UC Irvine UC Irvine Previously Published Works

Title

Impact of Clinical Factors on 18F-Flotufolastat Detection Rates in Men With Recurrent Prostate Cancer: Exploratory Analysis of the Phase 3 SPOTLIGHT Study.

Permalink

https://escholarship.org/uc/item/6v1938cz

Journal Advances in Radiation Oncology, 9(8)

ISSN

2452-1094

Authors

Lowentritt, Benjamin Jani, Ashesh Helfand, Brian <u>et al.</u>

Publication Date

2024-08-01

DOI

10.1016/j.adro.2024.101532

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <u>https://creativecommons.org/licenses/by/4.0/</u>

Peer reviewed



Scientific Article

Impact of Clinical Factors on ¹⁸F-Flotufolastat Detection Rates in Men With Recurrent Prostate Cancer: Exploratory Analysis of the Phase 3 SPOTLIGHT Study



Benjamin H. Lowentritt, MD,^a,* Ashesh B. Jani, MD,^b Brian T. Helfand, MD,^c Edward M. Uchio, MD,^d Michael A. Morris, MD,^e Jeff M. Michalski, MD,^f Albert Chau, MSc,^g Phillip Davis, MD,^h Brian F. Chapin, MD,ⁱ and David M. Schuster, MD^j, on behalf of the SPOTLIGHT Study Group

^aChesapeake Urology Research Associates, Towson, Maryland; ^bDepartment of Radiation Oncology, Winship Cancer Institute of Emory University, Atlanta, Georgia; ^cNorthShore University Health System, Evanston, Illinois; ^dUniversity of California Irvine Medical Center, Irvine, California; ^eAdvanced Molecular Imaging and Therapy, Glen Burnie, Maryland; ^fDepartment of Radiation Oncology, Washington University School of Medicine, St Louis, Missouri; ^gBlue Earth Diagnostics Ltd, Oxford, United Kingdom; ^hBlue Earth Diagnostics, Monroe Township, New Jersey; ⁱDepartment of Urology, The University of Texas MD Anderson Cancer Center, Houston, Texas; and ^jDivision of Nuclear Medicine and Molecular Imaging, Department of Radiology and Imaging Sciences, Emory University, Atlanta, Georgia

Received 6 December 2023; accepted 16 March 2024

Purpose: ¹⁸F-Flotufolastat (¹⁸F-rhPSMA-7.3) is a newly approved prostate-specific membrane antigen targeting radiopharmaceutical for diagnostic imaging of prostate cancer (PCa). SPOTLIGHT (National Clinical Trials 04186845) evaluated ¹⁸F-flotufolastat in men with suspected PCa recurrence. Here, we present results of predefined exploratory endpoints from SPOTLIGHT to evaluate the impact of clinical factors on ¹⁸F-flotufolastat detection rates (DR).

Methods and Materials: The impact of baseline prostate-specific antigen (PSA), PSA doubling time (PSAdt), and International Society of Urologic Pathology Grade Group (GG) on ¹⁸F-flotufolastat DR was evaluated among all SPOTLIGHT patients with an evaluable scan, with DR stratified according to the patients' prior treatment (radical prostatectomy \pm radiation therapy [RP] or radiation therapy only [RT]). The patients underwent positron emission tomography 50 to 70 minutes after receiving ¹⁸F-flotufolastat (296 MBq IV), and scans were read by 3 blinded central readers, with the majority read representing agreement between ≥ 2 readers. **Results:** In total, 389 men (median PSA: 1.10 ng/mL) were evaluable. By majority read, ¹⁸F-flotufolastat identified distant lesions in 39% and 43% of patients treated with prior RP or RT, respectively. The overall DR broadly increased with increasing PSA (<0.2 ng/mL: 33%; ≥ 10 ng/mL: 100%). Among patients with PSA <1 ng/mL, 68% had positive scans, and 27% had extrapelvic findings. PSAdt was available for 145/389 (37%) patients. PSAdt did not appear to influence ¹⁸F-flotufolastat DR (77%-90% across all PSAdt categories). Among patients with prior RP, DR ranged from 70% to 83% across PSAdt categories, and 100% DR was reported for all post-RT patients. In total, 362/389 (93%) patients had baseline GG data. Overall DRs were uniformly high (75%–95%) across all GG. When stratified by prior treatment, DRs across all GG were 69% to 89% in patients with prior RP and $\geq 96\%$ in patients with prior RT.

The data sets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

*Corresponding author: Benjamin H. Lowentritt, MD; Email: blowentritt@chesuro.com

https://doi.org/10.1016/j.adro.2024.101532

Sources of support: This study was funded by Blue Earth Diagnostics Ltd, Oxford, UK.

^{2452-1094/© 2024} The Authors. Published by Elsevier Inc. on behalf of American Society for Radiation Oncology. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Conclusions: ¹⁸F-Flotufolastat-positron emission tomography enabled the accurate detection of recurrent PCa lesions across a wide range of PSA, PSAdt, and International Society of Urologic Pathology GG, thus supporting its clinical utility for a broad range of patients with recurrent PCa.

© 2024 The Authors. Published by Elsevier Inc. on behalf of American Society for Radiation Oncology. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Introduction

Accurately determining the location and extent of recurrent prostate cancer lesions with a sensitive imaging modality that allows their early detection may facilitate optimal decision- making for the management of patients with biochemical recurrence (BCR), as indicated by rising prostate-specific antigen (PSA) levels. Specifically, the identification of distant disease at the time of consideration of salvage radiation therapy (RT) would allow physicians and patients to opt for systemic or metastases-directed therapy, thus foregoing unnecessary curative salvage radiation treatment that would ultimately be futile and sparing patients from potential radiation-induced side effects.^{1,2}

Similarly, confidently confirming the absence of disease with a sensitive imaging modality in patients with rising PSA may help support the decision to delay initiation of systemic therapy (androgen deprivation therapy/ novel hormone therapy, chemotherapy, or both), which is also associated with significant side effects.³⁻⁵

¹⁸F-Flotufolastat (¹⁸F-rhPSMA-7.3) is a novel, next-generation, high-affinity prostate-specific membrane antigen (PSMA)-targeting radiopharmaceutical that has recently been approved by the Food and Drug Administration for positron emission tomography (PET) of PSMA-positive lesions in men with suspected metastasis who are candidates for initial definitive therapy or for men with suspected BCR based on serum PSA level.^{6,7} Early clinical data showed ¹⁸F-flotufolastat to have lower average urinary excretion than reported values for other renally cleared PSMA-PET radiopharmaceuticals,⁸ and a recent post hoc analysis of 2 phase 3 clinical trials confirmed that the urinary excretion of ¹⁸F-flotufolastat does not impact image assessment for the majority of patients.⁹

The phase 3 SPOTLIGHT study (National Clinical Trials 04186845) evaluated the diagnostic accuracy of ¹⁸F-flotufolastat in men who developed BCR after prior curativeintent treatment of prostate cancer.¹⁰ The primary endpoints of SPOTLIGHT have been reported previously and show ¹⁸F-flotufolastat to have a clinically meaningful diagnostic performance in patients with BCR of prostate cancer, with a verified detection rate (VDR) of 57%.¹⁰

It is well known that certain clinical factors, such as PSA levels, PSA kinetics (eg, PSA doubling time [PSAdt]), and Gleason scores, can influence the diagnostic performance of some PET radiopharmaceuticals, including ¹¹C- or ¹⁸F-choline and ¹⁸F-fluciclovine.¹¹⁻¹⁴ This is likely because higher baseline PSA and Gleason scores and

shorter PSAdt are a reflection of disease aggressiveness and burden and have been recognized as independent prognostic factors for prostate cancer.^{15,16}

Data for other PSMA-targeting radiopharmaceuticals such as ⁶⁸Ga-PSMA-11 and ¹⁸F-piflufolastat (¹⁸F-DCFPyL) have also reported an association between increasing PSA levels, Gleason scores, and DR in patients with BCR.^{17,18} The diagnostic utility of PSMA-PET in patients with BCR is being increasingly recognized,¹⁹ leading to its inclusion in the latest prostate cancer guidelines.^{7,12}

Here, we present results of predefined exploratory efficacy endpoints from the SPOTLIGHT study to evaluate the impact of clinical factors such as baseline PSA, PSAdt, and International Society of Urologic Pathology (ISUP) Grade Group²⁰ on the ¹⁸F-flotufolastat DR in patients with suspected BCR.

Methods and Materials

Study design and patients

SPOTLIGHT was a phase 3, prospective, multicenter, open-label, single-arm study conducted in accordance with the Declaration of Helsinki and the International Council on Harmonization Guidelines for Good Clinical Practice. The study protocol was approved by each study site's independent ethics committee, and all patients provided written informed consent.

The full methods of SPOTLIGHT have been reported previously,¹⁰ but in brief, men (>18 years) with elevated PSA suspicious for recurrence of previously treated, localized prostate adenocarcinoma were eligible for inclusion if they were being considered for curative-intent salvage therapy.

An elevated PSA was defined as ≥ 0.2 ng/mL with a subsequent confirmatory value of ≥ 0.2 ng/mL for patients previously treated with radical prostatectomy (RP) \pm adjuvant therapy or as nadir +2 ng/mL for patients treated with prior RT, brachytherapy, or focal gland therapy. Patients were required to have discontinued androgen deprivation therapy ≥ 16 weeks before screening.¹⁰

The patients received 8 mCi (296 MBq) \pm 20% ¹⁸F-flotufolastat, administered as an intravenous bolus injection, and PET/computed tomography (CT) was conducted 50 to 70 min later.¹⁰

Images were read by 3 trained, independent central readers who were blinded to all clinical information.¹⁰ The readers considered a lesion suspicious if ¹⁸F-flotufolastat

uptake was greater than physiological uptake in that tissue or greater than adjacent background (where no physiological uptake was expected).¹⁰

For this predefined exploratory analysis, the impact of baseline PSA levels, PSAdt, and ISUP Grade Group on the overall patient- and region-level DR (defined as the number of patients with \geq 1 PET-positive lesion, divided by the number of patients who had an evaluable PET/CT scan) was evaluated in the evaluable PET scan population (EPSP; ie, all patients who received an ¹⁸F-flotufolastat injection and underwent PET/CT). Results are further stratified according to patients' prior treatment (RP \pm RT vs RT only).

Patient demographics and baseline characteristics were recorded at screening. PSAdt was calculated by doing a regression of historical natural log PSA on the date of measurement and dividing natural log 2 (0.693) by the slope, using the last 3 values in the 2 years before ¹⁸F-flotufolastat administration (1 month was assumed to be 30.5 days). In cases with <3 acceptable measurements in the previous 2 years, PSAdt was considered missing. PSAdt was categorized as <6, \geq 6 to <12, \geq 12 to <24, \geq 24 months, or not estimable (for nonchanging and decreasing PSA [slope \leq 0]).

DR data are summarized here as point estimates (percentages) for the majority read (agreement between ≥ 2 readers), alongside the corresponding 2-sided, exact 95% CI. The study was not designed to compare the different subgroups and therefore no hypothesis has been set a priori for intergroup comparisons and no formal analyses for statistical differences were performed.

Results

Patients

In total, 420 patients were enrolled across 27 sites (24 in the United States, 3 in Europe) between May and December 2020 (Fig. E1). Of these, 389 had an evaluable ¹⁸F-flotufolastat scan and comprised the EPSP.

Baseline demographics and disease characteristics are summarized in Table 1. Mean age was 68 years, and majority of patients (60%) had a Gleason score of 7. Median baseline PSA was 1.10 ng/mL. In total, 305/389 (78%) patients (median [range] PSA, 0.68 [0.09-32.20] ng/mL) had previously undergone RP, and 76/389 (20%) (median [range] PSA, 4.41 [0.03-134.60] ng/mL) had previously been treated with RT only.

Overall and regional ¹⁸F-flotufolastat DR stratified by patients' prior treatment

Figure 1A presents the overall DR (by majority read) at patient-level and by region. In the 389 patients with an

Table 1 Baseline characteristics for the evaluable PET scan population

	EPSP (N = 389)
Age, years	
Mean	68.3
SD	7.93
Range	43-86
Gleason score, n (%)	
≤ 6	39 (10%)
7	232 (60%)
≥8	103 (26%)
Missing	15 (3.9%)
ISUP grade group, n (%)	
1	39 (10%)
2	104 (27%)
3	116 (30%)
4	40 (10%)
5	63 (16%)
Missing	27 (6.9%)
Time from initial prostate cancer diagnosis	s, months
Median	69
Range	2-409
Prior therapy, n (%)	
With prior prostatectomy	305 (79%)
- With radiation therapy	137 (45%)
- Without radiation therapy	168 (55%)
Without prior prostatectomy	84 (22%)
- Radiation therapy	76 (90%)
- Other therapy	7 (8.3%)
- No other therapy	1 (1.2%)
Baseline PSA, ng/mL	
Median	1.10
Range	0.03-134.6
PSA <0.5, n (%)	121 (31%)
PSA ≥0.5 – <1.0, n (%)	67 (17%)
PSA ≥1.0 - <2.0, n (%)	45 (12%)
PSA ≥2.0 – <5.0, n (%)	88 (23%)
PSA ≥5.0 – <10.0, n (%)	36 (9%)
PSA ≥10.0, n (%)	32 (8%)
<i>Abbreviations:</i> EPSP = evaluable PET scan population; ISUP = International Society of Urologic Pathology; PET = positron emission tomography; PSA = prostate-specific antigen.	

evaluable ¹⁸F-flotufolastat-PET, the overall DR was 83% (322/389; 95% CI, 78.6%-86.4%). In the prostate/bed, the DR was 38% (146/389; 95% CI, 32.7%-42.6%); 23% of



Figure 1 (A) Overall (patient-level) and regional ¹⁸F-flotufolastat detection rates in patients with suspected biochemical recurrence. (B) ¹⁸F-Flotufolastat detection rates in patients treated with prior radical prostatectomy \pm radiation therapy or (C) prior radiation therapy only.

patients (89/389; 95% CI,18.8%-27.4%) had positive findings confined to the prostate/bed. In pelvic lymph nodes, the DR was 30% (117/389; 95% CI, 25.6%-34.9%), and in other (extrapelvic) sites, the DR was 40% (156/389; 95% CI, 35.2%-45.2%).

Figure 1B and 1C present the overall and regional DR (by majority read) for patients treated with prior RP or with prior RT only. Overall (patient-level) DR in patients treated with prior RP was 78% (239/305; 95% CI, 73.3%-82.9%; Fig. 1B). In the prostate bed, DR was 27% (81/305;

95% CI, 21.7%-31.9%), with 18% of this subgroup (54/305; 95% CI, 13.6%-22.5%) having ¹⁸F-flotufolastat-positive lesions in the prostate bed only. DR was 31% (95/305; 95% CI, 26.0%-36.7%) in pelvic lymph nodes and 39% (119/305; 95% CI, 33.5%-44.7%) in other (extrapelvic) sites (Fig. 1B).

In total, 75/76 (99%; 95% CI, 92.9%-100.0%) of patients with prior RT had a positive ¹⁸F-flotufolastat scan (Fig. 1C). Most of these patients had positive findings in the prostate (58/76; 76%; 95% CI, 65.2-85.3), but only 32/76 (42%; 95% CI, 30.9-54.0) had positive findings confined to the prostate. ¹⁸F-Flotufolastat-avid pelvic lymph nodes were detected in 25% (19/76; 95% CI, 15.8-36.3) of patients with prior RT and, notably, extrapelvic lesions (eg, "other") were detected in 43% (33/76; 95% CI, 32.1-55.3) (Fig. 1C).

Impact of baseline PSA levels on ¹⁸Fflotufolastat DR

We examined the impact of baseline PSA levels on ¹⁸F-flotufolastat DR in all patients who underwent ¹⁸F-flotufolastat-PET (EPSP). Figure 2 shows the majority read data, stratified by baseline PSA levels; full patient- and region-level DR are provided in Table E1.

Moderate to high DR were observed across most PSA categories. The overall (patient-level) DR broadly increased with increasing PSA and ranged from 33% (1/3; 95% CI, 0.8%-90.6%) at PSA <0.2 ng/mL to 100% (32/32; 95% CI, 89.1%-100.0%) at PSA \geq 10 ng/mL (Fig. 2A). In total, 64% (77/121) of patients with a PSA <0.5 ng/mL and 68% (128/188) of patients with a PSA <1 ng/mL had a positive ¹⁸F-flotufolastat scan by majority read (Fig. 2A).

In the prostate/prostate bed, DR also broadly increased in line with PSA levels, with values ranging from 22% (95% CI, 15.2%-30.8%) at PSA <0.5 ng/mL to 69% (95% CI, 50.0%-83.9%) at PSA \geq 10 ng/mL (Fig. 2B).

Detection in pelvic lymph nodes was more consistent across the PSA categories. The DR was lowest for patients with PSA levels <0.5 ng/mL (18%; 95% CI, 11.8%-26.2%), but it was consistently higher across PSA levels from 0.5 to 1.0 ng/mL (37%; 95% CI, 25.8%-50.0%) to \geq 10 ng/mL (31%; 95% CI, 16.1%-50.0%; Fig. 2B).

For other (extrapelvic) sites, DR broadly increased with rising PSA levels, with values ranging from 21% (95% CI, 13.8%-29.0%) at PSA <0.5 ng/mL to 66% (95% CI, 46.8%-81.4%) at PSA \geq 10 ng/mL (Fig. 2B).

For patients with PSA <0.2 ng/mL, DR was 33% in each of the 3 regions (95% CI for all, 0.8%-90.6%), although there were limited numbers of patients in this category.

Overall, regional DRs with ¹⁸F-flotufolastat were broadly consistent across all low-PSA categories below 0.5 ng/mL. Of note, extrapelvic lesions were observed in 21% (25/121; 95% CI, 13.8%-29.0%) of patients with a



Figure 2 (A) Patient-level and (B) region-level ¹⁸F-flotufolastat detection rates (majority read) stratified by baseline prostate-specific antigen.

PSA <0.5 ng/mL and in 27% (51/188; 95% CI, 20.9%-34.1%) of all patients with PSA <1 ng/mL (Fig. 2B, Table E1).

Representative images from a patient with low baseline PSA (<0.1 ng/mL) are shown in Figure 3.

¹⁸F-Flotufolastat DR stratified by PSAdt

PSAdt did not appear to influence the ¹⁸F-flotufolastat DR among the 145/389 (37%) patients for whom PSAdt could be determined; overall (patient-level) DR by majority read were 84% (37/44; 95% CI, 69.9%-93.4%), 77% (34/44; 95% CI, 62.2%-88.5%), 82% (23/28; 95% CI, 63.1%-93.9%), and 90% (26/29; 95% CI, 72.6%-97.8%) across PSAdt categories <6, ≥ 6 to <12, ≥ 12 to <24, and ≥ 24 months, respectively (Fig. 4A).

There was also no clear association between PSAdt and DR by region, irrespective of prior treatment (Table E2).

Among patients previously treated with RP, DR by majority read were 78% (25/32; 95% CI, 60.0%-90.7%), 70% (23/33; 95% CI, 51.3%-84.4%), 77% (17/22; 95% CI, 54.6%-92.2%), and 83% (15/18; 95% CI, 58.6%-96.4%) for

PSAdt of <6, ≥ 6 to <12, ≥ 12 to <24, and ≥ 24 months, respectively (Fig. 4B). All patients with prior RT had a positive scan (100% DR) irrespective of PSAdt (Fig. 4C).

¹⁸F-Flotufolastat DR stratified by ISUP Grade Group

In patients for whom baseline ISUP Grade Group data were available (362/389; 93%), overall DR (majority read) were uniformly high, ranging from 75% to 95% across all ISUP Grade Groups (Fig. 5A). In patients with prior RP the DR were 89% (16/18; 95% CI, 65.3%-98.6%), 69% (55/80; 95% CI, 57.4%-78.7%), 81% (79/98; 95% CI, 71.4%-87.9%), 86% (25/29; 95% CI, 68.3%-96.1%), and 84% (51/61; 95% CI, 71.9%-91.8%), for Grade Groups 1, 2, 3, 4, and 5, respectively (Fig. 5B). In patients with prior RT, DRs were 100% (16/16; 95% CI, 79.4%-100%), 96% (23/24; 95% CI, 78.9%-99.9%), 100% (17/17; 95% CI, 80.5%-100%), 100% (10/10; 95% CI, 69.2%-100%), and 100% (2/2; 95% CI, 15.8%-100%) for Grade Groups 1, 2, 3, 4, and 5, respectively (Fig. 5C).



Figure 3 Representative ¹⁸F-flotufolastat-positron emission tomography (PET) images. Maximum intensity projection (A) and fused ¹⁸F-flotufolasta-PET/computed tomography images (B,C) of a 71-year-old patient with biochemical recurrence after radical prostatectomy (baseline prostate-specific antigen: 0.1 ng/mL; prostate-specific antigen doubling time: 30.7 months). ¹⁸F-Flotufolastat-avid lesions were identified in the prostate bed (left seminal vesicle) and in pelvic lymph nodes (B,C), which were subsequently confirmed as true positive by imaging standard of truth (¹⁸F-fluciclovine-PET).

There was a trend toward higher DR in the prostate/ bed at lower Grade Groups and higher DR in pelvic lymph node and extrapelvic sites at higher Grade Groups, irrespective of prior treatment, although low numbers of patients in some of the ISUP categories limit meaningful conclusions (Table E2).

Discussion

Overall DR (without verification of imaging findings) still represents one of the main endpoints traditionally reported in diagnostic imaging studies of prostate cancer. Here, we report exploratory endpoint data from SPOT-LIGHT to assess the overall patient- and region-level DR in relation to various clinical parameters such as baseline PSA level, PSAdt, and ISUP Grade Group, as well as previous treatment. This analysis is of relevance because these factors, particularly PSA levels, are known to influence the DR of PET radiopharmaceuticals,¹¹⁻¹⁴ likely as a reflection of disease burden.

Our data show that, among all evaluable patients, the overall DR of ¹⁸F-flotufolastat by majority read was high (83%). DRs by region were similarly distributed in the prostate/prostate bed and other extrapelvic sites (38%-40%), and DR in pelvic lymph nodes was slightly lower (30%). DR remained consistently high when patients were stratified by prior treatment, especially in patients treated with prior RT, who reported DR of 99% compared with 78% in patients treated with prior RP, although this higher DR among post-RT patients is likely a reflection of their higher median PSA levels. Importantly, 39% and 43% of patients treated with prior RP or RT, respectively,

had positive ¹⁸F-flotufolastat scans in distant (extrapelvic) sites. It must be noted, however, that these DR are unverified and include both true-positive and any false-positive results.

As could be expected, overall (patient-level) DR in our study broadly increased with increasing PSA, and a similar pattern was observed in the prostate/bed and in extrapelvic sites when DRs were analyzed by region. Importantly, DRs with ¹⁸F-flotufolastat-PET were high across a broad range of PSA categories, indicating that this is a highly sensitive imaging technique even at very low PSA values (<0.5 ng/mL), where almost two-thirds of patients were found to have positive scans, and a fifth of patients had extrapelvic lesions. The DR of ¹⁸F-flotufolastat-PET in patients with PSA <0.5 ng/mL (64%) compares favorably with DR of ¹⁸F-piflufolastat and ⁶⁸Ga-PSMA-11 in a similar population (36% and 38%, respectively).^{21,22}

In this analysis, 3 patients had a PSA <0.2 ng/mL, which is below the threshold of the American Society for Radiation Oncology/American Urologic Association definition of BCR (2 consecutive rises in PSA \geq 0.2 ng/mL)²³ as well as the European Association of Urology (EAU)-European Society for Radiotherapy and Oncology (ESTRO)-International Society of Geriatric Oncology (SIOG) definition (PSA level >0.4 ng/mL and rising after RP).¹² One patient with PSA <0.2 ng/mL was found to have a positive ¹⁸F-flotufolastat-PET scan, again highlighting the potential clinical utility of this test in patients with very low PSA levels, although this needs confirmation in a larger group of patients.

Previous studies with ⁶⁸Ga-PSMA-11-PET and ¹⁸Fpiflufolastat in recurrent prostate cancer have frequently reported a clear association between positive PET scans



Figure 4 ¹⁸F-Flotufolastat detection rates (majority read) by prostate-specific antigen doubling time in (A) all patients with prostate-specific antigen doubling time data available (n = 145) and stratified by prior treatment; (B) prior radical prostatectomy \pm radiation therapy (n = 105); and (C) prior radiation therapy only (n = 38).

and various factors such as baseline PSA, PSAdt, Gleason score, and prior treatment.^{17,18,24} However, other studies have found that DRs do not always correlate with PSAdt or Gleason score.²⁵⁻²⁷ In our study, the overall DR with ¹⁸F-flotufolastat-PET increased with baseline PSA levels and was uniformly high across all PSAdt and ISUP Grade Groups regardless of prior treatment, although there were low numbers of patients in some categories.

Of note, the ability of ¹⁸F-flotufolastat-PET to detect distant lesions in a significant proportion of patients with BCR is clinically relevant, as the presence of metastases is likely to lead to changes in management, especially in cases where salvage local therapy in postradiation patients is being considered, as this procedure alone would be futile in patients with potentially metastatic disease. The value of ¹⁸F-flotufolastat-PET in this setting is concordant with other studies of ⁶⁸Ga-PSMA-11 and ¹⁸F-piflufolastat, which have also reported changes in management in a high proportion of patients with BCR and equivocal 7



Figure 5 ¹⁸F-Flotufolastat detection rates (majority read) by International Society of Urologic Pathology Grade Group in (A) all patients with available data (n = 362) and stratified by previous treatment; (B) prior radical prostatectomy \pm radiation therapy (n = 286); and (C) radiation therapy only (n = 69).

conventional imaging after undergoing ⁶⁸Ga-PSMA-11-PET or ¹⁸F-piflufolastat-PET to clarify equivocal lesions.²⁸⁻³²

Limitations of our study include the fact that 7% of patients had missing data for the ISUP Grade Group, and only 37% of patients had sufficient data to robustly determine a PSAdt. Although ¹⁸F-flotufolastat DR remained consistently high across all PSAdt and ISUP Grade Group categories, irrespective of prior treatment, this exploratory analysis was not powered to make any correlations or intergroup comparisons. In addition, the study did not include an active comparator and, in the absence of head-to-head studies of ¹⁸F-flotufolastat-PET with other PSMA-PET agents, drawing any comparisons between the performance of these agents should be done with

caution because of the potential impact of different patient populations, endpoints, scanning methods, and individual reader performance on imaging outcomes. Lastly, although the data here report the high overall DR for ¹⁸F-flotufolastat-PET, these do not represent verified findings. However, the previous report of the SPOT-LIGHT primary endpoint data show that among 366 of the patients evaluated who had standard-of-truth data (either histopathology [n = 69] or confirmatory imaging [n = 297]), the majority read VDR was 57% (208/366; 95% CI, 51.6-62.0), exceeding the prespecified statistical threshold, with an even greater VDR observed among the subset with a histopathology standard of truth (81% [56/69]; 95% CI, 69.9-89.6).¹⁰

Nonetheless, the encouraging DRs reported here with ¹⁸F-flotufolastat-PET across a wide range of PSA levels and ISUP Grade Groups irrespective of prior treatments are likely because of its favorable biodistribution profile, with sustained plasma bioavailability, limited urinary bladder activity at the point of imaging, and high-affinity receptor binding and internalization compared with other radiopharmaceuticals.^{8,9,33,34} Such properties may offer beneficial diagnostic advantages and likely contributed to the high DR reported with ¹⁸F-flotufolastat-PET, even in patients with very low PSA levels.

Conclusion

High DRs with ¹⁸F-flotufolastat were observed over a wide range of baseline PSA values, PSAdt categories, and ISUP Grade Groups, regardless of prior treatment. These results indicate that ¹⁸F-flotufolastat-PET may be a useful tool for treatment planning in a broad range of patients with early biochemical recurrence of prostate cancer where curative salvage therapy is of prime consideration.

Disclosures

Benjamin H. Lowentritt, none. Ashesh B. Jani has received speaker's honoraria from Blue Earth Diagnostics Ltd. Brian T. Helfand has acted as a study investigator for Blue Earth Diagnostics Ltd, but has no other conflicts to disclose. Edward M. Uchio reports a clinical trial contract with Blue Earth Diagnostics Ltd. Michael A. Morris has participated in advisory boards for Oranomed, RayzeBio, and Fusion, has a leadership or fiduciary role for AMIT, ACNM, and SNMMI, stock options for AMIT, Gentem Health, and SoftThread, and reports a US Patent application for a radioactive patient-delivery system. Jeff M. Michalski, none. Albert Chau received consultancy fees from Blue Earth Diagnostics Ltd for data management and statistical services. Phillip Davis is an employee of Blue Earth Diagnostics Inc. Brian F. Chapin, none. David M. Schuster has acted as a consultant for Global Medical

Solutions Taiwan, Progenics Pharmaceuticals, Inc, Heidelberg University, and DuChemBio Co Ltd. He participates through the Emory Office of Sponsored Projects in full compliance with Emory University—sponsored research and conflict of interest regulations in sponsored grants including those funded or partially funded by Blue Earth Diagnostics, Ltd, Nihon MediPhysics Co, Ltd, Telix Pharmaceuticals (US) Inc, Advanced Accelerator Applications, FUJIFILM Pharmaceuticals U.S.A., Inc, and Amgen Inc. He participates in educational initiatives with School of Breast Oncology, PrecisCa and provides medicolegal consulting vetted through Emory SOM.

Acknowledgments

We gratefully acknowledge all participating institutions and their patients. Medical writing support was provided by Dr S Cuscó PhD and Dr C Turnbull (Blue Earth Diagnostics Ltd, Oxford, UK).

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.adro.2024. 101532.

References

- Gandaglia G, Briganti A, Clarke N, et al. Adjuvant and salvage radiotherapy after radical prostatectomy in prostate cancer patients. *Eur Urol.* 2017;72:689-709.
- Wallis CJD, Glaser A, Hu JC, et al. Survival and complications following surgery and radiation for localized prostate cancer: An international collaborative review. *Eur Urol.* 2018;73:11-20.
- **3.** Gheorghe GS, Hodorogea AS, Ciobanu A, et al. Androgen deprivation therapy, hypogonadism and cardiovascular toxicity in men with advanced prostate cancer. *Curr Oncol.* 2021;28:3331-3346.
- Lafontaine ML, Kokorovic A. Cardiometabolic side effects of androgen deprivation therapy in prostate cancer. *Curr Opin Support Palliat Care*. 2022;16:216-222.
- Li H, Zhang M, Wang X, et al. Advancements in the treatment of metastatic hormone-sensitive prostate cancer. *Front Oncol*. 2022;12: 913438.
- FDA. Highlights of prescribing information: POSLUMA (Flotufolastat F 18) injection. https://www.accessdata.fda.gov/drugsatfda_ docs/label/2023/216023s000lbl.pdf. Accessed May 21, 2024.
- NCCN. NCCN clinical practice guidelines in oncology: Prostate cancer. Version 4.2024. https://www.nccn.org/professionals/physi cian_gls/pdf/prostate.pdf. Accessed May 21, 2024.
- Tolvanen T, Kalliokoski KK, Malaspina S, et al. Safety, biodistribution and radiation dosimetry of ¹⁸F-rhPSMA-7.3 in healthy adult volunteers. J Nucl Med. 2021;62:679-684.
- Kuo P, Hermsen R, Penny R, et al. Post-hoc analysis of the LIGHT-HOUSE and SPOTLIGHT studies to assess the impact of urinary activity on interpretation of ¹⁸F-rhPSMA-7.3 PET/CT. *J Nucl Med.* 2023;64. P52-P52.
- Jani AB, Ravizzini G, Gartrell BA, et al. Diagnostic performance and safety of ¹⁸F-rhPSMA-7.3 PET in men with suspected prostate

cancer recurrence: Results from a phase 3, prospective, multicenter study (SPOTLIGHT). J Urol. 2023;210:299-311.

- 11. Castellucci P, Ceci F, Graziani T, et al. Early biochemical relapse after radical prostatectomy: Which prostate cancer patients may benefit from a restaging ¹¹C-choline PET/CT scan before salvage radiation therapy? *J Nucl Med.* 2014;55:1424-1429.
- Mottet N, Cornford P, van den Bergh RCN, et al. EAU EANM -ESTRO - ESUR - ISUP - SIOG guidelines on prostate cancer. EAU Guidelines. 2023. https://d56bochluxqnz.cloudfront.net/documents/ full-guideline/EAU-EANM-ESTRO-ESUR-ISUP-SIOG-Guidelineson-Prostate-Cancer-2023_2023-06-13-141145_owmj.pdf. Accessed May 21, 2024.
- Savir-Baruch B, Lovrec P, Solanki AA, et al. Fluorine-18-labeled fluciclovine PET/CT in clinical practice: Factors affecting the rate of detection of recurrent prostate cancer. *AJR Am J Roentgenol.* 2019;213:851-858.
- 14. Treglia G, Ceriani L, Sadeghi R, et al. Relationship between prostatespecific antigen kinetics and detection rate of radiolabelled choline PET/CT in restaging prostate cancer patients: A meta-analysis. *Clin Chem Lab Med.* 2014;52:725-733.
- Howard LE, Moreira DM, De Hoedt A, et al. Thresholds for PSA doubling time in men with non-metastatic castration-resistant prostate cancer. *BJU Int.* 2017;120. E80-E6.
- Offermann A, Hohensteiner S, Kuempers C, et al. Prognostic value of the new prostate cancer international society of urological pathology grade groups. *Front Med (Lausanne)*. 2017;4:157.
- Cerci JJ, Fanti S, Lobato EE, et al. Diagnostic performance and clinical impact of ⁶⁸Ga-PSMA-11 PET/CT imaging in early relapsed prostate cancer after radical therapy: A prospective multicenter study (IAEA-PSMA Study). *J Nucl Med.* 2022;63:240-247.
- Mena E, Rowe SP, Shih JH, et al. Predictors of ¹⁸F-DCFPyL PET/CT positivity in patients with biochemical recurrence of prostate cancer after local therapy. *J Nucl Med.* 2022;63:1184-1190.
- **19.** Farolfi A, Calderoni L, Mattana F, et al. Current and emerging clinical applications of PSMA PET diagnostic imaging for prostate cancer. *J Nucl Med.* 2021;62:596-604.
- Egevad L, Delahunt B, Srigley JR, et al. International society of urological pathology (ISUP) grading of prostate cancer - An ISUP consensus on contemporary grading. *APMIS*. 2016;124:433-435.
- Fendler WP, Calais J, Eiber M, et al. Assessment of ⁶⁸Ga-PSMA-11 PET accuracy in localizing recurrent prostate cancer: A prospective single-arm clinical trial. *JAMA Oncol.* 2019;5:856-863.
- Morris MJ, Rowe SP, Gorin MA, et al. Diagnostic performance of ¹⁸F-DCFPyL-PET/CT in men with biochemically recurrent prostate

cancer: Results from the CONDOR phase III, multicenter study. *Clin Cancer Res.* 2021;27:3674-3682.

- Pisansky TM, Thompson IM, Valicenti RK, et al. Adjuvant and salvage radiotherapy after prostatectomy: ASTRO/AUA guideline amendment 2018-2019. J Urol. 2019;202:533-538.
- Perry E, Talwar A, Taubman K, et al. Pathological predictors of ¹⁸F-DCFPyL prostate-specific membrane antigen-positive recurrence after radical prostatectomy. *BJU Int.* 2022;130(Suppl 1):28-36.
- Eiber M, Maurer T, Souvatzoglou M, et al. Evaluation of hybrid ⁶⁸Ga-PSMA ligand PET/CT in 248 patients with biochemical recurrence after radical prostatectomy. *J Nuc Med.* 2015;56:668-674.
- 26. Afshar-Oromieh A, Holland-Letz T, Giesel FL, et al. Diagnostic performance of ⁶⁸Ga-PSMA-11 (HBED-CC) PET/CT in patients with recurrent prostate cancer: Evaluation in 1007 patients. *Eur J Nucl Med Mol Imaging*. 2017;44:1258-1268.
- 27. Markowski MC, Sedhom R, Fu W, et al. Prostate specific antigen and prostate specific antigen doubling time predict findings on ¹⁸F-DCFPyL positron emission tomography/computerized tomography in patients with biochemically recurrent prostate cancer. *J Urol.* 2020;204:496-502.
- 28. Arafa AT, Jain A, Skrobanek P, et al. Impact of piflufolastat F-18 PSMA PET imaging on clinical decision-making in prostate cancer across disease states: A retrospective review. *Prostate*. 2023;83:863-870.
- 29. Fendler WP, Ferdinandus J, Czernin J, et al. Impact of ⁶⁸Ga-PSMA-11 PET on the management of recurrent prostate cancer in a prospective single-arm clinical trial. *J Nucl Med.* 2020;61:1793-1799.
- 30. Gulhane A, Lin D, Dash A, et al. [⁶⁸Ga]-PSMA-11 can clarify equivoral lesions on conventional imaging and change management decisions among men with previously treated prostate cancer. *J Nucl Med.* 2022;63(Supplement 2):3065.
- **31.** Hope TA, Aggarwal R, Chee B, et al. Impact of ⁶⁸Ga-PSMA-11 PET on management in patients with biochemically recurrent prostate cancer. *J Nucl Med.* 2017;58:1956-1961.
- 32. Pouliot F, Gorin MA, Rowe SP, et al. Changes in planned disease management after piflufolastat F18 PET/CT in men with biochemically recurrent prostate cancer and low PSA levels: A secondary analysis of results from the CONDOR study. J Clin Oncol. 2023;41(6_suppl):61.
- Wurzer A, DiCarlo D, Schmidt A, et al. Radiohybrid ligands: A novel tracer concept exemplified by¹⁸F- or ⁶⁸Ga-labeled rhPSMAinhibitors. *J Nucl Med.* 2020;61:735-742.
- **34.** Wurzer A, Kunert JP, Fischer S, et al. Synthesis and preclinical evaluation of ¹⁷⁷Lu-labeled radiohybrid PSMA ligands (rhPSMAs) for endoradiotherapy of prostate cancer. *J Nucl Med.* 2022;63: 1489-1495.