Perirenal ^{18}F -FDG Uptake in a Patient with a Pheochromocytoma

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Abstract Increased ^{18}F -fluorodeoxyglucose (FDG) uptake of brown fat on ^{18}F -FDG positron emission tomography (PET) originating from physiological activation is a common incidental finding and is usually located in the neck, shoulder, and supraclavicular areas. We present a case of an incidental pheochromocytoma showing diffusely increased ^{18}F -FDG uptake in bilateral perirenal fat tissue as well as supraclavicular and paravertebral fat tissue on ^{18}F -FDG PET/CT. The patient had no clinical symptoms except hypertension, and a pheochromocytoma was confirmed in a post-surgical specimen. A pheochromocytoma should be considered a cause in cases of increased ^{18}F -FDG uptake of perirenal brown fat.

Keywords Pheochromocytoma · Brown fat · ^{18}F -FDG · Positron-emission tomography

Introduction

Brown fat is abundant in infants to regulate body temperature without shivering but diminishes with age. As a result, the proportion of brown fat relative to the total body mass is very small in adults [1, 2]. Cold exposure or food intake can stimulate brown fat, and activated brown fat increases glucose uptake [3]. Uptake of ^{18}F -fluorodeoxyglucose (FDG) by brown fat on ^{18}F -FDG positron emission tomography (PET)

is a common incidental finding [4] and may mimic tumor uptake [5].

We present a case of intense ^{18}F -FDG uptake of brown fat in perirenal as well as supraclavicular and paravertebral areas resulting from an incidental pheochromocytoma.

Case Report

A 53-year-old female was referred to our hospital to evaluate a uterine mass found incidentally during a medical checkup. She was on medication for hypertension and diabetes mellitus. She had no clinically remarkable symptoms or medical history.

An 85-mm-sized lobulated mass involving the uterine body and cervix was observed on pelvic magnetic resonance imaging (MRI) (Fig. 1a). A uterine malignancy could not be excluded completely based on the MRI findings. Therefore, the patient underwent an ^{18}F -FDG PET/CT scan after a 6-h fast. Her blood glucose level prior to injection of ^{18}F -FDG was 8.5 mmol/l, and her lean body mass was 35 kg (80 %). At the time of ^{18}F -FDG injection, the outdoor temperature was 14.7 °C and the room temperature was 26.8 °C. She was provided with a warming blanket in the injection room. The PET/CT scan was performed 60 min after intravenous injection of 370 MBq ^{18}F -FDG. Non-enhanced CT was performed for attenuation correction, and a subsequent emission scan was performed from the skull base to the proximal thigh. The uterine mass showed homogeneous mild ^{18}F -FDG uptake with a maximum SUV of 1.9, suggesting a leiomyoma rather than a uterine malignancy (Fig. 1b).

In addition to the uterine mass, there was symmetric multifocal increased ^{18}F -FDG uptake with a maximum SUV up to 11.7 in supraclavicular, paravertebral, and perirenal fat tissue (Fig. 2). In addition, a 65-mm-sized heterogeneous hypermetabolic mass with a maximum SUV of 9.3 was detected in the

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Fig. 1 T1-weighted transaxial MR image (a) shows an 85-mm-sized mass with low signal intensity involving the uterine body and cervix. Fused transaxial ^{18}F -FDG PET/CT image (b) shows mild homogeneous uptake into the uterine mass

left adrenal gland, which could not be excluded as an adrenal malignancy. To characterize the left adrenal mass, conventional contrast-enhanced abdominopelvic CT was performed, and a 65-mm-sized heterogeneously enhancing mass with an intramural cyst was detected in the left adrenal gland. A 24-h urine sample was collected under suspicion of a pheochromocytoma. The analysis revealed elevated vanillylmandelic acid [65.36 mg/day (normal, < 8 mg/day)], total metanephrine [4.87 mg/day (normal, < 0.8 mg/day)], and epinephrine [3,708.50 $\mu\text{g/day}$ (normal, < 80 $\mu\text{g/day}$)].

The patient underwent a left adrenalectomy and total hysterectomy on the same day. The left adrenal mass was histologically confirmed as a pheochromocytoma, and the uterine mass was confirmed as a uterine leiomyoma. In addition,

brown fat was identified in the perirenal tissue adjacent to the left adrenal mass (Fig. 3).

Discussion

Increased ^{18}F -FDG uptake originating from physiological activation of brown fat is usually located in the neck, shoulder, and supraclavicular areas [6]. In the present case, diffuse ^{18}F -FDG uptake was identified in the bilateral perirenal area and was probably related to the pheochromocytoma.

Physiological activation of brown fat due to cold exposure or food intake has been reported in adults [3]. Brown fat is rich in adrenergic receptors, and catecholamines increase glucose

Fig. 2 Maximum-intensity projection image of ^{18}F -FDG PET (a) shows symmetrical uptake in perirenal (*long arrows*) and paravertebral areas (*short arrows*) as well as intense uptake into the left adrenal gland (*arrowhead*). Fused transaxial ^{18}F -FDG PET/CT image (b) shows intense uptake into the left adrenal gland (*arrowhead*) and both perirenal fat areas (*long arrows*). Transaxial contrast-enhanced CT image (c) shows a 65-mm-sized heterogeneously enhanced mass with an intramural cyst in the left adrenal gland (*arrowhead*)

Fig. 3 Photomicrograph of the surgical specimen shows the pheochromocytoma and brown fat tissue. The pheochromocytoma is composed of large eosinophilic cells arranged in an alveolar and trabecular pattern with capillaries in between (*long arrow*). Brown fat cells have centrally located nuclei and multivacuolated cytoplasm (*short arrows*) (hematoxylin-eosin stain, original magnification, $\times 400$)

uptake by sympathetic stimulation of brown fat [7]. A relationship between plasma catecholamine levels and brown fat activity has been reported [8]. In the present case, extensive ^{18}F -FDG uptake into brown fat was postulated to have originated from sympathetic stimulation by the pheochromocytoma.

The differential diagnosis of ^{18}F -FDG uptake of brown fat includes a tumor, lymph node, and muscle [5, 9]. The advent of integrated PET/CT has enabled identifying brown fat uptake. Intense FDG uptake corresponding to no soft tissue other than fat can be considered brown fat [10]. The typical location and distribution of brown fat also helps differentiate it from other entities. Brown fat is commonly found in the neck, shoulder, and supraclavicular areas with a bilateral symmetric distribution and it may be found in the mediastinal, paravertebral, axillary, and perirenal areas [6]. In our case, high ^{18}F -FDG uptake of perirenal brown fat may have obscured the left adrenal tumor on ^{18}F -FDG PET/CT.

Pheochromocytoma is an uncommon characteristic catecholamine-secreting neoplasm derived from chromaffin cells [11]. Its annual prevalence is about 1–2 per 100,000 adults [12]. Excessive release of catecholamines can cause clinical symptoms such as hypertension, headache, palpitations, and diaphoresis [11]. In our case, the hypertension may have been related to the pheochromocytoma. About 10 % of pheochromocytomas are incidentally discovered on CT or MRI [13]. A biochemical diagnosis of pheochromocytoma is established by increased levels of catecholamines and their metabolites in a 24-h urine specimen [14].

Pheochromocytoma has been reported to be a cause of ^{18}F -FDG uptake into brown fat, and extensive ^{18}F -FDG uptake into perirenal brown fat has also been reported [15–18]. To our knowledge, however, there is no report about the difference in

SUV between brown fat with pheochromocytoma and brown fat without pheochromocytoma. In our case, low body weight, female sex, and low outdoor temperature could be prevalent factors causing increased ^{18}F -FDG uptake of brown fat [1]. Nevertheless, because the incidence of increased ^{18}F -FDG uptake into perirenal brown fat is much lower than that into supradiaphragmatic brown fat [18], it is highly possible that combined pheochromocytoma induced intense ^{18}F -FDG uptake into perirenal brown fat in our case.

In summary, we report a case of intense ^{18}F -FDG uptake in bilateral perirenal as well as supraclavicular and paravertebral fat tissue resulting from an incidental pheochromocytoma. A pheochromocytoma should be considered a cause of increased ^{18}F -FDG uptake into perirenal brown fat.

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Conflict of Interest Jihyun Park, Byung Hyun Byun, Chang Won Jung, Hansol Moon, Kyoung Jin Chang, Ilhan Lim, Byung Il Kim, Chang Woon Choi, and Sang Moo Lim declare that they have no conflict of interest.

Ethics Statement This study was approved by the Institutional Review Board at Korea Cancer Center Hospital (IRB no. K-1402-002-030) and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Acquisition of informed consent was exempted by the board because of the retrospective nature of the study. Details that might disclose the identity of the subjects were omitted.

References

1. Nedergaard J, Bengtsson T, Cannon B. Unexpected evidence for active brown adipose tissue in adult humans. *Am J Physiol Endocrinol Metab*. 2007;293(2):E444–52.
2. Cannon B, Nedergaard J. Brown adipose tissue: function and physiological significance. *Physiol Rev*. 2004;84(1):277–359.
3. Del Mar Gonzalez-Barroso M, Ricquier D, Cassard-Doulcier AM. The human uncoupling protein-1 gene (UCP1): present status and perspectives in obesity research. *Obes Rev*. 2000;1(2):61–72.
4. Yeung HW, Grewal RK, Gonen M, Schoder H, Larson SM. Patterns of (^{18}F) -FDG uptake in adipose tissue and muscle: a potential source of false-positives for PET. *J Nucl Med*. 2003;44(11):1789–96.
5. Cohade C, Osman M, Pannu HK, Wahl RL. Uptake in supraclavicular area fat (“USA-Fat”): description on ^{18}F -FDG PET/CT. *J Nucl Med*. 2003;44(2):170–6.
6. Hany TF, Gharehpapagh E, Kamel EM, Buck A, Himms-Hagen J, von Schulthess GK. Brown adipose tissue: a factor to consider in symmetrical tracer uptake in the neck and upper chest region. *Eur J Nucl Med Mol Imaging*. 2002;29(10):1393–8.
7. Chernogubova E, Cannon B, Bengtsson T. Norepinephrine increases glucose transport in brown adipocytes via β 3-adrenoceptors through a cAMP, PKA, and PI3-kinase-dependent pathway stimulating conventional and novel PKCs. *Endocrinology*. 2004;145(1):269–80.
8. Wang Q, Zhang M, Ning G, Gu W, Su T, Xu M, et al. Brown adipose tissue in humans is activated by elevated plasma catecholamines

- levels and is inversely related to central obesity. *PLoS One*. 2011;6(6):e21006.
9. Rosenbaum SJ, Lind T, Antoch G, Bockisch A. False-positive FDG PET uptake—the role of PET/CT. *Eur Radiol*. 2006;16(5):1054–65.
 10. Liu Y, Ghesani NV, Zuckier LS. Physiology and pathophysiology of incidental findings detected on FDG-PET scintigraphy. *Semin Nucl Med*. 2010;40(4):294–315.
 11. Bravo EL, Tagle R. Pheochromocytoma: state-of-the-art and future prospects. *Endocr Rev*. 2003;24(4):539–53.
 12. Johnson ER, Jones MD, Stewart JN. Occurrence of a pheochromocytoma after ingestion of imipramine. *J Am Osteopath Assoc*. 1979;78(5):332–5.
 13. Kudva YC, Young Jr WF, Thompson GB, Grant CS, van Heerden JA. Adrenal incidentaloma: an important component of the clinical presentation spectrum of benign sporadic adrenal pheochromocytoma. *Endocrinologist*. 1999;9(2):77–80.
 14. Lenders JW, Pacak K, Walther MM, Linehan WM, Mannelli M, Friberg P, et al. Biochemical diagnosis of pheochromocytoma: which test is best? *JAMA*. 2002;287(11):1427–34.
 15. Iyer RB, Guo CC, Perrier N. Adrenal pheochromocytoma with surrounding brown fat stimulation. *AJR Am J Roentgenol*. 2009;192(1):300–1.
 16. Kuji I, Imabayashi E, Minagawa A, Matsuda H, Miyauchi T. Brown adipose tissue demonstrating intense FDG uptake in a patient with mediastinal pheochromocytoma. *Ann Nucl Med*. 2008;22(3):231–5.
 17. Yamaga LY, Thom AF, Wagner J, Baroni RH, Hidal JT, Funari MG. The effect of catecholamines on the glucose uptake in brown adipose tissue demonstrated by (18)F-FDG PET/CT in a patient with adrenal pheochromocytoma. *Eur J Nucl Med Mol Imaging*. 2008;35(2):446–7.
 18. Cohade C. Altered biodistribution on FDG-PET with emphasis on brown fat and insulin effect. *Semin Nucl Med*. 2010;40(4):283–93.