Individualized threshold for tumor segmentation in ^{18}F-FDG PET/CT imaging: The key for response evaluation of neoadjuvant chemoradiation therapy in patients with rectal cancer?

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Summary

Introduction: The standard treatment for locally advanced rectal cancer (RC) consists of neoadjuvant chemoradiation followed by radical surgery. Regardless the extensive use of SUV_{max} in ^{18}F-FDG PET tumor uptake as representation of tumor glycolytic consumption, there is a trend to apply metabolic volume instead. Thus, the aim of the present study was to evaluate a noninvasive method for tumor segmentation using the ^{18}F-FDG PET imaging in order to predict response to neoadjuvant chemoradiation therapy in patients with rectal cancer.
Method: The sample consisted of stage II and III rectal cancer patients undergoing ^{18}F-FDG PET/CT examination before and eight weeks after neoadjuvant therapy. An individualized tumor segmentation methodology was applied to generate tumor volumes (SUV_{2SD}) and compare with standard SUVmax and fixed threshold ($SUV_{40\%}$, $SUV_{50\%}$ and $SUV_{60\%}$) pre- and post-therapy. Therapeutic response was assessed in the resected specimens using Dworak's protocol recommendations. Several variables were generated and compared with the histopathological results.
Results: Seventeen (17) patients were included and analyzed. Significant differences were observed between responders (Dworak 3 and 4) and non-responders for $SUV_{max\text{-}2}$ ($p<0.01$), $SUV_{2SD\text{-}2}$ ($p<0.05$), $SUV_{40\%\text{-}2}$ ($p<0.05$), $SUV5_{0\%\text{-}2}$ ($p<0.05$) and $SUV_{60\%\text{-}2}$ ($p<0.05$). ROC analyses showed significant areas under the curve ($p<0.01$) for the proposed methodology with sensitivity and specificity varying from 60% to 83% and 73% to 82%, respectively.
Conclusion: The present study confirmed the predictive power of the variables using a noninvasive individualized methodology for tumor segmentation based on ^{18}F-FDG PET/CT imaging for response evaluation in patients with rectal cancer after neoadjuvant chemoradiation therapy.

Keywords: Rectal Neoplasms. Neoadjuvant Therapy. Fluorodeoxyglucose F18. Positron-Emission Tomography.

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Article received: 6/24/2017
Accepted for publication: 7/17/2017

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http://dx.doi.org/10.1590/1806-9282.64.02.119

Introduction

Colorectal cancer corresponds to the third more incident (9.7%) and the fourth deadlier (8.5%) cancer of all cancers in the world.[1] In Brazil, it is the third more incident cancer.[2] Clinical T3/T4 or node-positive rectal cancer (locally advanced rectal cancer) patients are usually assigned to preoperative or postoperative chemoradiotherapy. Previous published studies have shown that preoperative chemoradiotherapy significantly improves disease-free survival and local control compared with postoperative chemoradiotherapy.[3,4]

In spite of different neoadjuvant chemoradiation therapy regimens available for treatment of rectal cancer (RC), down staging can be observed only in 20% of patients,[5] and

response to therapy is usually done with the analysis of the surgical specimens, known as the gold standard. Tumor regression grade is mostly associated with prognosis and is of great interest due to survival.[5] Complete and partial regression have improved long-term outcome in patients with rectal carcinoma after preoperative chemoradiation.[3-6]

The ability to predict responders to preoperative chemoradiation in RC using conventional imaging methods (CT, US, MRI) alone or in combination is a difficult task, with non-reliable data.[7,8] Accurate restaging before operation is important to determine the best surgical strategy. Surgical extension and aggressiveness, and sphincter preservation should be considered in light of the response to neoadjuvant treatment, ideally through a noninvasive test.[9]

Fluorine-18-labeled fluorodeoxyglucose-positron emission tomography studies (^{18}F-FDG) have been used to evaluate response to therapy in different cancer types.[10-13] In rectal cancer, previously published data have shown promising use of ^{18}F-FDG PET/CT as an important tool to discriminate responders from non-responders.[7-9,14-19] ^{18}F-FDG PET/CT is a test capable of providing metabolic information of viable cancer cells based on radiotracer retention in the compartment of interest, mediated by an enzyme-substrate reaction. However, there is no consensus on how the quantitative analysis should be used to predict response to therapy using ^{18}F-FDG PET/CT.

^{18}F-FDG-PET images have some limitations regarding the provision of accurate information on external and internal contours of the tumor because of the limited spatial resolution associated with this imaging modality. Despite the extensive use of the most intense ^{18}F-FDG tumor uptake value (known as SUV_{max}) to represent tumor glycolytic consumption using PET images, there is a trend to apply metabolic volume instead.

Due to the inherited heterogeneous behavior of cancer cells, expressing the glucose metabolism of the entire tumor in a single voxel might not be the best manner. Tumor metabolism using volume based on PET images seems a more precise representation than SUV_{max}. Thus, several approaches have been used for tumor segmentation with ^{18}F- FDG-PET images[20-26] for the evaluation of the metabolic pattern of the entire tumor. However, these results are still undergoing evaluation due to large variability depending on the choice of the threshold employed, and none of them were used as a non-subjective way to generate PET tumor volumes.[20-26]

Thus, the aim of our study was to evaluate a noninvasive and non-subjective method for tumor segmentation using ^{18}F-FDG PET/CT imaging to predict response to therapy in patients with rectal cancer that underwent neoadjuvant chemoradiation therapy. To date and to our knowledge, this is the first study to use this methodology to evaluate response to therapy in rectal cancer patients.

Method

The study retrospectively evaluated 17 patients with histopathological confirmation of adenocarcinoma of rectum whom underwent ^{18}F-FDG PET/CT before and eight weeks after neoadjuvant chemoradiation at our institution. Staging was done according to the TNM system[27] presented in the 7th edition of the American Joint Committee on Cancer (AJCC) and included colonoscopy, high-resolution magnetic resonance imaging (MRI) and abdominal and chest computerized tomography (CT) scans. Patients with baseline metastatic disease were excluded. All patients underwent standard neoadjuvant long-course chemoradiation as previously described.[4] Briefly, the regimen consisted of 50.4 Gy delivered on weekdays to the pelvis and a 9 Gy boost to the primary tumor. Concomitantly, chemotherapy (5-fluorouracil and leucovorin) was delivered on the 1st and 5th week of radiation therapy. Surgical resection of the rectum was performed after the second PET scan for all patients. The study was approved by the human research ethics committee, and all of the study's participants signed an informed consent form aware that their privacy rights would be observed.

^{18}F-FDG PET/CT scans were performed according to our research protocol for oncological patients using a Discovery 690 PET/CT scanner (GE, Milwaukee, WI, USA). Patients fasted for at least six hours before the intravenous administration of 3.7 MBq/kg (mean 251.6 ± 62.9 MBq and 244.2 ± 66.6 MBq, before and after therapy, respectively) body weight of ^{18}F-FDG. Blood glucose levels was checked before tracer administration (mean 95.2 ± 9.1 mg/dL and 95.8 ± 9.3 mg/dL, before and after therapy, respectively) and patients with glucose levels higher than 190 mg/dL were excluded from the study. CT scans were performed from the top of the head to mid thigh approximately 60 minutes (mean 95.8 ± 9.3 minutes and 91.1 ± 11.4 minutes, before and after therapy, respectively) after intravenous injection of ^{18}F-FDG using a low-dose protocol (120 kV, smart mA) for attenuation map without diagnostic purpose and without oral or intravenous contrast media. Then, PET images were acquired with 2 minutes per bed position for the same region. All PET images were reconstructed using OSEM-like reconstruction algorithm with 2 interations and 24 subsets.

The ^{18}F-FDG PET/CT images were evaluated independently by two board certified nuclear physicians

blinded to all imaging studies and clinical and pathological results. In case of discrepancy, the interpretation was made by consensus between the investigators. All lesions were analyzed semiquantitatively based on the maximum standardized uptake value (SUV_{max}) in the transaxial plane method normalized by lean body mass and were considered pre- and post-therapy (SUV_{max1} and SUV_{max2}, respectively).

In order to evaluate volumetric tumor glucose consumption, an algorithm for tumor segmentation using PET images was applied, which was initially validated in esophageal cancer patients.[28,29] This methodology uses the ^{18}F-FDG uptake in the liver as a control to individualize threshold for tumor segmentation. Briefly, a region-of-interest comprising the entire organ on a transaxial slice was drawn in the liver and mean and standard deviation of the uptake value of ^{18}F-FDG (L_{mean} and L_{SD}, respectively) were calculated. Meanwhile, the highest tumor uptake value in a voxel (T_{max}) was also calculated. Then, to individualize the threshold for tumor segmentation, a lower SUV value (T_{2SD}) was generated as a result of the following formula: $T_{2SD} = T_{max} - (L_{mean} + 2xL_{SD})$.[28] Figure 1 shows the segmentation methods applied.

Using a region-growing methodology, volumes of interest from a seed point (voxel with highest uptake of ^{18}F-FDG in the tumor: T_{max}) with an specific threshold (T_{2SD}) recognizes all surrounding areas to capture up voxels with the difference of initial value based on the segmentation algorithm. For that, a dedicated workstation was used (Advantage Windows Workstation, GE, Milwaukee, WI, USA).

After generating the target lesion volume (Vol_{2SD}), the program calculates the average SUV volume (SUV_{2SD}), and the product of Vol_{2SD} with SUV_{2SD} determines the total lesion glycolysis (TLG_{2SD}). Fixed thresholds (40%, 50% and 60%) were also applied to generate PET-volumes ($Vol_{40\%}$, $Vol_{50\%}$ and $Vol_{60\%}$, respectively), averaged SUVs ($SUV_{40\%}$, $SUV_{50\%}$ and $SUV_{60\%}$, respectively) and the total lesion glycolysis ($TLG_{40\%}$, $TLG_{50\%}$, and $TLG_{60\%}$, respectively). All variables were calculated for each patient before and after neoadjuvant therapy. In addition, percentage of differences between pre- and post-therapy analyses was also calculated for each parameter as follows: $\%\Delta SUV=[(SUV_1-SUV_2)/SUV_1]x100$, $\%\Delta Vol=[(Vol_1-Vol_2)/Vol_1]x100\%$ and $\%\Delta TLG=[(TLG_1-TLG_2)/TLG_1]$ x100.

Response was assessed using the protocol recommendations by Dworak et al.[30] Resected specimens were analyzed by the same pathologist with particular expertise in gastrointestinal diseases. Tumor response to neoadjuvant therapy was scored using the semiquantitative evaluation of histological regression according to the tumor regression grade (TRG) scale:[30] TRG 0, no response; TRG 1, residual cancer cells outgrowing fibrosis; TRG 2, fibrosis outgrowing residual cancer cells; TRG 3, presence of residual cancer cells; TRG 4, complete histopathological response, i.e. no viable cancer cells in the resected specimen. Applying this rating method, tumors were classified as either non-responders (TRG 0-2) or responders (TRG 3 or 4).

Statistical analysis was performed using MedCalc version 14.8.1 (MedCalc Software, Ostend, Belgium). Numerical variables were analyzed by Mann-Whitney test, and correlation test was applied to generate Pearson's coefficient. Differences were considered statistically significant for $p<0.05$. ROC analysis was performed to determine the metabolic parameters in predicting response to treatment.

Results

From March 2012 to November 2013, 17 patients were eligible and underwent ^{18}F-FDG PET/CT examination to assess therapeutic response after neoadjuvant chemoradiation. All tumors were adenocarcinoma of rectum. Eight men and nine women were included in the study. Patient age varied between 26 to 73 years with mean of 49.5 years. There were seven (41.2%) patients with rectal cancer stage II and ten (57.8%) patients with stage III. In terms of response to therapy, there were 11 (64.7%) non-responders (Dworak 0-2) and six (35.3%) responders (Dworak 3 and 4).

Table 1 shows various quantitative metabolic measurements using ^{18}F-FDG PET/CT images pre- and post-neoadjuvant therapy using different methodologies. All variables revealed significant reduction after chemoradiation therapy ($p<0.01$ for all). Table 2 shows the percentage changes among the variables evaluated in the present study.

Among all variables calculated using ^{18}F-FDG PET/CT images (Table 1), there were significant differences between responders (Dworak 3 or 4) vs. non- responders (Dworak 0-2) for SUV_{max-2} (5.8 ± 2.4 vs. 10.5 ± 3.0, $p<0.01$), SUV_{2SD-2} (3.3 ± 0.4 vs. 4.5 ± 1.2, $p<0.05$), $SUV_{40\%-2}$ (3.5 ± 0.9 vs. 6.2 ± 1.9, $p<0.05$), $SUV_{50\%-2}$ (4.1 ± 1.0 vs. 7.1 ± 2.1, $p<0.05$) and $SUV_{60\%-2}$ (4.7 ± 1.1 vs. 8.1 ± 2.4, $p<0.05$). However, there was no significant difference between responders and non-responders for all of percentage change variables presented in Table 2.

In order to determine the best cutoff values to differentiate responders from non-responders, ROC analyses were performed for all variables. Table 3 summarizes the variables with significant areas under the curve ($p<0.05$, except for the SUV_{2SD-1}). However, the variable SUV_{2SD-1} did not reach statistical significance ($p=0.055$) with the studied sample, the proposed methodology (SUV_{2SD-2}) was able to

TABLE 1 Metabolic measurements of ^{18}F-FDG PET/CT pre- and post-neoadjuvant therapy.

	2SD			40%			50%			60%		
Pre-therapy												
	SUV_{max-1}	Vol_{2SD-1}	SUV_{2SD-1}	TLG_{2SD-1}	$Vol_{40\%-1}$	$SUV_{40\%-1}$	$TLG_{40\%-1}$	$Vol_{50\%-1}$	$SUV_{50\%-1}$	$TLG_{50\%-1}$	$Vol_{60\%-1}$	$SUV_{60\%-1}$	$TLG_{60\%-1}$
Mean	24.0	81.5	7.3	681.7	23.4	12.7	344.3	13.7	15.1	232.5	7.1	16.9	133.2
Median	23.7	62.1	7.0	376.3	15.7	10.3	146.0	10.1	15.5	125.6	5.0	16.8	66.1
SD	8.9	72.5	2.3	797.8	21.7	5.6	430.0	13.4	5.6	284.9	7.6	6.2	165.2
Post-therapy													
	SUV_{max-2}	Vol_{2SD-2}	SUV_{2SD-2}	TLG_{2SD-2}	$Vol_{40\%-2}$	$SUV_{40\%-2}$	$TLG_{40\%-2}$	$Vol_{50\%-2}$	$SUV_{50\%-2}$	$TLG_{50\%-2}$	$Vol_{60\%-2}$	$SUV_{60\%-2}$	$TLG_{60\%-2}$
Mean	8.9	14.3	4.1	63.8	7.7	5.3	41.9	4.4	6.1	28.3	2.4	7.0	17.4
Median	8.1	9.6	3.7	39.5	4.9	4.5	23.0	2.6	5.1	13.5	1.2	5.8	7.1
SD	3.6	15.2	1.1	85.2	6.8	2.1	52.5	4.5	2.3	40.8	2.8	2.6	27.7

SUV: standardized uptake value; 2SD: individualized algorithm for tumor segmentation; 40%, 50% and 60%: fixed thresholds for tumor segmentation; Vol: tumor volume; TLG: total lesion glycolysis.

TABLE 2 Percentage change for metabolic measurements of ^{18}F-FDG PET/CT prior surgical resection.

Patient	$\%\Delta SUV_{max}$	2SD			40%			50%			60%		
		$\%\Delta VOl_{2SD}$	$\%\Delta SUV_{2SD}$	$\%\Delta TLG_{2SD}$	$\%\Delta Vol_{40\%}$	$\%\Delta SUV_{40\%}$	$\%\Delta TLG_{40\%}$	$\%\Delta Vol_{50\%}$	$\%\Delta SUV_{50\%}$	$\%\Delta TLG_{50\%}$	$\%\Delta Vol_{60\%}$	$\%\Delta SUV_{60\%}$	$\%\Delta TLG_{60\%}$
Mean	61.3	78.0	44.4	85.6	52.6	44.6	72.1	55.7	60.6	79.2	54.3	59.7	77.8
Median	63.3	82.9	40.3	93.3	59.6	60.7	88.5	72.1	56.8	91.7	70.2	56.8	90.7
SD	14.5	19.9	22.7	14.5	43.7	75.3	35.9	41.6	17.7	22.8	47.6	17.7	26.5

SUV: standardized uptake value; 2SD: individualized algorithm for tumor segmentation; 40%, 50% and 60%: fixed thresholds for tumor segmentation; %ΔSUVmax: percentage change in SUVmax; %ΔVol: percentage change in tumor volume; %ΔTLG: percentage change in total lesion glycolysis.

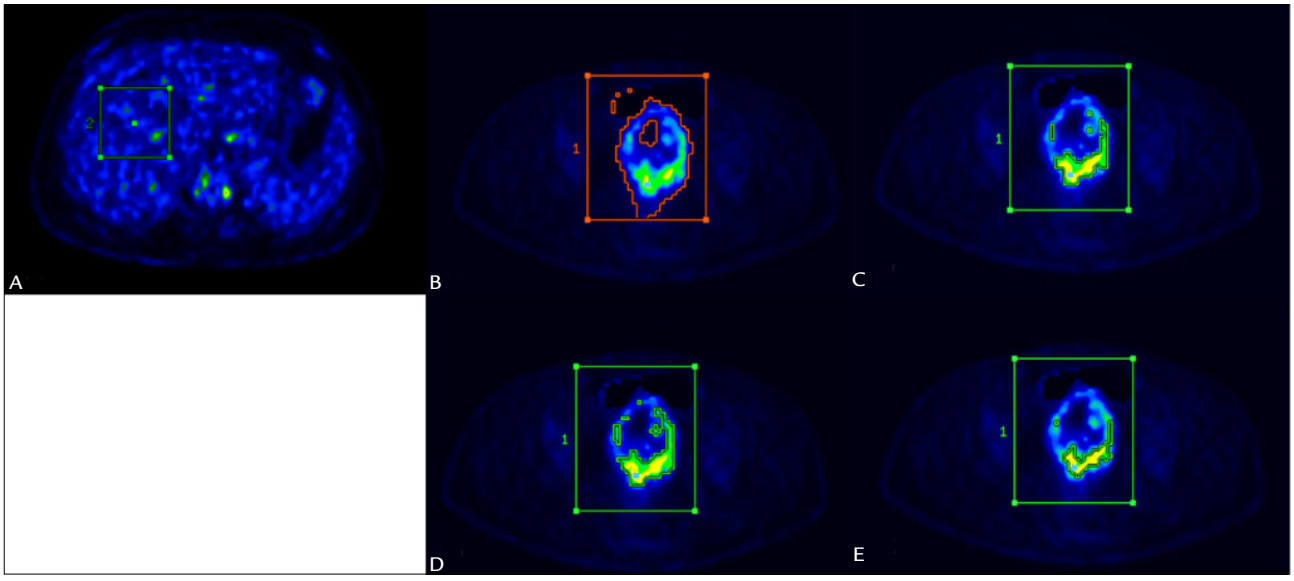

FIGURE 1 ^{18}F-FDG PET/CT tumor image segmentation methods. A. Region of interest (ROI) placed on a transaxial slice in liver. B. Tumor segmentation generated using 2SD individualized algorithm. C. Tumor segmentation generated using 40% threshold. D. Tumor segmentation generated using 50% threshold. E. Tumor segmentation generated using 60% threshold.

differentiate responders from non-responders with 60% and 82% of sensitivity and specificity, respectively. The proposed methodology showed lower sensitivity but higher specificity to discriminate responders from non-responders compared to fixed thresholds (Table 3). Figure 2 shows the significant ROC analyses for the thresholds applied. Figure 3 shows a typical example of ^{18}F-FDG PET/CT imaging tumor segmentation using 2SD individualized algorithm.

Discussion

There is an undeniable interest in assessing response to neoadjuvant chemoradiation in rectal cancer noninvasively with ^{18}F-FDG PET/CT. Tumor metabolic changes using volumetric analyses with PET images seem to be a more precise representation than SUV_{max}. However, there is no consensus about the threshold used for tumor segmentation in this matter. As far as we know, our study is the first in which the proposed methodology of using individualized threshold to segment tumor using ^{18}F-FDG PET/CT images in rectal cancer patients is addressed. This methodology has been applied in esophageal cancer patients[29] with promising results to predict response to neoadjuvant therapy and patient outcome. By using this methodology, SUV_{2SD-1} enabled the discrimination of responders from non-responders with reasonable sensitivity and specificity (83.3% and 72.7%, respectively), while the SUV_{2SD-2} showed approximate values (60.0% and 81.8%, respectively). SUV_{2SD-1} takes into account tumor heterogeneity and, therefore, could be used to predict patients with better outcome before the beginning of neoadjuvant therapy.

Accurate therapeutic response evaluation is crucial because it can guide optimization of the surgical approach (i.e. sphincter-sparing surgery in low rectal tumors), or less aggressive treatment in minimally-advanced tumors. Conventional imaging modalities cannot differentiate fibrosis from viable tumor cells in residual masses after neoadjuvant chemoradiation therapy, therefore being of limited impact on the prediction of pathological response.[7,8] On the other hand, ^{18}F-FDG PET/CT has been proven to be able to predict therapeutical response accurately.

Tumor response varies considerably and, in addition, not all patients benefit equally from treatment. Thus, assessment of potential predictors of histological response using ^{18}F-FDG PET/CT in patients undergoing preoperative treatment could help develop tailored therapy strategies. Our study showed that among the 35.3% of responders (Dworak 3 and 4), some analyzed variables were able to discriminate them from non-responders (SUV_{max-2}, SUV_{2SD-2}, $SUV_{40\%-2}$, $SUV_{50\%-2}$ and $SUV_{60\%-2}$) and the effectiveness of neoadjuvant therapy was in accordance with a previous study.[31]

Guerra et al.[32] showed that SUV_{max} after therapy was the best predictor of pathologic complete response (pCR). The values found were 3.6 ± 1.4 for responders and 6.6 ± 2.1 (p=0.0009) for non-responders.[32] Our study showed similar results for SUV_{max-2} with slightly higher values (5.3 ± 2.2 and 10.4 ± 2.9, respectively) compared to the findings of Guerra et al.[32] These differences could be related to the methodologies applied: 1. SUV correction for the patients' body weight rather than lean body mass, and 2. scan time after chemoradiation, twelve weeks instead of eight weeks applied in our study, respectively.

A study by Kim et al.[33] conducted univariate and multivariate analyses and found post-chemoradiation SUV_{max} as an independent predictor of complete pathological response (pCR). The predictive values of SUV_{max} post-chemoradiation proved to be a value for pCR with a sensitivity of 73.7%, specificity of 63.7% and accuracy of 64.9% for a cutoff value of 3.55. In our study, the cutoff value for SUV_{max-2} of 7.9 showed sensitivity of 83.3% and specificity of 72.7% to discriminate responders (Dworak 3 and 4) from non-responders (Dworak 0-2), a slightly different approach due to the same sample evaluated. Thus, both studies found that the predictive values of post- chemoradiation SUV_{max-2}

TABLE 3 ROC analyses results (only significant values are shown).

Variable	AUC	p-value	Cutoff value	Sensitivity (%)	Specificity (%)
SUV_{max-2}	0.894	0.0001	<7.9	83.3	72.7
SUV_{2SD-1}	0.750	0.055	<6.2	83.3	72.7
SUV_{2SD-2}	0.818	0.0034	<3.3	60.0	81.8
$SUV_{40\%-2}$	0.855	0.001	<4.5	100.0	63.6
$SUV_{50\%-2}$	0.864	0.0004	<5.2	100.0	63.6
$SUV_{60\%-2}$	0.864	0.0004	<6.0	100.0	63.6
$\%\Delta SUV_{40\%}$	0.758	0.037	>68.8%	66.7	81.8
$\%\Delta SUV_{50\%}$	0.758	0.037	>67.4%	66.7	81.8

AUC: area under the curve.

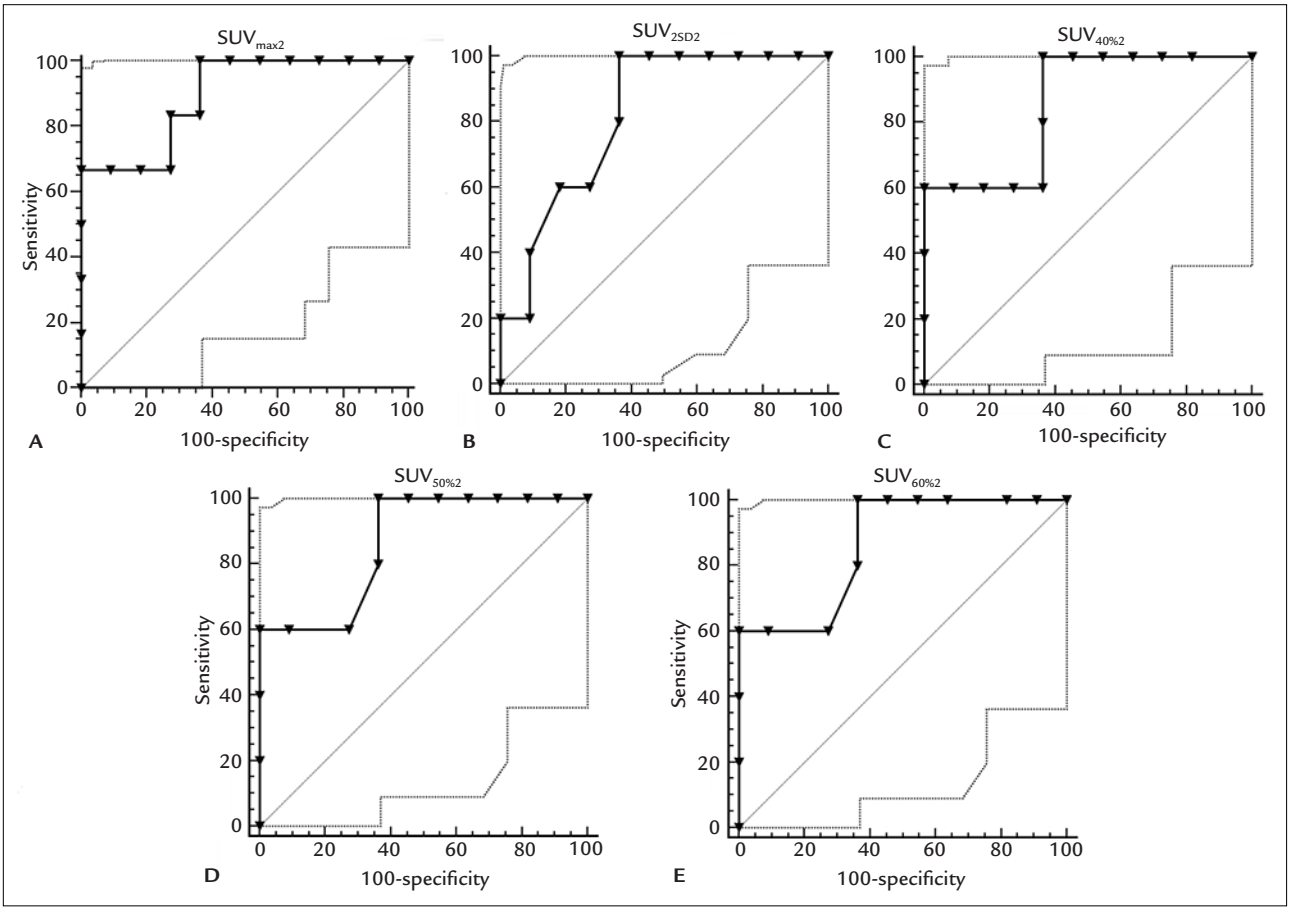

FIGURE 2 ROC analyses.

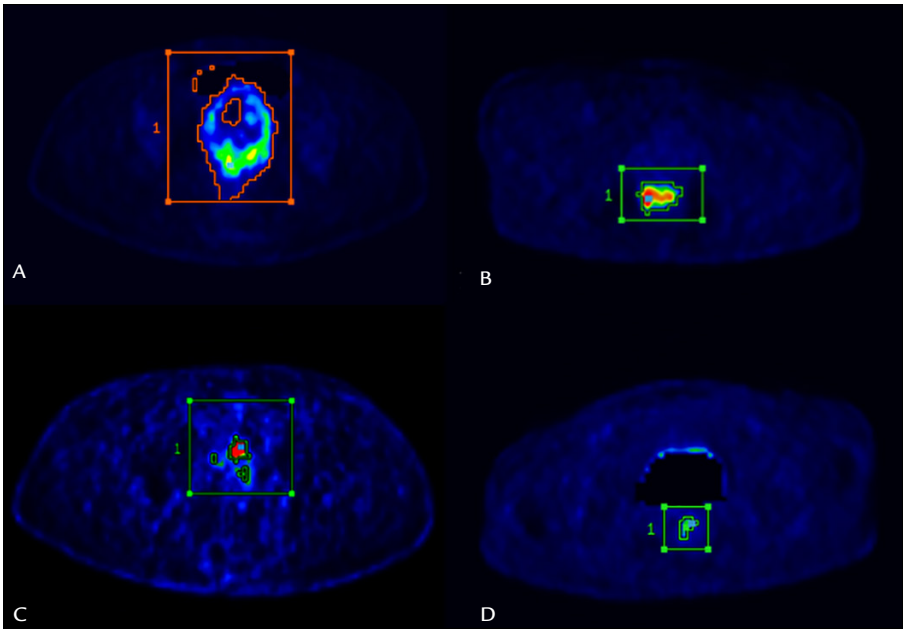

FIGURE 3 Typical example of ^{18}F-FDG PET/CT image tumor segmentation using 2SD individualized algorithm. A. Tumor segmentation pre-therapy in non-responder. B. Tumor segmentation post-therapy in non-responder. C. Tumor segmentation pre-therapy in responder. D. Tumor segmentation post-therapy in responder.

present low sensitivity and specificity to motivate a change in the treatment plan for locally advanced rectal cancer.

In the meta-analysis with the largest number of patients (n=1,527), Li et al.[34] found SUV_{max2} and Δ%TRP to determine pCR alone. The results of subgroup analysis showed that Δ%SUV_{max} before and after therapy had higher specificity to predict the degree of tumor regression than pCR alone. Unfortunately, Δ%SUV_{max} in our study was not strong enough to separate responders from non-responders due probably to the small sample size, which constitutes a limitation. The other potential issue related to the weakness of this variable might be related to inflammation after radiotherapy. Inflammatory cells can take ^{18}F-FDG up, mimicking viable cancer cells and limiting the use of this methodology for response evaluation.

The other variables $SUV_{40\%-2}$, $SUV_{50\%-2}$ and $SUV_{60\%-2}$ should be used with caution, since tumor segmentation using PET images with these thresholds has significant interference depending on the heterogeneity of the tumor. Thus, underestimation could be the main issue of this methodology to evaluate tumor response with unreliable results.

Conclusion

Our study confirmed the predictive power of the variables using a noninvasive individualized methodology for tumor segmentation based on ^{18}F-FDG PET/CT imaging for response evaluation in patients with rectal cancer after neoadjuvant chemoradiation therapy. The reliability of these results should be applied to a larger number of patients and cannot exempt responders from radical surgery. It is also worth noting that there is a need to standardize the methodology of the tests using ^{18}F- FDG PET/CT imaging so that the results can be compared. Although additional work remains to be done, the methodology presented in our study is of general interest, as it introduces a new perspective for the use of this imaging modality on the evaluation of chemoradiation therapy response, with potential clinical impact due to the personalized-type analysis for therapeutic response evaluation in rectal cancer patients.

Acknowledgments

The authors thank FAPEMIG for the financial support and Sofia Lage for proofreading the manuscript.

Resumo

Individualização na segmentação tumoral de imagens de ^{18}F-FDG PET/CT: a chave para avaliação de resposta terapêutica neoadjuvante em pacientes com câncer retal?

Introdução: O câncer retal (RC) é uma doença de importância global, e o tratamento padrão para o câncer retal localmente avançado compreende quimiorradiação neoadjuvante seguida de cirurgia radical. Independentemente do uso extensivo da captação tumoral mais intensa do ^{18}F-FDG (conhecida como SUV_{max}) como representativo do consumo glicolítico do tumor nas imagens de PET, há uma tendência para aplicar volume metabólico. Dessa forma, o objetivo do presente estudo foi avaliar um método não invasivo de segmentação tumoral utilizando a ^{18}F-FDG PET para predizer a resposta à quimiorradioterapia neoadjuvante em pacientes com câncer de reto.
Método: A amostra consistiu em pacientes com câncer retal em estádios II e III submetidos ao exame de ^{18}F-FDG PET/CT antes e oito semanas após a terapia neoadjuvante. Foi aplicada uma metodologia de segmentação tumoral individualizada para gerar volumes tumorais (SUV_{2SD}). A resposta terapêutica foi avaliada nos espécimes ressecados utilizando as recomendações do protocolo de Dworak. Várias variáveis foram geradas e comparadas com os resultados histopatológicos.
Resultados: Dezessete (17) pacientes foram incluídos e analisados. Foram observadas diferenças significativas entre os respondedores (Dworak 3 e 4) e não respondedores para SUV_{max-2} ($p<0,01$), SUV_{2SD-2} ($p<0,05$), $SUV_{40\%-2}$ ($p<0,05$), $SUV_{50\%-2}$ ($p<0,05$) e $SUV_{60\%-2}$ ($p< 0,05$). As análises ROC mostraram áreas significativas sob a curva ($p<0,01$) para a metodologia proposta, com sensibilidade e especificidade variando de 60% a 83% e 73% a 82%, respectivamente.
Conclusão: O presente estudo confirmou o poder preditivo das variáveis utilizando uma metodologia não invasiva individualizada para segmentação tumoral baseada em imagens ^{18}F-FDG PET/CT para avaliação da resposta em pacientes com câncer retal após tratamento com quimiorradiação neoadjuvante.

Palavras-chave: Neoplasias Retais. Terapia Neoadjuvante. Fluorodesoxiglucose F18. Tomografia por Emissão de Pósitrons.

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