

# Brown fat uptake of $^{18}\text{F}$ -FDG on dual time point PET/CT imaging

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## ABSTRACT

The aim of this report was to assess the changes in the  $^{18}\text{F}$ -fluorodeoxyglucose ( $^{18}\text{F}$ -FDG) uptake of brown fats on integrated positron emission tomography/computed tomography (PET/CT) imaging. The patient presented with an enlargement of the neck lymph nodes, and was suspicious for tuberculous lymphadenitis. A whole body PET/CT imaging was performed, followed by a delayed imaging of the neck and thoracic regions. A visually increased  $^{18}\text{F}$ -FDG uptake was taken as a positive finding. A semi-quantitative evaluation was performed using a maximum standardised uptake value (SUVmax) with a cut-off value above 2.5. There were a number of  $^{18}\text{F}$ -FDG avid activity areas seen at the supraclavicular, mediastinal, paravertebral and perirenal regions. These are in keeping with the physiological  $^{18}\text{F}$ -FDG uptake in brown fat. The differences in SUVmax between the two scans ranged from -20 percent to +20 percent. Based on our observation, dual time point imaging may not be a reliable method for assessing the  $^{18}\text{F}$ -FDG uptake of brown fat.

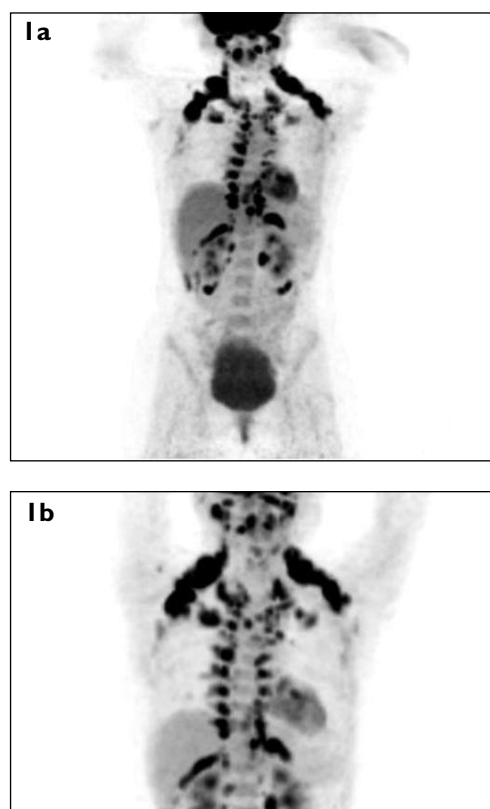
**Keywords:** brown fat, dual time point imaging,  $^{18}\text{F}$ -FDG, PET/CT

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## INTRODUCTION

In the last two decades, it was believed that the uptake of  $^{18}\text{F}$ -fluorodeoxyglucose ( $^{18}\text{F}$ -FDG) in the neck and shoulder regions was caused by muscle uptake. However, this issue was resolved after the introduction of fusion physiological and morphological imaging modalities, namely positron emission tomography/computed tomography (PET/CT), which clearly showed that the uptake was of brown fat.<sup>(1-4)</sup>

Human adipose tissue can be divided into two types, white fat and brown fat. White fat mainly serves to protect the body parts, while the main function of brown fat is heat generation. Brown fat has a high density of mitochondria in the fat cells and is rich in vascularisation. These features are responsible for the brownish colour



**Fig. 1** (a) Multi-imaging planar (MIP) image shows the initial whole body PET/CT imaging. (b) MIP of the second PET/CT imaging (limited from the base of the skull to the upper abdominal region and covering the whole liver) shows the distribution of high  $^{18}\text{F}$ -FDG uptake of brown fats.

of brown fat. Brown fat can be named according to its location: supraclavicular, mediastinal, paravertebral and perirenal. Supraclavicular fat can extend from the neck inferiorly to the shoulders, and sometimes, to the axillae. Mediastinal fat exists in small pockets that are linked with all the structures of the mediastinum. Paravertebral brown fat runs parallel to the thoracic vertebrae on either side of the spinal column and extends into the intercostal spaces. Perirenal fat tends to be concentrated on the top of the kidneys at the location of the adrenal glands.

The biological mechanism for the accumulation of  $^{18}\text{F}$ -FDG uptake in brown fat is well established.<sup>(1,5)</sup> Previous studies have mainly focused on supraclavicular brown fat,<sup>(1,2,6,7)</sup> whereas the other areas of brown fat have been under-reported. It is important for physicians to recognise these normal variants of  $^{18}\text{F}$ -FDG uptake

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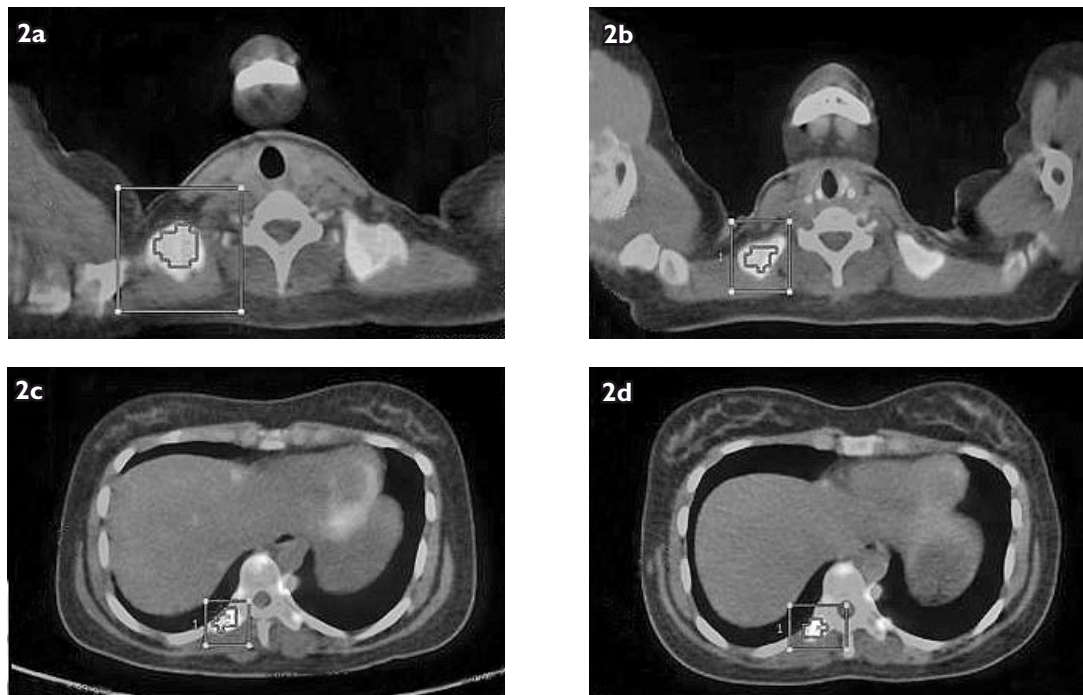
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**Fig. 2** Image acquisitions of  $^{18}\text{F}$ -FDG PET/CT show (a & b) an increase in the SUVmax values of the right supraclavicular brown fat from 17.6 on the initial scan to 20.1 on the delayed scan and (c & d) a decrease in the SUVmax values of the right paravertebral brown fat from 13.9 to 11.7.

in brown fat, so that they are not misinterpreted as a significant pathologic state. To the authors' knowledge, dual time point imaging (DTPI) using  $^{18}\text{F}$ -FDG PET/CT on brown fat, especially for the mediastinal and perirenal areas, has not been previously described.

### CASE REPORT

A 25-year-old Malay woman presented with a history of left lateral neck swelling for several weeks. There were no general symptoms of tuberculosis (TB) infection such as cough, low grade fever, night sweat or loss of weight. The patient had a family history of TB infection, and her sister had been diagnosed with pulmonary tuberculosis (PTB) infection seven months ago. The patient was screened for TB infection through blood investigation, sputum test and acid fast bacilli, but the results were negative. The aspiration of the swollen neck lymph node suggested a reactive node. The patient underwent a whole body PET/CT examination to assess the extension of the lesion.

A DTPI approach was applied during the scanning session. All imaging studies were performed on a dual-modality PET/CT system (Biograph 6, Siemens Medical Solutions Inc, Hoffman Estates, IL, USA). PET/CT imaging was started 46 minutes after an intravenous injection of 368.3 MBq of  $^{18}\text{F}$ -FDG. The total acquisition time for the initial whole body PET/CT was about 25 minutes. Using the same parameters, a delayed

PET/CT imaging was obtained about 121 minutes after the  $^{18}\text{F}$ -FDG injection (time interval between the first and second imaging was about 75 minutes), and it was limited to the neck, thorax and upper abdomen regions, covering the whole liver (Fig. 1).

In this case, a semi-quantitative evaluation method using the maximum standardised uptake value (SUVmax) was applied to evaluate the imaging findings. Inconsistencies in measurement were observed in the SUVmax values of the brown fat at different locations between the initial and delayed images. The initial SUVmax1 measured along the right and left supraclavicular, mediastinal, right and left paravertebral as well as the right and left perirenal were 17.6, 18.9, 7.0, 13.9, 7.4, 10.4 and 20.8, respectively. In the delayed imaging, the SUVmax2 of the mediastinal, right paravertebral and left perirenal declined to 5.6, 11.7 and 18.5, respectively, whereas the rest showed an increment (Fig. 2). The differences in SUVmax between the two readings, expressed as  $\Delta\%$ SUVmax, ranged from approximately  $-20\%$  to  $+20\%$  (Table I).

### DISCUSSION

Brown fat can lead to false positive interpretations for PET imaging. The aim of this report is to demonstrate the imaging characteristics of brown fat on  $^{18}\text{F}$ -FDG PET/CT, as described by several other studies.<sup>(1-4,6,8)</sup> It is well known that brown fat mainly functions in non-shivering

**Table I. The SUVmax and  $\Delta$ %SUVmax values of the different areas of brown fat.**

Area of brown fat	SUVmax 1 <sup>a</sup>	SUVmax 2 <sup>b</sup>	$\Delta$ %SUVmax <sup>c</sup>
Right supraclavicular	17.60	20.10	14.20
Left supraclavicular	18.90	22.70	20.11
Mediastinal	7.00	5.60	-20.00
Right paravertebral	13.90	11.70	-15.83
Left paravertebral	7.40	7.80	5.41
Right perirenal	10.40	11.20	7.69
Left perirenal	20.80	18.50	-11.06

SUVmax: maximum standardised uptake value

<sup>a</sup> Maximum SUV derived from first PET/CT imaging acquisition.

<sup>b</sup> Maximum SUV derived from second PET/CT imaging acquisition.

<sup>c</sup> The percentage differences in maximum SUV.

thermogenesis by stimulating the sympathetic nerve system, which can cause a significant increase of glucose uptake in brown fat.<sup>(9)</sup> The amount of glucose uptake in brown fat has been shown to be closely correlated with gender,<sup>(9,10)</sup> age,<sup>(9)</sup> cold exposure<sup>(2)</sup> and medications.<sup>(10,11)</sup>

The <sup>18</sup>F-FDG SUVs in our patient were in the range of those reported by Yeung et al.<sup>(3)</sup> and Hadi et al.<sup>(8)</sup> The four main areas of brown fat appearance on the <sup>18</sup>F-FDG PET/CT were highlighted and the SUVmax changes during DTPI protocol were observed. In our case, there were remarkable reductions in the SUVmax values between the two time points ( $\Delta$ %SUVmax), which can be seen clearly in the brown fat located at the mediastinal, paravertebral and perirenal areas, while the rests of the values showed a 5%–20% increment. No specific pattern was observed in the changes from either side of the body.

The inconsistent uptake of <sup>18</sup>F-FDG on DTPI protocol in our patient is similar to that in previous reports,<sup>(7,12)</sup> except that in our patient, premedications, such as muscle relaxants, were not prescribed prior to the examination, unlike in the other studies.<sup>(7,10)</sup> The patient's comfort was ensured by providing a warm blanket and maintaining a pleasant room temperature. In view of the heavy patient workflow in the department, we selected a two-hour interval for our second time point of imaging, as recommended in previous studies.<sup>(13,14)</sup>

In conclusion, based on our limited observation and in view of the inconsistent SUV changes in brown fat glucose uptake with time, DTPI protocol may not be a useful method for improving the diagnostic value of <sup>18</sup>F-FDG PET/CT examination at this point. In order to have a constructive understanding of the <sup>18</sup>F-FDG uptake of brown fat in DTPI imaging, further investigations with a larger group of patients are warranted.

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