Case Reports in Oncology

Case Rep Oncol 2024;17:640–645
DOI: 10.1159/000539333
Received: March 9, 2024
Accepted: May 6, 2024
Published online: June 11, 2024

Case Report

Disseminated Carcinomatosis of the Bone Marrow from Castration-Resistant Prostate Cancer Revealed by Choline Positron Emission Tomography-Computed Tomography

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Keywords
Disseminated carcinomatosis of the bone marrow · Choline PET/CT · Bone scintigraphy · Prostate cancer

Abstract
Introduction: Disseminated carcinomatosis of the bone marrow is caused by cancer metastasis to the bone marrow and is the diagnosis is very difficult by imaging. ***Case Presentation:*** We report a 75-year-old male with disseminated carcinomatosis of the bone marrow from castration-resistant prostate cancer revealed by ^{11}C-choline positron emission tomography-computed tomography (PET/CT). Although he already received radiotherapy to the prostate, combined androgen blockade, enzalutamide and apalutamide, and external beam radiotherapy for the pelvic bone metastases, serum prostate-specific antigen (PSA) value rapidly increased from 32 ng/mL to 104 ng/mL in recent 1 month. Bone scintigraphy showed almost no abnormal uptake in the whole body, whereas ^{11}C-choline PET/CT showed diffuse bone marrow ^{11}C-choline uptake. The disseminated carcinomatosis of the bone marrow was diagnosed from the discordant findings between bone scintigraphy and ^{11}C-choline PET/CT examinations and confirmed pathologically by iliac marrow biopsy pathologically. Although docetaxel therapy

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was started, PSA value continued rising and he died after 4 months of the diagnosis. ***Conclusion:*** The discordant findings of choline PET/CT and bone scintigraphy can diagnose disseminated carcinomatosis of the bone marrow from prostate cancer.

Introduction

Disseminated carcinomatosis of the bone marrow is caused by cancer metastasis to the bone marrow and is often accompanied by disseminated intravascular coagulation, leukoerythroblastosis, and microangiopathic hemolytic anemia [1]. The clinical course is rapid. The majority of disseminated carcinomatosis of the bone marrow cases originate from the stomach, whereas carcinomatosis arising from the prostate is rare [2]. Here we present a case of disseminated carcinomatosis of the bone marrow from castration-resistant prostate cancer revealed by ^{11}C-choline positron emission tomography-computed tomography (PET/CT) that could lead optimal management.

Case Presentation

Three years and 2 months ago, a 75-year-old man with biopsy-proven prostate cancer (Gleason score 5 + 4), serum prostate-specific antigen (PSA) level of 270.0 ng/mL, and clinical stage of T4N1M1 with multiple bone metastases shown by technetium 99m (^{99m}Tc) bone scintigraphy (Fig. 1) underwent radiotherapy to the prostate and combined androgen blockade therapy as initial treatments. The PSA value reached the nadir of 3.70 ng/mL. He received enzalutamide and apalutamide, and external beam radiotherapy for the pelvic bone metastases. However, PSA value rapidly increased from 32 ng/mL to 104 ng/mL in recent 1 month.

He underwent technetium ^{99m}Tc bone scintigraphy and ^{11}C-choline PET/CT examination to evaluate the patient current disease status for restaging. ^{99m}Tc bone scintigraphy showed almost no abnormal uptake in the whole body excluding small uptake in the sacrum reflecting sacral insufficiency fracture (Fig. 2), whereas ^{11}C-choline PET/CT showed diffuse bone marrow ^{11}C-choline uptake (Fig. 3). The disseminated carcinomatosis of the bone marrow was diagnosed from the discordant findings between the bone scintigraphy and ^{11}C-choline PET/CT examinations. His blood tests showed Hb level of 11.2 g/dL, WBC level of 4,930, LDH level of 220 U/L, ALP level of 86 U/L, and CRP level of 0.15 mg/dL. An iliac bone marrow biopsy was performed, the results of the histopathological examination revealed bone marrow metastasis of adenocarcinoma, and immunostaining for NKX3.1 was positive (Fig. 4). Although docetaxel therapy was started, PSA value continued rising (to 170 ng/mL at 1 month later, 282 ng/mL at 2 months later, 477 ng/mL at 3 months later, and 668 ng/mL at 4 months later), and he died after 4 months of the diagnosis.

Discussion

Osteoblastic activity can be evaluated using radionuclide bone scintigraphy, a widely used technique for assessment of disease extent and treatment response in osteoblastic bone metastasis from prostate cancer [2, 3]. However, intertrabecular, pure osteolytic bone

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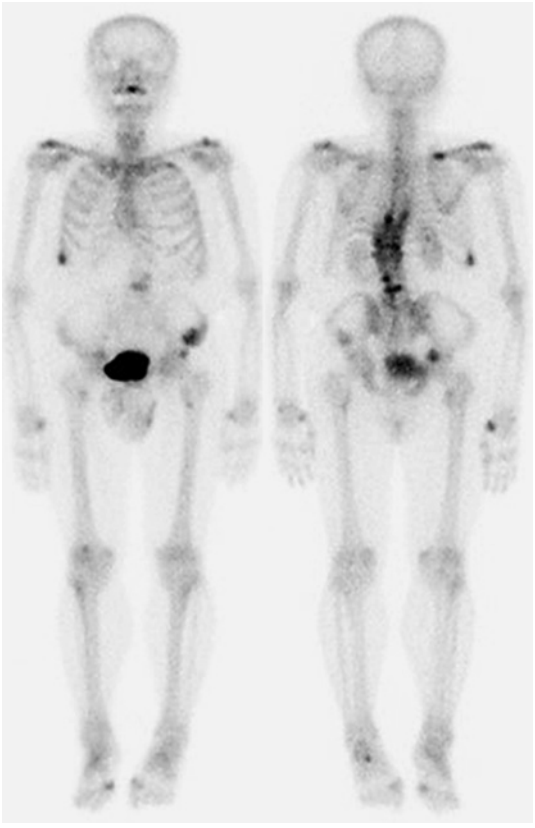

Fig. 1. Initial ^{99m}Tc bone scintigraphy at the time of prostate cancer diagnosis. Whole-body ^{99m}Tc bone scintigraphy showed abnormal uptakes in the bilateral femur, the bilateral scapula, and right rib, suggesting multiple bone metastases, and uptakes in the thoracic vertebra, reflecting nonspecific accumulation for the bone spicule.

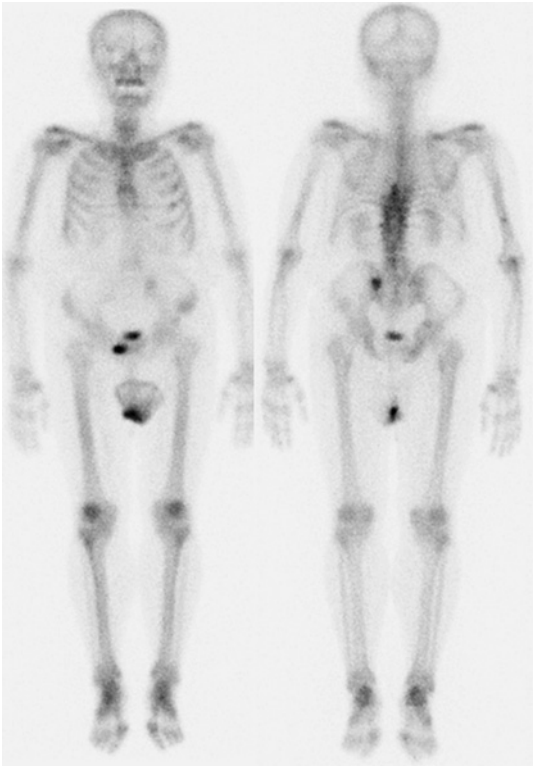

Fig. 2. ^{99m}Tc bone scintigraphy at the time of bone marrow metastasis diagnosis. Whole-body ^{99m}Tc bone scintigraphy showed almost no abnormal uptake in the whole body excluding small uptake in the sacrum, reflecting sacral insufficiency fracture.

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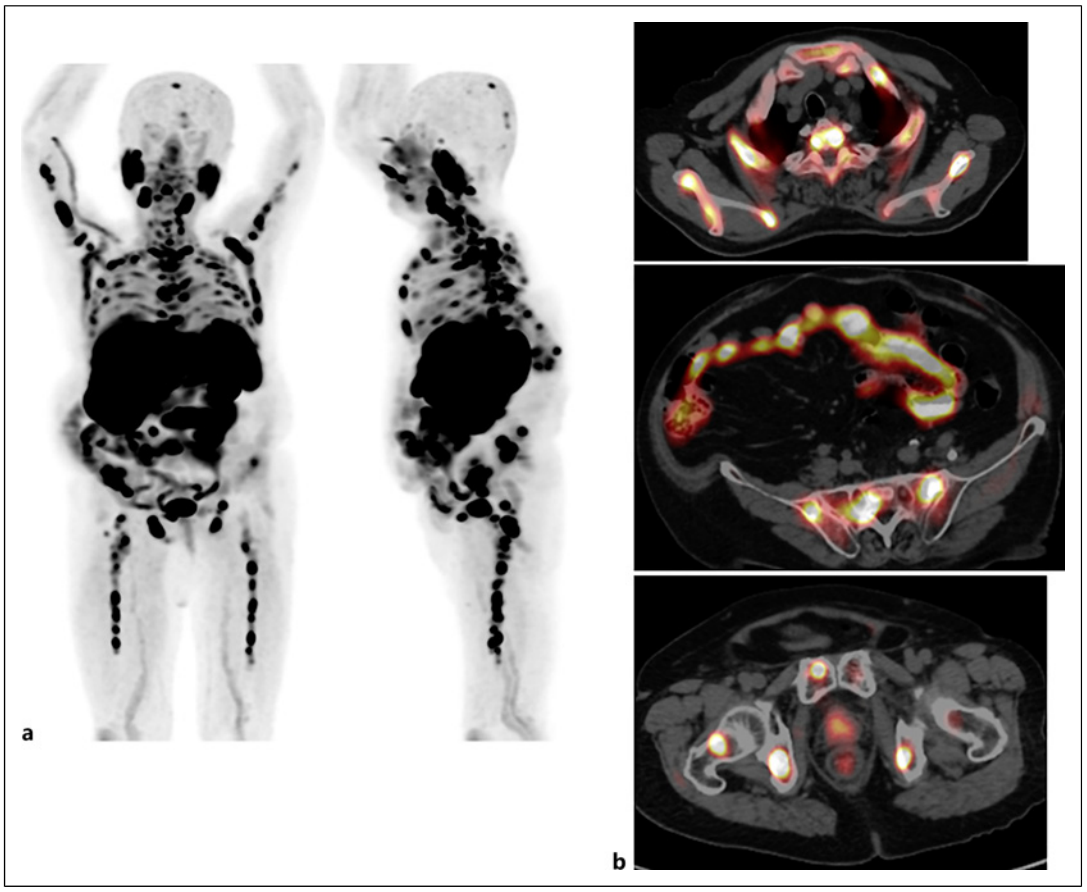

Fig. 3. ^{11}C-choline PET/CT at the time of bone marrow metastasis diagnosis. **a** Maximum intensity projection (MIP) ^{11}C-choline PET/CT showed diffuse bone marrow ^{11}C-choline uptake, confirming bone marrow metastasis. **b** Whole-body ^{11}C-choline PET/CT showed diffuse bone marrow ^{11}C-choline uptake, confirming bone marrow metastasis.

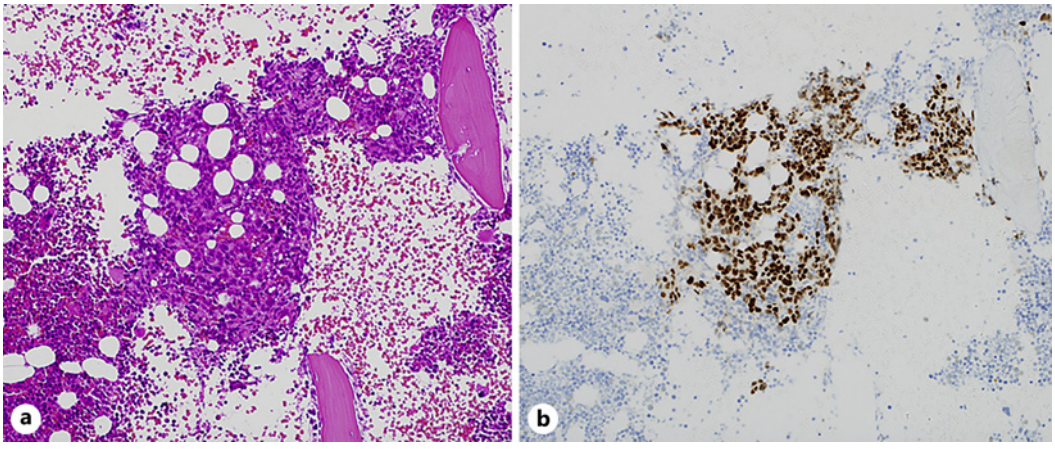

Fig. 4. Pathological finding of iliac marrow biopsy. **a** The iliac bone marrow biopsy (hematoxylin and eosin staining) revealed bone marrow metastasis of adenocarcinoma. **b** Immunostaining for NKX3.1 was positive.

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metastases, and bone marrow metastases could not be detected by bone scintigraphy [3, 4]. In the case of intertrabecular metastasis and bone marrow metastases, cancer cells are present between the bone trabecule, and the bone cortex is preserved without destruction.

On the other hand, ^{11}C-choline PET/CT is a useful modality for staging, restaging, evaluating treatment response of prostate cancer because that modality can diagnose local, nodal, bone, and visceral metastasis [5]. Moreover, ^{11}C-choline PET/CT can directly image tumor cell and detect all types of bone metastases (osteoblastic, osteolytic, mixed-type, and intertrabecular type) and bone marrow metastases in patients with prostate cancer [6]. ^{11}C-choline PET/CT can also evaluate tumor viability and treatment response in patients with prostate cancer [6, 7].

New and more sensitive PET tracers for prostate cancer, such as ^{18}F-fluciclovine and ^{68}Ga- or ^{18}F-prostate-specific membrane antigen (PSMA), have been recently introduced for clinical use in Western countries [3, 8], though ^{18}F-fluciclovine and PSMA are not yet available in Japan. European Association of Urology (EAU) guidelines (2019) recommend performing PSMA-PET/CT in patients with relapse PSA >0.2 ng/mL after radical prostatectomy or, in case of unavailability of PSMA-PET/CT and a PSA level ≥1 ng/mL, choline PET/CT is used [9].

Conclusion

The findings of choline PET/CT and bone scintigraphy can diagnose disseminated carcinomatosis of the bone marrow from castration-resistant prostate cancer. Choline PET/CT may be useful for evaluating viability of advanced prostate cancer with suspected metastatic lesions and treatment planning. The CARE Checklist has been completed by the authors for this case report, attached as online supplementary material (for all online suppl. material, see https://doi.org/10.1159/000539333).

Statement of Ethics

This report complies with the guidelines for human studies and includes evidence that the research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki. Written informed consent was obtained from the patient and his family for publication of this case report and any accompanying images. This retrospective review of patient data did not require ethical approval in accordance with local/national guidelines.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

This work was supported by JSPS KAKENHI grant number 22K07757.

Author Contributions

Concept and design: Kazuhiro Kitajima, Shingo Yamamoto, and Koichiro Yamakado; acquisition of data: Kazuhiro Kitajima, Shingo Yamamoto, Akihiro Kanematsu, Masato Tomono, Sayuri Nishimoto, Reona Wada, Miyu Hirayama, Jyunpei Kitamoto, Kiyoshi Takagaki,

Norihiro Kuroda, and Takako Kihara; drafting of the manuscript: Kazuhiro Kitajima; critical revision of the manuscript for important intellectual content: Shingo Yamamoto and Koichiro Yamakado. All authors approved final version of manuscript.

Data Availability Statement

All data generated or analyzed during this study are included in this article and its online supplementary material files. Further inquiries can be directed to the corresponding author.

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