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Vas deferens metastasis from prostate adenocarcinoma treated with daily-adaptive MR-guided SBRT on 1.5T MR-linac

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Introduction

Herein, we report a case of a patient who experienced a vas deferens (VD) relapse after radical prostatectomy (RP) and adjuvant radiotherapy that was treated with stereotactic MR-guided radiotherapy (MRgRT).

VD is a rare site of relapse after RP that can be identified by integrated multiparametric MR (mpMR) and prostate-specific membrane antigen (PSMA)–positron emission tomography/computed tomography (PET/CT) to increase the diagnostic accuracy [1–3].

The most frequent relapse sites within the prostate bed are: periurethrovesicular anastomotic region, retrovesicular spaces, periurethral region, seminal vesicles (SV), and penile bulb (ref). Rarely, prostate cancer (PCa) relapse far from the urethrovesicular anastomosis, at the resection level of the vas deferens (VD), or along the residual VD. While the VD is in continuity with the seminal vescicle (SV), the spread along the VD seems linked to the lymphatic drainage of the prostate along the VD to the external iliac lymphnodes [4]. In the case of oligorecurrence to the VD, stereotactic body radiotherapy (SBRT) might be a suitable treatment option. However, the VD is subjected to a high interfraction variability due to the bladder/bowel loops filling/mobility.

In this scenario, the introduction of MR-guided RT (MRgRT) via MR-Linac permits target visualization and treatment plan readjustment to the daily anatomical variation, unlike conventional RT where no online adaptation is possible [5].

Case description

A 68-year-old patient underwent RP in 2009, adjuvant RT, and androgen deprivation therapy for one year. The PSA remained undetectable until July 2017 (0.29 ng/mL), afterwards a slow progression up to 0.55 ng/mL (February 2019) was recorded. Previous imaging was negative. In May 2019, a ^{68}Ga-PSMA PET/CT showed a moderate focal uptake on a 5 mm nodule at the level of the right VD (SUVmax 5.1) (Fig. 1A). Considering the oligorecurrence, the patient was treated with SBRT on a 1.5T MR-linac (Unity, Elekta Sweden) (Fig. 2).

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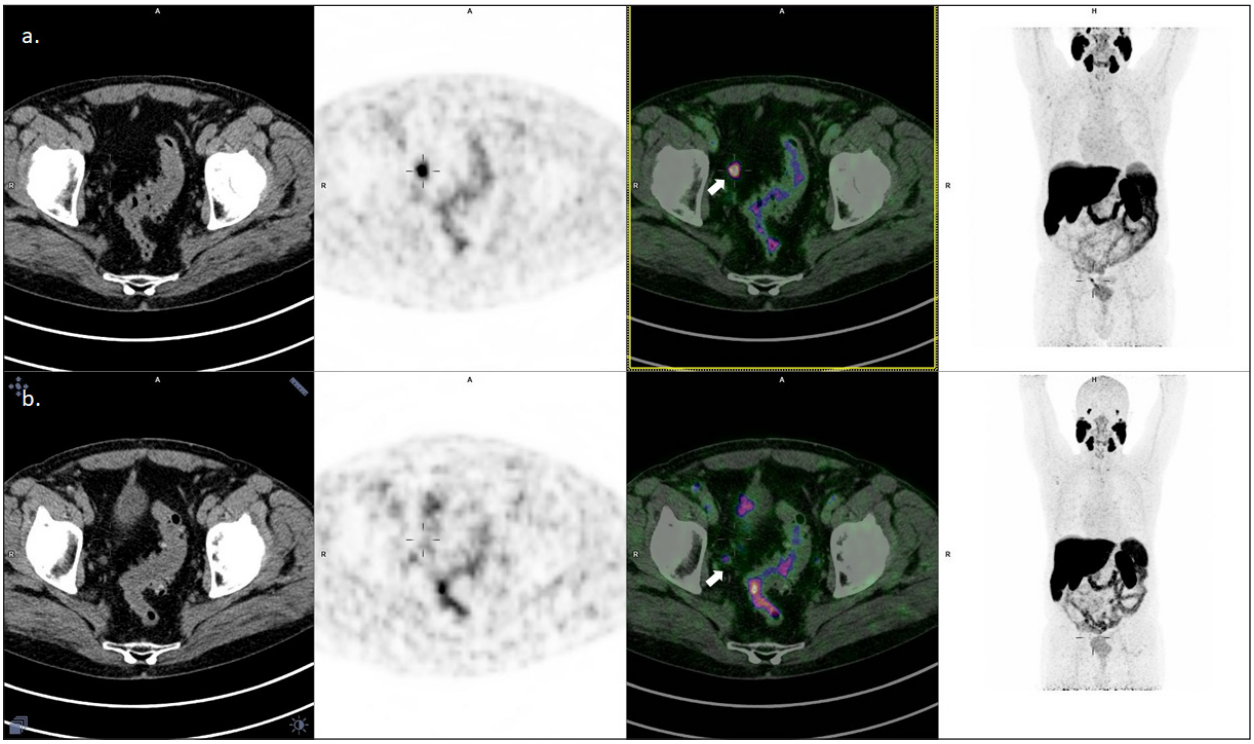

Figure 1. Gallium-68-prostate-specific membrane antigen (^{68}Ga-PSMA) positron emission tomography (PET)/computed tomography (CT) of a 68-year-old patient with rising PSA value. **A.** Axial CT showing thickening of right vas deferens (VD) compared to the contralateral. PET imaging showing intense uptake. Axial CT fused with PET showing anatomical correspondence of the uptake (the red arrow head indicates the pathological uptake); **B.** ^{68}Ga-PSMA PET/CT at the last follow-up showing complete metabolic response to treatment. Axial image, PET alone and fused images are showed. The red arrow head indicate residual VD with no uptake

At the first follow-up a new ^{68}Ga-PSMA PET/CT showed a complete response of the treated lesion and undetectable PSA (Fig. 1B). No treatment-related toxicity was reported. The patient continued follow-up and the last PSMA-PET/CT (July 2021) confirmed the response to treatment.

MR-guided radiotherapy procedures

Before simulation and each fraction, the patient was instructed to have his bladder half full (500 cc of water 15–20 min before the session) and empty rectum. A simulation-CT (slice thickness 3-mm) was acquired for dose calculation purposes, followed by a high-resolution MR acquired by 1.5T MR-linac. A T2-weighted MR scan was acquired during the simulation and before each fraction. The gross tumor volume (GTV) was the VD. The planning target volume (PTV) consisted of GTV + 5 mm margins in each direction. The rectum, bladder, and bowel loops were delineated as organs at risk. The SBRT schedule consisted of five fractions of 7 Gy (total prescription dose, Dp, 35 Gy) on 5 consecutive days. The dose distribution was normalized to assure that at least 95% of the PTV received at least 95% of Dp (33.2 Gy), while less than 2% of the PTV received 107% of Dp (37.5 Gy). Baseline treatment plans were generated using static field intensity-modulated radiotherapy (IMRT) delivered with 16 beams. Constraints for planning approval were the following: (1) for the rectum: V18Gy ≤ 35%, V28Gy ≤ 10%, V32Gy ≤ 5%, Dmax ≤ 35Gy; (2) for the bladder and bowel loops: Dmax ≤ 35Gy [6, 7]. The average treatment duration was 23 minutes. At the end of the delivery, a further post-MR scan was performed, to estimate the intrafraction organ motion.

Discussion

In the literature there are few cases of VD recurrence after RP, and no one reported treatment details. Valle et al. [8] and Priftakis et al. [9] reported a total of three VD recurrence case, detected by

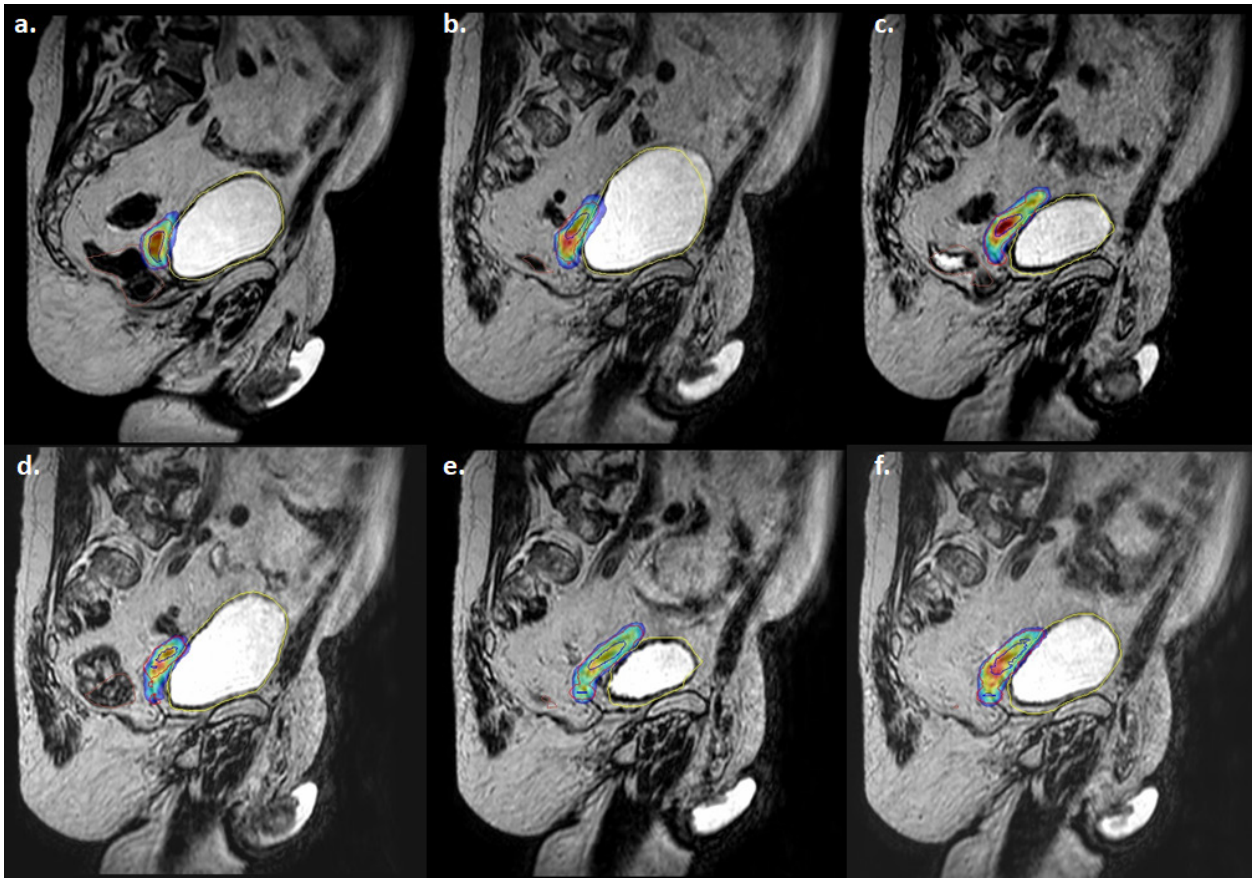

Figure 2. Daily-adapted treatment plans of the vas deferens (VD) metastasis. The two treatment plan "adaptive" strategies available for Elekta Unity are "adapt-to-position" (ATP) and "adapt-to-shape" (ATS). For ATP, the shape and weight of beam segments in the reference plan are adjusted to match the current position of target and organs-at-risk (OAR) based on rigid registration. In the case of ATS, the daily MR is re-contoured to adapt the treatment plan of the day. In the present case, ATS was performed in every session. In detail, before each fraction, a new T2-weighted MRI sequence (pre-MR) was performed and rigidly registered to the simulation MR. Through deformable registration, the original set of contours was projected onto the daily pre-MR and hence edited, as necessary, by the physician. A full reoptimization, such as starting from fluence, was performed by the physicist and, within the second optimization phase (i.e. the segmentation phase), a second verification MR scan was acquired to test whether any shift in target position or prominent changes in target and OAR shape during planning time occurred. If not, the patient was prepared again (by enema and/or drinking), and only after this repositioned for treatment. If yes, the treatment was delivered with patient monitoring by cine MRI, typically acquired on two coronal and sagittal planes. **A.** T2w MR scan (simulation MR) showing right VD thickening compared to the contralateral and relative reference treatment plan; **B–F.** T2w pre-treatment MR in the sagittal view showing online adaptive plans with dose distribution and different bladder filling

PET-MRI or PSMA-PET/CT. During RP, the VD are dissected and transposed caudally to their distal portion or to SV apex. The authors highlighted the importance of accurate imaging, especially when anatomy is modified.

The present patient was treated with 1.5T MR-linac, because MR allowed a better soft-tissues contrast [10], especially within the pelvis. The MR finding was represented by a wall thickening of the right VD, which corresponded to the focal uptake at the PSMA-PET/CT. Treatment accuracy was confirmed during follow-up by the complete response of the treated lesion and no treatment-related toxicity occurred.

MR-linac allows for daily replanning, which is particularly relevant for specific anatomical subsite subjected to high daily variation. The advantage of this technique is that it allows, moreover, to better control the dose to organs at risk. This may permit a safely delivery of SBRT in such particular cases.

Conflict of interest

Prof. Filippo Alongi is consultant for Elekta and received speaker honoraria.

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