Imaging of carotid artery plaques: correlation between 18F-FDG-PET and MRI findings

R. Kwee[1], R. van Oostenbrugge[2], W. Mess[3], R. van der Geest[4], C. Franke[5], H. ter Berg[6], A. Korten[7], B. Meems[8], G. Teule[9], J. van Engelshoven[10], J. Wildberger[10], and E. Kooi[10]

[1]Department of Radiology, Maastricht University Medical Center, Maastricht, Limburg, Netherlands, [2]Department of Neurology, Maastricht University Medical Center, Maastricht, Netherlands, [3]Department of Clinical Neurophysiology, Maastricht University Medical Center, Maastricht, Netherlands, [4]Department of Radiology, Leiden University Medical Center, Leiden, Netherlands, [5]Department of Neurology, Atrium Medical Center Heerlen, Heerlen, Netherlands, [6]Department of Neurology, Maasland Hospital Sittard, Sittard, Netherlands, [7]Department of Neurology, Laurentius Hospital Roermond, Roermond, Netherlands, [8]Department of Neurology, Vie Curi Medical Center, Venlo, Netherlands, [9]Department of Nuclear Medicine, Maastricht University Medical center, Maastricht, Netherlands, [10]Department of Radiology, Maastricht University Medical Center, Maastricht, Netherlands

Background and purpose.

Noninvasive plaque imaging by ^{18}F-FDG PET and MRI may be used to identify vulnerable plaques (i.e., plaques which have a high tendency to cause ischemic events).[1] ^{18}F-FDG PET is able to assess the severity of inflammation in carotid plaques,[2] whereas MRI allows evaluation of morphological and compositional plaque characteristics.[3,4] The purpose of this study was to assess whether ^{18}F-FDG PET and MRI findings strongly correlate or have to be seen as two complementary (separate) imaging modalities.

Methods.

Thirty symptomatic patients with moderate (30-69%) carotid artery stenosis underwent standard ^{18}F-FDG PET and a dedicated multisequence MRI protocol of the entire carotid artery plaque (time interval between both imaging modalities: 5.4 ± 3.5 days). ^{18}F-FDG PET was co-registered with contrast-enhanced CT, using a hybrid PET/CT scanner (Gemini TF 64, Philips Medical Systems, Best, Cleveland, OH, USA). The MRI protocol consisted of 3D T1-weighted (T1w) turbo field echo (TFE), 3D time-of-flight (TOF), multislice T2-weighted (T2w) turbo spin-echo (TSE), and pre- and post-contrast 2D TSE pulse sequences, using a 1.5-Tesla whole-body MRI system (Intera, Philips Medical Systems, Best, the Netherlands). ^{18}F-FDG PET was used to quantify degree of plaque inflammation (Figure 1). MRI was used to assess minimum lumen area, total vessel wall volume, total LRNC/hemorrhage volume, total volume of calcifications, total volume of fibrous tissue, and fibrous cap status of the plaque (Figure 2). Correlations between findings of both imaging modalities were evaluated by Spearman rank correlation analyses (strong correlation: $\rho \geq 0.8$) and independent-samples T tests.

Spearman rank correlation analyses did not reveal strong significant correlations between mean and maximum ^{18}F-FDG standard uptake value (SUV) of the plaque (normalized for mean blood SUV) and minimum lumen area, total vessel wall volume, total volume of calcifications, and total volume of fibrous tissue (as assessed by MRI). There was a weak-to-moderate correlation between maximum SUV and total LRNC/hemorrhage volume (Spearman $\rho = 0.38$, $P = 0.04$) (Table 1). There were no significant differences in both mean and maximum SUVs of plaques with an intact and thick FC and plaques with a thin and/or ruptured fibrous cap (Table 2).

Conclusions.

There are no strong correlations between ^{18}F-FDG PET and MRI-assessed morphological and compositional plaque characteristics. At present, ^{18}F-FDG PET and MRI should be regarded as complementary imaging modalities. Future prospective longitudinal studies will determine whether ^{18}F-FDG PET or MRI (or a combination of both) is most effective in identifying vulnerable plaques.

Figure 1. Fused ^{18}F-FDG PET/CT image of a transverse section of a plaque in the internal carotid artery. Region of interest (ROI) (red) encompassing the plaque was drawn on the CT image. On the co-registered ^{18}F-FDG PET image, mean and maximum SUV of ^{18}F-FDG was measured within this ROI. (ROIs were drawn on all slices where plaque was identified. Eventually, mean and maximum SUVs of the entire plaque were calculated.)

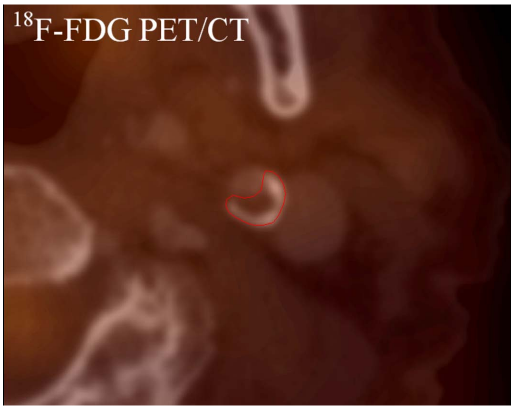

Figure 2. Co-registered T1w TFE, TOF, T2w TSE, pre- and postcontrast T1w TSE images of a transverse section of a plaque in the internal carotid artery. The right bottom panel displays the ROIs which were drawn: red=lumen; green=vessel wall; yellow=LRNC/hemorrhage; orange=calcifications; remaining vessel wall area=fibrous tissue. In this case, the FC was designated as being thin or ruptured (disrupted high signal area between LRNC/hemorrhage and the dark lumen of the carotid artery on the post-contrast T1w TSE image [arrow in post-contrast T1w TSE image]).

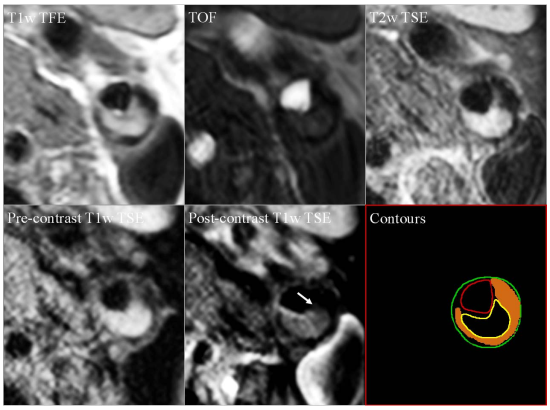

Table 1. Correlations between mean and maximum SUVs and MRI-assessed morphological and compositional plaque characteristics; results of Spearman rank correlation analyses.

	Mean SUV		Maximum SUV	
MRI-assessed parameter	Spearman ρ	*P* value	Spearman ρ	*P* value
Minimum lumen area	0.08	0.69	-0.01	0.94
Total vessel wall volume	0.06	0.76	0.16	0.39
Total LRNC/hemorrhage volume	0.29	0.12	0.38	0.04*
Total volume of calcifications	-0.04	0.84	0.07	0.71
Total volume of fibrous tissue	-0.07	0.70	-0.04	0.83

*$P < 0.05$

Table 2. Mean and mean maximum SUVs of plaques with an intact and thick vs. plaques with a thin and/or ruptured FC (as assessed on MRI); independent samples T-tests.

	Intact and thick FC	Thin and/or ruptured FC	*P* value
Mean SUV	1.20 ±0.19	1.30 ±0.20	0.19
Maximum SUV	1.47 ±0.25	1.62 ±0.35	0.18

References

1. Kwee RM, et al. Identifying vulnerable carotid plaques by noninvasive imaging. *Neurology*. 2008;70:2401-2409.
2. Tawakol A, et al. In vivo 18F-fluorodeoxyglucose positron emission tomography imaging provides a noninvasive measure of carotid plaque inflammation in patients. *J Am Coll Cardiol*. 2006;48:1818-1824.
4. Cappendijk VC, et al. Comparison of single-sequence t1w TFE MRI with multisequence MRI for the quantification of lipid-rich necrotic core in atherosclerotic plaque. *J Magn Reson Imaging*. 2008;27:1347-1355.
4. Cai J, et al. In vivo quantitative measurement of intact fibrous cap and lipid-rich necrotic core size in atherosclerotic carotid plaque: comparison of high resolution, contrast-enhanced magnetic resonance imaging and histology. *Circulation*. 2005;112:3437-3444.