

Combined evaluation of ^{18}F -FDG PET Metabolic Parameters and MRI Perfusion Parameters for the Prediction of Neoadjuvant Chemotherapy Response in Osteosarcoma

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Introduction

Osteosarcoma (OS) is the most common primary malignant bone tumor and most protocols of OS used today employ chemotherapy before surgery (neoadjuvant chemotherapy, NAC). Although the histologically assessed tumor necrosis rate is currently used as the standard of NAC response evaluation, it can be evaluated only in the resected specimen after completing NAC. To overcome this limitation, we evaluated the potential of metabolic parameters from ^{18}F -FDG PET and perfusion parameters from dynamic contrast enhanced (DCE) MRI for monitoring the histologic response to NAC in osteosarcoma, using sequential PET/CT and MR imaging.

Material and Methods

We prospectively registered 24 patients with high-grade OS treated with 2 cycles of NAC and surgery between 2010 and 2012. All patient underwent sequential ^{18}F -FDG PET/CT and MRI before (PET/MR1) and after NAC (PET/MR2). The whole-body PET/CT scanner (Biograph 6; Siemens Medical Solutions) was placed parallel to the 3.0T whole-body MR imaging scanner (MAGNETOM Trio A Tim; Siemens Medical Solutions). PET/CT imaging was performed 60 min after ^{18}F -FDG (7.4 MBq/kg) injection, with a 16.2 cm axial FOV in 3D mode at 210 s per bed position. DCE-MRI was performed using a 3D T1-weighted VIBE sequence (TR/TE, 752/10 ms; FOV, 450 mm; matrix, 279 × 448; slice thickness, 5 mm; 2 average; acquisition time, 3 min 7 s) immediately after the completion of the PET/CT scans. DCE series was acquired after Gd contrast agent (Omniscan®) IV injection (0.1 mmol/Kg at 1.5 mL/s). Maximum standardized uptake values (SUV) from ^{18}F -FDG-PET and variables of the volume transfer constant (K^{trans}) from DCE-MRI were measured on PET/MR1 (SUV1 and K^{trans}_1) and PET/MR2 (SUV2 and K^{trans}_2). Then, their percent changes were calculated and denoted as %SUV and % K^{trans} , respectively. After surgery, the effects on NAC were graded histopathologically: the necrosis of $\geq 90\%$ indicated a good response, and the necrosis of $< 90\%$ indicated a poor response. The optimum cutoff values of SUV, K^{trans} , and their combination for predicting good histologic response were assessed by receiver-operating-characteristic (ROC) curve analysis.

Results and Discussion

After the completion of neoadjuvant chemotherapy, all patients had tumors that demonstrate ^{18}F -FDG uptake greater than adjacent normal bone. The median SUV of the 24 patients decreased from 7.8 (IQR, 5.9 – 10.7) to 4.1 (IQR, 2.8 – 6.9) ($P < 0.001$), and the median K^{trans} decreased from 0.043 min^{-1} (IQR, 0.036 – 0.052) to 0.030 min^{-1} (IQR, 0.021 – 0.044) ($P = 0.002$) after NAC. In a subgroup of patients with a good histologic response, the median SUV decreased from 6.9 (IQR, 5.4 – 10.3) to 2.9 (IQR, 2.1 – 4.4) ($P < 0.001$), and the median K^{trans} decreased from 0.042 min^{-1} (IQR, 0.036 – 0.049) to 0.023 min^{-1} (IQR, 0.019 – 0.034) ($P = 0.013$) after NAC. In another subgroup of patients with a poor histologic response, however, there were no significant differences between SUV1 (median, 8.0; IQR, 6.3 – 11.2) and SUV2 (median, 6.8; IQR, 3.4 – 8.9) ($P = 0.148$) or between K^{trans}_1 (median, 0.045 min^{-1} ; IQR, 0.036 – 0.060) and K^{trans}_2 (median, 0.032 min^{-1} ; IQR, 0.028 – 0.047) ($P = 0.064$). Based on ROC curve analysis, SUV2 (AUC = 0.785) and K^{trans}_2 (AUC = 0.715) best predicted the histologic response among SUVs and K^{trans} s, respectively. The cutoff values, sensitivity, specificity, and accuracy for predicting good histologic response were < 5 , 92%, 58%, and 75%, respectively, for SUV2 and $< 0.03 \text{ min}^{-1}$, 58%, 83%, and 71%, respectively, for K^{trans}_2 . By using the combined criterion of SUV2 < 5 and $K^{\text{trans}}_2 < 0.03 \text{ min}^{-1}$, sensitivity, specificity, and accuracy for predicting good histologic response were 67%, 100% and 84%, respectively. These results suggest that the combined use of SUV2 and K^{trans}_2 may serve to discriminate good histologic response (Fig 1 – 3).

Conclusion

In the current preliminary study, both the metabolic parameters from ^{18}F -FDG PET and perfusion parameters from DCE-MRI are useful for predicting histologic response after NAC in osteosarcoma. Combining these two parameters may be an effective method to predict the histologic response to NAC.

Reference : Byun BH, Kong CB, Lim IH, et al. *J Nucl Med.* 2013; 54: 1053-1059

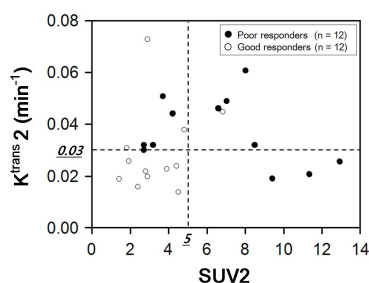


Fig. 1 Scatterplot showing relationship between SUV2 and K^{trans}_2 .

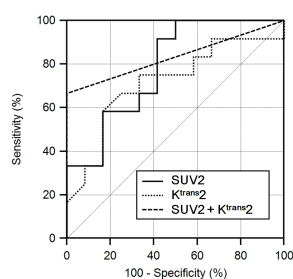


Fig. 2 ROC curves used to predict a good response to NAC with SUV2 and K^{trans}_2 .

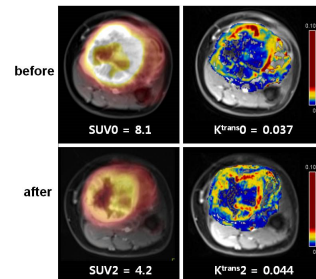


Fig. 3 Changes of tumor metabolism (SUV) and perfusion (K^{trans}) after NAC.