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Brown adipose tissue: Evaluation with ^{201}Tl and ^{99m}Tc-sestamibi dual-tracer SPECT

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Brown adipose tissue is one kind of adipose tissue and regulates body temperature and balance of energy via non-shivering thermogenesis. The authors present a case that strongly suggested the presence of activated brown adipose tissue in the neck, shoulders and axillary space by increased ^{18}F-FDG uptake. ^{99m}Tc-sestamibi and ^{201}Tl dual-tracer SPECT study showed increased ^{99m}Tc-sestamibi uptake and non-increased ^{201}Tl uptake in the corresponding ^{18}F-FDG uptake sites. Brown adipose tissue has dense mitochondria in the cells, which play an important role in thermogenesis. ^{99m}Tc-sestamibi uptake and retention depend on the mitochondrial activity but ^{201}Tl uptake does not. Therefore, the activity of mitochondria in activated brown adipose tissue may explain the discrepant uptake between ^{99m}Tc-sestamibi and ^{201}Tl.

Key words: brown adipose tissue, ^{18}F-FDG, ^{201}Tl, ^{99m}Tc-MIBI, PET

INTRODUCTION

BROWN ADIPOSE TISSUE has a unique ability to generate heat with non-shivering process for thermoregulation and utilization of excess caloric intake.[1] The heat generation is related to the metabolism of the mitochondria that have a specific carrier called uncoupling protein. It produces heat without subsequent production of ATP.[2,3] The tissue is locates mainly in the supraclavicular area, comprising up to 5% of body weight in newborns. It gradually diminishes with age but persistently exists in some adult humans.[1]

Recently some studies have reported the uptake of ^{18}F-FDG,[4–7] ^{123}I-MIBG[8] and ^{99m}Tc-tetrofosmin[9] in bilateral neck and shoulders indicating the presence of activated adipose tissue. We report findings with dual tracer SPECT with ^{201}Tl and ^{99m}Tc-sestamibi in a patient showing ^{18}F-FDG uptake in bilateral neck and shoulder fat tissue leadings to suspect the presence of activated brown adipose tissue and discuss the mechanism of these tracer uptake.

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CASE REPORT

A 25-year-old women underwent total thyroidectomy and cervical lymph node dissection for papillary adenocarcinoma. Because the increase of serum thyrogloblin persisted after the operation, ^{18}F-FDG PET was performed for the survey of metastatic lesions. Tomographic data acquisition was performed 90 minutes after intravenous injection of 370 MBq of ^{18}F-FDG with a PET scanner (Accel; Siemens). PET images were fused with those of X-ray CT using fusion software (eNTEGRA; General Electric Medical Systems). PET image delineated intense FDG accumulation bilaterally in the neck, supraclavicular region, and axillae (Fig. 1A, B). Fusion images confirmed that the uptake was located in the fatty tissue, not in the muscle (Fig. 1C). These findings strongly suggested the presence of activated brown adipose tissue, as verified in previous reports.[4–7] Dual-tracer SPECT with ^{201}Tl and ^{99m}Tc-sestamibi was also performed at 30

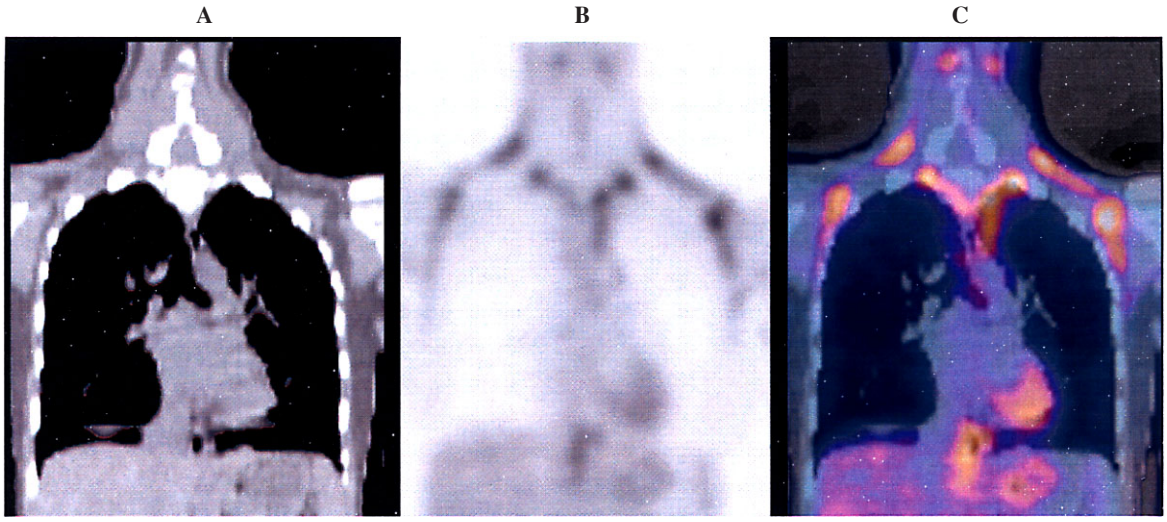

Fig. 1 Coronal slices of x-ray CT (A), ^{18}F-FDG PET (B) and PET/CT fusion image (C). ^{18}F-FDG PET image shows increased ^{18}F-FDG uptake in bilateral supraclavicular and axillary regions. The PET/CT image indicates that the uptake is located in the fat tissue but not in the muscle.

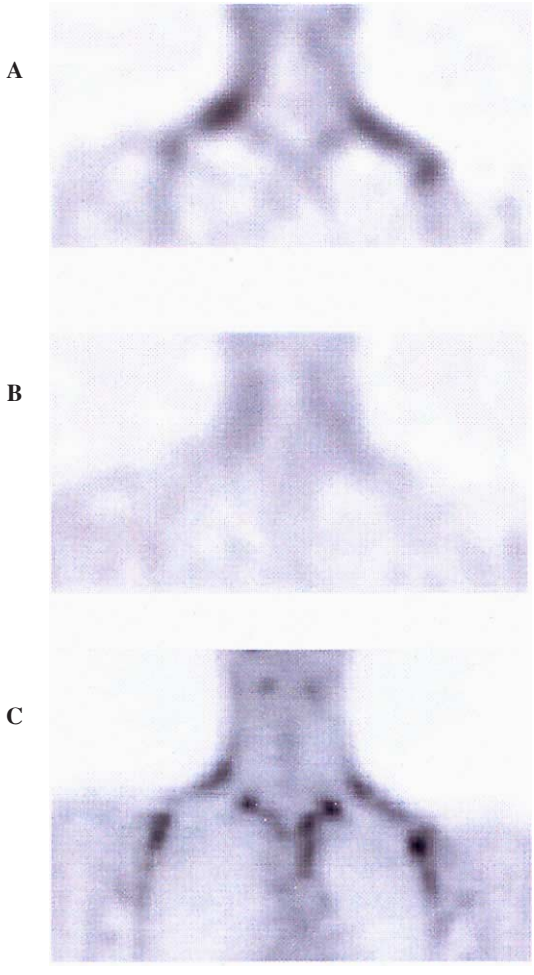

Fig. 2 Coronal slices of Tc-sestamibi SPECT (A), ^{201}Tl SPECT (B) and ^{18}F-FDG PET (C). Tc-sestamibi uptake is demonstrated in the area corresponding to ^{18}F-FDG uptake. On the other hand, there is no appreciable ^{201}Tl there.

minutes after intravenous injection of ^{201}Tl (74 MBq) and ^{99m}Tc-sestamibi (740 MBq) using a three-headed gamma camera system (9300A; Toshiba Medical). The images showed intense ^{99m}Tc-sestamibi uptake in the corresponding areas to the ^{18}F-FDG uptake (Fig. 2A, C). In contrast, ^{201}Tl uptake was not apparent (Fig. 2B, C).

DISCUSSION

Adipose tissue is found in two different forms, namely white adipose tissue and brown adipose tissue.[1] White adipose tissue serves to promote heat retention and as a source of energy. Brown adipose tissue is important for regulating body temperature via non-shivering thermogenesis especially in neonates.[1–3] The mechanism of heat generation is related to the metabolism of the mitochondria, and the generated heat is delivered through the blood. Brown adipose tissue is characterized by abundant vasculature and cells packed densely with mitochondria.[1–3]

Several reports have described the increased ^{18}F-FDG uptake in bilateral neck and shoulder fat tissue. Brown adipose tissue is located mainly in these regions, and the incidence of the ^{18}F-FDG uptake clearly increases in winter. These findings may be well explained by the uptake in active brown adipose tissue.[4–7] Brown adipose tissue extensively utilizes glucose,[1] which is stimulated during active thermogenesis.

^{201}Tl is handled similarly to potassium and is transported into cells by the active transport system involving the Na^+-K^+ ATPase pump system in cell membranes.[10] In contrast, ^{99m}Tc-sestamibi goes through the cell membrane by passive diffusion and is retained in cells where it is mainly associated with mitochondria.[11–13] Our

reported case showed the increased uptake of ^{99m}Tc-sestamibi in the activated brown adipose tissue and discrepant negative findings of ^{201}Tl uptake. The abundant blood flow and the dense high activated mitochondria in brown adipose cells may play a role in increased ^{99m}Tc-sestamibi uptake.

Recently, Fukuchi et al.[9] reported the increased uptake of ^{99m}Tc-tetrofosmin in brown adipose tissue in pediatric patients. They also mentioned that the uptake might explain not only perfusion increased but also mitochondrial density and function in brown adipose tissue. Although only part of ^{99m}Tc-tetrofosmin uptake is mediated by the active transport process,[11] mitochondrial function is important for the uptake and retention of both ^{99m}Tc-tetrofosmin and ^{99m}Tc-sestamibi.

In summary, this case showed positive uptake of ^{99m}Tc-sestamibi and negative uptake of ^{201}Tl in active brown adipose tissue. The uptake of ^{99m}Tc-sestamibi may reflect mitochondrial activity in brown adipose tissue.

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