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Original Article

^{18}F-choline PET/MR in suspected recurrence of prostate cancer☆

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ABSTRACT

Objective: To evaluate the usefulness of simultaneous ^{18}F-choline PET/MRI in the suspicion of prostate cancer recurrence and to relate ^{18}F-choline PET/MRI detection rate with analytical and pathological variables.
Material and methods: 27 patients with prostate cancer who received local therapy as primary treatment underwent a ^{18}F-choline PET/MRI due to suspicion of recurrence (persistently rising serum PSA level). ^{18}F-choline PET/MRI findings were validated by anatomopathological analysis, other imaging tests or by biochemical response to oncological treatment.
Results: ^{18}F-choline PET/MRI detected disease in 15 of 27 patients (detection rate 55.56%). 4 (15%) presented exclusively local recurrence, 5 (18%) lymph node metastases and 7 (26%) bone metastases. Mean PSA (PSA_{med}) at study time was 2.94 ng/mL (range 0.18–10 ng/mL). PSA_{med} in patients with positive PET/MRI was 3.70 ng/mL (range 0.24–10 ng/mL), higher than in patients with negative PET/MRI, PSA_{med} 1.97 ng/mL (range 0.18–4.38 ng/mL), although without statistically significant differences. Gleason score at diagnosis in patients with a positive study was 7.33 (range 6–9) and in patients with a negative study was 7 (range 6–9), without statistically significant differences.
Conclusion: ^{18}F-choline PET/MRI detection rate was considerable despite the relatively low PSA values in our sample. The influence of Gleason score and PSA level on ^{18}F-choline PET/MRI detection rate was not statistically significant.

PET/RM con ^{18}F-colina en la sospecha de recurrencia del carcinoma de próstata

Palabras clave:
PET/RM
Cáncer de próstata
Colina
Recurrencia

RESUMEN

Objetivo: Evaluar la utilidad de la PET/RM con ^{18}F-colina simultánea en la sospecha de recurrencia del carcinoma de próstata y relacionar su tasa de detección de enfermedad con variables analíticas y anatomopatológicas.
Material y métodos: Estudio retrospectivo de 27 pacientes con carcinoma de próstata que recibieron terapia local como tratamiento primario, a quienes se les realizó una PET/RM con ^{18}F-colina por sospecha de recurrencia (elevación mantenida de los niveles de PSA). Los hallazgos patológicos de la PET/RM con ^{18}F-colina fueron validados mediante el análisis anatomopatológico, otras pruebas de imagen o por la respuesta bioquímica al tratamiento oncológico.
Resultados: La PET/RM con ^{18}F-colina detectó enfermedad en 15 de los 27 pacientes (tasa de detección del 55,56%); 4 (15%) presentaron recurrencia exclusivamente local, 5 (18%) metástasis ganglionares y 7 (26%) metástasis óseas. El PSA medio (PSA_{med}) a la realización del estudio fue de 2,94 ng/mL (rango 0,18-10 ng/mL). Los pacientes con PET/RM positiva presentaron un PSA_{med} de 3,70 ng/mL (rango 0,24-10 ng/mL), mayor que los pacientes con PET/RM negativa, PSA_{med} de 1,97 ng/mL (rango 0,18-4,38 ng/mL), aunque sin diferencias estadísticamente significativas. La puntuación Gleason al diagnóstico de los pacientes con estudio positivo fue de 7,33 (rango 6-9), y la de los pacientes con estudio negativo fue de 7 (rango 6-9), sin diferencias estadísticamente significativas.

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Conclusión: La tasa de detección de la PET/RM con ^{18}F-colina fue considerable pese a los valores relativamente bajos de PSA en nuestra muestra. La influencia de la puntuación Gleason y del nivel de PSA en la tasa de detección de la PET/RM con ^{18}F-colina no fue estadísticamente significativa.

Introduction

Prostate cancer continues to be the second most frequent carcinoma diagnosed in men,[1] and the second cause of death by cancer among men in most Western countries.[2]

Despite therapeutic advances, there is a significant risk of recurrence following primary intention to cure treatment. Elevation of the prostate-specific antigen (PSA) above some thresholds (biochemical recurrence) is usually the first sign of suspicion of recurrence. From 27 to 53% of patients treated with radical prostatectomy (RP) or radiotherapy present biochemical recurrence.[1]

In the presence of biochemical recurrence it is important to determine whether there is local, regional or distant recurrence in order to establish the most adequate treatment. Different imaging techniques are used to do this.

Locoregional recurrence

For the evaluation of locoregional recurrence magnetic resonance (MR), especially multiparametric MR (mpMR) has shown promising results. Nonetheless, the changes induced by treatment (anatomical distortion, fibrosis, artifacts by surgical clips and alteration of the characteristics of the mpMR signal) may make interpretation difficult.[3] The elevated specificity of positron emission tomography (PET) with choline can help to establish the diagnosis in cases in which the mpMR sequences provide contradictory results.[4]

Distant metastasis

Prostate cancer tends to metastasize in bone and the lymph nodes, although it may also disseminate to other organs such as the liver and lungs.

The two imaging techniques of bone scintigraphy (BS) and computerized tomography (CT) are widely used to detect distant involvement. However, their sensitivity is relatively low except in patients with elevated PSA values. Therefore, in cases with exclusive biochemical recurrence after RP or radiotherapy, the European Association of Urology (EAU) only recommends their use if the PSA is higher than 10 ng/mL or with adverse PSA kinetics (PSA doubling time <6 months or PSA velocity >0.5 ng/mL/month).[1]

PET/CT with choline (^{11}C-choline or ^{18}F-choline) has shown to present a greater sensitivity and specificity for the detection of biochemical recurrence, leading to changes in the therapeutic management of 28–48% of the patients.[5–8] Similar to the previous techniques, it is PSA dependent. The PSA level at which PET/CT with choline should be indicated remains controversial. After RP it is usually recommended when the PSA is $\geq$1 ng/mL, since up to 80% of PET/CT with choline are negative when the PSA is less than this value.[2]

The indication of whole body MR is still not established in the suspicion of recurrence of prostate cancer. Nevertheless, MR has a greater sensitivity than CT for the detection of bone metastases.[9] In the metaanalysis of Shen et al., MR and PET/CT with choline showed greater accuracy than BS, with MR presenting the highest sensitivity and PET/CT the highest specificity.[10]

PET/MR on suspicion of recurrence of prostate cancer

The recently introduced PET/MR equipment can obtain morphological, functional and metabolic images in a single study, broadening the advantages of PET and MR with scarce exposure of the patients to ionizing radiation.

Few studies have evaluated the diagnostic yield of PET/MR with choline on suspicion of recurrence of prostate cancer,[9,11] but the results obtained have been encouraging.

The aim of this study was to evaluate the diagnostic performance of ^{18}F-choline PET/MR in the suspicion of recurrence of prostate cancer and analyze the relationship among the rate of detection, PSA level at the time of the study and the Gleason score at diagnosis.

Material and methods

Study population

The study included patients undergoing ^{18}F-choline PET/MR for suspicion of recurrence of prostate cancer during the period from January 1, 2015 to January 31, 2017. Suspicion of recurrence was based on the detection of elevated PSA levels maintained over time.

Twenty-seven men with a mean age of 71.25 years (range: 56–71) received local therapy as the primary treatment: 12 RP, 7 external radiotherapy (RT), 1 brachytherapy (BT), 4 RP + RT, 1 BT + RT, 1 cryotherapy and 1 high-intensity focused ultrasound (HIFU).

The median PSA (PSA_{med}) of the patients at the time of the study was 2.94 ng/mL (range: 0.18–10 ng/mL) and the mean Gleason score at diagnosis was 7.18 (range: 6–9).

The tumor stage at the initial diagnosis ranged from T1c to T4. Only one patient was classified as N+ (pT3bN1) after RP.

Acquisition of ^{18}F-choline PET/MR

The PET/MR acquisition was carried out in hybrid PET/MR equipment (Biograph mMR®; Siemens Healthcare, Erlangen, Germany) with 3T MR, PET detectors based on avalanche photodiodes (APD) and with an axial field of view (FOV) of 25.8 cm.

The patients were in fasting for 6 h and were intravenously administered 197–370 MBq of ^{18}F-fluorocholine. Immediately after the injection a 5 min dynamic PET study of the pelvis was made with simultaneous acquisition of axial and coronal T2 MR turbo spin echo (TSE) sequence. Thereafter, 9 patients underwent an axial T1 TSE sequence, and axial T1 perfusion and diffusion-weighted imaging (DWI) of the pelvis was performed in 15.

Forty-five min. after the injection of the radiotracer a whole body study was performed from the vertex to the upper third of the thighs with simultaneous acquisition of PET images (4 min/bed position) and T2 half-Fourier acquisition single-shot turbo spin-echo (HASTE) MR and axial DWI (b0_500_1000) (patients who had previously undergone DWI of the pelvis did not undergo the whole body DWI). Immediately afterwards, 0.1 mL/kg of weight of paramagnetic contrast (Gadovist® 1 M) was administered at 2.5 mL/s and a whole body post-contrast T1 volume interpolated breath-hold examination fat saturated (VIBE FS) sequence was obtained.

The PET images were reconstructed using an iterative algorithm ordered subset expectation maximization (OSEM 3D) method, with