



Prognostic Significance of the Imaging Parameters of Adipose Tissue and Bone Marrow on F-18 Fluorodeoxyglucose PET/CT in Patients with Malignant Melanoma

악성 흑색종 환자에서 시행한 F-18 Fluorodeoxyglucose PET/CT의 지방 조직 및 골수의 영상 파라미터들이 예후에 미치는 영향 평가

Ju Ha Lee, MD¹ , Sang Mi Lee, MD^{2*} , Jung Eun Kim, MD³ 

Departments of ¹Radiology, ²Nuclear Medicine, ³Dermatology, Soonchunhyang University Cheonan Hospital, Cheonan, Korea

Purpose Fluorodeoxyglucose (FDG) uptake of bone marrow (BM) and adipose tissue is known to reflect systemic inflammatory response to cancer cell. The objective of this study was to evaluate the prognostic value of F-18 FDG uptake of BM and determine characteristics of visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) on PET/CT images in malignant melanoma.

Materials and Methods We retrospectively reviewed 33 patients histopathologically diagnosed with malignant melanoma via FDG PET/CT staging. BM-to-liver uptake ratio (BLR), volume of VAT and SAT, CT Hounsfield unit (HU), and mean of standardized uptake value (SUVmean) of VAT and SAT on PET/CT were measured and prognostic values of these parameters for prediction of disease progression-free survival (DPFS) were evaluated.

Results Patients with stage III-IV melanoma had higher CT HU and SUVmean for SAT and VAT but lower volume of VAT compared with patients at stage I-II ($p < 0.05$). Survival analysis, patients with high CT HU of VAT and SAT, high SUVmean of VAT and SAT, and high BLR showed worse DPFS (all $p < 0.05$), indicating significant association. However, volume of SAT or VAT failed to show significant association with DPFS ($p > 0.05$).

Conclusion CT HU, SUVmean of SAT and VAT, and BLR provide prognostic information for DPFS in malignant melanoma.

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*Corresponding author

Sang Mi Lee, MD

Department of Nuclear Medicine,

Soonchunhyang Univeristy

Cheonan Hospital,

44 Suncheonhyang 4-gil,

Dongnam-gu, Cheonan 31151,

Korea.

Tel 82-41-570-3540

Fax 82-41-572-4655

E-mail gareen@naver.com

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ORCID iDs

Ju Ha Lee 

[https://](https://orcid.org/0000-0002-8727-9053)

orcid.org/0000-0002-8727-9053

Sang Mi Lee 

[https://](https://orcid.org/0000-0002-7943-3807)

orcid.org/0000-0002-7943-3807

Jung Eun Kim 

[https://](https://orcid.org/0000-0002-8399-8456)

orcid.org/0000-0002-8399-8456

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INTRODUCTION

Malignant melanoma, one of the most lethal malignancies in humans, is responsible for 60–80% of deaths caused by skin cancers (1). It originates from pigment-producing cells known as melanocytes that are mainly found in the skin, although they are also found in the ear, gastrointestinal tract, eye, oral and genital mucosa, and leptomeninges (2). Because the prognosis of melanoma depends on the presence and extent of metastatic lesions as well as histology of the primary tumor, imaging studies using radiographic and nuclear medicine techniques are important in evaluating malignant melanoma (3).

Recently, a number of studies have reported that inflammation is associated with the initiation and progression of cancer (4-6). Several studies have shown that serum markers of systemic inflammatory response such as C-reactive protein (CRP) and neutrophil-to-lymphocyte ratio (NLR) are correlated with the prognosis of patients with various carcinomas (4-6). Furthermore, in obese subjects, adipocytes secrete adipokines and proinflammatory cytokines that induce tumor formation in the tumor microenvironment (7). Therefore, obesity can cause low-grade chronic systemic inflammation known to be associated with carcinogenesis and clinical outcomes of various carcinomas (8-10). Although the degree of standardized uptake value (SUV) of bone marrow (BM) might be affected by the presence of micrometastasis of cancer cells and red BM hyperplasia, SUV of BM mainly reflects glucose metabolism in immune cells, and increased SUV of BM in patients with malignancy is attributed to systemic inflammatory response to cancer (11-13). Furthermore, CT Hounsfield unit (HU) and SUV of adipose tissue are correlated with immune reaction in adipose tissue and clinical outcomes (14).

Considering that the prognosis of malignant melanoma has significant associations with systemic inflammatory response (15, 16) and obesity (17-19), imaging parameters of BM and adipose tissue on PET/CT might have prognostic significance in patients with malignant melanoma. Although fluorodeoxyglucose (FDG) PET/CT has long been used for staging, assessment of treatment response, and prognosis of malignant melanoma (20-22), no studies have evaluated the association of clinical prognostic outcomes with PET/CT parameters of BM and adipose tissue using FDG PET/CT. Therefore, the objective of this study was to determine the association of SUV of BM and PET/CT parameters of subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) (including volume of SAT and VAT, CT HU and SUV of SAT and VAT) with disease progression-free survival (DPFS) in patients with malignant melanoma.

MATERIALS AND METHODS

SUBJECTS

This study was approved by the Institutional Review Board of our medical center, and the requirement to obtain informed consent was waived by the board due to its retrospective na-

ture (IRB No. 2019-02-012). We retrospectively reviewed medical records of all patients diagnosed with malignant melanoma in our institution. A total of 33 patients who were histopathologically diagnosed with malignant melanoma and staged with FDG PET/CT were enrolled in the present study. Exclusion criteria were: 1) patients who had received only supportive care without any curative or palliative treatment after staging, 2) those who had a history of other malignancies or BM disease, 3) those who had a history of major abdominal surgery which affected abdominal fat distribution, and 4) those who had active systemic inflammatory or infectious disease at the time of PET/CT scanning. All patients included in this study underwent blood tests, chest CT, bone scintigraphy, FDG PET/CT, and MRI before the start of treatment. Staging for malignant melanoma was based on the 7th edition of the American Joint Committee on Cancer TNM Staging System Guideline. Clinico-demographic data and clinical outcome results were retrospectively reviewed from medical records of enrolled patients. Body mass index (BMI) was calculated for each patient based on the height and body weight of the patient at the time of diagnosis.

FDG PET/CT

All subjects were fasted for at least 8 hours prior to intravenous injection of FDG. Prior to FDG injection, blood glucose levels were evaluated to determine if blood glucose level was < 200 mg/dL. PET/CT images were obtained from the skull to the proximal thigh using a dedicated scanner (Biograph mCT 128; Siemens Healthcare, Knoxville, TN, USA) within 1 hour after FDG injection (4.07 MBq/kg). Initially, CT scan for HU correction was performed without contrast enhancement using a standard protocol: 65 mAs, 120 kVp, automatic dose modulation, 1.0 mm pitch, 5 mm slice thickness. Afterwards, PET scanning was performed for 1.5 minutes per bed position in three-dimensional acquisition mode. PET images were reconstructed using maximization of ordered-subset expectations algorithm aligned with time-of-flight mode and HU correction.

PET/CT IMAGE ANALYSIS

All PET/CT images were retrospectively evaluated using the US Food and Drug Administration approved DICOM viewer of Osirix MD software (Pixmeo, Bernex, Switzerland) according to the method described in previous studies (23). SUV was calculated based on the patient's body weight. Volume of interest (VOI) was drawn for the primary tumor and the highest SUV of the primary tumor (SUV_{tumor}) was measured. Afterwards, adipose tissue parameters (volume, CT HU, and mean SUV of SAT and VAT) and SUV of BM were measured. VAT and SAT volumes in CT images were measured with three consecutive slices at the level of L4/L5 intervertebral space. Adipose tissue was defined as areas with CT HU ranging from -200 to -50 in CT images. The volume and CT HU were automatically calculated in units of cm³ and HU, respectively. SAT was defined as extraperitoneal fat tissue between skin and muscle while VAT was defined as intraabdominal fat tissue. SUV_{mean} of both SAT and VAT were calculated from PET images using the same areas of the adipose tissue on CT images. For measuring the SUV of adipose tissue, SUV_{mean} was calculated after removing physiologic uptake in bowel, urine. An example of the measurement is shown in Fig. 1.

SUV of BM was measured by plotting VOI on vertebral bodies of at least five vertebrae from

thoracic and lumbar spines (Fig. 2). For measuring an average SUV of each drawn VOI, an automatic isocontour set at 75% of the maximum SUV was used. This 75% cut-off value has shown good reproducibility between subjects for measuring SUV of BM (11). The average of each SUV obtained from five vertebrae was calculated and defined as SUV_{mean} of BM (BM SUV_{mean}). We then calculated the SUV of normal liver tissue to measure BM-to-liver uptake ratio (BLR) of SUV. The SUV_{mean} in the normal liver was measured by drawing three 1 cm-sized VOIs in the liver, two from the right lobe and one from the two left lobes. BLR was then calculated using the BM SUV_{mean} and SUV_{mean} of the liver SUV.

STATISTICAL ANALYSIS

The Mann-Whitney U test was performed to compare variables between groups. The Spearman's rank correlation was performed to evaluate correlations of BM SUV_{mean}, BLR, and adipose tissue parameters with serum inflammatory markers, including serum CRP lev-

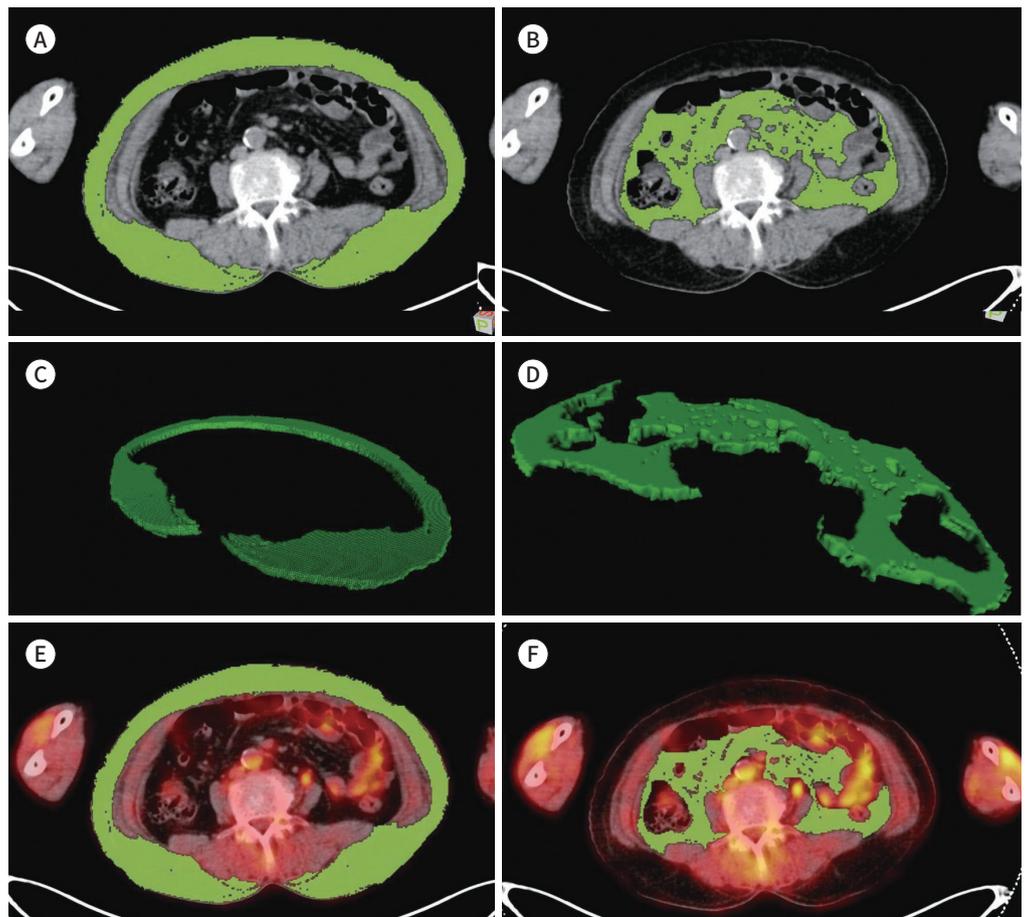
Fig. 1. Example of measurement of adipose tissue.

A, B. On consecutive transaxial CT images at L3/L4 level. The area of adipose tissue was automatically computed using a CT attenuation range from -50 to -200 HU.

C, D. Within the areas of adipose tissue on the 3 images, the volume and mean HU were automatically calculated.

E, F. The areas of adipose tissue on the 3 CT images were then exported to the corresponding fluorodeoxyglucose PET/CT images.

HU = Hounsfield unit



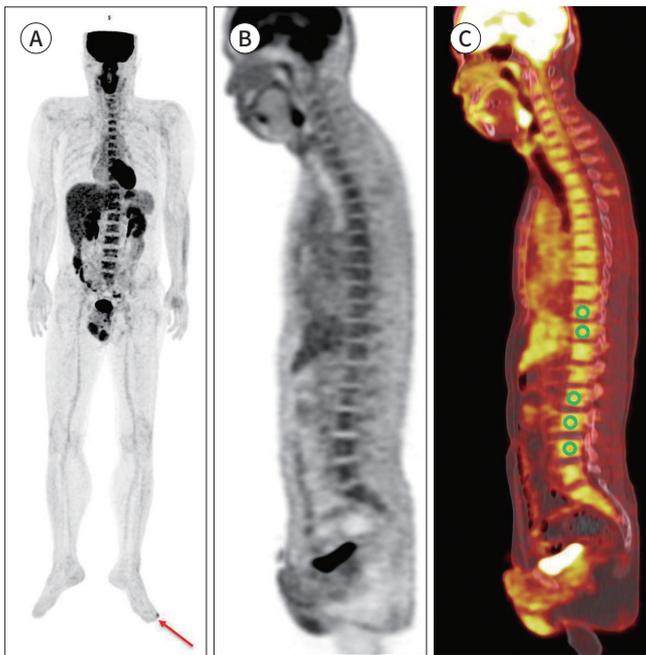


Fig. 2. Example of measurement of bone marrow. Maximum intensity projection (A), sagittal PET (B), and sagittal fused PET/CT images of FDG PET/CT (C). Spheroid-shaped five VOIs were drawn in vertebral bodies of thoracic and lumbar spines, and the average SUV of those VOIs was calculated. Primary malignant lesion was located left toe (arrow). FDG = fluorodeoxyglucose, SUV = standardized uptake value, VOI = volume of interest

el and NLR, SUV_{tumor}. For survival analysis, continuous variables were classified into two groups with specific cut-off values determined by receiver operating characteristic (ROC) curve analysis. The Kaplan-Meier analysis with log-rank test was used to compare DPFS of variables. Fisher's exact test was performed to evaluate the differences in recurrence rate according to stage and SUV_{mean} of adipose tissue. All statistical analyses were performed using MedCalc version 17.5.3 (MedCalc Software bvba, Ostend, Belgium). A *p*-value < 0.05 was considered statistically significant.

RESULTS

PATIENT CHARACTERISTICS

A total of 33 patients with malignant melanoma were enrolled in this study. Characteristics of enrolled patients are summarized in Table 1. The most common site of primary tumor location was the extremity (13/33, 39.4%). The majority of T, N, and M stages were T4 (15 patients), N0 (26 patients), and M0 (30 patients). Sixteen (48.5%) enrolled patients underwent excisional biopsy before FDG PET/CT scan. SUV_{tumor} was measured for the remaining 17 (51.5%) patients. Its median value was 7.30 (range 0.91–13.69). The median follow-up period of these enrolled patients was 14.7 months (range, 3.9–67.7 months). During the follow-up period, 8 (24.24%) patients experienced disease progression.

CORRELATION OF PET/CT PARAMETERS WITH STAGE AND SERUM INFLAMMATORY MARKERS

SUV_{mean} of BM and adipose tissue parameters were compared between patients with stages I–II and stages III–IV to evaluate the relationship between BM and adipose tissue parameters and stage. For adipose tissue parameters of PET/CT, patients with stages III–IV

Table 1. Clinical Characteristics of Enrolled Patients (n = 33)

Characteristics	No. of Patients (%)	Median (Range)
Age, years		69 (60-75)
Sex		
Female	14 (42)	
Male	19 (58)	
Location		
Extremity	13 (39.4)	
Body	11 (33.3)	
Others	9 (27.3)	
T stage		
T1	5 (15.2)	
T2	7 (21.2)	
T3	6 (18.2)	
T4	15 (45.5)	
N stage		
N0	26 (78.8)	
N1	3 (0.1)	
N2	0 (0.00)	
N3	4 (12.1)	
M stage		
M0	30 (90.9)	
M1	5 (15.1)	
TNM stage		
Stage I-II	26 (78.8)	
Stage III-IV	7 (21.2)	
BMI, kg/m ²		24.91 (14.61-32.87)
WBC, × 10 ¹² cells/L		6.04 (4.25-14.17)
Hemoglobin, g/dL		13.40 (8.40-17.70)
NLR		1.97 (0.86-6.25)
CRP, mg/L		1.16 (0.07-70.90)
LDH, IU/L		179.50 (102.00-437.00)
SUVtumor*		7.30 (2.89-24.00)
BM SUVmean		1.70 (1.18-2.50)
BLR		0.73 (0.48-1.34)
SAT		
Volume, cm ³		68.28 (2.07-156.26)
SUVmean		0.35 (0.25-0.53)
HU		-100.85 (-109.39--62.47)
VAT		
Volume, cm ³		42.74 (1.38-113.06)
SUVmean		0.70 (0.49-1.38)
HU		-94.60 (-108.43--78.14)
Treatment		
Operation	28 (84.9)	
Radiation therapy	2 (6.1)	
Target therapy	3 (9.1)	

*Measured in 17 patients.

BLR = BM-to-liver uptake ratio, BM = bone marrow, BMI = body mass index, CRP = C-reactive protein, HU = Hounsfield unit, LDH = lactate dehydrogenase, NLR = neutrophil-to-lymphocyte ratio, SAT = subcutaneous adipose tissue, SUVmean = mean of standardized uptake value, SUVtumor = maximum fluorodeoxyglucose uptake of primary tumor, VAT = visceral adipose tissue, WBC = white blood cell

showed higher HU of SAT (-87.55 vs. -102.51, $p = 0.002$) and VAT (-89.58 vs. -98.99, $p = 0.006$), higher SUVmean of SAT (0.42 vs. 0.33, $p = 0.021$) and VAT (0.79 vs. 0.68, $p = 0.012$), but lower volume of VAT (20.39 vs. 48.10, $p = 0.004$) than those with stages I–II. For BM parameters, both BM SUVmean (1.72 vs. 1.60) and BLR (0.74 vs. 0.72) showed no significant differences between the two groups (both $p > 0.05$).

Relationships of BM SUVmean, BLR, and adipose tissue parameters with serum inflammatory markers including CRP and NLR in enrolled patients were investigated. BLR had significant positive correlation with serum CRP level ($p = 0.049$; $r = 0.368$). However, it had no significant correlation with NLR ($p > 0.05$). BM SUVmean or adipose tissue parameters showed no significant correlation with serum CRP level or NLR ($p > 0.05$).

In correlation analysis of parameters of adipose tissue and BM with SUVtumor, none of the CT HU and SUVmean of adipose tissue parameters, BM SUVmean, and BLR showed significant association with SUVtumor ($p > 0.05$).

SURVIVAL ANALYSIS FOR DPFS

Predictive values of clinical factors and FDG PET/CT parameters for DPFS were assessed. Using ROC curve analysis, optimal cut-off values for NLR, CRP, BM SUVmean, BLR, SAT volume, SAT SUVmean, VAT volume, VAT SUVmean, SAT HU, and VAT HU were determined to be 2.5, 5 mg/dL, 1.73, 0.63, 90.00 cm³, 0.30, 23.65 cm³, 0.75, -102.15, and -100.00, respectively. On survival analysis with log-rank test, SUVmean of SAT and VAT, CT HU of SAT and VAT, BLR, and TNM stage were significant predictors for DPFS (all $p < 0.05$, Table 2). Patients with low SUVmean and HU of adipose tissue and low BLR had significantly better DPFS than those with high SUVmean and HU of adipose tissue and high BLR (Fig. 3). On the other hand, BMI, location of lesion, BM SUVmean, NLR, SAT volume, and VAT volume had no significant associations with DPFS (all $p > 0.05$) while serum CRP level showed marginal significance ($p = 0.050$). Analysis based on BMI 25 in adipose tissue volume and DPFS, all groups with BMI greater than or less than 25 had no significant associations with DPFS ($p > 0.05$).

We further evaluated the recurrence rates according to the combination of stage and SUVmean of adipose tissue (Table 3). The recurrence rates of patients with stage III–IV and high SUVmean of adipose tissue were up to 50–60%. In contrast, recurrence rates of those with low SUVmean were 0–15.79% irrespective of stage, although there were no statistical significant differences ($p > 0.05$).

DISCUSSION

In the present study, we evaluated the prognostic value of SUVmean of BM and HU and SUVmean of SAT and VAT in patients with malignant melanoma to evaluate whether the degree of inflammatory reaction in BM and adipose tissue had significant associations with clinical outcomes. Our study revealed significant correlation between DPFS and adipose tissue parameters, tumor stage, and BLR. This finding suggests that inflammatory reaction in BM and adipose tissue has significant correlation with tumor characteristics and clinical prognosis in malignant melanoma patients.

SUVmean of BM reflecting the activation of BM has shown significant positive correlation

Table 2. Univariate Analysis of Disease Progression-Free Survival

Variables	p-Value
Location (extremity vs. body vs. others)	0.579
BMI (25 kg/m ²)	0.311
NLR (< 2.50 vs. ≥ 2.50)	0.863
CRP (< 5.00 mg/dL vs. ≥ 5.00 mg/dL)	0.050
BM SUVmean (< 1.73 vs. ≥ 1.73)	0.223
BLR (< 0.63 vs. ≥ 0.63)	0.033
Volume of SAT (< 90.00 cm ³ vs. ≥ 90.00 cm ³)	0.151
SUVmean of SAT (< 0.30 vs. ≥ 0.30)	0.038
HU of SAT (< -102.15 vs. ≥ -102.15)	0.010
Volume of VAT (< 23.65 cm ³ vs. ≥ 23.65 cm ³)	0.214
SUVmean of VAT (< 0.75 vs. ≥ 0.75)	0.041
HU of VAT (< -100.00 vs. ≥ -100.00)	0.045
TNM stage (stage I-II vs. stage III-IV)	0.033
T stage (1-2 vs. 3-4)	0.911
N stage (0 vs. 1)	0.347
M stage (0 vs. 1)	0.297

BLR = BM-to-liver uptake ratio, BM = bone marrow, BMI = body mass index, CRP = C-reactive protein, HU = Hounsfield unit, NLR = neutrophil-to-lymphocyte ratio, SAT = subcutaneous adipose tissue, SUVmean = mean of standardized uptake value, VAT = visceral adipose tissue

with serum inflammatory markers (24, 25). Similarly, patients with lung cancer without BM metastasis showed higher SUVmean of BM than those with benign lung nodules (26). Furthermore, previous studies reported that BM uptake of FDG in patients with various malignancies can be used to predict prognosis, suggesting worse clinical outcomes in patients with high BM uptake (11-13). The present study also indicated that among patients with malignant melanoma, patients with high BLR on staging FDG PET/CT were at high risk of disease progression, supporting the hypothesis that systemic inflammatory response might play an important role in cancer progression (12).

Dysfunction of adipose tissue can trigger inflammatory cytokine secretion that affects systemic inflammatory response in the host and carcinogenesis eventually (27). CT HU of adipose tissue measured by non-enhanced CT reflects the quality of adipose tissue such as inflammatory and fibrotic changes. It is significantly associated with survival and prognosis of patients with malignant disease (28, 29). In a previous study on non-human species, increased CT HU of adipose tissue has been found to be low along with lipid content change and fibrotic change (30). These changes in adipocytes and adipose microenvironment might promote tumor growth (30). Previous studies have shown that CT HU of adipose tissue is associated with the inflammatory status of adipose tissue. It can be used as an indicator of adipose tissue dysfunction (23, 30). Several studies have also reported positive association between the HU of fat tissue and prognosis in variable diseases including pancreatic cancer and sarcoma (28, 31). Similarly, our study showed significant association between HU of fat tissue and prognosis.

Previous study demonstrated that SUV of the tumor and SUVmean of the adipose are in-

Fig. 3. Kaplan-Meier curves for distant progression-free survival according to different parameters: BLR (A), SUV of VAT (B), SUV of SAT (C), HU of VAT (D), HU of SAT (E), and stage (F).

BLR = bone marrow-to-liver uptake ratio, SAT = subcutaneous adipose tissue, SUV = standardized uptake value, HU = Hounsfield unit, VAT = visceral adipose tissue

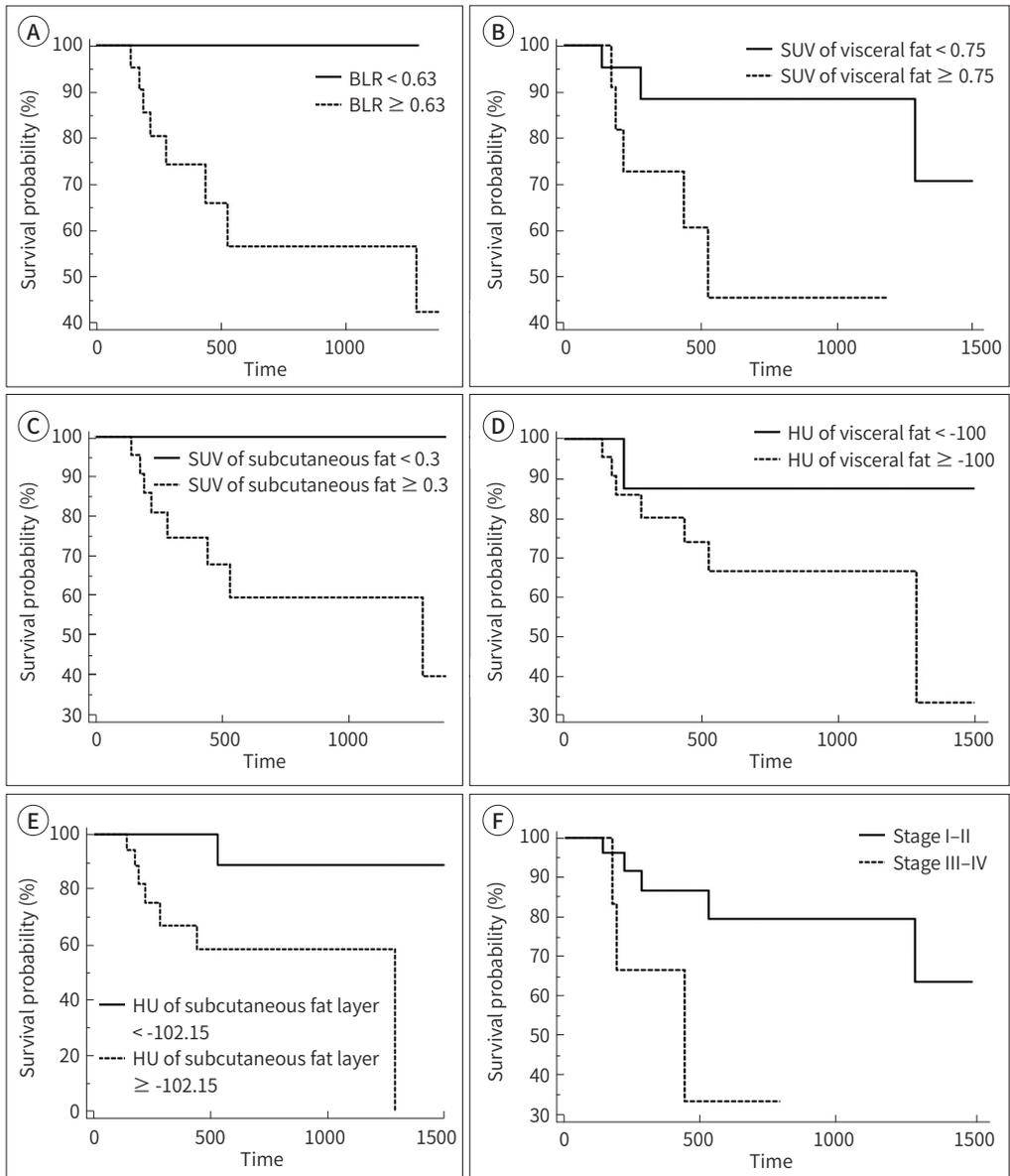


Table 3. Recurrence Rates According to Staging and Fluorodeoxyglucose Uptake of Adipose Tissue

Stage	Stage I, II	Stage III, IV
SUVmean of SAT < 0.30	1/7 (14.29)	0/1 (0)
SUVmean of SAT ≥ 0.30	4/19 (21.05)	3/6 (50)
<i>p</i> -Value	> 0.99	> 0.99
SUVmean of VAT < 0.75	3/19 (15.79)	0/2 (0)
SUVmean of VAT ≥ 0.75	2/7 (28.57)	3/5 (60)
<i>p</i> -Value	0.588	0.429

SAT = subcutaneous adipose tissue, SUVmean = mean of standardized uptake value, VAT = visceral adipose tissue

versely proportional in patients with pancreatic cancer (14). The study speculated that this finding may be due to decreased fatty acid uptake and lipoprotein catabolism of adipose tissue caused by lipoprotein lipase inhibiting substances secreted by tumor cells (14). In contrast, recent studies have reported contradictory results in colorectal cancer and pancreatic cancer (29, 32). Patients with higher CT HU and SUVmean in adipose tissue had significantly lower survival rate and prognosis than patients with lower values. In the present study, SUVmean of adipose tissue in malignant melanoma was also inversely proportional to DPFS. This might be due to the association of SUV and inflammatory change in adipose tissue as described above (23, 30). Along with CRP and adipose tissue parameters, CRP, a serum inflammatory marker, also showed marginal significance in predicting prognosis of patients with malignant melanoma in the present study.

Previous studies reported that obesity was a risk factor for melanoma (19). Inflammatory adipokines and leptin secreted by adipocytes can promote melanoma progression in mice (33). Elevated leptin levels can predict melanoma outside lymph node metastasis (34). Fang et al. (18) have shown that elevated BMI is associated with a risk of disease progression in melanoma. However, BMI cannot represent total body adipose tissue amount because muscle mass also contributes to BMI (35). Therefore, in this study, we measured volumes of SAT and VAT separately and determined the prognostic value of them along with other adipose tissue parameters. However, different from SUVmean and HU of adipose tissue, volumes of VAT and SAT failed to show significance for predicting DPFS. Qualitative characteristics of adipose tissue rather than the amount of adipose tissue might affect the prognosis of patients with malignant melanoma. Further study with more patients is needed to test this possibility.

NLR is also known to be related with systemic inflammatory response and survival in malignant melanoma (36). Nevertheless, NLR failed to show statistical significance in the present study. Considering that serum CRP level had significant correlation with BLR and borderline significance for predicting DPFS, serum CRP level might be more preferable serum inflammatory marker in patients with malignant melanoma. However, because of the small number of enrolled patients in the present study, further validation is warranted.

This study has several limitations. First, the total number of patients included in the study was small, making it impossible to perform multivariate analysis. Secondly, because almost half of the enrolled patients underwent excisional biopsy before PET/CT scan, the relationship between SUV of melanoma and clinical outcome could not be assessed. Finally, because this study retrospectively enrolled a small number of patients who had been referred to a single institution, results need to be validated in a multi-center study with a large pool of population.

In conclusion, CT HU, SUVmean of SAT and VAT, and BLR showed significant association with DPFS. Patients with low HU and SUVmean of SAT and VAT and low BLR showed better survival. Thus, qualitative characteristics of adipose tissue and SUVmean of BM facilitate the prediction of the risk of disease progression in patients with malignant melanoma.

Author Contributions

Conceptualization, L.S.M.; data curation, L.J.H.; formal analysis, L.S.M.; investigation, L.J.H.; methodology, L.S.M.; project administration, K.J.E.; resources, K.J.E.; software, L.S.M.; supervision, L.S.M.; validation, K.J.E.; visualization, L.J.H.; writing—original draft, L.J.H.; and writing—review & editing, L.S.M., K.J.E.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

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악성 흑색종 환자에서 시행한 F-18 Fluorodeoxyglucose PET/CT의 지방 조직 및 골수의 영상 파라미터들이 예후에 미치는 영향 평가

이주하¹ · 이상미^{2*} · 김정은³

목적 골수와 지방 조직의 F-18 Fluorodeoxyglucose (이하 F-18 FDG) 섭취는 악성 종양에 대한 전신 염증을 반영한다고 알려져 있다. 본 연구는 악성 흑색종에서 F-18 FDG PET/CT상 골수의 FDG 섭취와 내장 및 피하 지방 조직의 특성이 가지는 예후적 가치에 대해 평가하였다.

대상과 방법 병리학적으로 악성 흑색종으로 진단받은 환자 중 FDG PET/CT를 시행한 33명의 환자들을 진료차트를 분석하여 후향적으로 포함하였다. 골수 대 간의 FDG 섭취 비, 부피, CT Hounsfield unit (이하 HU) 및 FDG PET/CT상 내장 및 피하 지방 조직의 mean standardized uptake value (이하 SUVmean)을 측정하고, 이 매개 변수들을 가지고 질병 무진행 생존율에 미치는 예후적 가치에 대해 평가하였다.

결과 병기 III~IV의 환자는 병기 I~II의 환자에 비해 내장 및 피하 지방 조직의 CT HU 및 SUVmean 정도가 더 높았으며, 내장 지방 조직의 부피는 더 적었다($p < 0.05$). 생존 분석에서 내장 및 피하 지방 조직의 CT HU와 SUVmean, 그리고 골수 대 간 섭취 비는 악성 흑색종의 무진행 생존율과 의미 있는 관련성을 보였는데($p < 0.05$), 두 지방 조직의 CT HU 및 SUVmean이 높을수록, 골수 대 간 섭취 비가 높을수록 더 안 좋은 생존율을 보였다. 반면, 두 지방 조직의 부피는 악성 흑색종의 무진행 생존율과 유의한 연관성을 보이지 않았다($p > 0.05$).

결론 내장 및 피하 지방 조직의 CT HU 및 SUVmean, 골수의 SUVmean은 악성 흑색종에서 무진행 생존율을 예측할 수 있는 예후적 정보를 제공할 수 있다.

순천향대학교 천안병원 ¹영상의학과, ²핵의학과, ³피부과