The positive lesions on PET/CT revealed local recurrence in 24/114 (21.1%) patients, lymph nodes metastases in 54/114 (47.4%) and metastatic sites in bone, lung, and others in 75/114 (65.8%). A significant positive correlation was observed between the GS/ SUV_{max} and PSA level (r_1 = 0.375, r_2 = 0.336, P<0.001). As a result of the (^{18}F)-PSMA-1007 PET/CT, therapeutic decision-making changed in 60/114 (52.6%) patients. With a follow-up of 11.0 ± 6.4 months, 81/114 PSA were collected after treatment guided by (^{18}F)-PSMA-1007 PET/CT, and in 42/81 (51.9%) of patients, serum PSA levels decreased of more than 60%.

Conclusion: (^{18}F)-PSMA-1007 PET/CT has a high lesion detection rate for recurrent prostate cancer (PCa) and could have significant implications in decision-making treatment plan for the majority of PCa patients.

1. Introduction

Prostate cancer (PCa) is the second most common and the fifth deadly malignancy in men [1,2]. Biochemical recurrence is still common despite highly successful radical prostate surgery (RP) or radical external radiation [3]. Therefore, early detection of the locoregional recurrence or metastasis is crucial for directing salvage therapy with a curative intent. PSA values greater than 0.2 ng/ml as confirmed by two successive measurements, and any PSA increase of 2.0 ng/ml above the nadir after external beam radiation therapy (EBRT) or brachytherapy (BT) can be reliably associated with residual or recurrent disease [4,5].

It is necessary to localize the site of relapse early and accurately to guide therapeutic management. Classical imaging modalities such as computed tomography (CT), pelvic multiparametric magnetic resonance imaging (mpMRI) and whole-body bone scan were used to detect recurrence. Unfortunately, these imaging modalities frequently fail to detect an early recurrence. Various alternative imaging methods for accurate and precise localization of recurrent PCa are continuously needed to select the local or systemic salvage treatments [6–8]. Prostate-specific membrane antigen (PSMA), a class II transmembrane glycoprotein that provides a valuable target for

Abbreviations: BCR, biochemical recurrence; GS, the Gleason scores; SUVmax, maximum standardized uptake values; PSA, prostate-specific antigen; PCa, prostate cancer; RP, radical prostatectomy; EBRT, external beam radiation therapy; BT, brachytherapy; CT, computed tomography; mpMRI, pelvic multiparametric magnetic resonance imaging; PET-CT, positron emission tomography/computed tomography; S-RT, salvage radiation therapy; ADT, androgen deprivation therapy; SBRT, stereotactic body radiotherapy; LNM, lymph nodes metastases

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radiolabeled imaging, is significantly overexpressed in malignant prostate cells.The use of PSMA radioligands in the diagnosis of prostate cancer has great potential due to their improved sensitivity and specificity. Positron emission tomography-computed tomography (PET/CT) using this radiotracer is increasingly recommended for PCa diagnostics [9–11]. (^{68}Ga)-PSMA-11 is the present widely used tracer for PET/CT imaging in the detection of PCa recurrence [12]. However, compared with (^{68}Ga), (^{18}F)-labeled radiotracers have a longer half-life (110 min vs 68 min), which is more practical to centralize production and distribution [13–15]. Therefore, there has been great interest in developing the (^{18}F)-labeled PSMA compounds [16–18].

(^{18}F)-PSMA-1007 is a novel type of PSMA-based radiopharmaceutical for PCa. The use of (^{18}F)-PSMA-1007 PET has been reported to have high detection efficiency in biochemical recurrence of prostate cancer after radical prostatectomy [19]. Its diagnostic accuracy has also been demonstrated for lymph node staging and biochemical recurrence of prostate cancer compared to histopathological findings [20]. There was available evidence on the impact of (^{18}F)-PSMA-1007 PET/CT in therapeutic management for BCR [21]. For BCR patients with low PSA concentrations ($\leq$ 2.0 ng/ml), early therapeutic intervention guided by (^{18}F)-PSMA-1007 PET/CT can improve the disease control [22]. The high precision pretherapeutic imaging was critical to the use of new salvage strategies [23]. Clinically, the change in PSA value is often monitored to evaluate the impact on behavior changes. Thus, it is important to accurately estimate the location of recurrent lesions to provide the best therapeutic.

The purpose of our study was to investigate the detection rate of biochemical recurrence at different PSA levels and to assess how a positive (^{18}F)-PSMA-1007 PET/CT scan impacted subsequent treatment strategies and the biochemical response.

2. Materials and methods

2.1. Patients' characteristics

From March 2019 to July 2021, patients with biochemical recurrence after radical prostatectomy and extended pelvic lymph node dissection and who had undergone (^{18}F)-PSMA-1007 PET/CT were screened for retrospective inclusion in the present study. The inclusion criteria for the subjects were listed as follows:(a) known prostate cancer with biochemical recurrence after RP (b) proven BCR by serum PSA. The exclusion criteria were listed as follows:(a) PSA <0.2 ng/ml (b) clinical follow-up at other institutions (c) clinical data was incomplete (d) image quality display was poor or the patient body was postural restriction and could not lie supine for the imaging. We recorded the postoperative GS, the (^{18}F)-PSMA-1007 PET/CT findings simultaneous PSA values and treatments administered.

Management change was defined as changes in adding or removing a treatment modality, changing surgery or radiation therapy techniques.The treatment was classified as palliative and curative treatment. The palliative treatment included chemotherapy and endocrine therapy; the curative treatment included salvage radiation therapy, stereotactic body radiotherapy, metastasis dissection surgery.

The ethics committee of the First Affiliated Hospital of Wenzhou Medical University (WMU) approved this retrospective study and waived the requirement to obtain informed consent from the patients (2,018,045).

2.2. Radiopharmaceutical

The ABX advanced biochemical compounds (Radeberg, Germany) provided the precursor, cassettes, and reagents to synthesize the (^{18}F)-PSMA-1007. A GE TracerLab FN synthesizer produced (^{18}F)-PSMA-1007 according to the one-step procedure described above [24,25]. The radiochemical purity of the final product was > 90% as measured by high performance liquid chromatography.

2.3. Imaging protocol

The body PET/CT scanner (Gemini 64 TF, Philips Medical Systems, Best, The Netherlands) captured (^{18}F)-PSMA-1007 images and were performed approximately 2 h after an intravenous injection of 4.0 MBq/kg (^{18}F)-PSMA-1007 (median activity: 291.2 MBq; range: 185.0−366.3 MBq). To correct for attenuation, the low dose plain CT scans were performed from the base of the skull to the middle of the thigh with the following scan parameters: tube current of 110 mA, tube voltage of 140 Kvp, detector collimation of 64×0.625 mm, pitch of 0.829, a tube rotation speed of 0.5 s, section thickness of 5 mm and reconstruction thickness of 2.5 mm, and the PET scan was then performed to match the thickness of the CT section. PET images were obtained using three-dimensional mode with the following parameters: field of view, 576 mm; matrix of 144×144; slice thickness and interval, 5 mm. The emission scan time was 1.5 min per bed and the overlap between two adjacent bed positions was 50%. The images were reconstructed using an ordered subset expectation maximization (OSEM) algorithm. All collected images were displayed on Philips Extend Brilliance Workstation (EBW) 3.0 to reconstruct PET, CT, and PET/CT fusion images.

2.4. Image analysis

All (^{18}F)-PSMA PET/CT images were analyzed with a dedicated workstation (EBW3.0, Philips). PET imaging was independently read by 2 experienced nuclear medicine physicians with more than 10 years of clinical experience. Any disagreement was resolved by consensus. The criteria used to define PSMA-positive lesions at the location of suspected recurrence were consistent with the current literature [26–29]. Cases were also considered positive if following follow-up criteria were met. These included (1) increase in size or number of lesions from one imaging exam to the next, following appropriate clinical treatment; (2) increase in PSA in keeping with clinical disease progression, or decrease in response to treatment. With respect to the evaluation of local recurrence, lymph node, and distant metastases, focal uptake of (^{18}F)-PSMA-1007 higher than the surrounding background and independent of physiological uptake was considered suspicious for malignancy. Typical pitfalls in PSMA-PET/CT imaging (as celiac and other ganglia, fractures, degenerative changes) were frequently observed but were not considered pathological [30–32]. All suspicious lesions for recurrent PCa were recorded and classified as: (a) local recurrence, (b) lymph node metastases (stratified by pelvic, retroperitoneal and supradiaphragmatic locations), (c) bone metastases and (d) other metastases (like lung, adrenal gland). The highest SUVmax values were calculated and recorded for each patient.

2.5. Statistical analysis

At least two PSA measurements were taken in the 3 months prior to the PET/CT scan. Data was analyzed using SPSS version 26.0 software (SPSS,Chicago,IL). The conformity of the data to normal distribution was assessed with the Shapiro−Wilk test. The quantitative variables were shown as median (minimum/maximum), and the categorical variables were shown as number (n) and percentage (%). Spearman's correlation analysis was performed for the data of Gleason score, SUVmax and PSA value. And Mann−Whitney U tests were used to evaluate differences between single groups. The variables were analyzed at a 95% confidence level and P values of less than 0.05 were considered statistically significant.

3. Results

The clinical and pathologic characteristics of the enrolled 114 consecutive patients with BCR after primary radical prostatectomy for GS

Table 1
Clinical and pathologic characteristics of the 114 patients.

Number of patients	114
Age, mean ± SD (range)	70±7.9 (53–89)
Gleason score	
≤6	11 (10%)
7	38 (33.3%)
4 + 3	20 (17.5%)
3 + 4	18 (15.8%)
≥8	55 (48.2%)
unknown	10 (8.8%)
PSA value (ng/ml)	
Median (range)	1.48 (0.2–238.9)
Pathologic Primary Tumor Staging (pT)	
pT2b	17 (14.9%)
pT2c	28 (24.6%)
pT3a	12 (10.5%)
pT3b	20 (17.5%)
pT4	22 (19.3%)
unknown	15 (13.2%)
Pathologic Regional LN Staging (pN)	
pN0	62 (54.4%)
pN1	36 (31.6%)
pNx	16 (14%)
Positive Margin	
R0	34 (29.8%)
R1	45 (39.5%)
unknown	35 (30.7%)
Time between surgery and PET/CT Median month (range)	9.2 (4.2–16.5)
Treatment history after RP	
adjuvant radiotherapy	6
ADT at the time of PSMA PET	60
orchiectomy	3

Abbreviations: SD = standard deviation, PSA = prostate specific antigen, PET-CT=Positron emission tomography-computed tomography, ADT = androgen deprivation therapy.

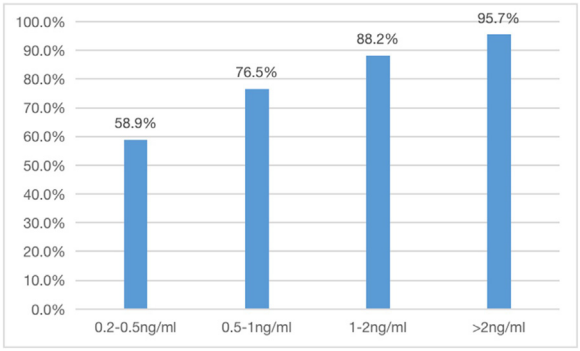

Fig. 1. Overall detection rate of ($_{18}$F)-PSMA-1007 PET/CT.

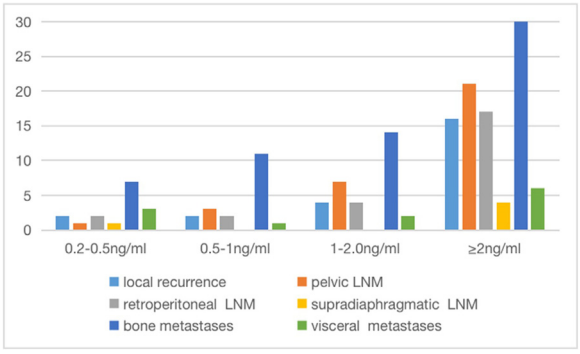

Fig. 2. Relative number of lesions grouped by different regions in relation to PSA-level.

6–10 is summarized in Table 1. The mean time interval between the RP and the (^{18}F)-PSMA-1007 PET/CT scan was 9.2 months.

Among the 114 patients, the median age was 71 years (range: 53–89 years) and the median baseline PSA level was 1.49 ng/mL (range: 0.2–238.9 ng/ml). (^{18}F)-PSMA-1007 PET/CT was positive in 92(80.7%) patients and negative in 22 (19.3%) patients. The median of PSA level in positive was 1.84 ng/ml (range: 0.2–238.9 ng/ml) and in negative was 0.32 ng/ml (range: 0.23–13.3 ng/ml). The PSA level was positively correlated with the positive detection rate (r = 0.371, $P < 0.001$). All relapses had mean ± SD of SUV_{max} of 13.6 ± 1.8 (range: 2.4–130.2). The locations of the lesions confirmed to be positive were stated in Table 2.

The detection efficacy of (^{18}F)-PSMA-1007 PET/CT was 95.7% (44/46) for a PSA value ≥ 2 ng/mL, 88.2% (15/17) for a PSA value 1–2 ng/mL, 76.5% (13/17) for a PSA value 0.5–1 ng/mL and 58.8% (20/34) for a PSA value 0.2–0.5 ng/ml (Fig. 1). As the Gleason score increased, the lesion detection rates also increased, and these were statistically significantly correlated ($p < 0.001$). The most common site of relapse was bones (54.4%, n = 62), followed by lymph nodes metastases (47.4%, n = 54): in the pelvis (28.1%, n = 32), in the retroperitoneum (21.9%, n = 25) and in supradiaphragmatic locations (4.4%, n = 5). Local recurrence was detected in 21% of patients (n = 24), in which both local recurrence and distant metastasis were seen in 6 and only local recurrence in 18. In addition, 22.8% patients (n = 21) had a single (^{18}F)-PSMA-1007 PET/CT positive lesion, 31.5% patients (n = 29) had two to five positive lesions (oligometastatic patients), and 45.7% patients (n = 42) had more than five positive lesions (multimetastatic patients) (Fig. 2). There was a statistically significant difference between the Gleason scores or the SUV_{max} and PSA values of the cases detected with lesions on (^{18}F)-PSMA-1007 PET/CT ($P < 0.001$) (shown in Table 3). When the patients were divided into four groups as 0.2–0.5 ng/mL, 0.5–1 ng/mL, 1–2 ng/mL, and >2 ng/mL, no statistically significant difference was observed among the groups in terms of Gleason score and the SUV_{max}.

Table 2
Different regions involved by recurrent PCa in (^{18}F)-PSMA1007-PET/CT.

Location of the lesion	Number of patients
local recurrence	24 (21.1%)
lymph node metastasis	54 (47.4%)
pelvic	32 (28.1%)
retroperitoneal	25 (21.9%)
supradiaphragm	5 (4.4%)
Bone metastasis	62 (54.4%)
Other metastasis	13 (11.4%)
bladder	8 (61.5%)
penis	3 (23.1%)
adrenal	2 (15.4%)
seminal vesicle	2 (15.4%)
rectum	2 (15.4%)
lung	1 (7.7%)
ureter	1 (7.7%)
peritoneum	1 (7.7%)

Abbreviations: PCa=prostate cancer; PET-CT=Positron emission tomography-computed tomography.

Table 3
Distribution of ages, Gleason scores, and SUVmax values by PSA groups in lesion-detected patients.

PSA groups (ng/ml)	Age Median (range)	Gleason Median (range)	SUVmax Median (range)
0.2–0.5	68 (55–84)	7 (6–9)	3.6 (2.9–95.9)
0.5–1	73 (61–86)	8 (6–9)	5.6 (3.5–38.5)
1–2	71 (63–85)	8 (7–9)	12.1 (4–36.8)
≥2	72 (53–89)	9 (6–10)	5.5 (2.4–130.2)
P value (general)	0.149 (r = 0.136)	<0.001 (r = 0.336)	<0.001 (r = 0.375)

Abbreviations: PSA = prostate specific antigen, SUV_{max}= maximum standardized uptake values.

Table 4
Changes in treatment intent, disease stage and management plan.

Variable	Value
change in treatment intent	60
to palliative	21
to curative	39
change in disease stage	72
upstaged	67
downstaged	5
ordering of additional diagnostic studies	65
computed tomography	18
magnetic resonance imaging	20
nuclear medicine	25
ultrasound	2

The location of a detectable recurrence or distant metastasis is important for patients' management. The clinician examined the treatment strategies adopted by patients after (^{18}F)-PSMA-1007 PET/CT examination. And after reviewing the (^{18}F)-PSMA-1007 PET/CT findings for 114 patients, the disease stage changed in 63.2% (93.1% of which were upstaged). Findings on (^{18}F)-PSMA-1007 PET/CT scans motivated additional images in 57.1% of patients. In our study, 52.6% of patients had significant changes in their treatment strategies (shown in Table 4 and Fig. 3). The treatment category of 34.2% of patients changed from palliative to curative treatment, and 18.4% changed from curative to palliative treatment.

The clinical treatment response for (^{18}F)-PSMA-1007 PET/CT positive lesions was monitored mostly by clinical follow-up (correlative imaging and/or decreasing or increasing PSA levels). Of the 114 patients, 81 post-treatment PSA serum levels were available. The mean follow-up period is 11.0 months, ranging from 1.0 to 23.3 months. In our series, 60 of these 114 patients had a change in treatment strategy and the follow-up showed that more than 70% of patients had a significant decrease of over 60% in the PSA levels. Moreover, 21 patients who had systemic metastases underwent PET/CT for the second or third time to review conditions. For positive patients, 63/92 of PSA levels had different degrees of decline and 10/92 increased in PSA. For negative patients, our study showed PSA levels decreased in 7 of 22 after S-RT and ADT but were elevated for the remaining patients who had not undergone salvage radiation, ADT, or other therapies. The sample subject received a second (^{18}F)-PSMA-1007 PET/CT to evaluate his biochemical response (only salvage radiation therapy) and showed a complete metabolic response (Fig. 4).

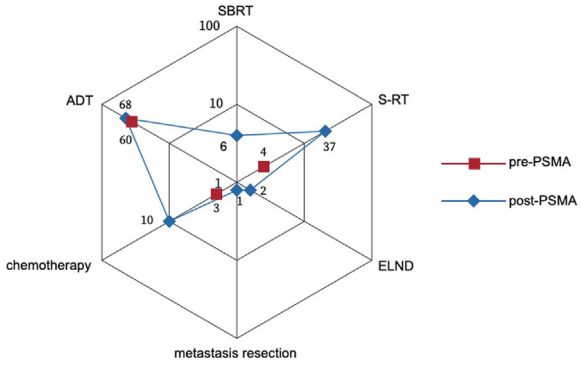

Fig. 3. Relationship between number of patients with pre-PSMA and post-PSMA treatment. ADT androgen deprivation therapy, SBRT stereotactic body radiotherapy, S-RT salvage radiation therapy, ELND selection lymph node dissection, chemotherapy, metastasis resection (such as lung liver, etc.).

4. Discussion

In this study, we confirmed the efficiency of (^{18}F)-PSMA-1007 PET/CT in detecting the biochemical recurrence of prostate cancer in different PSA groups and further explored the impact of (^{18}F)-PSMA-1007 PET/CT on treatment decision-making in the later stages. So far, only a few studies have evaluated the clinical strategy role of (^{18}F)-PSMA-1007 PET/CT in guiding patients with biochemical recurrence after RP.

Our overall detection rate was similar to one that of the study by Giesel et al. in 251 patients with 81.3% for (^{18}F)-PSMA-1007 PET/CT [19]. Our result showed that in patients within this range of PSA

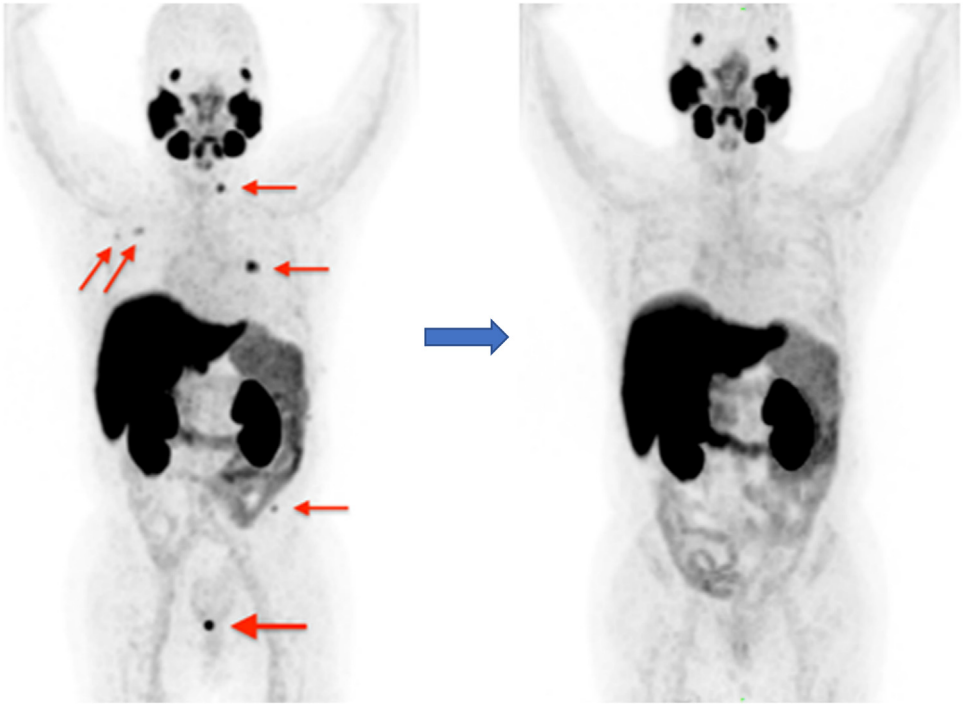

Fig. 4. The maximum intensity projection image showed the presence of anomalous ($_{18}$F)-PSMA concentration in the pelvic cavity, suggesting local recurrence of prostate cancer (left, thick arrow), local bones metastasis on pre-treatment examination (left, thin arrows), and their absence on post-treatment (S-RT and ADT) examination (right).

levels, the detection rate was slightly higher than the previously study found by Fendler at 75% in 635 patients (with a median PSA of 2.1 ng/mL) for (^{68}Ga)-PSMA-11 PET/CT [19,33]. Retrospectively, the recent meta-analysis on 68Ga-PSMA PET/CT showed that the tracer detected 95% of the lesions in patients with PSA values >2.0 ng/ml. It is noteworthy that 59% detection with (^{18}F)-PSMA-1007 when PSA 0.2−0.5 ng/ml vs 45% with (^{68}Ga)-PSMA [34]. The greatest possible source of advantage for (^{18}F)-PSMA-1007 is that the excretion in the bladder is much lower, which is a known shortcoming of (^{68}Ga)-PSMA, potentially hindering its diagnostic effect in the detection of local recurrence and local area disease [35–37].

When local recurrence on the images or PSA recurrence occurs after RP, salvage radiotherapy is now recommended in the absence of distant metastasis [38]. Salvage radiation therapy(S-RT) with or without androgen deprivation therapy (ADT) is currently the most promising therapeutic option for BCR [39]. PSA monitoring, as well as the selective use of S-RT or local surgical biopsy, have some advantages over adjuvant radiotherapy [40]. The fact that the detection rate of local recurrence and distant metastasis is high emphasizes the benefit of (^{18}F)-PSMA-1007 PET/CT for appropriate treatment (such as local or systemic treatment) for patients, especially for guiding S-RT treatment.

A significant change in treatment strategies changed in 52.6% of the patients after (^{18}F)-PSMA-1007 PET/CT. Of our 92 positive patients, 53 of them received treatment changes, and 44 (83.0%) had PSA dropped significantly. Among the positive patients with locoregional oligometastatic tumors, whose treatment intention changed to curative, we found that 35 patients received local S-RT and 6 received stereotactic body radiotherapy (SBRT), follow-up showed an evident decrease in PSA levels. SBRT is considered as a viable option in this study, while S-RT is usually adjusted to include PSMA-positive lesions in the irradiation range. In addition, 6 patients with multiple metastases also had a decrease in PSA levels after radiotherapy for multiple metastases. Therefore, in this selected group of patients, PSMA imaging resulted in significant management changes in approximately three-fifths of patients and benefited from it.

In our research, we also found that (^{18}F)-PSMA-1007 PET/CT results were negative in 22 of 114 patients with BR after initial PCa surgery. Of the negative, 7 patients were consistently treated with ADT before and after (^{18}F)-PSMA-1007 PET/CT. Futhermore, 4/7 patients also received S-RT in the prostate bed after PET/CT. And 15 of 22 were followed with PSA value. Follow-up PSA was absent in 7/22 patients. The patient showed an early response in all who were treated (according to the evidence that PSA<0.1 ng/mL or PSA level decreased >50%, PSA nadir<1.0 ng/mL after S-RT has prognostic significance) but increased in patients who were followed. Our results are like those of Bashir et.al who found 11 of 28 BCR patients had negative (^{18}F)-PSMA-1007 PET/CT results after the initial PCa surgery, 3 patients received prostate bed S-RT and 8 patients received follow-up PSA. The PSA level of all patients receiving treatment decreased, and the PSA level of follow-up patients increased [23]. Therefore, we infer that negative PSMA-PET/CT results after RP may lead to an underestimate of the extent of local recurrence. It showed PSA decline after S-RT in patients with negative (^{18}F)-PSMA-1007 PET/CT. PSMA-PET/CT screening for pre-rescue therapy is critical because it improves decision-making for referring clinicians and changes management plans for the majority of subject.

Clinicians usually see the results of PSMA-PET/CT as an opportunity for focused management. In fact, considering only therapeutic changes based on PSMA-PET/CT to assess the impact on patient management is insufficient, though essential. The most important thing to emphasize in our study is that a couple of PSA tests can be used to evaluate the opportunity of treatment options guided by the (^{18}F)-PSMA-1007 PET/CT results. In the months of follow-up following (^{18}F)-PSMA-1007 PET/CT, we collected the first results of PSA tests from 71.1% of patients. Among these, over 70% of patients had a clinically significant reduction of more than 60% and maintained stability at every subsequent examination. Some researchers discovered that patients with oligometastases may have a better chance of survival [41,42]. In our study, the PSA value of patients with oligometastases decreased more than that of patients with multimetastatses after changing the treatment under the guidance of PSMA (75% vs. 50%). Studies have shown that taking ADT can usually reduce PSA levels and lesion size. Afshar-Oromieh et al. found a statistically significant correlation between ADT and PSMA-PET/CT positivity [43]. Among our lesion-detected patients, the positive rate of patients who used ADT was significantly higher than that of patients who did not use ADT ($P < 0.05$). Our findings may be attributed to the increase in PSMA expression after taking ADT. In some cases, patients with no therapeutic change after (^{18}F)-PSMA-1007 therapy showed a high reduction in serum PSA level due to patients' taking ADT regularly, which lowers serum PSA. Furthermore, the Gleason score of patients is positively correlated with SUV_{max}. Apart from the positive correlation between PSA level and SUV_{max}, we believe that our findings may reflect the increase in the expression of PSMA as the Gleason score increases.

Our present study has several limitations. The analysis was performed retrospectively, and most cases were not histologically confirmed. Unfortunately, this is a common problem in studies involving BCR, because of the deep location of lesions in the pelvis, making it difficult to sample. As in most other studies, our sample was heterogeneous, so the PSA value varied widely, in addition the number of subgroups and change treatment were biased. In addition, the PSA doubling time for this study is not available. However, it provides regional confirmation that the PSA observed in patients receiving (^{18}F)-PSMA-1007 PET/CT guided therapy has substantially decreased. The follow-up time of the patients with biochemical recurrence in our study were relatively short, and a longer-term treatment evaluation effect cannot be obtained.

5. Conclusion

Our study supports the advantages of (^{18}F)-PSMA-1007 PET/CT for patients with biochemical recurrence after radical prostatectomy, even at low PSA level. In this cohort of 114 patients with recurrent PCa, 52.6% had a change in treatment strategies supported by this examination.

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Declaration of Competing Interest

All authors declare that they have no competing interests.

Author contributions

Jiang Jia: data acquisition, literature research, and manuscript writing. Xiaowei Ji, Lei Chen, Junjie Hong and Xuan Zheng: data acquisition and review, Kun Tang: study design and theoretical support. Xiangwu Zheng: design of the research program, review and revise of manuscript. All the authors agreed on the content of the final manuscript.

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