Image in keeping in mind

Temporal PET and MR imaging findings of the bone-marrow on ^{18}F-FDG PET/MRI after G-CSF administration

Japanese Archive of cases conference of clinical nuclear medicine 03, 2019 P.13-16
Received: February 21, 2019, Accepted: March 25, 2019

Department of Radiology, Kobe University Graduate School of Medicine

Feibi Zeng, M.D., Munenobu Nogami, M.D., Ph.D., Takashi Okunaga, R.T., Kazuhiro Kubo, R.T., Takamichi Murakami, M.D., Ph.D.

Corresponding author
Affiliation

Department of Radiology, Kobe University Graduate School of Medicine
Feibi Zeng, M.D. chouka0@hotmail.co.jp

Category
EBL

Abstract
To our knowledge, this is the first case report showing differences in the temporal PET and MR imaging findings of the bone-marrow on ^{18}F-FDG PET/MRI after G-CSF administration. PET/MRI performed one day after G-CSF administration showed remarkably increased FDG uptake on PET but normal signal intensities on MRI, in the bone marrow. Conversely, there was no increased FDG uptake but high signal intensities on diffusion-weighted imaging and T2 weighted images, 21 days after G-CSF administration. These findings suggest contiguous changes of glucose metabolism and cellularity of activated red bone marrow due to G-CSF administration.

Key words
malignant lymphoma, positron emission tomography, diffusion weighted MRI, granulocyte-colony stimulating factor, PET/MRI

Ethical comments
The institutional review board approved this study and waived the specific informed consent of each patient for this retrospective study.

Conflicts of interest statement
The authors declare no conflict of interest associated with this manuscript.

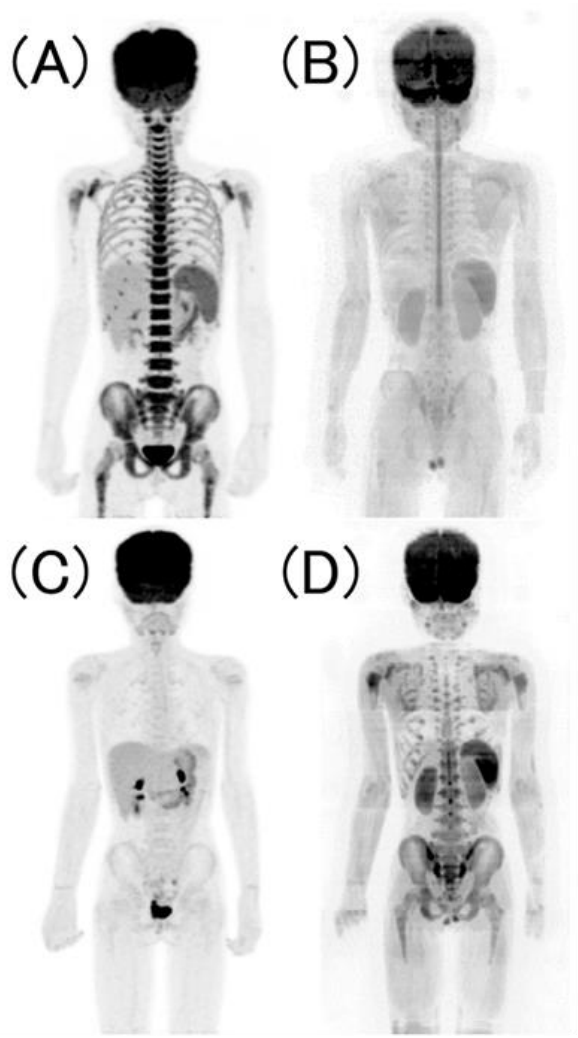

Fig.1 A 9-year-old boy presented with abdominal pain and was diagnosed with intussusception. An abdominal echography revealed the presence of an ileum tumor, and an ileectomy was performed. The patient underwent chemotherapy because the histopathological examination revealed diffuse large B-cell lymphoma with bone marrow involvement.

A maximum intensity projection (MIP) image of the PET component of PET/MRI performed one day after administration of Lenograstim (genetical recombination), short-term acting granulocyte-colony stimulating factor (G-CSF) showed remarkably increased FDG uptake in bone marrow of the trunk and proximal extremities corresponding to the distribution of the red bone marrow (A). However, MIP of the diffusion-weighted MR images with background suppression (DWIBS) (b = 1000) showed normal signal intensities (B). Conversely, reduced FDG uptake was found on MIP of the PET, 21 days after administration of G-CSF (C), whereas MIP of the DWIBS showed increased signal intensities in the entire bone marrow (D). The finding of the two PET/MRIs were concordant with CMR according to the Lugano classification 2014. Because no evidence of bone marrow involvement of lymphoma was found pathologically at all time-points of the PET/MRI examinations, G-CSF was considered to be the major cause of the temporal changes on PET/MRI. (A, B) and (C, D) were the imaging underwent after 1 cycle of induction therapy and after 2 cycles of induction therapy and 2 cycles of intensification therapy, respectively.

It is well known that FDG uptake of the bone marrow increases after G-CSF administration [1] and correlates with the neutrophil count [2]. Increased FDG uptake

in the bone marrow disappears around ten days to one month after the G-CSF administration [3-5], which is consistent with the temporal changes on the PET in this case.

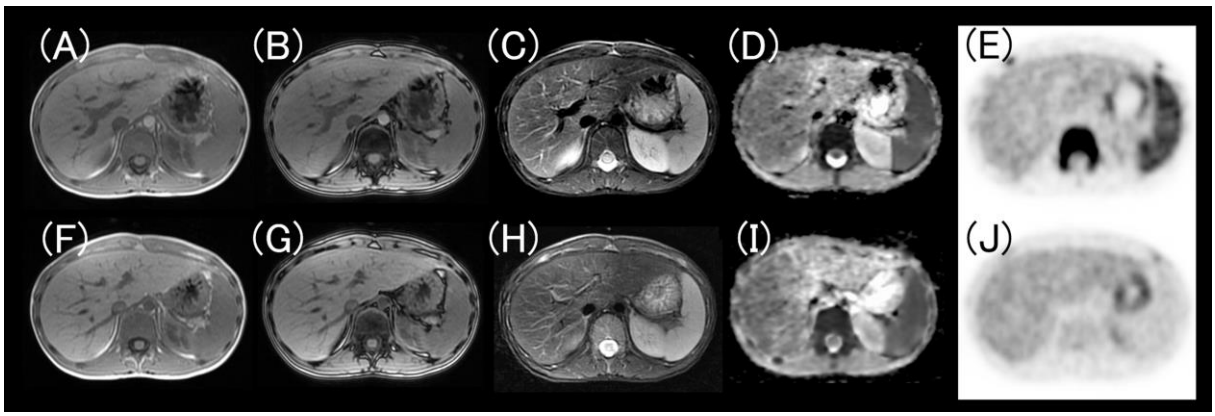

Fig.2 The figure shows axial images of the in/opposed phase of T1 weighted-images (WI) , fat-suppressed T2WI, apparent diffusion coefficient (ADC) map, and the FDG PET of PET/MRI performed one day (A to E, respectively), and 21 days (F to J, respectively) after G-CSF administration. At one day after G-CSF, MRI showed normal signal intensity (ratio of signal intensities of bone marrow to erector muscle on T2WI, 0.73; ADC, 2.5×10^{-3} mm^2/sec) (A to D), whereas PET showed increased FDG uptake of bone marrow (SUVmax, 7.7) (E). High signal intensity on T2WI and increased ADC were found 21 days after G-CSF (T2WI ratio, 1.61; ADC, 5.2×10^{-3} mm^2/sec) (H and I); however, FDG uptake reduced to normal level (SUVmax, 1.3) (J). No signal changes were seen on T1WI in both examinations (A, B, F, and G).

To our knowledge, this is the first case report showing differences in the temporal PET and MR imaging findings of the bone-marrow on 18F-FDG PET/MRI after G-CSF administration. In adult patients, G-CSF reportedly resulted in a prolongation of T1 relaxation time due to increased water content within the bone marrow [6, 7]. In other cases, prolongation of T2 relaxation time was found possibly due to bone marrow edema after G-CSF [8]. In our pediatric case, increased cellularity of bone marrow demonstrated by bone marrow aspiration (the ratio of nuclear cell to fat layer increased from 2.0 (1 day) to 2.3 (21 days)) was indicated. The increased cellularity found in the bone marrow aspiration on the day of second PET/MR was considered to affect the hyperintensity on DWI. T2WI and ADC map showed, however, high signal intensity on the second PET/MR as well, which might be speculated that increased water content in the bone marrow also affected the MR signal intensity in this case.

This PET/MRI case illustrates that increased glucose metabolism is seen early after G-CSF administration, followed by increased cellularity of the bone marrow.

References

1. Sugawara Y, Fisher SJ, Zasadny KR, Kison PV, Baker LH, Wahl RL. Preclinical and clinical studies of bone marrow uptake of fluorine-1-fluorodeoxyglucose with or without granulocyte colony-stimulating factor during chemotherapy. J Clin Oncol. 1998;16(1):173-80.
2. Murata Y, Kubota K, Yukihiro M, Ito K, Watanabe H, Shibuya H. Correlations between ^{18}F-FDG uptake by bone marrow and hematological parameters: measurements by PET/CT. Nucl Med Biol. 2006;33(8):999-1004.
3. Hanaoka K, Hosono M, Usami K, Tatsumi Y, Yamazoe Y, Komeya Y, et al. Fluorodeoxyglucose uptake in the bone marrow after granulocyte colony-stimulating factor administration in patients with non-Hodgkin's lymphoma. Nucl Med Commun. 2011;32(8):678-83.
4. Trout AT, Sharp SE, Turpin BK, Zhang B, Gelfand MJ. Optimizing the interval between G-CSF therapy and F-18 FDG PET imaging in children and young adults receiving chemotherapy for sarcoma. Pediatr Radiol. 2015;45(7):1001-6.
5. Kazama T, Swanston N, Podoloff DA, Macapinlac HA. Effect of colony-stimulating factor and conventional- or high-dose chemotherapy on FDG uptake in bone marrow. Eur J Nucl Med Mol Imaging. 2005;32(12):1406-11. Epub 2005 Aug 31.
6. Ryan SP, Weinberger E, White KS, Shaw DW, Patterson K, Nazar-Stewart V, et al. MR imaging of bone marrow in children with osteosarcoma: effect of granulocyte colony-stimulating factor. AJR Am J Roentgenol 1995;165:915-20.
7. Altehoefer C, Bertz H, Ghanem NA, Langer M. Extent and time course of morphological changes of bone marrow induced by granulocyte-colony stimulating factor as assessed by magnetic resonance imaging of healthy blood stem cell donors. J Magn Reson Imaging. 2001;14(2):141-6.
8. Hartman RP, Sundaram M, Okuno SH, Sim FH. Effect of granulocyte-stimulating factors on marrow of adult patients with musculoskeletal malignancies: incidence and MRI findings. AJR Am J Roentgenol. 2004;183(3):645-53.